MINISTRY OF ROADS AND HIGHWAYS
GHANA HIGHWAY AUTHORITY

PREPARATORY SURVEY
ON
THE PROJECT FOR THE IMPROVEMENT
OF
THE TEMA MOTORWAY ROUNDABOUT
IN
THE REPUBLIC OF GHANA

FINAL REPORT

February 2017

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

CTI ENGINEERING INTERNATIONAL CO., LTD.

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PREFACE

In response to the request from the government of Ghana, the government of Japan decided to conduct the “Preparatory Survey on the Project for the Improvement of the Tema Motorway Roundabout in the Republic of Ghana” and entrusted the survey to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a survey team headed by Mr. Ryohei Watanabe of CTI Engineering International Co., LTD. from March 2015 to March 2017.

The survey team held a series of discussions with the officials concerned of the Republic of Ghana, and conducted field studies associated with various engineering surveys. The results and findings of the field studies and the analysis results carried out in Japan are compiled in this report.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Republic of Kiribati for their close cooperation extended to the survey team.

February, 2017

Akira NAKAMURA
Director General
Infrastructure and Peacebuilding Department
Japan International Cooperation Agency

SUMMARY

1. Situation of Republic of Ghana (hereafter referred to as Ghana)

Although located along the Gulf of Guinea and Atlantic Ocean in the subregion of West Africa ninety-five percent (95%) of the country's transport is dependent on road transport. Ghana has been making remarkable progress recently in improving the road network. However, only half of the entire arterial roads is paved and 38% of the paved surface is severely deteriorated.

The Government of Ghana (GOG) formulated the National Transport Policy in 2008 and has been expanding and upgrading the international corridors. In particular, the policy puts high importance in the development of road network in the Greater Accra Region (GAR) that has a population of about 4 million as of 2010 and lying at the nodal point of three international transit corridors; i) Abidjan-Lagos Corridor, ii) Central Corridor, and iii) Eastern Corridor of Ghana with an aim to not only secure smooth flow of international logistics but also to resolve traffic issues of the region.

The Tema Motorway Roundabout is a 5-leg roundabout where traffic from Accra and Tema Port converge, causing heavy traffic congestion during rush hours. The congestion and speed retardation at the roundabout is becoming an impediment to smooth and safe movement of people and traffic. In addition, the number of cargo vessels at Tema Port has been increasing in an annual rate of 12% between year 2000 and 2012. The GOG is planning expansion of the port to correspond to the increase. The is expansion plan is anticipated to contribute to significant increase of traffic volume in this region and at the roundabout as well.

2. Requested Scope

The request made by the GOG is a phase wise improvement of Tema Intersection. The scopes of each phase are as follows;

- Phase-1: Construction of 1st tier flyover including detailed design and construction supervision
- Phase-2: Construction of 2nd tier flyover including detailed design and construction supervision

3. Survey Schedule

Survey schedule is shown in Table-1.

Table-1 Survey Schedule

Surveys (Site Survey etc.)	Period
1st Site Survey	April 7th 2015 ~ May 22nd 2015
Interim report Explanation	October 19th 2015 ~ October 31st 2015
2nd Site Survey	November 11th 2015 ~ December 20th 2015
Design Review and Traffic Safety by GHA	June 23rd 2016 ~ July 15th 2016
Draft Final Report Explanation	November 2nd 2016 ~ November 14th 2016

4. Project Scope

A preliminary comparison of improvement methods, which was based on conceptual images and limited was carried out and explained to the GOG during the IC/R meetings. The comparison was substantiated and application was justified by reflecting actual figures and data obtained from various engineering surveys and hearings conducted during the site surveys.

The project scope was then determined, discussed with JICA, explained to GHA and sought GHA's agreement. The agreed scope of the project is shown in Table-2.

Table-2 Project Scope

Requested Scopes	Target
Phase-1 Construction of 1st level flyover including improvement of the objective roundabout, the detailed design of a graded intersection and construction supervision	○ (to be undertaken by this project)
Phase -2 Construction of 2nd level flyover including, the detailed design of a flyover and construction supervision	–

5. Project Outline

The outline of the for Phase 1 is shown in Table 3.

Table-3 Outline of Project for Phase 1

Items				Specification and rough quantities
Outline Design	Length	East - West Direction (Motorway – Aflao Road)	Total Length	2,100m
			Depress Section	730m (Box culvert：190m、 Depress section：540m)
		North - South Direction (Harbor Road – Akosombo Road)		1,900m
		Lamps		7,000m
		Service Road		3,500m
	Design Speed			100km/h (Harbor Road : 80km/h)
	Road Width	Motorway	STA.0+0~8+20	31.9m
		Depress Section	STA.8+20～10+10	31.9m
		Aflao Road	STA.10+10～16+0	31.9m
		Harbor Road	STA.0+0～7+0	11.0m
		Akosombo Road	STA.7+0～14+20	11.0m
		Service Road		6.0m
	Numbers of Carriage way and Width	Motorway / Depress Section / Aflao Road		3 Lanes / 3.65m (3.65m×3=10.95m)
		Akosombo Road / Harbor Road		2 Lanes / 3.65m (3.65m×2=7.3m)
		Service Road		1 Lane / 3.0m (3.0m×1=3.0m)

Items			Specification and rough quantities
	Center Median and Shoulder	Motorway	10.0m / 3.0m
		Depress Section / Aflao Road	4.0m / 2.5m
		Akosombo Road /Harbor Road	4.0m / 2.5m
Structure	Asphaltic Concrete Pavement		t=11～15cm、136,300m^2
	Box Culvert		L=190m
	Retaking wall		H=1.4m～11.0m、L=640m
	Pedestrian Bridge		4 Numbers
	At Grade Intersection controlled by Traffic Signal		1 Location
	Road Lighting		Box culvert section :L=190m

6. Project Implement Schedule and Project Cost

The implementation period of the Project is estimated to be 8 month for detailed engineering design, and 36 months for construction work.

The project cost to be borne by the recipient country is estimated to be about 6.6 million Ghana Cedi (213 million Japanese Yen, GHC1.0=JPY32.26).

The cost to be borne by the Japan' Grant Aid is not shown in this report due to the confidentiality.

7. Project Evaluation

(1) Relevance of the Project

Implementation of the Project under Japanese Grant Aid has been verified from the following viewpoints:

- Large Scale of Beneficiaries

  The Project area is located in Tema City area and number of beneficially is estimated approximately 500 thousand residences and approximately 90 million users in total.

- The Effect of the Project

  The Project would contribute to easing traffic congestion and smoothing transportation of people and freight. These would consequently contribute to the improvement of transportation of network development for logistics throughout the nation and entire Western Africa Region.

- Human Security

  The Project would contribute to the securing stability of people's lives, development of their daily lives, and securing BHN (Basic Human Needs).

- Operation and maintenance of Facilities:

  As excessive advanced technique is not necessary, the Ghana side would be able to carry out adequate operation and maintenance work in planned consistent way

- Consistency with Long Development Plan

  This Project is consistent with the Policy and target described in the Government National Development Master Plan and would help in achieving enhancement of national trunk road network improvement.

- Impact to Environment

  There is no significant or permanent negative impact to environment and social condition.

- Necessity and Superiority of Japanese Technology

  Japanese most advanced and cutting-edge construction technology, such as time control, safety control, and quality control, is required to execute the Project under Japan's Grant Aid scheme without any serious issues.

(2) Effectiveness

1) Quantitative Effect

The expected quantitative effect to be produced through performing the works of target Project for economic cooperation is shown in the following Table 3. The values of base year before conducting the Project and target year in three (3) years over completion of the Project are respectively set up.

Table 3 Quantitative Effects

Index	Basic Value (Actual Record of 2015 year)	Target Value in 2023 (Project Completion Year)
Passenger Volume	86.6(Million)/year	156.8(Million)/year
Freight(Cargo) Volume	44.3(Million)/year	74.3(Million)/year
Travel Time per minute (AM peak hour at Accra-Aflao 2.0 km)	8.2 minute	2.0 minute

2) Qualitative Effect

The prospective effects are;

- To moderate traffic congestion and to provide uninterrupted traffic flows.
- To facilitate and grade up transit system in the West African Region.

a) Stable carrier-transit time and effectiveness in logistics leaving and arriving at the Tema Port will be improved.
b) Traffic safety of pedestrians and vehicles at the intersections will be improved.
c) Future emission of transport related greenhouse gases will be reduced.
d) Connecting links between Coastal Highways (Coastal Corridor) and East Highways (East Corridor) will be enhanced.

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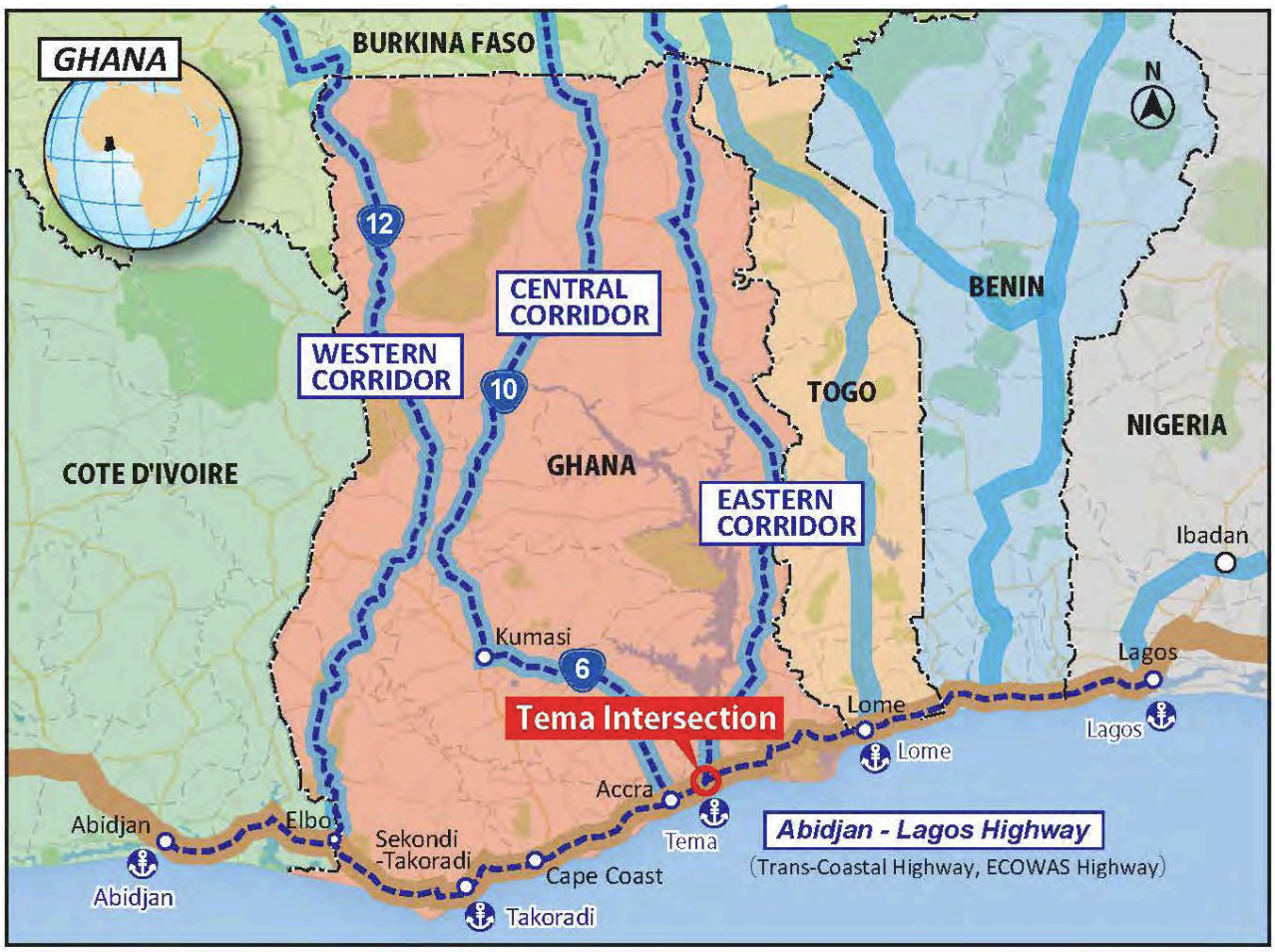


LOCATION MAP

PERSPECTIVE

Current Condition

After Completion

PHOTOS: Activities during First Field Visit (1/2)
(April 7, 2015 – May 22, 2015)

Courtesy call and meeting with GHA Officials

Courtesy call and meeting with MRH Officials

Courtesy call and meeting with MOF Officials

Technical meeting with GHA Official

Site inspection with geo-technical sub-consultant

Traffic survey

PHOTOS: Activities during First Field Visit (2/2)
(April 7, 2015 – May 22, 2015)

Inspection of service utilities

Truck Weigh Station near toll both in Tema

Current condition around the objective roundabout

Current condition of Circulatory road of objective roundabout

Distressed surface near objective roundabout

Clogging of drainage facilities

PHOTOS: Activities during Second Field Visit
(October 18, 2015 – November 1, 2015)

	
Courtesy call to MRH	IT/R explanation meeting with GHA Officials

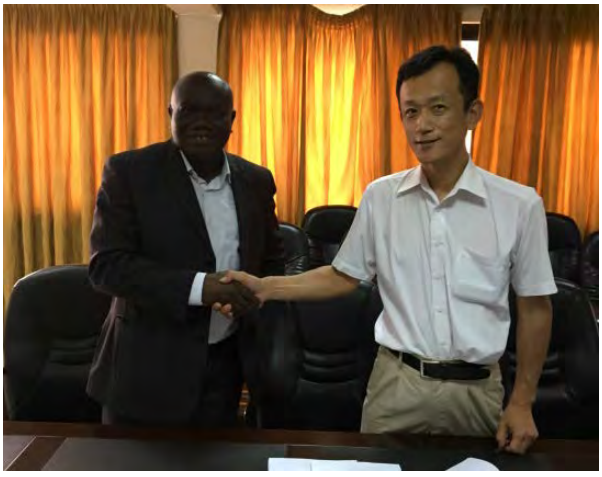
PHOTOS: Activities during Third Field Visit
(November 11, 2015 – December 20, 2015)

	
Courtesy call to Director of GHA	IT/R explanation meeting with GHA Officials
	
First Stakeholder Meeting	Observation well excavation

PHOTOS: Activities during Fourth Field Visit
(June 22, 2016 – July 16, 2016)

	
Technical Review explanation to MRH and GHA	Procurement survey (asphalt plant)
	
Groundwater level measurement (Observation well)	Congestion at objective roundabout

PHOTOS: Activities during Fifth Field Visit
(November 1, 2016 – November 15, 2016)

	
DOD explanation meeting with MRH and GHA	DOD explanation meeting with GPHA
	
A glimpse of second stakeholder Meeting	A glimpse of second stakeholder Meeting
	
Signing the MD between JICA and MRH	Signing the MD between JICA and MRH

LIST OF FIGURE

LIST OF TABLES

ABBREVIATIONS

A-RAP	:	Abbreviated Resettlement Action Plan
AADT	:	Annual Average Daily Traffic
AASHTO	:	American Association of State Highway Transportation Officials
CBR	:	California Bearing Ratio
D/D	:	Detailed Design
DHV	:	Design Hourly Volume
DF/R	:	Draft Final Report
DUR	:	Department of Urban Roads
EA	:	Environmental Assessment
ECOWAS	:	Economic Community of West African States
EIA	:	Environmental Impact Assessment
E/N	:	Exchange of Notes
EPA	:	Environmental Protection Agency
GHA	:	Ghana Highway Authority
GPHA	:	Ghana Ports and Harbour Authority
GRA	:	Greater Accra Region
GOG	:	Government of Ghana
GOJ	:	Government of Japan
IC/R	:	Inception Report
IEE	:	Initial Environmental Examination
IT/R	:	Interim Report
JICA	:	Japan International Cooperation Agency
JIS	:	Japanese Industrial Standard
LOS	:	Level of Service
MRH	:	Ministry of Roads & Highway
MTTU	:	Motor Transport and Traffic Unit
NTP	:	National Transport Policy
O/D	:	Outline Design
ODA	:	Official Development Assistance
PAPs	:	Project Affected Persons
PCU	:	Passenger Car Unit
PPP	:	Public Private Partnership
RAP	:	Resettlement Action Plan
R/D	:	Record of Discussion
ROW	:	Right of Way
SHRP	:	Strategic Highway Research Program
TAH	:	Trans African Highway
TDC	:	Tema Development Corporation
TMA	:	Tema Metropolitan Assembly
T/R	:	Technical Review

Chapter1 Background of the project

1.1 Introduction

Republic of Ghana is located along the Gulf of Guinea and Atlantic Ocean in the subregion of West Africa and shares borders with Togo in the east, Ivory Coast in the west and Burikina Faso in the north. Although all land, sea and air modes of transport is accomplished, ninety-five percent (95%) of the country's transport is dependent on road transport. Ghana has been making remarkable progress recently in improving the road network. However, the development still has a long way to go as only half of the entire arterial roads is paved. To make the situation worse, even the paved section is in poor condition as 38% of the paved surface is severely deteriorated where driving comfort is significantly low.

The Government of Ghana (GOG) formulated the National Transport Policy in 2008 and has been expanding and upgrading the international corridors to achieve integrated, efficient, and sustainable transport system and strengthen the function of the country as the transport hub of the West African region. In particular, the policy puts high importance in the development of road network in the Greater Accra Region (GAR) that has a population of about 4 million as of 2010 and lying at the nodal point of three international transit corridors; i) Abidjan-Lagos Corridor, a part of the Dakar to Lagos Trans African Highway (TAH) No.7 of the Economic Community of Western African States (ECOWAS), ii) Central Corridor, and iii) Eastern Corridor of Ghana that links Tema Port with Burkina Faso, Mali and Niger, to not only secure smooth flow of international logistics but also to resolve traffic issues of the region.

The Tema Motorway Roundabout is a 5-leg roundabout where traffic from Accra and Tema Port converge, causing heavy traffic congestion during rush hours. Speed at these times retard to below 10 km/h. The congestion and speed retardation at the roundabout is becoming an impediment to smooth and safe movement of people and traffic. In addition, the number of cargo vessels at Tema Port has been showing an annual increase of approximately 10% between year 2000 and 2012. The GOG is planning expansion of the port to correspond to the increase. The expansion of the port is anticipated to increase cargo vehicles to and from the port. This is expected to contribute to significant increase of traffic volume in this region and at the roundabout as well. In order to remedy such situation and to enhance smooth and safe traffic flow (logistics) both within the country and the West African Region, it is utterly and urgently important to undertake the improvement of the roundabout.

Under such circumstances, the GOG made a request in 2013 to the Government of Japan (GOJ) for a Grant Aid Assistance to implement "the Project for the Improvement of the Tema Motorway Roundabout (Project). The GOJ entrusted the survey to Japan International Cooperation Agency (JICA), the official agency to implement the Japanese Government's technical assistance and expediting proper execution of Japan's Grant Aid. JICA dispatched a consultant to carry out the survey.

This report compiles the results of the outline design drawing carried out reflecting the results of various engineering surveys undertaken in Ghana and information gathered from discussions and hearings conducted with the Ghana Highway Authority (GHA) and other relevant agencies of Ghana.

1.2 Requested Scope

The request made by the GOG is a phase wise improvement of Tema Intersection. The scopes of each phase are as follows;

- Phase-1: Construction of 1st tier flyover, including the detailed design and construction supervision
- Phase-2: Construction of 2nd tier flyover, including the detailed design and construction supervision

1.3 Current Situation and Issues of the Objective Roundabout

The Tema Motorway Roundabout is a major intersection located in the urban area of Tema Town on the Abidjan-Lagos highway. The Roundabout has five (5) legs. From the west in anti-clockwise direction, they are; (i) Accra-Tema Motorway, (ii) Tema-Hospital Road, (iii) Tema-Harbour Road, (iv) Tema-Aflao Road and (v) Tema-Akosombo Road. The roundabout has a 120m diameter mounted central island and an inscribed circle diameter of about 140m and a 2-lane circulatory roadway. Despite being relatively big, the roundabout is currently operating beyond its capacity and is experiencing heavy traffic congestion causing severe delays and lengthy travel time. The congestion is not only prevalent during peak hours but throughout the day time.

The traffic volume count results, as shown in **Table1.4.1-1**, indicate that during morning hours, congestion length on all legs excluding Hospital Road exceeds 100m, while the longest congestion is along Tema-Akosombo Road where the length is 1,100m. Although the congestion on Tema-Harbour Road and Tema-Hospital Road is comparatively less in the morning peak hour, it exceeds to several times the morning congestion length during evening hours.

Table1.4.1-1 Peak Hour Congestion Length at Entry Point

Direction	Peak Hour Congestion Length (m)	
	Morning	Evening
Accra-Tema Motorway (East Bound)	500	500
Tema-Hospital Road (North Bound)	20	170
Tema-Harbour Road (North Bound)	120	700
Tema-Aflao Road (West Bound)	600	450
Tema-Akosombo Road (South Bound)	1,100	600

The roundabout used to be controlled by traffic signals. Traffic volume had so much increased that use of these traffic signals was no more effective and the traffic control by signals was abandonment. Currently, congestion during peak hours is so severe (the traffic volume is so high) management within the roundabout is done with the help of traffic police from the Motor Transport and Traffic Unit (MTTU) of the Ghana Police Service. There are many factors that contribute to the congestion. Some of the major ones are briefly outlined below.

(1) Lack of Alternatives

Tema Roundabout is the only intersection where traffic converges from all directions. In fact, there are three

arterial roads, including the Accra-Tema Motorway running east-west, which connects Accra and its environs to the port of Tema. The other two roads are located south of the Motorway and run almost parallel to the Motorway. Both these roads end at the Tema-Harbour Road. Therefore, any vehicle bound beyond Tema, to the east or the north, must pass through theTema Roundabout.

(2) Location and Geometry of the Roundabout

Generally, roundabouts operate effectively on collector or feeder roads, where traffic volume is relatively low. It is most effective on a typical four-legged intersection with similar order of traffic volumes. Tema Motorway Roundabout is a 5-legged roundabout located on an international corridor and the roads coming to it consist of different classifications. Where Accra-Tema Motorway, Tema-Harbour Road and Tema-Aflao Road have two lanes on both the approach and exit ways, Tema-Hospital Road and Tema-Akosombo Road have only one lane. Vehicles have to merge into a single lane and when the volume is high the speed of the merging vehicle is significantly reduced causing obstruction to the flow behind and ultimately creating heaving congestion.

(3) High Ratio of Heavy Vehicles

The result of the traffic volume count indicates that the rate of heavy vehicles account to almost 10% and is predicted to show constant increase in the years ahead. The heavy vehicles use the entire circulatory road width (both lanes) of the roundabout causing significant decrease of traffic capacity inside the roundabout.

(4) Disorderly Use of Open Space

The open spaces, particularly between the Tema-Aflao Road and Tema-Akosomobo Road, are full of vendors/small shops. People disorderly cross the road, mini buses frequently stop at any location to load or off load passengers. All these are some of the causes of severe obstruction to the flow of the vehicles.

(5) Vendors and Jay Walkers

There are many commercial street vendors who sell around the roundabout. Although, the vendors come onto the road only when the vehicles stop, they obstruct the vehicle flow when crossing from one side to the other. Also, there is no designated location to cross the road, so people cross the roads at their own convenient locations causing disruption to traffic flow.

1.4 Natural Condition

1.4.1 Geography and Geology

Republic of Ghana is located along the Gulf of Guinea and Atlantic Ocean in the sub-region of West Africa and shares its border with Togo in the east, Ivory Coast in the west and Burkina Faso in the north. The topography of Ghana is relatively flat with many swampy areas along the coastline and tropical forest that is distributed from the west coast to the central part of the country. The project area is located at Tema, in the Greater Accra Region of Ghana, approximately 19 kilometers east of Accra and approx. 5 kilometers north of Tema Port.

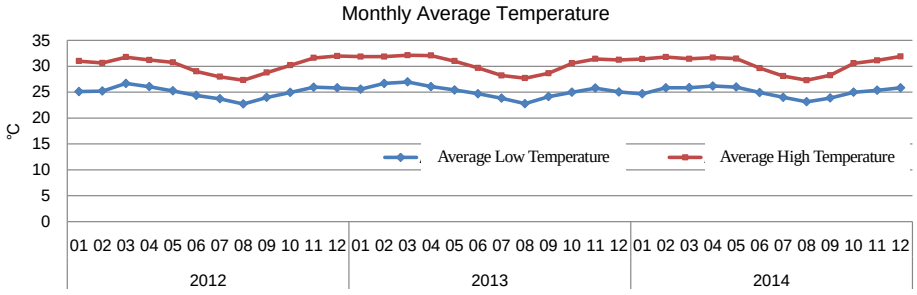
The geology of the area forms part of the Dahomeyan Series. The rocks of this geological system occur essentially as alternating belts of basic and acidic gneisses. Rocks of the series consist generally of muscovite – bitotite gneiss, quartz feldspar gneiss, augen gneiss and minor amphibolites. The area is known to exhibit little or no structural instability in its geology, the presence of faults and lineaments are not likely. Previous investigation as well as the present one has established that the area is underlain by GNEISS rock which has weathered to varying degrees.

1.4.2 Climate and Temperature

Climate of Ghana changes from a tropical humid climate to a Savanna climate from the southern plain to the central and northern basin.

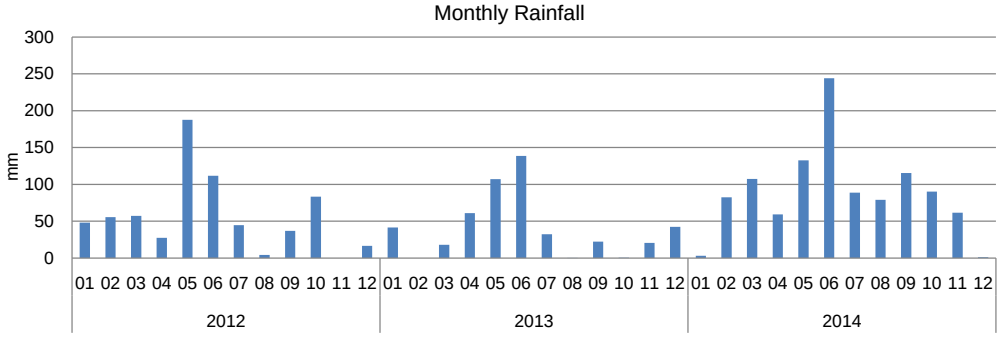
Tema, where the project area lies have dry equatorial climate and normally experiences two climate seasons in the year; the wet and dry season. The wet season usually extends from the middle of April to the end of October. The period between November and February is normally dry when the area is subjected to the North-East trade winds known as Harmattan winds. Monthly average temperatures and rainfall data for the last three consecutive years (2012 - 2014) are shown in **Figure 1.4.2-1** and **Figure 1.4.2-2** respectively. Mean temperatures are normally around 27 degrees Celsius. The peak levels are normally recorded during the dry season where temperatures rise to the range between 33 – 35 degrees. Minimum temperatures of 15 – 18 degrees are recorded during July and August.

Monsoon lies between March and October. The precipitation time varies but day-long rainfall is very rare. The maximum rainfall is seen between May and June where the monthly volume is observed at about 100mm.



Source: Ghana Meteorological Agency

Figure 1.4.2-1 Monthly Average Temperature

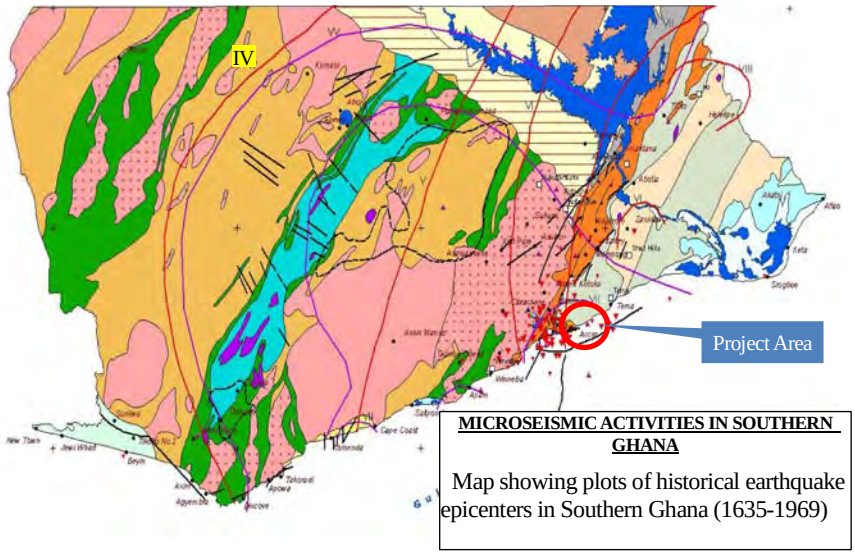


Source: Ghana Meteorological Agency

Figure 1.4.2-2 Monthly Rainfall

1.4.3 Earthquake

There are no major earthquake plates in Ghana, However, the southern part of the country occasionally experiences seismic activities. Records of damaging earthquakes in Ghana date as far back as 1615. Historical data indicate that the most seismically active areas in Ghana are the west of Accra. According to the modified Building Code Part 3, 1988, the project area is classified into Zone 3 in terms of seismic activities. This means the horizontal ground acceleration is 'A', which is usually equal to or greater than 0.35g for this zone. The Code recommends that a minimum horizontal acceleration of 0.35g should be used in designing important structures in this zone.



Source: Ghana-German Technical Cooperation Project 2006

Figure 1.4.3-1 Earthquake Zoning Map

1.5 Environmental and Social Considerations

1.5.1 Project Components

The components of the project are as following;

- Intersection Configuration : 3-tier partial free-flow intersection (Phase 2)
- Features : Road improvement of approx. 2.1km on east & west side
  730m depressed section (Box culvert 190m, depressed 540m)
  Road improvement o approx. 1.9km on north & south side
- Ancillaries : Service road approx. 3.5km
  Ramps approx. 7.0km, signal controlled at-grade intersection, lighting inside underpass, Drainage, safety measures, footbridges
- Required Land area : approx. 14.6 hector
- Construction Period : approx. 28 months (Phase 1)

1.5.2 Environmental Impact Assessment System

According to "Environmental Assessment Regulations 1999, LI 1652", development projects having potential environmental impacts must be registered with the Environmental Protection Agency (EPA) and

obtain an Environmental Permit. The proponents must conduct required procedure depending on SCHEDULE 1 and 2 in the Regulations. The proponents must submit an environmental registration form, project design and other required documents to EPA regional office in cases of projects listed in the SCHEDULE 1 or EPA central office in cases of projects listed in the SCHEDULE 2 respectively. All projects listed in the SCHEDULE 2 require implementation of Environmental Impact Assessment (EIA). Road construction projects require implementation of EIA as it is listed in SCHEDULE 2. This project is an improvement of a roundabout. However, implementation of EIA for this project is required as the improvement works include major construction works like that of new road construction projects.

1.5.3 Baseline of the Environmental and Social Condition

1.5.3.1 Natural Environment

(1) Fauna and Flora

There are no forests and wet lands and natural vegetation areas that are important for biodiversity in and around Tema intersection. According to field surveys conducted in December 2016, 3 species of reptiles (one is not identified), 4 breeds of birds and 8 species of trees existed in and around Tema intersection. All the identified species were common species.

(2) Protected Area and Forest Zone

Sakumo Lagoon (1,364 hectares) was designated as a Ramsar Site in 1992 and is a habitat for migratory birds and aquatic life in blackish water is located in 1.5 ~2 km west of Tema intersection. The area between Tema intersection and the Lagoon is mostly industrial and residential , and as such, pathways of surface or in water for wildlife migration are blocked. Rainwater in and around Tema intersection is not drained way to the Lagoon. Contamination of the lagoon at the estuary is very serious due to the fact that all domestic and industrial waste in and around Tema flows into the lagoon and the existence of a road along the coast does not allow a direct flow of the sea water into the lagoon, except at the estuary. There are no other protected areas or forest zones to serve as habitats for wildlife around Tema intersection.

1.5.3.2 Social Environment

(1) Social Economy

Tema intersection is a transportation hub of road networks connecting the nation's largest port. There are over 500 industries that produce chemicals, clothing, consumer electronics, electrical equipment, furniture, machinery, refined petroleum products and steel in the port zone, which also serves the "Free Economic Zone Areas". The free zone enterprises create employment in the factories. About 90 percent of the working population are employed in this zone. Unskilled women mainly work in service and sales sector derived from industry. Because agriculture, forestry and fishery are not thriving businesses in this area, the existence of these factories make a major contribution to poverty reduction measures in this area.

(2) Land use

The total land coverage of Tema Metropolitan Area is approximately 369 sq. km, about 45% of which has development plans. About 36% of the total land is used for residential, 7% for industrial and 4% for commercial purposes. Commercial activities are concentrated in the Central Business District and along some major radial roads including Tema intersection. Due to population growth, the current designated market areas in the Tema Metropolis are inadequate. The situation has led to the proliferation of commercial shops and stores in the form of simple structures, and shipping containers along the road corridors in Tema intersection.

The area around Tema intersection is within the Tema Development Corporation (TDC) Acquisition area managed by long-term lease hold, therefore problems associated with ownership of land is not anticipated to be high. However, there are some simple business stores within the Right of Way. The most prominent ones are facilities such as fast food joints, filling stations, bus terminals, sale of used cars and heavy machinery for hiring, and mechanic shops for car repairs that are related to transportation. The designated Tema Heavy Industry Area (about 50km2) lies southeast of Tema intersection. The open spaces, particularly between the Tema-Aflao Road and Tema-Akosomobo Road, are full of vendors/small shops.

Figure 1.5.3-1 Land Use Layout of Study Area

1.5.3.3 Pollution

(1) Noise Level

Measurement of noise level conducted at 5 points in and around Tema Roundabout under this survey

indicates that the noise levels except for the the measurement point at the center of the roundabout exceeded 75dB (as Aeq), that is the Permissible Noise Level in predominantly commercial areas.

(2) Air Quality

Air quality monitoring data around Tema Roundabout are not available. The air quality analysis conducted around Tema intersection in 2015 by a local consultant indicated that the PM10 and Total Suspended Particulate (TSP) levels (PM10 150 (µg/m3), TSP 290 (µg/m3)) exceed the Ambient Air Quality Standards in Ghana ((PM10 70 (µg/m3), TSP 230 (µg/m3)).

1.5.4 Scoping Result

Social impacts of the project are shown in the following Table as the scoping result.

Table 1.5.4-1 Scoping Result

Category	No.	Impact Item	Assessment		Reason / Remarks
			Pre-Construction Phase Construction Phase	Operation Phase	
Pollution	1	Air pollution	B-	B±	**Construction Phase:** Emission of dust and exhaust gas will increase due to construction equipment operations and traffic congestion in construction site. **Operation Phase:** In the future, the total amount of air pollutant caused by vehicle exhaust gas will increase. However, because of improved traffic efficiency, the amount may be reduced compared to current situation.
	2	Water pollution	B-	D	**Construction Phase:** Turbid water will be generated during rainfall periods. However, because there are no water resource areas, rivers and lakes in and around the project site, impact of turbid water caused by construction works will be very limited. **Operation Phase:** Because water quality of drains will not change significantly, water pollution is unlikely to occur.
	3	Waste	B-	D	**Construction Phase:** Construction waste caused by construction and demolition works, and general waste from construction office will be generated. **Operation Phase:** Considerable generation of solid waste is unlikely to occur.
	4	Soil pollution	D	D	Because materials that may cause soil pollution such as heavy metal and toxic organic matter will not be used in the construction and maintenance works, soil pollution is unlikely to occur.
	5	Noise and vibration	B-	B±	**Construction Phase:** Construction equipment operation will cause noise and vibration. **Operation Phase:** Increased traffic volume and speed will elevate noise level. However, decrease in horning frequency, the noise level might be reduced compared to current situation.
	6	Ground subsidence	D	D	Because the ground is hard and groundwater withdrawal will not be included, ground subsidence is unlikely to occur.
	7	Offensive odors	D	D	Because materials and equipment that may cause offensive odors will not be used in construction and maintenance works, considerable offensive odors is unlikely to occur.
	8	Bottom sediment	D	D	Because there are no rivers and lakes near by the project site, considerable impacts of turbid water caused by construction works or drainage form roads in operation phase on bottom sediment are unlikely to occur.

Category	No.	Impact Item	Assessment		Reason / Remarks
			Pre-Construction Phase Construction Phase	Operation Phase	
Natural Environment	9	Protected areas	D	D	Sakumo Ramsar Site (1,364 hectares) is located in a lagoon of approximately 1.5 km southwest from Tema roundabout. However, because the zone between the lagoon and Tema roundabout comprise residential and industrial area and drainage from Tema roundabout does not flow into the lagoon, impact on ecosystem in the Ramsar site is unlikely to occur.
	10	Ecosystem	D	D	Felling of roadside trees including Neem, Rain Tree and Royal Poinciana will be required in construction phase. However, Impact on urban ecosystem created around Tema roundabout will be very limited.
	11	Hydrology	D	D	**Construction Phase:** Considerable impact on ground water of pilling works is unlikely to occur. **Operation Phase:** Drainage system for rain water will not change significantly.
	12	Geographical features	D	D	Existing geographical features will not change considerably. Existing quarry site and borrow pit will be used for aggregate.
Social Environment	13	Resettlement/ Land Acquisition	B-	D	**Pre-Construction Phase:** Because there are no living quarters around Tema roundabout, number of resettlement of dwellers will be small. However, 150 simple business stores including kiosk, container shops, parasol shops and stallkeeper openings around Tema roundabout will be removed temporarily or relocated. Moreover, removal of commercial or office buildings and gas stations may be required. **Operation Phase:** Additional resettlement and land acquisition will not be required.
	14	Impoverished/Poor people	B±	D	**Construction Phase:** Disturbance in daily activities of street vendors which include impoverished people is likely to occur. Construction will create job opportunities to the poor as unskilled labor. **Operation Phase:** Considerable impact only on impoverished people is unlikely to occur.
	15	Ethnic minorities and indigenous peoples	D	D	Because the project is located in developed areas, considerable impact on ethnic minorities or indigenous peoples is unlikely to occur.
	16	Local economies, such as employment, livelihood, etc.	B±	B+	**Construction Phase:** Business activities of a gas station, several offices, shops and street vendors around Tema roundabout will be closed or suspended. Construction will create job opportunities to local people as unskilled labor. **Operation Phase:** Reduction of travel time by mitigated traffic jam will contribute to local economies. Adaptation of a new intersection configuration will change the land use plan.
	17	Land use and utilization of local resources	B-	B±	**Construction Phase:** Land acquisition will require change of land use such as from commercial area to road reserve. As a result, local resources will be partially lost. **Operation Phase:** Improved transportation will contribute to effective utilization of local resources. Adaptation of a new intersection configuration will change the land use plan.
	18	Water usage	D	D	Because there are no water resources around Tema Roundabout, considerable impact on water rights and its usage is unlikely to occur.

Category	No.	Impact Item	Assessment		Reason / Remarks
			Pre-Construction Phase Construction Phase	Operation Phase	
	19	Existing social infrastructures and services	B-	B-	**Pre-Construction Phase:** Relocation or protection of utilities (service lines) such as water and sewer pipes, electric cable, telephone line and gas pipe will be required. **Construction Phase:** Temporary traffic congestion, shift of bus and taxi stations, and disturbance of access to roadside facilities will occurred. **Operation Phase:** Crossing of roads by pedestrians would only be allowed at designated places (footbridge).
	20	Social institutions such as social infrastructure and local decision-making institutions	D	D	Because the project is located in a developed area, considerable impact on social institutions is unlikely to occur.
	21	Misdistribution of benefits and damages	C-	C-	Because the project lies in a developed area, considerable misdistribution of benefit among local people is unlikely to occur. However, misdistribution of benefit between relocated and remaining business stores may occur.
	22	Local conflicts of interest	C-	C-	Because the project lies in a developed area, considerable impact due to local conflict is unlikely to occur. However, local conflict between relocated and remaining business stores may occur.
	23	Cultural heritage	D	D	There are no cultural heritages around Tema Roundabout.
	24	Landscape	B-	D	**Construction Phase:** Loss of vegetation and construction work will change the landscape. **Operation Phase:** Appearance of footbridges will change the landscape. However, as Tema roundabout is located in commercial and industrial areas, particular landscape conservation measures will not be required.
	25	Gender	D	D	Because the project is improvement works of existing roundabout, considerable impact only on gender is unlikely to occur.
	26	Children's rights	D	D	Because the project is improvement works of existing roundabout, considerable impact only on children's rights is unlikely to occur.
	27	Infectious diseases such as HIV/AIDS	D	D	Because the project site is located in a well developed urban area, new considerable influx of infected persons as construction worker will not occur.
	28	Working conditions (including occupational safety)	B-	D	**Construction Phase:** Impact of waste from construction workers on sanitary conditions around the construction site is likely to occur. Because construction will include works in heights, various accidents may occur. **Operation Phase:** Road operation will not have impacts on working conditions.
	29	Accidents	B-	B±	**Construction Phase:** Labor accident, including tumble accident may involve pedestrians and street vendors **Operation Phase:** Decrease of minor accidents in Tema Roundabout will be expected. On the other hand, traffic accident may increase in newly constructed intersection at the initial stage.
Other	30	Trans-boundary impacts or climate change	D	D	Trans-boundary impacts such as climate change are unlikely to occur.

A+/-: Significant positive/negative impact is expected.
B+/-: Positive/negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown. (A further examination is needed, and the impact could be clarified as the study progresses)
D: No impact is expected
* Impact Items refer to "JICA Guidelines for Environmental and Social Considerations April 2010"

1.5.5 Main Mitigation Measures

- Resettlement :

  Authorities concerned shall prepare and strictly implement a proper Abbreviated Resettlement Action Plan (ARAP).

- Environmental pollution during construction phase :

  The contractor shall prepare and strictly implement mitigation measures against environmental pollution. The supervising consultant shall monitor the environmental conditions and complaints from the local people. If troubles of some sort occur, the supervising consultant shall direct the contractors to reconsider the construction technique and method.

- Impacts on local Society and Economy :

  The detail design consultant shall provide relevant information including the final design layout of the intersection and traffic move forecasting for reconsideration of the plan for land use to Tema Development Corporation (TDC) necessarily or upon request by the TDC.

1.5.6 Environmental Monitoring Plan

The environmental monitoring plan and draft form are shown in the following Tables.

Table 1.5.6-1 Environmental Monitoring Plan

Category	Environmental Item	Monitoring Item/ Parameter	Responsible Person and Organization	Location	Method	Frequency
Pollution	Air pollution	**Construction Phase:** ・Dust ・PM10、PM2.5、NOx、SOx	Supervising Consultant Contractor	Construction site	Visual observation and interview to pedestrians Instrumental analysis	Visual observation: Daily Interview: Monthly or as needed Instrumental analysis: Pre-Construction Phase 1 time, Construction Phase 5 times Total 6 times
		Operation Phase: ・PM10、PM2.5、NOx、SOx	GHA	Around Tema intersection.	Instrumental analysis	1 time in dry season and 1 time in rainy season per year for 2 years after completion Total 4 times
	Water pollution	**Construction Phase:** ・Turbid water and drainage conditions	Supervising Consultant Contractor	Construction site	Visual observation	During rainfall
	Waste	**Construction Phase::** ・Disposal methods of construction and general waste	Supervising Consultant Contractor	Construction site and disposal site	Visual observation and meeting with contractor	Visual observation: Daily Meeting: Monthly or as needed

Category	Environmental Item	Monitoring Item/ Parameter	Responsible Person and Organization	Location	Method	Frequency
	Noise and vibration	**Construction Phase:** ・Noise level ・Vibration level	Supervising Consultant Contractor	Construction site	Interview to local residents and pedestrians Instrumental measurement	Interview: Monthly or as needed Instrumental measurement: Pre-Construction Phase 1 time Construction Phase 5 times Total 6 times
		Operation Phase: ・Noise level ・Vibration level	GHA	In and around Tema intersection	Instrumental measurement	1 time per year for 2 years after completion Total 2 times
Social Environment	Resettlement/ Land Acquisition	**Pre-Construction Phase:** ・Progress of resettlement action plan	GHA	Around Tema intersection and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
	Poor people	**Construction Phase:** ・Activity conditions of street venders	Supervising Consultant Contractor	Construction site	Visual observation	Daily
	Local economies, such as employment, livelihood, etc.	**Pre-Construction Phase:** ・Progress of resettlement action plan	GHA	Around Tema intersection and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
		Construction Phase: ・Business activity around construction site ・Employment situation of unskilled labor	Supervising Consultant Contractor	Construction site	Site survey and interview to local people and unskilled labors	Monthly or as needed
	Land use and utilization of local resources	**Pre-Construction Phase:** ・Progress of resettlement action plan	GHA	Around Tema intersection and relocation sites	Site survey and meeting with PAP	Monthly or as needed
		Operation Phase: ・Condition of land use ・Condition of business activity	GHA TDC	In and around Tema intersection	Site survey and interview to local people	Monthly or as needed for 2 years after completion
	Existing social infrastructures and services	**Pre-Construction Phase:** ・Relocation status of existing infrastructure facilities	GHA	In and around Tema intersection	Site survey and meeting with facility owners	Monthly or as needed
		Construction Phase: ・Condition of traffic congestion around construction site	Supervising Consultant Contractor	Construction site	Visual observation	Daily

Category	Environmental Item	Monitoring Item/ Parameter	Responsible Person and Organization	Location	Method	Frequency
		Operation Phase: ・ Crossing conditions of pedestrians	GHA	In and around Tema intersection	Site survey and interview to local people	Monthly or as needed for 2 years after completion
	Misdistributio n of benefits and damages	**Pre-Construction Phase:** ・ Progress of resettlement action plan	GHA	Around Tema intersection and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
		Operation Phase: ・ Living situations of Project Affected Persons (PAPs)	GHA	Around Tema intersection and relocation sites	Site survey and meeting with PAPs	Monthly or as needed for 2 years after relocation
	Local conflicts of interest	**Pre-Construction Phase:** ・ Progress of resettlement action plan	GHA	Around Tema intersection and relocation sites	Site survey and meeting with PAPs	Monthly or as needed
		Operation Phase: ・ Living situations of Project Affected Persons (PAPs)	GHA	Around Tema intersection and relocation sites	Site survey and meeting with PAPs	Monthly or as needed for 2 years after relocation
	Landscape	**Construction Phase:** ・ Status of tree felling ・ Status of Planting works	Supervising Consultant Contractor	Construction site	Visual observation and meeting with contractor	Daily
	Working conditions (including occupational safety)	**Construction Phase:** ・ Workplace situations ・ Implementation status of accident prevention measures	Supervising Consultant Contractor	Construction site	Visual observation and meeting with contractor	Daily
Other	Accidents	**Construction Phase:** ・ Implementation status of accident prevention measures	Supervising Consultant Contractor	Construction site	Visual observation and meeting with contractor	Daily
		Operation Phase:: ・ Number of traffic accident	GHA	In and around Tema intersection	Site survey and traffic accident data	Monthly or as needed for 2 years after completion

Table 1.5.6-2 Draft Environmental Monitoring Form

Item	Parameter	Location	Frequency	Responsible Agency	Result
Construction Stage					
Air quality	PM10, PM2.5, NO, SOx	Construction site	1 time/half year	Supervising Consultant Contractor	
Noise and Vibration	Noise level Vibration Level	Construction site	1 time/half year	Supervising Consultant Contractor	

Item	Parameter	Location	Frequency	Responsible Agency	Result
Water Quality	Turbid water	Construction site	Rainfall time	Supervising Consultant Contractor	
Waste	Waste disposal	Construction site	Every day	Supervising Consultant Contractor	
Operation Stage					
Air quality	PM10, PM2.5, NO, SOx	Tema Intersection	2 times/year	GHA	
Noise and Vibration	Noise level Vibration Level	Tema Intersection	2 times/year	GHA	

1.5.7 Stakeholder Meeting

The first stakeholder meeting with relevant organizations and business enterprises was held on 11 December 2016. There were 39 participants including 3 women.

1.5.8 Land Acquisition and Resettlement

1.5.8.1 Range of Impact

Identified affected structures and private properties in the Provisional Road Width are shown in the following Table. These structures and properties will need resettlement, relocation and compensation. 14 structures of these structures are residence. The total number of residents are 59 persons.

Table 1.5.8-1 Affected Structures and Private Properties in PRW

Road Name	Type of Structure						Total
	Building	Metal Container	Wooden Structure	Wooden Kiosk	Shed	Wooden Table	
Tema Harbour Road	1	-	-	4	-	-	5
Tema-Aflao Road	1	56	5	42	19	2	125
Tema-Akosombo Road	3	12	10	1	2	2	30
Total	5	68	15	47	21	4	160

Figure 1.5.8-1 Distribution of Affected Structures

1.5.8.2 Contents of Compensation and Assistance

In Ghana, properties such as lands and structures lost by exploitation for public interests is generally subjected for monetary compensation. Project Affected Persons (PAPs) are categorized in Ghana into three types as follows;

1) Persons possessing official legal rights to own properties such as traditional lands and structures on the basis of custom admitted by laws and regulations
2) Persons possessing no official legal rights in national census, however identified ownership in social condition surveys
3) Persons unrecognized or not having legal rights, however claiming occupancy of properties

Because the area around Tema intersection has been managed by TDC, Most of the PAPs belong to the first category, . The entitlement matrix is shown in the following Table.

