Palestine Polytechnic University

College of Engineering and Technology
Civil & Architecture Engineering Department

Project Title

Evaluation and Design of Infrastructure in the Palestinian Camps

Case study: AL-Arroub Camp

Project Team

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Hebron – Palestine

June-2012

CERTIFICATION

Palestine Polytechnic University
(PPU)

Hebron – Palestine

The Project Entitled:

EVALUATION OF CAMPS IN WEST BANK AND DESIGN OF INFRASTRUCURE FOR "AL-ARROUB CAMP AS CASE STUDY"

BY

ANAS OWEIW **IBRAHIM AL-TWAYHA**

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In accordance with the recommendations of the project supervisor, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architecture Engineering in the college of Engineering and Technology in partial fulfillment of the requirements of the department for the degree of Bachelor of Science in Engineering.

Project Supervisor **Department Chairman**

June – 2012

اهداء

معلم البشرية ومنبع العلم نبينا محمد (صلى ا عليه وسلم)

إلــى.....

ينابيع العطاء الذين زرعوا في نفوسنا الطموح والمثابر...... آبائنا الأعزاء

إلـــى....

انهار المحبه التي لا تنضب..........أمهاتنا الاحبه

إلـــى....

من يحملون في نفوسهم ذكريات الطفولة والشباب.... اخوتنا واخواتنا

إلـــى....

كافة الأهل والأصدقاء

إلـــى....

من مهدوا لنا طريق العلم والمعرفه.......اساتذتنا الافاضل

إلـــى....

من ضحوا بحريتهم من اجل حريتنا....... اسرانا البواسل

إلـــى....

من وصلت رائحة دمائهم الزكيه الى السماء النديه ....شهداؤنا الابرار

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ABSTRACT

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After 1948 the Palestinians start a new stage of their life, About half of them immigrate to West Bank, Gaza Strip and all over the world to live in temporary Camp.

UNRWA "United Nation Relief and Work Agency" is the organization which works on rehousing the refugees and looking after their needs.

25% of the Palestinian refugees live in West Bank distributed on 19 camps from Jenin in the north to Al-Fawwar in the south they live in bad conditions, high population density, environmental problems and absence of physical infrastructure.

In the present study an evaluation of the Palestinian camps is to be done through studying the environmental, cultural, economic, social and infrastructure characteristics of three camps Jenin in the north, Qalndia in the middle and AL-Arroub in the south, then choose the worst one to design and /or redesign the basic parts of the physical infrastructure.

Project team concern with AL-Arroub camp as the worst camp, it’s located in south of WestCamp, 11 KM north of Hebron and It has an area 242 donums, its population is about 10444 in 2007 with 328 person/hac as population density. The most important part of physical infrastructure will be designed for this camp which are: wastewater

collection system, storm water drainage system and roads redesign. These parts of infrastructure reduce the environmental problems in the camp and make the life of the refugees better.

The results of the present study show that the Palestinian camps face an environmental problem caused by absence of physical infrastructure.

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CHAPTER ONE

INTRODUCTION

1.1 GENERAL

1.2 PROBLEM DEFINITION

1.3 OBJECTIVES AND GOALS

1.4 PREVIOUS STUDY

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1.6 ORGANIZATION OF STUDY

CHAPTER ONE

Introduction

1.1 General:

Definition of camp according to UNRWA: the camp is a piece of land putting under the control of UNRWA by the host government for the aim of rehousing the refugees and establishing constructions for looking after their needs.

The appearance of the Palestinian refugee camps in general as a result of the tragedy of forced displacement suffered by a large part of the Palestinian people due to the catastrophe that befell him in 1948 after the Israeli movement to seize their lands.

Many Palestinians were expelled to the west bank and Gaza strip; therefore temporary camps were established for the refugee in preparation for their return, which was confirmed by a resolution the General Assembly of UN (194) on 11 \ 12 \ 1948 and though it continued presence of refugees in places of refuge, and turned those places into permanent camps.

The Palestinians keep their communities on the degree of social cohesion and national identity. The misery for asylum in refugee camps became catalyst links to their land and the land of their fathers and grandfathers.

The association has turned into the camp to witness to the catastrophe and into the reluctance and resistance. As a result, the occupation forces clear the camps and resettlement away from the cities and the main streets and drove out many projects for that. Reference (al-farra and others, 1999).

Despite of misery and suffering the Palestinians lived for a long period of time in the camps and rejected the settlement and waive their legal rights and remained the legitimate right to return home. With these conditions, camps must be adequate to human live through good social services, educational services, and physical infrastructure services.

This study concern on the physical infrastructure in the west bank refugee camps, these camps contains 25% of the total of the refugees in Palestine and neighborhood countries, they are living in 19 refugee camps. In general the condition in these camps is so bad to human live.

That refugee shelters developed by the time from tents to civilization camps having many obstacles of population density, lack of water, lack of sewerage network , lake of solid waste management, environmental pollution, and invalid infrastructure.

This project doesn't mean that the refugees can't go back to their original land in near future if Allah will; on the contrary the goal here is to help refugees to live a decent life and support them until they return to their original homes.

1.1.1 Distribution of camps in the West Bank

The refugee camps in the west bank distributed (According to UNRWA) in 5 regions: Jerusalem, Nablus, Jericho, Hebron, and Bethlehem. Table 1.1 and figure 1.1 shows the names of these camps and how they distributed to Provinces in wWest Bank {1}.

Table 1.1: Distribution of camps in the West Bank. {1}

Name Of Camp	Region	Province	Population	Area (Donuum)
1-Qalandia	Jerusalem	Jerusalem	10759	253
2-Shuafat	Jerusalem	Jerusalem	11170	198
3-Am'ari	Jerusalem	Ramallah	10500	93
4-Jalazoun	Jerusalem	Ramallah	11393	240
5-Deir Ammar	Jerusalem	Ramallah	2404	145
6-Dheisheh	Bethlehem	Bethlehem	13156	340
7-Aida	Bethlehem	Bethlehem	4830	115
8-Beit Jibrin	Bethlehem	Bethlehem	2118	135
9-Ein Sultan	Jericho	Jericho	1966	708
10-Akabet Jaber	Jericho	Jericho	6581	689
11-Balata	Nablus	Nablus	23677	460
12-Askar	Nablus	Nablus	16261	162
13-Fara'a	Nablus	Nablus	7754	194
14-Ain Beit Almaa	Nablus	Nablus	6854	28
15-Tullkarm	Nablus	Tullkarm	18701	465
16-Noor Shams	Nablus	Tullkarm	9351	230
17-Jenin	Nablus	Jenin	15854	473
18-Al-Arroub	Hebron	Hebron	10444	242
19-Al-Fawar	Hebron	Hebron	8244	238

Figure 1.1: Distribution of the camps in West Bank. (Project Team)

1.1.2 Assets of residents of camps

The origin of the Palestinian camps turned into many Palestinian cities and villages can be shown in the following fig.

Figure (1.2): Assets of resident camps. {1}

1.2 Problem definition:

It was a new stage of life for the Palestinian after Al-Nakba in 1948, especially to the people whom migrate there lands and homes, they were about the half of the Palestinian people, and they were immigrate to all over the world and live in temporary camps and hopped to return quickly to their land and homes. By the time these people live in serious environment problems because there is no life facility and infrastructure, this shortage results is an unhealthy life.

When we talk about the refugee we should mention the UNRWA "United Nations Relief and Works Agency for Palestine Refugees" because it offered a huge helps to the refugees as foods, medic and temporary houses.

Because the team work can't study the camps outside the west bank we decided to make our study on the camps inside the west bank by chose three camps as sample to study, then we chose one camp as a case study to redesign the infrastructure facility to help the refugee to continue their life with the basic human needs and to help them to live in good environment.

1.3 Objectives and goals:

The very crowded area and high population density, without expanding in the boundary of the camp, and the absence of all infrastructure networks make these camps have serious environmental and infrastructure problems causes many healthy problems, and to reduce this problem project team want to make redesign for infrastructures of one of this camps according to analytical study.

The most important goal of the study is to analyze the environmental problem for refugee camps in west bank by studying the characteristics of environmental, cultural, economical, and social life in camps, and to determine the available health services and the problems that appear due to unavailable services to chose the worst camp to redesign its infrastructure facilities which consists of sanitary network, storm water drainage system, water network, and roads network.
The project will include different items as follow:

1. Evaluate and provide a sanitary network to the camp:

This well be done by evaluate the ways that the refugees dispose of waste water and post up the problem caused by the most suitable sanitary network absence. Then study and design the sanitary network including all subsidiaries with proper inclination, connection to the main municipality lines, manholes, disposal methods, and design wastewater flow.

2. Provide storm water derange system:

This study will concentrate on the basics of storm water drainage which considered one of the most important services that camps need, and the study will show the options that can solve this problem, that camps have a special condition in their areas and roads.

3. Evaluate and design a road network.

Evaluate and design of the road geometry and arrangement of visual elements of the road, such as track, distance vision, inclinations and wide of the road, in addition to identifying the main design criteria to determine the compatibility by engineering design of the road with the requirements of the required engineering.

This work will be done to provide the resident of this camp the basic human right, taking in mind that camps have asocial condition in everything especially in location, areas, lands, roads, buildings and striping.

1.4 Previous Studies:

There are many studies talking about refugee camps in west bank from different sides including social, economic, population, healthy, educational, and architectural, but there's no studies talking about infrastructure side.

The studies were as follow:

1) the studies of researcher Dr.Abd Al-Rahman Almoghrabi in the title of” Social and economic situations in west bank camp” in April, 2004{14}:

According to statistics in 2003 the refugees were about third of the Palestinian people, this is a good reason to study there situations. Because there is no fair solutions for the refugee until this day make it complicated case especially because they are suffering from economic and social problems.

Studying there economic and social situation help them in their life and may help to end their suffering in diasporas camp.

People in West Bank camps basically depend on the facilities and services that UNRWA provide and supplied them, such as health centers , schools , some of infrastructure …etc.

Poverty in Palestinian camps reaches to 32.8%, which form 26.5% from the total of poor people in Palestine. This is one of the highest ratios in Palestine if it is compared with other communities, and high size of family which it up of 7.5 persons per family in average

This study talking about health, social, economic, educational, house situations, extreme poverty, and the infrastructure in general, finally it ends with recommendations to improve the social and economical situation in the camps.

2) The studies of researcher Faisal Radwan in the title of “Local public committee's efficiency in refugee services in social development in west bank camps”, 2011{13}:

The goal of this study is to know the importance of local public committee in the camps and how the help the refugees, and the relationship with many variables as demographic distribution, gender, age groups, qualification, current place, social situations and people statistics. Rapid population growth in the camps without increasing the area of lands on which they live, resulting in to the negative impact on the buildings and residential units in terms of general appearance and health conditions (insulation and ventilation and air renewal), in addition to the negative effects what caused social problems, and reflected negatively "on a healthy population of the camp Physically and psychological".

According to questioner in this study the role of local public committee service is about 62.9%, because theses committee are very active in political and national activities, and a little activities in social, health, and environmental sides.

3) The studies of Amal Taslak in the title of of “Architectural and planning characteristics for west bank camps (case study Jenin camp) “, 2006 {12}:

The study focuses on analyzing urban fabric in west bank camps and analyzing the architectural characteristics , services , public facilities , and roads networks through the stages urban development , with considering the social and cultural sides that help in forming this fabric.

Rehabilitation of the Palestinian refugee camps from the development projects of the services and public facilities and housing as a physical environment within the list of cities and communities without prejudice to the Palestinian right of return**.**

1.5 Methodology:

The project consists of four phases, which are designed to be completed in accordance with time schedule show in (table 1.2). The description of each of the five phases of the project and tasks involved are listed below:

Table 1.2: phases of the project with their expected duration

Phase Number	Title	Duration								
		01/10	01/11	01/12	01/01	01/02	01/03	01/04	01/05	01/06
First phase	Data collection									
Second phase	Field work, Layout preparation									
Third phase	Estimation of waste water, storm water quantity. And Traverse works									
Forth phase	Infrastructure design and writing the report									

Infrastructure design means design of waste water network, storm water drainage system and road network.

1.5.1 First phase: Data collection

During this phase, available data and information were collected from different sources. Moreover, many site visits to the project area, the UNRWA offices and the local public committee were under taken. The first phase included the following activates:

1- Aerial photo and topographic maps for the area were collected.

2- Infrastructure for some of refugee camps were evaluated and studied.

3- Comparison between camps to choose the worst camp as a case study to design its infrastructure was made.

4- All needed maps from the aerial photo were prepared.

1.5.2 Second phase: Field works and layout preparation

A site visit to evaluate the contour maps and matching it with the actual ground elevation then preparing the layout for the three networks was made . The important tasks in this phase are:

1-Explore the site for the work to get a control point which are needed for the traverse measurements.

2- Field survey to measure the traverse, and make its correction by least square method.

3- Waste water network layout.

4- Storm water drainage system layout.

5- Road network.

1.5.3 Third phase: Estimation of Waste water and Storm water Quantities.

During third phase, available collection of hydrological data (temperature, wind speed, humidity, and rain fall intensity), and these phases were includes the following tasks:

1- Estimate the population density for study area.
2- Determination of waste water quantity.
3- Determination of storm water quantity.

1.5.4 Fourth phase: Infrastructure design and writing the report

During this phase the final design will in the last stage, and the project team prepared the specifications drawings, bill of quantities, preliminary maps.

1.6 Organization of the study:

The study report has been prepared in accordance with the objectives and goals of work.
The report consists of six chapters.

The first chapter entitled "Introduction" outlines the problem, project objectives, and phases of the project.

Chapter two entitled "Camps Evaluation" presents basic data and information about the camps.

Chapter three entitled "Characteristics of the Project Area" talk about the basic data on al-arroub camp. The topography, meteorological, Population data, water consumption, and wastewater production.

Chapter four entitled "Design Criteria" deals with the design criteria for water network, waste water collection network, storm water drainage system, and road network.

Chapter five "Analysis and Design" Define the area to be served by sewerage and Establish a system layout which includes the areas that are going to be served from waste water and storm water networks, existing streets and roads**,** show the estimation of quantities of waste water, storm water, traverse measurement and it’s correction by several methods.

Chapter six entitled "Bill of quantities" deals with the item of the project estimated quantity of each item.

Chapter seven entitled "Conclusions and Recommendations".

CHAPTER TWO

CAMPS EVALUATION

2.1. GENERAL.

2.2. GENERAL INFORMATION.

2.3. DEMOGRAPHIC INFORMATION.

2.4. INFRASTRUCTUR SERVICES.

CHPTER TWO

CAMPS EVALUATION

2.1 GENERAL:

This chapter makes an evaluation between three camps Jenin in the north, Qalandia in the middle and Al-Arroub in south of west bank to compare between them then to choose the worst camp as a case study, this evaluation depending on many factors such as location, population, education, economic conditions, and infrastructure conditions, to make this evaluation easer the following topics will study for each camp : General information as geographic location, historical background, and area at present. Demographic information as population, education, health status, residential conditions and economic conditions. Infrastructure services such as municipal services, organization, programs, and activities.

First: Jenin refugee camp

A.2.2 General Information:

A.2.2.1 Geographic location:

Jenin Refugee Camp lies in the north of West Bank, one km west of Jenin city, and it is surrounded by hills through Al Jedi valley (UNRWA). Figure (2.1) shows the location of Jenin refugee camp in Jenin city.

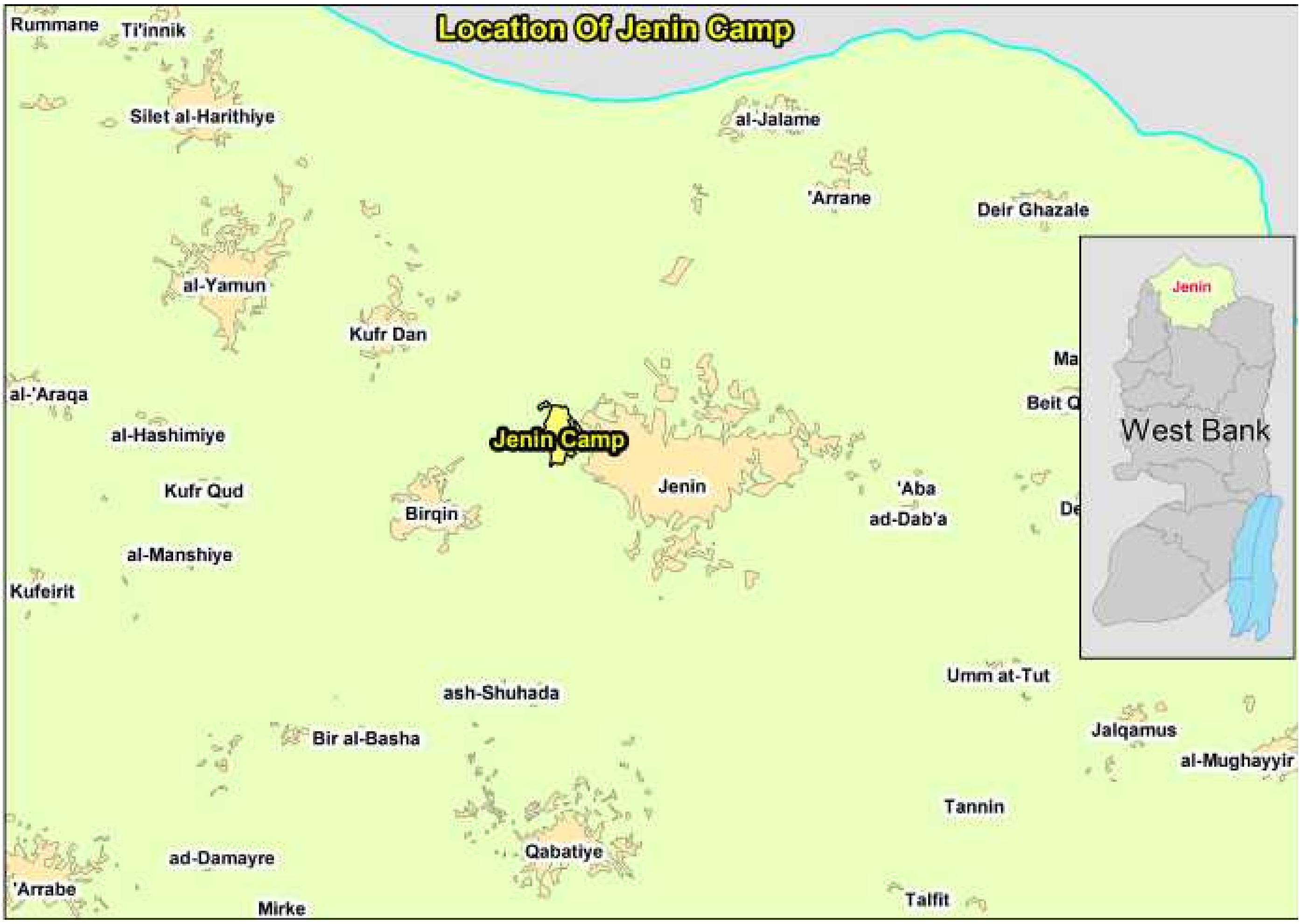

Figure (2.1): Location of Jenin camp, Project Team

A.2.2.2 History of the camp:

Jenin camp was officially established in 1953 on 372 donums and administrated by UNRWA to shelter the Palestinian refugee after the disaster (ALNAKBA). In 1966 the area of the camp was about 472 donums but it reduced to about 372 donums in 1987 and in 2000 it stabled on about 473 donums.

Jenin camp is considered to be the third camp in Palestine in terms of area after Aqbat Jabr camp and Ein el-Sultan camp. The Palestinian was expelled by the Israeli force from their original land, Carmel in Haifa and the Carmel Mountains, up to Marj Bin Amer and Wadi Araba {1}. See figure (2.2).

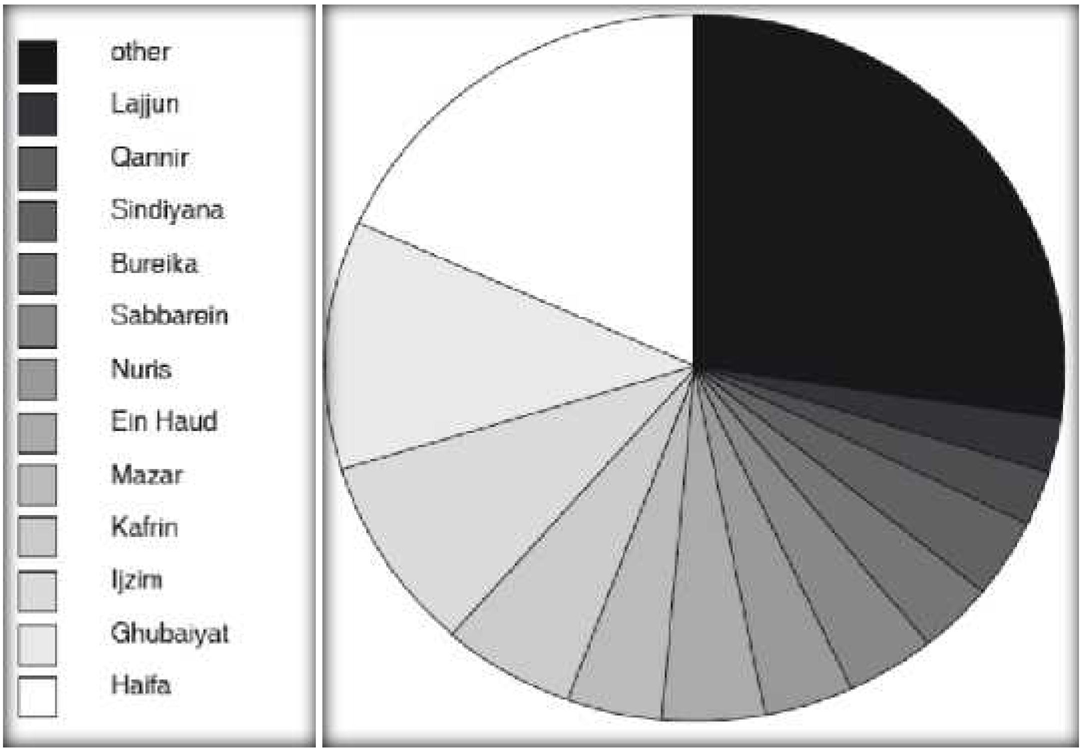

Figure (2.2): Percentage of Jenin camp population according to places of origin {1}.

A.2.2.3 Area at present:

Jenin camp is one of the biggest refugee camps in the west bank, but it’s also suffering from the crowded area. According to UNRWA the current area of the camp is 473 donums.

A.2.3 Demographic information:

A.2.3.1 Population:

Based on UNRWA statistics at 2007 the number of refugees is about 15854 in Jenin's camp, in 3730 family’s with an average individual 4.41 for each family, these families live in about 1478 shelter (According to UNRWA),and the population density in the camp is up to 348 person/hec.

Based on UNRWA statistics at 2007 the number of refugees is about 15854, 8117 of the refugees are male about 51.2% and 7737 are female about 48.8%.

The persons under 14 years are about 34.8%, 20.1% are between 15-24 years, 36.4% are between 25-60 , and 8.7% over 60 years, and figure (2.3) show the distribution .(UNRWA).

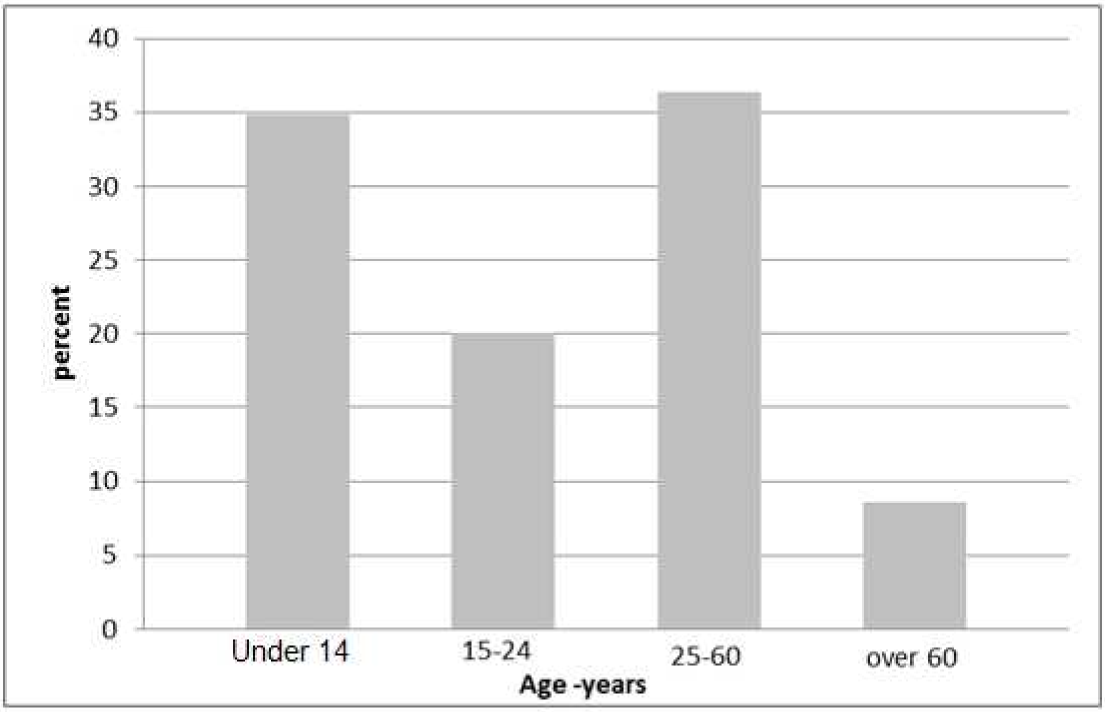

Chart (2.3): Age groups and the percentage of each group of the population in Jenin. {1}

A.2.3.2 Education:

There are overcrowded students in Jenin camp's schools. UNRWA build two schools in the outskirts of the camp in addition to an old school inside the camp, these three schools attended by about 1460 boys and 1412 girls, so it's should work with two periods, morning period and afternoon period.