Table 1.5.8-2 Entitlement Matrix

PAPs Type	Lost properties and rights	Entitlements				
		Compensation for loss of land (long-term lease hold right) and structures	Compensation for loss of assets	Compensation for loss of income	Moving allowance	Other assistance
Business Owner (License holder from TDC)	Loss of land Loss of structure	Compensation at on-going market price Compensation at full replacement cost value 1)	Pay full cost of removal and fixing of removable	Loss of income based on provision of business accounts. If business accounts are provided, replace loss of profits for period within which he/she relocates Implementation of income restoration program if needed	-	10% of compensation cost estimated by Land Valuation Board for inconvenience and disturbance
Business Tenant (No license holder from TDC)	No loss of land Loss of rental accommodation	No loss of structure so no compensation	-		Cover full cost	10% of compensation cost for inconvenience and disturbance
Residence Owners (License holder from TDC)	Loss of land Loss of structure	Compensation at-going market price Compensation at full replacement cost value	-	Implementation of income restoration program if needed	-	5% of compensation cost for inconvenience and disturbance
Residence Tenant (No license holder from TDC)	No loss of land Loss of rental accommodation	Relocate to location of choice	Six months rents on the basis of present rents	Implementation of income restoration program if needed	Coverage of full cost of transport expenses	5% of compensation cost for inconvenience and disturbance
License squatters and Encroachers	Loss of use of land	-	-	Payments in lieu of wages while moving (About USD 50 uniformly. The actual payment price is estimated on the basis of the census survey in the next stage.)	Coverage of full cost of transport expenses	Full cost of disconnection and reconnection of utility services. Payment for loss of connectivity

1) Full replacement cost value: Valuation of assets that helps determine the amount sufficient to replace lost assets and cover transaction costs (including "Compensation for loss of assets" and "Moving allowance" in this Matrix)

1.5.8.3 Monitoring Plan

The draft monitoring form of land acquisition and resettlement are shown in the following Table.

Table 1.5.8-3 Draft Monitoring Form of Land Acquisition and Resettlement

Preparation of Resettlement Site

No.	Explanation of the Site	Status Completed (date) or not)	Details	Expected Date of Completion
1.				
2.				

Public Consultation

No.	Date	Place	Contents of the construction / Main comments and answers
1.			
2.			

Resettlement Activity	Planned Total	Unit	Progress in Quantity			Progress in %		Expected Date of Completion	Responsible Organization
			During the Quarter	Till the Last Quarter	Up to the Quarter	Till the Last Quarter	Up to the Quarter		
Preparation of ARAP*									GHA
Employment of Consultants		Man-Month							
Implementation of Census Survey									
Approval of ARAP	Date of Approval :								
Finalization of PAPs List		No. of PAPs*							
Progress of Compensation Payment (All Lots)		No. of HHs*							
Lot 1		No. of HHs							
Lot 2		No. of HHs							
Progress of Land Acquisition (All Lots)		ha							
Lot 1		ha							
Lot 2		ha							
Progress of Asset Replacement (All Lots)		No. of HHs							
Lot 1		No. of HHs							
Lot 2		No. of HHs							
Progress of Relocation of People (All Lots)		No. of HHs							
Lot 1		No. of HHs							
Lot 2		No. of HHs							

*：ARAP： Abbreviated Resettlement Action Plan, PAPs： Project Affected Persons, HHs： Households

1.5.9 Environmental Checklist

Environmental checklist is shown in **Table 1.5.9-1**.

Table 1.5.9-1 Environmental Checklist

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) N (c) N (d) N	(a) The EIA report is preparing and will be submitted to Environmental Protection Agency in March, 2017. (b)(c) If the amendment of the EIA report is not required, the report will be approved within 50 days after the submission. (d) The other permissions related to environmental management are not required.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) Y	(a) Three stakeholder meetings were conducted in December, 2015 and the understanding has been obtained from local stakeholders. (b) The results of interview surveys to the local people and stakeholder meetings with the other relevant organizations were reflected in the design policy and mitigation measures for environmental impacts during constriction phase.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) Several alternative plans on the structure of the intersection have been examined with social and environmental considerations at the preparatory study.
2 Pollution Control	(1) Air Quality	(a) Is there a possibility that air pollutants emitted from the project related sources, such as vehicles traffic will affect ambient air quality? Does ambient air quality comply with the country's air quality standards? Are any mitigating measures taken? (b) Where industrial areas already exist near the route, is there a possibility that the project will make air pollution worse?	(a) - (b) -	(a)(b) Because the project site is located in industrial area, considerable air pollution is feared. However, continuous monitoring of the air quality is not conducted. It is unknown whether the air quality exceeds the environmental standards or not. In the future, total amount of air pollutant caused by vehicle exhaust gas will increase. However, because of improved traffic efficiency, the amount may be reduced compared to without project.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Water Quality	(a) Is there a possibility that soil runoff from the bare lands resulting from earthmoving activities, such as cutting and filling will cause water quality degradation in downstream water areas? (b) Is there a possibility that surface runoff from roads will contaminate water sources, such as groundwater? (c) Do effluents from various facilities, such as parking areas/service areas comply with the country's effluent standards and ambient water quality standards? Is there a possibility that the effluents will cause areas not to comply with the country's ambient water quality standards?	(a) N (b) N (c) N	(a) Turbid water will generate in the construction works. The turbid water will be disposed into existing drainage ditches along the roadside and not drain into the surrounding area. There are no intake facilities in and down the site. (b) Because drainage facilities have been constructed along the road, impact on water resources of runoff from road surface will not occur. (c) Development of parking or service areas which generate waste water in operation phase are not included in the project.
	(3) Wastes	(a) Are wastes generated from the project facilities, such as parking areas/service areas, properly treated and disposed of in accordance with the country's regulations?	(a) N	(a) Development of parking or service areas are not included in the project.
	(4) Noise and Vibration	(a) Do noise and vibrations from the vehicle and train traffic comply with the country's standards?	(a) N	(a) The noise level on the borderline of the right of way exceed the environmental standards at present. However, because the project site is located in commercial or industrial area, the impact on general population will not be serious. In the future, noise level caused by vehicle driving will increase. However, because flyover bridges will be installed in central part of the right of way as main driving lanes, the level on road side may be reduced compared to without project. To prevent increase in noise and vibration level, GHA should maintain favorable road surface condition.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) N	(a) There are no protected areas in the site and project affected areas.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Are adequate protection measures taken to prevent impacts, such as disruption of migration routes, habitat fragmentation, and traffic accident of wildlife and livestock? (e) Is there a possibility that installation of roads will cause impacts, such as destruction of forest, poaching, desertification, reduction in wetland areas, and disturbance of ecosystems due to introduction of exotic (non-native invasive) species and pests? Are adequate measures for preventing such impacts considered? (f) In cases the project site is located at undeveloped areas, is there a possibility that the new development will result in extensive loss of natural environments?	(a) N (b) N (c) N (d) N (e) N (f) N	(a) There are no ecological valuable habitats in and around the site. (b) The habitats of endangered species have not been identified in and down the site. (c) Significant ecological impact will not occur. (d) Wild animals migrating through the site have not been identified. (e)(f) The project will not cause destruction of forest and poaching because of construction works along existing road in urban area.
	(3) Hydrology	(a) Is there a possibility that alteration of topographic features and installation of structures, such as tunnels will adversely affect surface water and groundwater flows?	(a) N	(a) Alteration of topographic features and tunnel construction are not included in the project.
	(4) Topography and Geology	(a) Is there any soft ground on the route that may cause slope failures or landslides? Are adequate measures considered to prevent slope failures or landslides, where needed? (b) Is there a possibility that civil works, such as cutting and filling will cause slope failures or landslides? Are adequate measures considered to prevent	(a) N (b) N (c) N	(a)(b) Small-scale cutting and filling works are included in the construction. However, there are no steep slope areas to occur slope failures or landslides in and around the site. (c) Adequate cutting and filling prevent accidental and sufficient soil runoff.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
		slope failures or landslides? (c) Is there a possibility that soil runoff will result from cut and fill areas, waste soil disposal sites, and borrow sites? Are adequate measures taken to prevent soil runoff?		
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement?(b) Is adequate explanation on compensation and resettlement assistance given to affected people prior to resettlement?(c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement?(d) Are the compensations going to be paid prior to the resettlement?(e) Are the compensation policies prepared in document?(f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples?(g) Are agreements with the affected people obtained prior to resettlement?(h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan?(i) Are any plans developed to monitor the impacts of resettlement?(j) Is the grievance redress mechanism established?	(a) Y(b) Y(c) Y(d) Y(e) Y(f) Y(g) Y(h) Y(i) Y(j) Y	(a) The project is likely to require involuntary resettlement of about 14 households or 50 persons.(b) Explanations of basic policy on compensation and resettlement assistance have been conducted in the local stakeholder meetings.(c) The Abbreviated Resettlement Action Plan (ARAP) involves the result of socioeconomic survey including the inventory of losses owned by Project Affected Persons (PAPs), compensation with replacement costs and livelihood restoration plan.(d) The compensations will be paid prior to the resettlement.(e) The compensation policies are mentioned in the ARAP.(f) The ARAP considers particular attention to vulnerable people such as owners of small shops.(g) The agreement formation has been conducted in a series of the stakeholder meetings.(h) The organizational framework according to the ARAP has been established to properly implement resettlement. The capacity and budget will be secured to implement the plan.(i) The monitoring and evaluation are mentioned in the ARAP.(j) The grievance redress mechanism is mentioned in the ARAP.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Living and Livelihood	(a) Where roads are newly installed, is there a possibility that the project will affect the existing means of transportation and the associated workers? Is there a possibility that the project will cause significant impacts, such as extensive alteration of existing land uses, changes in sources of livelihood, or unemployment? Are adequate measures considered for preventing these impacts? (b) Is there any possibility that the project will adversely affect the living conditions of the inhabitants other than the target population? Are adequate measures considered to reduce the impacts, if necessary? (c) Is there any possibility that diseases, including infectious diseases, such as HIV will be brought due to immigration of workers associated with the project? Are adequate considerations given to public health, if necessary? (d) Is there any possibility that the project will adversely affect road traffic in the surrounding areas (e.g., increase of traffic congestion and traffic accidents)? (e) Is there any possibility that roads will impede the movement of inhabitants? (f) Is there any possibility that structures associated with roads (such as bridges) will cause a sun shading and radio interference?	(a) N (b) Y (c) N (d) Y (e) Y (f) N	(a) Because of improvement project of existing arterial road in developed area, the project will not cause significant adverse changes and impacts on the livelihood of the local people and road traffic in operation phase. (b) The project is likely to require replacement of about 150 shops or offices. The adequate compensations will be paid to the affected owners. (c) Because of improvement project of existing arterial road in developed area, mass immigration from other areas is unlikely to occur. (d) Traffic congestion and control, and relocation of bus stops will be inevitable in construction phase. The proper construction planning and traffic management will mitigate the impact. (e) Due to the improvement of the intersection structure, the project is likely to impede the movement of local inhabitants. Installation of pedestrian bridges will be included in the project. (f) Because the distance between newly constructed bridges and road side is too long and there are no residents around the project site, impact on sun shading and radio interference will not occur.
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a) N	(a) There is no heritage in the site and project affected areas.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) There are no valuable landscape sites in and around the project sites.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to land and resources to be respected?	(a) N (b) N	(a)(b) The project site is not area where ethnic minorities and indigenous people having unique culture and lifestyle are living.
	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures being taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) Construction works will comply with the laws and ordinances associated with the working conditions. (b) Because construction works on higher ground are included, tangible safety considerations to prevent labor accidents will be involved in the project. (c)(d) Because the construction works are conducted along existing arterial road in urban area, health program and safety training to construction workers, and considerations to local residents will be included in the environmental management plan.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?	(a) Y (b) Y (c) Y	(a) The adequate mitigation measures including coordination of construction time and methods and monitoring plans to reduce impacts of pollution during the construction will be prepared. (b) The construction activities will not adversely affect the natural environment. (c) Because the construction works are conducted along existing arterial road in urban area, countermeasures against traffic jam will be included in the execution scheme.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) Y (c) Y (d) Y	(a) The monitoring plans mentioned in the EIA report will be implemented during the construction and operation phase. (b)(c)(d) Because the EIA report is in progress, the specific monitoring plans have not been prepared yet. JICA survey team has submitted the draft monitoring plan to Ghana Highway Authority.
6 Note	Reference to Checklist of Other Sectors	(a) Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects including large areas of deforestation).(b) Where necessary, pertinent items described in the Power Transmission and Distribution Lines checklist should also be checked (e.g., projects including installation of power transmission lines and/or electric distribution facilities).	(a) N(b) N	(a) Deforestation is not included in the project.(b) Relocation of existing power transmission lines will be limited in the right of way and has no serious environmental impacts.
	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed, if necessary (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) N	(a) Impacts to transboundary or global environmental issues will not occur.

1) Regarding the term “Country's Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made. In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Chapter2 Contents of the Project

2.1 Basic Concept of the Project

2.1.1 Requested Scope

The request made by the GOG is a phase wise improvement of Tema intersection. The scopes of each phase are as follows;

- Phase-1: Construction of 1st tier flyover, including the detailed design and construction supervision
- Phase-2: Construction of 2nd tier flyover, including the detailed design and construction supervision

2.1.2 Survey Objective

The objective of the Survey was to;

- Understand the background, purpose, and scope of project under the Japanese grant aid assistance,
- Study the feasibility of the project in terms of effectiveness, technical and economic justification,
- Conduct outline design for minimum but optimal scope and scale of the project,
- Estimate project cost, and
- Propose the contents, implementation and maintenance plan as well as critical points to be undertaken by the GOG to achieve the outcome and targets set for the project.

2.1.3 Overall Goal, Targets and Expected Outcomes

The overall goal of the project is to contribute to the growth of the economy of Ghana and that of the West African Region. The purposes of the project on the other hand are;

- To improve the capacity of the Tema Roundabout and its legs (approach roads)
- To improve safety and efficiency of transport in the Greater Accra Region; and
- To provide uninterrupted traffic flows to facilitate trade and transit in the West African Sub-Region.

Furthermore, the outline of the project is as summarized in **Table 2.1.3-1**.

Table 2.1.3-1 Outline of the Project

Targets	Ultimate: Enhancement of transport efficiency and logistics in GAR Immediate: Improve traffic condition of traffics travelling along central Accra region and Tema Port
Expected Outcome	Graded intersection of Tema Roundabout
Location	Greater Accra Region(GAR), Tema City
Beneficiaries	Direct beneficiaries: Users of Tema Roundabout and people in the vicinity Indirect beneficiaries: 4 million people of GAR, Eastern International Corridor users

2.2 Outline Design of the Requested Japanese Assistance

2.2.1 Design Policy

2.2.1.1 Policies for Requested Scopes

A preliminary comparison of applicable configurations for the improvement of the existing roundabout was carried out and explained to the GOG during the IC/R meetings. However, the configurations compared were developed based on limited data and documents obtained prior to the commencement of the project. Therefore, to ensure effective and efficient improvement, comparison was repeated using data and information collected from various engineering surveys, discussions and hearings conducted with GHA and other stakeholders during the course of the first field survey. The factors such as cost effectiveness, urgency, social and environmental impacts were evaluated and the project's technical and economic viability and thus its justification for Japan's grant aid scheme was examined. The project scope was then determined, discussed with JICA, explained to GHA and sought GHA's agreement. The agreed scope of the project is shown in **Table 2.2.1-1**.

Initially, the GOG had its original plan for the improvement. This plan applies a configuration that seems to be aimed not only for the improvement to ease congestion at the roundabout but for conversion of the intersection to a full-control multi-layer interchange with justification that all connecting roads are motorways. However, the GOG agreed to drop out this configuration following explanation from the Survey Team that adoption of the configuration under the grant aid of Japan is not viable as the scope is vast, requires significant land acquisition including large number of resettlement of project affected people, and relocation of service utilities.

Table 2.2.1-1 Project Scope

Requested Scope	Target
Phase-1 Construction of 1st level flyover including improvement of the objective roundabout, the detailed design of a graded intersection and construction supervision	○ (to be undertaken by this project)
Phase -2 Construction of 2nd level flyover including, the detailed design of a flyover and construction supervision	―

2.2.1.2 Policies for Overall Improvement

(1) Consistency with Phase-2 Works

As aforementioned, the project scopes of this survey cover the components of Phase-1 only. However, planning of the component of Phase-2 is inevitable for the planning of Phase-1 components as the two phases need to be consistent with each other. Therefore, outline design of Phase-1 components is performed following preliminary design for the components of Phase-2. The design of Phase-1 components is carried out in such a manner that the project outcome is attained while construction efficiency of Phase-2 is also guaranteed.

Figure 2.2.1-1 Flow of the Survey

(2) Target Year

In general, it is difficult to predict changes of regional economy, population and development plan of the target area beyond 20 years. Thus, target year for this Project is taken as 2035 that is 20 years from 2015. The same target year will be applied for future traffic volume, which is the governing factor of the project scale.

(3) Limits of Improvement Scope

The improvement of Tema Motorway Roundabout is expected to alleviate the traffic congestion in the project area significantly. However, this may not be able to eliminate the congestion totally. Elimination of the congestion is achievable only if a comprehensive improvement that will undertake simultaneous improvement of sections beyond those undertaken in this improvement or improvement of other roads, interchanges and various facilities is executed. For example, in the case of Tema-Akosombo Road, it might be necessary to improve the road all the way up to Ashaiman Roundabout (about 1.5 km north of Tema Motorway Roundabout) or even further as severe traffic congestion is prominent here. Therefore, it might be necessary to improve not only Tema roundabout but also Ashaiman Roundabout and the connecting road. The limits of improvement scope (start and end points) to be undertaken by the grant aid of Japan however, will be between the points that will be affected by the improvement plan of the existing roundabout. The GOG is requested to undertake the improvement of other sections at its own expenses considering the importance and necessities.

(4) Consistency with the Existing Plans

Information received by the Survey Team revealed that plans for improvement of the objective intersection exists. For example, Ghana Ports and Harbour Authority (GPHA) is said to be planning improvement/widening of the Tema Port access road (Hospital Road: linking the port and Ashaiman Interchange), which is scheduled to be carried out by Department of Urban Roads (DUR). On the other hand, GHA is also under the process of carrying out the improvement (widening) of Tema-Accra Motorway under the Public-Private-Partnership (PPP) Scheme, which envisages to widen the motorway to six-lane road in accordance with the requirement of ECOWAS. Furthermore, there are plans for widening of Harbour Road also. However, all the above-mentioned projects are either at a conceptual stage or are yet to kick off.

Therefore, the survey carried out assumed that there were no existing plans under progress that could potentially create conflicts with this plan and that the other to-be implemented improvement plans shall be made consistent with the output of this project.

(5) Consistency with National and Regional Plans

The Tema Roundabout lies on Abidjan-Lagos Highway, which is a part of the Dakar to Lagos Trans African

Highway (TAH) No. 7. The vision of the ECOWAS is to have 3-lane dual carriageway from Lagos to Abidjan in the short term. Therefore, it is important that the improvement plan should account for the design requirement for the Lagos-Abidjan Highway as well as initiatives for the Tema Port development, and be "fit for purpose" to realize long-term solution for streamlining the international and domestic traffic flows interrupted by the congestion at the roundabout. However, the existing Accra-Tema Motorway is currently a 2-lane dual carriageway road and the Aflao Road becomes 2-lane single carriage road from about a few kilometers beyond the Tema Roundabout. Under such situation, it may not be ideal to provide 3-lane dual carriageway if it is not required within the target year. In such a case, the improvement plan will provide number of lanes as derived from the traffic demand forecast. However, space for 3-lanes will be secured for widening by GOG in the future necessarily.

(6) Levels of Service

Level of Service (LOS) is defined as the operating conditions on the facility in terms of traffic performance measures related to speed and travel time, freedom to maneuver, traffic interruptions, and comfort and convenience. **Table 2.2.1-2** shows the general relation between LOS and the general operating conditions.

Table 2.2.1-2 General Definitions of Levels of Service

Levels of Service	General Operating Conditions
A	Free flow
B	Reasonable free flow
C	Stable flow
D	Approaching unstable flow
E	Unstable flow
F	Forced or breakdown flow

Source: Highway Capacity Manual

Technical Notes (T/N) compiled that served as agreement on basic technical conditions for the design was approved by GHA on 20th May and 18th December, 2015. In this T/N, LOS of each road is mentioned as 'B' or 'C'. Essentially, LOS becomes lower during peak traffic hours. Taking high LOS as targets for the design stage will result in an excessive design of roads and structures. To ensure technical and economic viability of the project to be implemented under Japan's grant aid scheme, the target LOS during morning hours for improvement is taken to be 'D' (Refer to **Figure 2.2.2-1**, page **70**).

On the other hand, it is noteworthy that the future traffic demand, which is fundamental for the improvement plan, has been calculated with an assumption that until year 2035 there are no development/improvement works of road network in the neighboring region of Tema Roundabout. This means, possibility of changes in traffic pattern (LOS improvement due to diversion of traffic currently using the roundabout to improved or newly developed roads in the area), has not been considered.

(7) Imposition of One-way Traffic

As aforementioned, the objective intersection is composed of 5-legs of which 4 roads are arterials while one road (the Tema-Hospital Road, also known locally as the Container Road) is an urban road. To make the intersection simple, safe and effective, it is preferable that the improved intersection is composed of same class roads (4 trunk road legs). Therefore, the improvement plan excludes the Tema-Hospital Road and treats it as one-way traffic flow road restricting traffics from entering the intersection. Road function of Tema-Hospital road shall be separately studied by planning a service road.

(8) Crossing Method

Motorway - Aflao Road runs in the east-west direction. Harbour Road - Akosombo Road runs in the north-south direction. Intersection at different levels is required to separate these two directions. During phase-2, Motorway-Aflao Road is planned to run through an underpass (1st tier), turning ramps on the grade level (2nd tier) and Harbour Road-Akosombo Road over a flyover (3rd tier). The reasons for such type of consideration are;

- Motorway – Aflao Road is a high priority international corridor and is a part of Abidjan-Lagos Highway where through traffics should be allowed without conflicts.
- Even though North-South direction will be improved by provision of a fly-over, it is not expected to be effective enough until one of the connecting roads (Akosombo Road), which is currently a two-lane single carriageway is widened.
- Project scale would have been much larger if expansion of Akosombo Road from a two-lane single carriageway to a two-lane dual-carriageway was included in this project and would have possibly lowered viability of the project to be implemented under the grant aid of Japan, in terms of urgency and economy.
- Construction of the flyover is easier if the road to be constructed prior to it is an underpass.

(9) Comparison of Improvement Methods

Several improvement methods were selected and compared based on the policies mentioned earlier. The optimum plan that contributes in achieving the following outcomes items the most was selected.

- Improvement of the capacity of Tema intersection, its approach roads and other roads in the area,
- Enhance safety and efficiency of transport in the Greater Accra Region; and
- Provide uninterrupted traffic flows to facilitate trade and transit in the West African Sub-Region

2.2.1.3 Policies for Engineering Surveys

Engineering surveys were conducted with the purpose to collect higher level information, details and relevant data to be used for planning, design, and cost estimate for the improvement of the roundabout. Since the roundabout connects arterial roads in an urban area, it is necessary for studies to be conducted at each stage of the project, thus during design stage, construction stage and in-service stage. On the other hand, the higher volume of traffic currently being experienced at the roundabout as well as the existence of numerous

underground facilities means the project would not only affect residents living in the vicinity but road users also. Therefore, engineering survey needs to be comprehensively done.

After clarifying the issues and problems, various engineering surveys were carried out so that necessary data for designing can be sufficiently obtained.

The scope of works is shown in **Table 2.2.1-3** and the outline of the surveys conducted is briefly discussed thereafter.

Table 2.2.1-3 Engineering Surveys

Surveys	Purposes	Locations	Scopes	Methodologies
1. Climate/Hydrology	To understand as well as to collect the data for conducting suitable construction planning	In and around Tema Motorway Roundabout	・ Temperature, precipitation, water level of gullies, natural disaster, etc.	Collection of available data and site observation
2. Topography Survey	To collect data and information on the features of the site to prepare the documents required for conducting the design works	In and around Tema Motorway Roundabout	・ Longitudinal survey ・ Cross section survey ・ Plane table survey ・ Temp. bench mark	Subcontracting
3. Geo-Technical Investigation	For collecting data to understand the soil properties and its distribution condition for conducting design of pavement and the facilities of the objective road	Areas along objective road and borrow pit	・ Site investigation ・ Drilling, SPT Test ・ Groundwater level ・ Trial Pit and CBR test ・ DCP test ・ Fill material ・ Base course material	Subcontracting
4. Groundwater Observation	To collect data of groundwater level	In and around Tema Roundabout	・ Monthly groundwater level	Subcontracting
5. Inventory Survey	To comprehend the existing condition of road incidental facilities so that it could be reflected in the design work	Areas along objective road	・ Existing Inventory Survey	Collection of available data and site observation
6. Traffic Survey	To collect Traffic data for future traffic demand forecast	On all the roads connecting to Tema Roundabout	・ Counting during peak hour	Subcontracting
7. Existing Drainage Survey	To comprehend the existing condition of road incidental facilities so that it could be reflected in the design work	Areas along objective road	・ Confirm the existing drainage systems/ trends ・ Grasp the existing provision of drainage facilities ・ Confirm the existing drainage downstream end	Collection of available data and site observation
8. Other Surveys	To collect the information and data to consider for design	Areas along objective road	・ Existing pavement ・ Current traffic operation ・ Pedestrian volume ・ Pavement surface condition ・ Land use ・ Gender and Population ・ Economic & industrial survey	Collection of available data and site observation

(1) Climate and Hydrology

As mentioned in Section 1.4 , climate at Tema, where the objective roundabout is located have dry equatorial climate. The maximum temperature lies between 27 and 33 degrees Celsius and the minimum temperature between 22 and 26 degrees Celsius.

Monsoon lies between March and October. The precipitation time varies but day-long rainfall is very rare if not nil. The maximum rainfall is seen between May and June where the monthly volume is about 100mm.

(2) Topographic Survey

1) Survey Objective

Topographic survey was carried out to capture the terrain condition including features on the ground such as houses, buildings, trees and shapes and structures of the roundabout and the existing roads etc. to prepare the documents required for conducting the outline design.

2) Survey Scopes

The scopes of the survey are shown in **Figure 2.2.1-2**. The red line boundary is the limits of plane table survey. Scopes of longitudinal and cross section survey are highlighted in blue.

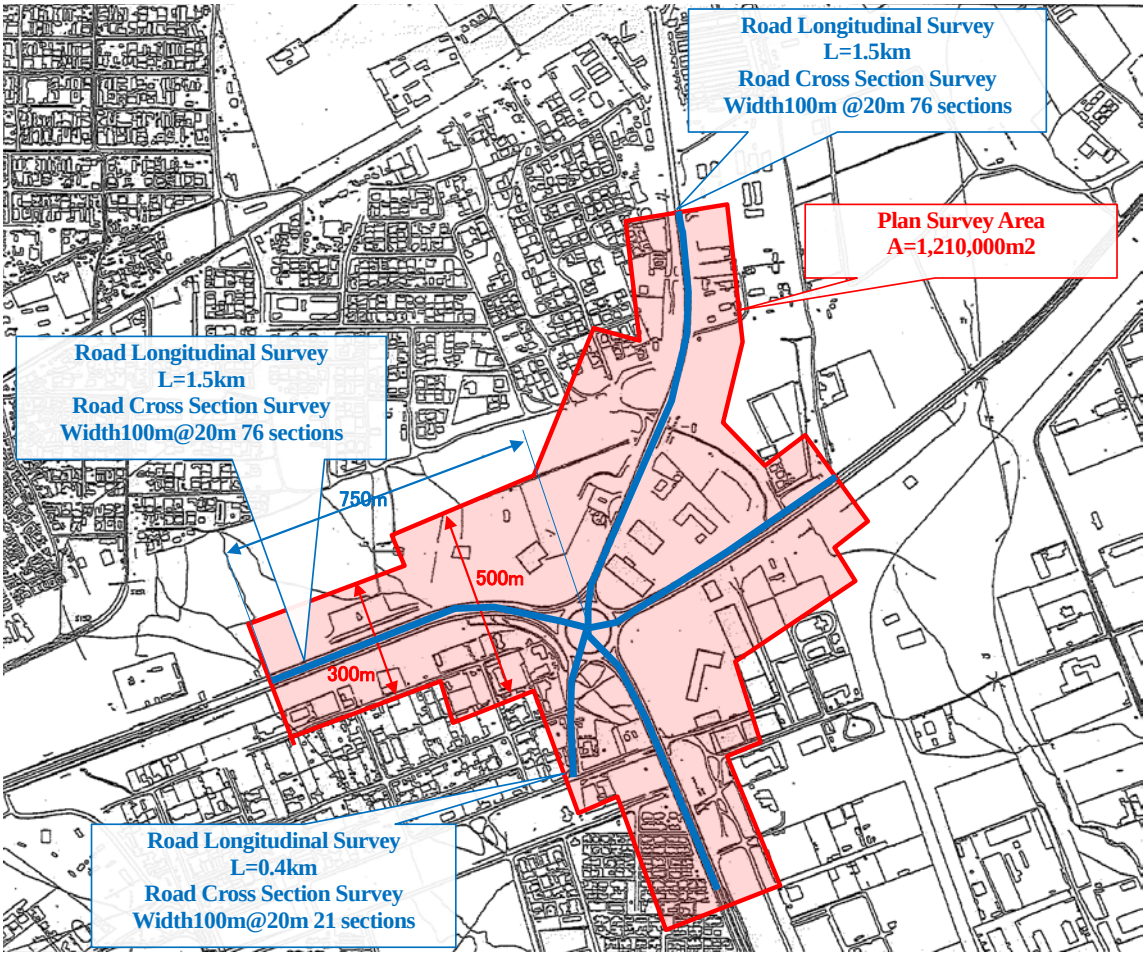


Figure 2.2.1-2 Area and Scope of Topographic Survey

3）Survey Period

The survey was conducted during the first field survey from April to May 2015. Additional survey to supplement the output of the previous survey was conducted between November and December 2015.

4）Survey Items

The survey included the following items;

5）Establishment of Bench Marks

Level survey was conducted to install benchmarks (concrete stakes) at 9 locations within the area shown in **Figure 2.2.1-2**. The coordinates and levels of these bench marks have been referred from the National Bench Mark (NBM). The coordinates in terms of both Ghana Grid and WGS84 and the elevation of the referred national benchmarks and the temporary benchmarks installed are shown in **Table 2.2.1-4**, its locations in **Figure 2.2.1-3**, and the type of these benchmarks are depicted in **Photo 2.2.1-1**.

Table 2.2.1-4 Details of Benchmarks Installed

Bench marks	ID	Abbreviation on the map	Ghana Grid		WGS84		Elevation / Height (m)	Remarks
			Northing (m)	Easting (m)	Northing (m)	Easting (m)		
National Benchmarks	SS66	-	101849.410	364862.714	618654.342	812175.92	51.452	Existing
	SG/11/01/GPS3	GPS3	112354.665	383339.21	629233.633	830634.81	35.294	
	GAMA/T/11/11/1	GAMA1	112374.167	383399.017	629253.324	830694.53	35.524	
Project Benchmarks	TMRP/T/04/15/1	BM1	112195.225	382521.283	629071.14	829816.50	24.842	Newly installed
	TMRP/T/04/15/2	BM2	111779.614	383670.685	628659.08	830968.55	32.596	
	TMRP/T/04/15/3	BM3	112882.703	384116.274	629764.87	831410.78	28.546	
	TMRP/T/04/15/4	BM4	113288.864	383593.825	630169.65	830886.37	42.018	
Temporary Benchmarks	TBM/T/04/15/1	TBM1	112029.785	383332.938	628908.34	830629.58	33.465	Newly installed
	TBM/T/04/15/2	TBM2	111873.468	383607.266	628752.81	830904.73	32.186	
	TBM/T/04/15/3	TBM3	112864.716	384011.312	629746.50	831305.77	29.226	
	TBM/T/04/15/4	TBM4	113206.962	383597.121	630087.67	830889.95	40.669	
	TBM/T/04/15/5	TBM5	112259.604	382672.034	629136.11	829967.19	24.522	

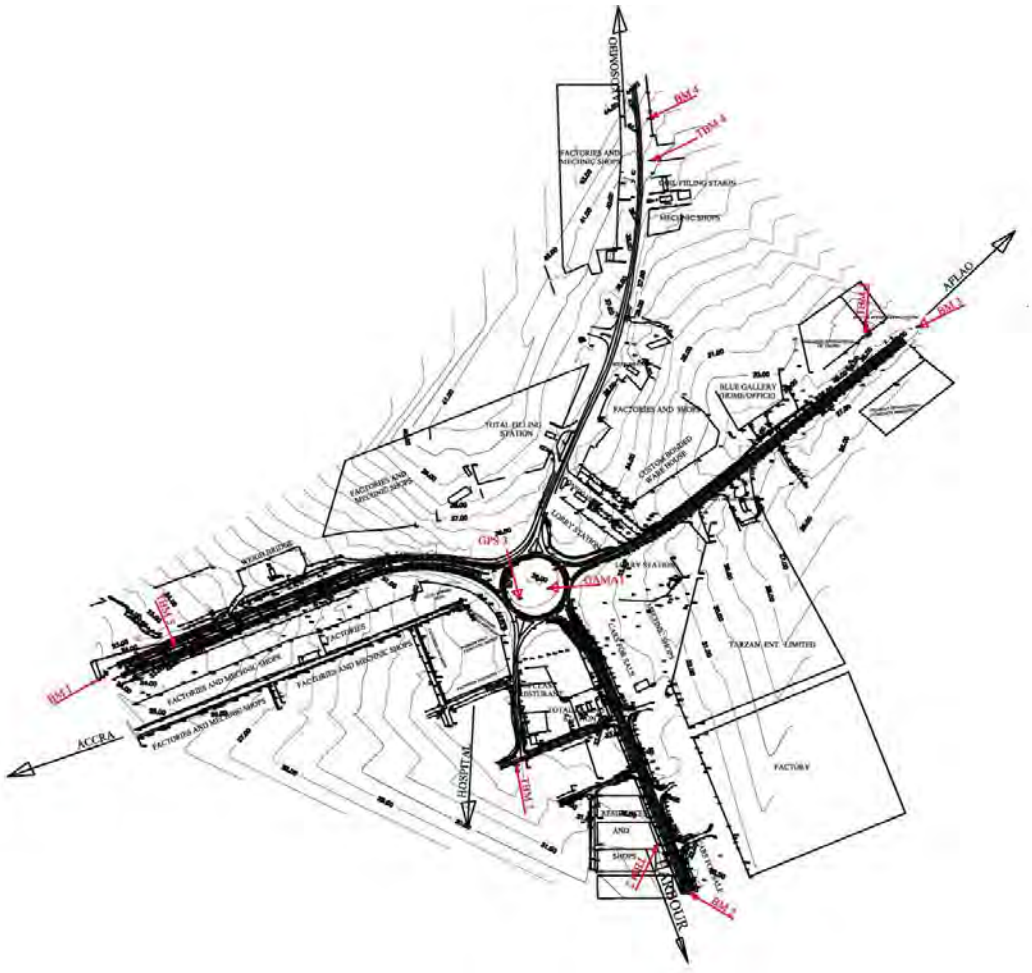


Figure 2.2.1-3 Location of the Benchmarks

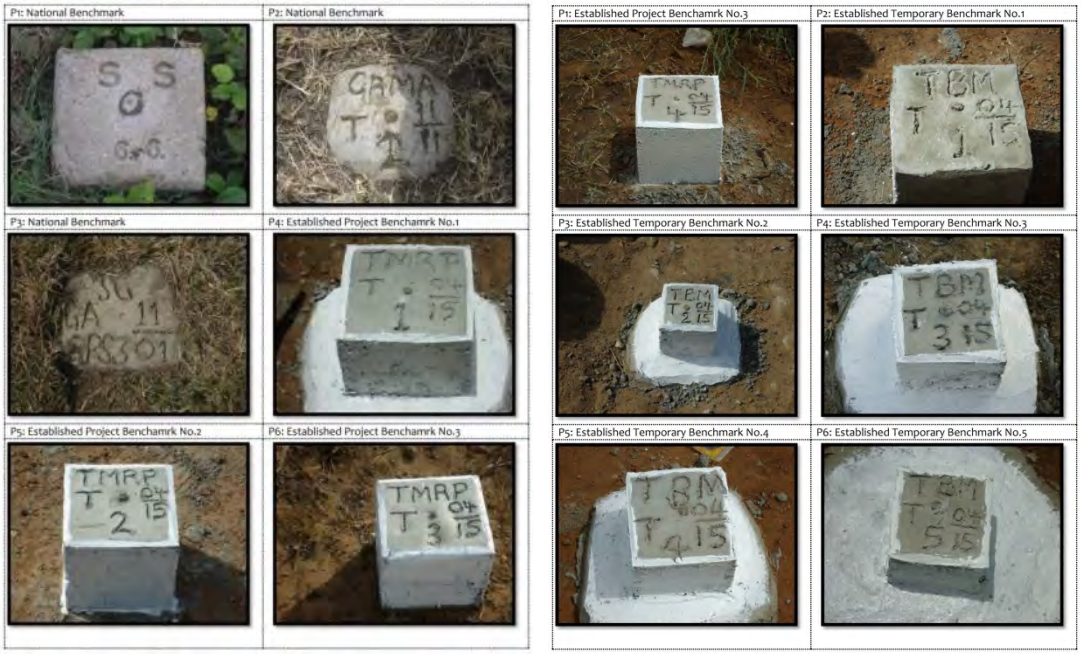


Photo 2.2.1-1 Project Benchmarks

6）Plan Survey

The plan survey of the topography, land use and existing drainage facilities were carried out for an approximate area of 121 hectares as shown in **Figure 2.2.1-2**. Features such as houses, drainage facilities, fences, poles, plantations, trees etc. were also measured. All these features are reflected in the topographic survey map (drawing).

7）Road Alignment/Longitudinal Survey

Centerline (tentative centerline) survey was carried out followed by longitudinal survey along all the legs of the roundabout. The length covered on each leg, as shown in **Figure 2.2.1-2** is 850m each from the roundabout in the east-west direction, 1,000m to north direction (Akosombo Road) and 400m for Hospital Road. The survey results are incorporated in the profile drawing.

8）Cross Section Survey

Cross Section Survey at 20 m intervals was conducted along the centerline for all legs of the roundabout. The elevation of undulations on the cross section were surveyed and correlated with the TBM. The results were incorporated in the cross section drawings.

(3) Geo-technical Investigation

1）Objectives

The objectives of the investigations were;

- To provide specific site information to confirm and amplify the geotechnical and geomorphologic findings of the desk study;
- To obtain detailed knowledge of the soils to be encountered at the site and their likely behavior on substructures ;
- To foresee and provide against difficulties and delays that may arise during construction due to groundwater and other local conditions;
- To establish design parameters and present basis for the design of substructures.

2）Contents

The investigation consists of field work and laboratory work. The scopes of each work are shown in **Table 2.2.1-5**.

Table 2.2.1-5 Investigation Items and Its Scopes

Items	Scopes (works performed)
1. Geotechnical	1. Exploratory borings with standard penetration tests, sampling and 2. confirmation of natural ground water level 3. Laboratory soil tests on samples collected from boreholes 4. CBR tests at the existing road and the planed road 5. Dynamic Cone Penetration test, and

Items	Scopes (works performed)
2. Material	1. Laboratory tests on soil samples, and 2. Laboratory tests on aggregate samples

3) Investigation Period

The investigation works commenced in the middle of April 2015 and completed in the middle of June 2015.

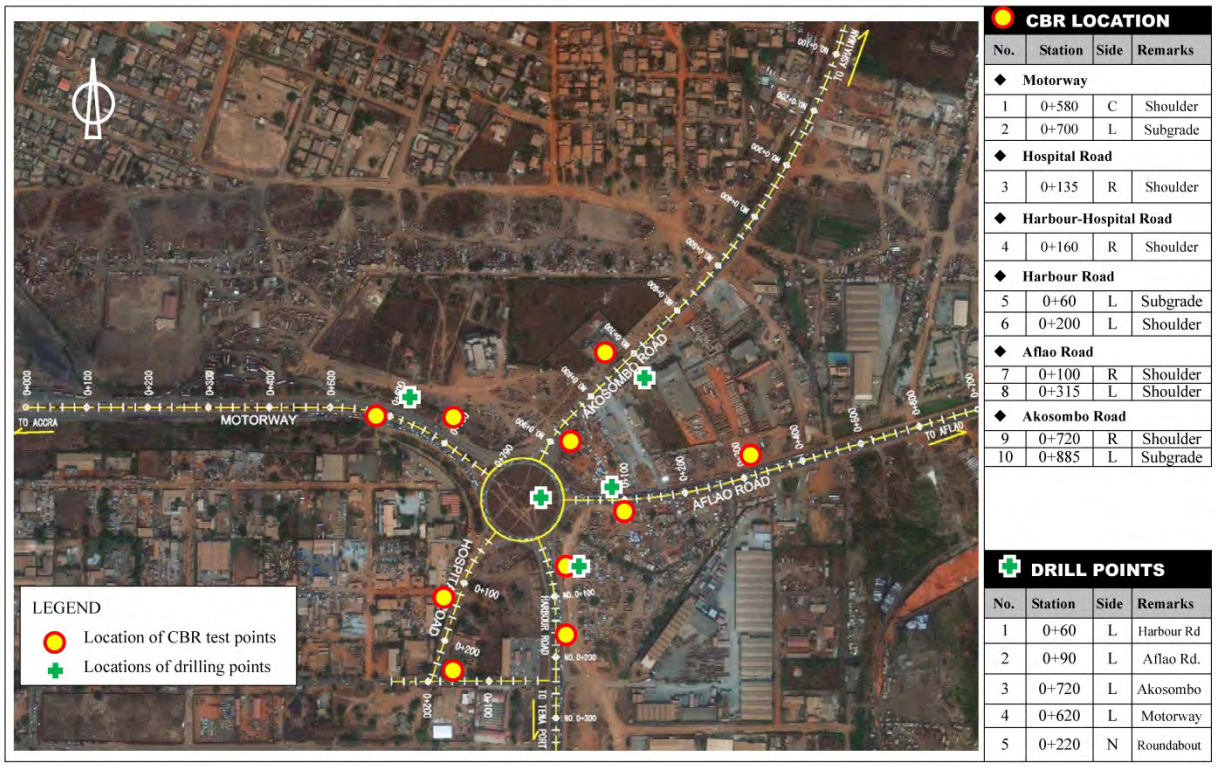
4) Results of Investigation

A) Geotechnical Investigation

The approach adopted for the geotechnical investigation consisted of:

- Desk study and field reconnaissance (geological and geotechnical information on the project area)
- Drilling and sample extraction (soil and rock (in case of weathered rocks) samples.
- Laboratory testing of selected soil and rock samples from the drilling holes.

The ground investigation was undertaken in accordance with the ASTM D220. For drilling and sample extraction, five (5) boreholes were drilled at the site. The location of the boreholes are indicated in **Figure 2.2.1-4**. In-situ Standard Penetration Test (SPT) was carried out at every 1m interval up to till refusal was recorded.



CBR LOCATION

No.	Station	Side	Remarks
◆ Motorway			
1	0+580	C	Shoulder
2	0+700	L	Subgrade
◆ Hospital Road			
3	0+135	R	Shoulder
◆ Harbour-Hospital Road			
4	0+160	R	Shoulder
◆ Harbour Road			
5	0+60	L	Subgrade
6	0+200	L	Shoulder
◆ Aflao Road			
7	0+100	R	Shoulder
8	0+315	L	Shoulder
◆ Akosombo Road			
9	0+720	R	Shoulder
10	0+885	L	Subgrade

DRILL POINTS

No.	Station	Side	Remarks
1	0+60	L	Harbour Rd
2	0+90	L	Aflao Rd.
3	0+720	L	Akosombo
4	0+620	L	Motorway
5	0+220	N	Roundabout

Figure 2.2.1-4 Location of Drilling Points and CBR Test

a) Laboratory Testing

The disturbed and SPT samples recovered from the boreholes have been tested at the laboratory for the following items;

- Moisture/water content (ASTM D2216)
- Unit weight (ASTM C29)
- Specific gravity (ASTM D854)
- Grading/Sieve analysis (sieving + Hydrometer test, ASTM D422)
- Liquid and plastic limits (ASTM D431)

b) Findings

The profiles of each bore holes are shown in **Figure 2.2.1-5**. The composition of the ground, soil distribution layer and its N-value and soil properties for all five (5) locations where drilling was conducted are summarized in **Table 2.2.1-6**. It was confirmed that weathered rock of which N value is greater than 50 exists in the ground about 10m deep. Therefore, this shall be regarded as foundation ground.

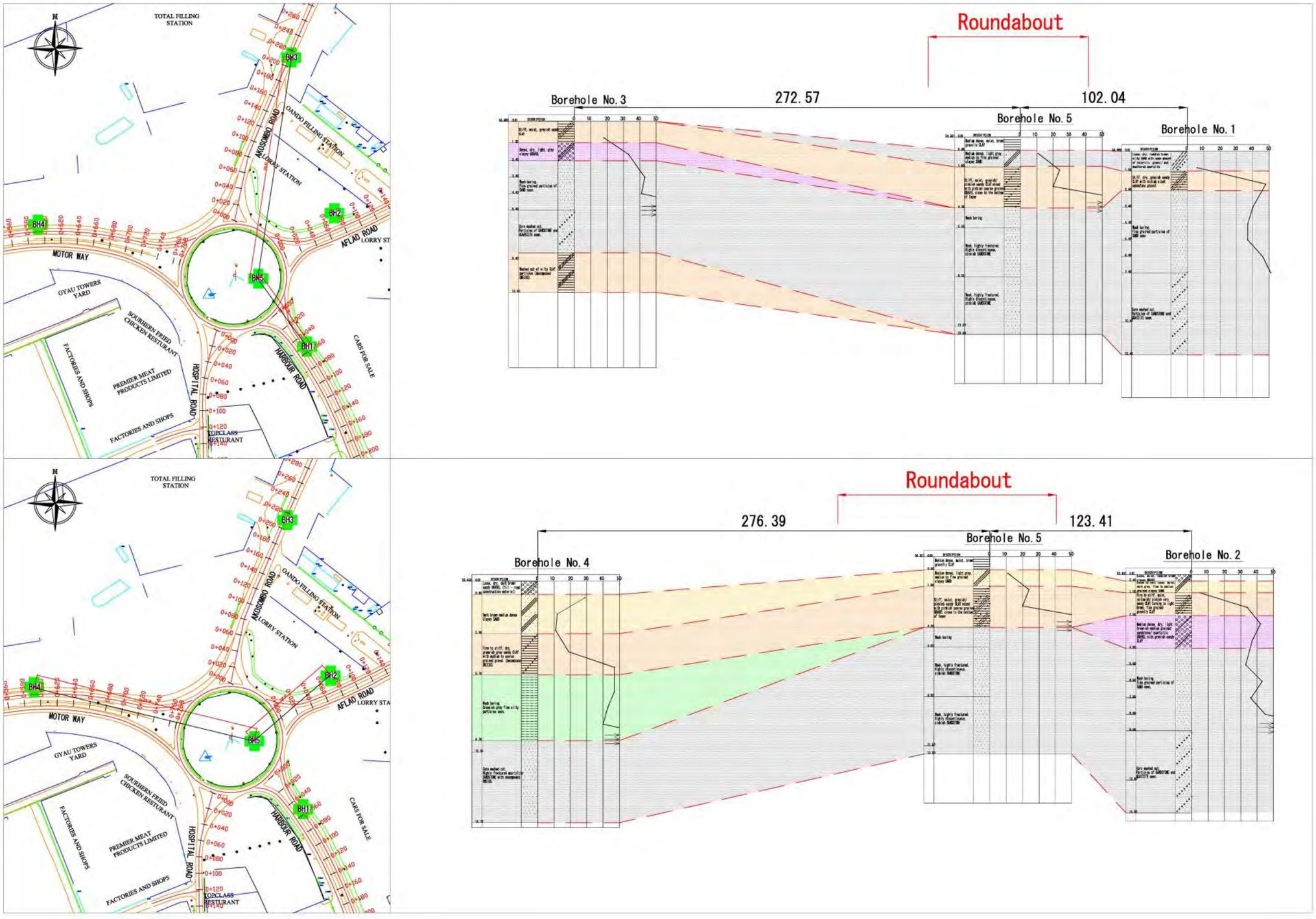


Figure 2.2.1-5 Profile of Boreholes

Table 2.2.1-6 Summary of Drilling Results

No.	Depth (m)	Layer Thickness (m)	Soil Properties	N-value (Nos.)	Remarks
BH1	1.2	1.2	Loose, dry, reddish brown silty **SAND**	6	Auger-boring
	2.4	1.2	Stiff, dry, greyish sandy **CLAY** with medium sized sandstone particles.	48	
	7.4	5.0	SANDSTONE and QUARTZITE	33-51	Wash out
	>12.4	>5m	Rock	>50	**Refusal**
BH2	0.4	0.4	Loose, moist, reddish brown clayey GRAVEL (fill)	-	Auger-boring
	1.1	0.7	Loose to very loose, moist, dark grey, fine to medium grained clayey **SAND**	5	
	2.5	1.4	Firm to stiff, moist, yellowish brown sandy **CLAY**	34	
	4.5	2.0	Medium dense, dry, light brownish medium grained sandstone/ quarzitic GRAVEL with greyish sandy CLAY	37-42	
	9.5	5.0	Fine grained particles of SAND	33-45	Wash out
	>14.5	5m>	Fine grained particles of SAND	>50	**Refusal**
BH3	1.3	1.3	Stiff, moist, greyish sandy CLAY	-	Auger-boring
	2.4	1.1	Dense, dry, light grey clayey GRAVEL	18	
	5.4	3.0	Fine grained particles of SAND	34	Wash out
	8.4	3.0	Particles of SANDSTONE and QUARTZITE	41	
	>10.4	>2.0	silty CLAY (decomposed GNEISS)	>50	**Refusal**
BH4	0.8	0.8	Loose, dry, dark brown sandy GRAVEL(Fill Material)	-	Auger-boring
	5.7	4.9	Firm to stiff, dry, greenish grey sandy CLAY	11-29	
	9.7	4.0	Greenish grey silty CLAY particles	40-49	
	12.7	3.0	**Decomposed gneiss**	>50	Wash out
	>14.7	>2.0			**Refusal**
BH5	0.8	0.8	Medium dense, moist, brown gravelly CLAY	-	Auger-boring
	1.8	1.0	Medium dense, light grey, medium to fine grained clayey SAND	11	
	4.3	2.5	Stiff, moist, sandy CLAY with coarse grained GRAVEL	20-50	
	8.5	4.2	Highly fractured Sandstone	>50	Wash out
	>12.0	>3.5			**Refusal**

c) Others

i) Earthquake Considerations

The range of horizontal ground acceleration, A, is usually equal to or greater than 0.36g for zones with these characteristics. The modified Ghana Building Code Part 3 (1988) classifies

the area as lying in zone III in terms of seismic activity. The range of horizontal ground acceleration, A, is usually equal to or greater than 0.35g for this zone. The code recommends that a minimum horizontal acceleration of 0.35g should be used in designing important structures in this zone.

ii) Groundwater

Drilling carried out for geo-technical investigation during first site survey could not confirm existence of groundwater. An alternative method was applied by providing observation wells at 5 locations within the project area and the groundwater level was recorded. Detail is provided in Section 2.2.1.3 (4) .

B) Material Investigation

a) Trial Pitting

Trial pitting was carried out manually using pick-axes and shovels at ten (10) locations along all the legs of the roundabout. All but three of the ten test pits were sunk at the road shoulders rather than the center-line to ensure that road usage was not interfered with during the period of fieldwork. The other three trial pits were sunk outside the existing roadway where the newly planned road layout is expected to be.

b) Dynamic Cone Penetration

To evaluate the integrity and strength characteristics of the existing pavement and the subgrade, DCP testing was carried out at ten (10) locations along all the 5 legs of roads connecting the motorway roundabout.

c) Laboratory Testing

The bulk samples taken from the trial pits were subjected to standard identification and classification tests for the determination of the following parameters:

- Soil Classification (USCS)
- Moisture/water content (ASTM D2216)
- Specific gravity (ASTM D854)
- Compaction tests (4.5kg rammer method, AASHTO T180)
- Soaked CBR test (AASHTO T193)

The laboratory-testing program was carried out using methods recommended in the relevant ASTM Standards.

d) Findings

Almost all the pavement structure on all the five-leg roads adjoining the Tema Motorway Roundabout is essentially of the same material quality. Except for Motorway leg, the pavement structures are constructed of crushed-stone base course overlying a well compacted, reddish

brown, fine to medium coarse, lateritic gravel material- serving in almost all cases as both the sub-base and subgrade material. This lateritic type is reasonably well graded. It appears to have been taken from the only known soil pit near the project area - the TDC Kpone gravel pit which is now disused. On the hospital roads, however, the subgrades are made of moist, brownish grey, moderately dense clayey sand. All the in-situ CBR values obtained from the DPCTs were higher that their corresponding values obtained from the soaked 96 hr. submersion in water. This may well be explained by the fact that the investigations were carried out at a time of dry weather condition where the in-situ CBRs were expected to be their highest

(4) Groundwater Level Observation

1) Purpose

To study the countermeasures to be taken for structure and road design in the depressed section in the east-west direction, groundwater level observation has been conducted at the observation wells which were installed at 2 locations near Tema Roundabout.

2) Locations and Observation Period

Groundwater level observation was conducted at locations shown in **Figure 2.2.1-6**. Observation has been continued since November 2015 and will last for 1 year.

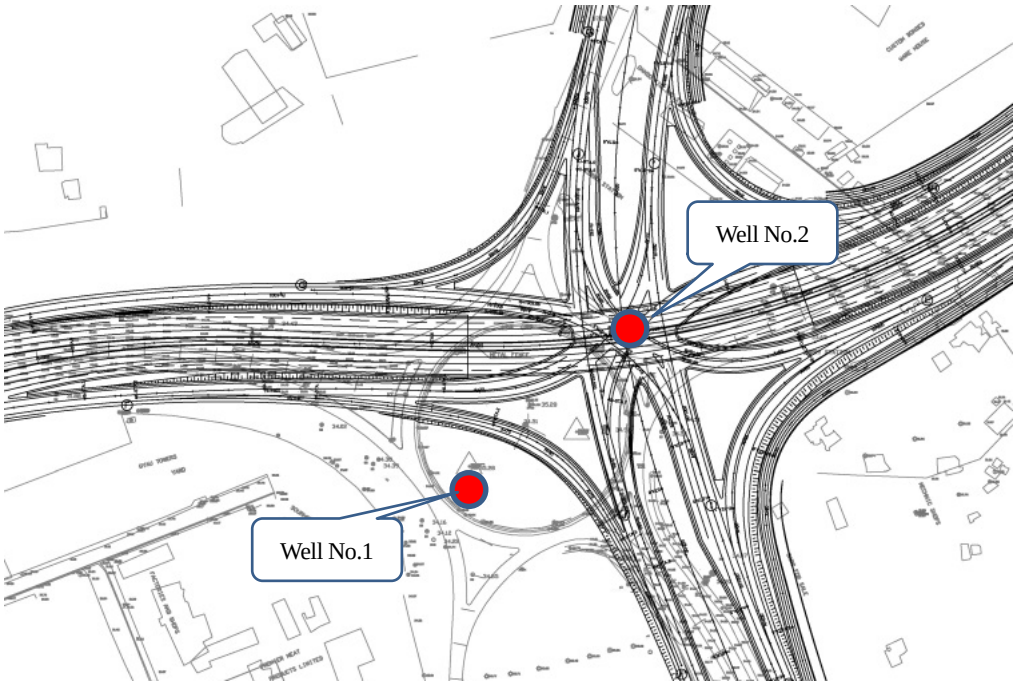


Figure 2.2.1-6 Location of Observation Well

3) Observation Method

Observation wells were installed to a depth of about 5 meter from the surface of foundation ground with N value greater than 50. Observation of groundwater was done twice every month from December 2015 till July 2016. A Well sounder equipped with detector was used as a measuring tool to monitor the groundwater level.

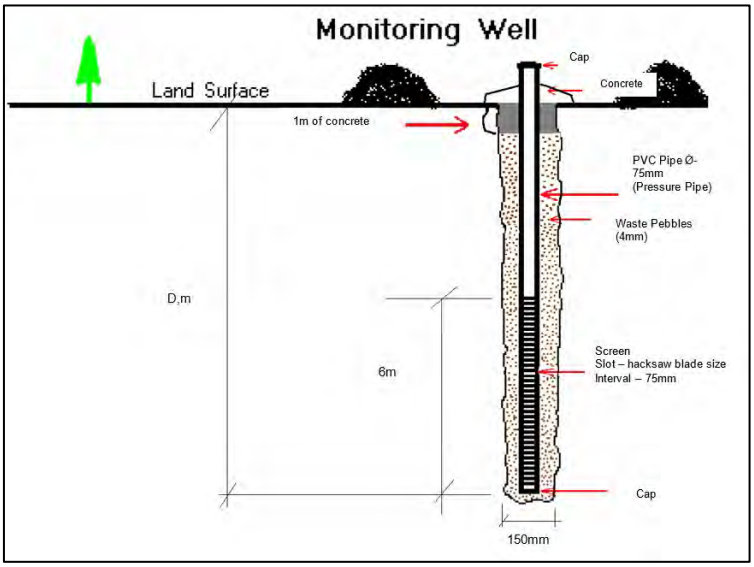


Figure 2.2.1-7 Detail of Observation Well

Table 2.2.1-7 Installation of Observation Well

		
Installation Work		Top of Observation Well

4） Results and Findings

Observation results are summarized in **Table 2.2.1-8**. There are not large differences between dry season (December) and rainy season (May). However, as existence of groundwater was confirmed, countermeasures to the groundwater shall be considered for structure design and pavement design.

Table 2.2.1-8 Observation Results

DATE	TIME	WELL 1 (m)	WELL 2 (m)
2015/12/2	9:38am	6.10	6.54
2015/12/15	14:00pm	5.90	6.46
2015/12/17	1:45pm	6.90	6.36
2015/12/23	1:15pm	7.10	6.44
2016/1/7	10:00am	7.25	6.57
2016/1/20	10:30am	7.39	6.62
2016/2/3	12:10pm	7.43	6.67
2016/2/17	10:35am	7.50	6.75
2016/3/2	9:00am	7.33	6.69
2016/3/17	9:45am	7.34	6.69
2016/5/13	10:23am	7.45	6.69
2016/6/3	11:30am	7.47	6.69
2016/6/17	10:23am	6.85	6.22
2016/7/7	11:15am	6.76	6.2

(5) Road Inventory Survey

1）Objectives

The objectives of road inventory survey are;

- To know the current situation of the area that will be affected by this project in the future;
- To obtain detailed information to study drainage plan and service roads at the outline design stage;
- To check the topographic survey result.

2）Survey Period and Survey Items

Inventory survey of the roads was conducted from middle of April till middle of June 2015. Inventory items, its breakdown and inventory methods are listed in **Table 2.2.1-9**.

Table 2.2.1-9 Inventory Items

Survey Items	Breakdown	Methodology
1. Road reserves	・ROW Stakes	Using optical distance measuring device
2. Road parameters/condition	・Pavement condition ・Carriage way ・Shoulder ・Median ・Curb ・Sidewalk	By using tape measure
3. Drainage	・Route ・Flow direction ・Shape and material of drainage structures	
4. Access to abutting buildings	・Private houses ・Gas station ・Bus station ・Shop	

(6) Underground Facility Survey

1）Objectives

The objectives of the survey are;

- To obtain detailed information to study the improvement plan of Tema Motorway Roundabout, and
- To provide information to GHA and relevant agencies of the underground facilities that might be affected by/during the construction.

2）Survey Period

The Survey commenced in the middle of May 2015 and completed at the end of May 2015.

3）Survey Items

Survey items, responsible companies and methodology of the survey are summarized in **Table 2.2.1-10**.

Table 2.2.1-10 Survey Items

Survey Items	Company	Methodology
1. Water pipe	・Ghana Water Company Limited (GWCL)	By collecting data or information from the companies and trial digging at site.
2.Communication pipe/cable	・MTN ・Vodafone ・Milicom Ghana (TIGO) ・GLO	
3. Electricity pipe/cable	・Electricity Company of Ghana (ECG)	

4）Findings

The findings from this survey are as illustrated in **Figure 2.2.1-8**. As is apparent from the figure, existence of several utilities (service lines) was confirmed. Removal of these service lines that will be affected by the improvement plan must be done under the responsibility of the GOG.

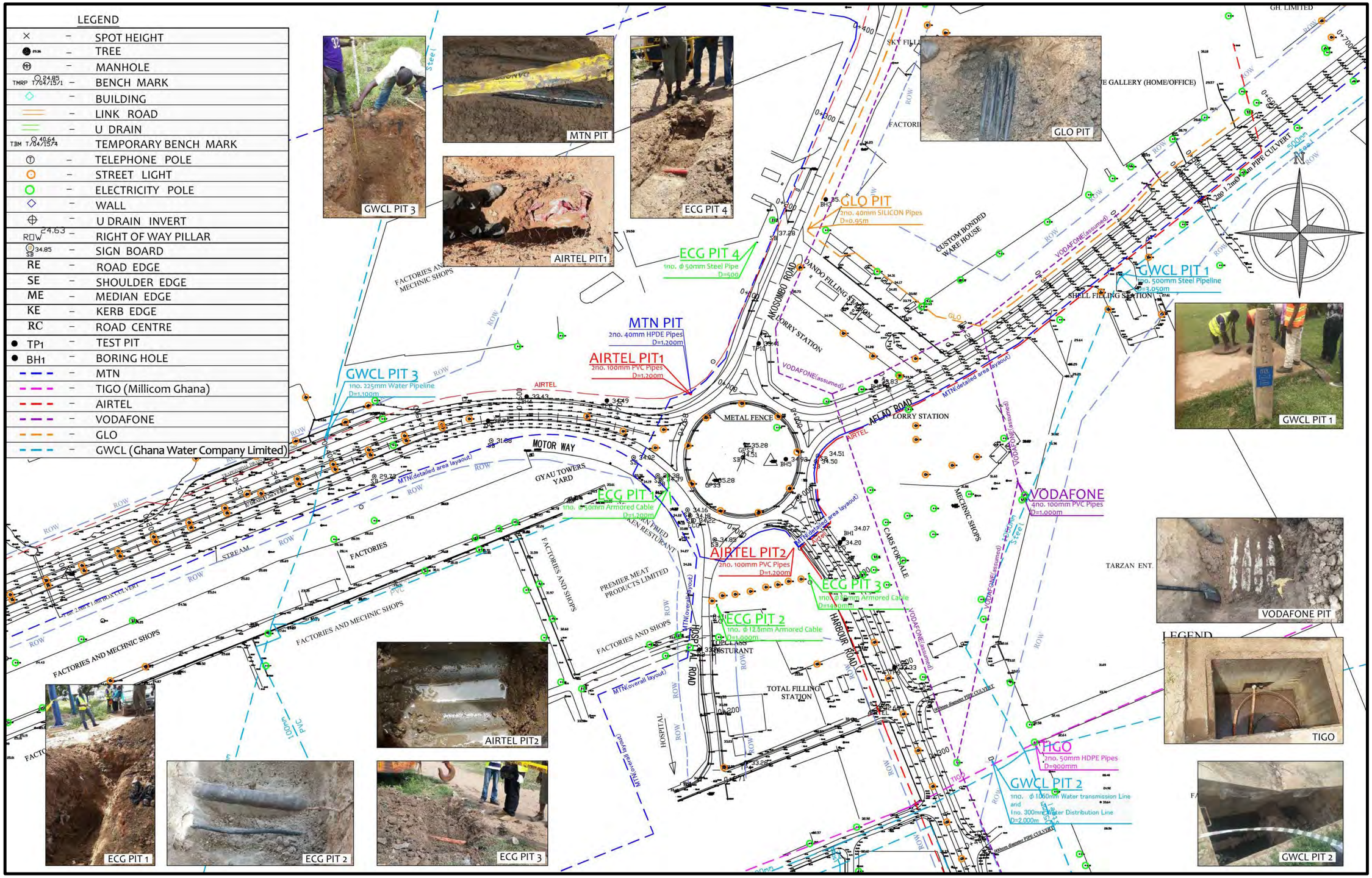


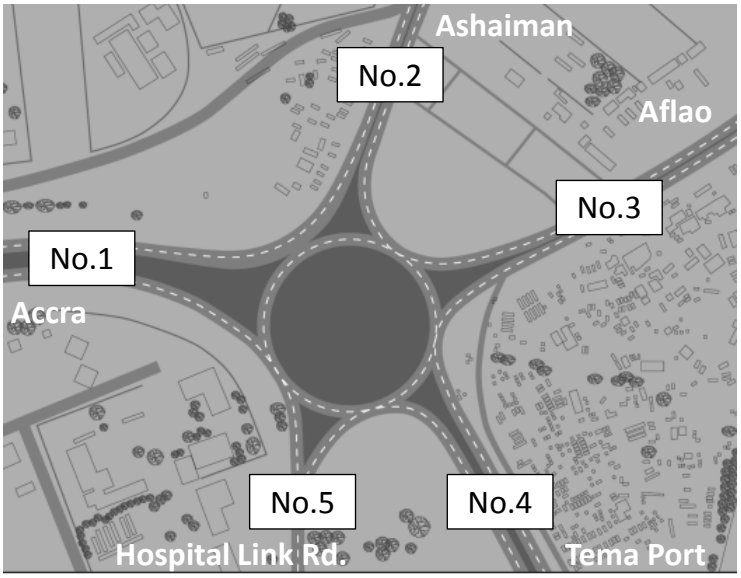
Figure 2.2.1-8 Underground Facility Map

(7) Traffic Survey

1) Implementation of Traffic Survey

This chapter summarizes the results of the traffic survey with an aim to provide basic data for formulating an improvement plan of Tema Motorway Roundabout along with the results of traffic demand forecast.

Traffic surveys were carried out on all 5 legs of the existing Tema roundabout shown in **Figure 2.2.1-9**. The survey consisted of four items as shown in **Table 2.2.1-11**, and the survey was subcontracted to a local consultant. The traffic survey was implemented from 14 to 17 April 2015.



Source: JICA Survey Team

Figure 2.2.1-9 Location of Traffic Survey Stations

Table 2.2.1-11 Summary of Traffic Survey

Survey Item	Survey Contents
Traffic count survey	1 weekday, 24 hours, by vehicle type, by direction
Turning volume count survey	1 weekday, morning and evening peak 2 hours, by vehicle type, by direction
Traffic congestion length survey	1 weekday, morning and evening peak time
Travel speed survey	1 weekday, morning and evening peak time

Source: JICA Study Team

The classification of vehicles in the survey was done in accordance with the classification of vehicles in the GHA pavement design manual. In this survey, the vehicle types were classified into eight (8) types, as shown in **Table 2.2.1-12**.

Table 2.2.1-12 Classification of Vehicles in the Survey

Classification of vehicles in the survey	GHA classification of vehicles
1. Motor Cycle	Motor bike
2. Passenger Car	Car
	Taxi
	Pick-up/Van/4WD vehicle
3. Minibus	Small bus
4. Bus	Medium bus/Mammy wagon
	Large bus
5. Light Truck	Light truck
6. Heavy Truck	Medium truck
	Heavy truck
7. Trailer	Semi-trailer (Light, Heavy)
	Truck-trailer
8. Others	Extra-large truck & others

Source: JICA Survey Team

2) Results of Traffic Volume Survey on Road Sections

Table 2.2.1-13 shows the results of the road section traffic survey for each leg of the roundabout. The maximum traffic volume was counted at station 3 on the Tema-Aflao Road, with 33,169 vehicles per day. This was followed by the total traffic volume at station 2 on the Tema-Akasombo Road with 29,505 vehicles per day, station 4 on the Tema-Harbour Road with 28,290 vehicles per day, and station 1 on the Accra-Tema Motorway of 23,854 vehicles per day. The traffic volume at station 5 was 12,855 vehicles per day. Looking at the composition of vehicle types, the highest proportion of large size vehicle was on Harbour Road at 15%. Next was station 1 on the Accra-Tema Motorway at 12%. The other locations had percentages values not exceeding 10%.

Table 2.2.1-13 Road Section Traffic Count for Each Location

Classification	No.1 Accra-Tema Motorway		No.2 Tema-Akosombo Rd.		No.3 Tema-Aflao Rd.		No.4 Tema Harbour Rd.		No.5 Tema-Hospital Rd.	
	Volume	%	Volume	%	Volume	%	Volume	%	Volume	%
Motorcycle	1,977	8%	2,230	8%	1531	5%	1846	7%	746	6%
Car & Taxi	11,885	50%	18,975	64%	21875	66%	16330	58%	9750	76%
Minibus	4,643	19%	4,716	16%	5379	16%	4771	17%	1252	10%
Bus	177	1%	607	2%	329	1%	983	3%	81	1%
Light Truck	2,393	10%	1,369	5%	1705	5%	1232	4%	520	4%
Heavy Truck	1,218	5%	951	3%	993	3%	1256	4%	292	2%
Trailer	1,158	5%	484	2%	1037	3%	1387	5%	55	0%
Others	403	2%	173	1%	320	1%	485	2%	189	1%
Total (All type of Veh.)	23,854	100%	29,505	100%	33,169	100%	28,290	100%	12,885	100%
Share of Large size Veh.	*2956*	*12%*	*2215*	*8%*	*2679*	*8%*	*4111*	*15%*	*617*	*5%*
Share of Large size truck	*2,779*	*12%*	*1608*	*5%*	*2350*	*7%*	*3128*	*11%*	*536*	*4%*
Total PCU	28,579	-	31,947	-	37,292	-	33,966	-	13,633	-

Source: JICA Survey Team

Table 2.2.1-14 and **Table 2.2.1-15** show the measured traffic volume and the percentages during the peak hour. From the measured results, the peak hour in the morning is from 7:30 until 8:30. This applies to all locations. The peak percentage for the total of all the entering traffic volume was 7.5%. In terms of location, the peak percentage for Tema-Harbour Road was the highest at 9.1%. The evening peaks varying trends with respect to each location. The section total at the peak in the evening was from 17:30 to 18:30, but the percentage was 5.1%, so the peak was clearly not as high as that of the morning peak.

Table 2.2.1-14 Measured Traffic Volume and Peak Percentages in the Morning

Survey Station	Road Name	Daily Traffic (veh./day)			Morning Peak (Veh./hr) 7:30 - 8:30			Morning Peak (%) 7:30 - 8:30		
		Entry	Exit	Total	Entry	Exit	Total	Entry	Exit	Total
No.1	Accra-Tema Motorway	11,180	12,674	23,854	874	826	1,700	*7.8%*	*6.5%*	*7.1%*
No.2	Tema-Akosombo Road	15,442	14,063	29,505	1,234	790	2,024	*8.0%*	*5.6%*	*6.9%*
No.3	Tema-Aflao Road	17,389	15,780	33,169	1,236	1,141	2,377	*7.1%*	*7.2%*	*7.2%*
No.4	Tema Harbour Road	10,858	16,422	27,280	908	1,563	2,471	*8.4%*	*9.5%*	*9.1%*
No.5	Tema-Hospital Road	8,953	3,932	12,885	527	403	930	*5.9%*	*10.2%*	*7.2%*
Total		63,822	62,871	126,693	4,779	4,723	9,502	*7.5%*	*7.5%*	*7.5%*

Source: JICA Survey Team

Table 2.2.1-15 Measured Traffic Volume and Peak Percentages in the Evening

Survey Station	Road Name	Daily Traffic (veh./day)			Evening Peak (Veh./hr) 17:30 -18:30			Evening Peak (%) 17:30 -18:30		
		Entry	Exit	Total	Entry	Exit	Total	Entry	Exit	Total
No.1	Accra-Tema Motorway	11,180	12,674	23,854	410	729	1,139	*3.7%*	*5.8%*	*4.8%*
No.2	Tema-Akosombo Road	15,442	14,063	29,505	874	805	1,679	*5.7%*	*5.7%*	*5.7%*
No.3	Tema-Aflao Road	17,389	15,780	33,169	891	1,143	2,034	*5.1%*	*7.2%*	*6.1%*
No.4	Tema Harbour Road	10,858	16,422	27,280	379	523	902	*3.5%*	*3.2%*	*3.3%*
No.5	Tema-Hospital Road	8,953	3,932	12,885	573	147	720	*6.4%*	*3.7%*	*5.6%*
Total		63,822	62,871	126,693	3,127	3,347	6,474	*4.9%*	*5.3%*	*5.1%*

Source: JICA Survey Team

3）Results of Turning Volume Count Survey

Traffic volume by direction was calculated based on the results of roadside OD (Origin-Destination) interview survey conducted at each of the 5 legs of the Tema Roundabout. The survey of traffic volume by direction was conducted in the morning and evening peak hours. The effective number of samples obtained at each cross-section was greater than 30%. The samples obtained were converted into traffic volume by time, by direction and by vehicle type using the survey results. From above, the results of the traffic count by direction at Tema Roundabout are as shown in **Table 2.2.1-16**.

Traffic volume from 07:00 to 08:00 hours from inflow point 2 to outflow point 1 was the highest at 633 vehicles per hour or 13% of the total. Next, from inflow point 3 to outflow point 4 the traffic volume was 483 vehicles per hour or 10%. From 8:00 to 9:00 hours the traffic volume from inflow point 3 to outflow point 4 was the largest at 746 vehicles per hour or 15% of the total. Next, from inflow point 2 to outflow point 4 the traffic volume was 440 vehicles per hour or 9%.

Table 2.2.1-16 Peak Traffic Volume and Percentages against the Total Traffic Volume

Morning time 7 a.m. Veh./hr

Turning Volume		Outflow					
		1	2	3	4	5	Total
Inflow	1	13	235	258	301	118	926
	2	633	29	146	396	126	1,330
	3	386	139	13	483	198	1,220
	4	208	398	292	3	17	918
	5	22	144	246	54	2	469
	Total	1,262	947	956	1,238	461	4,863

Volume Share		Outflow					
		1	2	3	4	5	Total
Inflow	1	0%	5%	5%	6%	2%	19%
	2	13%	1%	3%	8%	3%	27%
	3	8%	3%	0%	10%	4%	25%
	4	4%	8%	6%	0%	0%	19%
	5	0%	3%	5%	1%	0%	10%
	Total	26%	19%	20%	25%	9%	100%

Morning time 8 a.m. Veh./hr

Turning Volume		Outflow					
		1	2	3	4	5	Total
Inflow	1	29	308	282	213	34	865
	2	432	41	111	440	182	1,207
	3	370	90	6	746	85	1,297
	4	164	406	277	-	27	873
	5	46	167	295	67	-	576
	Total	1,041	1,012	972	1,466	327	4,818

Volume Share		Outflow					
		1	2	3	4	5	Total
Inflow	1	1%	6%	6%	4%	1%	18%
	2	9%	1%	2%	9%	4%	25%
	3	8%	2%	0%	15%	2%	27%
	4	3%	8%	6%	0%	1%	18%
	5	1%	3%	6%	1%	0%	12%
	Total	22%	21%	20%	30%	7%	100%

Evening time 17 p.m. Veh./hr

Turning Volume		Outflow					
		1	2	3	4	5	Total
Inflow	1	3	180	158	67	35	443
	2	400	52	128	162	83	824
	3	448	74	20	267	60	868
	4	81	239	41	1	4	366
	5	51	213	228	78	-	571
	Total	983	758	574	575	182	3,072

Volume Share		Outflow					
		1	2	3	4	5	Total
Inflow	1	0%	6%	5%	2%	1%	14%
	2	13%	2%	4%	5%	3%	27%
	3	15%	2%	1%	9%	2%	28%
	4	3%	8%	1%	0%	0%	12%
	5	2%	7%	7%	3%	0%	19%
	Total	32%	25%	19%	19%	6%	100%

Evening time 18 p.m. Veh./hr

Turning Volume		Outflow					
		1	2	3	4	5	Total
Inflow	1	21	170	190	38	27	446
	2	386	87	115	171	83	842
	3	434	67	6	240	53	799
	4	92	58	36	-	24	210
	5	106	204	158	37	-	505
	Total	1,039	585	505	486	187	2,802

Volume Share		Outflow					
		1	2	3	4	5	Total
Inflow	1	1%	6%	7%	1%	1%	16%
	2	14%	3%	4%	6%	3%	30%
	3	15%	2%	0%	9%	2%	29%
	4	3%	2%	1%	0%	1%	7%
	5	4%	7%	6%	1%	0%	18%
	Total	37%	21%	18%	17%	7%	100%

Source: JICA Survey Team

Also, an OD survey was additionally implemented on Tema-Hospital Road to confirm the status of traffic detouring from the Tema Roundabout. Specifically, it was to investigate by-passing traffic from Accra towards Ashaiman (survey road-station 2) and Aflao (survey road-station 3) going to outflow point 2 and 3 via Hospital Link Road. The results showed that traffic volume equivalent to about 10% of the total traffic volume according to the direction on Tema-Hospital Road were detouring

4）Results of the traffic Congestion Length Survey

Longest traffic congestion with respect to the time period was obtained from the traffic survey. The length of congestion is the length of the line of vehicles from the point of intersection with the roundabout. The result is shown in

Table 2.2.1-17. The maximum length of congestion measured in the morning was 1,100 m, which occurred on the Tema-Akasombo Road. On the Accra-Tema Motorway 500 m was measured on the Tema-Aflao Road 600 m was measured and on the Tema-Harbour Road and the Tema-Hospital Road 120 m length of traffic congestion was measured. All these were measured between 8:00 hours and 9:00 hours.

In the evening the maximum length of congestion was 700 m measured on the Tema-Harbour Road. On the Accra-Tema Motorway 500 m was measured between 18:00 and 19:00 hours. On the Tema-Akasombo Road 600 m was measured between 17:00 and 18:00 hours. On the Tema-Aflao Road 450 m was measured. On the Tema-Hospital Road traffic congestion of length 170 m was measured.

Table 2.2.1-17 Traffic Congestion Length during Peak Hours (units: m)

No.	Road	7:15	7:30	7:45	8:00	8:15	8:30	8:45	9:00
No.1	Accra-Tema Motorway	215	200	300	500	500	500	450	400
No.2	Tema-Akosombo Rd.	170	1,000	1,000	1,100	1,100	1,100	800	800
No.3	Tema-Aflao Rd.	400	300	450	590	350	500	450	600
No.4	Tema-Harbor Rd.	-	60	40	100	100	120	90	120
No.5	Tema-Hospital Rd.	24	-	52	100	100	120	120	120
No.	**Road**	**17:15**	**17:30**	**17:45**	**18:00**	**18:15**	**18:30**	**18:45**	**19:00**
No.1	Accra-Tema Motorway	250	350	400	400	500	500	400	300
No.2	Tema-Akosombo Rd.	600	600	400	240	240	300	141	200
No.3	Tema-Aflao Rd.	450	450	450	450	450	400	50	50
No.4	Tema-Harbor Rd.	270	300	330	340	320	550	650	700
No.5	Tema-Hospital Rd.	120	120	120	170	170	170	170	170

Source: JICA Survey Team

5）Results of Traffic Speed Survey

A travel speed survey was carried out on sections between each inflow point to the Tema Roundabout. The traveling speed results of the peak times are shown in **Table 2.2.1-18**. On the Tema-Akasombo Road the traveling speed was less than 5 km/h. The delay time to arrive at the intersection was 13 minutes. Apart from Tema-Harbour Road, the driving speeds for all the inflow points were less than 10 km/h.

Table 2.2.1-18 Traveling Time Results during Peak Hours

Survey Station	Road Name	Length (m)	Observed Result		Delay Time (min)
			Travel Time (min)	Travel Speed (km)	
No.1	Accra-Tema Motorway	1,000	6.9	8.7	No.1
No.2	Tema-Akosombo Rd.	1,000	14.3	4.2	No.2
No.3	Tema-Aflao Rd.	1,000	10.7	5.6	No.3
No.4	Tema-Harbour Rd.	1,000	4.5	13.3	No.4
No.5	Tema-Hospital Rd.	300	2.3	7.8	No.5

Source: JICA Survey Team

6）Calculation of Annual Average Traffic Volume

A) Basic Considerations

Based on the traffic survey results the annual average traffic volume was calculated. The annual average traffic volume was calculated by applying a day of the week correction and a month correction to the measured traffic volume results. The values of each of the corrections used were obtained from the results of study in previous years by GHA. The day of the week correction was 0.81, and the month correction was 1.20. Note that the annual average traffic demands at the intersection were obtained taking into consideration the length of congestion.

B) Traffic Volume on Road Section

Table 2.2.1-19 shows the annual average daily traffic volume (AADT) separately for inflow, outflow and section at the Tema Roundabout. The table shows AADT was greatest on the Tema-Aflao Road at 32,240 vehicles per day. Next was Tema-Akosombo Road at 28,679 vehicles per day, Tema-Harbour Road at 26,516 vehicles per day, and the Accra-Tema Motorway at 23,186 vehicles per day. For Tema-Hospital Road the result was 12,524 vehicles per day. Note that the results for Accra - Tema Motorway were lower than those for the other sections, but this was due to a separate route to access the Tema Port area before the Team Roundabout.

Table 2.2.1-19Annual Average Daily Traffic Volume (AADT)

Survey Station	Road Name	Daily Traffic (veh./day)			Morning Peak (Veh./hr)			Evening Peak (Veh./hr)		
					7:30 - 8:30			17:30 -18:30		
		Entry	Exit	Total	Entry	Exit	Total	Entry	Exit	Total
No.1	Accra-Tema Motorway	10,867	12,319	23,186	1,005	896	1,900	554	821	1,374
No.2	Tema-Akosombo Road	15,010	13,669	28,679	1,371	857	2,228	896	906	1,803
No.3	Tema-Aflao Road	16,902	15,338	32,240	1,358	1,237	2,595	991	1,287	2,278
No.4	Tema Harbour Road	10,554	15,962	26,516	912	1,695	2,607	529	589	1,118
No.5	Tema-Hospital Road	8,702	3,822	12,524	531	437	968	584	165	749

Source: JICA Survey Team

C) Directional Traffic Volume

Table 2.2.1-20 shows the directional annual average traffic volume at the peak hours on Tema Roundabout. The values here would be the traffic volume in the case that the detour traffic determined in the additional survey travelled via the Tema Roundabout without detouring. **Table 2.2.1-21** shows the traffic volume in terms of PCU. The above results are examined in the next section to obtain the future traffic demand for a standard planning year.

Table 2.2.1-20 Annual Average Traffic Volume according to Direction at Peak Hours (vehicles per hour)

		Outflow					
MOTOR		1	2	3	4	5	Total
Inflow	1	3	13	22	28	18	84
	2	64	3	12	76	14	169
	3	11	11	5	14	12	53
	4	16	27	27	0	0	70
	5	2	18	11	2	0	33
	Total	96	72	77	120	44	409
CAR		1	2	3	4	5	Total
Inflow	1	8	127	293	136	42	606
	2	221	14	121	385	144	885
	3	147	80	9	563	111	910
	4	52	156	224	2	18	452
	5	14	83	170	42	1	310
	Total	442	460	817	1128	316	3163
MINIBUS		1	2	3	4	5	Total
Inflow	1	0	92	67	98	7	264
	2	91	12	31	66	6	206
	3	70	15	1	147	11	244
	4	51	149	86	0	1	287
	5	3	9	29	14	0	55
	Total	215	277	214	325	25	1056
LARGE BUS		1	2	3	4	5	Total
Inflow	1	0	2	1	2	0	5
	2	4	3	4	5	0	16
	3	1	0	0	4	0	5
	4	2	4	1	0	0	7
	5	0	1	1	0	0	2
	Total	7	10	7	11	0	35
LIGHT TRUCK		1	2	3	4	5	Total
Inflow	1	6	6	24	13	2	51
	2	23	0	3	6	3	35
	3	28	2	0	13	6	49
	4	14	7	12	0	0	33
	5	2	2	9	2	0	15
	Total	73	17	48	34	11	183
TRUCK		1	2	3	4	5	Total
Inflow	1	1	10	16	10	0	37
	2	11	1	10	18	7	47
	3	18	1	1	14	0	34
	4	6	1	9	0	1	17
	5	2	4	8	5	0	19
	Total	38	17	44	47	8	154
TRAILER		1	2	3	4	5	Total
Inflow	1	0	3	3	4	0	10
	2	4	0	0	3	0	7
	3	16	6	0	10	1	33
	4	4	5	11	0	0	20
	5	0	0	0	0	0	0
	Total	24	14	14	17	1	70
OTHERS		1	2	3	4	5	Total
Inflow	1	0	0	14	12	20	46
	2	0	0	1	1	1	3
	3	8	0	0	10	4	22
	4	0	9	0	0	0	9
	5	0	0	5	1	0	6
	Total	8	9	20	24	25	86
All veh.		1	2	3	4	5	Total
Inflow	1	18	253	440	303	89	1103
	2	418	33	182	560	175	1368
	3	299	115	16	775	145	1350
	4	145	358	370	2	20	895
	5	23	117	233	66	1	440
	Total	903	876	1241	1706	430	5156

Source: JICA Survey Team

Table 2.2.1-21 Annual Average Traffic Volume according to Direction at Peak Hours (PCU per hour)

		Outflow					
MOTOR		1	2	3	4	5	Total
Inflow	1	2	7	11	14	9	43
	2	32	2	6	38	7	85
	3	6	6	3	7	6	28
	4	8	14	14	0	0	36
	5	1	9	6	1	0	17
	Total	49	38	40	60	22	209
CAR		1	2	3	4	5	Total
Inflow	1	8	127	293	136	42	606
	2	221	14	121	385	144	885
	3	147	80	9	563	111	910
	4	52	156	224	2	18	452
	5	14	83	170	42	1	310
	Total	442	460	817	1128	316	3163
MINIBUS		1	2	3	4	5	Total
Inflow	1	0	92	67	98	7	264
	2	91	12	31	66	6	206
	3	70	15	1	147	11	244
	4	51	149	86	0	1	287
	5	3	9	29	14	0	55
	Total	215	277	214	325	25	1056
LARGE BUS		1	2	3	4	5	Total
Inflow	1	0	4	2	4	0	10
	2	8	6	8	10	0	32
	3	2	0	0	8	0	10
	4	4	8	2	0	0	14
	5	0	2	2	0	0	4
	Total	14	20	14	22	0	70
LIGHT TRUCK		1	2	3	4	5	Total
Inflow	1	6	6	24	13	2	51
	2	23	0	3	6	3	35
	3	28	2	0	13	6	49
	4	14	7	12	0	0	33
	5	2	2	9	2	0	15
	Total	73	17	48	34	11	183
TRUCK		1	2	3	4	5	Total
Inflow	1	2	20	32	20	0	74
	2	22	2	20	36	14	94
	3	36	2	2	28	0	68
	4	12	2	18	0	2	34
	5	4	8	16	10	0	38
	Total	76	34	88	94	16	308
TRAILER		1	2	3	4	5	Total
Inflow	1	0	9	9	12	0	30
	2	12	0	0	9	0	21
	3	48	18	0	30	3	99
	4	12	15	33	0	0	60
	5	0	0	0	0	0	0
	Total	72	42	42	51	3	210
OTHERS		1	2	3	4	5	Total
Inflow	1	0	0	42	36	60	138
	2	0	0	3	3	3	9
	3	24	0	0	30	12	66
	4	0	27	0	0	0	27
	5	0	0	15	3	0	18
	Total	24	27	60	72	75	258
All veh.		1	2	3	4	5	Total
Inflow	1	18	265	480	333	120	1216
	2	409	36	192	553	177	1367
	3	361	123	15	826	149	1474
	4	153	378	389	2	21	943
	5	24	113	247	72	1	457
	Total	965	915	1323	1786	468	5457

Source: JICA Survey Team

(8) Survey of Existing Drainage System

1) Objectives

The objectives of the Survey are;

- To confirm the existing drainage systems
- To grasp the dimensions and layout of existing provision of drainage facilities
- To confirm the locations of drainage outlets

2) Survey Period

The survey was conducted between 1st May, 2015 and 16th May, 2015 (16 days).

3) Survey Items

Major items surveyed are as follows:

- Flow pattern/directions
- Dimensions and sizes of drainage facilities
- Condition of drainage outlets

4) Survey Result

A) Drainage Flows / Systems

Existing Drainage Flows (wide area)

Existing Road Surface Drainage Flows

Figure 2.2.1-10 Existing Drainage Flows / Systems

B) Waterlogging Area after Rainfall

Poor drains, undulations in topography and lack of timely and proper maintenance are causing waterlogging in the project area. Hearings were carried out with residents to identify the locations. **Figure 2.2.1-11** indicates the result of the hearings (waterlogging areas).

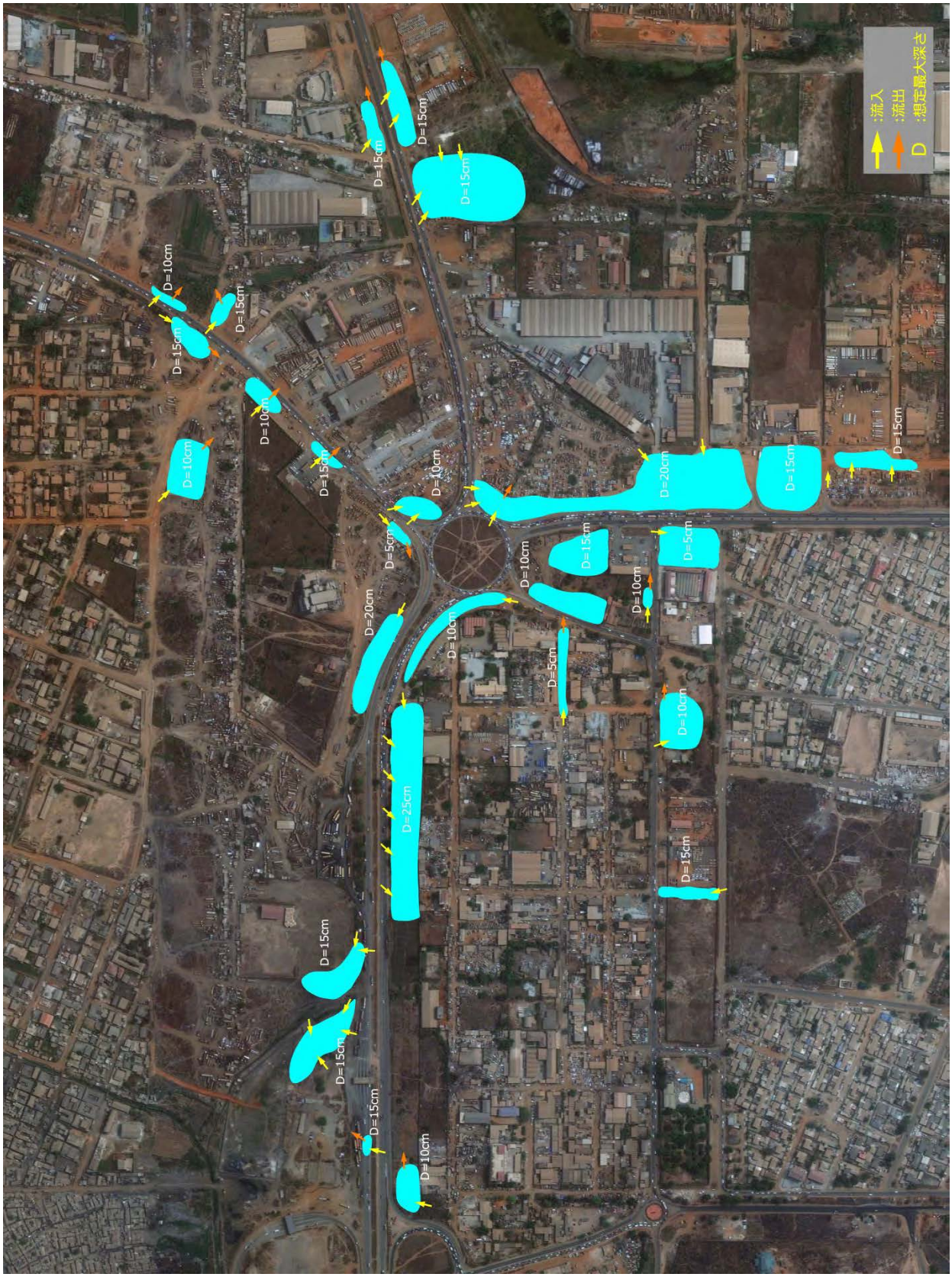


Figure 2.2.1-11 Flooded Area

2.2.1.4 Policy for Land Use

(1) Current Situation

1）Land Use of Tema

There are commercial facilities (hotels, restaurants, shops and sales of heavy machines), stock yard for containers and bus terminals. Residential facilities and schools are also densely located in southwest of Tema roundabout. In this area, many car repair shops exist. It's about 36% of the total land use of the land.

Figure 2.2.1-12 Land Use around Tema Roundabout

2）Heavy Industrial Area

Southeast of Tema roundabout is designated as Tema Heavy Industrial Area (about 50km2) and functions as a trading hub.

Figure 2.2.1-13 Heavy Industrial Area

3）Industries in Tema City

The main industrial activities of Tema City are aluminum processing, oil refining, food processing, cement manufacturing and construction material production. In addition, five quarry sites are located north at an approximate distance of 20km from Tema Roundabout.

4）Statistics of Tema Port

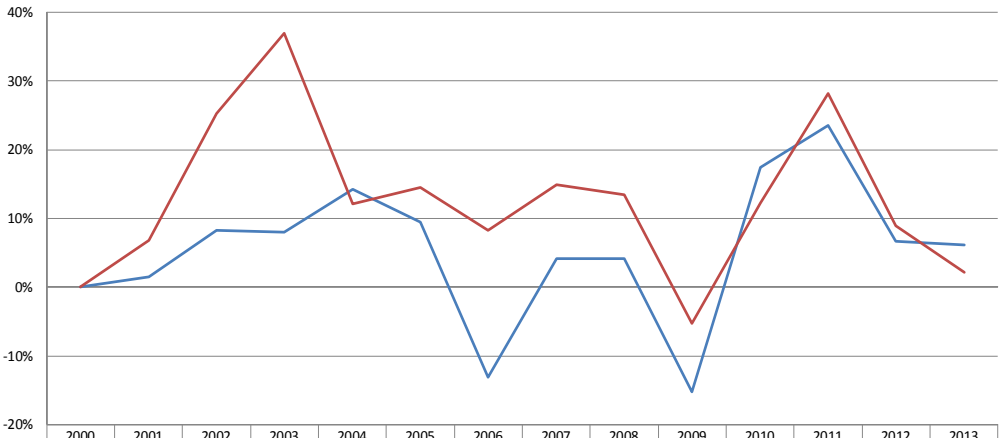
Axle load regulation was enhanced in 2009, and handling freight flows decreased at one time, but operative improvement has been performed since 2008. As a result, it has been increasing since 2010. Below are the trends between 2000 and 2013.

Table 2.2.1-22 Trends in Container Cargo Volumes in Tema Port

TEMA PORT PERFORMANCE 2000-2013

Years	Vessel call (units)	Total cargo traffic	Growth Rate of Total cargo traffic (year-on-year)	Export tonnes	Import tonnes	Transit tonnes	Transhipment tonnes	Container traffic (TEUs)	Growth Rate of Container traffic (year-on-year)
2000	1,163	6,219,517	-	910,779	5,083,439	144,973	17715	166,963	-
2001	1,169	6,314,968	2%	932,931	5,13,07	261,251	38165	178,342	7%
2002	1,272	6,841,481	8%	821,042	5,186,690	627,773	151233	223,377	25%
2003	1,172	7,391,268	8%	809,589	5,490,893	885,093	138,520	305,868	37%
2004	1,381	8,447,655	14%	1,072,006	6,403,422	764,128	71,082	342,882	12%
2005	1,643	9,249,977	9%	1,182,469	6,936,688	875,325	155,815	392,761	15%
2006	1,994	8,046,838	-13%	955,084	5,675,027	887,589	339,841	425,408	8%
2007	1,672	8,378,682	4%	1,099,094	6,120,583	843,656	119,209	489,147	15%
2008	1,568	8,727,049	4%	1,305,451	6,120,583	864,307	195,326	555,009	13%
2009	1,634	7,406,490	-15%	981,075	5,694,280	509,124	192,565	525,694	-5%
2010	1,787	8,696,951	17%	1,154,826	6,823,488	447,071	236,615	590,147	12%
2011	1667	10,748,943	24%	1,532,139	8,431,531	614,078	171,195	756,899	28%
2012	1,521	11,468,962	7%	1,477,390	9,383,462	530,457	50,403	824,238	9%
2013	1,553	12,180,615	6%	1,493,956	10,014,243	620,668	51,748	841,989	2%

Source: Ghana Ports & Harbours Authority



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Growth Rate of Total cargo traffic (year-on-year)	0	2%	8%	8%	14%	9%	-13%	4%	4%	-15%	17%	24%	7%	6%
Growth Rate of Container traffic (year-on-year)	0	7%	25%	37%	12%	15%	8%	15%	13%	-5%	12%	28%	9%	2%

Refer to "TRENDS IN TRANSPORT AND LOGISTICS ON THE TEMA-OUAGADOUGOU-BAMAKO CORRIDOR, West Africa Trade Hub Technical Report #51, USAID, May 2013".

Figure 2.2.1-14 Trends in Container Cargo Volumes in Tema Port

5）Tema Port Expansion Project

According to the "PORT OF TEMA PROJECTS: 2012 -2018" being conducted by GPHA, many projects as shown in **Table 2.2.1-23**, are completed or on-going. These projects are considered to promote much heavy traffic in near future in Tema Roundabout.

Table 2.2.1-23 Tema Port Expansion Project List

No.	Project Title	Duration
1.	Construction of Bulk Cargo Handling Jetty – Tema Port	2013 - 2014
2.	Dredging of Canoe Basin and Wreck Removal – Tema Fishing Hbr.	Completed-2013
3.	Reconstruction of Net Mending Wharf – Tema Fishing Hbr	2012 - 2013
4.	Installation of Optical Character Recognition System (OCR), Tema	2013 - 2013
5.	Purchase of Multipurpose Tug Boat & Security Patrol Boat, Tema	Arrived
6.	Purchase of Container Handling Equipment, Tema	Arrived
7.	Construction of 130-bed Maritime Hospital Tema	2012 - 2015
8.	Rehabilitation of Loading Arms at Oil Berth, Tema	Completed-2013
9.	Consultancy Services for Design of Satelite Truck Village, Ashaiman	2013 - 2013
10.	Tema Port Upgrade and Expansion	2013 - 2018
11.	Master Terminal Software Installation	2013 - 2014
12.	Coastal Fishing Ports and Fish Landing Sites	2014 - 2016
13.	Transit Truck Park (World Bank Project)	2013 - 2015
14.	Re-Modeling of Office Building for Tema Port Head Office	2013 - 2013
15.	Bathymetric and Geotechnical Investigations, Tema	2013 - 2013
16.	Building and delivering of Pilot Launch for the Port of Tema	2013 - 2013

Source: GPHA HP

(2) Basic Policy

Basic policy for the improvement of the Tema Roundabout were established based on above conditions. The project location is surrounded by residential and industrial facilities. Thus, implementation of the project shall make sure influence of the project on these facilities is minimum.

The extension of Tema Port in future is expected to increase heavy or freight vehicles. For traffic demand forecast, growth ratio shall be considered as one of the calculation parameters.

In the case that the functional points on traffic will be caused by implementation of the project, functional compensation plan shall be made by planning service roads or footbridges.

2.2.1.5 Procurement Policies

(1) Procurement of Labors

1）Labor Environment

The study on the labors required for the construction work affirmed the followings;

- There are about 10 companies in Ghana that has experience of depressed road and road improvement.
- Specialized labors for management of construction site or operation of equipment could be procured in Tema or Accra.