After reconstruction the camp - after Israeli attack in 2002 one school constructed in addition to the three schools, to decrease the overcrowded student in the schools, and the two period's school reduced to about 42%, but there is a problem that these schools just for elementary stage and the students of the secondary stage should go to Jenin city.

There is shortage of facilities in schools of the camp, like laboratories, libraries …etc. And there were huge effects of first and second "Intifada", Israeli occupation on literacy percentage, and phenomenon of schools drop-out increased; due to closing schools long periods, so the literacy percentage exceeds 33.4% of female older than 12 years, and 20.9% of male elder than 12 years, according to Palestinian Central Statistical Office (PCSO) {4}.

On the other side the percentage of who completed high education (secondary and above) reached 18.9% of females and 22% of males according to (PCSO) 2003, and according to field visits in 2005. We can't ignore the effect of occupation on level of academic fraud. The camp contains only one or two kindergartens.

The UNRWA tried to compensate the specified academic lost time by establishing new classes to help the students in their education by giving them books and providing them multi choices to help them in study.

A.2.3.3 Health Status:

The UNRWA is the main provider of health services, by a health center that serves 5780 registered families; this center consists of several clinics, such as: Physician Clinic, Dental Clinic, also contains Medical Lab, and Physiotherapy Centre. {1}

The health sector in Jenin camp lacks health services available at night as the clinics are only open during the day. The camp is also without, various medical equipment, medicines and emergency services.

A.2.3.4 Residential Conditions:

The number of housing units according to UNRWA records when establishment of the camp was equal 807 units, but in 2005 according to engineering department of the UNRWA it became 1350 housing units. {1}

The types of Housing Unit depending on construction materials according to Health Hazard Evaluation (HHE) of the UNRWA in 2007{1}:

- 0% is asbestos, wood, zinc.
- 1% is stone.
- 0% is concrete.
- 99% are load bearing hollow blocks.

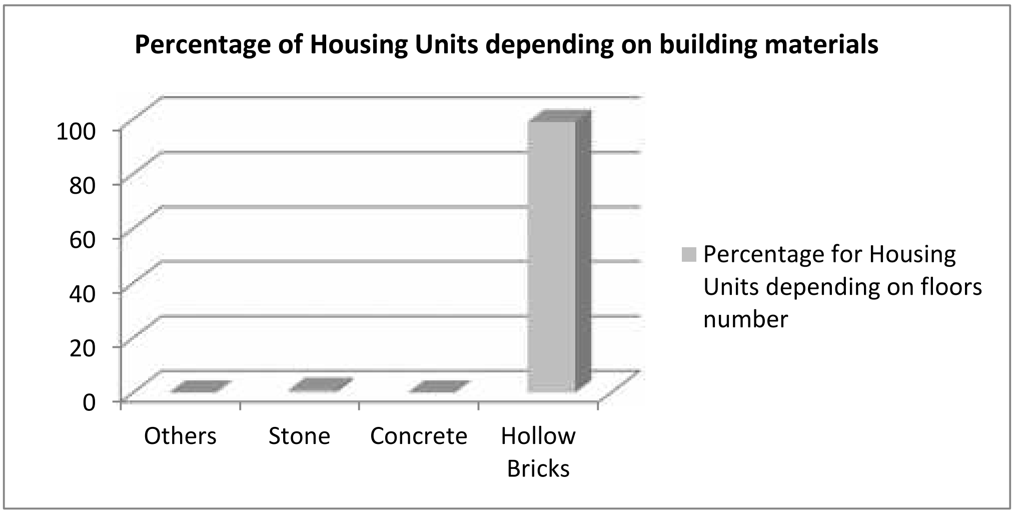

Chart (2.4): Percentage of Housing Units in Jenin camp depending on building materials {1}

As for the number of floors in the camp according to Central Statistics Office (CSO) of UNRWA in 2007 , residential units which consists of ground floor it accounted 2% of housing units , 70% consists of First Floor , 15% consists of two floors , and 13% consists of more than two floors , See the following chart:

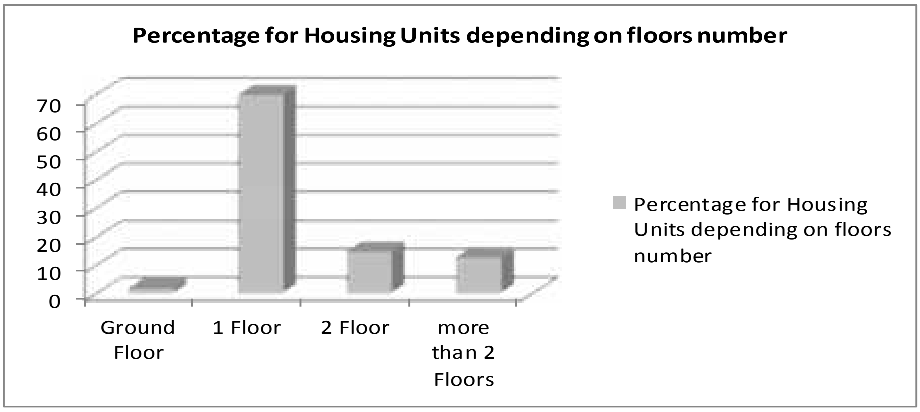

Chart (2.5): Percentage of Housing Units in Jenin depending on floors number {1}

A.2.3.5 Economic conditions:

First stage: from 1953-1987

There is many factors effect on the camp on this stage of time, when Jenin camp established the refugee start works to feed their families and making live, they are work farmers in the camp or workers in Jenin city. But there still large number of unemployment people.

After 1967, some refugees were able to return to occupied territories to work there especially in Haifa and Khdera, and one of the reasons helped the refugees to work is the good relationship with the people in Jenin city and Haifa so that allowed them to work in small trades, other factor helped them is the migration of many refugee to the Jordan and the Gulf to funded their families. {1}.

Second stage: after 1987

The Israeli occupation prevent the refugees to work inside the occupied lands, so that affect the economic situation in Jenin camp, but in 1995 when the Palestinian Authority received the administration of Jenin camp the economic situation get better slowly until the second Intifada in 2000, during the Intifada the occupation prevent the people to work in the occupied territories and that led to more poverty between the refugee and increase the unemployment to about 70% of the total refugees.

And the invasion that happened in 2002 to the camp in the third of April make the situation worse because the camp was a main target to the Israeli attack to destroy the camp because the legendary resistance that the resident of camp show against the Israeli repression machine.

After these two distresses the camp adopted on the external helps from the UNRWA, in 2002 a study from Beer Zeit University showed that about 48% of Refugees in Jenin camp are employees ,And this study mention that the unemployment inside the camp is about three times than out of the camp, so it reached about 33% according to the international bank in 2001 and that was a reason for increasing the unemployment inside the camp, and according to the office of the special coordinator of UNRWA in the occupied territories the unemployment reach to about 55% inside the camp{1}.

A.2.4 Infrastructure services:

The issue of infrastructure conditions in the west bank camps has not been discussed before, although it’s one of the camps chronic problems. The purpose of this study is to discuss the complicated infrastructure conditions on samples of west bank camps.

A.2.4.1 Municipal services:

The infrastructure networks in Jenin's camp are not good, because it is not designed on the engineering basics:

- Telecommunication: the shelters in the camps are connected to the communication network “PALTEL".

- Water Supply: all shelters in the camp have indoor water connection, and the average water available for person is 50 liters per day.

- Electricity: Nearly all the refugee has electricity in their houses, supplied by Jenin municipality.

- Sewage system: all of shelters in the camp are connected to public sewage network, supplied by Jenin municipality, but sewerage services in the camp are poor and rapidly deteriorated due to the absence of proper infrastructure elements, the constructed sewers systems are characterized by lack of long term planning, absence of proper municipal connections, the situation is usually treated on temporary basis, which cause health hazards.

- Storm water network: as well camps in west bank, jenen camp suffering from lack storm water drainage, the situation is resolved on partial solutions are given to chronic problems as flood of rain water in roads , ingress of water to homes , disrupt traffic in winter , and damage to students during departure and return from their schools .

-Road network:
The roads in this camp are three types:
Asphalt represents 10%, unpaved represents 0%, and concrete represents 90 %.{ 1}

A.2.4.2 Organizations, Programs and Activities:

Like other camps Jenin camp administrated by UNRWA, which there is many services in refugee camp as:

One camp services office.

One boy's school and one girl's school.

One health center.

One food distribution Centre.

One youth center.

And there is a local public committee service responding on the activities that the UNRWA don’t administrate.

Figure 2.6 represent Jenin camp layout. And figure 2.7 represent important site in Jenin camp.

A3 LAYOUT 2.6

A3 SITES 2.7

Second: Qalandia Refugee camp

B.2.2 General Information:

B.2.2.1 Geographic location:

It is about 11 km to the north of Jerusalem in the top of mountain, its bounded by Khrbet Al ram from south , Kofor Akab from north, and the major road- that connect south with north of west bank- from west.{1}

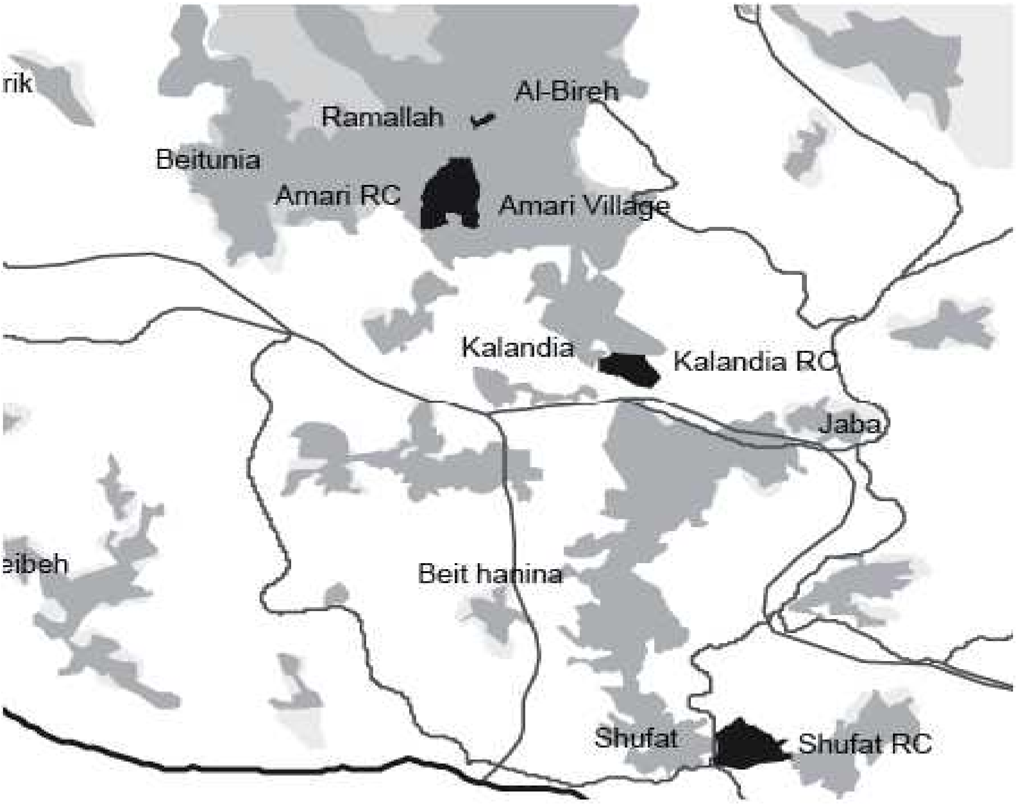

Figure (2.8): Location of Qalandia camp {1}.

B.2.2.2 History of the camp:

Qalandia refugee camp established in 1949 by United Nations Relief and Works Agency (UNRWA), the camp take its name related to Qalandia village in Jerusalem which the camp is established on.

The UNRWA rents the lands from the Hashemite Kingdom of Jordan in1950 to cover about3000 refugees.

Original inhabitants came from 52 villages in the Al-Ludd, Ramleh, Haifa, Jerusalem and Hebron. See figure (2.9).

In 1965 many families were added to the Qalandia camp from the surrounding villages, and after 1967 war, several families immigrated from Emmaus and Latrun. But unfortunately there is about 170 families are not considered as refugees, but the difficult condition forced them to live in the camps.

The refugee life condition in 1948 was very difficult and they were live in tents, after that the UNRWA provided them small rooms (11M^2) for each family, high population density and small houses make the refugees to expand horizontally, and this cause's crowded camp.

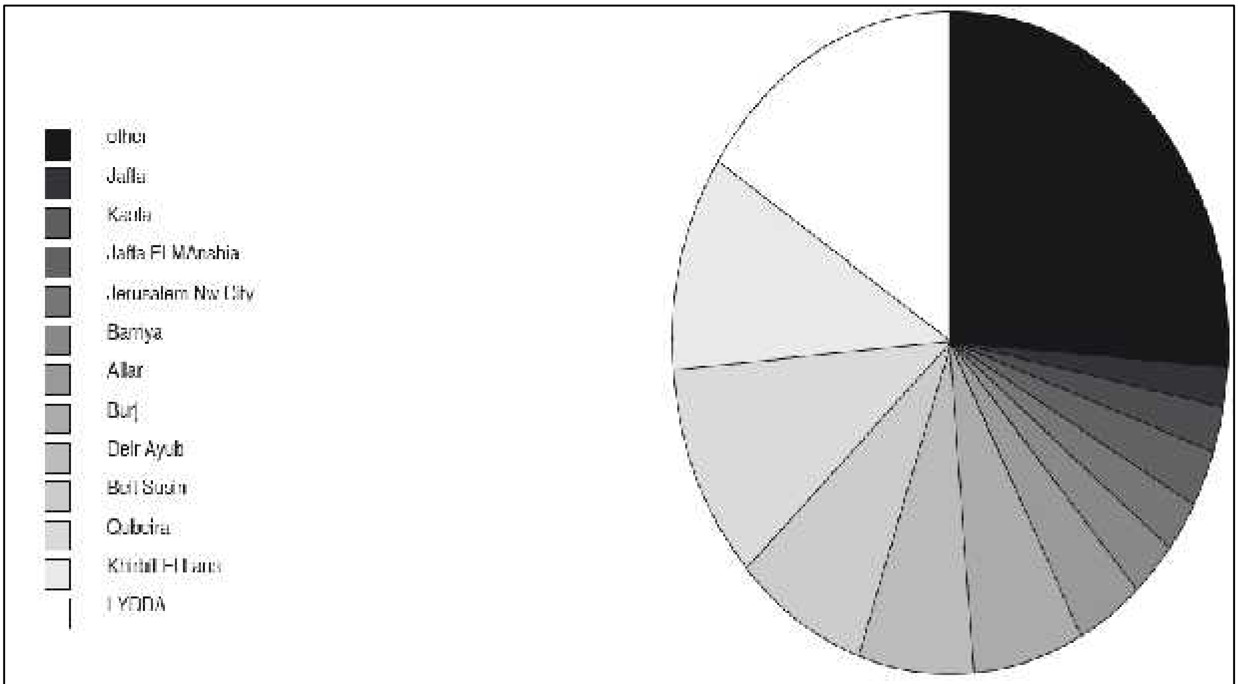

Figure (2.9): Percentage of Qalandia camp population according to places of origin {1}.

B.2.2.3 Area at present:

The area expanded with the time due to the population growth, but it still so small besides of huge population density. According to URWA Reports; the recent area is 253 donums.

B.2.3 Demographic Information:

B.2.3.1 Population:

Based on UNRWA statistic on the year of 2007, the number of refugees in Qalan
dia is about 10759 refugees in 2430 family with average individual 4.6 for each family, these families live in about 870 shelters. {1}
The last population statics shows that about 5552 of the refugees are male about 51.6% and 5207 are female about 48.4%.
The persons under 14 years are about 35.6%, 21.3% are between15-24, 37.0 % between 25-60 years and about 6.1% are over 60. {1}

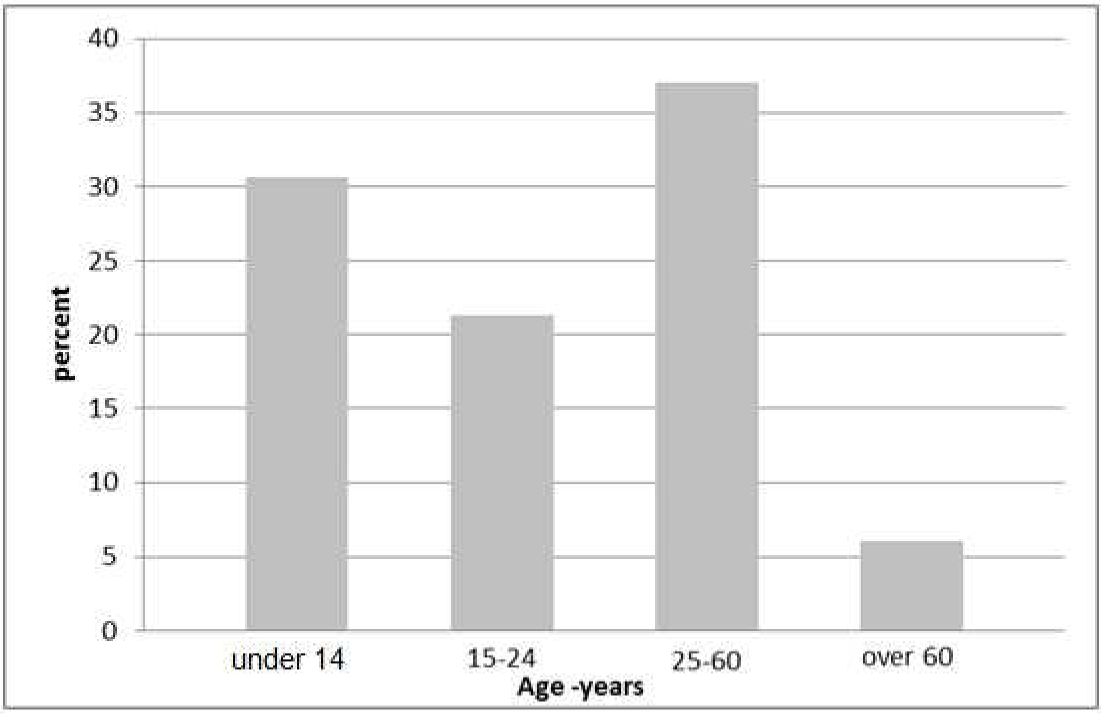

Figure (2.10): Age groups and the percentage of each group of the population in Qalandia camp. {1}

B.2.3.2 Education:

The educational attainment in Qalandia Refugee Camp According to last statistics in 2007 UNRWA , there are four schools in Qalandia camp two administrated by the UNRWA and the other are governmental school, there are about 856 students in two boys schools and about 915 students in girls school.
There are four schools in the present, for elementary stage there are three schools supervised by UNRWA, and there is just one secondary school supervised by government. The following table shows the number of schools by name, stage, gender, and supervising authority according to UNRWA.

The number of students in Qalandia refugee camp according to UNRWA services within refugee camps (2007) about 1771 , 856 are male were 310 studying elementary school and 546 in prep school ,and there are 915 female, were 361 studying in elementary school , and 476 studying in prep school.

B.2.3.3 Health Status:

The UNRWA is the main provider of health services, there is a health center that serves about 1932registerd families, this center consists of several clinics, such as: Physician Clinic , and Dental Clinic , And also contains Medical Lab , and Physiotherapy Centre .There are also five private health centers in the camp and one physiotherapy unit. {1}

B.2.3.4 Residential Conditions:

The number of housing units according to UNRWA records was 250 units when the camp established, but in 2005 according to UNRWA there are about 850 units. {1}

The types of housing units depending on construction materials according to Health Hazard Evaluation (HHE) of the UNRWA in 2007.{1}:

1- 0% is asbestos, wood, zinc.

2-0% is concrete.

3-10% is stone.

4-90% is cement bricks.

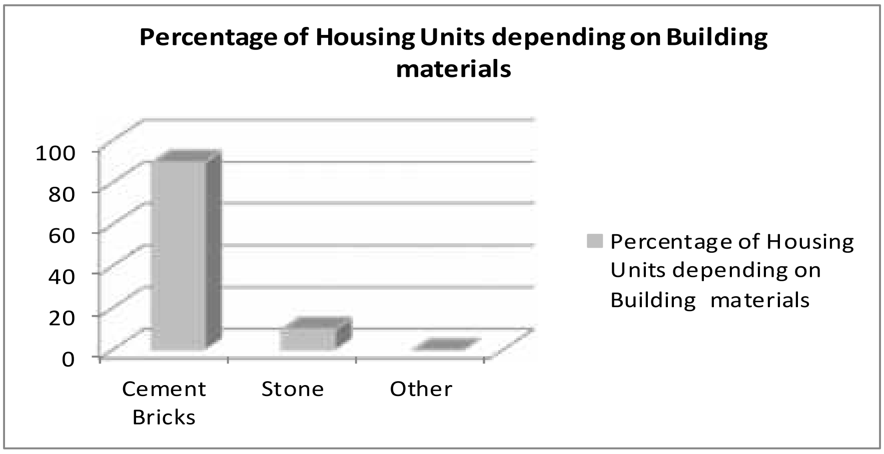

Figure (2.11): Percentage of Housing Units in Qalandia camp depending on building materials {1}

As for the number of floors in the camp according to Central Statistics Office (CSO) of UNRWA in 2007 ,the residential units are consists of ground floor are about 10% of housing units, 50%

consists of First Floor , 35% consists of two floors , and 5% consists of more than two floors , See the following chart.

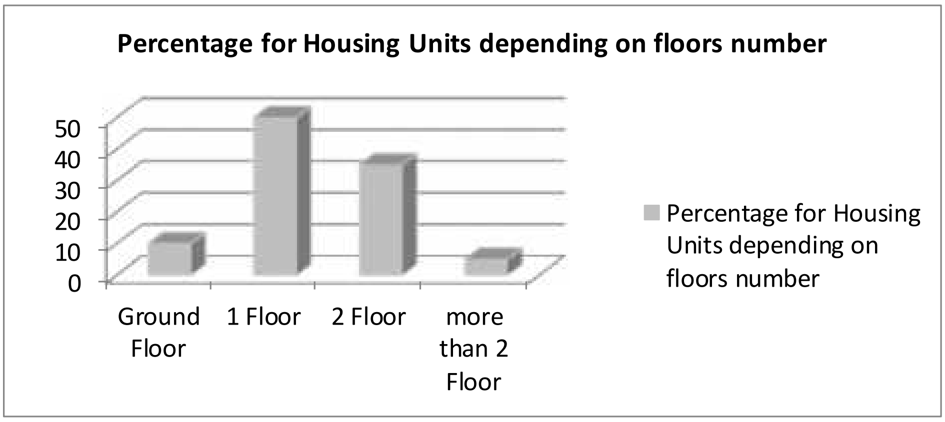

Figure (2.12): Percentage of Housing Units in Qalandia depending on floors number. {1}

B.2.3.5 Economic conditions:

The refugees in Qalandia camp in general are working in Israeli private sector and technical works.

1- 99% of refugees male work in Israeli private sectors.

2- 2% of female works in public sector and UNRWA.

Some refugees are working in small shops and minimarkets, and there is a shoes factory established by local public committee services to reduce the number of unemployment refugees.

B.2.4 Infrastructure services:

Like other refugee camps the infrastructure networks in Qalandia is bad, because it is not designed on the engineering basics.

B.2.4.1 Municipal Services:

Telecommunication: About 90% of the shelters in the camp are connected to the telecommunication network PAL-COM (Palestinian).

- Water: The water networks serve about 100 % of the refugee but it is not sufficient because the lack of water especially in summer and the owner of distribution network is Jerusalem Water Undertaking JWU (Palestinian company).

- Electricity: The entire refugee has electricity in their houses and from Jerusalem District Electrical Company.

-Sewage system: there is public sewage network system covers most of the refugee camp, but still there are many houses have cesspits, sewage system is considerd not good , because the sewage network is not designed on engineering basics, built in uncontrolled way, and it is suffering from leaking out the pipes especially at connection points. Also the network closed some times because of solid wastes.

-Storm water system: there is no storm water drainage system in this camp so the roads flood in winter.

-Roads networks: the roads in this camp are three types

1- Paved roads 75%.
2- Unpaved roads 5%.
3- Concrete roads 20%.

So it’s reflected the bad situation in roads of qalandia camp.

B.2.4.2 Organization, Program, Activities:

Like other camps Qalandia camp administrated by UNRWA, which there is many services in refugee camp as:

- One camp services office.
- Tow boy's school and tow girl's school.
- One health center.
- One physiotherapy Unit.
- One food distribution Centre.

And there is a local public committee service responding on the activities that the UNRWA don’t administrate.