2）Working Conditions

The working conditions in Ghana are regulated by the labor law and are summarized as follows;

A) Basic work time

The working time in a day shift should be 8 hours per day and below 48 hours per week.
The employee working in a day shift would work during 6 A.M. to 8 P.M. and in a night shift would work from 8 P.M. to 6 A.M the next day.

B) Overtime

In the case of overtime or working on an off day, 100% allowance must be added to the basic salary. (200% in total).

C) Salary Insurance:

Under the law, salary insurance for labors is settled as "The payment for labors must prior to other debt. The payment for labors will not be affected by tender, bankruptcy and succession. On top of that, salaries must be paid immediately."

D) Bonus (13^{th} month salary)

All workers are eligible for receiving bonus (double pay) on the 12th month after working for a year. This bonus is also refered to as the 13th month salary. If within a year they work for more than a month, workers are eligible for receiving extra salary agreed upon in the contract of employment in accordance with the length of their working period.

E) Severance Wage

In the case of termination of appointment of an employee after one year of employment, employer ought to pay one month's worth of salary as a severance wage for them

3）Conclusion

From above speculations, labors including engineering work execution supervisors, skilled workers and construction equipment operators could be recruited in Tema or Accra. In addition, it is possible to undertake construction work by subletting the work to local contractors. Although contract for the construction works for the project will be made with the Japanese contractor, local resource shall be utilized by considering their capacity or experiences.

(2) Procurement of Construction Materials

Most of the material required can be locally procured excluding special materials such as bearings for approach cushion slab, admixtures for modified asphalt and water proof material.

Other material not readily available in the local markets will be procured from Japan.

(3) Procurement of Construction Equipment

Construction equipment will generally be procured locally. Market survey conducted under this project shows that most of the construction equipment that would be used are possessed by the contractors in Accra. These equipment, particularly the typical ones such as the backhoes and bulldozers are available for lease. Cranes are also readily available but extra-heavy ones are difficult to be procured.

2.2.1.6 Policy for Traffic Demand Forecast

(1) Basic Considerations

The future traffic demand was predicted by the method of multiplying the current traffic volume by the growth rate of traffic volume. The percentage increase in traffic volume was calculated separately. **Table 2.2.1-24** shows the percentage increase in traffic volume estimated in various surveys in Ghana. However, the target of estimation was the whole country, and the basis of the calculations is not clear. For Tema Roundabout it was necessary to take into consideration the change in traffic volume near the Tema Roundabout in recent years and the volume of cargo handled by Tema Port in the future. Therefore, it was decided that the numbers below be used as reference only, and to carry out a separate calculation in this survey. In calculating the growth rate in the traffic volume, first a demand forecast model was built for two type of vehicle using the toll revenue of the Accra - Tema Motorway as an explained variable. The explanatory variables were the population of the Tema region and the cargo volume handled in the port. From the demand forecast model, the traffic growth rate in the toll revenue was calculated, and this was applied as the percentage increase in the traffic volume. Note that it was considered that a more sophisticated study based on the TDC Development Plan and comprehensive plan for the roads was necessary, but as usable data was not available, a macroscopic approach was undertaken in this survey.

Also, it is anticipated that in the future cross-border traffic, mainly trucks, will increase. However, congestion at Tema Roundabout is mainly caused by traffic during the morning peak hours. During this period, the cross-border traffic is limited. In road design, the analysis is carried out for the peak hours. Therefore, in this demand prediction of cross-border traffic was not particularly taken into consideration.

Table 2.2.1-24 Percentage Increase in Traffic Volume from Past Surveys

No.	Name of Study	Year of Estimation	Estimation Method
1	Highway Network Master Plan2020(JICA, GHA,2000)	2020	Separate calculation 7.2%
2	Integrated Transport Plan for Ghana (EU, Ministry of Finance and Economic Planning, 2010.6)	2035	Separate calculation States only that the percentage increase in passengers will be 8.7%.
3	Final Report: Detailed Design of Nkwanta Yendi Road and Two Interchanges at Tema and Ashaiman Roundabout (2011?)	2035	Separate calculation (p54) 3 scenarios set. Percentage increase for each vehicle type provided for each 5 year. Passenger cars 5%-6%, Freight vehicles 3.6%-4.4%
4	Preparatory Survey on Eastern Corridor Development Project in the Republic of GHANA (JICA, MRH,2013)	2036	Separate calculation Provides estimated values for each year at representative cross-sections. Each 10 year: 1.19%, 1.51%, 1.75%
5	PPP study: Takoradi – Accra (2013)	2025	Separate calculation Passenger cars 7%, goods vehicles 7.2%

Source: JICA Survey Team

(2) Socio-economic Framework

In calculating the future traffic demand, first the socio-economic framework was set based on the available data. The set framework included the local population, and the volume of cargo handled at Tema Port. The considerations behind calculation of each of the indices were as outlined below. Note that demand forecast model using the number of vehicle registrations was also investigated, but because the correlation to the population was high, the number of vehicle registrations was not applied, but was represented by the population.

1）Population

The population framework was set using the population of the Greater Accra Region, excluding the Ga West District. This was because it was judged that the traffic volume at the Tema Roundabout has a high correlation with this region. The values for the framework as are shown in **Table 2.2.1-25**, which were set taking into consideration the values from past population census in Ghana, and the urban population of Ghana according to UN estimates.

Table 2.2.1-25 Population Framework for the District around Tema Roundabout

Year	Accra Metropolitan	Tema	Dangme West	Dangme East	Total
2000	1,658,937	506,400	96,809	93,112	2,355,258
2010	2,076,546	671,824	122,836	130,795	3,002,001
2011	2,142,129	693,042	126,716	134,926	3,096,813
2012	2,209,784	714,930	130,718	139,187	3,194,619
2013	2,279,575	737,510	134,846	143,583	3,295,515
2014	2,351,571	760,803	139,105	148,118	3,399,597
2015	2,425,841	784,831	143,498	152,796	3,506,966
2020	2,728,839	902,985	210,846	204,475	4,047,145
2025	3,011,449	1,024,140	309,802	273,634	4,619,025
2030	3,262,379	1,148,298	455,200	366,184	5,232,062
2035	3,447,302	1,272,783	668,839	490,037	5,878,961

Source: JICA Survey Team based on population census in Ghana

2）Transaction Volume at Tema Harbour Port

The central predicted values from the Ghana Master Ports Development Plan -Cargo Forecast- were adopted for the volumes of cargo that would be handled at Tema Port in the future. Marine transshipment volume, which does not affect the land traffic, was excluded. Dry bulk cargos, general cargos, container cargos, and liquid cargos were on the other hand included. **Table 2.2.1-26** shows the cargo volume handled in the past and cargos predicted to be handled in the future at the Tema Harbour Port.

Table 2.2.1-26 Volumes Handled Framework at Tema Port

Year	Volume Handled (kilo tons)
2010	8,460
2011	10,578
2012	11,419
2013	12,129
2014	15,370
2015	18,610
2020	26,350
2025	35,480
2030	44,800
2035	55,130

Source: Statistic data and Forecast by GPHA

(3) Building the Demand Forecast Model

In calculating the growth rate in the traffic volume, first a demand forecast model was built for two types of vehicles using the toll revenue of the Accra - Tema Motorway as an explained variable. The explanatory variables were the population of the Tema region, and the volume of cargos handled at Tema Port. From the demand prediction model the percentage increase in the toll revenue was calculated, and this was applied as the growth rate in the traffic volume. There were 2 types of prediction model, a passenger car model and a freight vehicle model. The model equation was a linear regression equation. **Table 2.2.1-26** shows the model parameters. For both models the coefficient of determination was high, so the applicability was good.

Table 2.2.1-26 Model Parameters

Passenger car model	**Coefficient (population)**	**Constant term ('000)**	**Coefficient of determination**
	0.74	-1481	0.99
Goods vehicle model	**Coefficient (cargo volume at port)**	**Constant term ('000)**	**Coefficient of determination**
	1.10	-1365	0.90

Source: JICA Survey Team

Table 2.2.1-27 Revenue of Toll Gate

Year	Revenue of Toll gate ('000 Cedi)
2010	8,300
2011	9,600
2012	11,000
2013	12,600
2014	14,400

Source: Ghana Road Fund

(4) Estimated Growth Rate of Traffic Volume

The future toll revenue was estimated based on the model prepared in the previous section. The average annual percentage increase for each 5 year obtained from the estimation results are shown in **Table 2.2.1-28**. Note that the values for light truck were taken to be the average of the values for passenger cars and heavy trucks, because light trucks have characteristics intermediate between the two types.

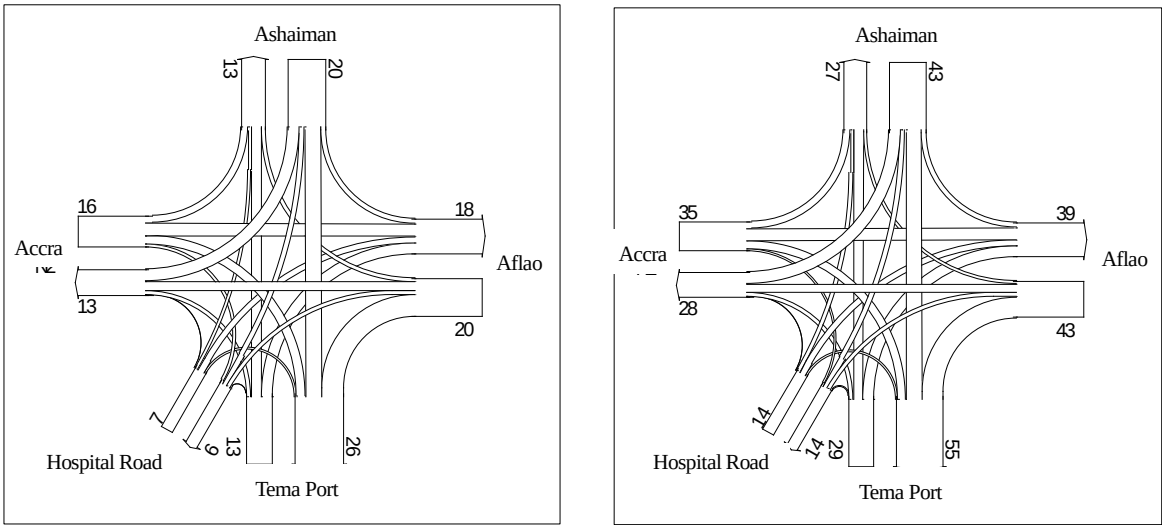
Table 2.2.1-28 Growth Rates in Traffic Volume

Period of growth rate	Passenger cars	Light trucks	Heavy trucks
2015-2020	8.52%	8.08%	7.65%
2020-2025	6.27%	6.33%	6.40%
2025-2030	5.08%	5.00%	4.93%
2030-2035	4.25%	4.30%	4.35%

Source: JICA Survey Team

(5) Results of Traffic Demand Forecast

The traffic demand was forecasted by multiplying the growth rate of the future traffic volume by the present traffic volume. The traffic volume for each direction at the peak hours was calculated as the input condition for the intersection design. Estimates were produced for 2 points in time: for the operation target year (2020), and for the planning target year (2035). The traffic volume for the total number of vehicles by each direction is shown in **Figure 2.2.1-15**. Also, traffic volumes for each vehicle type for each year are shown in **Table 2.2.1-29** and **Table 2.2.1-30**.



Unit: 100veh./h
Source: JICA Survey Team

Figure 2.2.1-15 Future Traffic Volume according to Direction at Peak Hours (2020, 2035)

Table 2.2.1-29 Traffic Volume according to Direction at Peak Hours in 2020 (vehicles per hour)

		Outflow					
MOTOR		1	2	3	4	5	Total
Inflow	1	5	20	33	42	27	127
	2	96	5	18	114	21	254
	3	17	17	8	21	18	81
	4	24	41	41	0	0	106
	5	3	27	17	3	0	50
	Total	145	110	117	180	66	618
CAR		1	2	3	4	5	Total
Inflow	1	12	191	441	205	63	912
	2	333	21	182	579	217	1332
	3	221	120	14	847	167	1369
	4	78	235	337	3	27	680
	5	21	125	256	63	2	467
	Total	665	692	1230	1697	476	4760
MINIBUS		1	2	3	4	5	Total
Inflow	1	0	138	101	147	11	397
	2	137	18	47	99	9	310
	3	105	23	2	221	17	368
	4	77	224	129	0	2	432
	5	5	14	44	21	0	84
	Total	324	417	323	488	39	1591
LARGE BUS		1	2	3	4	5	Total
Inflow	1	0	3	2	3	0	8
	2	6	5	6	8	0	25
	3	2	0	0	6	0	8
	4	3	6	2	0	0	11
	5	0	2	2	0	0	4
	Total	11	16	12	17	0	56
LIGHT TRUCK		1	2	3	4	5	Total
Inflow	1	9	9	35	19	3	75
	2	34	0	4	9	4	51
	3	41	3	0	19	9	72
	4	21	10	18	0	0	49
	5	3	3	13	3	0	22
	Total	108	25	70	50	16	269
TRUCK		1	2	3	4	5	Total
Inflow	1	1	14	23	14	0	52
	2	16	1	14	26	10	67
	3	26	1	1	20	0	48
	4	9	1	13	0	1	24
	5	3	6	12	7	0	28
	Total	55	23	63	67	11	219
TRAILER		1	2	3	4	5	Total
Inflow	1	0	4	4	6	0	14
	2	6	0	0	4	0	10
	3	23	9	0	14	1	47
	4	6	7	16	0	0	29
	5	0	0	0	0	0	0
	Total	35	20	20	24	1	100
OTHERS		1	2	3	4	5	Total
Inflow	1	0	0	20	17	29	66
	2	0	0	1	1	1	3
	3	12	0	0	14	6	32
	4	0	13	0	0	0	13
	5	0	0	7	1	0	8
	Total	12	13	28	33	36	122
All veh.		1	2	3	4	5	Total
Inflow	1	27	379	659	453	133	1651
	2	628	50	272	840	262	2052
	3	447	173	25	1162	218	2025
	4	218	537	556	3	30	1344
	5	35	177	351	98	2	663
	Total	1355	1316	1863	2556	645	7735

Source: JICA Survey Team

Table 2.2.1-30 Traffic Volume according to Direction at Peak Hours in 2035 (vehicles per hour)

		Outflow					
MOTOR		1	2	3	4	5	Total
Inflow	1	10	42	71	90	58	271
	2	206	10	39	245	45	545
	3	35	35	16	45	39	170
	4	51	87	87	0	0	225
	5	6	58	35	6	0	105
	Total	308	232	248	386	142	1316
CAR		1	2	3	4	5	Total
Inflow	1	26	409	943	438	135	1951
	2	711	45	389	1239	463	2847
	3	473	257	29	1811	357	2927
	4	167	502	721	6	58	1454
	5	45	267	547	135	3	997
	Total	1422	1480	2629	3629	1016	10176
MINIBUS		1	2	3	4	5	Total
Inflow	1	0	296	216	315	23	850
	2	293	39	100	212	19	663
	3	225	48	3	473	35	784
	4	164	479	277	0	3	923
	5	10	29	93	45	0	177
	Total	692	891	689	1045	80	3397
LARGE BUS		1	2	3	4	5	Total
Inflow	1	0	6	3	6	0	15
	2	13	10	13	16	0	52
	3	3	0	0	13	0	16
	4	6	13	3	0	0	22
	5	0	3	3	0	0	6
	Total	22	32	22	35	0	111
LIGHT TRUCK		1	2	3	4	5	Total
Inflow	1	19	19	76	41	6	161
	2	73	0	9	19	9	110
	3	88	6	0	41	19	154
	4	44	22	38	0	0	104
	5	6	6	28	6	0	46
	Total	230	53	151	107	34	575
TRUCK		1	2	3	4	5	Total
Inflow	1	3	31	50	31	0	115
	2	34	3	31	56	22	146
	3	56	3	3	43	0	105
	4	19	3	28	0	3	53
	5	6	12	25	16	0	59
	Total	118	52	137	146	25	478
TRAILER		1	2	3	4	5	Total
Inflow	1	0	9	9	12	0	30
	2	12	0	0	9	0	21
	3	50	19	0	31	3	103
	4	12	16	34	0	0	62
	5	0	0	0	0	0	0
	Total	74	44	43	52	3	216
OTHERS		1	2	3	4	5	Total
Inflow	1	0	0	43	37	62	142
	2	0	0	3	3	3	9
	3	25	0	0	31	12	68
	4	0	28	0	0	0	28
	5	0	0	16	3	0	19
	Total	25	28	62	74	77	266
All veh.		1	2	3	4	5	Total
Inflow	1	58	812	1411	970	284	3535
	2	1342	107	584	1799	561	4393
	3	955	368	51	2488	465	4327
	4	463	1150	1188	6	64	2871
	5	73	375	747	211	3	1409
	Total	2891	2812	3981	5474	1377	16535

Source: JICA Survey Team

2.2.1.7 Policies for Intersection Improvement Plan

(1) Preconditions

Preconditions for Improvement plan mentioned below have been discussed and agreed with GHA in the T/N signed in July 2016.

- Phase-1 will only include the depressed section of the east-west direction, the ramps and at-grade intersections. However, the final stage of the improvement (Phase-2) shall be considered so that implementation of Phase-2 can be made consistent with minimal recovery works.
- To accomplish the project objectives, it is necessary that the roads, nearby interchanges and other facilities be improved simultaneously with the improvement of the Tema Motorway Roundabout. For example, in the case of Tema-Akosombo Road, it might be necessary to improve the road up to Ashaiman Roundabout (about 1.5 km north of Tema Motorway Roundabout). However, the limits of improvement scope (start point and end point) will be between the points that will have tangible effect from the improvement plan.
- The objective intersection (roundabout) is composed of 5 roads. This includes the Tema-Harbour Road and Tema-Hospital Road that lie under the jurisdiction of the DUR. It is therefore necessary to explain and obtain views of the DUR on the improvement plan. Also, there are several utilities (water pipes, electricity & telecommunication cables) belonging to different companies buried within the area. Timely and proper coordination with relevant agencies will be ensured by GHA for relocation of the utilities (service lines) such that it will not affect the proposed plan.
- One way will be imposed at Tema-Hospital Road. GHA will coordinate with the DUR for the imposition.

(2) Policies of Improvement Plan

Following policies apply to the improvement of the existing roundabout.

- The fundamental type to be applied for the improvement will be a grade separated intersection,
- The plan will to the possible extent be within the existing right-of-way to minimize the area to be acquired,
- The east-west direction will be depressed and north-south direction graded. Connections will be provided through ramps,
- The facilities that are deemed difficult to be relocated will be avoided to the possible extent (minimization of relocation and resettlement),
- Grade separation will be avoided for traffics plying between Accra and Tema Harbour as the loaded trailers will have difficulty negotiating the vertical grades on the graded ramps,
- Direct access from buildings/stores will be allowed only through service roads,
- The scale of the project will be viable to be implemented under the grant assistance of Japan, in terms of technology, cost and environmental and social considerations.

(3) Methodology of the Improvement Plan

Figure 2.2.1-16 shows the procedural flow of the Study on the improvement plan.

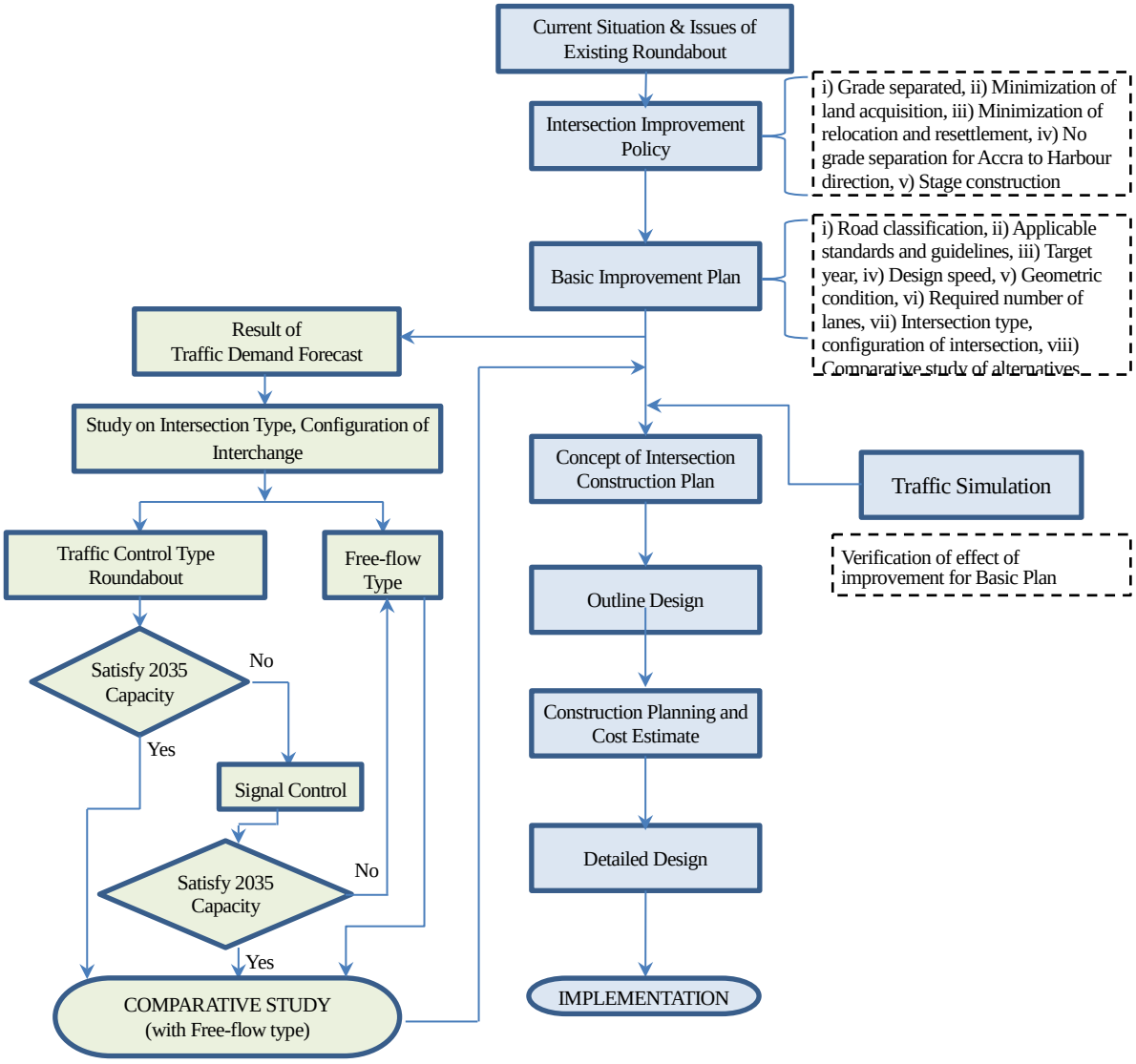


Figure 2.2.1-16 Study Flow of Improvement Plan

1) Classification of Roads

Roads from five directions merge at the objective roundabout. These roads have different classifications and the authorities responsible also vary. The functional classification of these roads in accordance with the Ghana Road Design Guideline 1991 and its responsible authority is given in **Table 2.2.1-31**. There will be no change in the classification of the roads after the improvement.

Table 2.2.1-31 Classification of Roads and Responsible Authorities

Objective Roads	Functional Classification	Responsible Authority
Accra-Tema Road	Motorway	GHA
Tema-Aflao Road* Tema-Akosombo Road*	National Highway	GHA
Tema-Harbour Road Tema-Hospital Road	Urban Road	DUR

Objective Roads	Functional Classification	Responsible Authority
*: According to GHA, these roads are also classified into motorway. However, these roads are neither access controlled nor its alignment meet the requirement.		

2) Applicable Standards and Guidelines

The improvement plan of the objective roundabout will fundamentally follow the prevailing standards and guidelines of Ghana. However, for items not covered in these standards and guidelines, other international standards and guidelines, as listed below will be referred to. This will also apply to the urban roads including bridges that the DUR is responsible for.

The above policy regarding application of standards and guidelines was discussed and agreed upon with GHA.

- Standards/Guidelines for Planning and Design of Road / Intersection

  i) Road Design Guide (GHA, March 1991)
  ii) A Policy on Design of Highways and Streets (American Association of State Highway and Transportation Officials: AASHTO, 2001)
  iii) Highway Capacity Manual (Transportation Research Board, 2010)
  iv) Japan Road Structure Ordinance June, 2015

- Standards/Guidelines for Planning and Design of Structures (Retaining Walls, Culverts etc.)

  i) Design Guideline for Retaining Wall (Japan Road Association, 2010)
  ii) Design Guideline for Culvert (Japan Road Association, 2010)

- Standards/Guidelines/Manuals for Pavement Design

  i) Pavement Design Manual (GHA, 1998)
  ii) Guide for Design of Pavement Structure (American Association of State Highway and Transportation Officials: AASHTO, 1993)
  iii) Pavement Design Guidelines (Japan Road Association, 2006)

- Guide/Guidelines for Drainage Design

  i) Road Design Guide (GHA, March 1991)
  ii) Guidelines for Drainage Design (Japan Road Association, 2006)

- Standards/Guidelines for Street Lighting Design

  i) Road Lightning Installation Guidelines and Explanation (Japan Road Association, 2007)
  ii) LED Road and Lightning Installation Guidelines [Draft] (Ministry of Land, Infrastructure, Transport and Tourism, 2011)

3）Target Year

AASHTO suggests that prediction of traffic forecast and potential development of the vicinity beyond 20 years cannot be done with any degree of accuracy due to probable changes in the general regional economy, population and land development in the area. Accordingly, the target year for design is set for 20 years.

4）Design Speeds

Design speeds of the roads that compose the roundabout based on the Ghana Road Design Guideline are as listed in **Table 2.2.1-32**.

Table 2.2.1-32 Design Speeds

Existing Road	Design Speed (km/h)	Remarks
Accra-Tema Motorway	100	For through traffics and not for those on turning lanes or ramps
Tema-Aflao Road	100	
Tema-Akosombo Road	100	
Tema-Harbour Road	80	
Tema-Hospital Road	40	
Ramps	50	

2.2.2 Basic Construction Plan

2.2.2.1 Intersection Improvement Plan

(1) Selection of Optimum Configuration

In general, two types of improvement methods can be applied for the improvement of the existing roundabout; a partial free-flow type (traffic control type) or an absolute free-flow type (junction type).

A clover type and a deformed loop type (initial concept of the GOG), the two simplest configurations among the free-flow types and a compact diamond type from partial free-flow type was selected followed by a preliminary comparative study. The result of the comparison, which recommended partial free-flow type as the optimum alternative, was explained to GHA during the IC/R Meeting. However, the preliminary comparison was based on conceptual images and limited data. GHA insisted for a more detailed comparison using actual conditions, figures including findings and information collected from discussions conducted with various stakeholders. The Survey Team repeated the comparison using the results of various engineering surveys carried out during the first and second site surveys and justified the results of the preliminary comparative study. The intersection type and the selected configuration was verified in the manner shown in **Table 2.2.2-1**.

Table 2.2.2-1 Studied / Verified Items for Intersection Improvement Plan

No.	Studied / Verified Items	Description
1	Intersection Plan for Phase-2	i) Capacity of the roundabout type will be calculated to check if it can manage the traffic of the target year ii) Capacity of the signal control type will be calculated to check if it can resolve the congestion problem iii) Detailed comparative study of configuration types that will have sufficient capacity from the above two types (traffic control type) including free-flow types will be conducted to select the optimum alternative.
2	Check of Improvement Effect by Traffic Flow Simulation	i) Reproduction of present situation ii) Simulation result for each alternative
3	Intersection Plan for Phase-1	i) Capacity limit in Phase-1 ii) Target construction area in Phase-1 iii) Traffic signal layout

(2) Intersection Improvement Plan for Phase-2

1) Traffic Control Capacity of Roundabout

The traffic control capacity of a roundabout for the case of partial free-flow type was calculated based on the method of Highway Capacity Manual 2010. The capacity was calculated for target periods 2035, 2028 and 2025. The results are shown in **Table 2.2.2-2**. The result indicates that the LOS at the roundabout will fall to F (heavily congested) as early as in the year 2020, meaning that the traffic will experience extreme congestion by 2020 and beyond. This implies provision of a roundabout will not be appropriate in resolving the issue of congestion.

Table 2.2.2-2 Traffic Control Capacity of Roundabout

Case			Simulation-01	Simulation-02	Simulation-03
Completion year			2035	2028	2020
Check	Degree of saturation	Eastbound	19.96	6.19	2.17
		Westbound	11.47	5.79	3.11
		Northbound	2.47	1.23	0.69
		Southbound	15.52	5.11	2.14
	LOS	Eastbound	F	F	F
		Westbound	F	F	F
		Northbound	F	F	D
		Southbound	F	F	F
		Intersection	F	F	F

2) Traffic Control Capacity of Signalized Intersection

Next, traffic control capacity of a signalized intersection for the partial free-flow type was analyzed, in the similar manner as to the roundabout. Analysis results are summarized in **Table 2.2.2-3**. The row highlighted in red is the LOS at the intersection. The results indicate that the LOS B during off-peak hours and LOS D during peak hours can be achieved in the year 2035 if the number of turning lanes as shown in **Figure 2.2.2-1** is provided and the effective green light time of the traffic signal is set in the manner shown in **Table 2.2.2-3**.

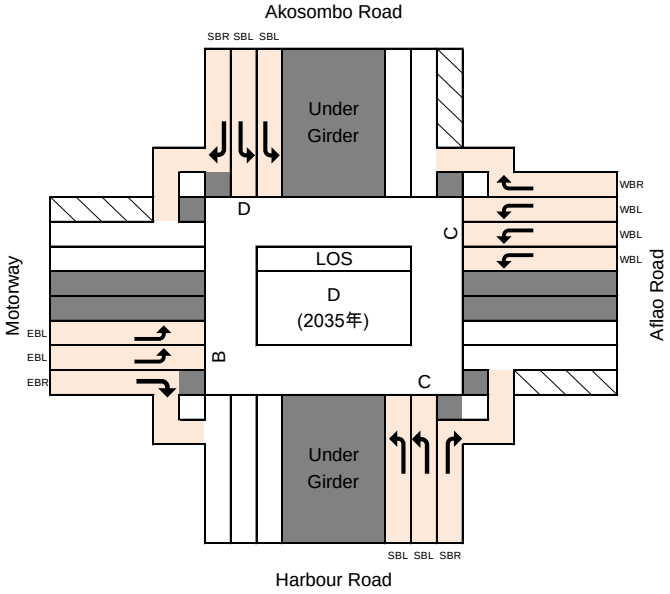


Figure 2.2.2-1 Lanes and LOS of Signalized Intersection of Partial Free-Flow Type in Phase-2

Table 2.2.2-3 Capacity Analysis of Signalized Intersection in Phase-2

Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	812		0	2953	0		536		0	584		0

Signal Information										
Cycle, s	75.0	Reference Phase	2							
Offset, s	0	Reference Point	End							
Uncoordinated	Yes	Simult. Gap E/W	On	Green	0.0	41.0	0.0	0.0	22.0	0.0
Force Mode	Fixed	Simult. Gap N/S	On	Yellow	0.0	4.0	4.0	4.0	4.0	4.0
				Red	0.0	2.0	1.0	1.0	2.0	1.0

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	3	8	7	4
Case Number	1.3	3.0	1.2	4.0	1.2	3.0	1.3	3.0
Phase Duration, s	47.0	0.0	47.0	0.0	28.0	0.0	28.0	0.0
Change Period, ($Y+R_c$), s	6.0	6.0	6.0	0.0	6.0	5.0	5.0	5.0
Max Allow Headway (*MAH*), s	2.1	0.0	2.1	0.0	2.1	0.0	2.1	0.0
Queue Clearance Time (g_s), s	14.0		43.0		14.0		10.4	
Green Extension Time (g_e), s	0.9	0.0	0.0	0.0	0.5	0.0	0.6	0.0
Phase Call Probability	1.00		1.00		1.00		1.00	
Max Out Probability	0.00		1.00		0.00		0.00	

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5		12	1	6		3		18	7		14
Adjusted Flow Rate (*v*), veh/h	829		0	3013	0		547		0	596		0
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1658		1438	1673	1900		1627		1519	1627		1548
Queue Service Time (g_s), s	12.0		0.0	41.0	0.0		12.0		0.0	8.4		0.0
Cycle Queue Clearance Time (g_c), s	12.0		0.0	41.0	0.0		12.0		0.0	8.4		0.0
Capacity (*c*), veh/h	2004		423	3029	3		1146		832	1190		848
Volume-to-Capacity Ratio (*X*)	0.413		0.000	0.995	0.000		0.477		0.000	0.501		0.000
Available Capacity (c_a), veh/h	9377		3313	3029	1316		1320		6738	6304		3527
Back of Queue (*Q*), veh/ln (95th percentile)	11.5		0.0	32.2	0.0		8.9		0.0	9.0		0.0
Overflow Queue (Q_3), veh/ln	0.0		0.0	0.0	0.0		0.0		0.0	0.0		0.0
Queue Storage Ratio (*RQ*) (95th percentile)	1.83		0.00	5.10	0.00		1.44		0.00	1.46		0.00
Uniform Delay (d_1), s/veh	17.4		0.0	32.4	0.0		29.3		0.0	25.8		0.0
Incremental Delay (d_2), s/veh	0.1		0.0	15.1	0.0		0.1		0.0	0.1		0.0
Initial Queue Delay (d_3), s/veh	0.0		0.0	0.0	0.0		0.0		0.0	0.0		0.0
Control Delay (*d*), s/veh	17.5		0.0	47.4	0.0		29.4		0.0	25.9		0.0
Level of Service (LOS)	B			D			C			C		
Approach Delay, s/veh / LOS	17.5	B		47.4	D		29.4	C		25.9	C	
Intersection Delay, s/veh / LOS	37.9						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	3.2	C	2.8	C	2.9	C	2.9	C
Bicycle LOS Score / LOS		F	5.5	F		F		F

 HCS 2010™ Streets Version 6.3 Generated: 7/7/2015 10:36:56 PM

3）Comparative Study of Alternatives

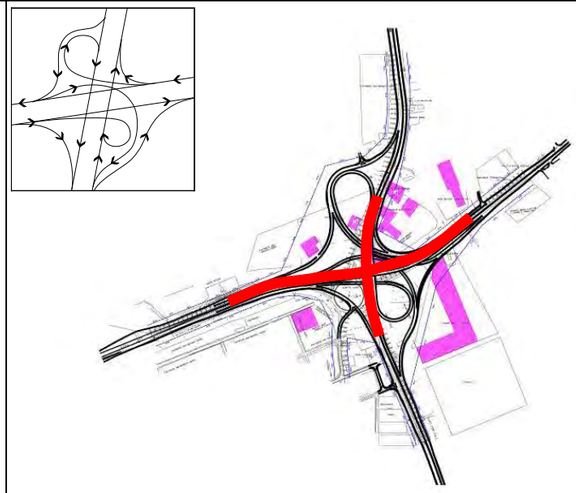
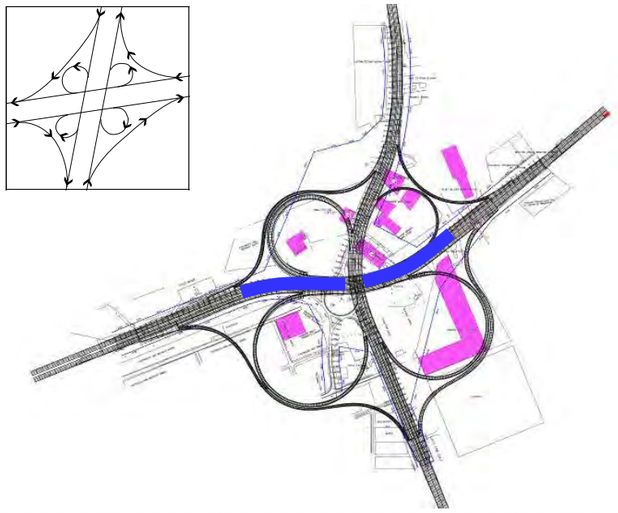
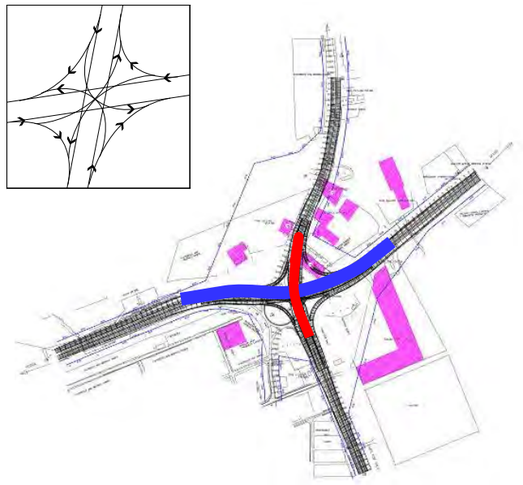
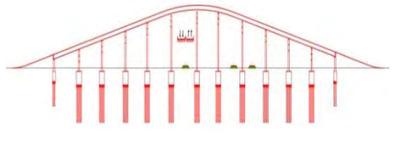
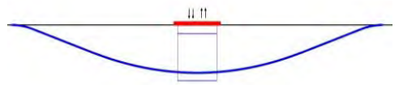
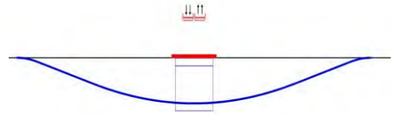
The alternatives undertaken for the comparative study are as mentioned in **Table 2.2.2-4**.

Table 2.2.2-4 Alternatives for Comparison and Reasons for its Selection

No.	Alternatives	Configuration	Selection Reason
1	Existing Plan (GOG Free-Flow Type)	Deformed Loop	It is the configuration type proposed in the Feasibility Study by a third country consultant and well accepted by GHA.
2	Free-Flow Type	Clover-leaf	It is the only possible free-flow configuration for a two-layer grade separated alternative
3	Consultant Recommended Type	Compact Diamond	It is the configuration that guarantees the required traffic functions while considerations to cost, environmental impact and stage construction is given.

The comparative study of the above alternatives is summarized in **Table 2.2.2-5**. Based on the result and after discussion with and agreement of GHA, the Compact Diamond Type (consultant recommended type) was selected and applied in the project.

Table 2.2.2-5 Comparative Study of Intersection Configuration

Evaluation Criteria		EXISTING PLAN (GOG PLAN) Deformed Loop Type		FREE-FLOW TYPE Clover Leaf Type		CONSULTANT RECOMMENDED TYPE Compact Diamond Type	
PLAN OUTLINE							
Profile Outline of East-west Direction (Abidjan-Lagos Corridor)							
Traffic Function	1. Configuration Outline	・ Free-flow 3-tier grade separated ・ Both vertical and adjacent loops are non-symmetrical and are generally suitable for junctions where traffic volume is high. Small curves, many conflict points steep vertical grades, huge land acquisition, high construction cost etc. It is also confusing as the intended and actual drive direction is different as well as combined weaving of merging and diverging traffics exists.		・ Free-flow 2-tier grade separated ・ Typical type for a 4-leg graded intersection and is suitable for interchanges of high standard highways. ・ Weaving lengths provided separately for merging and diverging traffics, conventional driving type and thus drivability is high		・ Partial free-flow 3-tier grade separated ・ Typical type for a 4-leg graded intersection and is suitable for interchanges of high standard highways. ・ Left turning vehicles converge at one point at the intersection making the intersection symmetrical and enhance easy, comfortable and safe driving.	
	2. Travel Length/Time	・ The loops and other ramps have small radius of curvature and are lengthy. Grades of loop ramps are high for being a 3-tier structure and may cause travel difficulty for heavy vehicles.		・ The loops and other ramps have small radius of curvature and are the longest. However, grades of loop ramps are moderate for being a 2-tier structure		・ Operational under conventional driving, symmetrical and travel distance is least.	
	3. Level of Service (LOS)	・ Level of service is high as there is no conflict of ramps.		・ Level of service is high as there is no conflict of ramps.		・ Conflict of ramps exists and thus LOS is less than other alternatives. However, traffic can be effectively , efficiently and safely controlled using traffic signals	
	4. Access to Abutting Properties	・ Utilize substantially huge land and to secure proper connectivity with the existing road network and access from abutting properties, large scale improvement will be required		・ Access from abutting at all quarters can be maintained but improvement will be required for securing connectivity with existing road network also.		・ Utilize limited land and large scale improvement is not required to secure proper connectivity with the existing road network and access from abutting properties	
	5. Pedestrian Convenience	・ The interval of cross points is long as the graded section is long. Walking distance is long even if the crossings are provided underneath the graded section.		・ The interval of cross points is short as the span of graded section is short. Provision is possible inside the ramp also.		・ Similar to 'Deformed Loop Type'	
Economic	1. Facility Scale/Cost	・ Total length of graded section : 2.900 m (2^{nd} tier : 950m, 3^{rd} tier :1,950m) ・ Ramp Length : 5,723 m	Estimated Cost : 16.0 Billion JPY	・ Depressed Section Length : 640 m ・ Ramp Length : 7,760 m	Estimated Cost : 7.0 Billion JPY	・ Depressed Section Length : 640 m ・ 2-tier graded section Length : 550 m ・ Ramp Length : 5,152 m	Estimated Cost : 9.0 Billion JPY (Phase 1:6.0 Bil. Phase 2: 3.0 Bil.)
	2. Traffic Obstacles during Construction	・ Controllable by providing a detour and its shifting. Requires long period ・ Difficulty adapting stage construction		・ Shifting of traffic is easy and the period is short ・ Difficulty adapting stage construction		・ Controllable by providing a detour and its shifting. Requires long period ・ Adaptation of stage construction is possible	
	3. Land Acquisition	・ Land Acquisition :297,840m2 ・ Outside ROW : 5,890m2	Large	・ Land Acquisition : 751,020 m2 ・ Outside ROW : 292,900 m2	Extreme	・ Land Acquisition : 146,140m2 ・ Outside ROW : 0m2	Medium
	4. Removal of Obstacles	・ Gas Station: 3 nos., Major facilities: 1 no., Houses: approx. 120 nos. ・ Obstacles (5,050m)	Plenty	・ Gas Station: 3 nos., Major Facilities: 5 nos., Houses: approx. 200 nos. ・ Obstacles (15,000m)	Plenty	・ Gas Station: 2 nos., Major Facilities: 0, Houses: approx. 30nos. ・ Obstacles (2,700m)	Medium
	5. O & M Cost	・ 2^{nd} tier and 3^{rd} tier graded section and long distance ramps	Huge	・ 2^{nd} tier graded section and long distance ramps	Small	・ Depressed section and 2^{nd} tier graded section and signalized intersection	Medium
Environment	1. Land Acquisition, Resettlement	・ Huge land, large buildings/structures and access from abutting properties are issues but possible within the existing ROW	Fairly low	・ Requires huge land and construction within existing ROW is difficult. Therefore high land acquisition cost	Low	・ Acquisition of land is minimum and construction can be within existing ROW	High
	2. Traffic Limitations during Construction	・ Conflict occurs during construction of loop ramps		・ Conflict occurs during construction of loop ramps		・ Traffic control during construction done by provision of roundabout within existing ROW	
Construction	1. Adaptability of Stage wise Construction	・ Complete construction desirable as it functions only after all directions are open to traffic as it has a 2-tier graded structure in combination with loop ramps		・ Temporary operation by providing at-grade intersection at connecting points of loop ramps. However, it will have two close signalized intersection, which is not appropriate from safety point of view,. Therefore, complete construction is desirable.		・ As the configuration consists of an at-grade intersection, stage construction in each direction is possible. The outcome (functionality) can be expected even when a particular direction is completed.	
	2. period	35 months		28 months		30 months (Phase1 : 26 months , Phase 2 : 24 months)	
Evaluation/Feasibility to be undertaken by Japanese Grant Aid Scheme		Requires huge land acquisition and removal of large numbers of obstacles and big scale structures. In addition construction cost is highest. Not feasible under Japanese Grant Aid Scheme	×	Requires huge land acquisition and removal of large numbers of obstacles and lots of big scale structures. Not feasible under Japanese Grant Aid Scheme.	△	Land acquisition is minimum and the plan is feasible to be constructed within the existing ROW. Number of obstacles to be removed is least. Feasible under Japanese Grant Aid Scheme, given that stage construction is applied	○

(3) Traffic Flow Simulation

1) Basic Policy

Traffic behavior after improvement of the intersection may be complicated because the turning traffics will meet at the intersection using the on/off ramps. Whether the improvement meets the expected project outcome needs to be checked and verified accordingly. A traffic flow simulation will be carried out to examine the outcome of the project.

2) Objective and Methodology

The objective of traffic flow simulation is to visually check the effect of improvement in the future. For traffic flow simulation, specific computer software is used to simulate dynamic traffic behavior. Result of the traffic survey and future traffic demand is used as input for the analysis.

3) Simulation Result

Simulation results indicate that the intersection type (compacted diamond type) applied was totally capable to manage the vehicles in the intersection during single green light phase even in year 2035. The LOS calculated for year 2035 was 'D', which means the intersection will experience gradual congestion after year 2035.

Figure 2.2.2-2 3-tier with At-grade Signal Controlled Intersection (Compact Diamond Type)

(4) Intersection Plan for Phase-1

1) Traffic Control Capacity of the Intersection

Capacity analysis of the intersection during Phase-1 was analyzed for partial free-flow type based on the method recommended in the Highway Capacity Manual 2010 in the similar manner to that of Phase-2. The results indicate that LOS 'D' during off-peak hours can be achieved if the number of turning lanes shown in **Figure 2.2.2-3** and the effective green light time in **Table 2.2.2-6** are provided.

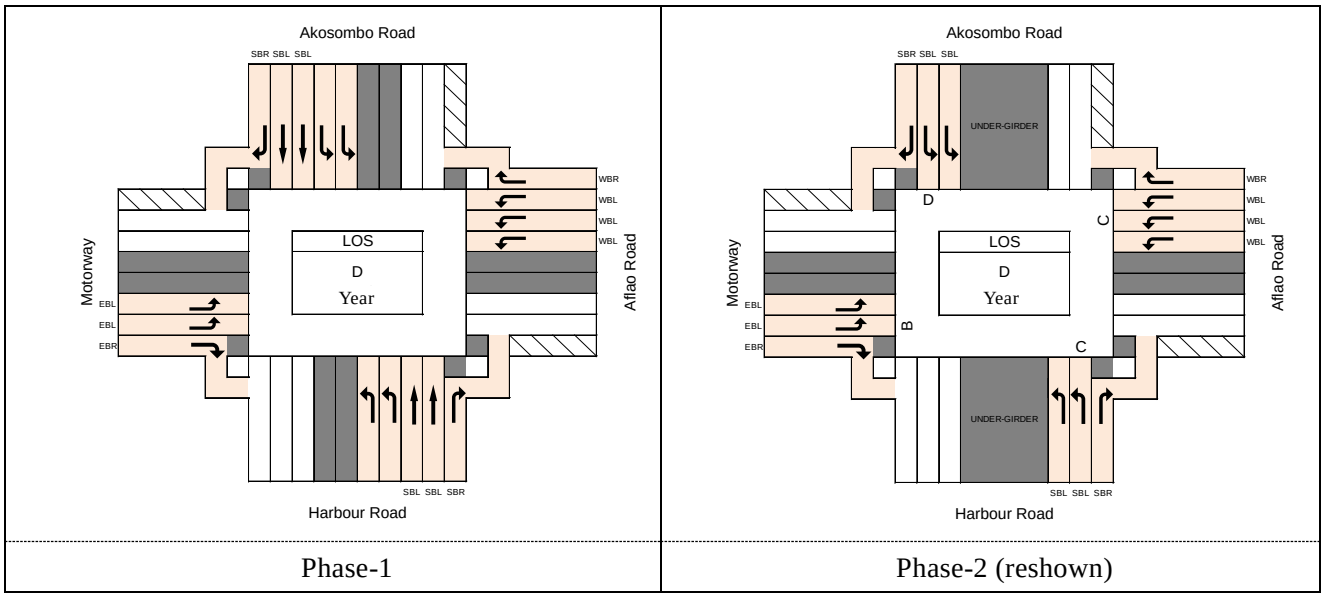


Figure 2.2.2-3 Lanes and LOS of Signalized Intersection of Partial Free-Flow Type

Table 2.2.2-6 Capacity Limit in Phase-1

Year	Hourly volume to be operated in Phase-1 during peak hour (Veh/h)	LOS
2020	3953	C
2023	**4785**	**D**
2024	5063	E
2025	5340	F

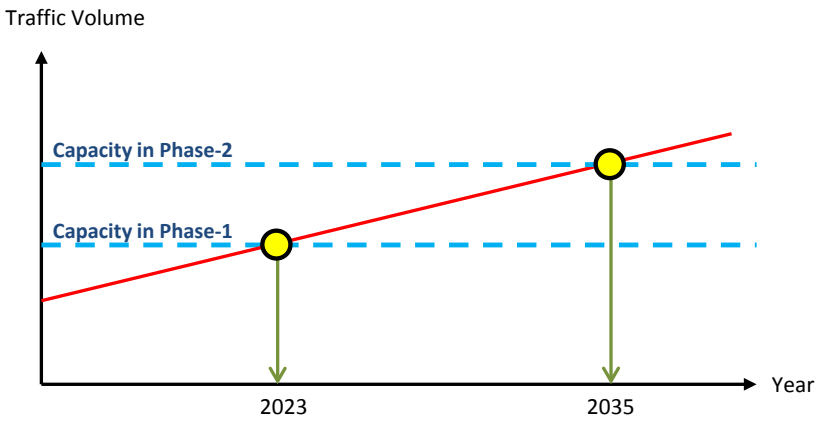


Figure 2.2.2-4 Basic Consideration on Stage Construction

Table 2.2.2-7 Analysis Result of Signalized Intersection in Phase-1

Demand Information	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Demand (*v*), veh/h	459		0	1670		0	303	687		327	1339	

Signal Information										
Cycle, s	105.5	Reference Phase	2							
Offset, s	0	Reference Point	End							
Uncoordinated	Yes	Simult. Gap E/W	On	Green	17.4	9.6	0.0	24.1	15.4	9.0
Force Mode	Fixed	Simult. Gap N/S	On	Yellow	4.0	4.0	4.0	4.0	4.0	4.0
				Red	2.0	2.0	2.0	2.0	2.0	2.0

Timer Results	EBL	EBT	WBL	WBT	NBL	NBT	SBL	SBT
Assigned Phase	5	2	1	6	7	4	3	8
Case Number	1.1	3.0	1.1	3.0	2.0	4.0	2.0	4.0
Phase Duration, s	23.4	0.0	39.0	15.6	15.0	30.1	36.4	51.5
Change Period, ($Y+R_c$), s	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Max Allow Headway (*MAH*), s	2.1	0.0	2.1	0.0	2.1	2.0	2.1	2.0
Queue Clearance Time (g_s), s	16.8		33.4		11.0	23.3	12.1	43.8
Green Extension Time (g_e), s	0.5	0.0	0.0	0.0	0.0	0.7	0.0	1.5
Phase Call Probability	1.00		1.00		1.00	1.00	1.00	1.00
Max Out Probability	0.00		1.00		1.00	0.00	1.00	0.00

Movement Group Results	EB			WB			NB			SB		
Approach Movement	L	T	R	L	T	R	L	T	R	L	T	R
Assigned Movement	5		12	1		16	7	4		3	8	
Adjusted Flow Rate (*v*), veh/h	468		0	1704		0	309	701		334	1366	
Adjusted Saturation Flow Rate (*s*), veh/h/ln	1658		1438	1673		1519	1627	1723		1627	1706	
Queue Service Time (g_s), s	14.8		0.0	31.4		0.0	9.0	21.3		10.1	41.8	
Cycle Queue Clearance Time (g_c), s	14.8		0.0	31.4		0.0	9.0	21.3		10.1	41.8	
Capacity (*c*), veh/h	686		1	1771		137	277	789		939	1476	
Volume-to-Capacity Ratio (*X*)	0.683		0.000	0.962		0.000	1.116	0.888		0.355	0.926	
Available Capacity (c_a), veh/h	5124		381	1771		201	277	3128		939	3099	
Back of Queue (*Q*), veh/ln (95th percentile)	10.8		0.0	22.8		0.0	12.2	15.2		7.8	26.5	
Overflow Queue (Q_3), veh/ln	0.0		0.0	0.0		0.0	0.0	0.0		0.0	0.0	
Queue Storage Ratio (*RQ*) (95th percentile)	1.73		0.00	3.61		0.00	1.98	2.41		1.27	4.24	
Uniform Delay (d_1), s/veh	48.6		0.0	37.4		0.0	51.4	47.5		38.6	43.6	
Incremental Delay (d_2), s/veh	0.5		0.0	13.4		0.0	89.0	1.4		0.1	1.2	
Initial Queue Delay (d_3), s/veh	0.0		0.0	0.0		0.0	0.0	0.0		0.0	0.0	
Control Delay (*d*), s/veh	49.1		0.0	50.9		0.0	140.4	48.9		38.7	44.7	
Level of Service (LOS)	D			D			F	D		D	D	
Approach Delay, s/veh / LOS	49.1	D		50.9	D		76.9	E		43.6	D	
Intersection Delay, s/veh / LOS	53.5						D					

Multimodal Results	EB		WB		NB		SB	
Pedestrian LOS Score / LOS	3.3	C	3.0	C	3.0	C	2.9	C
Bicycle LOS Score / LOS		F		F	1.3	A	1.9	A

2） Target Construction Area in Phase-1

In accordance with the planning policies mentioned in the preceding section, target construction area in phase-1 shall be determined in the following manner.