Figure 2.13 represent Qalandia camp layout. And figure 2.14 represent important site in it.

A3 Layout

2.13

A3 Site

2.14

Third: Al-Arroub refugee camp

C.2.2 General Information:

C.2.2.1 Geographic location:

Al-Arroub refugee camp is located in the south of West Bank about 11 km north of Hebron and 15 km south of Bethlehem, on the main road between Bethlehem and Hebron , it is bordered from the east Beit Fajar, Israeli settlements from the north, Beit Ummar from the west, and from the south there is Sa'aer .{5}

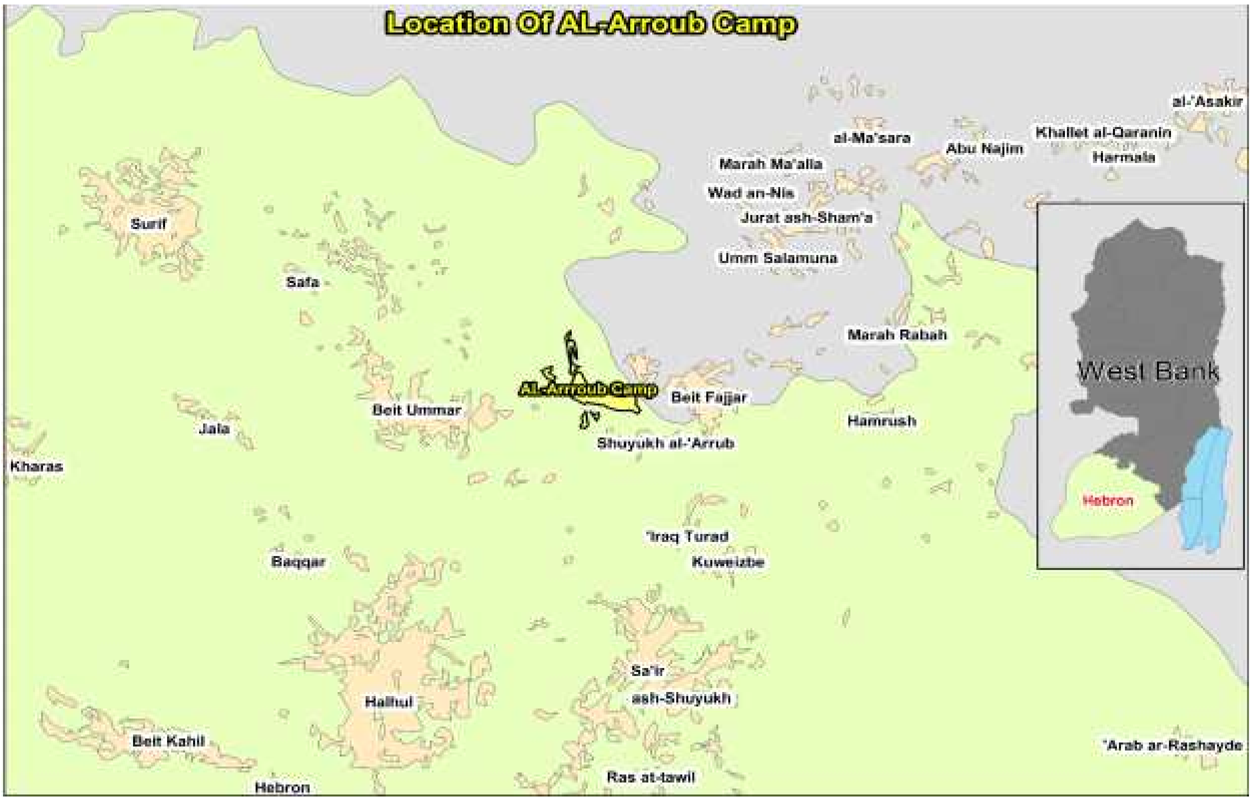

Figure (2.15): Location of AL-Arroub camp (Project Team)

C.2.2.2 History of camp:

Established in 1949 by the United Nations Relief and Works Agency (UNRWA), Al-Arroub Refugee Camp began as a place for Palestinian refugees after the Palestinian Catastrophe, ‘Al Nakba’, when they were forced to leave their original villages by the Israeli army. These refugees lived in Al-Arroub area on only 242 donums, UNRWA when established the camp build 807 housing units for them according to their family size. Since its establishment in 1949, the camp remains supervised by UNRWA, which provides essential services and needs from health, education to humanitarian assistance.

Villages which they were expelled up to 33 villages located in the Ramleh, Hebron and Gaza such as: Iraq Almansheia, Zakaria, Ajor, Al-Qostanteniah Al-Faloja, Al-Dawayma, and Beit Ntef. And the figure (2.16) shows the proportion of the camp population from their original villages. {5}

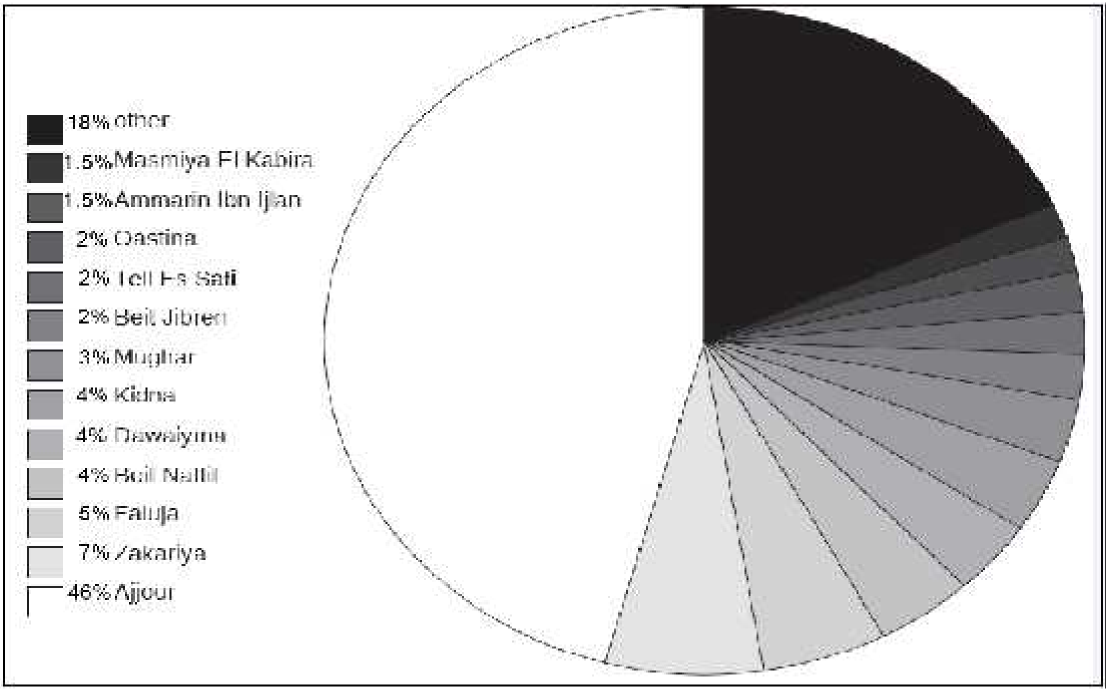

Figure (2.16): Percentage of AL-Arroub camp population according to places of origin. {1}

For the legal status of land, all West Bank camps were set up on plots of land leased by UNRWA from the Hashemite Kingdom of Jordan in 14/03/1951. No lease agreement with private individuals. When camps were established, most of the land was already state land, while small private plots had been leased by the host government from local land owners, the area of the camp at a present time 242 donums, 77.43% is private land, and 22.4% government land.

C.2.2.3 Area at present:

The area expanded with the time due to the huge population growth, but it still so small besides of huge population density and so crowded, also no current possibility to expand out the camp's borders. According to URWA reports; the recent area is 242 donums.

C.2.3 Demographic Information:

C.2.3.1 Population:

Based on UNRWA statistics at 2007, the total population of AL-Arroub camp was 10444 refugee distributed in 1358 family , The average family size was 5.8 for each family, these families living in 1420 housing units (including upper floors) ,Also the population density in the camp up to 328 person/hac . {5}

Demographic characteristics:

The last population statics in 2007 by (PCBS) shows that about 5316 of the refugees are male about 50.9% From the total population and 5128 are female about 49.1% from the total population, therefore the sex ratio in the camp was 104 male for every 100 female. {4}

The Age Groups in the AL-Arroub Camp classified by UNRWA as follows:

The persons under years are about 42.7% this percentage shows that the community in the AL-Arroub camp is a young society, 19.8% are between 15-24 years , 32.8% are Between 25-60 years , and 4.7% older than 60 years , and the following figure(2.17) shows that (UNRWA, 2008).

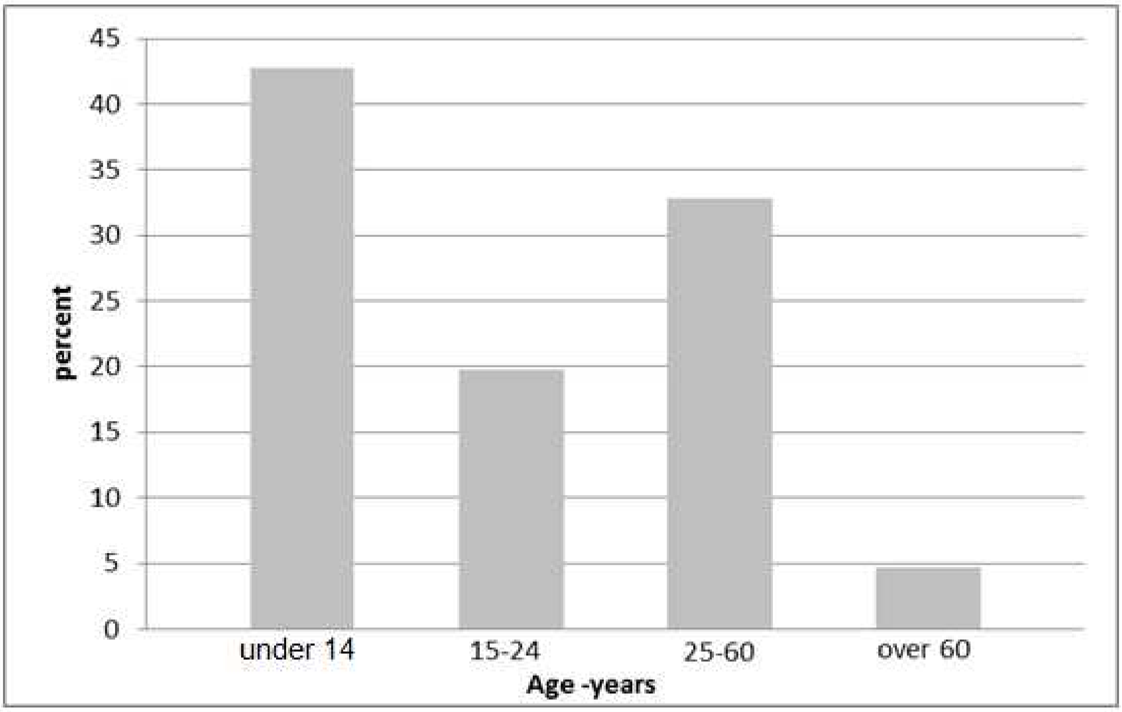

Figure (2.17): Age groups and the percentage of each group of the population in AL-Arroub camp. {1}

C.2.3.2 Education:

The educational attainment by gender in Al 'Arroub Refugee Camp According to last statistics in 2007 by Palestinian Central Bureau of Statistics (PCBS) , for the population aged over 10 years ,table (2.1) shows that 5.5 % of the population were illiterate ,Where the percentage of male illiterate 26.4% and 73.6% of females . The table also shows that 10.8% from the people can read and write without formal education , 20% had completed the elementary stage, 29% had completed preparatory stage, 16.7% had completed secondary stage , 18% from residents of camp completed the higher education study (associate diploma and more).{5}

Table (2.1): Al 'Arroub Refugee Camp Population (10 years and above) by educational attainment by Gender. {5}

Gender	Illiterate	Can read and write	Elementary	Preparatory	Secondary	Associate Diploma	Bachelor	Higher Diploma	Master	PhD	Total
Male	79	287	541	884	480	209	231	8	31	8	2758
Female	220	304	541	703	431	243	256	2	5	1	2706
Total	299	591	1082	1587	911	452	487	10	36	9	5464

There are four schools in the present, for the elementary stage there are three schools supervised by UNRWA, And secondary stage just it one supervised by government. The following table shows the number of schools by name, stage, gender, and supervising authority according to ARIJ field survey data, 2007.

Table (2.2): The schools in AL-Arroub refugee camp by name, stage, gender, and supervising authority. {5}

NO.	School Name	Stage	Gender	Supervising Authority
1.	AL-Arroub Co-education Agriculture Secondary School	Secondary	Co-education	Governmental
2.	AL-Arroub Elementary Boys School	Elementary	Male	UNRWA
3.	First AL-Arroub Elementary Girls School	Elementary	Female	UNRWA
4.	Second AL-Arroub Elementary Girls School	Elementary	Female	UNRWA

The number of students in AL-Arroub refugee camp according to UNRWA services within refugee camps (2007) ,about 2100 students , 1043 are male ,whom 362 studying in second shift ,as female 1057, whom 581 studying in first school for girls , and 476 studying in second school for girls. {1}

C.2.3.3 Health Status:

The UNRWA is the main provider of health services, By a health center that serves 2880 registered families in which, This center consists of several clinics, such as: Physician Clinic , and Dental Clinic , And also contains Medical Lab , and Physiotherapy Centre .

There are also two private clinics in the camp, General Medicine Clinic, and Dental Clinic, and there are also two pharmacies. {1}

The health sector in Al 'Arroub Camp lacks health services available at night as the clinics are only open during the day. The camp is also without an ambulance, various medical equipment, medicines and emergency services. Camp residents are forced to travel about two or twelve kilometers to reach Beit Fajar and Hebron health clinics and hospitals, respectively. {5}

C.2.3.4 Residential Conditions:

The number of housing units according to UNRWA records when establishment of the camp was equal 807 units, but in 2005 according to engineering department of the UNRWA it became 1350 housing units. {1}

The types of Housing Units depending on construction materials according to Health Hazard Evaluation (HHE) of the UNRWA in 2007. {1}

1- 0% is asbestos, wood, zinc.

2- 11.7% are stone.

3- 0.5% is concrete.

4- 87.8% are cement bricks.

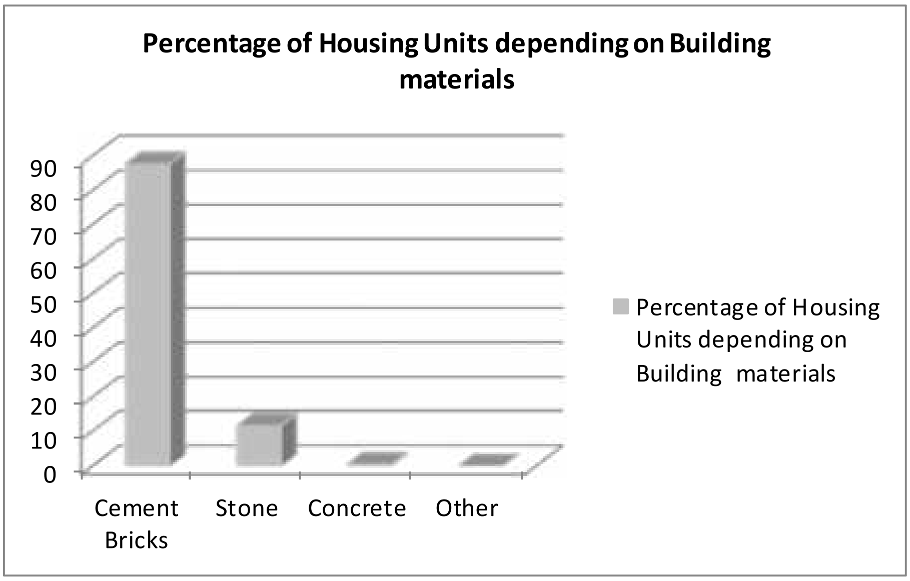

Figure (2.18): Percentage of Housing Units in AL_Arroub depending on building materials. {1}

As for the number of floors in the camp according to Central Statistics Office (CSO) of UNRWA in 2007 , residential units which consists of ground floor it accounted 15% of housing units, 50% consists of First Floor , 33% consists of two floors, and 2% consists of more than two floors , See figure (2.19) .

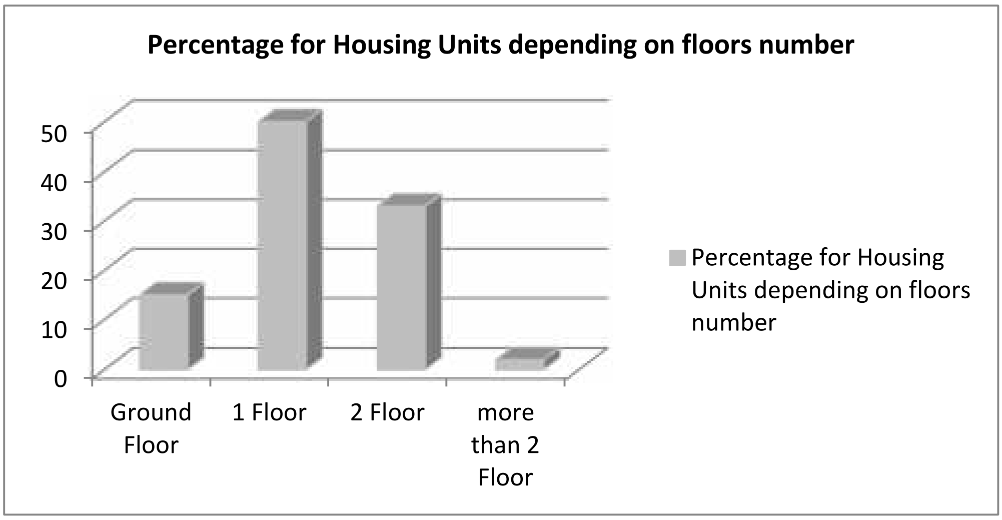

Figure (2.19): Percentage of Housing Units IN AL_Arroub camp depending on floors number. {1}

C.2.3.5 Economic Conditions:

The employment rate in AL-Arroub camp according to Palestinian Central Bureau of Statistics (PCBS) in 2007 is 80.4%, whom 78% are male, and 22% are female. {4}

Most of the refugees are working as an employees , where this ratio up to 50% of the employment rate, while the rest are working in the private sector , Services Sector ,and in Israeli labor market .Figure (2.20) shows the percentage for each sector from employment sectors. {5}

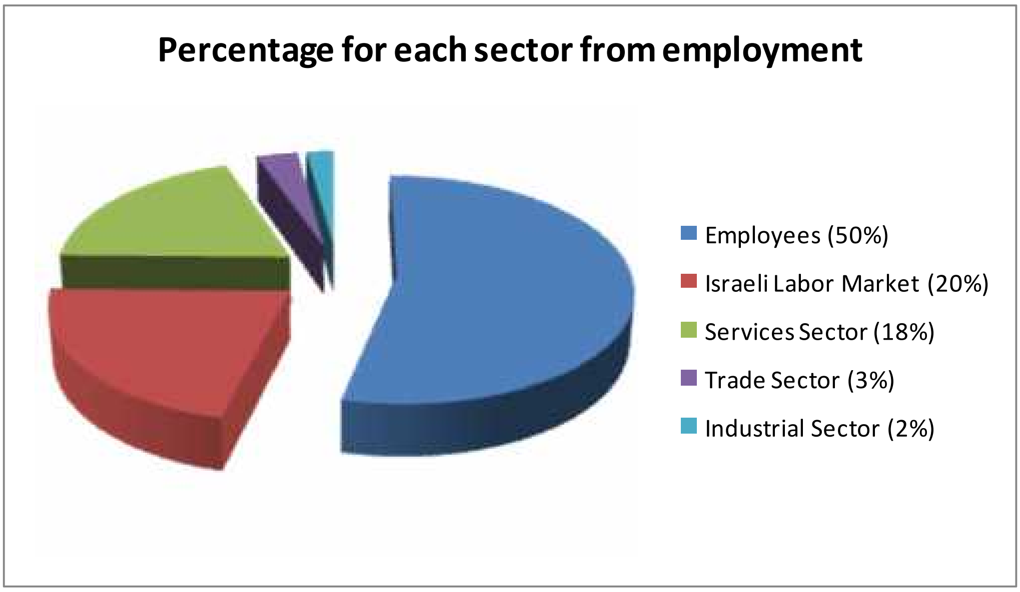

Figure (2.20): Employment percentage for each sector from employment sectors in AL-Arroub camp by field survey conducted in the Camp {5}

C.2.4 Infrastructure:

Like other refugee camps the infrastructure networks in Al-Arroub camp is very bad, because it is not designed on the engineering basics, and the camp were found on temporal basis waiting for the solution of refugee's problem. Accordingly, infrastructures which were not developed during the past years despite the increase in refugee's numbers and the development in social and economic conditions among refugees.

C.2.4.1 Municipal Service:

- Telecommunication: About 90% of the shelters in the camps are connected to the communication network PALTEL.

- Water: The water supply pattern has been developed from distribution by water tanker to public water stand pipes then into household connections. The development was done by various uncoordinated efforts. It was based on temporary basis which did not consider the future demands of population. The water networks serve about 100 % of the refugee but it is not sufficient because the lack of water especially in summer.

- Electricity: Nearly all the refugee has electricity in their houses and the public local committee dispread it after purchasing it from Israeli electricity distribution network.

- Sewage system: In 2002 a sewage network built in Al-Arroub, in the beginning UNRWA installed sewer lines in the major street of the camp and connected them to the main municipal line. Other sewer lines were connected to old lines and passed beside houses (UNRWA). The existing sewerage system is still working and serves some of the population. The disadvantages of this system is that the flooded manholes, and lack of long term planning, absence of proper municipal connections, the situation is usually treated on temporary basis, which cause health hazards.

- Storm water drainage system: there is no proper storm water drainage system in the camp; however, it's have one culvert exist in camp were its constructed to dispose of storm water into a near valley passing beside the camp, but it's not efficient, because it's considered small, comparing it with the quantity of rain water, so in rainy season the alleys and streets are usually flooded, and they become a source of potential hazards that endanger the near houses and public health.
- Road network: Al-Arroub has deteriorated roads, because it is not built on the engineering basics .Which it is suffer from improper slopes and lack of asphalt quantities…etc. the roads in this camp are three types.

1- Asphalt roads 10%.
2- Unpaved roads 0%.
3- Concrete roads 90%.

So it's present the bad situation in roads of Al-Arroub camp.

C.2.4.2 Organizations, Programs, Activities:

Like other camps Al-Arroub camp administrated by UNRWA, which there is many services in refugee camp as:

One camp services office.

One boy's school and one girl's school.

One health center.

One food distribution Centre.

One youth center.

And there is a local public committee service responding on the activities that the UNRWA don’t administrate.

Figure 2.21 represent AL-Arroub camp layout. And figure 2.22 represent important site in AL-Arroub camp.

A3 layout 2.21

A3 site 2.22

The following table evaluates and compare between camps to choose the most needed infrastructure camp.

Table (2.3): comparison between camps. (Project Team)

Names of Refugee camp / Comparing Factors		AL-Arroub Camp	Qalandia Camp	Jenin camp
1. General Information:				
Year of establishment		1949	1949	1953
Area at present (dunum)		242	253	423
2.Demographic profile:				
UNRWA registered camp population at present		10444 Persons	10759 persons	15854 persons
3.Spatial/Physical information:				
Numbers of building at present		1420 units, Including upper floor	870 units , including upper floors	1478 units ,including upper floors
Population density (c/ha)		328	575.9	199.8
4.Technical infrastructures /services:				
Water supplier		UNRWA water	Jerusalem Water Undertaking	Jenin Municipality
Average water available per person		75 l/day	40 l/day	50 l/day
Sewer disposal facilities	Cesspits	Yes	Yes	No
	Public sewage network	Yes	Yes	yes (owner: Jenin Municipal)
	private sewage connection	No	No	No
Storm-water drainage		No	No	No

After obtaining this information it's clear that all camps have a bad conditions such as : " living situation , widespread unemployment , poverty , high density population and low level of services provided, bad infrastructure conditions , like unequal availability of sewage networks , lack of storm water networks, and unpaved roads. And therefore all of these camps are in need of assistance and rehabilitation.

Qalandia camp is ruled out for political reasons, as a part of this camp is followed administratively for the Israeli hold and therefore researchers stumble on them to enter the region.

Jenin camp is ruled out because that a part of its infrastructure is better than others, as it has a sewage networks built after 2002 events.

So this study will concern on AL-Arroub camp and it will be work with redesigning the infrastructure of this camp.

CHAPTER THREE

CHARACTERISTICS OF THE PROJECT AREA "AL-ARROUB CAMP"

3.1 GENERAL.

3.2 PROJECT AREA.

3.3 METROLOGICAL DATA.

3.4 POPULATION.

3.5 WATER CONSUMPTION.

3.6 WASTEWATER QUANTITY

3.7 STORM WATER.

3.8 ROADS STATUS.

3.1 General

In this chapter, we will talk about the basic data on Al-arroub camp. Topography, meteorological, Population data, water consumption, and wastewater production.

(Figure 3.1) General View of AL-Arroub Camp (Nov.2011)

3.2 Project Area

Al-Arroub is a Palestinian refugee camp located in the southern West Bank along the Hebron-Jerusalem road in the Hebron Governorate.