- Shape and ROW for intersection shall not be changed from Phase-1 to Phase-2 to minimize rework by removal or relocation of road facilities.
- Since the signalized intersection in Phase-1 is not capable of controlling the right-turn vehicle, exclusive right-turn lane(s) for Phase-2 shall be constructed and used during Phase-1 stage of the project.
- Construction of ramps of Phase-2 is required to be done during Phase-1 of the project because the ramps have an important function to connect the two crossing roads. Therefore, all ramps shall be completed during Phase-1.

3） Traffic Signal Layout Plan

A) Typical Layout of Traffic Signal on National Roads in Ghana

In general, traffic signals on national roads of Ghana are provided with a LED (Light Emitting Diode) type lamps. **Figure 2.2.2-5** shows typical layout of traffic signals on national roads. Generally, standing type traffic signals (single pole) are installed in inflow (entry) side and lamps with overhang beam are installed in outflow (exit) side.

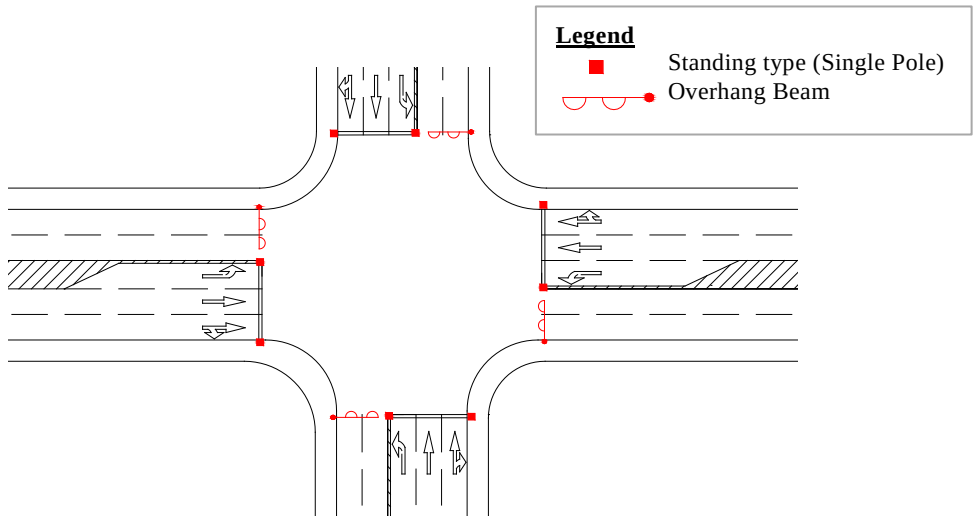


Figure 2.2.2-5 Typical Layout of Existing Traffic Signals on National Roads in Ghana

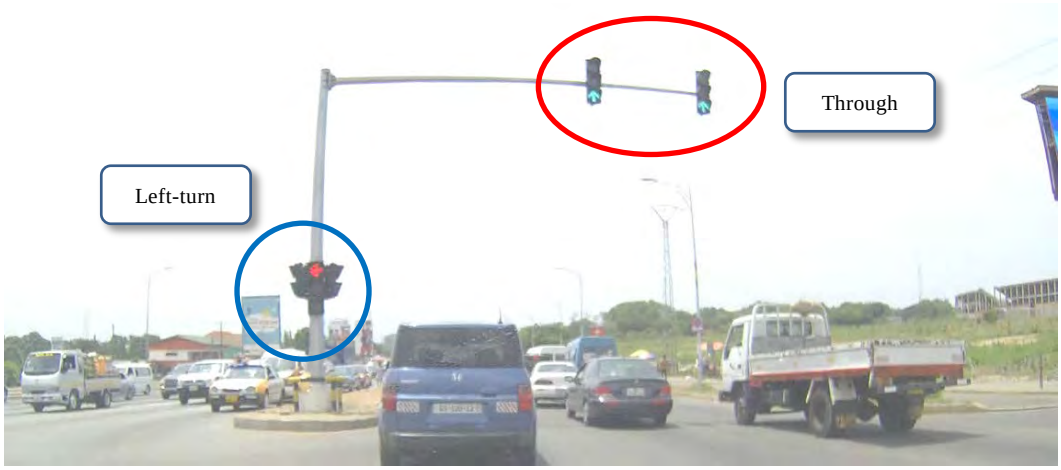


Figure 2.2.2-6 Current Situation (1)

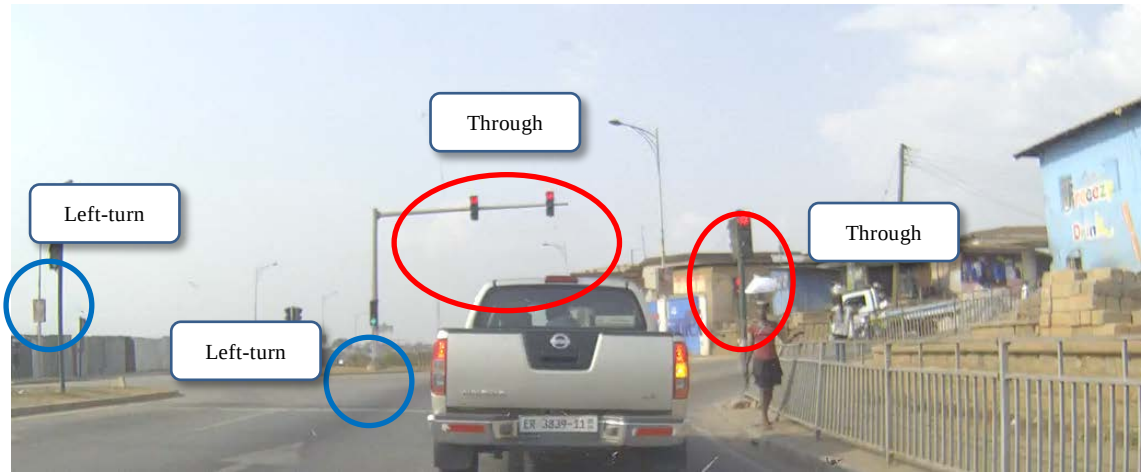


Figure 2.2.2-7 Current Situation (2)

B) Policies on Traffic Signal Layout

Traffic signal layout shall correspond to typical layout on national roads in Ghana. In the case of installation of traffic signal on a wide road, gate (gantry) type is generally used instead of single pole overhang beam (cantilever) type. Although ROW of intersection remains unchanged regardless of the phases, removal and relocation will be required because traffic operation patterns during Phase-1 and Phase-2 will vary and not be similar. To minimize the removal and relocation work, single pole shall be basically applied as much as possible instead of gate (gantry) type.

C) Traffic Signal Wiring System

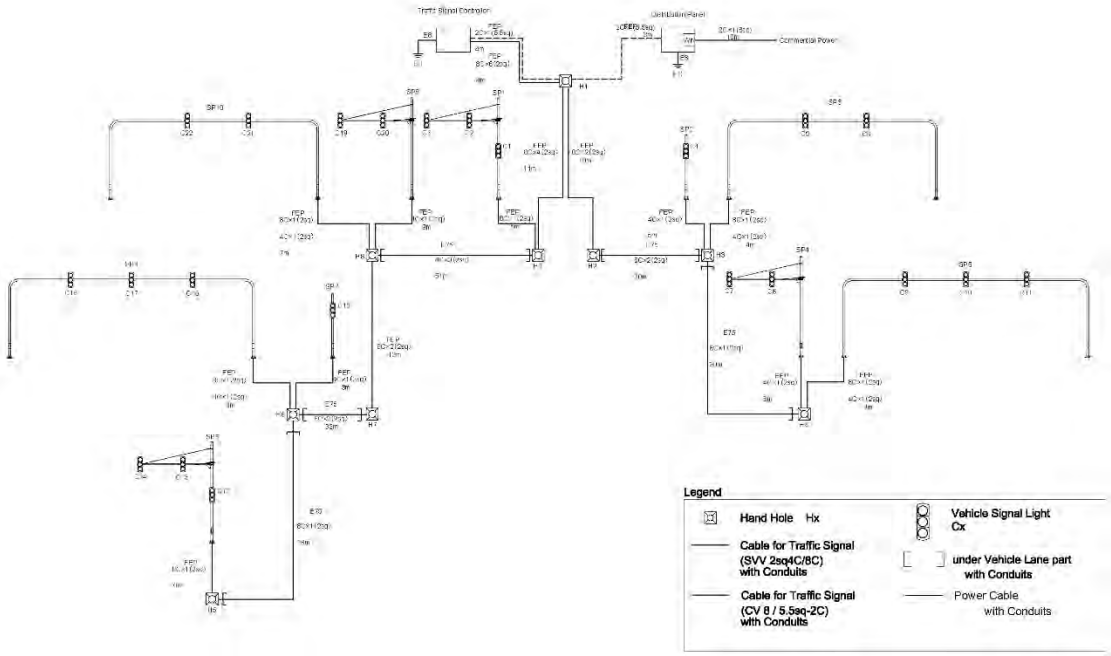


Figure 2.2.2-8 Traffic Signal Wiring System in Phase-1

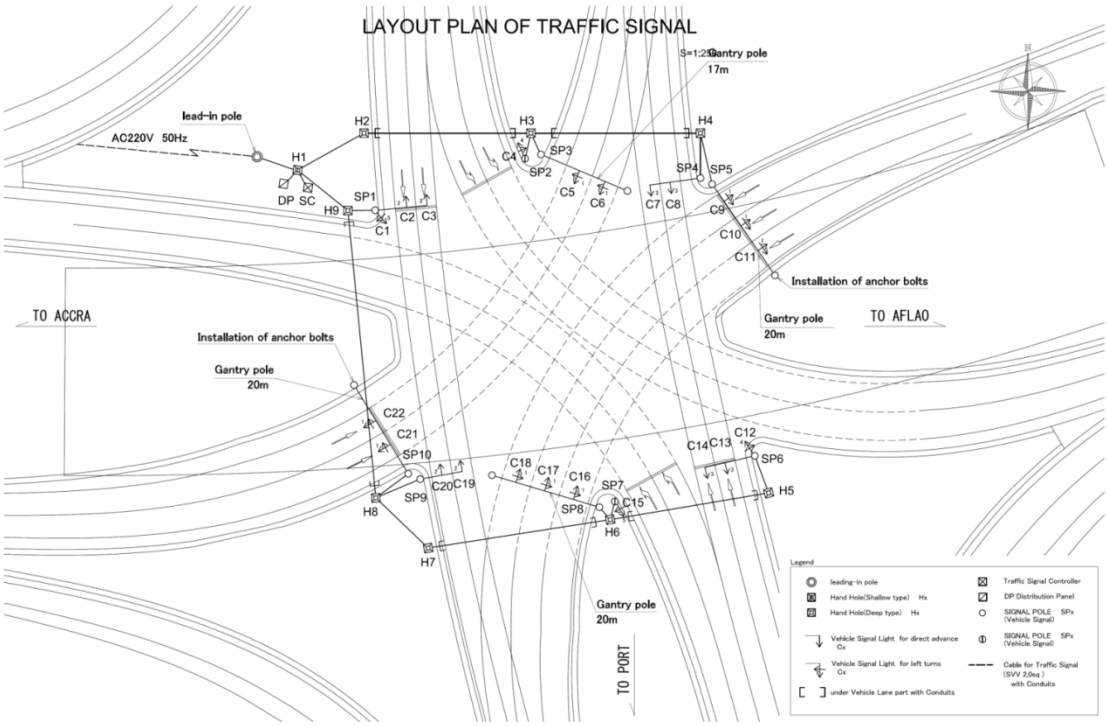


Figure 2.2.2-9 Traffic Signal Layout Plan in Phase-1

(5) Intersection Improvement Plan

Figure 2.2.2-10 shows the intersection improvement plan for Phase-1.

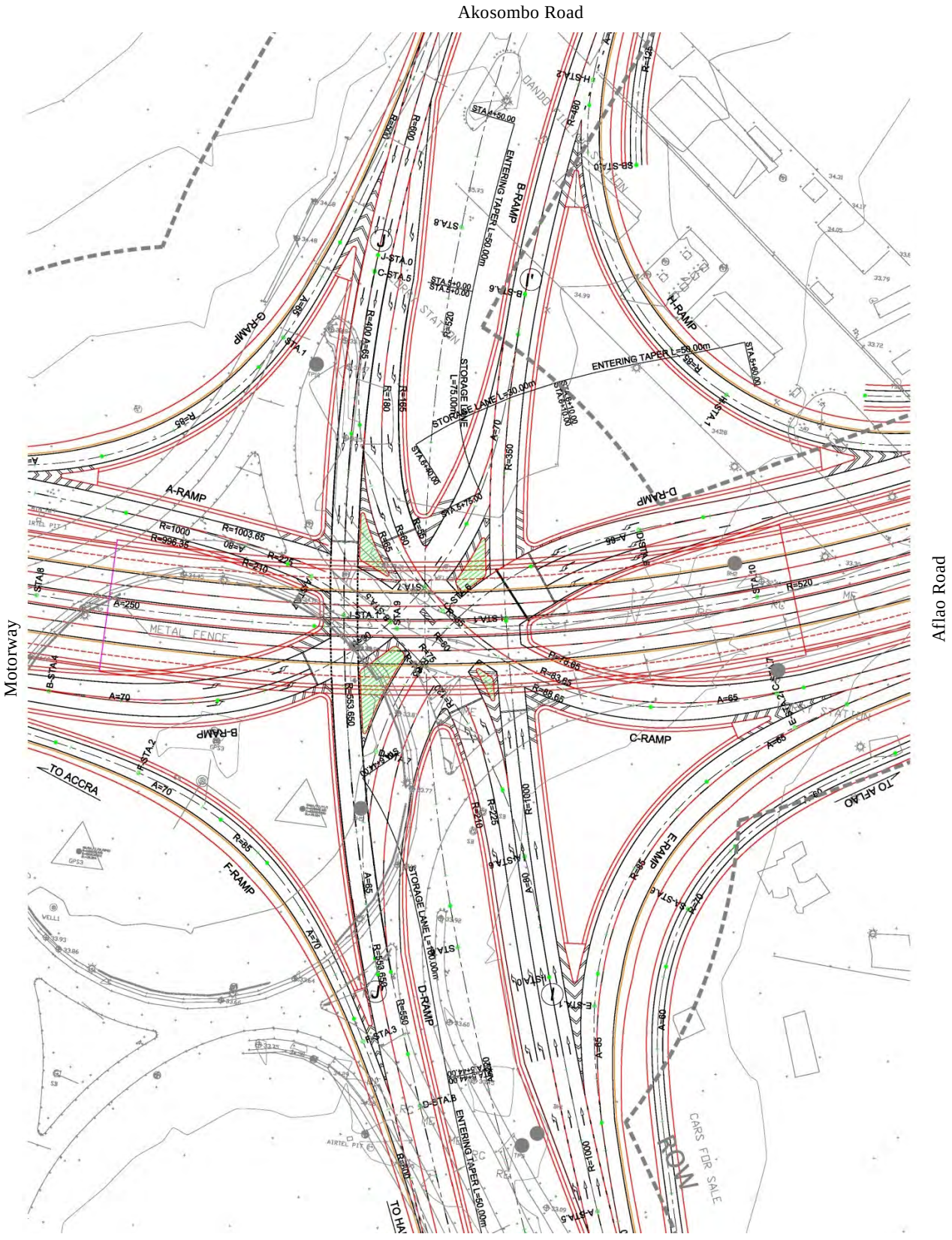


Figure 2.2.2-10 Intersection Plan in Phase-1

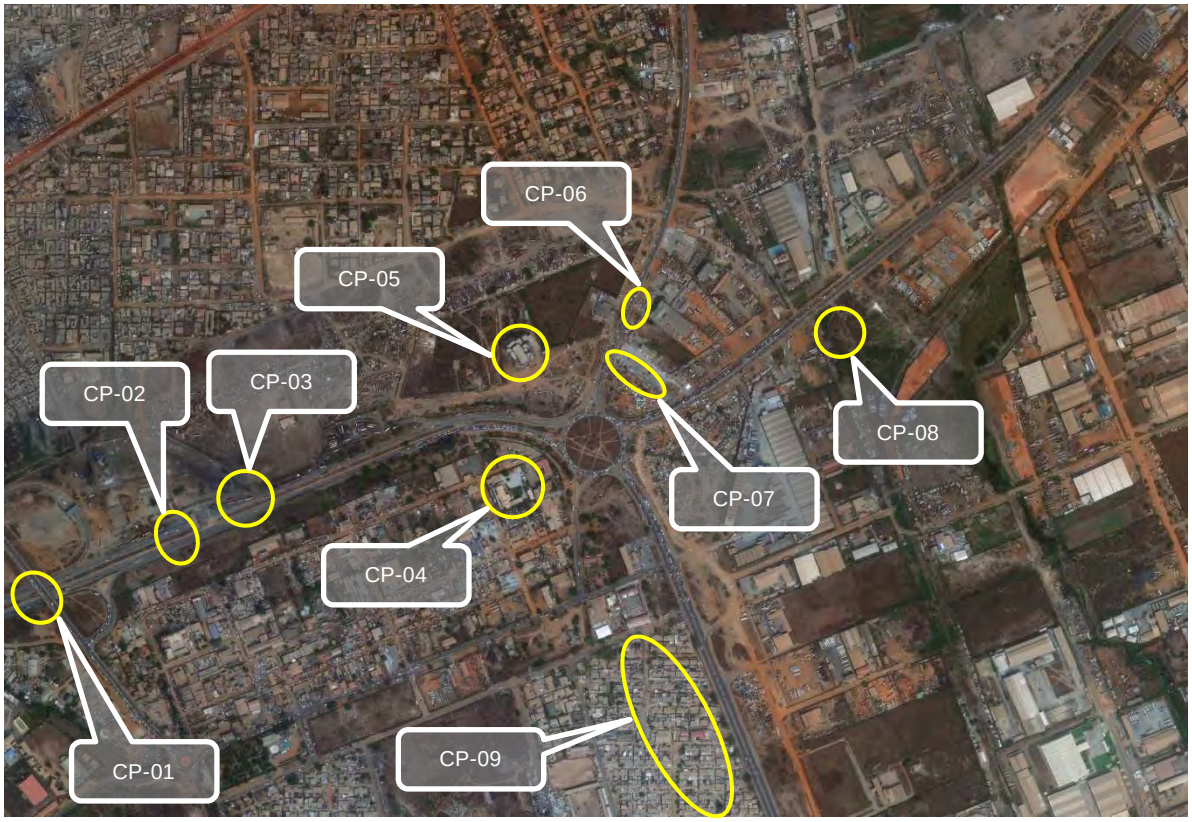
2.2.2.2 Road Plan

(1) Control Points

Control points taken into consideration for delineation of horizontal and vertical alignments are shown in the aerial photo, while the measures taken for each of these control points are listed up in **Table 2.2.2-8**.

Table 2.2.2-8 Control Points

Locations of Control Points



No.	Control Points	Measures
CP-01	Bridge of Ashaiman Interchange	Completely avoided
CP-02	Toll Gate on Motorway	Completely avoided
CP-03	Flow End of Drainage	Set as control point for vertical alignment
CP-04	Hotel	Completely avoided
CP-05	Complex under Construction	Completely avoided
CP-06	4-story Shopping Center	Completely avoided
CP-07	Fuel Station	Avoided to the possible extent
CP-08	Flow End of Drainage	Set as control point for vertical alignment
CP-09	Residential Area along Harbour Road	Avoided to the possible extent

(2) Right of Way (ROW)

Figure 2.2.2-11 illustrates the ROW of each road at Tema Roundabout in accordance with the information made available by GHA and DUR.

Figure 2.2.2-11 Existing Road Reserve (ROW) of Each Road at Tema Roundabout

(3) Geometric Conditions/Parameters

The classifications of roads are shown in **Table 2.2.2-9** and the geometric conditions to be applied for each objective road are summarized in **Table 2.2.2-10**. It has been agreed with GHA that excepting the Harbour Road and Tema-Hospital Road, the design speed of all other roads will be 100km/h. The design speed of the Tema- Harbour Road and Tema-Hospital Road will be 80km/ and 50 km/h respectively.

Table 2.2.2-9 Classification of Roads

Objective Roads	Functional Classification
Accra-Tema Road	Motorway
Tema-Aflao Road* Tema-Akosombo Road*	National Highway
Tema-Harbour Road Tema-Hospital Road	Urban Road

Table 2.2.2-10 Geometric Conditions

Standards and Geometric Conditions (Ghana Roads Design Guideline)

HIGHWAY / ROAD CLASSIFICATION			Motorway	National	Inter-regional	Urban
GENERAL						
Min. Design Speed (km/hr)	Flat Terrain (inside bracket for urban area)		120 (100)	100 (80)	80 (60)	80 (60)
	Rolling Terrain (inside bracket for urban area)		100 (80)	80 (60)	60 (40)	60 (40)
	Mountenous (inside bracket for urban area)		80 (60)	60 (40)	50 (30)	50 (30)
Level of Service			B	C	C	D
CROSS-SECTION ELEMENTS						
Road Cross Section Width	ROW Width (m)	Urban	90	90	60	-
	Min. Median (m)	Rural	10	10	2- 4	4
		Urban	2- 4	2- 4	2- 4	2- 4
	Median Shoulder		0.5-0.75	0.3 - 0.5	0.3 - 0.5	0.3 - 0.5
	Vehicle Lane	Flat/Rolling	3.65	3.65-3.25	3.65 - 3.25	3.65-3.25
		Mountenous	3.50	3.5-3.25	3.5 - 3.0	
	Ramp width (m)		3.65 - 3.5	-		
	Right Shoulder (m)	Flat/Rolling	3.00	2.50	2.50	2.0 - 3.0
		Mountenous	3.00	3.00	2.00	-
VERTICAL ELEVATION CONTROLS						
Minimum Vertical Clearance (m)	Carriageway		5.5	5.5	5.5	5.5
	Sidewalk		2.5	2.5	2.5	2.5
TRAFFIC VOLUME						
Design Traffic Volume (ADT)			>10,000	>10,000	3,000-10,000	<150
STRUCTURE LOADING						
Structure Live Loading (Minimum)			BS 5400 or Equivalent (B-load Japan)			
PAVEMENT STRUCTURE						
Pavement	Surface Type		Flexible Pavement			
	Crossfall (%)		1.5 - 2.0	1.5 - 2.5	1.5 - 2.5	1.5 - 2.5
GEOMETRIC CONDITIONS						
HORIZONTAL ALIGNMENT			**Design Speed**			
			120	**100**	**80**	**40**
Min. Horizontal Curvature	Desirable (5% SE)	m	1030	700	420	100
	Minimum (9%SE)	m	540	370	230	50
Maximum Superelevation		%	Urban Areas: Desirable 5% ,Acceptable 9%			
Min. Curvature Length		m	200	170	140	70
Min. Transition Curve Length		m	67	56	44	22
Radius not requiring Transition Curve		m	1310	910	580	150
Values of Superelevation with respect to Radius of Curvature		6%	996	694	441	174
		5%	1206	849	540	212
		4%	1527	1091	674	273
		3%	1910	1348	880	347
		Reverse (2%)	3510	2560	1710	525
Min. Radius not requiring Superelevation		m	7500	5000	3500	800
Superelevation Run-off			1/200	1/175	1/150	1/100
VERTICAL ALIGNMENT						
Max. Gradient	Standard	%	2	3	4	7
	Gradient with limitations	% (m)	3% (800m)	4% (700m)	5%(600m)	8% (400m)
		% (m)	4% (500m)	5% (500m)	6% (500m)	9% (300m)
		% (m)	5% (400m)	6% (400m)	7% (400m)	10% (200m)
Sight Distance	Stopping	m	210	160	110	40
	Passing	m	780	620	500	210
Min. Radius Crest Curve	K-Value		111	64	30	4
	Radius	m	11000	6400	3000	400
Min. Radius Sag Curve	K-Value		40	28	18	5
	Radius	m	4000	3000	2000	500
Min. Vertical Curve Length		m	100	85	70	35

Note: Those not provided in GRDG is referred from AASHTO's Standard as shown by the italic figures

(4) Horizontal Alignment

Horizontal alignment that meets the geometric requirements was planned taking into consideration the measures against the control points as mentioned in **Table 2.2.2-8** and safety and comfort of driving at a high speed. Horizontal curve radii that don't require widening was applied with an aim to keep the scale of the box culvert at the underpass as small as possible. For better understanding of the plan, the ramps were tentatively named for design purpose as shown in **Figure 2.2.2-12**.

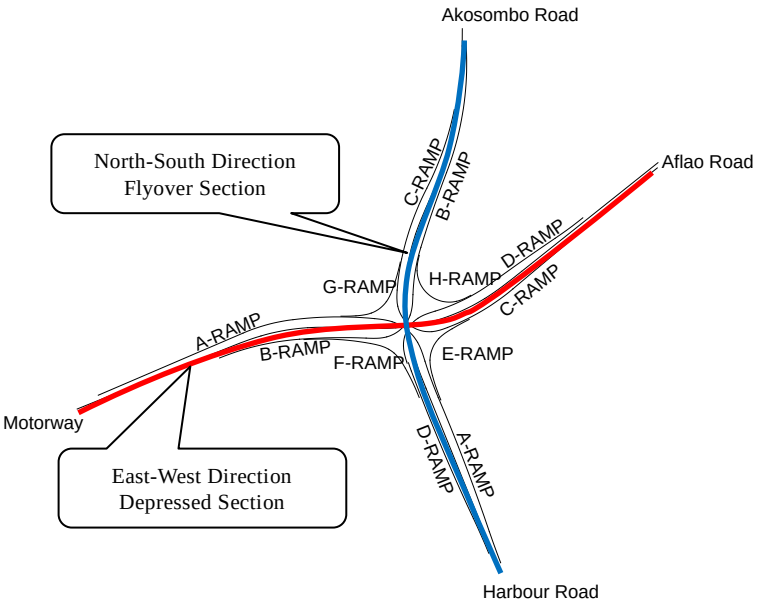


Figure 2.2.2-12 Horizontal Alignment of Main Carriageway and Ramps

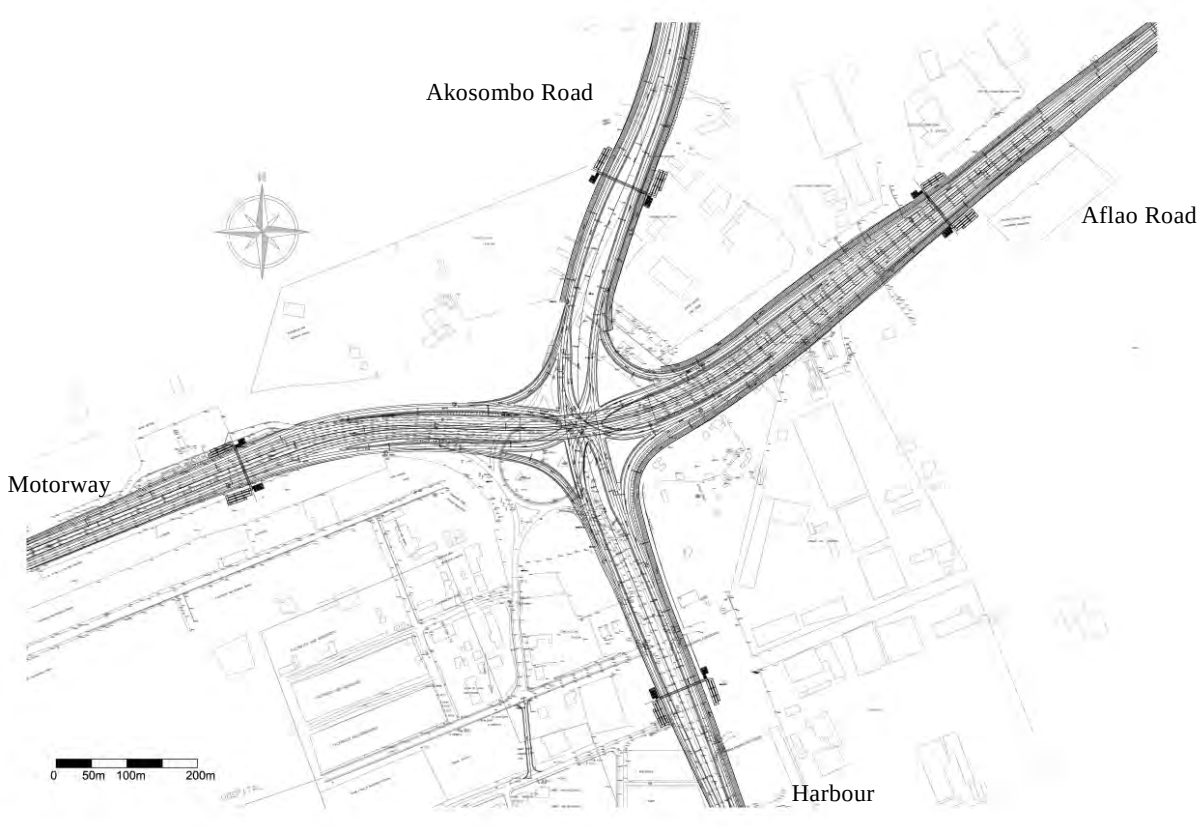


Figure 2.2.2-13 Plan of Main Carriageway and Ramps

(5) Vertical Alignment

Vertical alignment was planned in a manner that not only satisfies the geometric requirements but also addresses the measures to be considered for the control points. A minimum vertical grade of 0.4% was applied such that the road surface water collected can be naturally conveyed/transported to the end flow (outlets) of the drainage. The outlets taken into consideration in the plan are the streams that are currently serving as outlets.

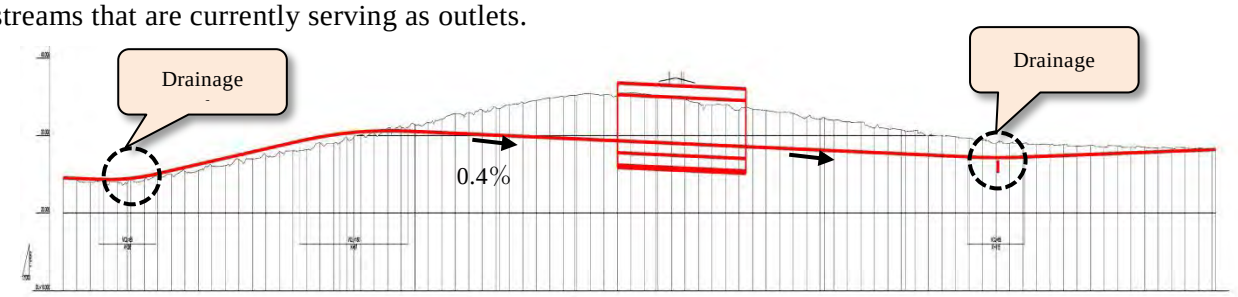


Figure 2.2.2-14 Profile in the East-West Direction

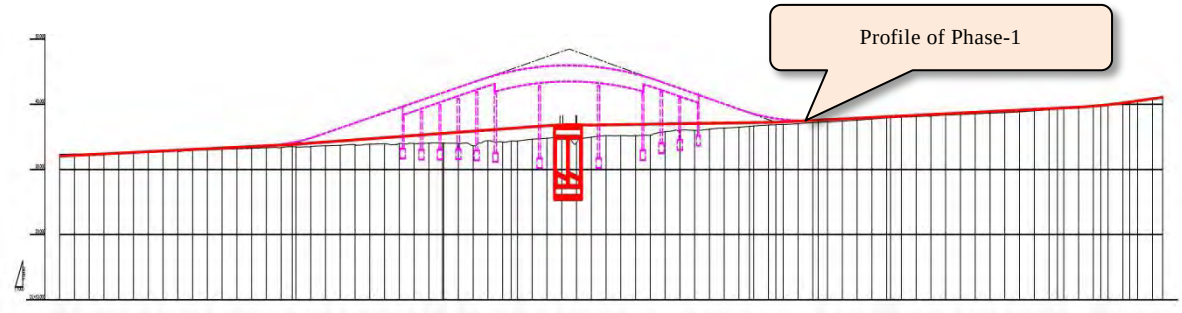


Figure 2.2.2-15 Profile in the North-South Direction

(6) Cross Section Elements

Table 2.2.2-11 indicates the proposed cross section elements of each leg. ROW and lane widths of the objective roads are based on the Ghana Road Design Guideline or in accordance with the existing parameter.

Table 2.2.2-11 Proposed Cross Section Elements

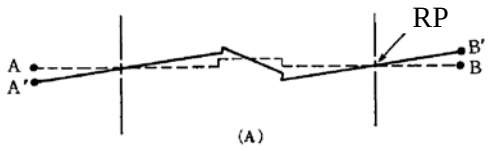
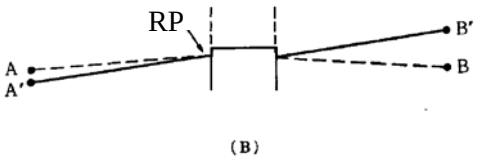
Existing Roads	Median Width (m)	Shoulder (m)		Lane(s) (m)	ROW
		Inner	Outer*		
Accra-Tema Motorway	10	0.5	3.0*	3.65	45
Tema-Hospital Road	-	-	1.5	3.65	33
Tema-Harbour Road	4.0	0.5	2.0	3.65	45
Tema-Aflao Road	4.0	0.5	2.5	3.65	45
Tema-Akosombo Road	4.0	0.5	2.5	3.65	45
*: The width of outer shoulders provided can be reduced to a minimum of 0.6m along structures (flyover). **: 3.0m wide shoulder consists of 0.5m wide unpaved shoulder (verge).					

(7) Reference Points in Road Design

There are two methods in determining the reference points (hereinafter, RP) of a road for the design of vertical alignment and cross section on divided highways. These methods are described in **Table 2.2.2-12**. As the objective roads are wide (4-10m median strip with dual or triple lane double carriageway) and has a superelevated stretch of about 800m, the effect on the abutting houses/residences

or facilities as well as to the sectional area of the box culvert at the underpass is less if the reference point is taken in the middle of carriageways. Therefore, Type A is applied for the alignments in this project.

Table 2.2.2-12 Reference Point in Road Design

Items	Type A : Middle of Carriageway	Type B : Edge of Median
Image		
Feature	It is applicable to a section with superelevation. Elevation difference between right edge and left edge of the road can be smaller	Since RP is close to center of the road, it is simple to design according to design standard.
Condition	Having median and being large in width	none in particular
Applied	○	–

(8) Design Vehicle

As agreed with the GHA during the technical note meeting, the vehicle to be considered for the design will be WB-20 defined by AASHTO. The basic dimension of the vehicle is illustrated in **Figure 2.2.2-16**.

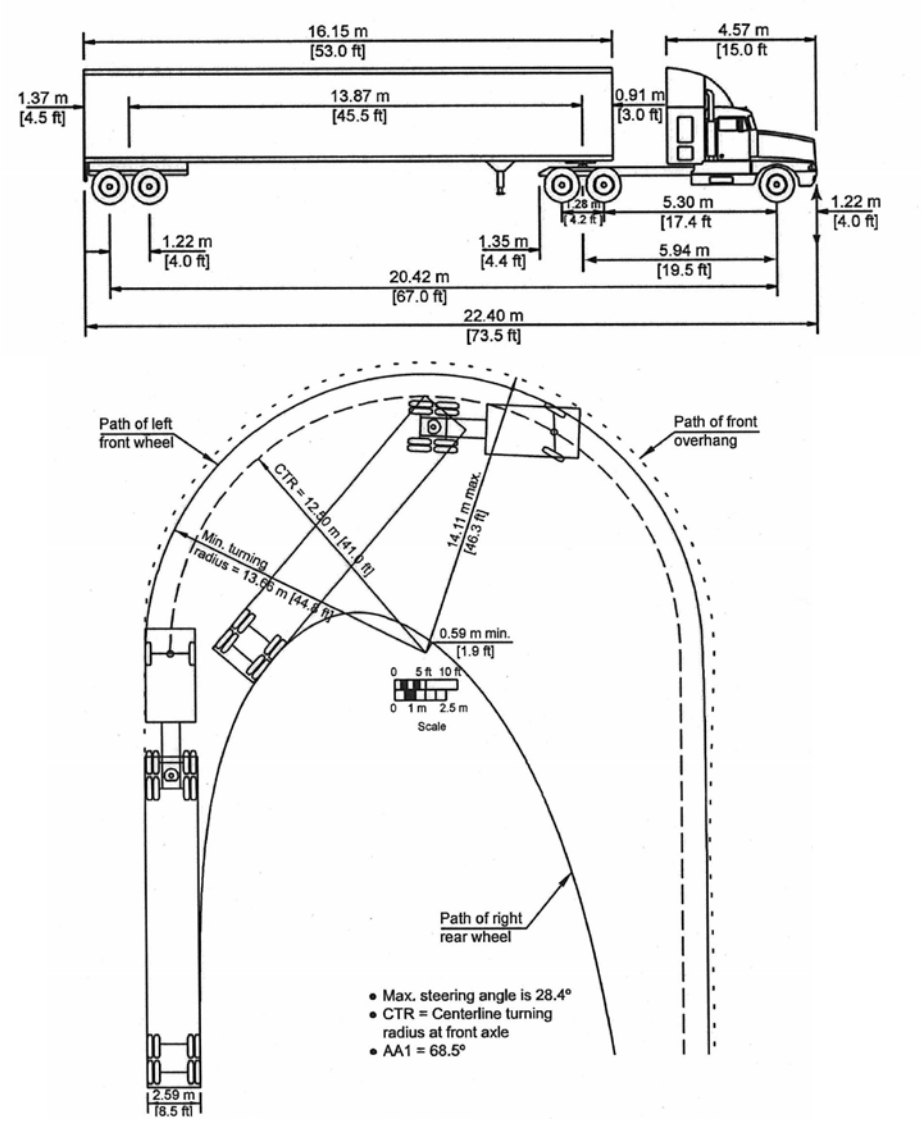


Figure 2.2.2-16 Design Vehicle

(9) Required Number of Lanes

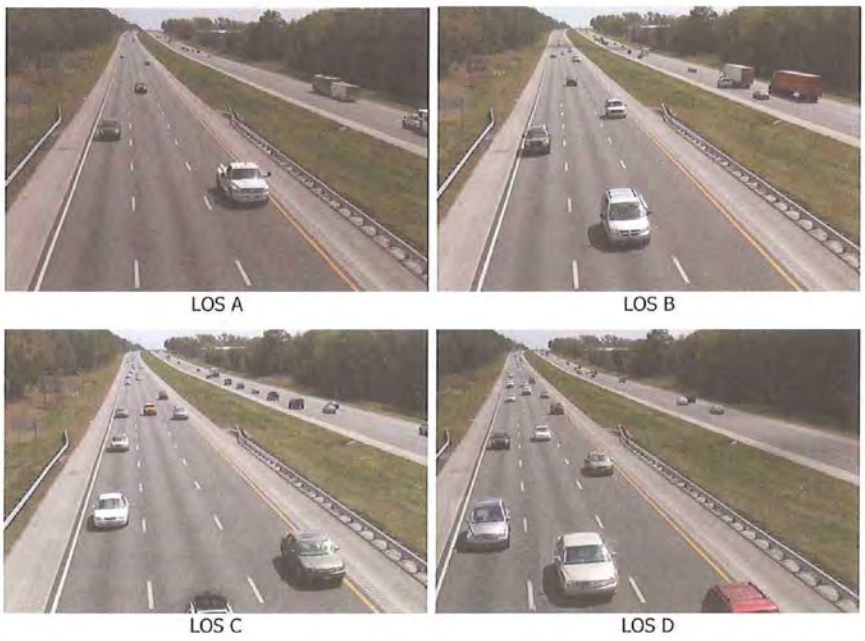
1）Conditions for Calculation of Required Number of Lanes

Following conditions will apply for calculation of required number of lanes;

- The east-west direction will be depressed and north-south direction graded. Connections between these roads will be provided through ramps,
- The required number of lanes will be calculated based on the method recommended by the Highway Capacity Manual 2010. Design Hourly Traffic Volume (DHV) and traffic capacity will be calculated with respect to the target LOS,
- DHV is calculated by converting the Average Annual daily Traffic (AADT) to hourly traffic volume using the time factor (K) and directional factor (D). However, parameters required for Ghanaian formula is not available. Therefore, DHV will be calculated with reference to the method applied in previous JICA study,
- Access limit will be imposed on Accra-Tema Motorway, Tema-Aflao Road and Tema-

Akosombo Road. Tema-Harbour Road will have an imposition of o. Access from abutting properties will be through service lanes,

- As aforementioned in Section 2-1-6, traffics from Hospital Road will not be allowed in the intersection,
- The LOS agreed in the T/N is 'B' for Tema-Motorway, Tema-Aflao Road and Tema-Akosombo Road and 'C' for Tema-Harbour Road. However, securing the agreed LOS even during peak hours is uneconomical and apparently unrealistic. Therefore, the number of lanes has been calculated taking the LOS of the target year as 'D' (stable to unstable flow), meaning the saturation (ratio of volume by capacity). **Figure 2.2.2-17** shows the condition of flow at each level of service.



Source: Highway Capacity Manual 2010

Figure 2.2.2-17 Examples of LOS

2) Calculation/Result of Required Number of Lanes

Number of lanes was calculated for all legs of the existing Tema Roundabout, the ramps, and the legs of graded intersection (for graded intersection type configuration). The results are summarized hereunder.

A) Road Section

Road section means the section excluding ramps, graded roads and section within the intersection for partial free-flow configuration. The result of required number of lanes on road sections of each leg is shown in **Table 2.2.2-13**. The results show that for the conditions provided, 4-lanes are sufficient on Accra-Tema Motorway. However, Tema-Aflao Road needs 6-lanes. Therefore, in order to maintain continuity with Tema-Aflao Road, as well as taking the Ghanaian PPP scheme (which has plans to widen the Motorway to 6-lanes) into

consideration, it is decided that the Motorway will be planned to have the road space for 6-lanes. However, pavement will be applied on the inner 4-lanes only.

Table 2.2.2-13 Required Number of Lanes on Road Sections

Road			Accra-Tema Motorway	Tema-Akosombo Road	Tema-Aflao Road	Tema Harbour Road	Tema Hospital Road
Type of highway			Freeway	Freeway	Freeway	Multi lane	Two lane
Access			Full control	Full control	Full control	Partial control	Partial control
Studied length (m)			760	940	800	600	270
Peak hour traffic volume (veh/h)	Inbound	Passenger car	2498	2540	3593	4974	1201
		Heavy vehicle	239	156	264	307	105
		Sub total	2737	2696	3857	5281	1306
	Outbound	Passenger car	3098	3893	3950	2594	1273
		Heavy vehicle	302	228	292	165	84
		Sub total	3400	4121	4242	2759	1357
	Higher value	Passenger car	3098	3893	3950	4974	1273
		Heavy vehicle	302	228	292	307	105
Demand volume (veh/h)			3400	4121	4242	5281	1378
FFS (Free-flow speed)		km/h	100	100	100	80	40
		mi/h	62.5	62.5	62.5	50	25
Lane width		m	3.65	3.65	3.65	3.65	3.65
		ft	12.0	12.0	12.0	12.0	12.0
Lateral Clearance		m	2.5	2.5	2.5	2	1.5
		ft	8.2	8.2	8.2	6.6	4.9
Total Ramp Density		ramps/mi	0.33	0.17	0.17	-	-
Peak Hour Factor		-	0.98	0.98	0.98	0.98	0.98
Terrain Segments		Grade (%)	2	1	1	level	level
% of Heavy vehicle		Inbound	8.9	5.5	6.9	6.0	6.2
		Outbound	8.7	5.8	6.8	5.8	8.0
		Applied value	8.9	5.8	6.9	6.0	8.0
Passenger-car equivalent (PCE)			2.5	2.5	2.5	2.5	2.5
Target LOS			D	D	D	D	D
Access-Point Density (access points/mi)		Inbound	-	-	-	8	14
		Outbound	-	-	-	8	14
Number of lanes Required		**Inbound**	**2**	**3**	**3**	**3**	**1**
		Outbound	**2**	**3**	**3**	**3**	**1**

B) Flyover (Graded Section)

The sections that are elevated (flyover) and accommodate through traffics (vehicles going straight) are subjected to flyover. That is the flyover section of north-south bound (Akosombo-Tema Harbour) or east-west bound (Accra-Aflao). The results of the required number of lanes on these flyover sections are presented in **Table 2.2.2-14**. The result indicates that 4-lanes are sufficient for both Motorway-Aflao Road and Akosombo-Harbour Road for both cases. However, for the reasons mentioned above, the Motorway will be planned to have a space for 6-lanes whose 4-lanes (inner side) will be paved.

Table 2.2.2-14 Required Number of Lanes on Flyovers (Graded Section)

Road		Motorway - Aflao Road		Akosombo - Harbour Road	
Direction		EB	WB	SB	NB
Type of highway		Freeway	Freeway	Freeway	Multi lane
Peak hour traffic volume (veh/h)	Passenger car	1368	930	2360	1186
	Heavy vehicle	43	25	6	28
Demand volume (veh/h)		1411	955	2366	1214
FFS (Free-flow speed)	km/h	100	100	100	80
	mi/h	62.5	62.5	62.5	50
Lane width	m	3.65	3.65	3.65	3.65
	ft.	12.0	12.0	12.0	12.0
Lateral Clearance	m	2.5	2.5	2.5	2
	ft.	8.2	8.2	8.2	6.6
Total Ramp Density	ramps/mi	0.33	0.17	0.17	-
Peak Hour Factor	-	0.98	0.98	0.98	0.98
Terrain Segments	Grade (%)	3.0%	3.0%	3.0%	3.0%
% Heavy track		3.0%	2.6%	0.3%	2.3%
Passenger-car equivalent (PCE)		2.5	2.5	2.5	2.5
LOS as of 2035		B	A	C	A
Number of lanes Required		**2**	**2**	**2**	**2**

C) Ramps

The concept of on-ramp and off-ramp is shown in **Figure 2.2.2-18**. Vehicles diverting from the main road and going to another main road (ahead of the intersection) are off-ramp traffic, and vehicles merging into the main road after diverting from another main road (beyond the intersection) are on-ramp vehicles.

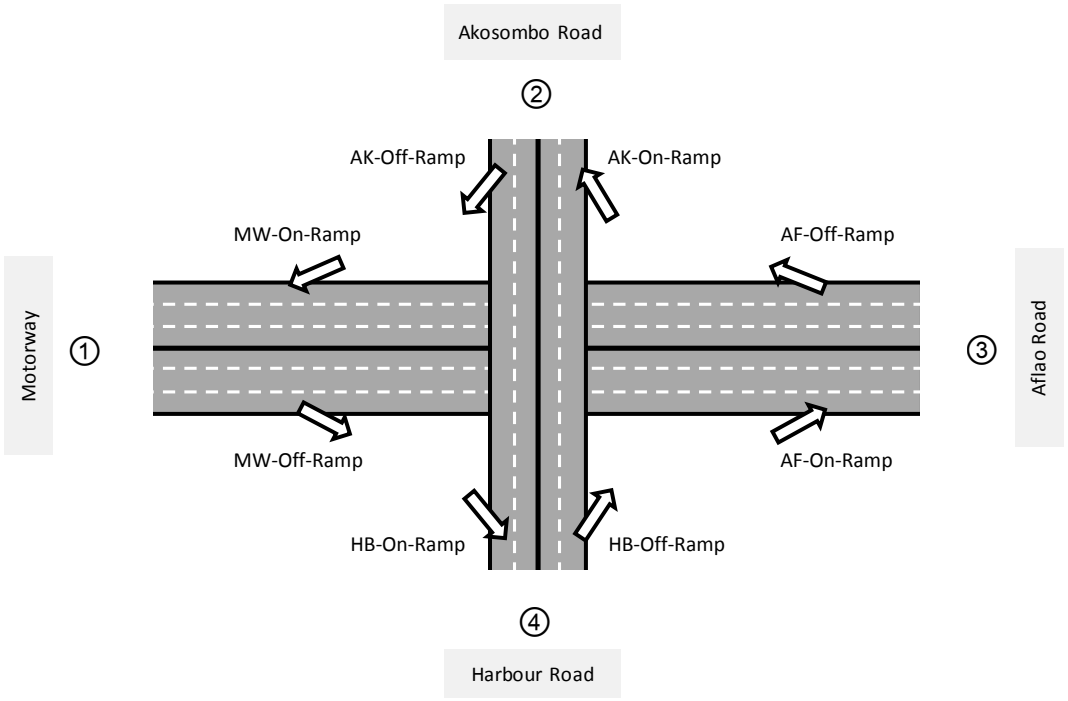


Figure 2.2.2-18 Conceptual Image of Ramps

Table 2.2.2-15 Required Number of Lanes on Ramp Section

No.			①		②		③		④	
Road			Motorway		Akosombo Road		Aflao Road		Harbour Road	
Ramp Type			On	Off	On	Off	On	Off	On	Off
Volume		Freeway	955	1411	1214	2366	1411	955	2366	1214
		Ramp	1346	2066	378	1926	1939	3321	1288	2471
FFS (Free-flow speed)	Freeway	km/h	100	100	100	100	100	100	80	80
		mi/h	62.5	62.5	62.5	62.5	62.5	62.5	50	50
	Ramp	km/h	50	50	50	50	50	50	50	50
		mi/h	31.25	31.25	31.25	31.25	31.25	31.25	31.25	31.25
Ave. % of Hv	Freeway		3%	3%	2%	0%	3%	3%	0%	2%
	Ramp		6%	9%	6%	6%	7%	5%	8%	7%
Grade			Level	Level	Level	Level	Level	Level	Level	Level
Peak Hour Factor			0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Number of lanes Required			**1**	**2**	**1**	**2**	**1**	**2**	**1**	**2**
LOS			**B**	**B**	**B**	**B**	**C**	**B**	**C**	**A**

D) Summary

The result of number of lanes to be provided for each section under this improvement plan is indicated in **Table 2.2.2-15**. The results come from the calculation described above as well as consideration taken in view to secure consistency with future plans of GOG and ECOWAS.

Table 2.2.2-16 Summary of Required Number of Lanes for All Sections

Sections		Accra-Tema Motorway	Tema-Aflao Road	Tema-Akosombo Road	Tema-Harbour Road	Tema-Hospital Road
Road Section (both sides combined)		6 (4-lanes paved)	6	6	6	2
Flyover section (both sides combined)		6 (4-lanes paved)	6 (4-lanes paved)	4	4	-
Ramps	OFF	2	2	2	2	Ramps
	ON	1	1	1	1	

(10) Typical Cross Section

Following drawings shows typical cross section.

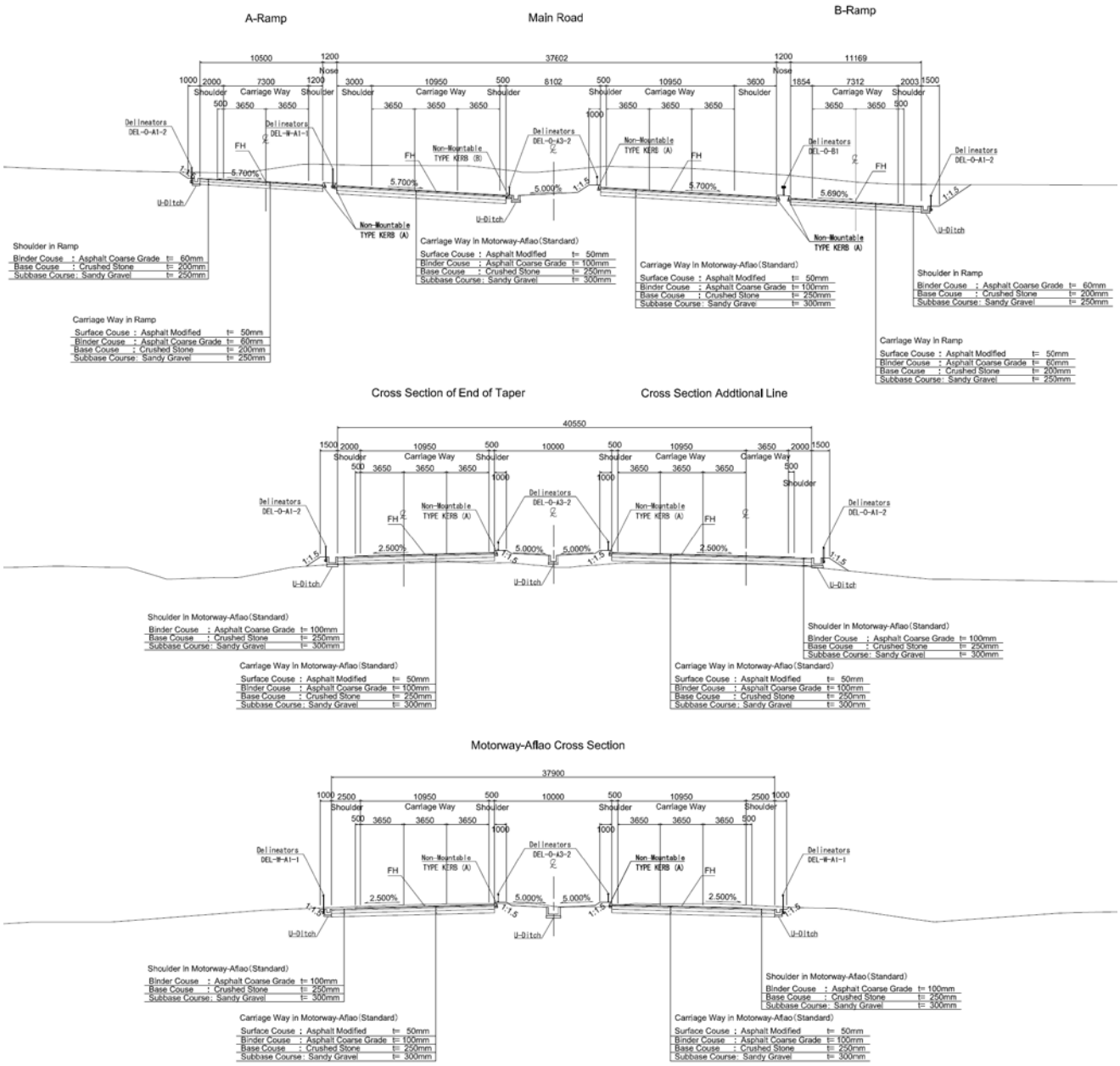


Figure 2.2.2-19 Motorway-Aflao Road: Typical Cross Section (1)

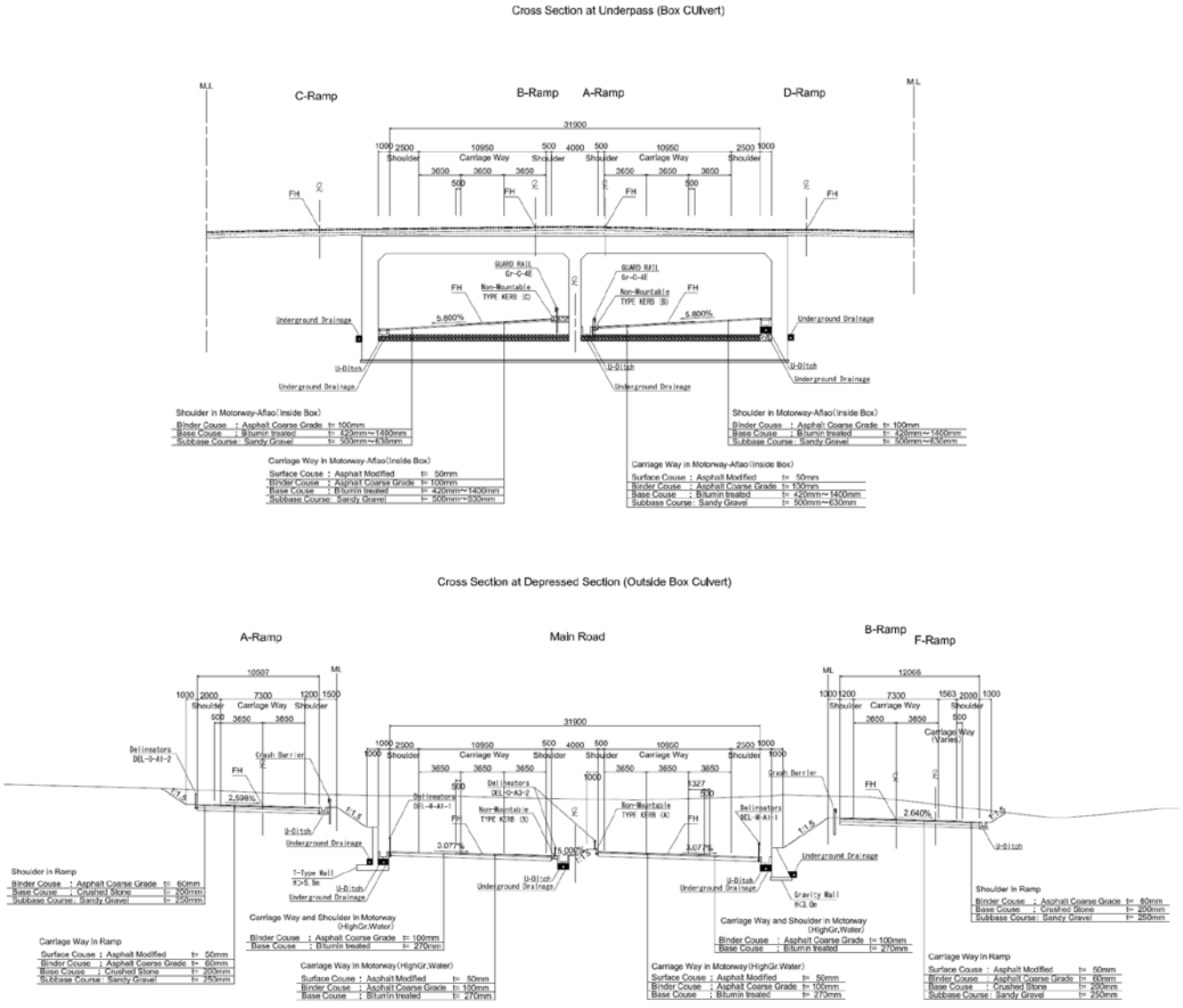


Figure 2.2.2-20 Motorway-Aflao Road: Typical Cross Section (2)

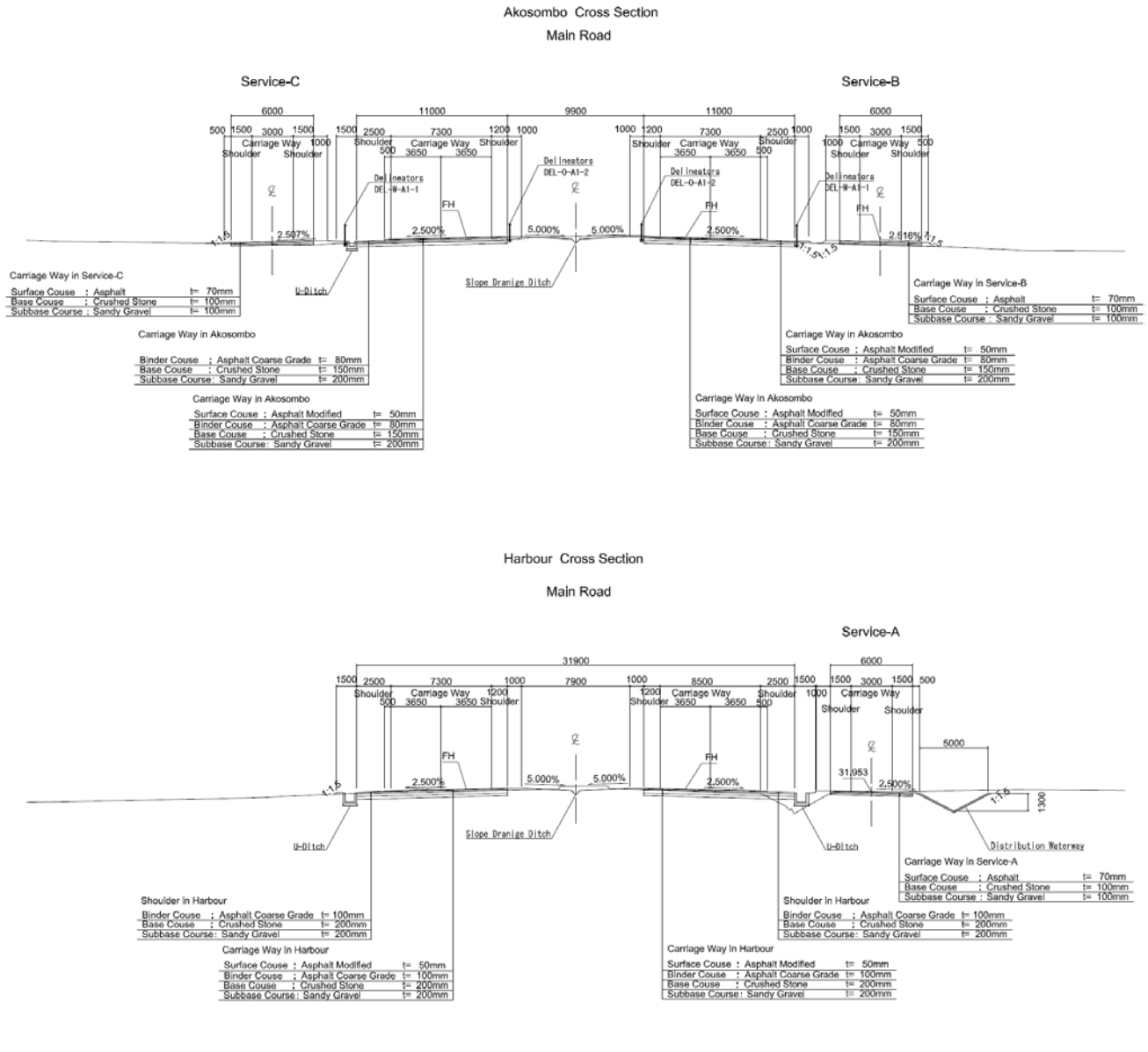


Figure 2.2.2-21 Harbour Road - Akosombo Road: Typical Cross Section

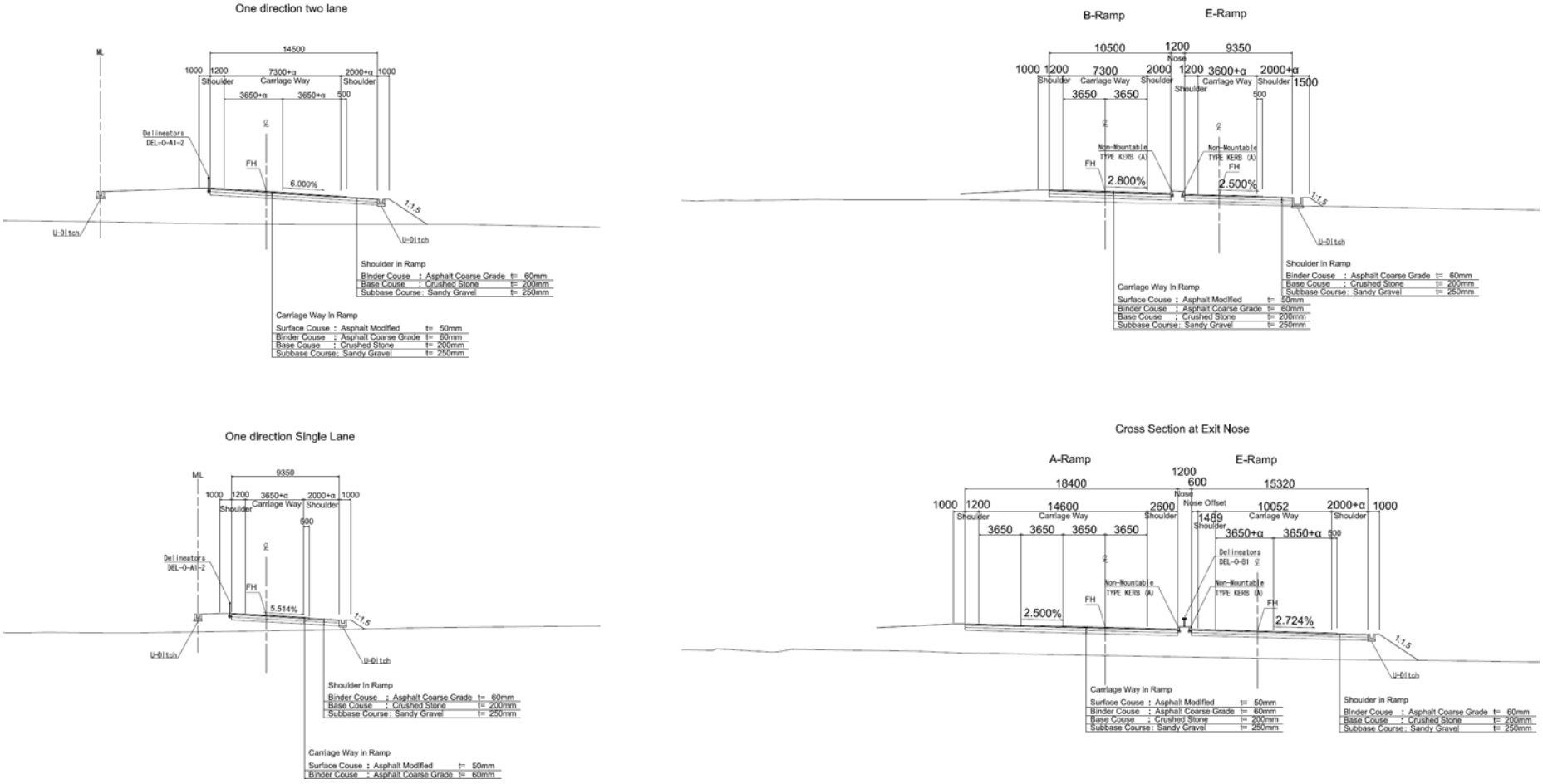


Figure 2.2.2-22 Ramp: Typical Cross Section

2.2.2.3 Structure Plan

(1) Outline

In the East-West direction, proposed height of the road goes below the existing ground level. Thereby, this section will be depressed with an underpass at the intersecting point with the north-south direction. **Photo 2.2.2-1** shows an example of an underpass. As can be understood from the photo, this type of underpass will require provision of retaining walls along the depresses section and a culvert or a bridge at the underpass.

Photo 2.2.2-1 Example of Depressed and Underpass Section

(2) Basic Policy

Basic policies for planning of structures are;

- Retaining wall shall be applied instead of earth cut in order to minimize influence to the surrounding environment.
- The structures applicable for retaining purpose will be selected from conceivable alternatives.
- A box culvert is planned for underpass structure at the intersection point of east-west and north-south direction roads.

(3) Design Condition

Design conditions of retaining walls are as summarized below.

Table 2.2.2-17 Design conditions of Retaining Wall

Type of retaining wall		Inverted-T Type
Maximum wall height		H＝10.0m
Upper Load	Design live load (Weight of design vehicle)	250kN
	Unit weight of backfilling soil	γ=19kN/m3

Table 2.2.2-18 Design condition for BOX Culvert

Inner section of BOX Culvert		B (16.45+16.45) m x H 7.5m
Max. vertical gradient		i＝0.4%
Width of carriageway		W=13.95m
Upper Load	Design live load (Weight of design vehicle)	250kN
	Pavement	t=80mm

Table 2.2.2-19 Material Condition

Design strength of concrete	σck=24 kN/m3
Allowable bending compressive stress of concrete	σck=8.0 kN/mm2
Allowable shearing stress of concrete	τa=0.39 N/mm2
Allowable adhesion stress of concrete	τa=1.6 N/mm2
Allowable tensile stress of rebar	σsa=180 N/mm2
Used diameter of rebar	12mm, 16mm, 20mm, 25mm
Allowable bearing capacity of foundation ground	600 kN/m2

(4) Scope of Structures

The sections where structures (retaining walls and box culvert) are planned are shown in **Figure 2.2.2-23**.

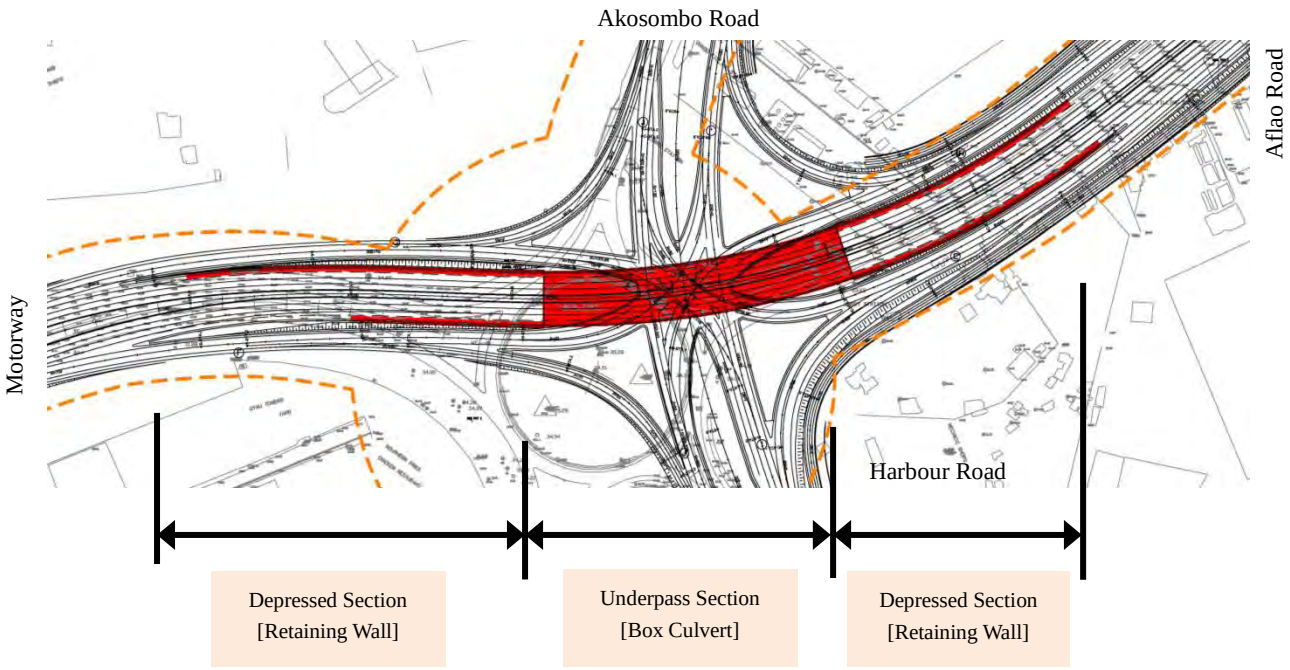
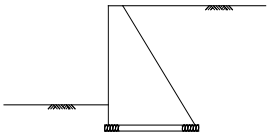
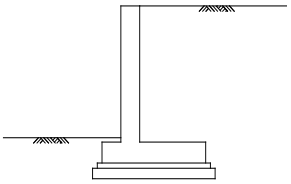
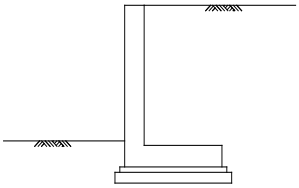


Figure 2.2.2-23 Scope of Structures

(5) Selection of Retaining Wall Types

Table 2.2.2-20 shows the types of retaining walls that are commonly applicable along the depressed section. The comparison results show that inverted-T Type and Gravity Type are recommendable for application in this section. The former is recommended where the height exceeds 3m and the latter for heights lesser than 3m. Both the types are not only comparatively economical but are also effective in minimizing the rear side excavation area. Minimizing the excavation area at the rear side of the retaining walls is important to ensure that the detour for maintaining the existing traffic flow during construction can be provided within the existing ROW.

Table 2.2.2-20 Comparison of Retaining Wall Types

Type		Gravity Type	Inverted-T Type	L-Type (Cast in place)
Image				
Feature		• Resistant against earth pressure by self weight • Plain concrete structure	• Resistant against earth pressure by self weight and soil weight on the slab • Wall and slab are resittant as cantilever beam against external force.	
Coverage Height		Lower than around 5m	3～10m	
Scale of Rear side excavation		Middle	Middle	Large
Ratio of Cost	3.0m	1.0	0.6	0.7
	4.0m	1.3	0.9	1.0
	5.0m	2.0	1.2	1.3
	6.0m	-	1.8	1.9
	7.0m	-	2.4	-
	8.0m	-	3.3	-
Evaluation		**Recommendable**	**Recommendable**	Not Recommendable
Applied		Section where wall height is lower than 3m.	Section where wall height is higher than 3m.	Not applicable

(6) Box Culvert

Typical cross section at the underpass (box culvert) is shown in **Figure 2.2.2-24**. The underpass lies in a curved alignment and has a maximum superelevation of 5.8%.

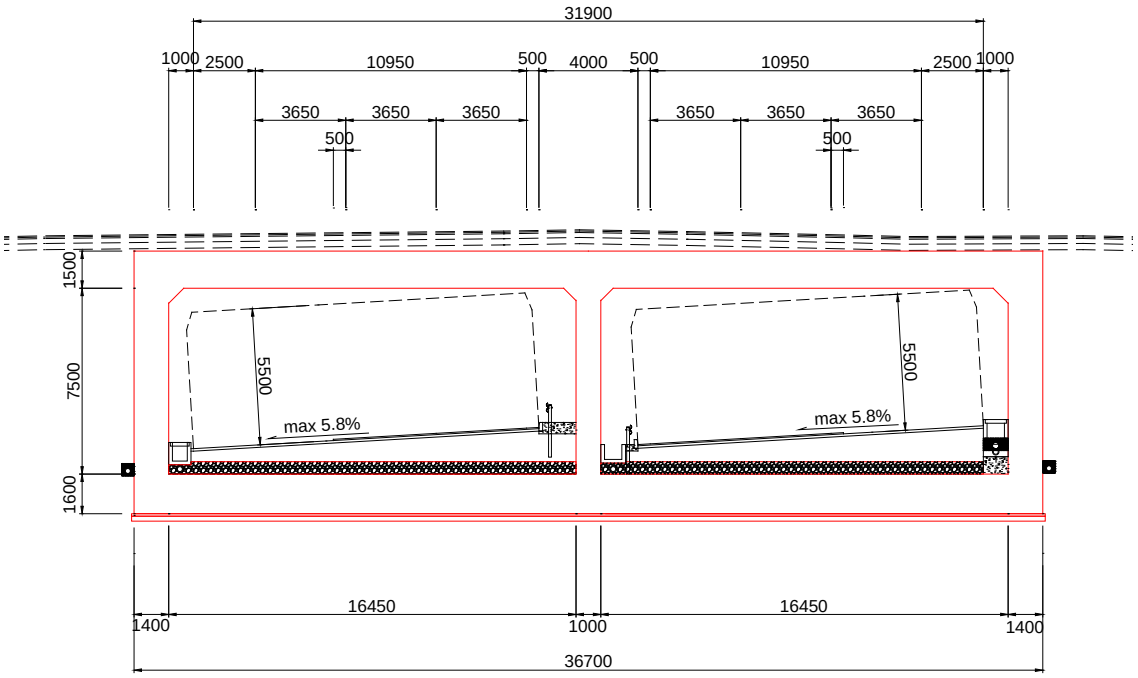


Figure 2.2.2-24 Typical Cross Section of Box Culvert

(7) Measures against Groundwater Leakage

1) Basic Policy

The groundwater observation has confirmed existence of groundwater at the project area. The level of groundwater is at about 6 to 7 meters from the ground surface. In particular, observation well No.2 which is located close to the planned box culvert recorded the highest groundwater level at an approximate depth of 6 meters from the surface. As shown in **Figure 2.2.2-26**, this level is slightly higher than the bottom slab of the box culvert.

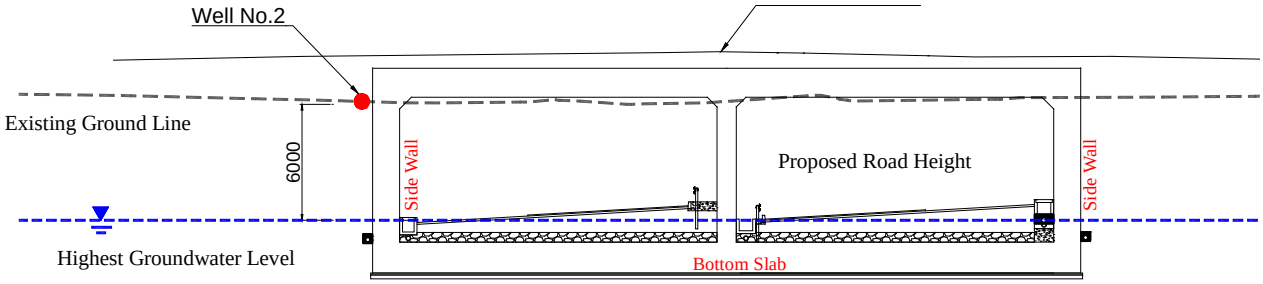


Figure 2.2.2-26 Groundwater Level (within box culvert section)

Joints or openings in the side walls and within the bottom slab of the box culvert could be outlets where the groundwater could be leaked, especially in the future when there are drastic changes in climatic conditions.

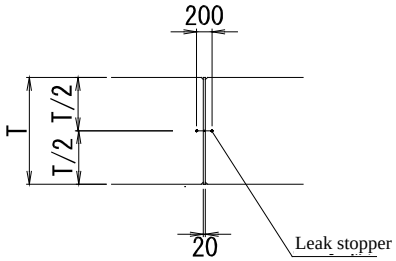


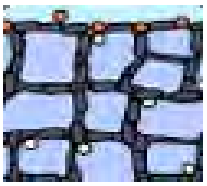
Figure 2.2.2-25 General Measure against Water Leakage

In general, measures as shown in **Figure 2.2.2-26** is applied at joints of all walls in a box culvert, but this is mainly for preventing leakage caused by rainfall. In the presence of groundwater this may not be functionally sufficient. Therefore, additional measure was applied to make the structure more resistant to the leakage of water. The measure applied was selected following a comparison of various options, which is discussed in the next section.

2) Additional Measure against Groundwater Leakage

Table 2.2.2-21 shows the applicable additional measures for preventing leakage of groundwater. Taking into consideration the fact that the box culvert will be installed under the ground, application of water resistant sheet and liquid membrane are most suitable in terms of construction efficiency and cost. Application of concrete admixture is also effective and can be applied in the arch concrete above the bottom slab.

Table 2.2.2-21 Comparison of Measures against Groundwater Leakage

Methods	Installation of Waterproof Sheet	Application of Liquid Membrane	Application of Barrier Penetrant	Application of Concrete Admixture
Outline				
	Impermeable gum sheet is manually pasted with adhering agent.	Liquid material consisting primarily of "High-Polymerized Compound" is applied to surface of concrete to form the waterproofing layer.	Silane or Silicate will be impregnated into the concrete to fill up small voids and prevent water penetration.	Concrete admixture, which induces chemical reaction to generate silica component, creates watertight concrete with self-reactive healing function for crack repair.
Durability	Protection sheet is additionally required since the waterproof sheet is easily damaged by earth filling during the construction. The sheet is inferior in deformational flexibility to cracks in concrete.	Protection sheet is additionally required since the waterproof sheet is easily damaged by earth filling during the construction. The membrane is excellent in deformational flexibility to cracks in concrete.	Re-coating is required every 10 years since this type easily deteriorates. It is unsuitable for underground structures.	Durability is sustained as long as concrete keeps its soundness. There is no fear that damage will occur by the backfilling of embankment during construction.
Workability	Accomplished skills and accuracy in flatness of concrete surface are required in order to firmly adhere to the sheet to the concrete.	Construction work is comparatively easy at shorter time by using spray type.	Construction work is comparatively easy at shorter time by using spray type.	Work Time will be saved due to simple work such as mixing the concrete admixture at the time of concrete batching.
Cost Ratio	1.80	1.20	0.80	1.00
Evaluation (Application)	Applicable (bottom slab expansion joints)	Applicable (side wall construction joints)	Not Applicable	Applicable (Bottom slab/ arch Concrete)

3）Applied Area

The areas where the additional measures for preventing leakage of groundwater are to be applied are as shown in **Figure 2.2.2-27**.

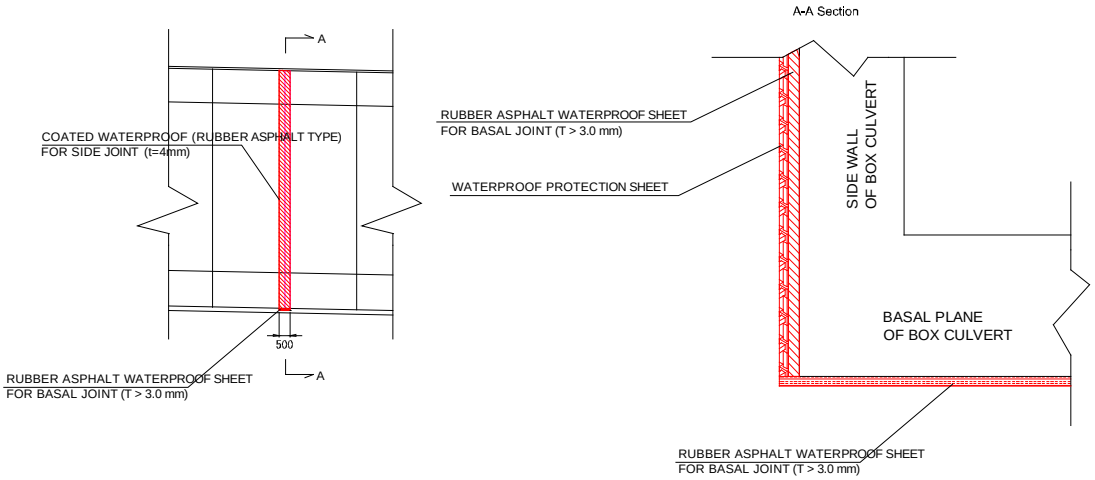


Figure 2.2.2-27 Application Areas of Additional Measures for Preventing Groundwater Leakage

2.2.2.4 Pavement Plan

(1) Condition of Existing Pavement

The existing pavement on the Motorway is a rigid type (concrete) pavement. Other roads have flexible

(asphaltic) pavement. Although partial deterioration on the pavement surface was found, most of the pavement is still under the good to fair condition.

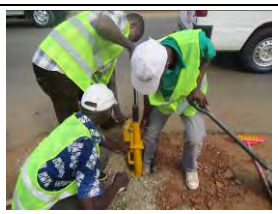
As shown in **Figure 2.2.2-28**, existing pavement survey was conducted by soil compaction tester for the purpose to roughly evaluate existing pavement condition and to check if the laboratory test result is appropriate. In the survey, an average of 3 separately measured CBR values at a point was taken as the field CBR at that point. For pavement design, CBR obtained from laboratory test was used.

Figure 2.2.2-28 Existing Pavement Survey by Soil Compaction Tester

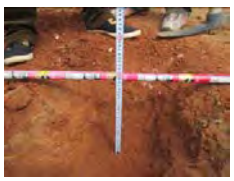
1）Accra- Tema Motorway

Thickness	Material	CBR Value	Photos
Surface Course t=20cm(Carriage way) t=5cm (Shoulder)	【Carriage way】 Cement Concrete	-	 
	【Shoulder】 Asphalt concrete	-	 
Base Course/ Sub-base Course t=35cm	CLAY with Gravel	188	 
Subgrade	Clayey Sand	99 (Surface on subgrade) 23 (10cm down from surface)	 

2）Tema-Hospital Road

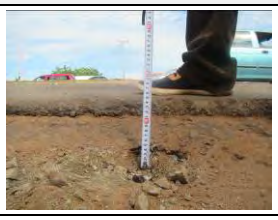
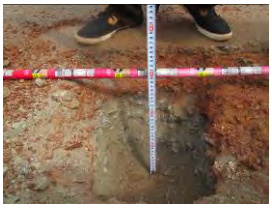
Thickness	Material	CBR Value	Photos
Surface Course t=8cm	【Carriage way】 Asphalt concrete 【Shoulder】 Asphalt concrete	-	 
Base Course/ Sub-base Course t=25cm	Crashed stone	96 (Surface on base-course)	 
Subgrade	Clayey Sand	105 (Surface on subgrade)	

3）Tema-Harbour Road

Thickness	Material	CBR Value	Photos
Surface Course t=15cm(Carriage way)※1 t=5cm(Shoulder)	【Carriage way】 Asphalt concrete 【Shoulder】 Asphalt concrete	-	 
Base Course/ Sub-base Course t=30cm	CLAY with Gravel	202 (Surface on base-course)	 
		145 (15cm down from surface)	 
		128 (25cm down from surface)	
Subgrade※3	CLAY with Gravel	39 (30cm down from subgrade)	 

※1. Height of pavement was assumed to be up to the height of the curb
※2. Existence of subgrade was not confirmed under 50 cm from the surface
※3. Unpaved section outside of carriage way was assumed to be subgrade.

4）Tema-Aflao Road

Thickness	Material	CBR Value	Photos
Surface Course t=15cm(Carriage way) t=5cm(Shoulder)	【Carriage way】 Asphalt concrete 【Shoulder】 Asphalt concrete	-	 
Base Course/ Sub-base Course t=15cm	Crashed stone	N/A (Surface on base-course) 113 (5cm down from surface)	 
Subgrade	Sandy CLAY with Gravel	99 (Surface on subgrade)	 

5）Tema-Akosombo Road

Thickness	Material	CBR Value	Photos
Surface Course t=10cm(Carriage way) t=10cm(Shoulder)	【Carriage way】 Asphalt concrete 【Shoulder】 Asphalt concrete	-	 
Base Course/ Sub-base Course t=10cm	Crashed stone	82 (Surface on base-course)	 
Subgrade	Sandy CLAY with Gravel	111 (Surface on subgrade) 63 (10cm down from subgrade)	 

(2) Basic Policies

Basic policies for pavement design are as follows;

- Flexible pavement which is common in Ghana shall be applied.
- AASHTO Guide for Design of Pavement Structure, 1993 shall be adopted.
- Countermeasures for groundwater shall be considered.
- Minimum pavement thickness to be applied will be 10cm or more.
- The possible future increment of heavy traffic passing the objective intersection is anticipated.

At the intersection, drivers would have to negotiate curves at low driving speed. Against plastic deformation of wearing course of pavement, modified asphalt shall be applied to the wearing course. For the service roads and temporary detour, modified asphalt shall not be applied.

- As traffic volumes differ, pavement of main carriageway and ramp shall be designed separately.
- Pavement structure of temporary detour shall be designed for the year 2020 with an assumption that the project will be implemented in 2019 and complete by year 2020. Although pavement composition may vary due to difference of traffic volume and CBR values, the pavement structure that has the biggest layer values will be applied for all the roads.

(3) Pavement Design

1) Design Period

Design period shall be 15 years as stipulated in the Pavement Design Manual (GHA).

2) Design Parameters

Design parameters are summarized in **Table 2.2.2-23**. The Structural Number (SN) required for the asphalt pavement will be calculated from the following formula.

$$\mathrm{Log}_{10}(W_{18}) = Z_R \times S_0 + 9.36 \times \mathrm{Log}_{10}(SN+1) - 0.20 + \frac{\mathrm{Log10}\{\Delta PSI/(4.2-1.5)\}}{0.40 + \{1094/(SN+1)^{5.19}\}} + 2.32 \times \mathrm{Log}_{10}(M_R) - 8.07$$

Table 2.2.2-22 Design Parameters (Inputs) of Pavement Design

Item	Description	Design Condition	Remarks
Design Period	The period of time that an initial pavement structure will last before it needs rehabilitation.	15 years (2020 – 2034)	
Traffic Load	The traffic load is expressed by cumulative number of 18-kip equivalent single axle load (ESAL) applications (w_{18}) during the performance period and is calculated based on the future traffic volume which is converted to 18-kip ESALs applying the axle load equivalency factors given in the AASHTO Guide.	Calculated by traffic demand forecast	
Reliability	Means of incorporating some degree of certainty into the design process.	・ The level of reliability (R)=90% ・ Standard normal deviate corresponding to level of reliability (Z_R) = -1.282 ・ Combined standard error of the traffic prediction and performance prediction (S_o) = 0.44	
Performance Criteria	The Present Serviceability Index (PSI) is used to represent pavement performance. The total change in PSI (△ PSI) is defined as the difference between initial serviceability index (p_0: value immediately after construction) and terminal serviceability index (p_t: lowest index that will tolerate before rehabilitation, resurfacing or reconstruction)	p_0 = 4.2 pt = 2.5	p_0=4.2 pt=2.5 △PSI=1.7
Roadbed Soil	The resilient modulus (M_R) is used. The AASHTO Guide introduces the equation	CBR=9.6～20	M_R=14,400psi～30,000

Item	Description	Design Condition	Remarks
Property	estimating M_R from CBR as M_R = 1,500 x CBR (CBR is regarded as 20 in case of CBR more than 20)	(calculated based on CBR investigation)	
Pavement Layer Material Properties	The pavement strength is expressed by the structural number (SN) which is calculated as : $SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$ where a_i=i^{th} layer coefficient D_i=i^{th} layer thickness (inches) m_i=i^{th} layer drainage coefficient	・ Asphalt concrete wearing course : a_1=0.41 (E_{AC}=425,000 psi) ・ Asphalt concrete binder course : a2=0.39 (E_{AC}=425,000 psi) ・ Base : :a_4=0.14 ・ Subbase : a_5=0.11	
Drainage Condition	The factor to modify the SN considering the effects of drainage.	m_4=m_5=1.0 (water removed within 1 week, and pavement structure is exposed to moisture levels approaching saturation during 5% of the year)	

3）Design Traffic Volume

Table 2.2.2-23 shows design traffic volumes calculated using traffic survey data conducted in April 2015.

Table 2.2.2-23 Design Traffic Volume

Road	Design Traffic Volume (vehicle / day)					
	Car, Taxi, Minibus	Bus	Light Truck	Heavy Truck	Trailer	Others
Motorway	16,528	177	2,393	1,218	1,158	403
Akosombo Road	23,691	607	1,369	951	484	173
Aflao Road	27,254	329	1,705	993	1,037	320
Harbour Road	21,101	983	1,232	1,256	1,387	485

Design traffic volume for ramps was calculated based on the directional traffic volume during peak hours.

Table 2.2.2-24 Design Traffic Volume

Road	Section	Conversion factor	Traffic Volume by Deirection (Vehicle/day)					
			Car, Taxi, Minibus	Bus	Light Truck	Heavy Truck	Trailer	Others
Motorway	Right turn lane	45.2%	7,471	80	1,082	551	523	182
	Left turn lane	25.4%	4,198	45	608	309	294	102
	Common section	70.6%	11,669	125	1,689	860	818	285
Akosombo Road	Right turn lane	47.6%	11,277	289	652	453	230	82
	Left turn lane	11.0%	2,606	67	151	105	53	19
	Common section	58.6%	13,883	356	802	557	284	101
Aflao Road	Right turn lane	11.4%	3,107	38	194	113	118	36
	Left turn lane	55.8%	15,208	184	951	554	579	179
	Common section	67.2%	18,315	221	1,146	667	697	215
Harbour Road	Right turn lane	32.8%	6,921	322	404	412	455	159
	Left turn lane	24.5%	5,170	241	302	308	340	119
	Common section	56.3%	11,880	553	694	707	781	273

Accurate forecasting of traffic volume on service roads from the traffic volume obtained from the traffic count survey is virtually not possible as presently there are no service roads in the project area. Therefore, the volume is determined assuming 3% of the total traffic will use the service road. The assumed traffic volumes are as shown in **Table 2.2.2-25**.

Table 2.2.2-25 Design Traffic Volume

Road	Design Traffic Volume (vehicle / day)			Remarks
	Car, Taxi, Minibus	Bus	Truck	
Motorway	496	5	72	No service road
Akosombo	711	18	41	
Aflao	818	10	51	
Harbour	633	20	37	

Source: JICA Survey Team

4）Growth Rates of Traffic Volumes

Growth rates of traffic volumes were determined subject to the result of future traffic demand.

5）CBR of Subbases

Figure 2.2.2-29 illustrates locations of the field CBR tests, and **Table 2.2.2-26** shows the results of laboratory CBR tests. In pavement design, CBR obtained from laboratory test was applied.

Figure 2.2.2-29 Location of Field CBR Test

Table 2.2.2-26 Laboratory Test Result

SAMPLE ID	CHAINAGE (KM)	REFERENCE	SOIL CLASSIFICATION	NATURAL MOISTURE CONTENT (%)	SPECIFIC GRAVITY	PLASTICITY INDEX (%)	COMPACTION		CBR		IN-SITU CBR
							MDD (g/cm^3)	OMC (%)	95% MDD	98% MDD	%
M1C Lay.1	1 - 0+580	Shoulder	GM	2.90	2.62	10.1	2.26	4.8	75	84	95
M1C Lay.2			GW	3.50	2.598	18.1	2.26	6.5	45	54	46
M1C Lay.3			GP	3.40	2.569	9.2	2.175	6.0	35	42	44
M2L Lay. 1	2 - 0+700	Subgrade	SW	4.00	2.685	NP	2.025	6.2	64	72	96
M2L Lay. 2			SM	4.60	2.61	NP	N.A	N.A	N.A	N.A	129
M2L Lay. 3			CH	5.20	2.564	31.5	2045	13.5	7	10	28
H1R Lay-1	3 - 0+135	Shoulder	GW	4.40	2.85	non-plastic	2.335	7.2	65	93	75
H1R Lay. 2			GM	6.10	2.685	7	2.227	7.8	52	70	73
H1R Lay. 3			GC	8.60	2.672	12.8	1.871	13.2	21	26	40
HH1R Lay 1	4 - 0+160	Shoulder	GW	2.50	2.753	NP	2.398	5.0	89	112	132
HH1R Lay 2			GM	3.40	2.638	3.5	2.25	7.0	45	54	56
HH1R Lay 3			GM	4.00	2.698	NP	2.32	5.0	28	35	32
TH2L Lay.1	5 - 0+200	Shoulder	GM	2.50	2.653	9.5	2.198	7.4	75	90	153
TH1L Lay. 1	6 - 0+60	Subgrade	GM	6.00	2.618	10.6	2.19	6.5	55	75	280
TH1L Lay. 2			GC	5.50	2.637	10.5	2.2	6.7	50	65	47
TH1L Lay. 3			GM	5.00	2.58	11.5	2.21	8.5	42	53	151
A1R Lay.1	7 - 0+100	Shoulder	GW	3.60	2.658	3.2	2.378	5.2	85	109	111
A1R Lay.2			GM	3.50	2.653	11.8	2.21	7.2	55	65	96
A2L Lay. 1	8 - 0+315	Shoulder	GM	3.60	2.605	10.5	2.195	7.5	60	72	191
A2L Lay. 2			GW	2.30	2.712	NP	2.39	5.5	78	103	211
A2L Lay. 3			GM	3.00	2.615	9.5	2.26	7.5	67	78	94
AS1R Lay. 1	9 - 0+720	Shoulder	GW	1.40	2.69	NP	2.39	5	88	112	85
AS1R Lay. 2			GM	2.80	2.593	9.5	2.205	7.5	63	87	101
AS1R Lay 3			GM	2.40	2.614	9.3	2.25	7.3	67	87	49
AS2L Lay. 1	10 - 0+885	Subgrade	SW	3.20	2.658	4.2	2.253	6.2	60	73	702
AS2L Lay. 2			GM	3.50	2.668	8.3	2.23	7	62	79	97
AS2L Lay. 3			GM	4.20	2.605	9.1	2.2	8.2	54	72	21

MDD - Maximum Dry Density OMC - Optimum Moisture Content CBR - California Bearing Ratio

From the above result, all CBR values were high, except for one point on the Motorway. In pavement design of AASHTO, an equation to obtain Resilient Modulus (MR) on the subbase is taken as 20% even if the actual value is bigger than that.

6）Result

Pavement structures (calculation results) of main carriageways, ramps and service roads are shown in **Table 2.2.2-27**.