It is fifteen kilometers south of Bethlehem, thirty five kilometers south of Jerusalem, eleven kilometers north of Hebron, border it from east bait fjar, bait omar from west, aseon colonies from north, and Sa'aer village from south. (Figure 3.2) shows the camp's location. Total land area is 242 donums according to UNRWA. The elevation of the candidate site ranges from (700 to 890) meter above the sea level. {5}

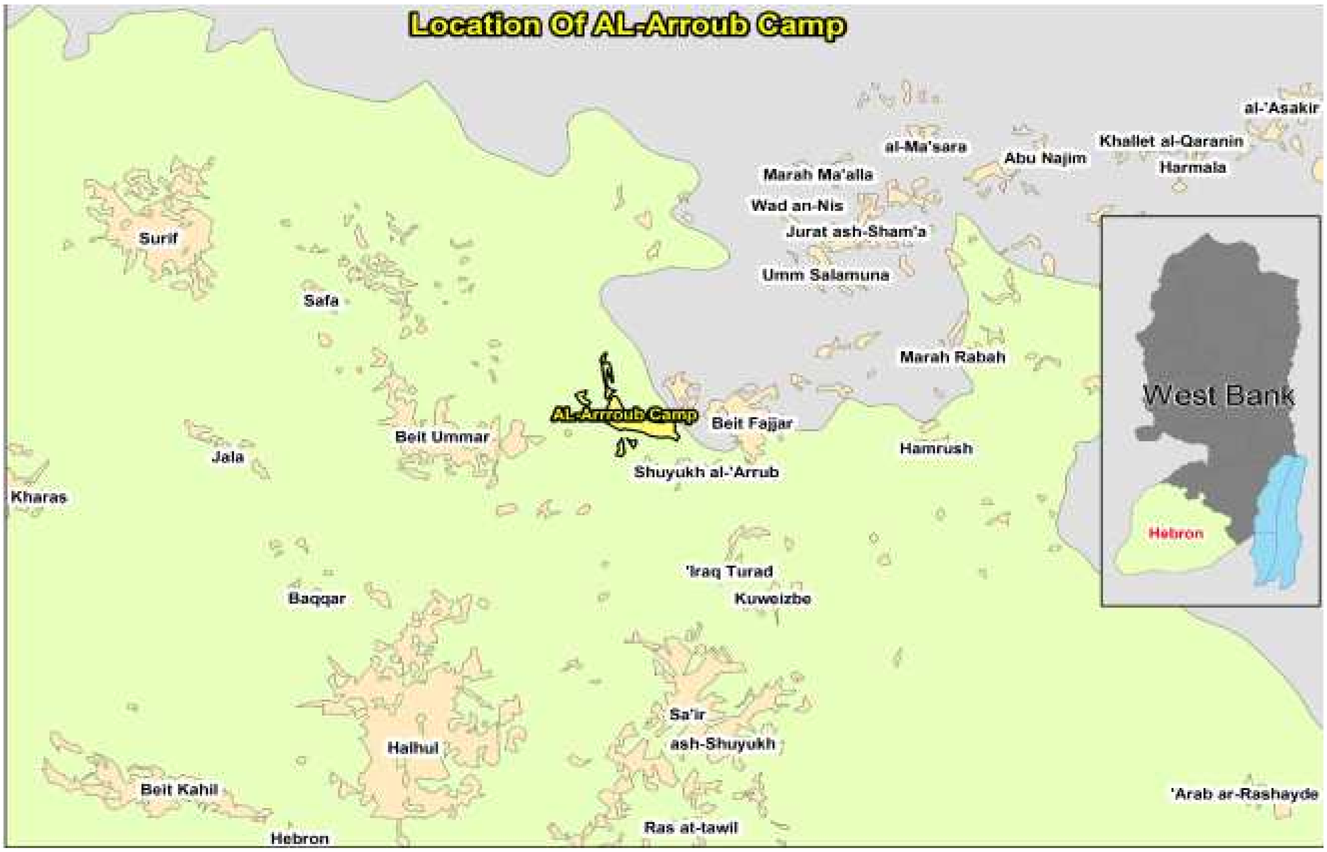

Figure (3.2): Location map, (Project team)

3.3 Meteorological Data:

The hydrology of region depends basically on its climate, and secondarily on topography. Climate is largely dependent on geographical position of the earth surface, humidity, temperature, and wind. These factors are affecting on evaporation and transpiration. So this study will include needed data about these factors. The climate of Al-aroub camp wet and the same climate of surrounding area. The camp is part of Hebron district witch is raised about 875 meters above the sea level.

3.3.1 Rainfall:

The average annual rainfall at area reaches approximately 650 mm .Rainfall occurs between October and May while it rarely rains in the summer season these information are given in table (3.1)

Table (3.1): monthly rainfall in Al-Arroub camp, {6}

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Total Rainfall (mm)	158	131	98	30	5	0	0	0	0	14	73	124

3.3.2 Temperature:

The temperature is characterized by winter; minimum temperature is recorded against the day of observation, and the maximum temperature against the previous day. The annual average maximum temperature values is (21.1**c**˚) and the annual average minimum temperature values is (10.4**c**˚) are given in table (3.2).

Table (3.2): monthly Temperature in Al-Arroub camp, {6}

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean Max. Temp.(c˚)	12.3	13.0	16.5	20.9	25.7	28.5	29.6	30.0	28.4	25.7	20.4	14.7
Mean Min. Temp.(c˚)	4.4	4.8	6.3	8.1	12.3	14.7	15.9	16.2	14.4	12.1	9.6	6.4
Mean Temp.(c˚)	8.4	8.9	11.4	14.5	19.0	21.6	22.8	23.1	21.4	18.9	15.0	10.6

3.3.3 Relative Humidity

Humidity is the ratio of the amount of water in the air at a give temperature to the maximum amount it could hold at that temperature, expressed as a percentage. The average annual relative humidity in the Al-Arroub camp is 67%. The highest percentage is observed during winter is 78% are given in table (3.3)

Table (3.3): monthly mean relative humidity in al-Arroub camp, {6}

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean RH (%)	77	78	71	65	57	54	59	64	70	64	72	75

3.3.4 Wind:

Al-Arroub camp Exposed in summers to hot and dry north and northern-east winds coming from the Arabian Peninsula, and daily winds blowing in daytime from the Mediterranean toward the ground and the median mountainous area due to differences in air pressure between the ground and water that temper the temperature and increase the air humidity. While in winter the area is under the influence of reverse westerly winds coming from the Mediterranean.

The wind is to take a path that is not straight an example of wind is a twisty path through the woods. The mean annual wind speed in the Al-Arroub camp is 7.1 (Km/h). The highest percentage is observed 10.8(km/h) are given in table (3.4).

(Table 3.4): monthly mean wind speed in al-Arroub camp. {6}

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean Wind Speed (Km/h)	8.6	10.1	10.8	9.7	6.5	5	5	5.4	5	5.8	5.8	7.9

3.4 Population:

3.4.1 Population projection:

The base for the forecast is the 2007 population for Al-Arroub camp obtained from PCBS of 7822 parsons. The annual growth rates for the next nine years are also obtained from the PCPS and they are presented in (Table 3.5).

(Table 3.5) annual growth rate (Project Team)

Year	Annual growth rate %
2008	3.35
2010	3.40
2012	3.40
2014	3.36
2016	3.28

To calculate the population at the end of the design period (year 2036), a geometric increase is assumed, represented by the following equation:

$$P = P_0 * (1+ r)^n \quad (3.1)$$

Where:

P_f: Future population.
P_o: Current population.
n: Design period.
r: Population growth.

3.4.2 Population Forecast for Al-Arroub camp

According to UNRWA in 2007, the population of Al-Arroub camp was approximately 10444 refugees distributed in 1358 family. The camp has approximately the same population density of camps on west bank with 432(c/ha), and annual average population growth of (3.35 %) from table 3.5.

Table 3.6 presents the population projection up to the design horizon of 2036. The data show that the population of Al-Arroub camp is estimated to be 27156 in year 2036.

(Table 3.6) Population Forecast for Al-Arroub camp (Project Team)

Year	2011	2015	2020	2025	2030	2036
Population(capita)	11915	13594	16029	18900	22285	27156

3.5 Water Consumption

3.5.1 Introduction:

Water demand in Al-Arroub camp, like other West Bank towns, is continuously increasing due to the increasing in population. The population of Al-Arroub camp is estimated about 11915 for year 2011 and 27156 for year 2036. The result of all this is obvious, the total water requirement is ever on the increase, and per capita water consumption is also on increase. Water consumption is not constant, yearly, monthly, weekly, daily and hourly variations in water consummations are observed. Certain dry years cause more consumption. In hot months water is consumed in drinking, bathing, and watering lawns and gardens. On holidays and weekends the water consumption may be high.

Even during day water use various with high use during morning hours and low use at night. Maximum daily demand or maximum daily consumption usually occurs during summer months. According to the water consumption data obtained from the UNRWA, the total water consumption for the Al-Arroub camp is approximately 809 cubic meters per day .the total water consumption per dounm equal 3.3 cubic meters per day. Average water available per person (75 l/c. day). {1}

3.5.2 Forecast water consumption:

The present average consumption of water for domestic use in Al-Arroub camp does not represent the present and actual demand of water. So, it is estimated the water consumption in Al-Arroub camp will dramatically increase during the next few years.

The forecast of the future water demand is made on the following assumptions:

1. Upgrading the existing water supply system.
2. Present annual demand is 75 1/c.d, and the rate of increase in the annual water demand per capita is equal to 2 %.
3. Present population is 11915, and population growth rate is equal 3.35 %.
4. Design period equal 25 years, up to 2036.

Based on the above assumptions, the water consumption of Al-Arroub camp were estimated at years 2015, 2020, and 2025 and 2036 per capita for the same years were calculated. Is presented in Table 3.7:

(Table 3.7) water consumption Forecast in Al-Arroub camp (Project Team)

Year	Population	Water Demand (L/day)	
		Per Capita	Total
2007	10444	75	873300
2015	13594	87	1182678
2025	18900	102	1973160
2036	27156	119	3459674.4

3.6 Wastewater Quantity:

Sanitary sewage is mostly the spent water of the community draining into the sewer system. It has been observed that a small portion of spent water is lost in evaporation, seepage in ground, leakage, etc. Usually 80% of the water supply may be expected to reach the sewers.

In overall the amount of Domestic wastewater produced per capita per day is usually 80% of water consumption. Al-arroub doesn’t produced industrial wastewater quantity because alarroub don’t has industrial zones

(Figure 3.3) Wastewater manholes with very short distance.

Figure 3.3 Illustrate how much the distance between manholes is short, which mean that the wastewater network does not designed on an engineering standards.

(Figure 3.4) Infiltration of rainfall to wastewater network.

Figure (3.4) illustrate the infiltration of rainfall to wastewater which causes an increasing of quantity of water and produce an additional load to the wastewater network.

3.7 Storm Water

There is no proper storm water drainage system in the camp; however, it’s have one culverts exist in camp were constructed to dispose of storm water into a near valley passing in the camp, but it's not efficient, because it’s considered small with compared of quantity of rain water, so in rainy seasons the alleys and streets are usually flooded, and they become a source of potential hazards that endanger the near houses and public health.

(Figure 3.5) A Culvert crossing the camp in left image, and the way where it cross "beside the wastewater" in right image

(Figure 3.6) Accumulative of Water at culvert.

The Figure represent, the ditches considered not efficient, because it is small with compared of quantity of rain water, so in rainy seasons the streets are usually flooded as show, and they become a source of potential hazards that endanger the near houses and public health.

3.8 ROADS STATUS.

Al-Arroub has deteriorated roads, because it is not built on the engineering basis, and its show on picture

(Figure 3.7) Improper of road slopes, and asphalt cracks

The slopes in Al-Arroub roads are improper and the asphalt is cracks.

Chapter Four

Design Parameters

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Chapter Four

Design Parameters

4.1 WASTEWATER COLLECTION SYSTEM DESIGN

4.1.1 General

Once used for its intended purposes, the water supply of a community is considered to be wastewater. The individual conduits used to collect and transport wastewater to the treatment facilities or to the point of disposal are called sewers.

There are three types of sewers: sanitary, storm, and combined. Sanitary sewers are designed to carry wastewater from residential, commercial, and industrial areas, and a certain amount of infiltration /inflow that may enter the system due to deteriorated conditions of sewers and manholes. Storm sewers are exclusively designed to carry the storm water. Combined sewers are designed to carry both the sanitary and the storm flows.

The network of sewers used to collect wastewater from a community is known as wastewater collection system. The purpose of this chapter is to define the types of sewers used in the collection systems, types of wastewater collection systems that are used, the appurtenances used in conjunction with sewers, the flow in sewers, the design of sewers, and the construction and maintenance of sewers.

4.1.2 Municipal Sewerage System

Types Of Sewers:

The types and sizes of sewers used in municipal collection system will vary with size of the collection system and the location of the wastewater treatment facilities. The municipal or the community sewerage system consists of (1) building sewers (also called house connections), (2) laterals or branch sewers, (3) main and submain sewers, (4) trunk sewers.

House sewers connect the building plumbing to the laterals or to any other sewer lines mentioned above. Laterals or branch sewers convey the wastewater to the main sewers. Several main sewers connect to the trunk sewers that convey the wastewater to large intercepting sewers or the treatment plant.

The diameter of a sewer line is generally determined from the peak flow that the line must carry and the local sewer regulations, concerning the minimum sizes of the laterals and house connections. The minimum size recommended for gravity sewer is 200 mm (8 in).

Sewer Materials:

Sewers are made from concrete, reinforced concrete, vitrified clay, asbestos cement, brick masonry, cast iron, ductile iron, corrugated steel, sheet steel, and plastic or polyvinyl chloride or ultra polyuinyl chloride. Concrete and ultra polyvinyl chlorides are the most common materials for sewer construction.

4.1.3 Types Of Wastewater Collection Systems

Gravity Sewer System:

Collecting both wastewater and storm water in one conduit (combined system) or in separate conduits (separate system). In this system, the sewers are partially filled. A typical characteristic is that the gradients of the sewers must be sufficient to create self-cleansing velocities for the transportation of sediment. These velocities are 0.6 to 0.7 m/s minimum when sewers are flowing full or half-full. Manholes are provided at regular intervals for the cleaning of sewers.

Pressure Type System:

Collecting wastewater only. The system, which is entirely kept under pressure, can be compared with a water distribution system. Sewage from an individual house connection, which is collected in manhole on the site of the premises, is pumped into the pressure system. There are no requirements with regard to the gradients of the sewers.

Vacuum Type System:

Collecting wastewater only in an airtight system. A vacuum of 5-7 m is maintained in the system for the collection and transportation of the wastewater. There is no special requirement for the gradients of the sewers.

Pressure and vacuum–types systems require a comparatively high degree of mechanization, automation and skilled manpower. They are often more economical than gravity system, when applied in low population density and unstable soil conditions. Piping with flexible joints has to be used in areas with expansive soils.

4.1.4 Sewer Appurtenances

Manholes:

Manholes should be of durable structure, provide easy access to the sewers for maintenance, and cause minimum interference to the sewage flow. Manholes should be located at the start and at the end of the line, at the intersections of sewers, at changes in grade, size and alignment except in curved sewers, and at intervals of 40-60 m in straight lines.

The general shapes of the manholes are square, rectangular or circular in plan, the latter is common. Manholes for small sewers are generally 1.0-1.2 m in diameter. For larger sewers larger manhole bases are provided. The maximum spacing of manholes is 40-60 m depending on the size of sewer and available size of sewer cleaning equipment {9}.

Standard manholes consist of base, risers, top, frame and cover, manhole benching, and step-iron. The construction materials of the manholes are usually precast concrete sections, cast in place concrete or brick. Frame and cover usually made of cast iron and they should have adequate strength and weight.

Drop Manholes:

A drop manhole is used where an incoming sewer, generally a lateral, enters the manhole at a point more than about 0.6 m above the outgoing sewer. The drop pipe permits workmen to enter the manhole without fear of being wetted, avoid the splashing of sewage and corrosion of manhole bottom .

House Connections:

The house sewers are generally 10-15 cm in diameter and constructed on a slope of 2% m/m. house connections are also called, service laterals, or service connections. Service connections are generally provided in the municipal sewers during construction. While the sewer line is under construction, the connections are conveniently located in the form of wyes or tees, and plugged tightly until service connections are made. In deep sewers, a vertical pipe encased in concrete is provided for house connections.

Inverted Siphons

An inverted siphon is a section of sewer, which is dropped below the hydraulic grade line in order to avoid an obstacle such as a railway or highway cut, a subway, or a stream. Such sewers will flow full and will be under some pressure; hence they must be designed to resist low internal pressures as well as external loads. It is also important that the velocity be kept relatively high (at least 0.9 m/s) to prevent deposition of solids in locations, which would be very difficult or impossible to clean.

Since sewage flow is subject to large variation, a single pipe will not serve adequately in this application. If it is small enough to maintain a velocity of 0.9 m/s at minimum flow, the velocity at peak flow will produce very high head losses and may actually damage the pipe. Inverted siphons normally include multiple pipes and an entrance structure designed to divide the flow among them so that the velocity in those pipes in use will be adequate to prevent deposition of solids {2}.

4.1.5 Design Parameters

Flow Rate Projections:

The total wastewater flow in sanitary sewers for industrial area is made up of two components:

(1) Domestic

(2) Infiltration.

Sanitary sewers are designed for peak flows from domestic, and peak infiltration allowance for the entire service area. The flow rate projections are necessary to determine the required capacities of sanitary sewers.

- The peak coefficient

In general, this coefficient increases when the average flow decrease, it will be determined from the practice and experience of the designer. The following relation has been used commonly by the designer and gives satisfactory results:

$$Pf = 1.5 + 2.5 / \sqrt{q} \qquad (4.1)$$

Where, q (in l/s) is the daily average flow rate of the network branch under consideration and Pf is the peak factor.

Hydraulic Design:

As mentioned earlier and according to usual practice, the sewers will be designed for gravity flow using Manning's formula:

$$V = (1/n)\, R^{2/3}\, S^{1/2} \qquad (4.2)$$

Depending on pipe materials, the typical values of n is 0.015

1. Minimum and Maximum Velocities

   To prevent the settlement of solid matter in the sewer, the literature suggested that the minimum velocity at half or full depth – during the peak flow period – should not be less than 0.6 m/s, Usually, maximum sewer velocities are limited to about 3 m/s in order to limit abrasion and avoid damages which may occur to the sewers and manholes due to high velocities.

2. Pipes and Sewers

   Experience indicates a minimum diameter of 200 mm (8 in) for sewer pipes. For house connections.

Pipe Materials: Different pipe materials may be recommended for the sewers. Polyvinyl chloride, vitrified clay or polyethylene material for small size pipes (approximately up to the size 400 mm in diameter).

Centrifugal cast reinforced concrete pipes may be used for larger diameter.

3. Manholes and Covers

Manholes should be located at changes in size, slope direction or junction with secondary sewer. Manholes spacing generally does not exceed 60 m.

4. Sewer Slope

For a circular sewer pipe, the slope must be between the minimum and maximum slope, the minimum and maximum slope is determined from minimum and maximum velocity. Generally the natural ground slope is used because it is the technical and economic solution, the solution is therefore recommended.

5. Depth of Sewer Pipe

The depth of sewers is generally 1.5 m below the ground surface. Depth should be enough to receive the sewage by gravity, avoid excessive traffic loads, and avoid the freezing of the sewer. It is recommended that the top of sewer should not be less than 1.5 m below basement floor {9}.

Important Numbers:

- Maximum velocity = 3 m/s
- Minimum velocity = 0.6 m/s
- Maximum slope = 15%
- Minimum slope = 0.5%
- H/D = 70%
- Minimum diameter 200 mm
- Minimum cover 1.5 m
- Maximum cover 5 m

4.2 STORM DRAINAGE SYSTEM DESIGN

4.2.1 General :

Rapid effective removal of storm runoff was a luxury not found in many cities in the early nineteenth century. Today, the modern city dweller has come to think of this as an essential service. Urban drainage facilities have progressed from crude ditches and stepping stones to the present intricate coordinates systems of curbs, gutters, inlets, and underground conveyance.

The design must consider meteorological factors, geomorphologic factors, and the economic value of the land, as well as human value considerations such as aesthetic and public safety aspects of the design. The design of storm water detention basins should also consider the possible effects of inadequate maintenance of the facility

4.2.2 Storm Water Runoff:

Storm water runoff is that portion of precipitation which flows over the ground surface during and a short time after a storm. The dependence parameters that controlled the quantity of the storm water which carried by a storm or combined sewer are the surface of the drainage area (A, ha), the intensity of the rainfall (i, l/s.ha), and runoff coefficient C dimensionless (the condition of the surface). There are many methods and formulas to determine the storm flow, and in all of them above parameters show up. One of the most common methods is Rational method which will be discussed below.

Rational Method:

The rational method has probably been the most popular method for designing storm systems. It has been applied all over the world and runoff is related to rainfall intensity by the formula,

$$Q = C.i.A \qquad (4.3)$$

Where :

Q = peak runoff rate (l/sec)

C = runoff coefficient, which is actually the ratio of the peak runoff rate to the average rainfall for a period known as the time of concentration.

i = average rainfall intensity, mm/min, for period equal to the time of concentration

A = drainage area, hectar.

For small catchments areas, it continues to be a reasonable method, provided that it is used properly and that results and design concepts are assessed for reasonableness. This procedure is suitable for small systems where the establishment of a computer model is not warranted.

The steps in the rational method calculation procedure are summarised below:

1. The drainage area is first subdivided into sub-areas with homogeneous land use according to the existing or planned development.

2. For each sub-area, estimate the runoff coefficient *C* and the corresponding area *A*.

3. The layout of the drainage system is then drawn according to the topography, the existing or planned streets and roads and local design practices.

4. Inlet points are then defined according to the detail of design considerations. For main drains, for example, the outlets of the earlier mentioned homogeneous sub-areas should serve as the inlet nodes. On the other hand in very detailed calculations, all the inlet points should be defined according to local design practices.

5. After the inlet points have been chosen, the designer must specify the drainage sub-area for each inlet point A and the corresponding mean runoff coefficient *C*. If the sub-area for a given inlet has non-homogeneous land use, a weighted coefficient may be estimated.

6. The runoff calculations are then done by means of the general rational method equations for each inlet point, proceeding from the upper parts of the watershed to the final outlet. The peak runoff, which is calculated at each point, is then used to determine the size of the downstream trunk drain using a hydraulic formula for pipes flowing full.

7. After the preliminary minor system is designed and checked for its interaction with the major system, reviews are made of alternatives, hydrological assumptions are

verified,new computations are made, and final data obtained on street grades and elevations. The engineer then should proceed with final hydraulic design of the system.

Runoff Coefficient, C:

Runoff coefficient is a function of infiltration capacity, interception by vegetation, depression storage, and evapotranspiration. It is requires greatest exercise of judgment by engineer and assumed constant, actually variable with time. It is desirable to develop composite runoff coefficient (weighted average) for each drainage area as:

$$C = \frac{\sum Ci.Ai}{\sum Ai} \tag{4.4}$$

Where :

Ai = i th area.

Ci = i th runoff coefficient.

The range of coefficients with respect to general character of the area is given in the following tables (Table 4.1and Table 4.2).

Table 4.1: The Range of Coefficient With Respect to General Character of the Area {8}

Description of Area	Runoff Coefficients
Business	
Down town Neighborhood	0.70 to 0.95 0.50 to 0.70
Residential	
Single-Family Multi-unit, detached Multi-unit, attached	0.30 to 0.50 0.40 to 0.60 0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment	0.50 to 0.70

Industrial	
Light Heavy	0.50 to 0.80 0.60 to 0.90
Parks, Cemeteries	0.10 to 0.25
Playground	0.20 to 0.35
Railroad yard	0.20 to 0.35
Unimproved	0.10 to 0.30

Table 4.2: The Range of Coefficient With Respect to Surface Type of the Area {8}

Character of Surface	Runoff Coefficients
Pavement	
Asphalt and concrete Brick	0.70 to 0.95 0.70 to 0.85
Lawns, Sandy soil	
Flat, 2 percent Average,2to7percent Steep, 7 percent	0.05 to 0.10 0.10 to 0.15 0.15 to 0.20
Roofs	0.75 to 0.95
Lawns, heavy soil	
Flat, 2 percent Average,2 to 7percent Steep, 7 percent	0.13 to 0.17 0.18 to 0.22 0.25 to 0.35

Rainfall Intensity, i:

In determining rainfall intensity for use in rational formula it must be recognized that the shorter the duration, the greater the expected average intensity will be. The critical duration of rainfall will be that which produces maximum runoff and this will be that which is sufficient to produce flow from the entire drainage area. Shorter periods will provide lower flows since the total area is not involved and longer periods will produce lower average intensities. The storm sewer designer thus requires some relationship between duration and expected intensity. Intensities vary from place to another and curves or equations are specified for the areas for which they were developed.

The rainfall intensity depends on many factors through which we can do our calculations; we can list these factors as follow:

1. Average frequency of occurrence of storm (1/n) or (f).

Average frequency of occurrence is the frequency with which a given event is equaled or exceeded on the average, once in a period of years. Probability of occurrence, which is the reciprocal of frequency, (n) is preferred by sum engineers. Thus, if the frequency of a rain once a 5-year (1/n=5), then probability of occurrence n=0.20. Selection of storm design rain frequency based on cost-benefit analysis or experience. There is range of frequency of often used:

a. Residential area: f = 2 to 10 years (5 year most common).
b. Commercial and high value districts: f = 10 to 50 (15 year common).
c. Flood protection: f = 50 year.

2. Intensity, duration and frequency characteristics of rainfall.

Basic data derived from gage measurement of rainfall (Point rainfall) over a long period can be used to obtain a rainfall height diagram that show the relation between the height of rain (mm) and time (min). The slope of the curve or rain height per unit time is defined as rain intensity:

$$i = (\Delta \text{ height of rain} / \Delta \text{ time}) \left[\frac{mm}{\min}\right]$$

The rain intensity in liter per second . hectare is equal:

$$i\left(\frac{l}{s.ha}\right) = 166.7i\left[\frac{mm}{\min}\right]$$

in order to drive intensity-duration-frequency curves long-term observation of rainfall is needed. Analysis of such observation is given in any text in sanitary engineering.

3- Time of Concentration

The time of concentration is the time required for the runoff to become established and flow from the most remote part (in time) of the drainage area to the point under design.

$$t_c = t_i + t_f \tag{4.5}$$

Where t_c: time of concentration.

t_i: inlet time.

t_f: flow time.

Time of flow in storm, $t_f = \dfrac{\text{Length of pipe line (L)}}{\text{Velocity of flow (v)}}$

Inlet time (t_i): is the time required for water to flow over ground surface and along gutters to drainage inlet. Inlet time is function of rainfall intensity, surface slope, surface roughness, flow distance, and infiltration capacity and depression storage.

4.2.3 Hydraulic Consideration

Introduction:

storm water usually designed as open channels except where lift stations of the flows, and the fact that an unconfined or free surface exists. The driving are required to overcome topographic barriers. The hydraulic problems associated with these flows are complicated in some cases by the quality of the fluid, the highly variable nature force for open-channel flow and sewer flow is gravity. For the hydraulic calculations of sewers, it is usually assumed uniform flow in which the velocity of flow is constant, and steady flow condition in which the rate discharge at any point of a sewer remains constant {10}.

Hydraulic design equations:

In principle all open channel flow formulas can be used in hydraulic design of sewer pipes. The following are the most important formulas:

1. Chezy's formula:

$$V = C\sqrt{RS} \tag{4.6}$$

Where V: the velocity of flow (m/s).

C: the Chezy coefficient; $C = \frac{100\sqrt{R}}{m+\sqrt{R}}$.

Where:

m = 0.35 for concrete pipe or 0.25 for vitrified clay pipe

R: the hydraulic radius (m)

S: the slope of the sewer pipe (m/m).

2. Darcy-Weisbach formula: It is not widely used in wastewater collection design and evaluation because a trial and error solution is required to determine pipe size for a given flow and head loss, since the friction factor is based on the relative roughness which involves the pipe diameter, making it complicated. Darcy-Weishbach formula states that

$$H = a \frac{L \times V^2}{D \times 2g} \tag{4.7}$$

Where H: the pressure head loss (mwc).

L: the length of pipe (m).

D: the diameter of pipe (m)

λ : the dimensionless friction factor generally varying between 0.02 to 0.075.

3. The Manning formula: Manning’s formula, though generally used for gravity conduits like open channel, it is also applicable to turbulent flow in pressure

conduits and yields good results, provided the roughness coefficient n is accurately estimated. Velocity, according to Manning's equation is given by:

$$V = (1/n)\ R^{2/3}\ S^{1/2} \tag{4.8}$$

Where:

n: the Manning's roughness coefficient [$1/n\ (k_{str}) = 75\ m/s^{1/3}$].

R: the hydraulic radius = area /wetted perimeter (R = A/P)

- For circular pipe flowing full, R= (D/4).
- For open channel flowing full, R= [(b*d)/ (b+2d)].

The Manning's roughness coefficient depends on the material and age of the conduit. Commonly used values of n for different materials are given in Table (4.3).

Table 4.3 Common Values of Roughness Coefficient Used in the Manning Equation {8}

Material	Commonly Used Values of n
Concrete	0.013 and 0.015
Vitrified clay	0.013 and 0.015
Cast iron	0.013 and 0.015
Brick	0.015 and 0.017
Corrugated metal pipe	0.022 and 0.025
Asbestos cement	0.013 and 0.015
Earthen channels	0.025 and 0.003
PVC	0.011

Hydraulics of Partially Field Section:

The filling rate of a sewer is an important consideration, as sewers are seldom running full, so storm water sewers designed for 70% running full, that is means only 70% of the pipe capacity should be utilized to carry the peak flow.

Partially filled sewers are calculated by using partial flow diagram and tables indicating the relation between water depth, velocity of flow and rate flow .The hydraulic characteristics are similar as for open channels, but the velocity of flow is reduced by increased air friction in the pipe with increasing water level, particularly near the top of the pipe. The velocity of flow and the flow rate are reduced at filling rates between 60% and 100%; the water level in the pipe is unstable at filling rates above 90% or 95%.

4.2.4 Storm Water Sewers Design

Designing a community storm system is not a simple task. It requires considerable experience and a great deal of information to make proper decisions concerning the layout, sizing, and construction of a storm network that is efficient and cost-effective. The design engineer needs to generally undertake the following tasks {9}:

1. Define the service area.
2. Conduct preliminary investigations.
3. Develop preliminary layout plan and profile.
4. Selection of design parameters.
5. Review construction considerations.
6. Conduct field investigation and complete design and final profiles

Service Area:

Service area is defined as the total area that will eventually be served by the drainage system. The service area may be based on natural drainage or political boundaries, or both. It is important that the design engineers and project team become familiar with the surface area of the proposed project.

Preliminary Investigation:

The design engineer must conduct the preliminary investigations to develop a layout plan of the drainage system. Site visits and contacts with the city and local planning agencies and state officials should be made to determine the land use plans, zoning regulations, and probable future changes that may affect both the developed and undeveloped land. Data must be developed on topography, geology, hydrology, climate, ecological elements, and social and economic conditions. Topographic maps with existing and proposed streets and other utility lines provide the most important information for preliminary flow routing {9}.

If reliable topographic maps are not available, field investigations must be conducted to prepare the contours, place bench marks, locate building, utility lines, drainage ditches, low and high areas, stream, and the like. All these factors influence the sewer layout.

Layout Plan:

Proper storm sewer layout plan and profiles must be completed before design flows can be established. The following is a list of basic rules that must be followed in developing a sewer plan and profile.

1. Select the site for disposal of the storm water at the end of the network, generally the lowest elevation of the entire drainage area.
2. The preliminary layout of storm sewers is made from the topographic maps. In general, sewers are located on streets, or on available right-of-way; and sloped in the same direction as the slope of the natural ground surface.
3. The trunk storm sewers are commonly located in valleys. Each line is started from the intercepting sewer and extended uphill until the edge of the drainage area is reached, and further extension is not possible without working downhill.
4. Main storm sewers are started from the trunk line and extended uphill intercepting the laterals.
5. Preliminary layout and routing of storm sewage flow is done by considering several feasible alternatives. In each alternative, factors such as total length of storm sewers, and cost of construction of laying deeper lines versus cost of construction, operation, and maintenance of lift station, should be evaluated to arrive at a cost- effective drainage system.
6. After the preliminary storm sewer layout plan is prepared, the street profiles are drawn. These profiles should show the street elevations, existing storm sewer lines, and manholes and inlets. These profiles are used to design the proposed lines.

Finally, these layout plans and profiles are revised after the field investigations and storm sewer designs are complete. {11}

Selection of Design Parameters:

Many design factors must be investigated before storm sewer design can be completed. Factors such as design period; peak, average, and minimum flow; storm sewer slopes and minimum velocities; design equations …etc. are all important in developing storm sewer design. Many of the factors are briefly discussed below.

1. Design Flow Rate

Storm water sewers should be designed to carry the largest storm that occurred in the period of design; commonly it is 5 years because of consideration of the cost and the frequently factors.

2. Minimum Size

The minimum storm sewer size recommended is 250 to 300 mm for closed system, and for open channel depend on the type of profile that selected.

3. Minimum and Maximum Velocities

In storm water sewers, solids tend to settle under low-velocity conditions. Self-cleaning velocities must be developed regularly to flush out the solids. Most countries specify minimum velocity in the sewers under low flow conditions. The minimum allowable velocity is 0.75 m/s, and 0.9 m/s is desirable. This way the lines will be flushed out at least once or twice a day. The maximum velocities for storm water system are between 4 to 6 m/s. The maximum velocity is limited to prevent the erosion of sewer inverts.

4. Slope

For closed system minimum slopes determined from minimum velocities, for minimum velocity 1 m/s, the slopes are shown in Table (4.4).

Table 4.4 Minimum Recommended Slopes of Storm Sewer (n = 0.015) {8}

Pipe Diameter (D)		**Slope (min)**	**Slope (max) =1/D**
Mm	**Inch**	**Mm**	**Cm**
250	10	0.00735	0.04
300	12	0.00576	0.033
450	18	0.00336	0.0222
600	24	0.00229	0.0167

Note: for a velocity of 0.75m/s the slopes shown above should be multiplied by 1.56.

Maximum slopes determined from maximum velocities, 1/D (cm) can be used as a guide. For open channel, the slope also depends on the profile type, and generally used as the slope of the road.

5. Depth

The depth of storm sewers when using closed system is generally just enough to receive flow but not less than 1 m below the ground surface. Depth depends on the water table, lowest point to be served, topography, and the freeze depth. But for the open channel it is at the ground surface.

6. Appurtenances

Storm Sewer appurtenances include manholes, inlets, outlets and outfall, and others. Appropriate storm sewer appurtenances must be selected in design of storm water sewers.

7. Design Equations and Procedures

Storm water sewers are mostly designed to flow partially full. Once the peak, average, and minimum flow estimates and made general layout and topographic features for each line are established, the design engineer begins to size the sewers. Design equations proposed by Manning, Chezy, Gangullet, Kutter, and Scobey have been used for designing sewers and drains. The Manning equation, however, has received most widespread application. This equation is expressed below:

$$V = (1/n)\ R^{2/3}\ S^{1/2} \quad (4.9)$$

And as mentioned earlier, the runoff flow is calculated using the following formula:

$$Q = C.i.A \quad (4.3)$$

Various types of nomographs have been developed for solution of problems involving sewers flowing full. Nomographs based on Manning's equation for circular pipe flowing full and variable n values are provided in Figure(4.1). Hydraulic elements of circular pipes under partially-full flow conditions are provided in Figure (4.2). It may be noted that the value of n decreases with the depth of flows Figure(4.1). However, in most designs n is assumed constant for all flow depths. Also, it is a common practice to use d, v, and q notations for depth of flow, velocity, and discharge under partial flow condition while D, V, Q notations for diameter, velocity, and discharge for sewer flowing full. Use of equations 4.8 and 4.9 and (Figures 4.1 and 4.2), one can design the drainage system.

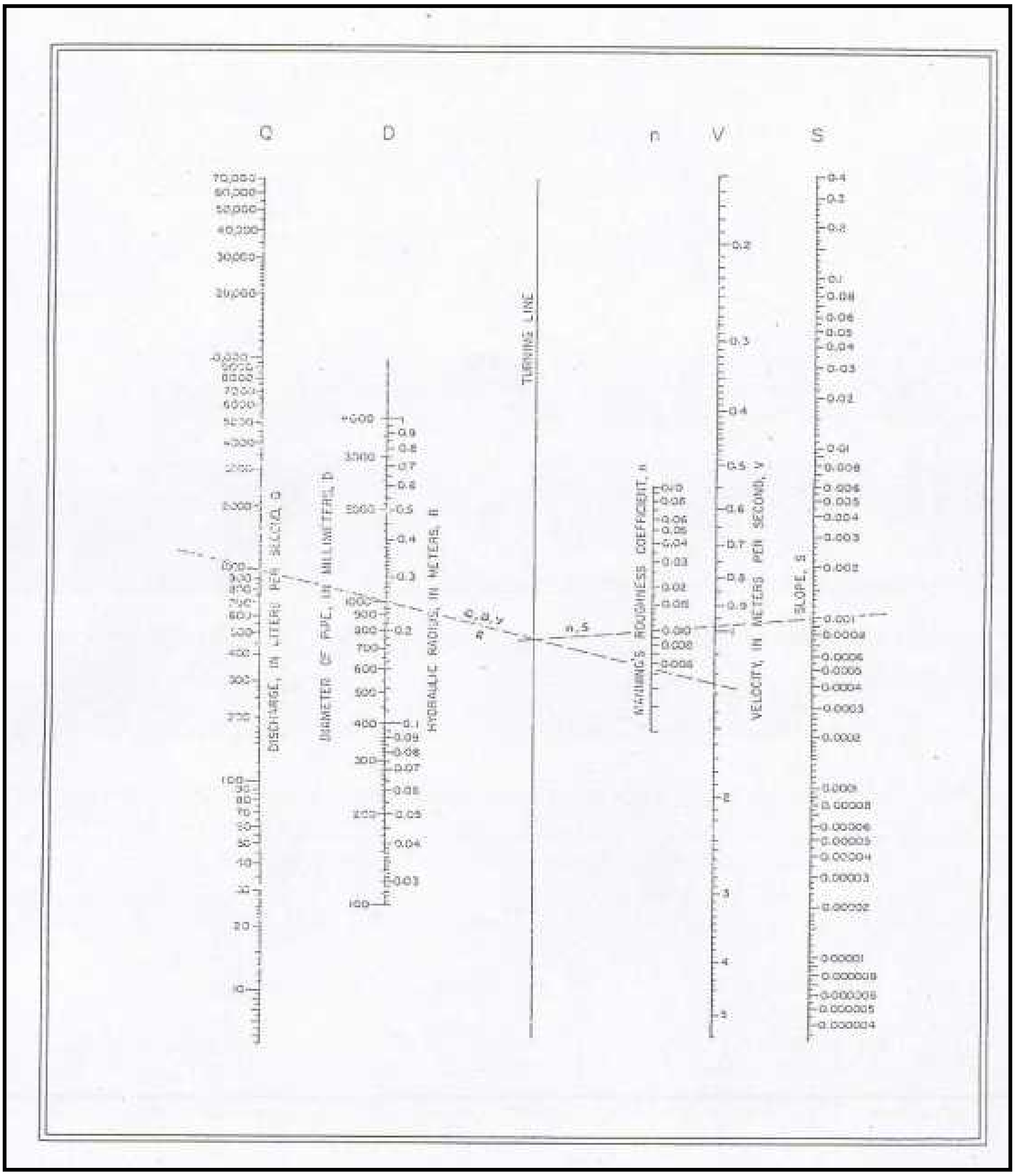


Figure4.1 Nomo graph for solution of manning formula{3}

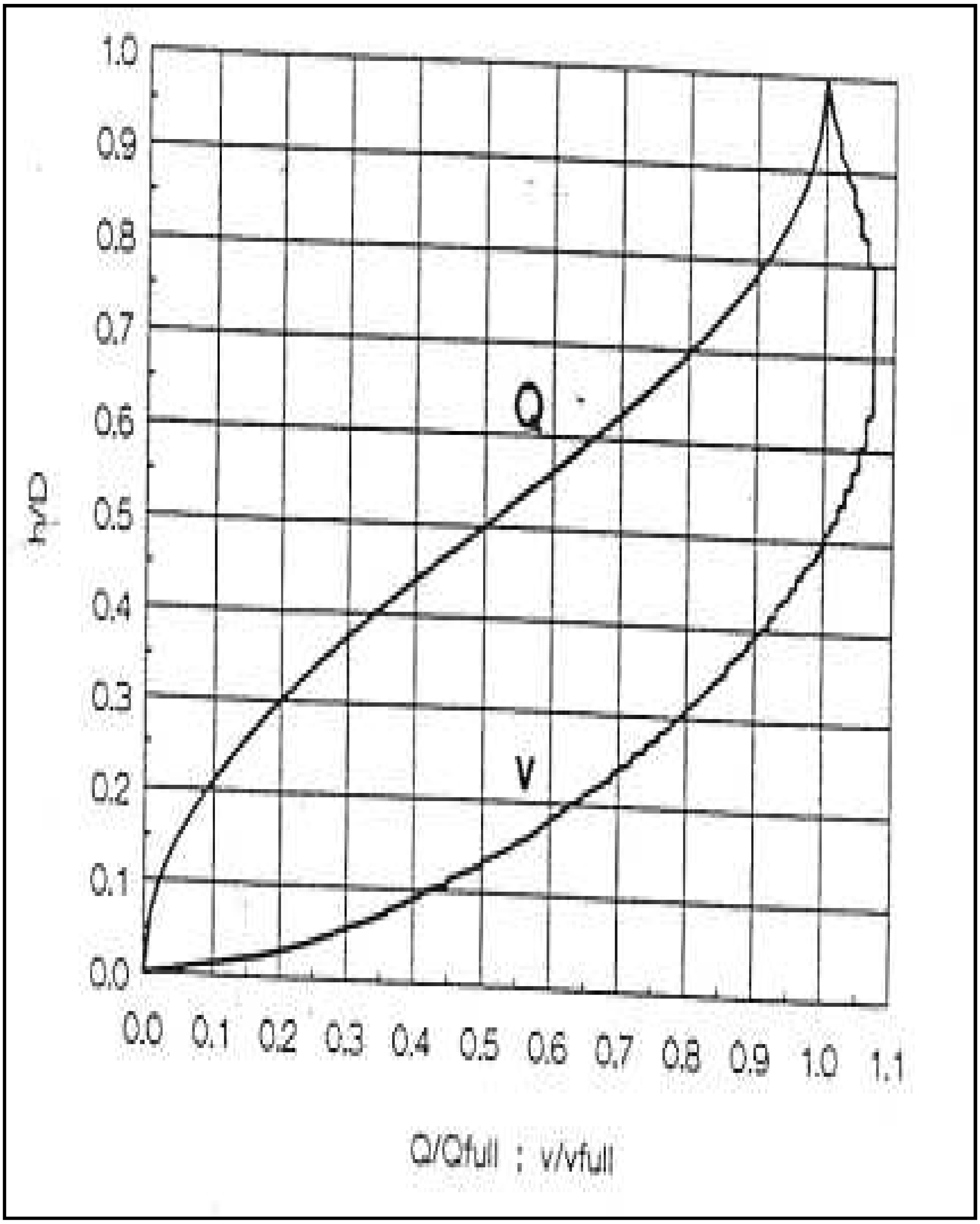


Figure 4.2 Hydraulic properties of circular sewer{3}

Design Computation:

After the preliminary sewer layout plan and profile are prepared, the design computations are accomplished. Design computations for sewers are repetitious and therefore, are best performed in a tabular format.

Preparation of Maps and Profile:

It is important that the detailed drawings be prepared and specifications completed before the bide can be requested. The contract drawings should show (1) surface features, (2) depth and character of material to be excavated, (3) the existing structures that are likely to be encountered, and (4) the details of sewer and appurtenances to be constructed.

Important Numbers:

- Maximum velocity = 5 m/s
- Minimum velocity = 1 m/s
- Maximum slope = 15%
- Minimum slope = 0.5%
- H/D = 100%
- Minimum Diameter 250-300 mm
- Minimum cover 1 m
- Maximum cover 5 m

4.3 Roadways And Geometric Design:

During this work the main road of the camp will be redesign, this requiers field work and computer work to redesign, this will be as following:

1- Using aerial photograph to select the primary route.
2- Select the best places for traverse stations and set it on the ground using GPS.
3- Making the traverse by GPS stations, then use total station to calculate the coordinate of stations and make traverse corrections.
4- Making field survey using Total Station and show all road description depending on traverse stations.
5- Planning and redesign the road paths and do the vertical and horizontal curves calculations.
6- Make the profile and cross section.
7- Survey quantity calculations.

A.4.3 Traversing

A.4.3.1 General:

Since the advent of EDM and Total Station equipment, traversing has emerged as the most popular method of establishing control networks not only in engineering surveying but also in geodetic work, in civil engineering it lends itself ideally to surveys and dimensional control of route-type projects such as highway and pipeline construction. {7}

Traverse networks have the following advantages:

1 . Little reconnaissance is required compared with that needed for an interconnected network of points.

1. Observations only involve three stations at a time so planning the task is simple.
2. Traversing may permit the control to follow the route of a highway, pipe line or tunnel, etc., with the minimum number of stations.

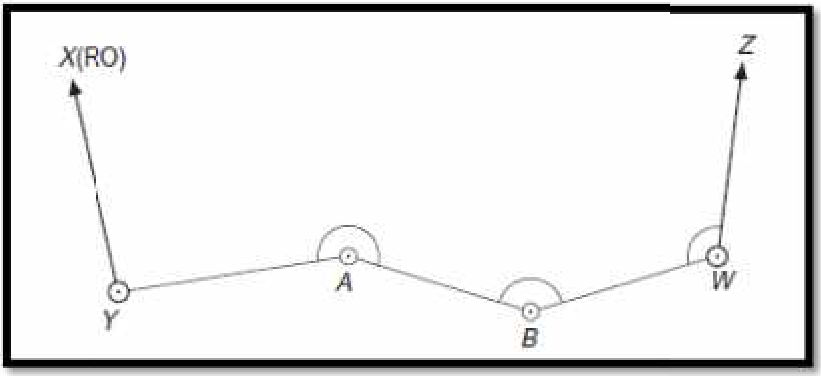
A.4.3.2 Types of traverse:

There are three types of traverse, each type used in different condition. The liability of a traverse to undetected error makes it essential that there should be some external check on its accuracy. To this end the traverse may commence from and connect into known points of greater accuracy than the traverse. In this way the error vector of misclose can be quantified and distributed throughout the network, to produce geometric correctness. Such a traverse is called a 'link' traverse.{7}

Alternatively, the error vector can be obtained by completing the traverse back to its starting origin. Such a traverse is called a 'polygonal' or 'loop' traverse. Both the 'link' and 'polygonal' traverse are generally referred to as 'closed' traverses.

The third type of traverse is the 'free' or 'open' traverse, which does not close back onto any known point and which therefore has no way of detecting or quantifying the errors.

1. Link Traverse:



Fig(4.3): Link Traverse

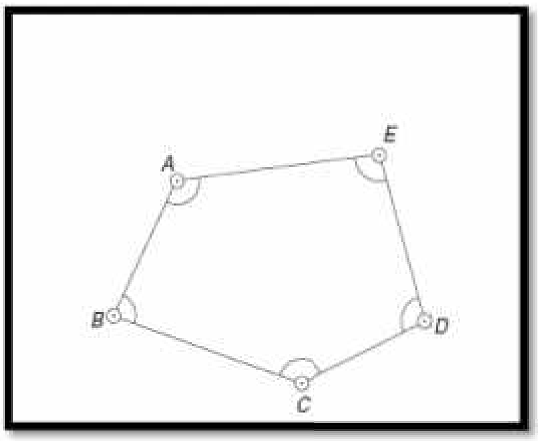
Figure (4.3) illustrates a typical link traverse commencing from higher order point Y and closing onto Point W, with terminal orienting bearing to points X and Z. Generally, points X, Y, W and Z would be part of a higher order control network, although this may not always be the case. It may be that when tying surveys into the OSNG, due to the use of very precise Total Station equipment the intervening traverse is more precise than the relative positions of the NG stations. This is purely a problem of scale arising from a lack of knowledge, on the behalf of the surveyor, of the positional accuracy of the grid points. In such a case, adjustment of the traverse to the NG could result in distortion of the intervening traverse.

The usual form of an adjustment generally adopted in the case of a link traverse is to hold points Y and W fixed whilst distributing the error throughout the intervening points.

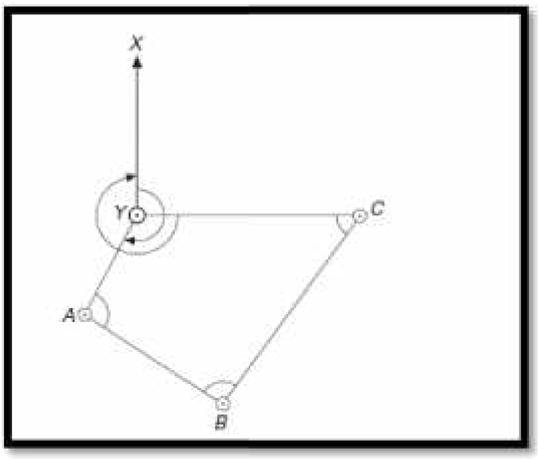
This implies that points Y and W are free from error and is tantamount to allocating a weight of infinity to the length and bearing of line YW. It is thus both obvious and important that the control into which the traverse is linked should be of a higher order of precision than the connecting traverse.