Table 2.2.2-27 Pavement Structure

Pavement Composition (Material)		Station	Surface Course	Binder Course	Base Course		Subbase Course		Total Thickness (mm)	Remarks
			Asphalt		Bitumin treated	Crushed Stone	Sandy Gravel	Sand		
PAVEMENT COMPOSITION (mm)	Motorway (Standard Section)	00+00 ～ 06+40	50	100	-	250	300	-	700	Subgrade replacement t=350mm
	High Gr. Water Section	06+40 ～ 12+00	50	100	270	-	-	-	420	
	Inside Box	08+20 ～ 10+10	50	100	170	-	-	-	220-700	Leveling layer 50-400mm, Drainage Layer t=100mm
	Aflao (Standard Section)	12+00 ～ 17+05	50	80		200	200			
	Akosombo Road	8+65 (7+06.090 ～ 14+95	50	80	-	150	200	-	480	Inside parenthesis is for Phase-1 (from box edge)
	Harbour Road	00+00 ～ 4+65 (6+70.197)	50	100	-	200	200	-	550	Inside parenthesis is for Phase-1(to box edge)
	Flyover	4+65 ～ 8+65	80	-	-	-	-	-	80	Including 40mm leveling layer
	Motorway-Akosombo		50	60	-	200	250	-	560	
	Intersection		50	50	-	200	250	-	550	ボックス上の舗装。橋梁同様8cm（表層＋レベリング）
	Service Road		70		-	100	100	-	270	

(4) Application of Modified Asphalt Concrete

1）Outline

Modified asphalt concrete is asphalt having high fluidity and abrasion produced by mixing straight asphalt with a polymer or rubber. In Japan, its commercial use begun in 1963.

In Ghana, PG 76 and PG 82 have been used recently. PG stands for Performance Grade, which is a standard defined by Superpave (Superior Performance Pavement) and proposed in SHRP (Strategic Highway Research Program). PG 76 means that maximum surface temperature to assure flexibility and stress-relaxation is 76 degrees Centigrade regardless of area or season.

2）Application in the Project

Modified asphalt concrete is planned to be provided on the wearing course at main carriageway and ramps including the intersection. However, this will not be provided on service roads.

3）Justification for Application of Modified Asphalt Concrete

A) Application at Intersection

Since the objective intersection is located on the international corridor, the intersection is expected to see significant rise in the number of heavy vehicles in the future. With the on-going expansion project at Tema Port, it is expected that freight vehicle to and from the port will also increase. The pavements on existing roads are seen to be in a deteriorated state even under the present traffic volume. Typical deteriorations found on the roads in an around Tema Roundabout are shown in **Table 2.2.2-28**. Major causes of these defects are rapid

acceleration/deceleration and curved path of heavy traffic at low speed.

Table 2.2.2-28 Typical Defects

		
Alligator Crack	Deformation	Pothole

Also, all the left-turning ramps and through lanes on north-south direction meet at the intersection which is located on top of the box culvert at the depressed section (east-west direction). As such, the pavement here is anticipated to experience distress, which could have adverse effect on the box culvert (top slab).

B) Application on Main Carriageway and Ramps

Due to improvement of the intersection, driving speed on Motorway – Aflao Road will drastically rise (it is high even at present). However, driving speed could occasionally reduce depending on the traffic conditions. Slow movement of vehicles inflicts bigger damages to the pavement surface possibly leading into rutting. Rutting can pose immense danger to vehicles driving at high speeds, especially, since the horizontal alignment of the depressed and underpass has a combination of opposite curves (S-shaped curve). Bad visibility in association with deformations caused by partial load applied due to superelevation could be adverse factors that affect traffic safety. Also, stagnation of rainfall water at rutted portions might also cause severe traffic accidents.

On the other hand, ramps are sections where rapid acceleration/deceleration is repeated and its horizontal curve radius is relatively small. In the curve section, deformation and rutting caused by partial load applied on the surface is likely to occur. Also, traffic congestions on ramps can easily occur because of its smaller width and could potentially become bottle necks. On the main carriageway also, there is the possibility of traffic accidents to occur due to rutting.

4）Availability and Applicability of Modified Asphalt Concrete

A) Production

For the application of modified asphalt concrete in this project, an admixture, which will be procured in Japan and transported to the site, is planned to be used for modifying the asphalt. The hearings conducted with the manufacturers regarding applicability have revealed the followings;

- Local asphalt plants have experience of producing modified asphalt concrete.
- Local plants apply batch type plant (use of admixture for plant mix type is possible).

・ The nearest plant is in a distance of around 8kilometers from the project site.

B) Performance

Modified asphalt concrete types commonly used in Japan are classified into Performance Grade 64 (PG64) and PG 70. The figures indicate the maximum surface temperature where performance ability of the material is endorsed. The surface temperatures on the existing roads the Survey Team had measured are shown in **Table 2.2.2-29**. The temperatures measured are all below 64 degrees Centigrade and is favorable for application of modified asphalt concrete.

Table 2.2.2-29 Surface Temperature Survey Result

Time	Motorway		Aflao Road		Harbour Road		Akosombo Road	
	Concrete (Roundabout)	Concrete (Standard)	Concrete (Roundabout)	Asphalt	Concrete (Roundabout)	Asphalt	Concrete (Roundabout)	Asphalt
10:00-10:30	46.8℃	47.4℃	49.3℃	49.3℃	48.8℃	49.9℃	48.4℃	48.2℃
12:00-12:30	55.2℃	55.2℃	53.1℃	53.9℃	54.1℃	56.1℃	52.6℃	56.0℃
14:00-14:30	52.4℃	53.0℃	53.4℃	53.2℃	52.0℃	56.0℃	51.0℃	53.1℃
16:00-16:30	47.3℃	46.3℃	47.2℃	48.4℃	48.6℃	48.5℃	45.3℃	46.4℃

C) Quality Control Test

According to the information gathered from hearings conducted, there are no organizations or companies which are capable of doing a quality control test. Thus, the tests such as wheel tracking test for modified asphalt concrete is conducted in Denmark or South Africa by exporting asphaltic material. Since it is possible to transport the material overseas, the test can be done in Japan also.

5) Countermeasures to Groundwater

6) Outline

Groundwater can have adverse effects on the pavement in the depressed and underpass section. Although the pavement has a less chance of being affected by the groundwater from behind the retaining walls, risk of damages from the water infiltrating into the pavement due to piping phenomenon caused by the head water difference is relatively high. This issue should be properly addressed in order to mitigate or prevent the deterioration of the pavement.

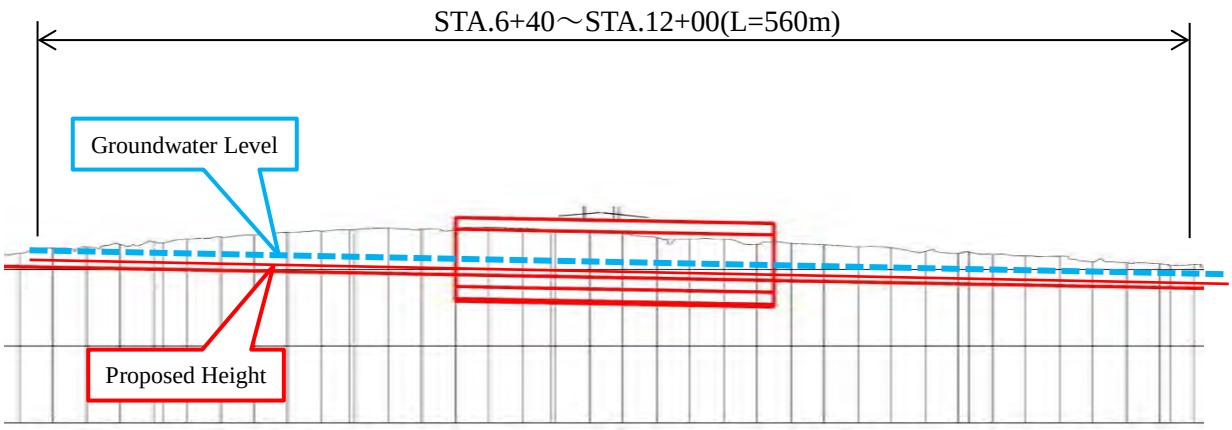


Figure 2.2.2-30 Area to be Considered Countermeasures

7） Countermeasure Plan

A) Provision of Underground Drainage Pipe

In order to adequately drain the water seaping under the pavement due to pressurization caused by water head difference, underground drainage facility with perforated drain pipes having a diameter of 200mm and surrounded by crushed stones and non-woven fabrics as shown in **Figure 2.2.2-31** shall be provided. The locations to be provided are shown in **Figure 2.2.2-32** and **Figure 2.2.2-33**.

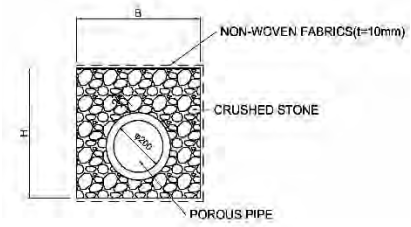


Figure 2.2.2-31 Underground Drainage Pipe

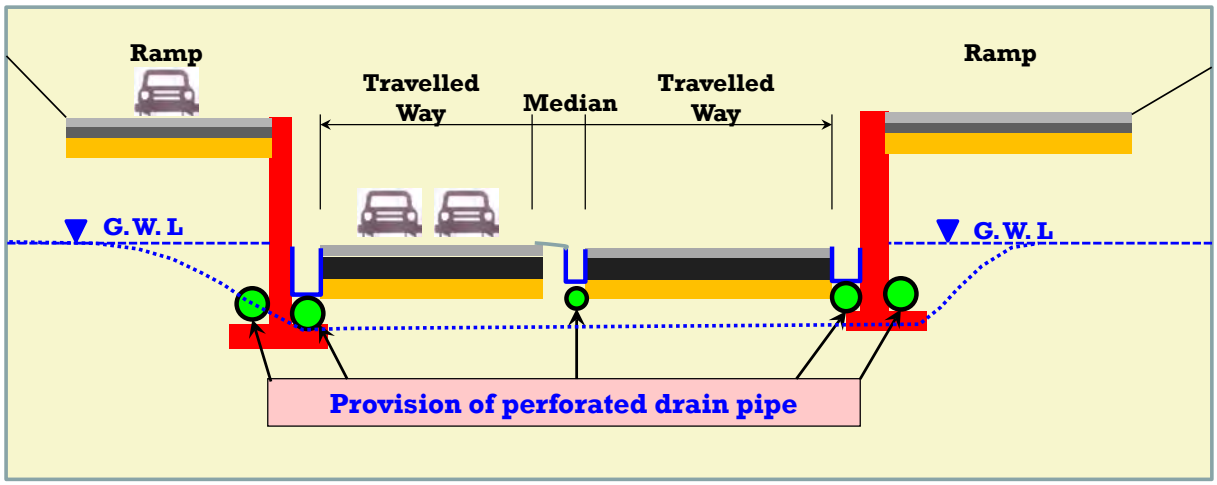


Figure 2.2.2-32 Underground Drainage Pipe Layout in Depressed Section

B) Application of Asphalt Stabilized Material

To prevent damage to the base course of the pavement from piping, asphalt stabilized material having high resistivity and perforated pipes will be applied. The locations where the perforated drain pipes are planned to be provided is shown in **Figure 2.2.2-33** or **Figure 2.2.2-35**.

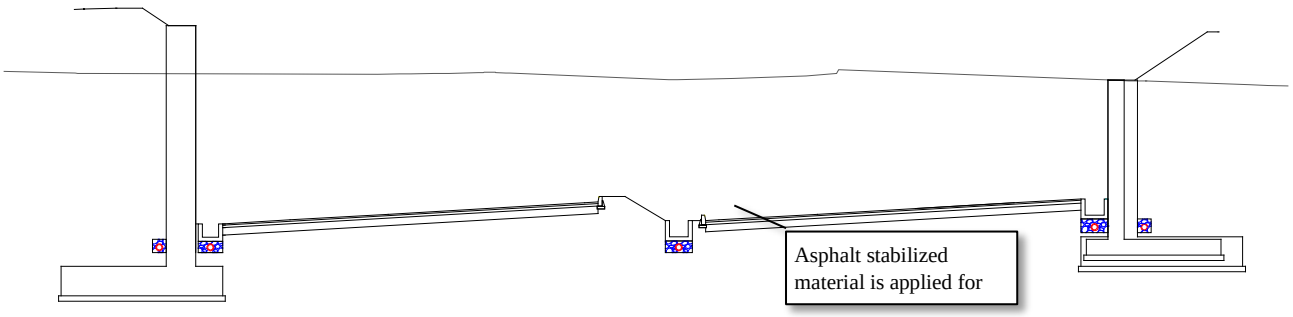


Figure 2.2.2-33 Typical Cross Section in Depressed Section

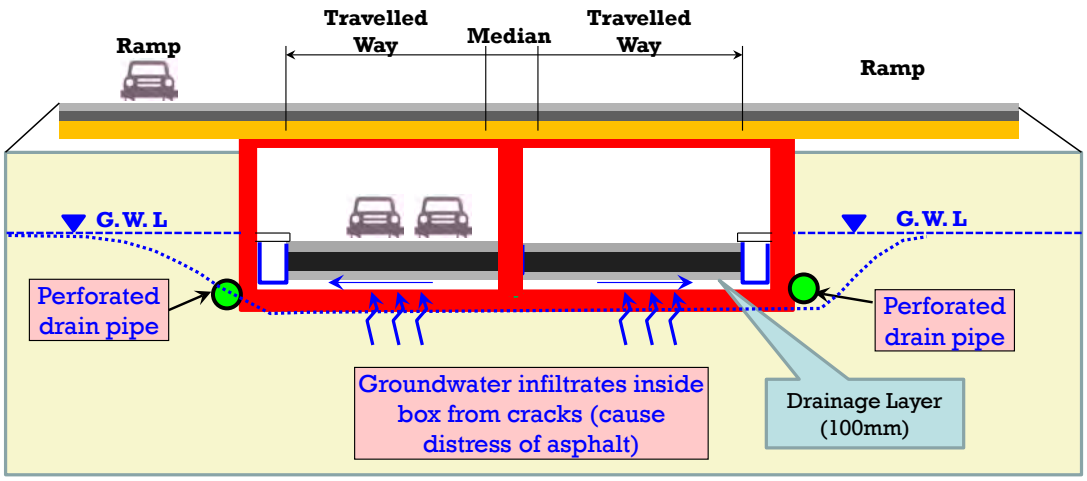


Figure 2.2.2-34 Underground Drainage Pipe Layout in BOX Culvert Section

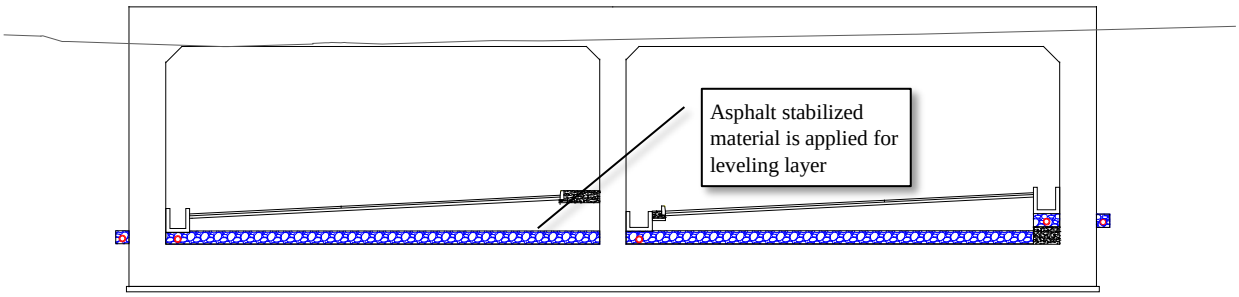


Figure 2.2.2-35 Typical Cross Section in Depressed Section

2.2.2.5 Drainage Plan

(1) Basic Policies

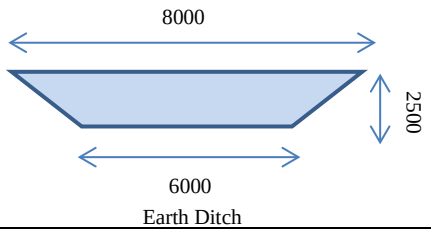
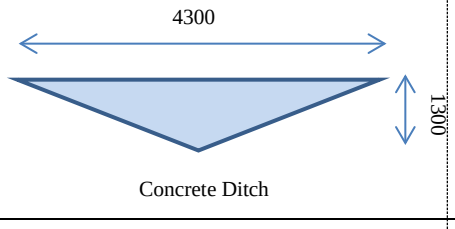
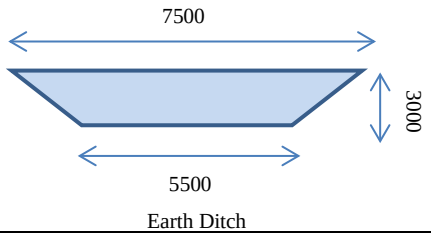
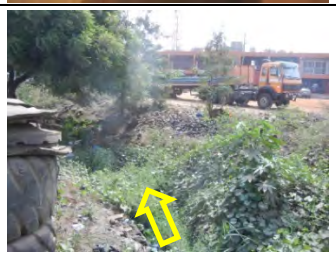
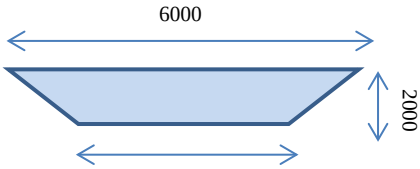
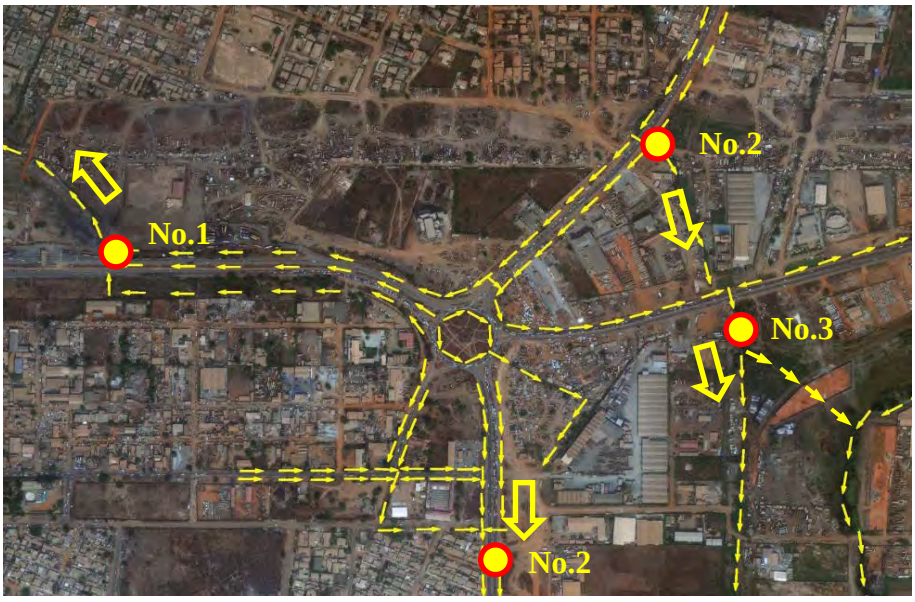
The following basic policies are set.

- Planned drainage system shall follow the existing system as much as possible, and drained at existing outlets (river or channel),
- Existing V-shape ditches and other drainage facilities that would be affected by the project will be replaced. Similar type with similar dimension will be provided,
- Catch basins shall be installed at connecting points of U-ditches and between U-ditches and cross-drainage facilities.

(2) Drainage Outlets

Surface water collected is transported and drained out in one of the outlet facilities listed in **Table 2.2.2-30**.

Table 2.2.2-30 Drainage Outlets

No.	Road/ Location	Description	Photo
1	Motorway (north side)		
2	Harbour Road (south side)		
3	Akosombo Road (north side)		
4	Aflao Road (south side)		
			

(3) Design Condition

1）Applied Parameters

Following parameters shall be applied in accordance with Road Design Guide (GHA, March

1991).

- Rainfall Intensity: 127mm/h
- Frequency of Occurrence: 5 years
- Run-off Coefficient: 0.9
- Coefficient of Roughness of Drainage Facility: 0.015

2）Design Flow

Design flow shall follow the method prescribed in Road Design Guide (GHA, March 1991) in **Figure 2.2.2-36** and **Figure 2.2.2-37**.

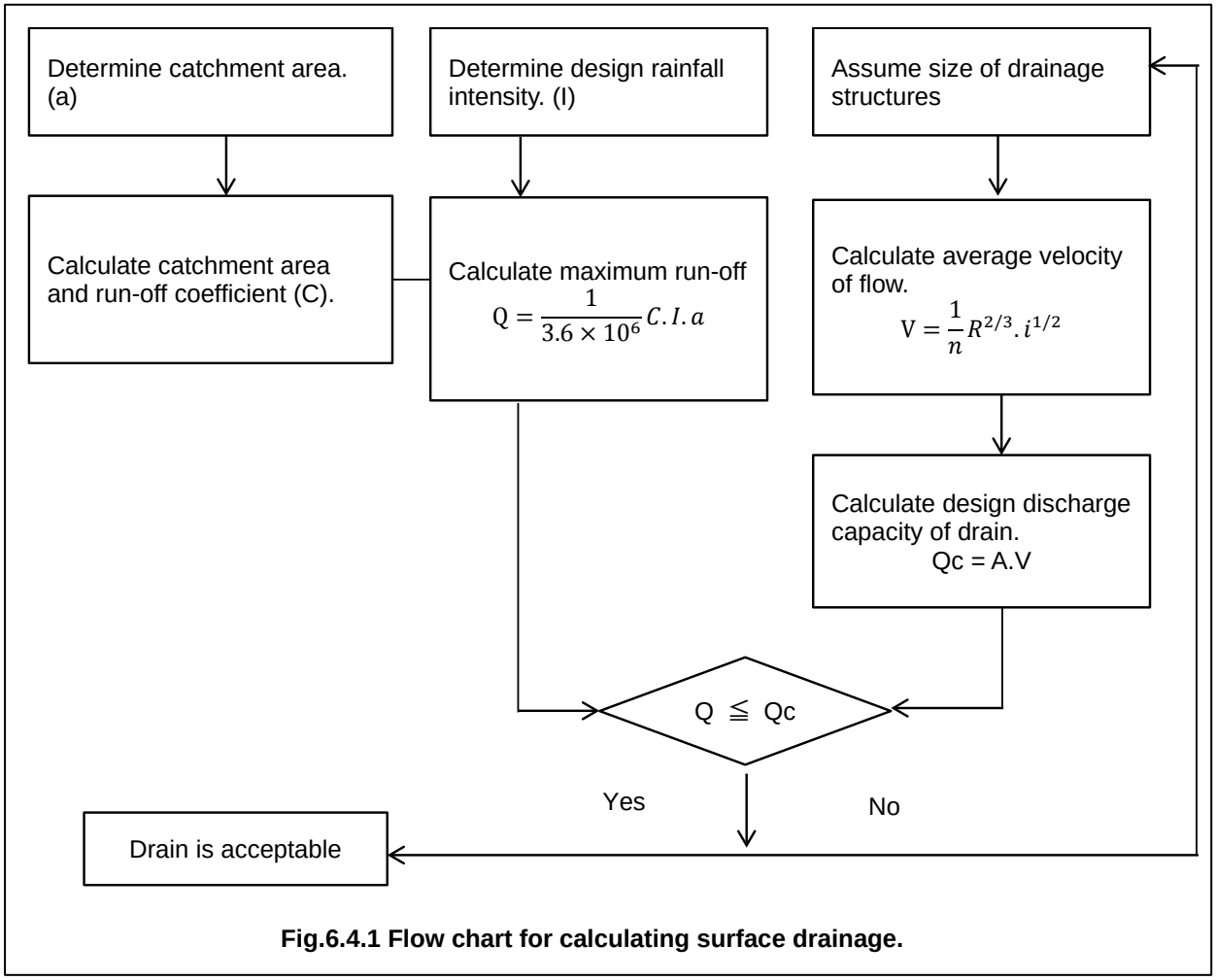


Fig.6.4.1 Flow chart for calculating surface drainage.

Figure 2.2.2-36 Design Flow

The maximum run-off is obtained from following equation.

$$Q = \frac{1}{3.6 \times 10^6} C.I.a$$

or

$$Q = \frac{1}{3.6} C.I.A \quad \cdots\cdots (6\text{-}1)$$

Q; Maximum run-off from the catchment area (m^3/sec).

C; Run-off coefficient (a coefficient which represents ratio of run-off to rainfall).

I; Average rainfall intensity (mm/h).

Figure 2.2.2-37 Calculating Formula of Run-off

3) Drainage System

Figure 2.2.2-38 gives the general layout of the drainage system. Rainwater on the road surface is conveyed to one of the four outputs; one on each leg. The type of drainage facility and its dimension are calculated using the methods explained hereabove. The calculation and the results are attached in Appendix-5.

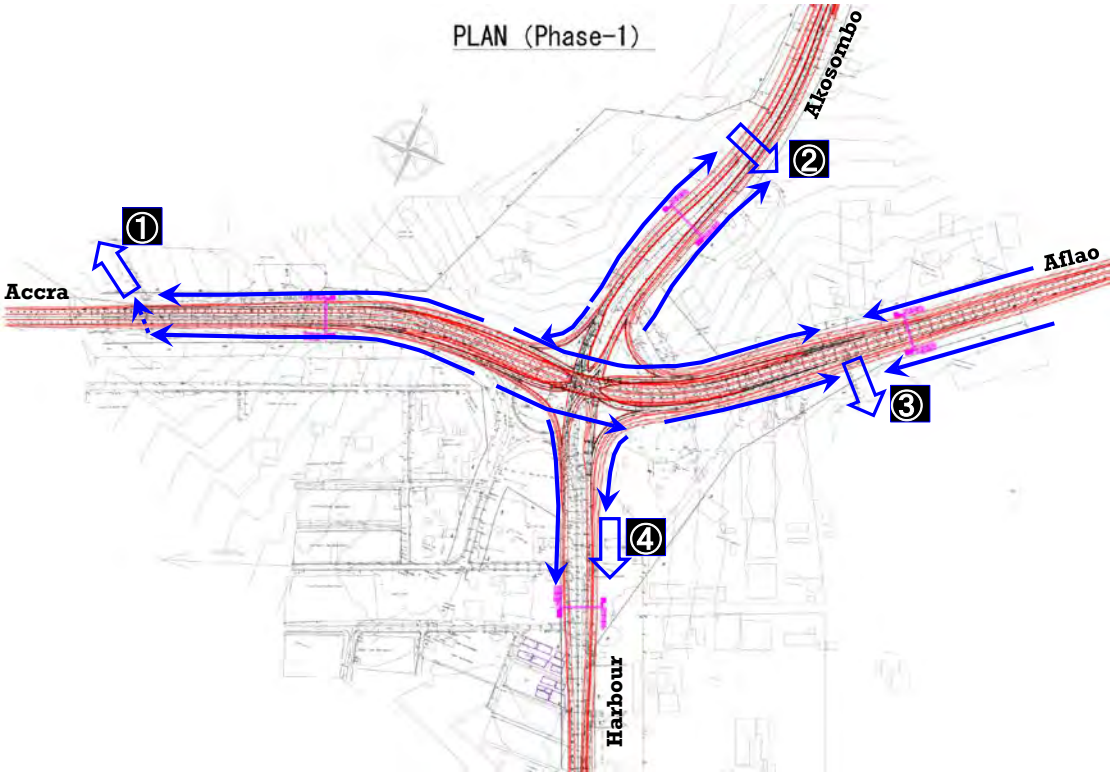


Figure 2.2.2-38 Drainage Plan

2.2.2.6 Street Lightning Plan

(1) Basic Policies

Provision of lights along the roads is not included in this project. However, lightning is planned to be

provided inside the box culvert at the underpass. The proposed box culvert section is about 190m long and being positioned in the S-curve segment, provision of street lightning is important to secure safety for traffic within that section.

The layout of the lights was determined following illuminance distribution calculation.

Provision of the facility including electric cables to connect to lead-in pole is covered by the project. However, connection to the grid and power supply to the distribution board would be the responsibility of GHA as agreed upon in T/N.

(2) Selection of Lamp

A list of lamp types is presented in **Table 2.2.2-31**. Use of LED (Light Emitting Diode) is recently common in Ghana. Therefore, although the initial cost is higher compared to other lamps, it is desirable to provide LED for as;

- The efficiency and ability to endurance is higher
- It is stable against temperature fluctuation
- It provides proper light color and color rendering properties
- It provides good visual performance and induction effect against car fumes and fog.

Table 2.2.2-31 Type of Lamp and Characteristics

Type of Lamp		Color	Color Rendering Properties	Influenced by Temperature		Dimming	Instant Re-Start
				Efficiency	Start		
High-pressure sodium vapor lamp	With incorporated starter	Pale yellow	Fair	No	No	Gradual dimming	No
	With mouthpieces	White				Gradual dimming	Yes
Fluorescent lamp	For exclusive used as high-frequency lighting, straight tube lump	White	Good	Yes	Yes	Continuous dimming	Yes
	For exclusive use as high-frequency lighting, double tube lamp	White	Good	Yes	Yes	Continuous dimming	Yes
	For exclusive use as high-frequency lighting, electrode-less	White	Good	Yes	Yes	Gradual dimming	Yes
	For rapid-start lamp	White	Good	Yes	Yes	Continuous dimming	Yes
Metal halide lamp	For low starting voltage	White	Good	No	No	No	No
Ceramic metal halide lamp		White	Good	No	Yes	*	*
Fluorescent mercury lamp		White	Good	No	No	Gradual dimming	No
Low pressure sodium lamp		Orange	Bad	No	No	No	Yes
LED (Light Emitting Diode)		White	Good	Yes	Yes	Gradual & continuous dimming	Yes

* Metal halide lamp has both “Yes” and “No” in dimming and instant start.
Source: Road Lightning Installation Guidelines and Explanation, Japan Road Association

(3) Design Condition

Design conditions of lights inside the box culvert are shown in **Table 2.2.2-32**.

Table 2.2.2-32 Design Conditions

Design Speed	100km/h
Light source of lightning for Snow Shed inside	LED
Pavement	Asphalt Concrete
Conversion factor of average illuminance	K=18(lx/cd/m2)
Road width	W=16.45(m)
Maintenance factor	M=0.65
Average illuminance	20 (lx) or more

(4) Lamp Layout

For cost-effectiveness, the lamps will be arranged in a staggered manner, and the lamps shall be installed on top of inner and side wall of the box culvert in 45 degree.

(5) Illuminance Distribution

Illuminance distribution was calculated. The results are shown in **Table 2.2.2-33** and **Figure 2.2.2-39**.

Table 2.2.2-33 Calculation Result

	CULVERT 1	CULVERT 2
AVERAGE ILLUMINANCE (lx)	21.2 > 20 [OK]	20.6 > 20 [OK]
CONVERSION LUMINANCE (cd/m²)	1.17	1.14

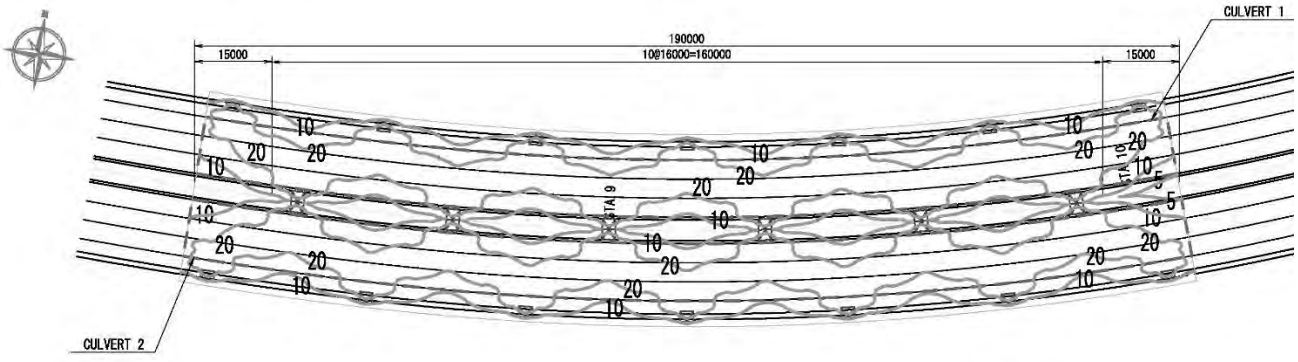


Figure 2.2.2-39 Illuminance Distribution

(6) Layout Plan

Figure 2.2.2-40 illustrates the layout plan of the lamps.

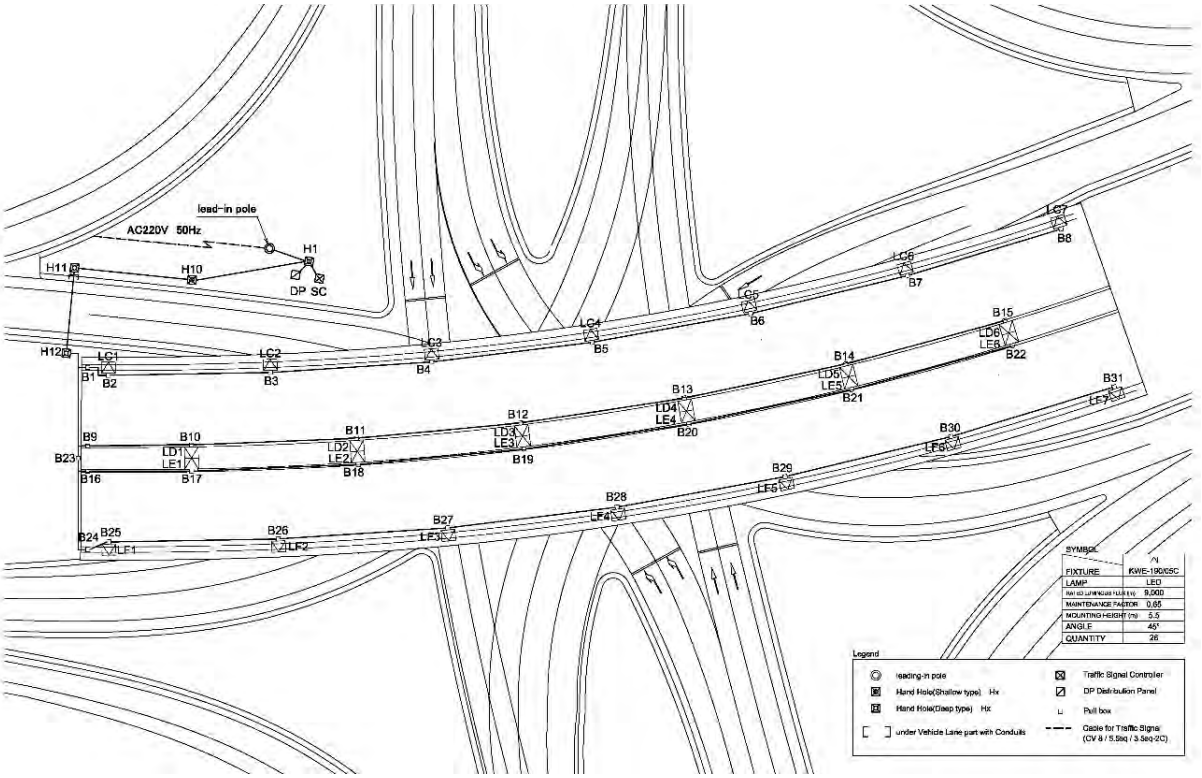


Figure 2.2.2-40 Street Lighting Layout Plan

2.2.2.7 Traffic Safety Facility Plan

(1) Basic Policy

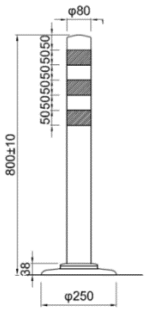
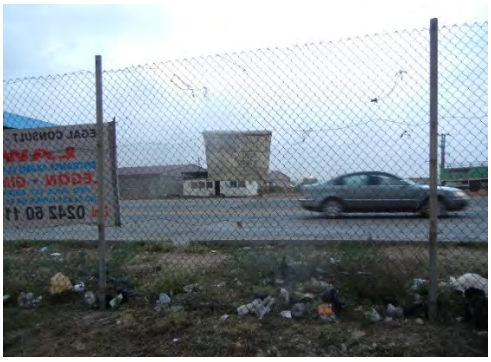
Basic policies for planning traffic safety facilities are outlined below.

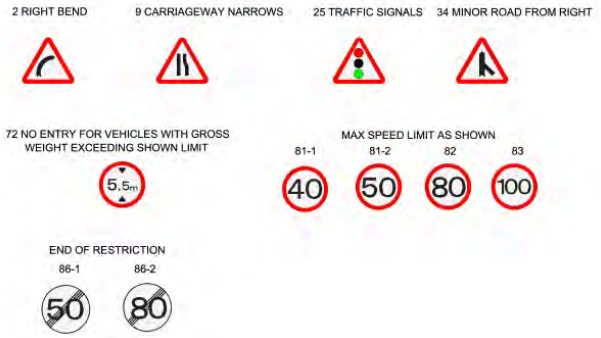
- To prevent traffic from erroneously approaching a median and for proper visibility of the median to drivers, a reflector shall be installed along the median.
- Reflector shall be installed where drainage exists outside of shoulder.
- Reflector shall be installed at merging and diverging sections of ramp terminal and along curve sections of ramps.
- Crash barrier shall be installed at sections where height differences exceed 3 meters.
- Crash barrier shall be installed at the inner shoulder of box culvert in order to prevent vehicles from crashing against the inner wall.
- Cushion drum shall be installed at diverging points of ramp nose in order for impact relaxation at the time of crashing.
- Guard fence shall be installed in borders between ramps and service roads.
- Traffic sign for attracting attention of a driver shall be installed accordingly.

(2) Applied Traffic Safety Facilities

The facilities that are to be provided along with its image and the sections to be provided are given in **Table 2.2.2-34**.

Table 2.2.2-34 Applied Traffic Safety Facility

No.	Facility	Image	Section to be Provided
1	Reflector	 	● Both side of Median ● Border between ramp and service road ● Merge and diverge section ● Curve section on ramp
2	Crash Barrier		● Over 3 meter height difference ● Inner wall in BOX culvert
3	Cushion Drum		● Diverging Point at ramp nose
4	Guard Fence		● Border between a ramp and a service road

No.	Facility	Image	Section to be Provided
5	Traffic Sign		● Where appropriate

2.2.2.8 Considerations for Pedestrians (Pre-improvement Function Recovery)

(1) Basic Policies

It is important that the existing facilities/services for use of pedestrian should be recovered/compensated after improvement. In this context, service roads and footbridges are planned to be provided. Basic policies for provision of these facilities are as follows;

- Pedestrian shall not be allowed to cross the road through the intersection after improvement,
- Service roads to facilitate access to and from abutting properties shall be planned. Service roads shall be provided at locations agreed upon with GHA in the T/N,
- Footbridges shall be provided on all four legs of the intersection to facilitate crossing roads for pedestrians without interrupting the traffics.

(2) Service Roads

1）Design Conditions

Design conditions of service roads are shown in **Table 2.2.2-35**.

Table 2.2.2-35 Design Conditions of Service Road

Item	Applied
Design Speed	40km/h
Width of Carriageway	3.0m
Width of Shoulders	1.5m (Both side)
Crossfall	2.5%
Max. Superelevation	6.0%
Max. Vertical Gradient	6.0%
Pavement Structure	Asphalt Concrete (See ‘2.2.2.4 Pavement Plan’ about thickness)

2）Provision Area

Service roads are planned at areas shown by red lines in **Figure 2.2.2-41**. The area or the scope of service roads was determined with discussions with GHA.

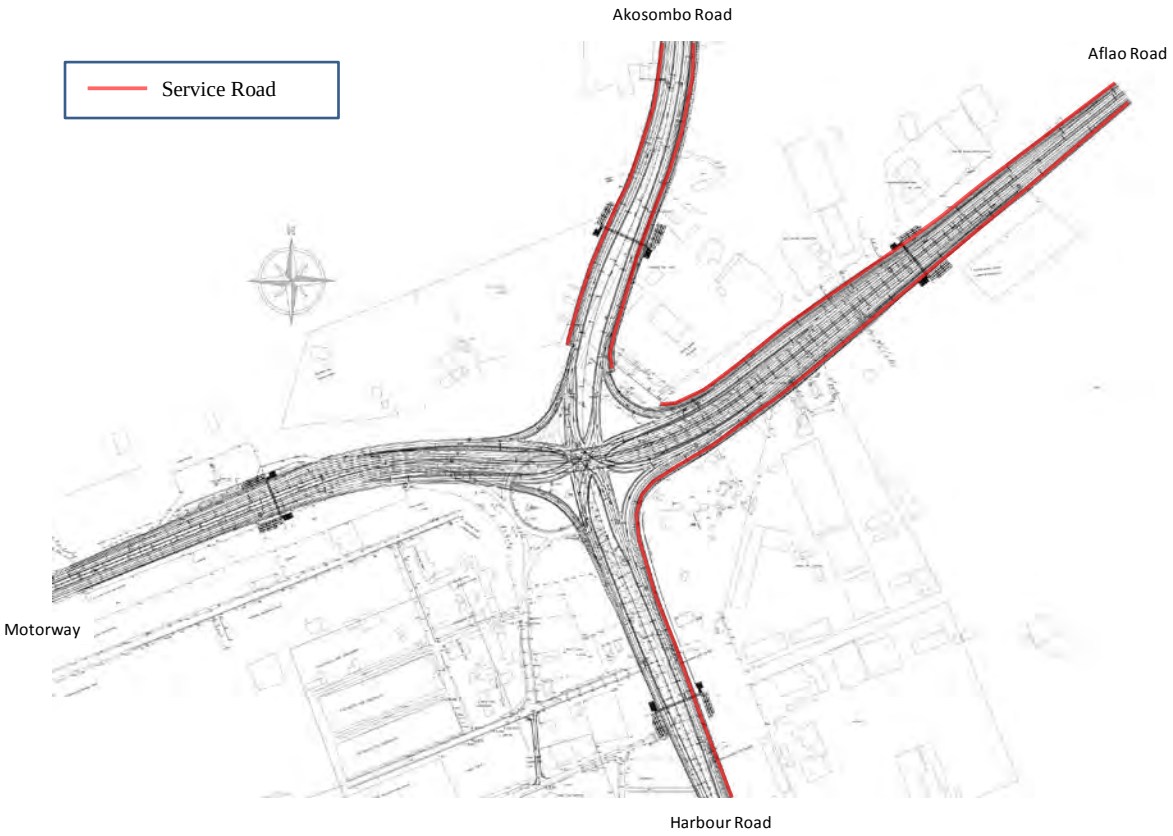


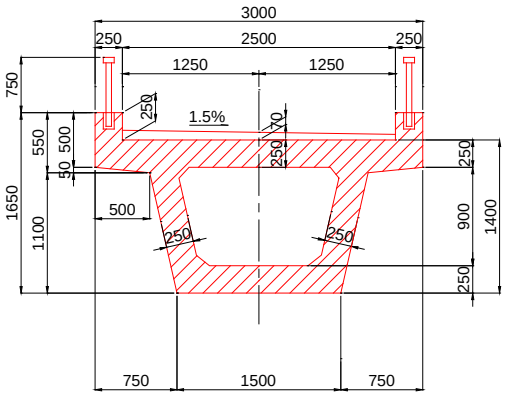
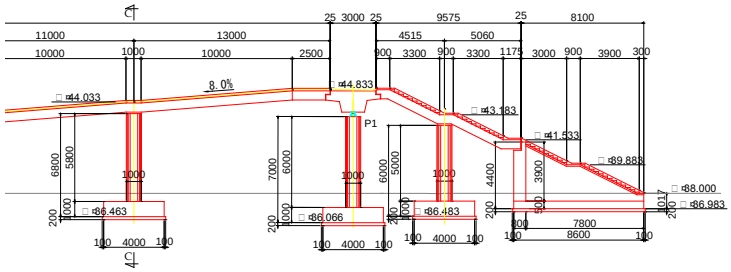
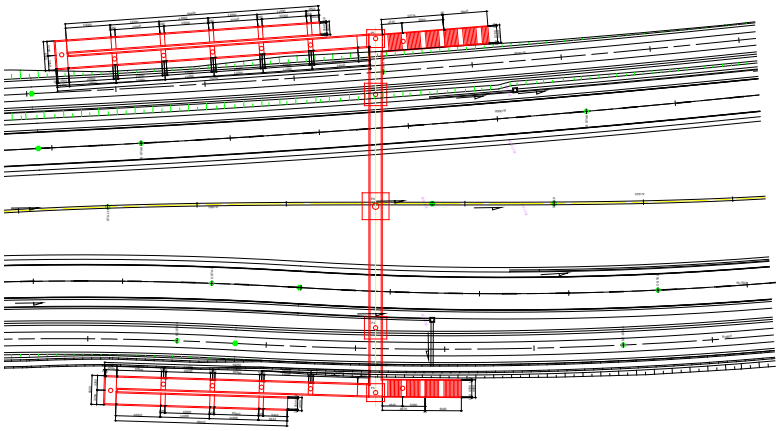
Figure 2.2.2-41 Service Road Plan

(3) Footbridges

1）Application of GHA Standard Drawing

Footbridges shall be designed in reference with the standard drawings of GHA. Footbridges are planned to be provided on all four legs of the intersection. However, the outline design is conducted only for the footbridge at Harbor Road (Sta. 10+40). The design for each footbridge will be carried out during the detailed design stage. The outline of the footbridge is summarized in **Table 2.2.2-36** .

Table 2.2.2-36 Footbridge Outline

Item	Description
Material	Reinforced Concrete
Superstructure	
Step and Slope	
Max. Gradient of Slope	8.0%
Plan	

2） Locations

Figure 2.2.2-42 shows locations of footbridge to be provided. The design for footbridges on other legs of the intersection will be done individually during the D/D stage.

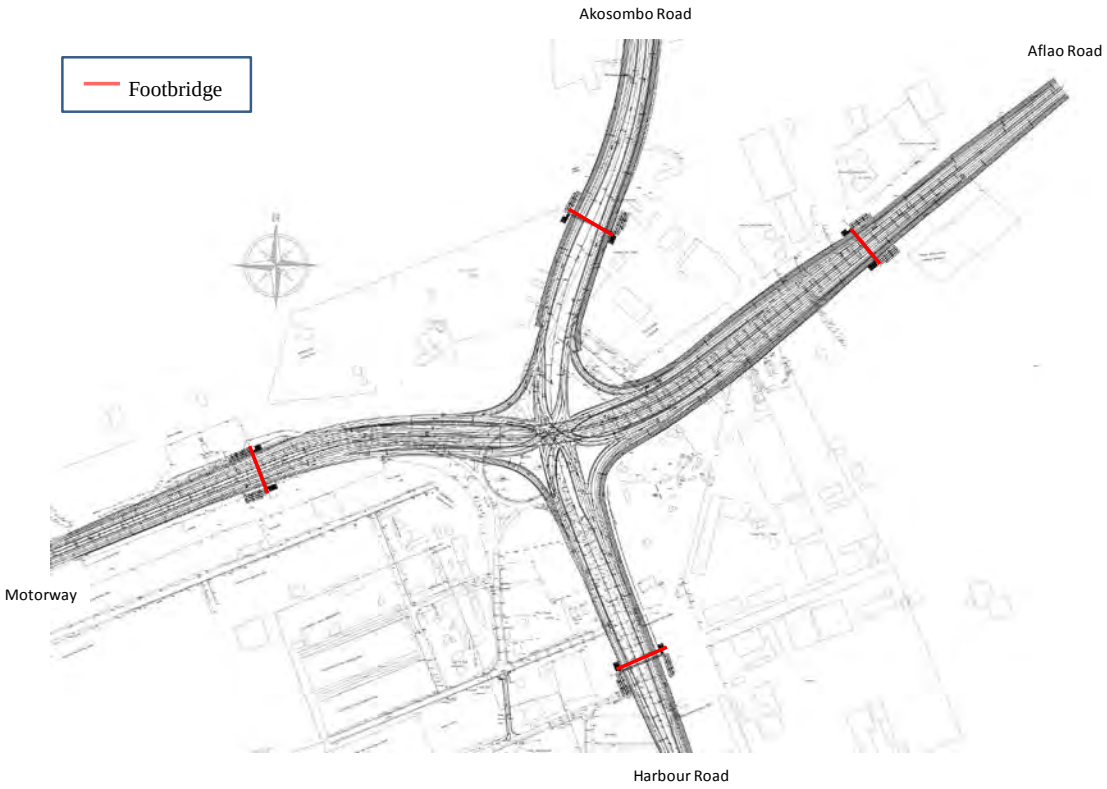


Figure 2.2.2-42 Footbridge Layout

2.2.3 Outline Design Drawing

(1) Plan Overview

Plan overview is shown in **Figure 2.2.3-1**.

Figure 2.2.3-1 Plan Overview

(2) Outline Design Drawing

Outline Design Drawing is attached in Appendix-6 and its table of contents is shown in **Table 2.2.3-1**. In the drawing, cross section except depressed / underpass section of main carriageway and profile / cross section of ramps are omitted.