The link traverse has certain advantages over the remaining types, in that systematic error in distance measurement and orientation are clearly revealed by the error vector.{7}

2. Loop Traverse:



Fig(4.4.a): Loop Traverse(independent)

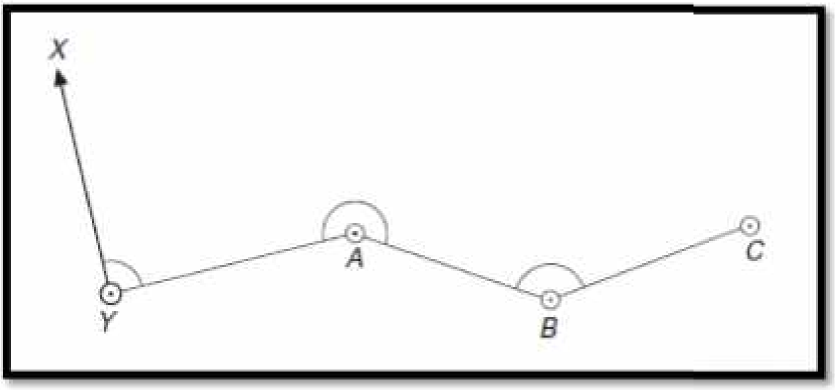


Fig(4.4.b): Loop Traverse(oriented)

Figures (4.4.a)and (4.4.b) illustrate the concept of a polygonal traverse. This type of network is quite popular and is used extensively for peripheral control on all types of engineering sites. If no orientation facility is available, the control can only be used for independent sites and plans and cannot be connected to other survey systems.

In this type of traverse the systematic errors of distance measurement are not eliminated and enter into the result with their full weight. Similarly, orientation error would simply cause the whole network to swing through the amount of error involved and would not be revealed in the angular misclosure.{7}

3. Open(free) Traverse:



Fig(4.5): Open Traverse

Figure (4.5) illustrates the open traverse which does not close into any known point and therefore cannot provide any indication of the magnitude of measuring errors.

In all surveying literature, this form of traversing is not recommended due to the lack of checks. Nevertheless, it is frequently utilized in mining and tunnelling work because of the physical restriction on closure.{7}

A.4.3.3 Accuracy Standards For Traverse:

Table (4.5) shows Horizontal Control Accuracy Standards For Traverse(By The Federal Geodetic Control Subcommittee (FGCS).

Using each order depending on the type of work, small surveying works used third order but huge construction use first order.{7}

* Table (4.5) : Horizontal Control Accuracy Standards For Traverse(By The Federal Geodetic Control)

Order	1st	2 nd		3 rd	
Class		**I**	**II**	**I**	II
Angular Closure	**1.7”√n**	**3.0”√n**	**4.5”√n**	**10.0”√n**	12.0”√n
Linear Closure (after angul. adj.)	0.04√∑L or, 1/100,000	0.08√∑L or, 1/50,000	0.20√∑L or, 1/20,000	0.40√∑L or, 1/10,000	0.80√∑L or, 1/5,000

A.4.3.4 Adjustment of Traverse using"Least square method":

$$X = J^T J \;^{-1} J^T K \qquad (4.10)$$

Where:

X: Unkown Matrix.

J: Jacobean Matrix.

K: Observation Matrix.

V: Variance Matrix.

And here are the matrices forms:

- The Jacobean Matrix:

$$J= \begin{matrix} \frac{\partial F_1}{\partial dx_1} & \frac{\partial F_1}{\partial dy_1} & \frac{\partial F_1}{\partial dx_2} & \frac{\partial F_1}{\partial dy_2} & \dots\dots\dots\dots & \frac{\partial F_1}{\partial dx_n} & \frac{\partial F_1}{\partial dy_n} \\ \frac{\partial F_2}{\partial dx_1} & \frac{\partial F_2}{\partial dy_1} & \frac{\partial F_2}{\partial dx_2} & \frac{\partial F_2}{\partial dy_2} & \dots\dots\dots\dots & \frac{\partial F_2}{\partial dx_n} & \frac{\partial F_2}{\partial dy_n} \\ & \vdots & & & & & \\ & \vdots & & & & & \\ \frac{\partial F_{m-1}}{\partial dx_1} & \frac{\partial F_{m-1}}{\partial dy_1} & \frac{\partial F_{m-1}}{\partial dx_2} & \frac{\partial F_{m-1}}{\partial dy_2} & \dots\dots\dots\dots & \frac{\partial F_{m-1}}{\partial dx_n} & \frac{\partial F_{m-1}}{\partial dy_n} \\ \frac{\partial F_m}{\partial dx_1} & \frac{\partial F_m}{\partial dy_1} & \frac{\partial F_m}{\partial dx_2} & \frac{\partial F_m}{\partial dy_2} & \dots\dots\dots\dots & \frac{\partial F_m}{\partial dx_n} & \frac{\partial F_m}{\partial dy_n} \end{matrix} \qquad (4.11)$$

- Distance Observation Reduction:

$$F_{x_i,y_i,x_j,y_j} = \sqrt{x_j - x_i \;^2 + \; y_j - y_i \;^2} \qquad (4.12)$$

- Linearization:

Taking the derivatives of last equation

$$\frac{\partial F}{\partial x_i} = \frac{x_i - x_j}{IJ} \qquad (4.13)$$

$$\frac{\partial F}{\partial y_i} = \frac{y_i - y_j}{IJ} \qquad (4.14)$$

$$\frac{\partial F}{\partial x_j} = \frac{x_j - x_i}{IJ} \qquad (4.15)$$

$$\frac{\partial F}{\partial y_j} = \frac{y_j - y_i}{IJ} \qquad (4.16)$$

- Angle Observation reduction:

$$\theta = Az_{IF} - Az_{IB} \qquad (4.17)$$

$$\theta = \tan^{-1}\frac{x_f - x_i}{y_f - y_i} - \tan^{-1}\frac{x_b - x_i}{y_b - y_i} + D \qquad (4.18)$$

- Taking the derivatives of the last equation:

$$\frac{\partial F}{\partial x_i} = \frac{y_i - y_b}{IB^2} - \frac{y_i - y_f}{IF^2} \qquad (4.19)$$

$$\frac{\partial F}{\partial y_i} = \frac{x_b - x_i}{IB^2} - \frac{x_f - x_i}{IF^2} \qquad (4.20)$$

- Observation matrix K:

$$K = \begin{matrix} F_1 - F_{1o} \\ F_2 - F_{2o} \\ \vdots \\ \vdots \\ \vdots \\ F_n - F_{no} \end{matrix} \qquad (4.21)$$

- The weight Matrix W:

$$W=\begin{bmatrix} \sigma {F_1}^2 & & & & & \\ & \sigma {F_2}^2 & & & & \\ & & \sigma {F_3}^2 & & & \\ & & & \ddots & & \\ & & & & \ddots & \\ & & & & & \sigma {F_n}^2 \end{bmatrix} \quad (4.22)$$

- Unknown Matrix X:

$$X=\begin{bmatrix} dx_1 \\ dy_1 \\ dx_2 \\ dy_2 \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ dx_n \\ dy_n \end{bmatrix} \quad (4.23)$$

- Variance matrix V:

$$V=\begin{bmatrix} V1 \\ V2 \\ V3 \\ V4 \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ Vn \end{bmatrix} \quad (4.24)$$

- Corrected coordinates:
- $X = X_o + d_x$ (4.25)
- $Y = Y_o + d_y$ (4.26)

B.4.3 Geometric Design Elements:

From an operational viewpoint, it is the geometric characteristics of the roadway that primarily influence traffic flow and operations. Three main elements define the geometry of a highway section:

- Horizontal alignment.
- Vertical alignment.
- Cross-sectional elements.

B.4.3.1 Horizontal alignment of Roadways:

- **Degree of curvature:**

Degree of curvature is the central angle D subtended by a chord of 30 meter.

- $D = \frac{1718.87}{R}$ OR $D = \frac{30\Delta}{L}$ (4.27)

- **Horizontal Curves:**

When a highway changes horizontal direction, making the point where it changes direction a point of intersection between two straight lines is not feasible.

The change in direction would be too abrupt for the safety of modem, high-speed vehicles. It is therefore necessary to interpose a curve between the straight lines. The straight lines of a road are called tangents because the lines are tangent to the curves used to change direction.

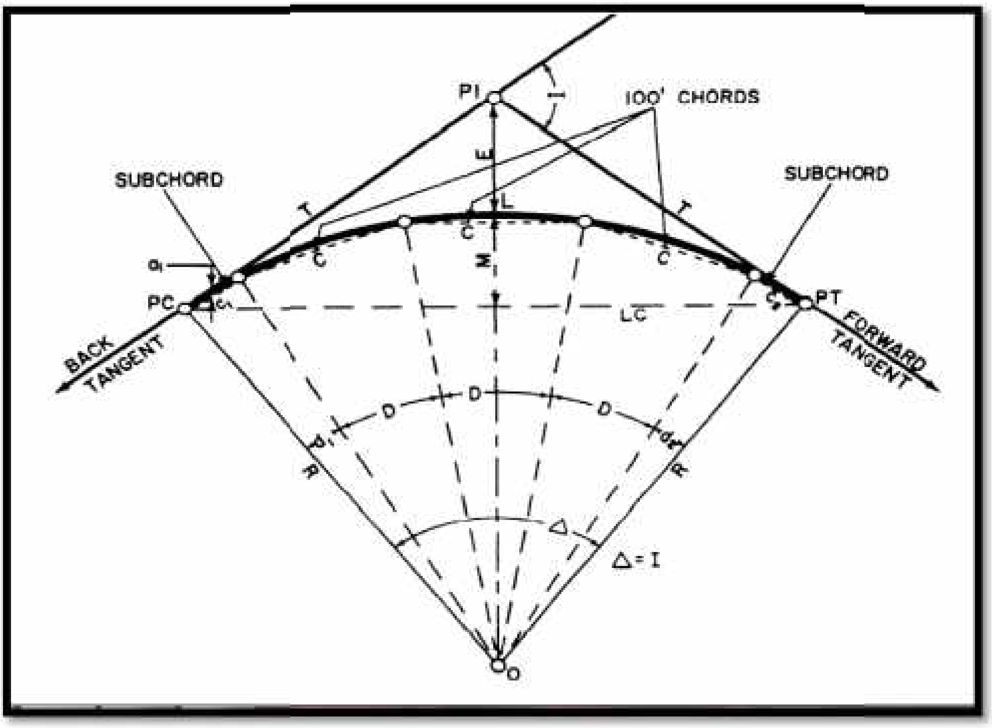
The principal consideration in the design of a curve is the selection of the length of the radius or the degree of curvature. This selection is based on such considerations as the design speed of the highway and the sight distance as limited by headlights or obstructions.{7}

Types of Horizontal Curves:

1- Circular Curves.
2- Compound Circular Curves.
3- Broken Back Circular Curves (not used in the project).
4- Reversed Circular Curves (not used in the project).
5- Transition Curve.

1. Simple Circular Curves:

The simple curve is an arc of a circle .The radius of the circle determinesthe sharpness or flatness of the curve, this type of curves will used in this project.{7}



Fig(4.6): Simple Circular Curve.

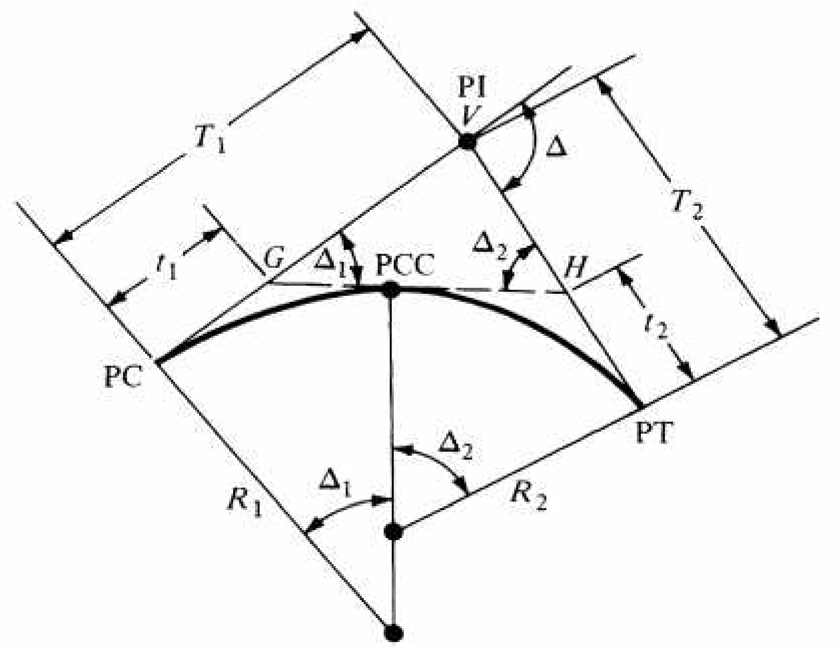
Simple Curve Elements:

- PI: point Of Intersection.
- I: Intersection Angle.
- R: Radius.
- PC: Point of curvature.
- D: Degree of Curve
- T: tangent distance.
- E: External distance.
- M: Middle Ordinate.
- LC: Long Chord.
- L: Curve length.
- Δ: Deflection Angle.

- Simple Curves Equation:
- $\theta^{\backslash} = \theta - 2\emptyset$ (4.28)
- $L = \frac{\pi R \Delta}{180}$ (4.29)
- $c = \frac{R}{20}$ (4.30)
- $\delta^{\backslash} = 1718.8 * \frac{c}{R}$ (4.31)
- $T = R \tan\frac{\Delta}{2}$ (4.32)
- $E = R \quad \sec\frac{\Delta}{2} - 1$ (4.33)
- $M = R \quad 1 - \cos\frac{\Delta}{2}$ (4.34)
- $LC = 2R \sin\frac{\Delta}{2}$ (4.35)

2. **Compound curves:**

Compound curve consists of two curves that are joined at a point of tangency and are located on the same side of a common tangent. Though their radii are in the same direction, they are of different values. Fig(4.7)



Fig(4.7) compound curve.

Where:

R_1 and R_2 = radii of simple curves forming the compound curve
θ_1 and θ_2 = intersection angles of simple curves
t_1 and t_2 = tangent lengths of simple curves

T_1 and T_2 =tangent lengths of compound curves
Δ= intersection angle of compound curve

- Compound Curves Equation:

$$\Delta = \Delta 1 + \Delta 2 \quad (4.36)$$

$$t1 = R1 \tan \frac{\Delta 1}{2} \quad (4.37)$$

$$t2 = R2 \tan \frac{\Delta 2}{2} \quad (4.38)$$

3. Reverse Curves:

Reverse curves usually consist of two simple curves with equal radii turning in opposite directions with a common tangent. They are generally used to change the alignment of a highway. Figure (4.8) shows a reverse curve with parallel tangents.

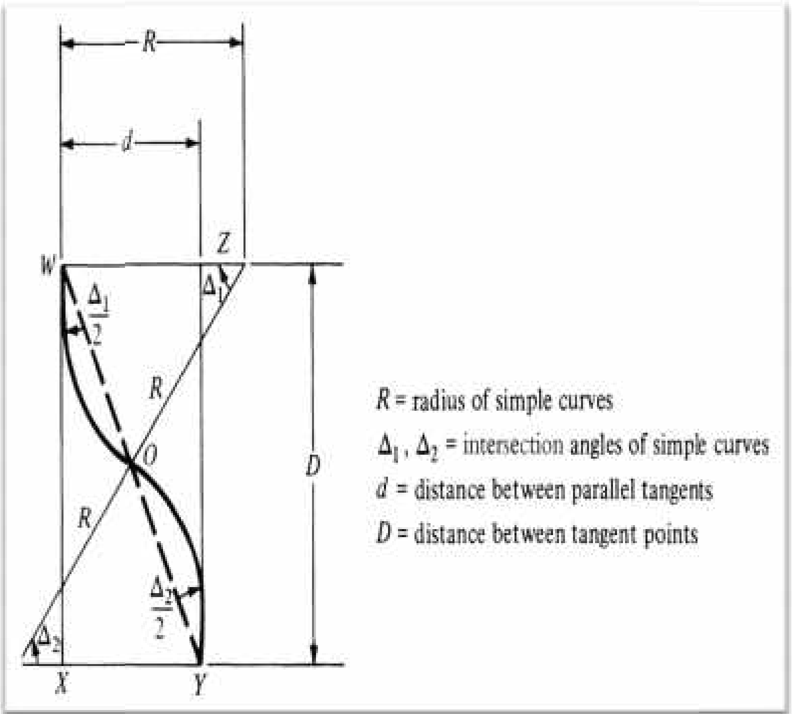
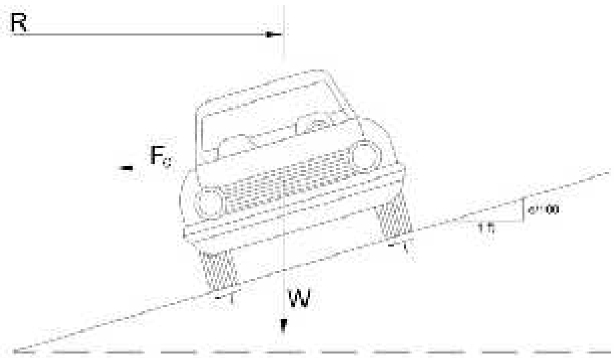


Figure (4.8) Geometry of a Reverse Curve with Parallel Tangents

Reverse curves are seldom recommended because sudden changes to the alignment may result in drivers finding it difficult to keep in their lanes. When it is necessary to reverse the alignment, a preferable design consists of two simple horizontal curves, separated by a sufficient length of tangent between them, to achieve full super elevation. Alternatively, the simple curves may be separated by an equivalent length of spiral, which is described in the next section.

- **Super Elevation of Horizontal Curve:**

Superelevation is the banking of the roadway along a horizontal curve so motorists can safely and comfortably maneuver the curve at reasonable speeds. As speeds increase and horizontal curves become tighter a steeper superelevation rate is require see figure (4.9).



Fig(4.9)Super Elevation

$$e = \frac{(V*0.75)^2}{127R} \quad (4.39)$$

Where:

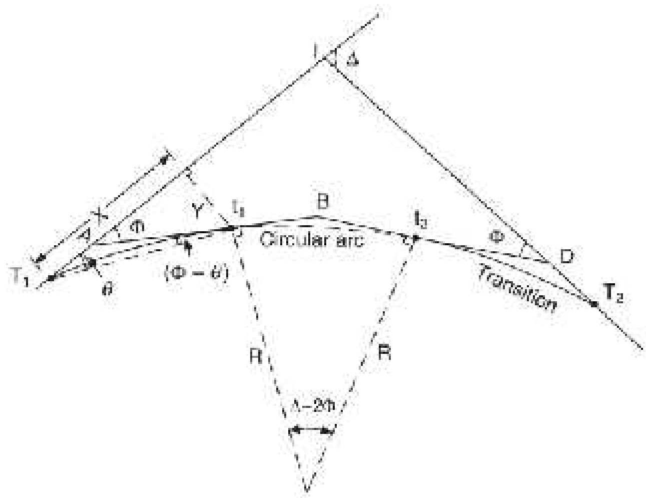
- R: Radius of the curve.
- V: vehicles speed.
- F: Side friction.
- e: Super elevation rate.

But if e is grater than e_{max} (9%) side fraction f should be:

$$f = \frac{(V*0.75)^2}{127R} - e_{max} \quad (4.40)$$

4. Transition curves

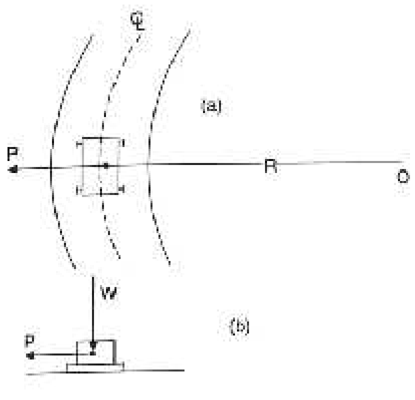
The transition curve is a curve of constantly changing radius. If used to connect a straight to a curve of radius R, then the commencing radius of the transition will be the same as the straight (∞), and the final radius will be that of the curve R ,see figure (4.10).

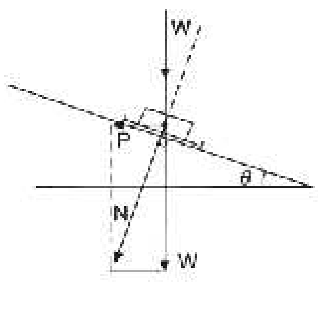


Fig(4.10): Transition curve

When the vehicle enters the curve of radius R at tangent point T1, an additional centrifugal force (P) acts on the vehicle, as shown in figures (4.11a and 4.11b). If P is large the vehicle will be forced to the outside of the curve and may skid or overturn. In Figure (4.11b) the resultant of the two forces is shown as N, and if the road is super-elevated normal to this force, there will be no tendency for the vehicle to skid. It should be noted that as:

P = WV2/Rg (4.41)





Fig(4.11a)centrifugal force

Fig(4.11b)super elevation

- **Sight Distance on Horizontal Curves:**

One of the most fundamental design criteria for all highway facilities is that a minimum sight distance equal to the safe stopping distance must be provided at every point along the road way. On horizontal curves, sight distance is limited by roadside objects (on the inside of the curve) that block drivers' line of sight. Roadside objects such as buildings, trees, and natural barriers disrupt motorists' sigh lines.

Safe stopping distance used in each of these equations may be computed as:

$$d = 0.278\ v\ t + \frac{v^2}{254((\frac{a}{9.81})\pm G))} \quad (4.42)$$

Where:
d=safe stopping distance, m
v = design speed, km\h
t = reaction time, secs
G =grade, %

B.4.3.2 Vertical Alignment of Roadways:

The vertical alignment of a highway is the profile design of the facility in the vertical plane. The vertical alignments composed of a series of vertical tangents connected by vertical curves. Vertical curves are in the shape of a parabola. This provides for a natural transition from a tangent to a curved section as part of the curve characteristics. Therefore, there is no need to investigate or provide transition curves, such as the spiral for horizontal curves.

- **Geometric Characteristics of Vertical Curves:**

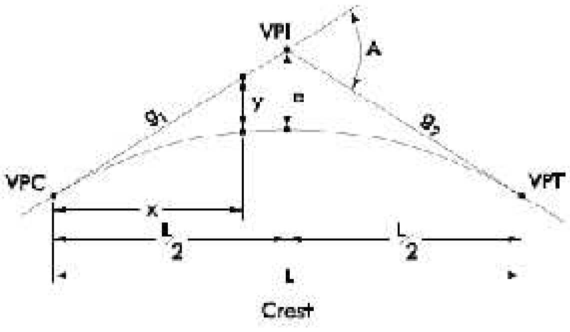
In addition to horizontal curves that go to the right or left, roads also have vertical curves that go up or down. Vertical curves at a crest or the top of a hill are called summit curves, or over verticals. Vertical curves at the bottom of a hill or dip are called sag curves, or under verticals.

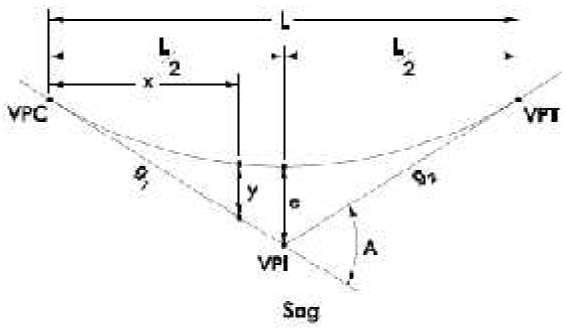
Vertical curves are used to connect stretches of road that go up or down at a constant slope. These lines of constant slope are called grade tangents.

Vertical curves are in the shape of parabola see figure (4.12). In general, there are two types of vertical curves:

- Crest vertical curves.
- Sag vertical curves.

The rate of slope is called the gradient, or simply the grade. Grades that ascend in the direction of the stationing are designated as plus; those that descend in the direction of the stationing are designated as minus. Grades are measured in terms of percent; that is, the number of feet of rise or fall in a 100 foot horizontal stretch of the road.{7}





Fig(4.12): Vertical Curve.

Vertical Curves Elements:

- A = Algebraic difference in gradients, g2 - g1.
- L = Total length of vertical curve.
- K = Rate of vertical curvature.
- VPC = Vertical Point of Curvature.
- VPT = Vertical Point of Tangency.
- VPI = Vertical Point of Intersection.
- x = Horizontal distance to any point on the curve from the VPC.
- xt = Turning point, which is the minimum or maximum point of the curve.
- e = Vertical offset or middle ordinate, which is the vertical distance from the VPI to the arc.
- y = Vertical distance at any point on the curve to the tangent grade.
- r = Rate of change of grade.
- EVPC = Elevation of VPC.
- EVPT = Elevation of VPT.
- Ex = Elevation of a point on the curve at a distance x from the VPC.
- Et = Elevation of the turning point.

Vertical curves equations:

- $A = g_2 - g_1$ (4.43)
- $K = \frac{L}{A}$ (4.44)
- $R = \frac{A}{100L}$ (4.45)
- $e = \frac{AL}{800}$ (4.46)

Minimum length of vertical curves:

- Crest vertical curves:

  When S is less than L

- $L = \frac{AS^2}{100(\sqrt{2h_1} + \sqrt{2h_2})^2}$ (4.47)

  When S is greater than L

- $L = 2S - \frac{200(\sqrt{h_1} + \sqrt{h_2})^2}{A}$ (4.48)

Where:

- L = Length of vertical curve.
- S = Sight distance.
- A = Algebraic difference in gradients.
- h1= Height of eye above roadway surface.
- h2= Height of object above roadway surface.

- Sag vertical curves:

  When S is less than L

- $L = \frac{AS^2}{120+3.5S}$ (4.49)

  When S is greater than L

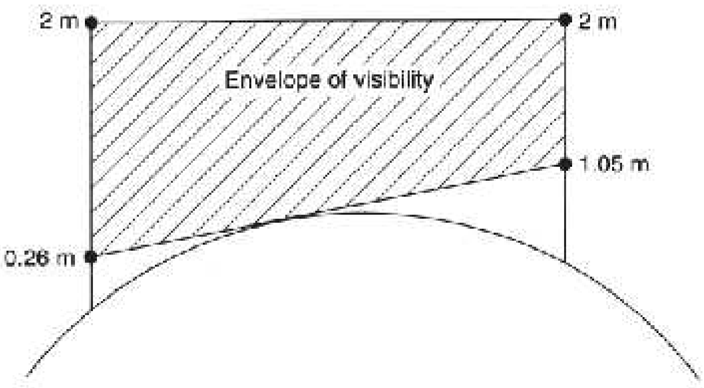
- $L = 2S - (\frac{120+3.5S}{A})$ (4.50)

Where:

- L = Length of vertical curve.
- S = Sight distance.
- A = Algebraic difference in gradients.

- Stopping sight distance:

Stopping sight distance is required at all locations along the highway, to see an 150 mm (0.5 ft) object. The stopping sight distance is typically required at all intersections and approaches.



Fig(4.13)visibility on vertival curve

- $SSD = 0.278Vt + \frac{V^2}{254(f \pm g)}$ (4.51)

Where:

- SSD = required stopping sight distance, m.
- V = speed.
- t = perception-reaction time, sec., typically 2.5 sec. for design
- f = coefficient of friction, typically for a poor, wet pavement
- g = grade, decimal.

- Passing Sight Distance :

Passing sight distance (PSD) is a key consideration in the design of two –lane highways and the marking of passing and no-passing zones on two-lane highways.

PSD= d1 + d2 + d3 + d4

Where:

dl = distance traveled during perception and reaction time and during initial acceleration to the point of encroachment on the left lane;

d2 = distance travelled while passing vehicle occupies the left lane .

d3 = distance between passing vehicle and opposing vehicle at the end of passing maneuver

d4 = distance travelled by an opposing vehicle for two-thirds of the time the passing vehicle occupies the left lane or 2/3 of d2

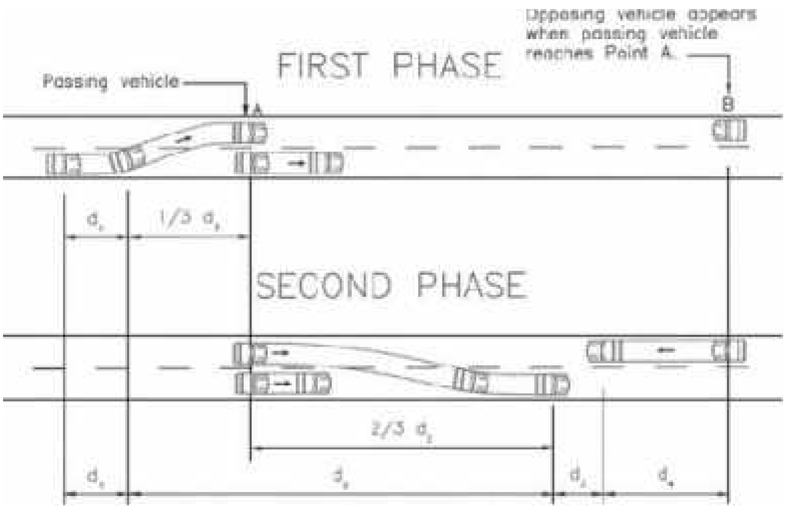


Figure (4.14) Passing Sight Distance for two lanes

B.4.3.3 Cross-Section Elements

The cross-section of a highway includes a number of elements critical to the design of the facility. The crosss ection view of a highway is a 90° cut across the facility from roadside to roadside see figure (4.15). The cross-section includes the following features:

- Travel lanes
- Shoulders
- Side slopes
- Curbs
- Medians and median barriers
- Guardrails
- Drainage channels

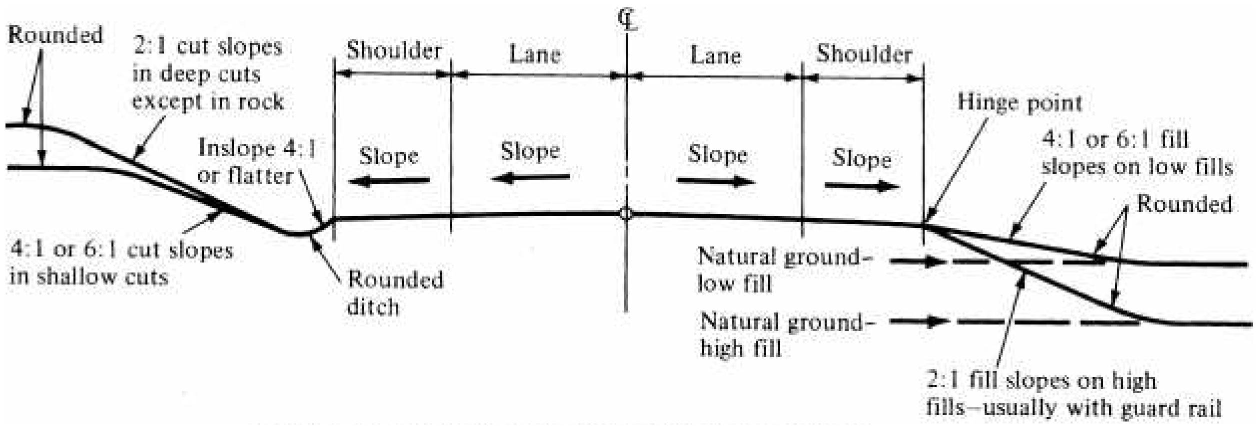


Figure (4.15) Typical Cross Section for Two-Lane Highway

Travel Lanes and Pavement:

Paved travel lanes provide the space that moving (and sometimes parked) vehicles occupy during normal operations. The standard width of a travel lane is 12 ft (metric standard is 3.6 m), although narrower lanes are permitted when necessary. The minimum recommended lane width is 9 ft(metric standed2.7 m) . lanes wider than 12 ft are sometimes provided on curves to account for the off-tracking of the rear wheels of large trucks . Narrow lanes will have a negative impact on the capacity of the roadway and on operations . in general, 9 ft acceptable only on low-volume, low speed rural or residential roadways.

- In this project the used minimum lane width is 2.75 m.

Shoulders:

A shoulder is the portion of the roadway contiguous with the traveled way that accommodates stopped vehicles, emergency use, and lateral support of sub-base, base , and surface courses (of the roadway structure), Shoulders are generally considered necessary on rural highways serving a significant mobility function

- For low volume urban roads and difficult terrain, no shoulder is provided in this project.

Side-Slopes for Cuts and Embankments:

Where roadways are located in cut sections or on embankments, side-slopes must be carefully designed to provide for safe operation. In urban areas, sufficient right-of-way is generally not available to provide for natural side-slopes, and retaining walls are frequently used.

Table (4.6) Guide for Earth Slope Design

Height of Cut or Fill (ft)	*Earth Slope, for Type of Terrain*		
	Flat or rolling	Moderately steep	*Steep*
0-4	6:1	6:1	4:1
4-10	4:1	4:1	2:1
10-15	4:1	2.5:1	1.75:1
15-20	2:1	2:1	1.5:1
Over 20	2:1	2:1	1.5:1

- From table (4.6), in this project the side slope is 4:1

Curbs and Gutter:

Curbs are raised structures made of either Portland cement concrete or bituminous concrete (rolled asphalt curbs) that are used mainly on urban highways to delineate pavement edges and pedestrian walkways. Curbs are also used to control drainage, improve aesthetics, and reduce right of way. Curbs can be generally classified as either vertical or sloping. Range in height from 6” to 8” with steep sides, and are designed to prevent vehicles from leaving the roadway. Gutters or drainage ditches are usually located on the pavement side of a curb to provide the principal drainage facility for the highway. They are sloped to prevent any hazard to traffic, and they usually have cross slopes of 5 to 8 percent and are 1 to 6 ft wide. Gutters can be designed as V-type sections or as broad, flat, rounded sections see figure (4.16).

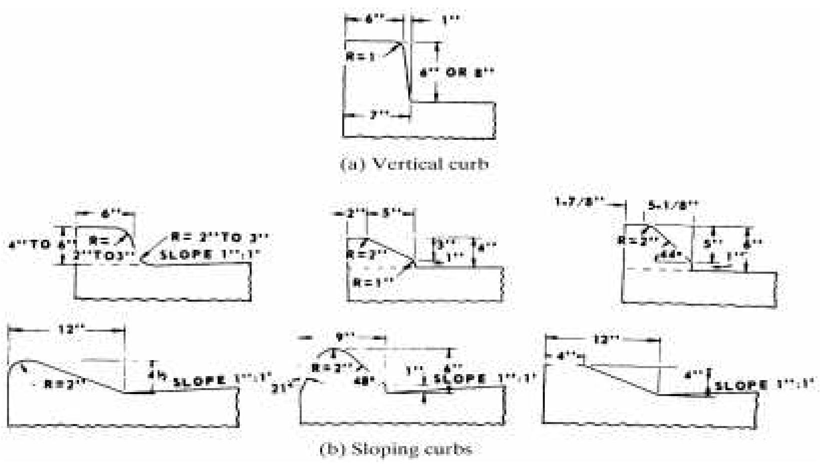


Figure (4.16) Typical Highway Curbs

- Vertical curbs that are used on edge of side walk to prevent vehicles from leaving the roadway.

Median:

A median is the section of a divided highway that separates the lanes in opposing directions. The width of a median is the distance between the edges of the inside lanes, including the median shoulders. Medians can either be raised, flush, depressed, or paint striped.

- The median used in this project is a paint-striped separation median.

Guard Rails:

Guard rails are longitudinal barriers placed on the outside of sharp curves and at sections with high fills. Their main function is to prevent vehicles from leaving the roadway. They are installed at embankments higher than 8 ft and when shoulder slopes are greater than 4:1. Shapes commonly used include the W beam and the box beam. The weak post system provides for the post to collapse on impact, with the rail deflecting and absorbing the energy due to impact.

- When side slope is not greater than 4:1 and embankment higher less than 8 ft, then the region don’t need guard rail.

Sidewalks:

Sidewalks are usually provided on roads in urban areas, but are uncommon in rural areas.

- The road in this project is providing in sidewalk in areas with high pedestrian concentrations at adjacent to schools.

C.4.3 Traffic control device and traffic stream characteristic

Traffic control devices are the media by which traffic engineers (communicate with drivers. Virtually every traffic law, regulation, or operating instruction must be communicated through the use of devices that fall into three broad categories:

- C.4.3.1 Traffic markings
- C.4.3.2 Traffic signs
- C4.3.3 Traffic signals

The MUTCD (Manual on Uniform Traffic Control Devices) states that the purpose of traffic control devices is “to promote highway safety and efficiency by providing for orderly movement of all road users on streets and highways, throughout the Nation.
It also defines five requirements for a traffic control device to be effective in fulfilling that mission. A traffic control device must:

1. Fulfill a need
2. Command attention
3. Convey a clear, simple message
4. Command respect of road users
5. Give adequate time for a proper response

Communicating with the Driver:

The driver is accustomed to receiving a certain message in a clear and standard fashion, often with redundancy. A number of mechanisms are used to convey messages.These mechanisms make use of recognized human limitations, particularly with respect to eyesight. Messages are conveyed through the use of:

1. Color. Color is the most easily visible characteristic of a device. Color is recognizable long before a general shape may be perceived and considerably before a specific legend can be read and understood. The principal colors used in traffic control devices are red, yellow, green, orange, black, blue, and brown. These are used to code certain types of devices and to reinforce specific messages whenever possible.

2. Shape. After color, the shape of the device is the next element to be discerned by the driver. Particularly in signing, shape is an important element of the message, either identifying a particular type of information that the sign is conveying or conveying a unique message of its own.

3. Pattern. Pattern is used in the application of traffic markings. In general, double solid, solid, dashed, and broken lines are used. Each conveys a type of meaning with which drivers become familiar. The frequent and consistent use of similar patterns in similar applications contributes greatly to their effectiveness and to the instant recognition of their meaning.

4. Legend. The last element of a device that the driver comprehends is its specific legend. Signals and markings, for example, convey their entire message through use of color, shape, and pattern. Signs, however, often use specific leg end to transmit the details of the message being transmitted. Legend must be kept simple and short, so that drivers do not divert their attention from the driving task, yet are able to see and understand the specific message being given.

C.4.3.1 Traffic Markings:

Traffic markings are the most plentiful traffic devices in use. They serve a variety of purposes and functions and fall into three broad categories:

- Longitudinal marking
- Transverse markings
- Object markers and delineators

Colors and Patterns:

Five marking colors are in current use: yellow, white, red, blue, and black. In general, they are used as follows:

A. Yellow line’s separate traffic traveling in opposite directions.

B. White markings separate traffic traveling in the same direction, and are used for all transverse markings.

C. Red line's delineate roadways that shall not be entered or used by the viewer of the marking.

D. Blue markings are used to delineate parking spaces reserved for persons with disabilities.

E. Black markings are used in conjunction with other markings on light pavements. To emphasize the pattern of the line, gaps between yellow or white markings are filled in with black to provide contrast and easier visibility.

Normally, line markings are 4 to 6 inches wide. Wide lines, which provide greater emphasis, should be at least twice the width of a normal line. Broken lines normally consist of 10 -ft line segments and 30-ft gaps. Similar dimensions with a similar ratio of line segments to gaps may be used as appropriate for prevailing traffic speeds and the need for delineation. Dotted lines usually consist of 2 -ft line segments and 4-ft (or longer) gaps. MUTCD suggests a maximum segment -to-gap ratio of 1:3 for dotted lines.

Longitudinal Markings:

Longitudinal markings are those markings placed parallel to the direction of travel. The vast majority of longitudinal markings involve centerlines, lane lines, and pavement edge lines.

Longitudinal markings provide guidance for the placement of vehicles on the traveled way cross -section and basic trajectory guidance for vehicles traveling along the facility. The best example of the importance of longitudinal markings is the difficulty in traversing a newly paved highway segment on which lane markings have not yet been repainted. Drivers do not automatically form neat lanes without the guidance of longitudinal marlungs; rather, they tend to place themselves some what randomly on the cross-section, encountering many difficulties. Longitudinal markings provide for organized flow and optimal use of the pavement width.

Transverse Markings:

Transverse markings, as their name implies, include any and all markings with a component that cuts across a portion or all of the traveled way. When used, all transverse markings are white.

- Application of transverse marking:

1. STOP Lines: stop lines are not mandated by the MUTCD. In practice, STOP lines are almost always used where marked crosswalks exist, and in situations where the appropriate location to stop for a STOP sign or traffic signal is not clear.

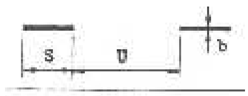
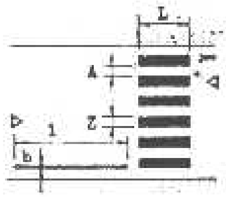
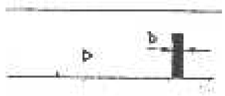
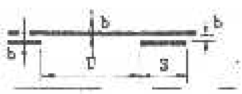
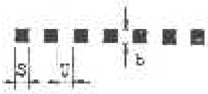
2. Crosswalk Markings: while not mandated by the MUTCD, it is recommended that crosswalks be marked at all intersections at which “substantial” conflict between vehicles and pedestrians exists. They should also be used at points of pedestrian concentration and at locations where pedestrians might not otherwise recognize the proper place and/or path to cross. A marked crosswalk should be 6 ft or more in width.

3. Word and Symbol Markings: the MUTCD prescribes a number of word and symbol markings that may be used, often in conjunction with signs and or signals. These include arrow markings indicating lane-use restrictions. Such arrows (with accompanying signs) are mandatory where a through lane becomes a left - or right-turn-only lane approaching an intersection. Word markings include “ONLY,” used in conjunction with lane use arrows, and “STOP,” which can be used only in conjunction with a STOP line and a STOP sign. “SCHOOL” markings are often used in conjunction with signs to demark school and school-crossing zones. The MUTCD contains a listing of all authorized.

Object Markers:

Object markers are used to denote obstructions either in or adjacent to the traveled way. Object markers are mounted on the obstruction in accordance with MUTCD standards and guidelines. In general, the lower edge of the marker is mounted a minimum of 4 ft above the surface of the nearest traffic lane (for obstructions 8 ft or less from the pavement edge) or 4 ft above the ground (for obstructions located further away from the pavement edge).

table(4.7) type and application of traffic marking{16}

TYPE	MARKING	THICKNESS CM	RATIO S/V M	APPLICATION
Lane lines (white)		10-20	3/6 3/9 3/3	- Between lanes of the same direction - at channelization
Pedestrian crossing (white/black)		b= 10-20 I >=10m L=2.5m Z=50-70 A=Z or Z+20		Pedestrian crossing are necessary at: - intersections. -near schools , shopping a.s.o. - in residential areas> - on streets with heavy traffic>
Stop line (white)		>=30		-stop streets. - light signals. - rails crossing>
Double axial line (white)		10-20	3/6 3/9	At inadequate sight distance for one direction at -curves. -crests & sags.
Limitation line (white)		30-50	٠.٣/0.3 0.5/0.5	On secondary roads when meeting with main roads.

C.4.3.2 Traffic Signs:

The MUTCD provides specifications and guidelines for the use of literally hundreds of different signs for myriad purposes. In general, traffic signs fall into one of three major categories:

A. Regulatory signs: Regulatory signs convey information concerning specificbtraffic regulations. Regulations may relate to right -of-way, speed limits, lane usage, parking, or a variety of other functions.

B. Warning signs: Warning signs are used to inform drivers about upcoming hazards that they might not see or otherwise discern in time to safely react.

C. Guide signs: Guide signs provide information on routes, destinations, and services that drivers may be seeking.

A. Regulatory Signs:

Regulatory signs shall be used to inform road users of selected traffic laws or regulations and indicate the applicability of the legal requirements. Regulatory signs shall be installed at or near where the regulations apply. The signs shall clearly indicate the requirements imposed by the regulations and shall be designed and installed to provide adequate visibility and legibility in order to obtain compliance.

The regulatory signs in this category have special designs reflecting the extreme danger that exists when one is ignored. These signs include the STOP and YIELD signs, which assign right -of-way at intersections, and WRONG WAY and ONE WAY signs, indicating directional flow. The STOP and YIELD signs have unique shapes, and they use a red background color to denote danger. The WRONGWAYsign also uses a red background for this purpose see figure (4.17).

Figure (4.17) regulatory signs.

B. Warning Signs:

Warning signs call attention to unexpected conditions on or adjacent to a highway or street and to situations that might not be readily apparent to road users. Warning signs alert road users to conditions that might call for a reduction of speed or an action in the interest of safety and efficient traffic operations see figure (4.18).

Figure (4.18) Warning signs.

C. Guide Signs:

Guide signs provide information to road users concerning destinations, available services, and historical facilities. They serve a unique purpose in that drivers who are familiar or regular users of a route will generally not need to use them; they provide critical information, however, to unfamiliar road users. They serve a vital safety function: a confused driver approaching a junction or other decision point is a distinct hazard see figure (4.19).

Figure (4.19) guide signs.

C.4.3.3Traffic Signals:

The MUTCD defines seven types of traffic signals:

1. Traffic control signals.
2. Pedestrian signals.
3. Emergency vehicle traffic control signals.
4. Facilities ramps.
5. Traffic control signals for freeway entrance.
6. Traffic control signals for moveable bridges Lane-use control signals.
7. In-roadway lights.

Traffic Stream Characteristics:

Traffic stream parameters fall into two broad categories.

- Macroscopic parameters describe the traffic stream as a whole:
- Microscopic parameters describe the behavior of individual vehicles or pairs of vehicles within the traffic stream.

The three principal macroscopic parameters that describe a traffic stream are:

1. Volume or rate of flow,
2. Speed,
3. Density.

Volume and Rate of Flow:

Traffic volume is defined as the number of vehicles passing a point on a highway, or a given lane or direction of a highway, during a specified time interval. The unit of measurement for volume is simply “vehicles,” although it is often expressed as “vehicles per unit time.” Units of time used most often are “per day” or “per hour.”

Daily Volumes:

As noted, daily volumes are used to document annual trends in highway usage. Forecasts based upon observed trends can be used to help plan improved or new facilities to accommodate increasing demand. There are four daily volume parameters that are widely used in traffic engineering:

- Average annual daily traffic (AADT): The average 24-hour volume at a given location over a full 365 -day year; the number of vehicles passing a site in a year divided by 365 days (366 days in a leap year).

- Average annual weekday traffic (AAWT): The average 24 -hour volume occurring on weekdays over a full 365 -day year; the number of vehicles passing a site on weekdays in a year divided by the number of weekdays (usually 260).

- Average daily traffic (ADT): The average 24- hour volume at a given location over a defined time period less than one year; a common application is to measure an ADT for each month of the year.

- Average weekday traffic (AWT): The average 24- hour weekday volume at a given location over a defined time period less than one year; a common application is to measure an AWT for each month of the year.

Hourly Volumes:

Daily volumes, while useful for planning purposes, cannot be used alone for design or operational analysis purposes. Volume varies considerably over the 24 hours of the day, with periods of maximum flow occurring during the morning and evening commuter “rush hours.” The single hour of the day that has the highest hourly volume is referred to as the peak hour. The traffic volume within this hour is of greatest interest to traffic engineers for design and operational analysis usage. The peak -hour volume is generally stated as a directional volume (i.e., each direction of flow is counted separately). Highways and controls must be designed to adequately serve the peak-hour traffic volume in the peak direction of flow.

In design, peak -hour volumes are sometimes estimated from projections of the AADT. Traffic forecasts are most often cast in terms of AADTs based on documented trends and/or forecasting models. Because daily volumes, such as the AADT, are more stable than hourly volumes, projections can be more confidently made using them. AADTs are converted to a peak -hour volume in the peak direction of flow. This is referred to as the “directional design hour volume” (DDHV), and is found using the following relationship:

$$DDHV = AADT*K*D \qquad (4.52)$$

where:
K = proportion of daily traffic occurring during the peak hour the peak direction of flow.
D = proportion of peak hour traffic traveling in the peak direction of flow.

CHAPTER FIVE
ANALYSIS AND DESIGN

5.1 Waste Water Collection System

5.1.1 General

5.1.2 Layout of the System

5.1.3 Design Computation

5.1.4 SewerCad Program Works

5.2 Drainage Collection System

5.2.1 General

5.2.2 Layout of the System

5.2.3 Design Computations

5.2.4 SewerCad Program Works

5.3 Analysis and Adjust Traverse Network

5.3.1 General

5.3.2 Traverse Adjustment

5.3.3 Observation

5.3.4 Coordinate Determination for Unknown Station before Correction

5.3.5 Traverse Error Reduction

5.3.6 Coordinate Error Correction Method

5.3.7 Soil Tests

5.3.7.1 Proctor Compaction Test

5.3.7.2 California bearing Ratio (CBR)

5.3.8 Adjustment of Periodic Counts

5.3.9 Structural Design of Road

5.3.10 Design the Thickness of Layer

Chapter Five
ANALYSIS AND DESIGN

5.1 Wastewater Collection System

5. 1.1 General:

In this chapter, project team evaluate and design wastewater collection system for Al-Arroub camp, and develop a future plans for construction of the collection system, corresponding on population growth, water consumption, and after that calculate wastewater production in the future, in order as preliminary plan to reduce the problem causes by the disposal of wastewater in the area, the layout of the system established is presented followed by discussion of detailed design computation and the final design and specifications of the suggested wastewater collection system.

5. 1.2 Layout of the System:

The first step in designing a sewerage system is to establish an overall system layout that includes a plan of the area to be sewered, showing roads, streets, other utilities, topography, and all buildings to be drained in Drawing (D1) a Topography map is shown in appendix B .Care must be taken to provide adequate terminal manholes that can later be connected to the system constructed serving the area.

In establishing the layout of wastewater collection system for Al-Arroub Camp, the following basic steps were followed:

1. Obtain a topographic map of the area to be served.
2. Locate the drainage outlet. This is usually near the lowest point in the area and is often along a stream or drainage way. In Al-Arroub Camp, the lowest point is in the southern-east part of the camp.
3. Sketch in preliminary pipe system to serve all the contributors.

4. Pipes are located so that all the users or future users can readily tap on; they are also located so as to provide access for maintenance and thus are ordinarily placed in streets or other rights-of-way.
5. Sewers layout is followed natural drainage ways so as to minimize excavation and pumping requirements. Large trunk sewers are located in low-lying areas closely paralleling streams or channels.
6. Establish preliminary pipe sizes. Eight inches pipe size (usually the minimum allowable) can serve several hundred residences even at minimal grades.
7. Revise the layout so as to optimize flow-carrying capacity at minimum cost. Pipe lengths and sizes are kept as small as possible, pipe slopes are minimized, and followed the ground surface slope to minimize the depth of excavation, and the numbers of appurtenances are kept as small as possible.
8. The pumping is avoided across drainage boundaries. Pumping stations are costly and add maintenance problems.

The final layout of wastewater collection system for Al-Arroub camp is illustrated in drawing (D2, D3) in appendix B.

5.1.3 Design Computation:

The detailed design of sanitary sewers involves computation of the quantity of wastewater expected from the surroundings and upstream areas to the next pipe in series, subject to the appropriate design constrains. The design computations in the example given below.