Table 2.2.3-1 Table of Contents

No.	DRAWING TITLE	SHEET NO.	No. of Sheets
1.	GENERAL	GN - 01 ～ 04	4
	PROJECT LOCATION MAP	GN - 01	1
	KEY PLAN	GN - 02 ～ 04	3
2.	TYPICAL CROSS SECTIONS	TP - 01 ～ 04	4
3.	PLAN	PL - 01 ～ 18	18
4	INTERSECTION PLAN	IP - 01	1
5	PROFILE	PR - 01 ～ 24	24
6	CROSS SECTION	CS - 01 ～ 105	105
7	OUTLINE OF STRUCTURES ALONG MOTORWAY-AFLAO ROAD (UNDERPASS)	US - 01 ～ 07	7
	GENERAL DRAWINGS	US - 01 ～ 03	3
	STRUCTURE OF CULVERT	US - 04 ～ 05	2
	STRUCTURE OF RETAINING WALLS	US - 06 ～ 07	2
8	OUTLINE OF PEDESTRIAN BRIDGES	PB - 01 ～ 3	3
9.	OUTLINE OF PAVEMENT STRUCTURE	PS - 01	1
10	DRAINAGE PLAN	DP - 01 ～ 18	18
11	OUTLINE OF DRAINAGE STRUCTURES	DR - 01 ～ 04	4
	SIDE DITCH	DR - 01	1
	CROSS DRAINAGE	DR - 02	1
	CATCH BASIN AND UNDERGROUND DRAINAGE	DR - 03	1
	DISTRIBUTION WATERWAY	DR - 04	1
12	OUTLINE OF ROAD ANCILLARIES	RA - 01 ～ 36	38
	ANCILLARY PLAN	RA - 01 ～ 18	18
	LAYOUT OF REFLECTORS	RA - 19 ～ 25	7
	LAYOUT OF TRAFFIC SIGNS	RA - 26 ～ 32	7
	MEDIAN BLOCK, KERB AND EDGE BLOCK (FLUSH KERB)	RA - 33	1
	CRASH BARRIER AND REFLECCTORS	RA - 34	1
	CROSS PREVENTION FENCE	RA - 35	1
	TYPICAL TRAFFIC SIGNS	RA - 36	1
	PAVEMENT MARKINGS	RA - 37 ～ 38	2
13	TRAFFIC SAFETY FACILITIES	TS - 01 ～ 13	10
	LAYOUT OF TRAFFIC SIGNAL	TS - 01	1
	WIRING SYSTEM OF TRAFFIC SIGNAL	TS - 02	1
	DETAIL OF TRAFFIC SIGNAL	TS - 03 ～ 06	4
	LAYOUT OF STREET LIGHT (UNDERPASS)	TS - 07	1
	WIRING SYSTEM OF STREET LIGHT (UNDERPASS)	TS - 08	1
	DETAIL OF STREET LIGHT (UNDERPASS)	TS - 09	1
	DETAIL OF CABLES AND HAND HOLE	TS - 10	1
Subtotal (number of sheets)			237

< REFERENCE DRAWINGS >			
1.	GENERAL DRAWING OF FLYOVER SECTION (PHASE-2)	RF - 01 ~ 03	3
2.	INTERSECTION PLAN (PHASE-2)	RF - 04 05	2
3.	TEMPORARY DETOUR DURING CONSTRUCTION	RF - 06 ~ 08	3
Total number of sheets			245

2.2.4 Implementation Plan

2.2.4.1 Implementation Policies

The basic policies for implementation of the project are as follows:

- This project will be implemented under the Grant Aid Scheme of the Government of Japan (GOJ) in accordance with the Grant Agreement (G/A) and the Exchange of Notes (E/N) between the Republic of Ghana and the GOJ.
- The executing agency for the implementation of the project is the Ghana Highway Authority (GHA) of the Republic of Ghana.
- The consulting services including detailed design, tender-related works and construction supervision services, will be provided by a Japanese consulting firm in accordance with the consultancy contract that shall be signed with the Republic of Ghana.
- The construction works will be executed by a Japanese construction firm that shall be selected through pre-qualification and bidding, in accordance with the construction work contract that shall be signed between the said construction firm and the Republic of Ghana.
- The basic policies for the construction/procurement of this project are as follows:
  - The equipment, materials and labor for construction shall be, to the possible extent, procured locally. In cases where local procurement is not possible, they shall be procured either from a third country or from Japan where it is most economical provided the required quality and supply quantity are secured.
  - Construction methods and the construction processes shall be adequately determined taking the local climate, topography, geology and natural conditions including the characteristics of nearby rivers into consideration.
  - The contractor's site organization shall be planned to satisfy the established construction specifications and construction management standards set for this project. Likewise, the consultant's organization shall be based on such specified project management standards.
  - To ensure safety during construction, an appropriate traffic management plan including deployment of traffic personnel at vantage positions shall be considered.
  - In order to reduce the influence of construction works on the environment of the project site, appropriate/necessary environmental preservation measures, such as the selection of temporary garbage dumping sites specified by the Republic of Ghana shall be adopted.

2.2.4.2 Implementation Condition

(1) Points to Be Considered during Implementation

Approximately 23,000 to 32,000 vehicles ply the objective intersection daily and is therefore not reasonable to block the roads during construction. Therefore, construction methods which does not hinder existing traffic operations and in addition ensure the security of the traffic operations must be adopted.

(2) Detour Plan during Construction

1) Basic Policy

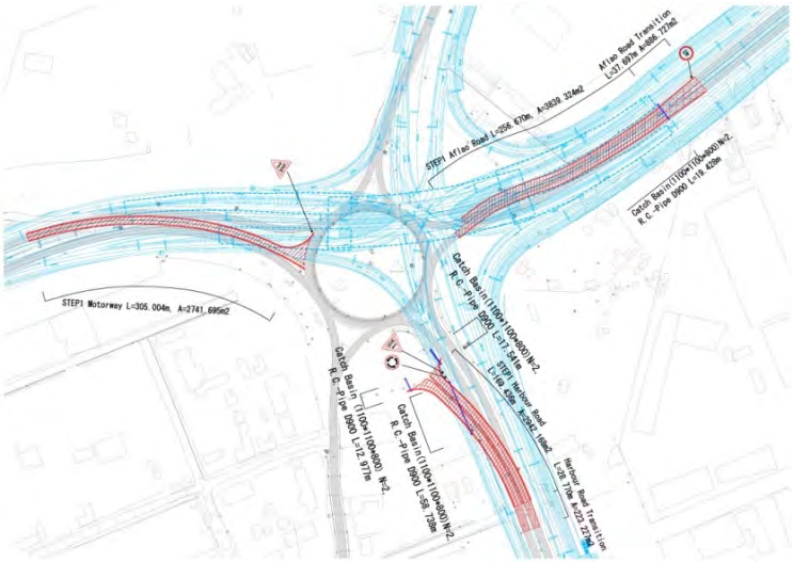
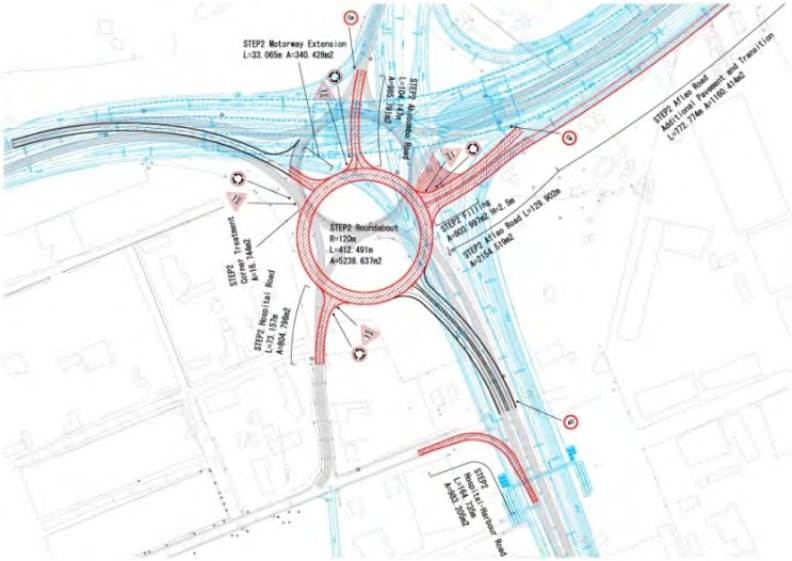
Basic policies are shown below.

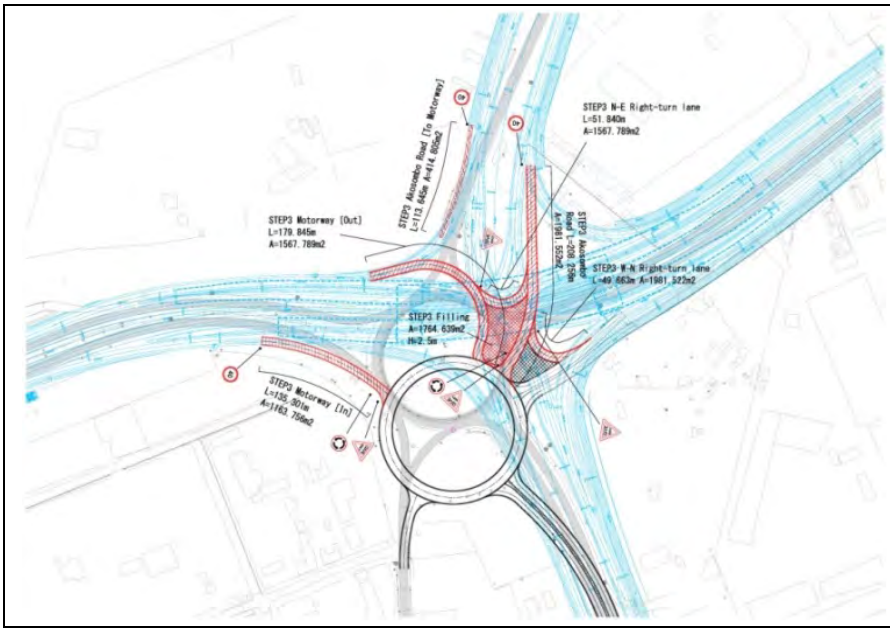
- Number of carriage lanes and lane widths of the detour shall be equivalent to the number of the existing traffic lanes,
- Size of temporary roundabout shall be equivalent to the size of the existing roundabout,
- Volume of rework shall be minimized by utilizing the permanent (completed) roads as the temporary detour,
- Detours shall be planned by considering soil volume balance in addition to above policies.

2) Conditions

- Design speed of the detours shall be 40km/h,
- All geometric conditions (alignment requirements) will comply for the above design speed,

3) Detour Plan and Step-wise Construction

	STEP 1 ・ Construction work under present condition ensuring an Existing traffic lane
	STEP 2 ・ Construction work of East-side part of BOX Culvert



STEP 3
- Construction work of West-side part of BOX Culvert

Figure 2.2.4-1 Detour Plan

2.2.4.3 Scope of Works

The responsibilities to be borne by Japan and the Republic of Ghana are summarized in **Table 2.2.4-1**.

Table 2.2.4-1 Responsibility of Each Government

Items	Contents/Requirements	Responsible Country		Remarks
		Japan	Ghana	
Land acquisition	Procurement before construction		○	
Weigh station	Relocation before construction		○	
Electric power for traffic signal and street lighting	Power supply		○	
Procurement	Materials and equipment		○	Specific material will be procured from Japan.
	Customs clearance	○	○	
Land provision	Land Acquisition necessary for construction		○	Project Office, Accommodation Construction Yard
	Other than above	○		
Removal/Relocation of utilities	Relocation of Obstruction		○	Water pipe, electric cable, communication cable, sign board
Main Construction	Road, box culvert, retaining wall and traffic safety facility	○		

2.2.4.4 Procurement and Construction Supervision

Basically, the government of Ghana will select a Japanese Consultant for assisting the executing agency in the contractor bidding process and for rendering construction supervision service of the project.

(1) Detailed Design

The major works to be carried out by the Consultant during the detailed design stage include the followings:

- Undertake consultations with concerned authorities of Ghana and carry out field surveys,

- Carry out detailed design and prepare design drawings
- Estimate project cost

The duration of the detailed design is about 5 months.

(2) Bidding Process

The major tasks to be undertaken between the time of inviting contractors to bid and the time for signing of contract for construction includes:

- Preparation of bid documents (in parallel with the detailed design).
- Bid announcement
- Pre-qualification of bidders
- Bidding
- Evaluation of bid documents
- Preparation of Contract Agreement

The duration of the bid-related activities is about 4 months.

(3) Construction Supervision

The Consultant will supervise the Contractor's planning and implementation of the construction contract. The major tasks under this stage include:

- Verification/Approval of related surveys and quantities
- Review/Approval construction plans
- Quality Control
- Process Control
- Work Output Control
- Safety Management
- Turnover Inspection and Acceptance

The duration of construction supervision is approximately 28 months. The construction supervision team shall consist of: 1-Resident/Chief Engineer (Japanese), 1-Site Inspectors (Local), 1-Clerk of Works (Local) and 1-Utility Personnel (Local). A construction supervision engineer would be dispatched at the time of construction of structural components and asphalt pavement.

A safety control officer is necessary to supervise, direct and cooperate with a contractor's safety manager so that occurrence of an accident may be prevented.

2.2.4.5 Quality Control Plan

The tasks to be carried out for quality control during the construction period are as follows:

- Concrete Works
- Reinforcing Bars and Formworks
- Earthwork
- Pavement Works

Based on the above, the quality control of main items for concrete works is presented in **Table 2.2.4-2** while the quality control of main items for pavement is presented in **Table 2.2.4-3**.

Table 2.2.4-2 Quality Control Plan of Concrete Works

Item	Test Items	Test Method	Test Frequency
Concrete	Cement Property/Physical Test	AASHTO M85	Once before trial mix and once every 500m^3 batch of concrete; or once during production of cement (Mill sheet)
Aggregate	Property/Physical Test	AASHTO M6	Once before trial mix and once every 500m^3 batch of concrete; and every change of source/quarry location (check supplier data)
	Property/Physical Test	AASHTO M80	Once before trial mix and once every 500m^3 batch of concrete; and every change of source/quarry location (check supplier data)
	Sieve Analysis	AASHTO T27	Once a month
	Alkali-silica Reactive Test(Mortar Bar Method)	ASTM C1260	Once before trial mix and every change of source/quarry location (check supplier data)
	Mineral Composition Test	ASTM C295	Once before trial mix and every change of source/quarry location (check supplier data)
Water	Water Quality Test	AASHTO T26	Once before trial mix and when necessary
ADMIXTURE	Quality Test	ASTM C494	Once before trial mix and when necessary (Mill Sheet)
Concrete	Slump Test	AASHTO T119	Once every 75m^3 or per batch
	Air Content Test	AASHTO T121	Once every 75m^3 or per batch
	Compressive Strength Test	AASHTO T22	6 Samples per batch or 6 samples for every 75m^3 of concrete (3 samples each for 7-day strength and 28-day strength)
	Temperature	ASTM C1064	Once every 75m^3 or per batch

Table 2.2.4-3 Quality Management Plan for Earthwork and Pavement Work

Item	Test Items	Test Method	Test Frequency
Embankment	Density Test (Compaction)	AASHTO T191	Every 500m^2
Base course	Material Test (Sieve Analysis)	AASHTO T27	Once before placing and once every 1,500m^3 or change in source/quarry location.
	Material Test (CBR Test)	AASHTO T193	Once before placing and once every 1,500m^3 or change in source/quarry location.
	Dry Density Test (Compaction)	AASHTO T180	Once before placing and twice every 1,500m^3 or change in source/quarry location.
	Field Density Test (Compaction)	AASHTO T191	Every 500m^2
Asphalt paving	Material Test (Sieve Analysis)	AASHTO M43,M80	Once before placing and once every 1,500m3 or change in source/quarry location.

Item	Test Items	Test Method	Test Frequency
	Material testing (density and percentage of absorption).	AASHTO T84	
	Density-in-situ examination.	AASHTO T209	Every 200m
	Temperature survey		Every track
Modified asphalt paving	Marshall stability test	ASTM D 1559-89	Design stage: Five samples every a mix, three pieces = 15 times Trial mix stage: : Three samples every a mix, three pieces= 9 times Paving stage: Once before placing
	Dynamic Stability Test	Measurement of Plastic Deformation by Wheel Tracking Machine	At Trial Mix: Once per 1 mix At Construction : Once per paving asphalt of 1,000 ton
	Other test	JIS	as may be necessary

2.2.4.6 Procurement Plan

The major construction materials and equipment to be procured, based on field research for procurement, are mentioned below.

(1) Procurement of Major Construction Materials

1）Procurement of Ready-mixed Concrete

Ready-mixed Concrete for the retaining wall and box culvert shall be procured from the local concrete plants (85m3 per hour) which are located in a distance of 19 km from construction site. shows the plant in production.

2）Procurement of Base and Subbase Materials

Base and subbase materials shall be procured from quarrying plant located at Shai Hill on Akosombo road.

Photo 2.2.4-2 shows the plant in production.

Photo 2.2.4-1 Concrete Plant in Production

Photo 2.2.4-2 Quarry Plant in Production

3） Procurement Area of Major Construction Materials

Procurement area of major construction materials are summarized into **Table 2.2.4-4**.

Table 2.2.4-4 Procurement Area of Major Construction Materials

Item		Procurement Area			Procurement Reason Description	Procurement Routes Local
Item Name	Description	Local	Third County	Item Name		
Materials for structures						
Reinforcing bars	D13～D32	○				Near construction site
Aggregate for concrete	20～25N/mm2	○				Near construction site
Macadam	150～200mm	○				Shai Hill
Base	Graded grain crushed stone	○				Shai Hill
Subbase	Crushed stone	○				Shai Hill
Embankment		○				Near construction site
Bitumen		○				Near construction site
Temporary Materials						
Gasoline, Diesel oil		○				Near construction site
Wooden form		○				Accra
Plywood		○				Accra
Temporary Steel	H-steel	○				Near construction site
Support	Supported frame	○				Accra

4） Procurement of Special Materials

Special materials which can not be procured in Ghana include an admixture for modified asphalt concrete, joint material for approach cushion slab and waterproofing materials. These materials shall be procured in Japan.

(2) Procurement of Major Construction Equipment

Photo 2.2.4-3 shows major construction equipment which can be procured from local contractors and leasing company.

Concrete pump vehicle

Concrete mixer vehicle

Bulldozer

Backhoe & road roller

Backhoe

Photo 2.2.4-3 Major Construction Equipment to be Procured

Construction equipment to be procured is summarized in **Table 2.2.4-5**.

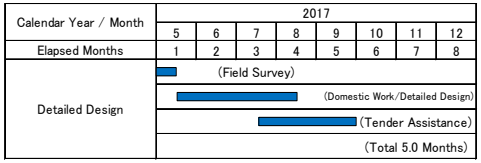
Table 2.2.4-5 Major Construction Equipment to be Procured

Item		Procurement				Procurement Routes Rent/ Buy	Item Local (Ghana)
		Area/Rent	Reason				
Item Name	Description		Local (Ghana)	Item Name	Description		
Backhoe	0.45m^3	Rent	○				Accra
Backhoe	0.8m^3	Rent	○				Accra
Backhoe	1.4m^3	Rent	○				Accra
Dump Track	10t	Rent	○				Accra
Dump Track	4t	Rent	○				Accra
Bulldozer	21t	Rent	○				Accra
Bulldozer	15t	Rent	○				Accra
Tire Roller	8～20t	Rent	○				Accra
Road Roller	10～12t	Rent	○				Accra
Motor Grader	W=3.1m	Rent	○				Accra
Truck with Crane	16～25t	Rent	○				Accra
Concrete Breaker	600～800kg	Rent	○				Accra
Vibrator Roller	Riding Type 3～4t	Rent	○				Accra
Water Pomp	φ100mm、15kw	Rent	○				Accra
Diesel Generator	22KVA	Rent	○				Accra

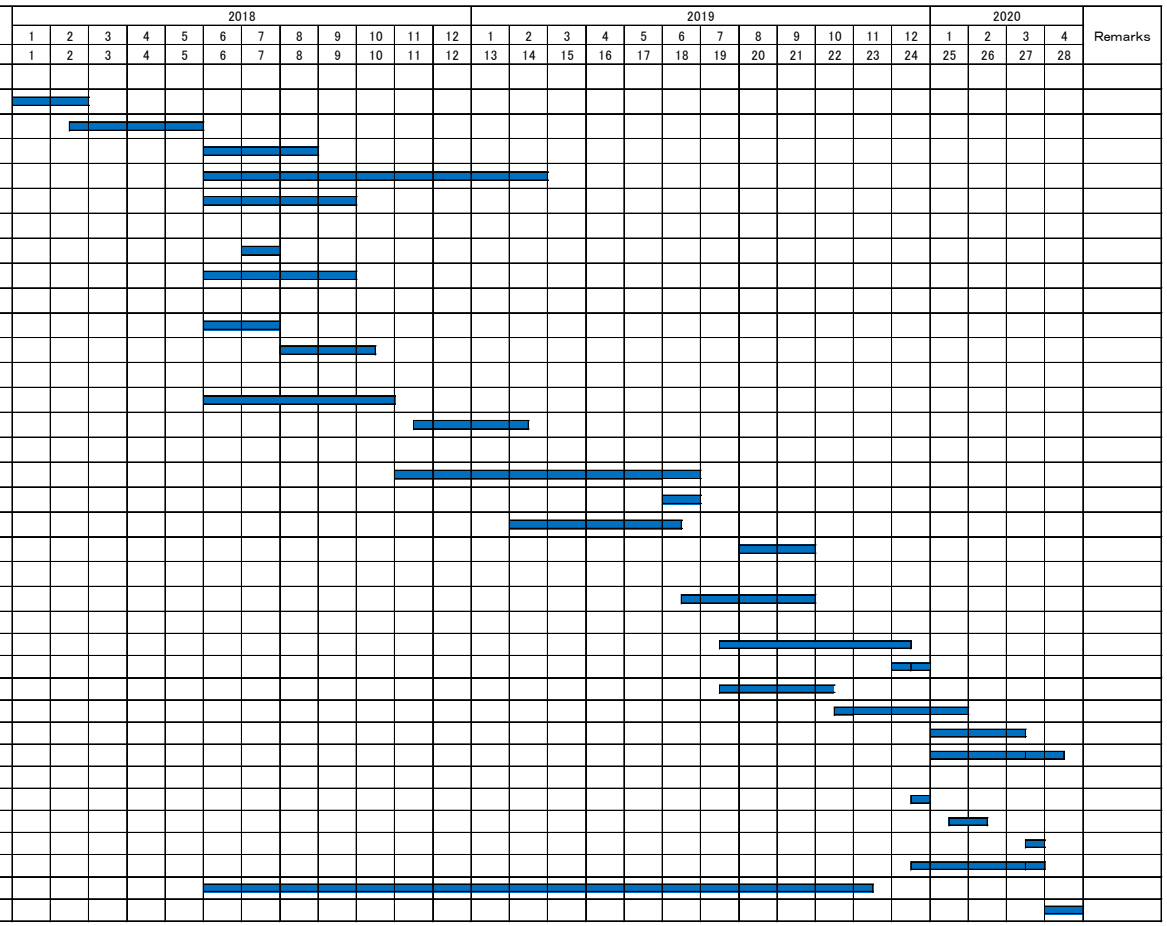
2.2.4.7 Implementation Schedule

Table 2.2.4-6 presents the implementation schedule of detail design and construction period.

Table 2.2.4-6 Implementation Schedule



No.	Item	Specification	Unit	Quantity	Remarks
	Preparation				
	Temporary work				
STEP 1	Detour				
STEP 1	Ramp	Excluding intersection			
STEP 1	Service road	4 routes	m	3,318	
STEP 1	Retaining wall No.2, left side				
STEP 1	Gravitiy type retaining wall	Concrete volume	m3	58	
STEP 1	Inverted T-type retaining wall	Concrete volume	m3	1,413	
STEP 1	Retaining wall No.2, right side				
STEP 1	Gravitiy type retaining wall	Concrete volume	m3	54	
STEP 1	inverted T-type retaining wall	Concrete volume	m3	664	
STEP 1	Retaining wall No.1, left side				
STEP 1	Inverted T-type retaining wall	Concrete volume	m3	730	
STEP 2	Temporary roundabout, detuor				
STEP 2	BOX culvert on the east side				
STEP 2	BOX culvert	Concrete volume	m3	18,268	
STEP 2	Approach cushion slab, back filling	Concrete volume	m3	522	
STEP 2	Pavement for Aflao Road	Area of surface	m2	26,131	
STEP 3	Detour				
STEP 3	Retaining wall No.1, right side				
STEP 3	inverted T-type retaining wall	Concrete volume	m3	1,021	
STEP 3	BOX culvert on the west side				
STEP 3	BOX culvert	Concrete volume	m3	9,061	
STEP 3	Approach cushion slab, back filling	Concrete volume	m3	153	
STEP 3	Pavement for Akosombo Road	Area of surface	m2	10,898	
STEP 3	Pavement for Motorway	Area of surface	m2	26,131	
STEP 4	Pavement for Intersection	Area of surface	m2	3,916	
STEP 4	Pavement for Harbour Road	Area of surface	m2	8,543	
STEP 4	Traffic safety facility				
STEP 4	Street lighting	Iluminat	Nos	26	
STEP 4	Traffic signal	Poles	Nos	6	
STEP 4	Traffic sign				
STEP 4	Ramp	Intersection			
	Footbridge	4 Span Continuous RC Box Girder Bridge	Location	4	
	Miscellaneous work				



2.3 Obligations of Recipient Country

The undertakings required from the GOG for the smooth execution of this project are as follows:

- To provide documents, data and information necessary for the execution of this project;
- To acquire land for construction yard;
- To secure land for construction yard, stock yard, disposal area for construction debris, site office yard, and detour routes;
- To secure borrow pits, spoil-banks, and industrial waste disposal areas;
- To obtain all necessary permits, to coordinate and share necessary information with concerned organizations regarding the method of road occupancy of the Motorway, procedure for allowing public vehicles, traffic restrictions, and day-time, night time works;
- To get the public informed and take necessary steps before hand regarding blockage of road for public vehicles during relocation of overhead facilities such as traffic signs;
- To coordinate with concerned organizations and agencies in charge of underground utilities pertaining to its protection, reinforcement / repair and to pre inform all road users and local inhabitants in case disruption of water and electricity are anticipated;
- To coordinate with concerned organizations and agencies in charge of street lights and electronic traffic signs regarding its protection and/or its relocation and to take necessary steps to inform road users beforehand in case disruption of electricity is anticipated;
- To obtain necessary permits that would allow the personnels engaged in the construction work such as the supervision engineer, construction workers etc. to access ROW;
- To obtain necessary permits that would allow the construction vehicles and equipment to enter and exit the ROW;
- To bear the cost of bank charges such as the Advising Commission and Payment Commission to the Japanese bank where an account related to the project is opened.
- To bear the value-added-tax related to the project;
- To bear all expenses required for 15 % of VAT (Value Added Tax)
- To bear all expenses required for 2.5 % of NHI (National Health Insurance)
- To assist in the process for exemption of materials imported for the construction work from taxation and Customs clearance in order to ensure smooth inland transportation;
- To assist in the process for exemption of Japanese nationals engaged in the construction work from Customs duties and other fiscal levies on products and services necessary for the execution of the project;
- To assist in the process for exemption of Japanese nationals from all legislation measures necessary for entering and staying in the Republic of Ghana;
- To ensure proper use and maintenance of the road after its construction;
- To cooperate in solving potential troubles with the local people or any third party in connection with the execution of the project;
- To bear all expenses required for the execution of the project, other than those borne by the Grant-Aid of Japan.

2.4 Project Operation Plan

2.4.1 Organization for Operation and Maintenance

2.4.1.1 Organizational Framework

Roads in Ghana are administered by the Ministry of Roads and Transport (MRT) through three agencies namely- Ghana Highway Authority (GHA), Department of Feeder Roads (DFR) and the Department of Urban Roads (DUR).

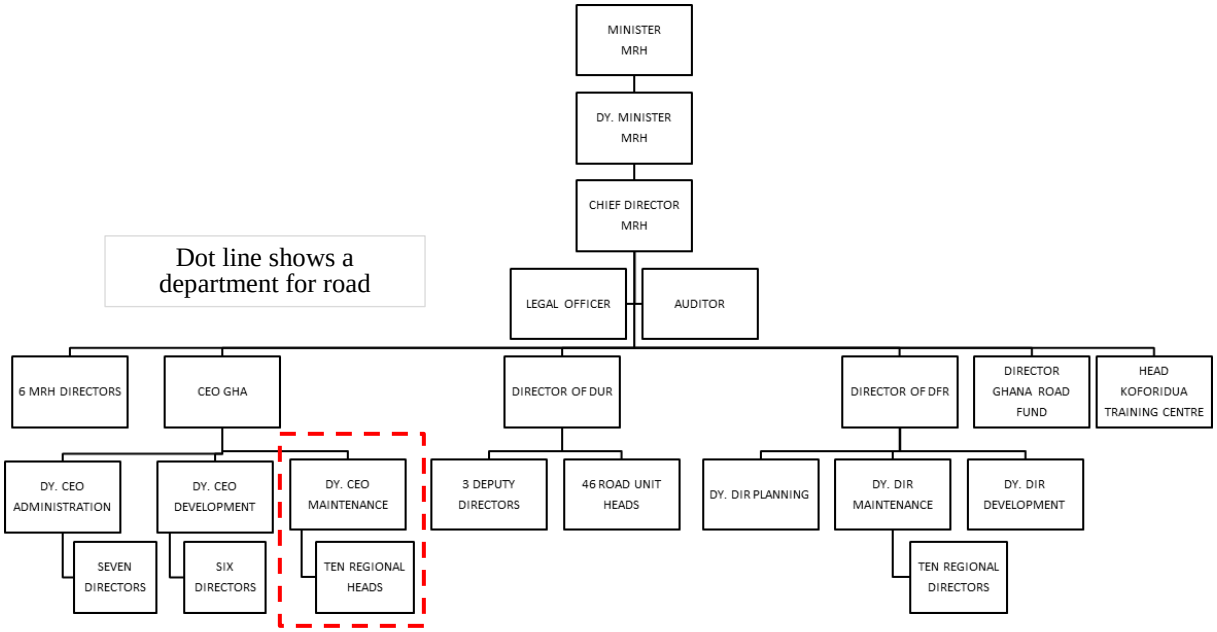


Figure 2.4.1-1 Organizational Framework

As shown in **Figure 2.4.1-1** ,Maintenance Department which has 10 regional heads nationwide is responsible for road maintenance.

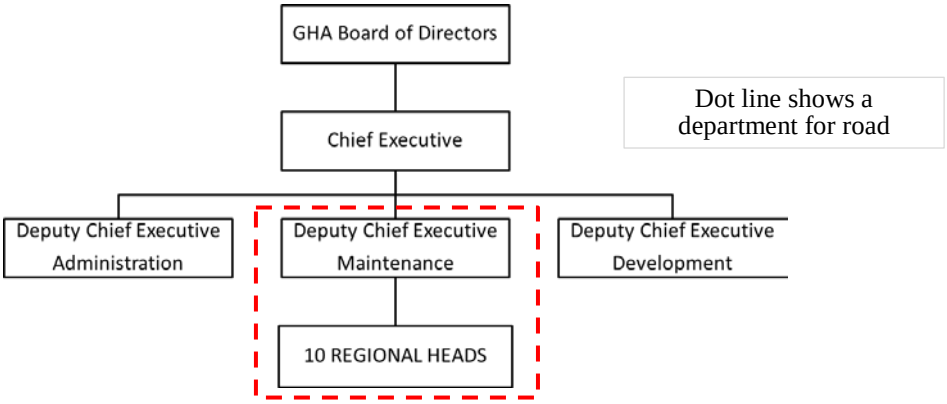


Figure 2.4.1-2 Department in Charge of Maintenance in GHA

Table 2.4.1-1 Regionals Heads of Maintenance Department

Northern Sector	Upper East Region Upper West Region Northern Region Brong Ahofo Region Ashanti Region
Southern Sector	Eastern Region Central Region Western Region Great Accra Region Volta Region

Regional Head s are operated as shown in **Figure 2.4.1-3**.

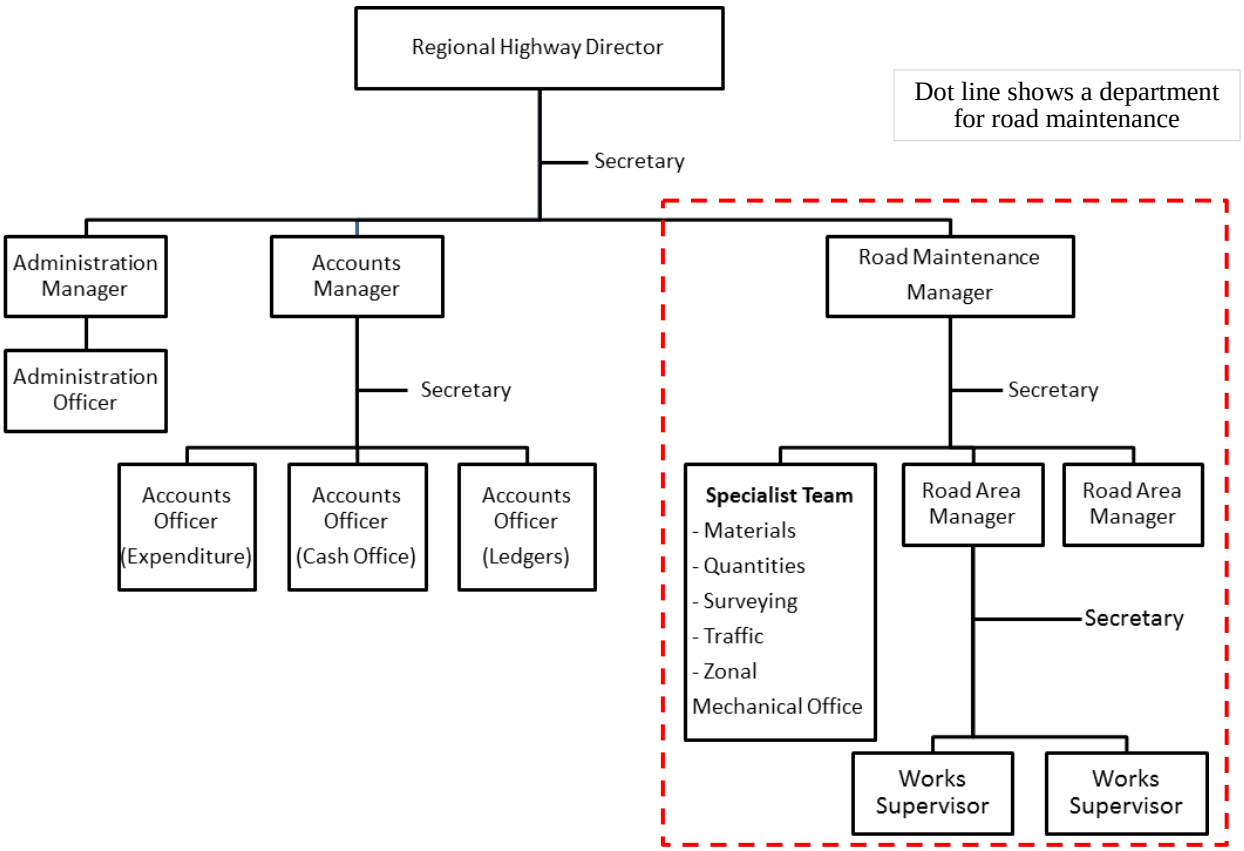


Figure 2.4.1-3 Organization of Regional Head

For purposes of maintenance in the regions, each region is divided into GHA Road Areas, the number and size of each depending on the number and geographical spread of projects in the region.

Road Areas shall have the three primary responsibilities of

- Collecting road data,
- Inspecting roads and
- Supervising road maintenance

Table 2.4.1-2 GHA Road Areas

Region Ashanti Region	No. of Areas 3	Covered Areas Kumasi, Mampong, Bekwai
Eastern Region	4	Koforidua, Oda, Nsawam, Nkawkaw
Volta Region	3	Ho, Hohoe, Keta
Central Region	3	Cape Coast, Dunkwa, Winneba
Western Region	3	Takoradi, Tarkwa, Wiawso
Greater Accra Region	1	Accra
Brong-Ahafo Region	4	Sunyani, Goaso, Kintampo, Atebubu
Northern Region	4	Tamale, Yendi, Gambaga, Saula
Upper East Region	1	Bolgatanga
Upper West Region	2	Wa, Tumu
Total No. of Road Areas	28	

Each Region has a Special Team made up of personnel with specialization in materials, topographic surveying, traffic and quantity surveying It can be deduced that this team is a pool of expertise. Road maintenance for this project is responsible for Greater Accra Region.

2.4.1.2 Road Sector Personnel in GHA

Table 2.4.1-2 shows road sector personnel in GHA by Staff Category as of 2015.

Table 2.4.1-3 Road Sector Personnel in GHA

Staff Category	Male	Female	Under 30	30-40	40-50	50-60	Over 60	Total
Directors	30	2	-	-	7	25	-	32
Engineers	139	16	41	37	30	47	-	155
Quantity Surveyors	22	2	1	8	6	9	-	24
Economists	1	1	-	1	-	1	-	2
Technicians	155	11	18	48	17	83	-	166
Planners (Valuers)	4	-	-	2	-	2	-	4
Accountants	115	35	2	15	15	118	-	150
Administrators	28	69	7	10	11	69	-	97
Drivers	206	0	5	48	42	111	-	206
Others	801	215	173	182	128	533	-	1016
Total by Age	1501	351	247	351	256	998	-	1852

2.4.2 Contents of Operation and Maintenance

Road maintenance work conducted by GHA is shown below. Most of the works are done by subcontracting.

- Pavement repair
- Road structure repair
- Cleaning on pavement surface and drainage
- Planting
- Traffic signal and street lighting
- Bridge inspection and repair

2.4.3 Points to Consider in Road Operation and Maintenance

To realize full benefits of the project and its facilities, and to sustain its operation and keep it in good

driving condition, it is important to improve its durability. In addition, the objective road is as the full access controlled motorway hence it is of sgreat ignificance to secure the highway characteristics which matter most to the driver which includes speed of travel, safety, comfort, and convenience, and alsoimplementing facility maintenance related to road functional management, traffic management and safety management. The following needs should be noted:

Inspect the facility regularly to abreast with its condition at all times

Regular cleaning of road and incidental road facilities – especially drainage system

Implementing regular facility inspection, cleaning and maintenance related to road functional management, traffic management and safety management

Secure budget necessary for maintenance

With that in mind, it is important to allocate budget for operation and maintenance.

2.5 Project Cost Estimate

2.5.1 Initial Cost Estimation

2.5.1.1 Japan's Contribution

The cost borne by the Japan's Grant Aid is not shown in this report due to the confidentiality.

2.5.1.2 Ghana's Contribution

The cost to be borne by the Government of Republic of Ghana is estimated to be about 6.6 million Ghana Cedi (213 million Japanese Yen). Breakdown is presented in **Table 2.5.1-1**.

Table 2.5.1-1 Project Cost Borne by Ghana Government

Item		Cost (GH₵)	Cost (million Japanese Yen)
(1) Bank Charges		392,374	12.7
(2) Land acquisition, Removal / Relocation of Utilities, etc.	Land acquisition	2,050,000	66.1
	Street lightning/ electric poles	70,000	2.2
	Underground facilities	560,000	18.1
	Buildings, houses and shops	3,140,000	101.3
	Trees	40,000	1.3
	Bill board	350,000	11.3
	Sub total	6,210,000	200.3
Total		6,602,374	213.0

2.5.1.3 Cost Estimation Condition

Cost Estimation Date	:	December 2015
Foreign Exchange Rate	:	GH₵1.00＝32.26 JPY US$1.00=121.93 JPY
Construction Period	:	Schedule of construction supervision is shown in the implementation schedule
Others	:	The project is carried out based on the Japanese Government's Grant Aid Scheme.

2.5.2 Operation and Maintenance Cost

Table 2.5.2-1 represents operation and maintenance cost for the major works. Since operation and maintenance works are conducted by subcontracting, there are no technical problems on maintenance work.

Table 2.5.2-1 Maintenance Item to be checked and Annual Maintenance Cost

Category	Facility Name	Items to be checked	Frequency	Personnel	Equipment	Total Number	Cost (1,000 GHC)
Periodic Inspection	Pavement	Crack etc.	4 times/year 5 days/time	2 persons	Scoop/Hammer/ Sickle/Barricade	40 persons/year	2.66
	Drainage	Sediment Deposition/Obstacle					
	BOX Culvert / Retaining Wall	Damage/Deformation/Peeling etc.					
	Traffic Safety Facility	Reflector, Crash Barrier, etc.			Pickup	20 vehicles/year	12.58
	Subtotal						15.24
Routine Maintenance	Pavement	Cleaning	4 times/year 5 days/time	10 persons	Scoop/Barricade	200 persons/year	24.09
	Drainage	Removal of Obstacle or Sediment					
	Footbridge	Cleaning			Small Truck	20 vehicles/year	12.58
	Subtotal						36.68
Repair	Pavement	Crack etc.	2 times/year 7 days/time	6 persons	Worker	84 persons/year	3.44
	Drainage	Damaged part etc.			Plate Compactor	14 vehicles/year	10.15
	BOX Culvert / Retaining Wall	Damaged part etc.			Small Truck	14 vehicles/year	9.45
	Traffic Safety Facility	Damaged part etc.			Roadbed Material	50.0m3/ year	3.7
	Median	Crack etc.			Asphalt	10.0t/ year	7.52
	Reflector	Crack etc.			Cement	130 bags/ year	4.72
	Street Lighting	Exchange of Lamp			Cobbled Stone	3.0m3/ year	0.23
	Footbridge	Damaged part etc.			Lane Marking	50m/ year	0.35
	Traffic Signal	Exchange of Lamp			Lamp for Traffic Signal	2 lamps/ year	31.92
	Traffic Safety Facility	Damaged part etc.			Lamp for Street Lighting in BOX Culvert	4 lamps/ year	50.29
	Subtotal						121.78
Total							173.70

Chapter3 Project Evaluation

3.1 Preconditions to implement the project

The Project preconditions related to the required undertaking from the Republic of Ghana are as follows:

i) Banking Arrangement (B/A) with a Bank in Japan shall be concluded within one (1) month after the signing date of Grant Agreement (G/A).
ii) The payments will be made when payment requests are presented by the Bank under an Authorization to Pay (A/P). This A/P shall be issued to the Bank that concluded B/A within one (1) month after Consulting Service Agreement is made.
iii) Before the date of formal invitation to Pre-Qualification, such public utilities, like power poles, electric lines/cables, and communication network lines/pipes as will interrupt the Project works shall be all relocated to the locations where no hindrance and inconvenience shall occur.
iv) It is essential that land for Project construction shall be acquired prior to public announcement of Pre-Qualification and no pending issues in relation to this shall be left behind.
v) The Weigh Station close to the Tema Toll Gate at Accra-Tema Motorway shall be moved to the location to pose no troubles on work implementation.
vi) Prior to commencement of the works, adequate and proper compensations and resettlement in accordance with ARAP shall be undertaken for the sake of the PAPs.
vii) Any necessary actions for tax exemption shall be taken keeping to the regulations of E/N and G/A.
viii) Quick and smooth customs declaration and import tax formalities shall be totally finished when the imported materials or goods arrive from Japan and any other third countries.
ix) Approval of necessary EIA for the Project shall be obtained within one (1) month after G/A is formally signed. Throughout all the construction period, quarterly monitoring Report shall be prepared for submittal to JICA. This Report shall describe monitoring data about such potential natural environmental items as air quality, water pollution, etc. which are more likely to give impacts on the works during construction phase and even after it is completed.
x) During construction period, eminent assistance shall be given to traffic handling and management plus safety control management.
xi) The power pipes/lines and water supply pipes/lines necessary for the construction work at site shall be routed and installed.
xii) As a means of dispute resolution while the works proceed, discussion and assistance in good earnest shall be made to reach agreement on disputes with people in the vicinity or any other third party around.

3.2 Necessary input by recipient country

To derive benefit from the entire Project and to make it sustainable, the necessary input by recipient country is shown as follows.

(1) Management and Maintenance

To secure the service life(durability) of pavement, approach road, structure, and other related appurtenant facilities, periodic maintenance inspection or patrol shall be firmly carried out under annual approximate maintenance cost of Ghana Cedis GH₵ 173,700 as shown in *****. This budget shall be secured.

It is necessary as well to get it repaired appropriately and instantly soon after the damage is discovered.

Routine maintenance operations such as cleaning, removal of sediment, debris and obstacles on the road pavement surface or at the drainage facilities shall be done.

This action will bring about further and bigger improvement of road services and more safer transport measures for the road users.

Bearing in mind that regular maintenance, inspection and safety patrol to check the road lights and traffic signals are an absolute must. In terms of sustainable safety performance, daily maintenance inspection shall be performed surely and steadily. It is highly suggested to take consideration into building up the traffic management system to deal with traffic control of left-turn vehicles on the road by way of directing traffic flow by the policeman in case of sudden black-out.

(2) Pedestrian Off-Limits at the Intersection

Since pedestrian is not allowed to go and come across the intersection after Project is completed, it is required to keep constant control and sufficient watch over pedestrian's stepping in at the intersection.

This action shall require full collaboration with the Police authority.

(3) Regulating Illegally Overloaded Vehicles

The fact remains that Government of Ghana have been conducting control of overloading and that they have been checking up on illegal overloads at the existing Weigh Station nearest to the Tema Roundabout.

It has been discovered that the Weigh Station is inconvenience and disturbance to the Project execution

program and thus its absolute relocation shall be instantly fulfilled by the Government of Ghana.

Judging from securing durability of pavement structures, it is required that this Weigh Station is surely removed. Its operation shall quickly start to continue to crack down on the vehicle overloading at the newly relocated Weigh Station.

3.3 Important assumptions

The important assumptions of the Project outcome are as described below:

(1) Consideration of building new bus terminal

There is large scale bus terminal building located North-East and South-East direction from the existing intersection. This bus terminal has occupied part of the inside area of Right of Way and, therefore, it is

not perfect and public governmental building property. However, a big number of people have got to use the bus services for their transportation including long distance bus service.

Taking full account of the benefit and convenience to the people in the vicinity, construction of new public bus terminal building shall be greatly needed in cordial co-operation with any concerned organizations.

(2) Increase of traffic lanes at Accra-Tema Motorway

Eastern and Western Highways passing through Tema Motorway roundabout is regarded to be a part of Accra-Tema Motorway. The Government of Ghana is planning to have 3-lane carriageway in each directions (both inbound lane and outbound lane) on Accra-Tema Motorway which is to be widened under PPP Scheme. Feasibility Study on its development is going on. This Motorway is taking up the position of a component of total development plan of ECOWAS, namely, Abidjan-Lagos Highway Development (Trans-Coastal Highway, ECOWAS Highway).

In the top-level governmental conference among the leaders from each concerned country, the idea that design of inbound and outbound 3-lane carriageways all through the distance in Abidjan-Lagos Highway is accepted.

In view of the above circumstances, the adopted structural design requirement for Eastern and Western Highways are to cope with the works for this 3-lane carriageway expansion. Earliest widening to 3-lanes both for inbound lane and for outbound lane on the Eastern and Western Highways shall be carried out to produce rapid effects of the Project.

(3) Improvement of Ashaiman Roundabout

Southern and Northern Highways are linked to Ashaiman Roundabout with 52-meter diameter, located in the distance of approximately 1.5 km north of Tema Motorway Roundabout.

Traffic congestion at Tema Motorway Roundabout comes partly from the current severe congestion at Ashaiman Roundabout. Early commencement of the Project is of importance since the Government of Ghana well understand this Ashaiman Roundabout improvement will turn out to be a good solution to inconvenient traffic flow at Tema Motorway Roundabout. The primary objective of improving heavy congestion at Ashaiman Roundabout is to moderate and ease traffic congestion at Tema Motorway Roundabout.

3.4 Evaluation

3.4.1 Relevance

- 506,000 residents of Tema City (calculated based on the survey result in 2000) are direct beneficiaries of the Project. On the other hand, an approximate 86.6 million people is assumed (2015 survey) users of Tema Motorway Roundabout.
- This Project will contribute to easing traffic congestion and smoothing transportation of people and freight as well. It is highly expected that this will eventually lead to a comprehensive transportation network development for logistics throughout the nation and entire West African Regions.

- Traffic capacity increase to possibly respond to Tema International Port development will be expected.
- Expansion and development of major national integrated arterials covering international transit road as a part of it will be brought about. This Project will be immediately and strongly needed to secure stability of people's lives, development of their daily lives, and securing BHN (Basic Human Needs).
- Excessively advanced technique is not necessary for this Project. The Government of Republic of Ghana can manage to run, operate and maintain the improved road, related structures, and facilities by using own fund, own local manpower and locally available technical skills.
- National integrated trunk road network system including international transit road as a part will be equally consistent with the policy and target described in the Government National Development Master Plan. This Project can help in achieving enhancement of national trunk road network improvement.
- There is little negative impact upon environmental and social condition.
- Performing the Project will justify the incentive as well as necessity to utilize Japanese most advanced and cutting-edge construction technology, such as time control, safety control, and quality control. Through the Japan's Grant Aid Scheme, the Project will be conducted adequately without any serious issues.

3.4.2 Effectiveness

(1) Quantitative Effect

The expected quantitative effect to be produced through performing the works of target Project for economic cooperation is shown in the following **Table 3.4.2-1**. The values of base year before conducting the Project and target year in three (3) years over completion of the Project are respectively set up.

Table 3.4.2-1Table-4-4.1 Quantitative Effects

Index	Basic Value (Actual Record of 2015 year)	Target Value in 2023 (Project Completion Year)
Passenger Volume	86.6(Million)/year	156.8(Million)/year
Freight(Cargo) Volume	44.3(Million)/year	74.3(Million)/year
Travel Time per minute (AM peak hour at Accra-Aflao 2.0 km)	8.2 minute	2.0 minute

(2) Qualitative Effect

The prospective effects are;

- To moderate traffic congestion and to provide uninterrupted traffic flows.

- To facilitate and grade up transit system in the West African Region.
- Stable carrier-transit time and effectiveness in logistics leaving and arriving at the Tema Port will be improved.
- Traffic safety of pedestrians and vehicles at the intersections will be improved.
- Future emission of transport related greenhouse gases will be reduced.
- Connecting links between Coastal Highways (Coastal Corridor) and East Highways (East Corridor) will be enhanced.