- **Design example: Design a gravity flow sanitary sewer**

1. To design a gravity flow trunk sanitary sewer for the area to outfall (line S1L1) in (Figure 5.1). Assume that the following design criteria have been developed and adopted based on an analysis of local conditions and codes.
2. For water consumption uses 75 L/c.d in 2007 and 120 L/c.d for the future in 2036 when the rate of increase in the consumption of water is equal 2% per year.

3. The wastewater calculates as 80% of the water consumption.
4. For infiltration allowance use 10% of the domestic sewerage flow.
5. For the hydraulic design equation use the Manning equation with n value of 0.011.
6. The population at the present time is 11915 while in the future "after 25 years" it is predicted to be equal 27156 persons with growth rate reach to 3.35 %.
7. Peaking factor depending on the formula :

$$P_f = 1.5 + \left(\frac{2.5}{\sqrt{q}}\right) \qquad (4.1)$$

8. Minimum pipe size: The building code specifies 200mm (8in) as he smallest pipe permissible for this situation.
9. Minimum cover (minimum depth of cover over the top of the sewer). The Minimum depth of the cover is 1.5m.
10. Minimum velocity: To prevent the deposition of solids at low wastewater flows. Use minimum velocity of 0.6 m/s during the peak flow conditions.

Solution:

1. Lay out the trunk sewer. Draw a line to represent the proposed sewer (Figure 5.1).
2. Locate and number of the manholes. Locate manholes at (1) change in direction, (2) change in slope, (3) pipe junctions, (4) upper ends of sewers, and (5) intervals from 50 to 60 m or less. Identify each manhole with a number.
3. Prepare a sewer design computation table. Based on the experience of numerous engineers, it has been found that the best approach for carrying out sewer computations is to use a computation table. The necessary computations for the sanitary sewer are presented in (Table 5.1). The data in the table are calculated as follow:
   a. The entries in columns 1 and 2 are used to identify the line numbers and street sewer name.
   b. The entries in columns 3 through 5 are used to identify the sewer manholes, their numbers and the spacing between each two manholes.

c. The entries in column 6 used unit sewage. = (80% * future water consumption * population density) by unit cubic meter per day divided area in dounum.
d. The entries in columns 7 and 8 are used tributary area, column 7 used incremental area, and column 8 used total area in dounum.
e. To calculate domestic maximum flow rates columns 9, 10, 11, 12 are used. Column 9 is domestic average sewage flow (unit sewage * total area), Column 10 used peak factor, Column 11 represents the Maximum domestic (Q) in (m3/day), the value of it is obtained from multiplying column 9 by column 10. Column 12 gives the infiltration allowance, which equal (0.10 * Column 9).
f. The entries in columns 13 (total average flow rate) is calculated by sum the Column 9 and Column 12.
g. The entries in columns 14 (total maximum flow rate) is calculated by sum the Column 11 and Column 12.
h. The entries in column 15 are Q max separately (not cumulative).
i. By using autocad program, the elevations of Manholes have been found out using the contour lines around it.
j. Save the drawing sheet containing the line as dxf drawing sheet.

The needed tables are attached in appendix A Page 179.

A3 S1L1

Table 5.1 Wastewater Quan

5.1.4 SewerCAD program works:

a. Open SewerCAD, select file → import →DXF Background to import the DXF file, figure (5.2) below shows this step.

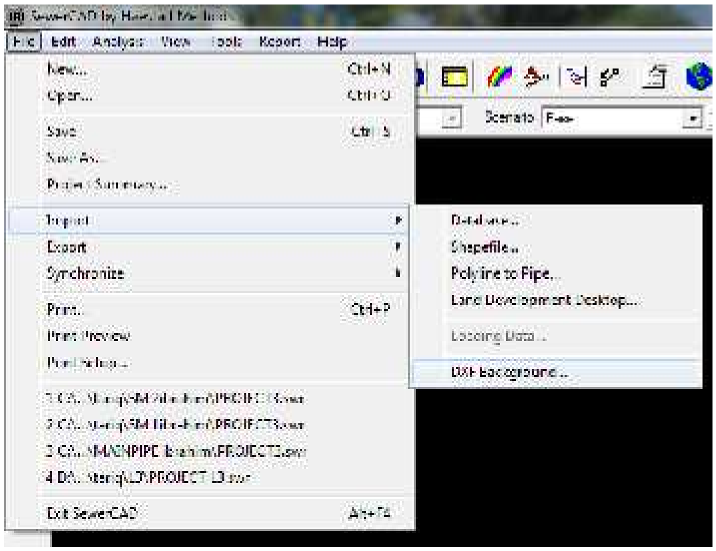


Figure (5.2) Importing DXF file

b. Specify file location is then press open, figure (5.3) below shows this step. And figure (5.4) shows line (SL1).

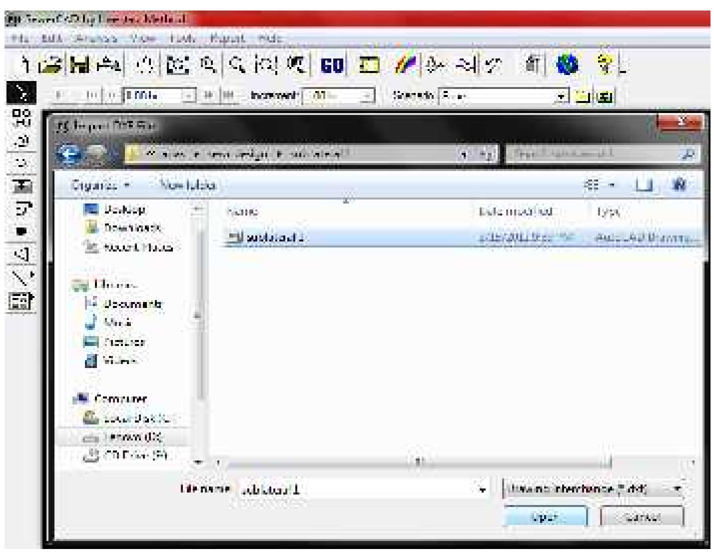


Figure (5.3) Opening the DXF file.

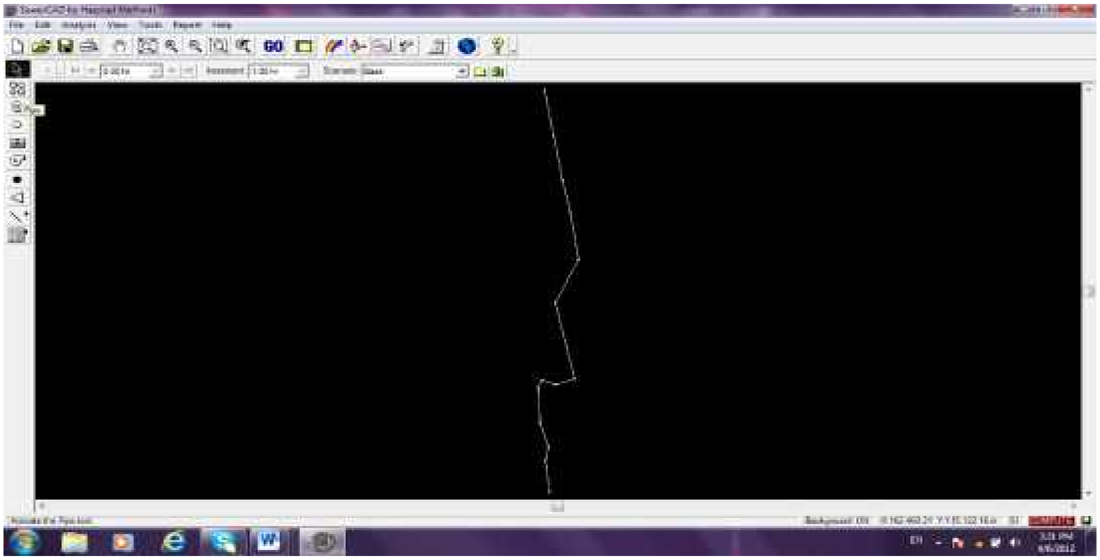


Figure (5.4) S1L1 Line.

c. Press pipe icon, a massage will appear tell you to create a project see figure (5.5).

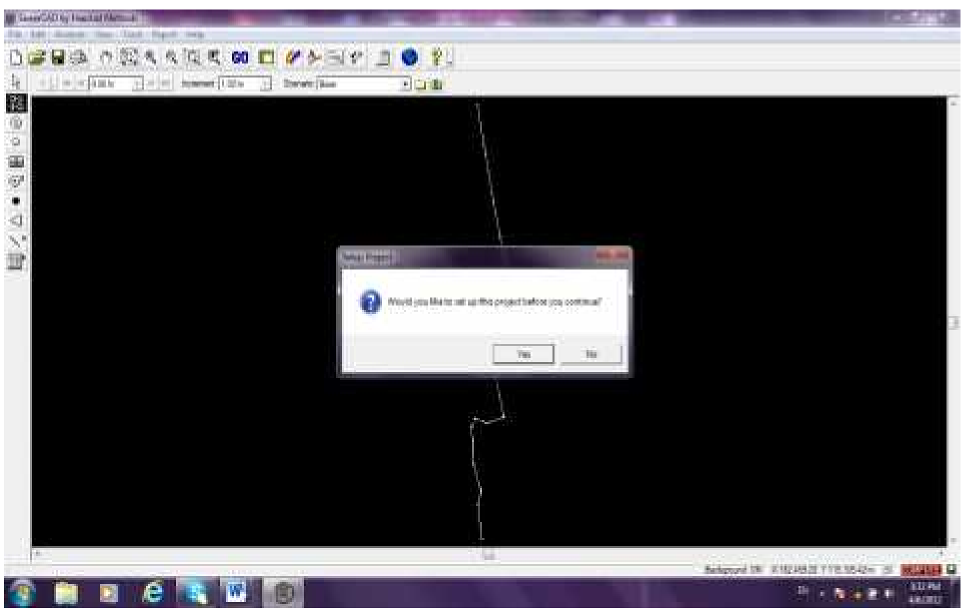


Figure (5.5) Creating Project

d. Press yes and define the project then press next twice, then select finish, the figure (5.6) below show this step.

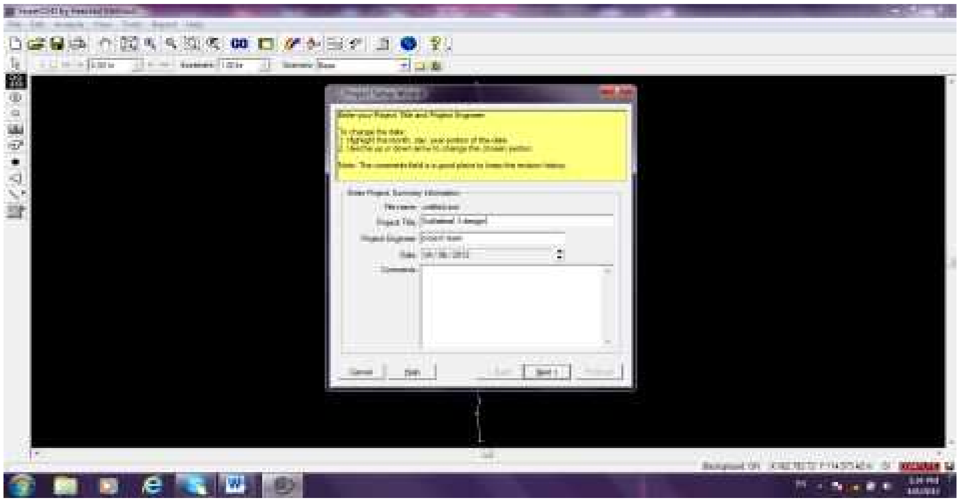


Figure (5.6) Defining the project

e. Press pipe icon and connect between manholes, figure (5.7) below shows the step.

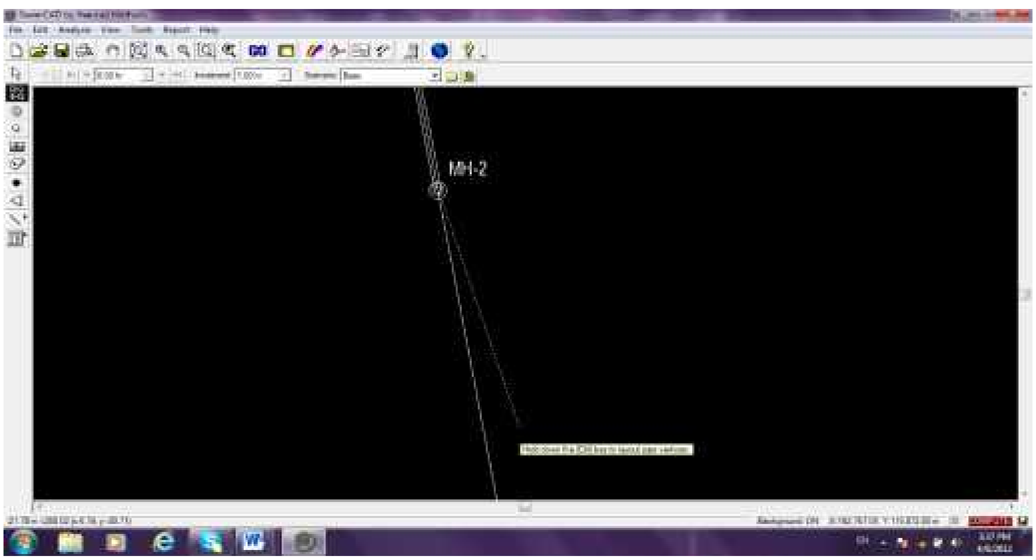


Figure (5.7) Creating a pipe network.

f. After you connect between all manholes, press on the out let icon and click on the last manhole, then press yes to replace the manhole with outlet, the figure (5.8) below shows the step.

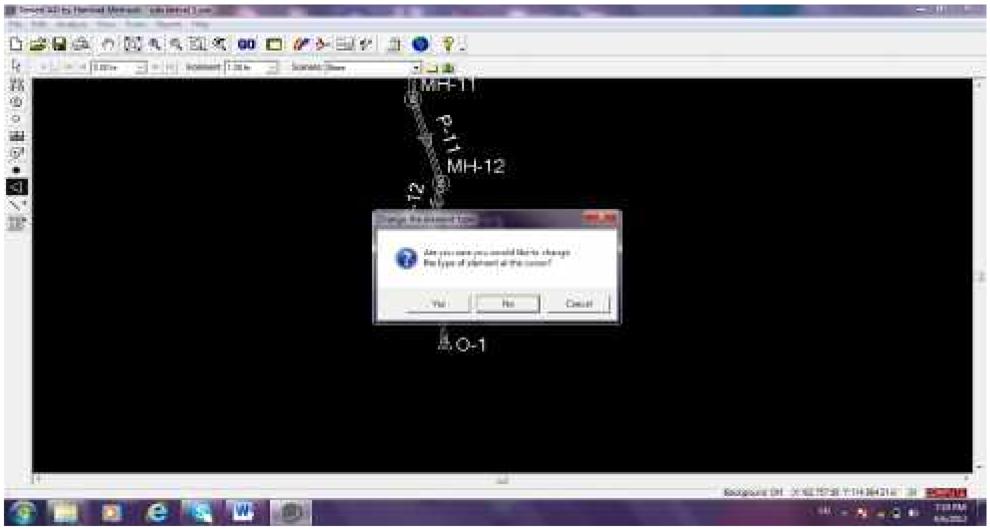


Figure (5.8) Creating outlet

g. Save your project, then select analysis → alternatives → physical properties → edit, then start editing gravity pipe, see figure (5.9).

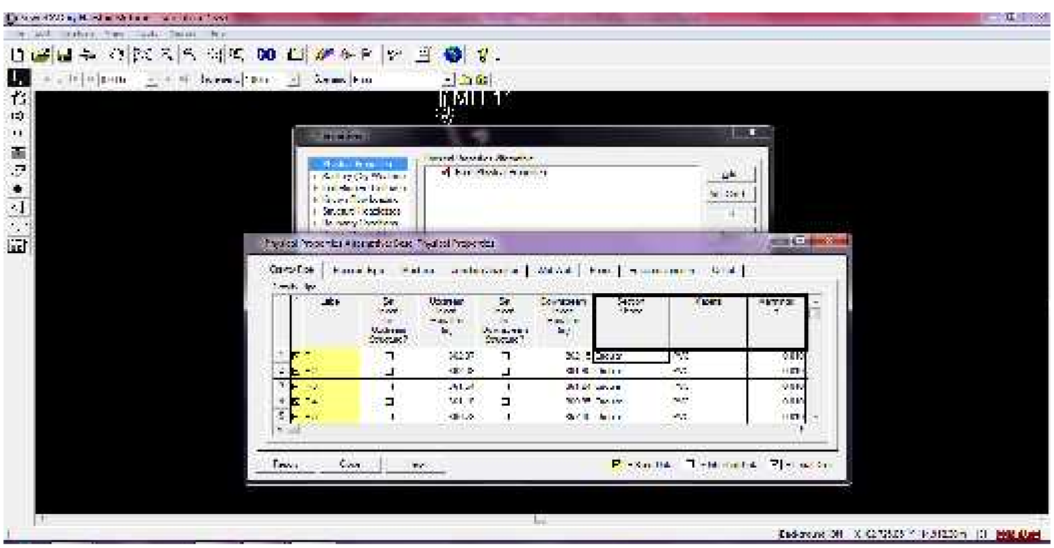


Figure (5.9) Editing design parameters

h. Select manhole to enter the ground elevations of manholes, then select out let to enter its elevation. Then press close. Figure (5.10) below shows the step.

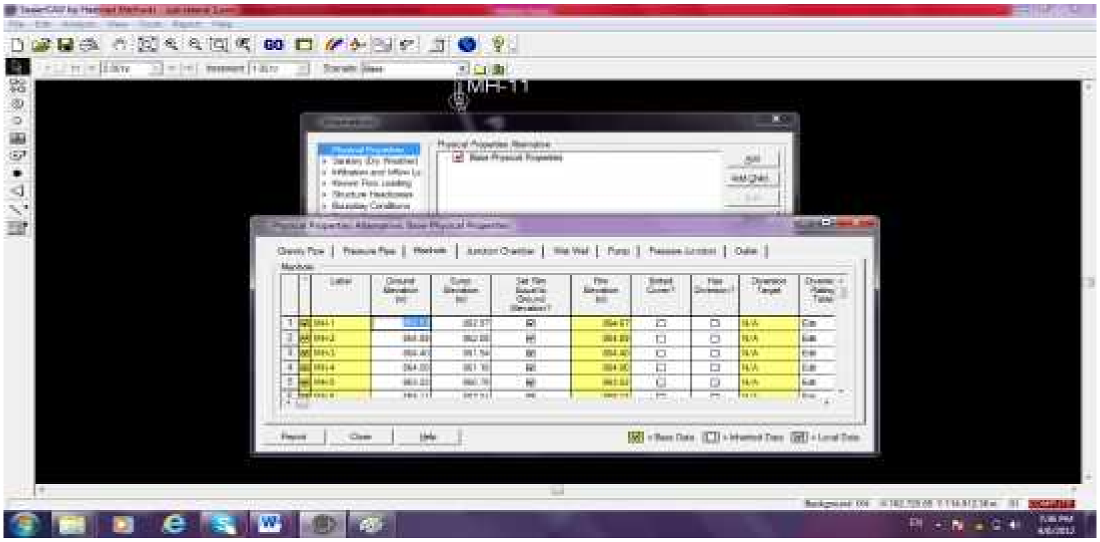


Figure (5.10) Editing design parameters

i. Select sanitary (dry weather) → edit → manhole to select the type of load and to enter the load for each manhole, figure (5.11) below shows the step.

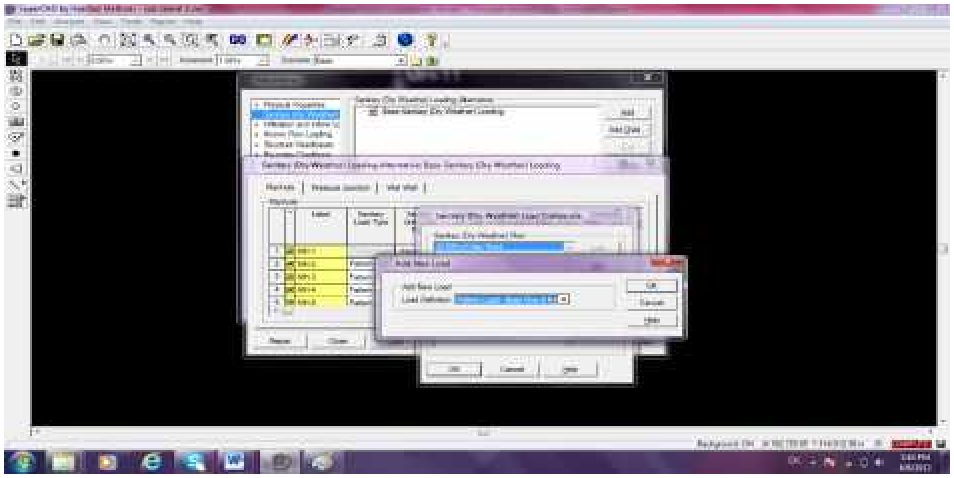


Figure (5.11) Editing design parameters

j. After doing this for each manhole press close, then select design constrains → edit to enter the design specifications, figure(5.12) below shows the step.

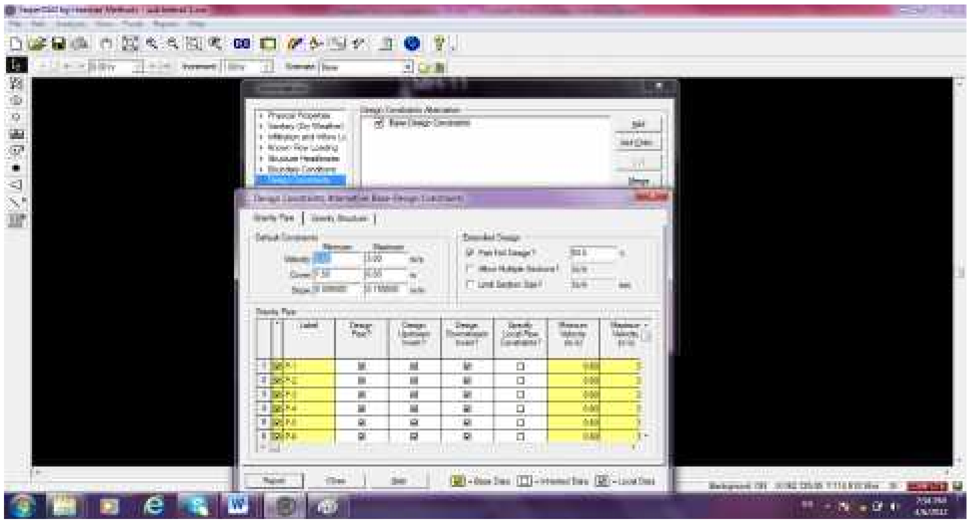


Figure (5.12) Editing design parameters

k. Last step press save, press GO button to start design then press on GO, figure (5.13) below shows the step.

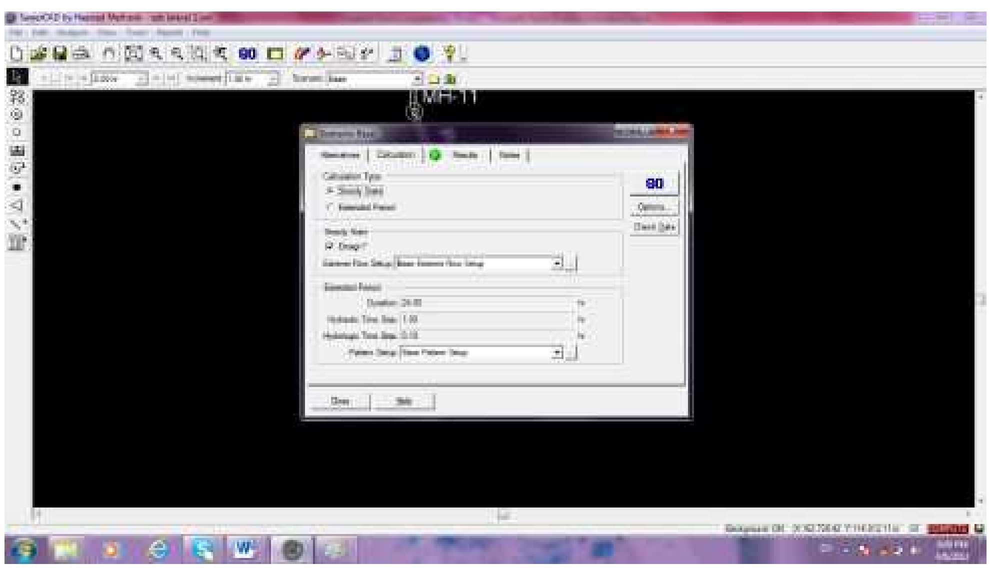


Figure (5.13) checking the design

l. If you have green light that mean there is no problems in the design work, but if you have yellow or red light that's mean there is problem, read the massages and fix these problems.

m. After finishing design work we need to show the pipe line profile and the profile, gravity pipe report and gravity node report. Press profile button to make the profile see fig (5.14), here we should put the scale of the profile. The profiles for this project are attached in appendix C. We can get the required tables by pressing tabular report button see figure (5.15), and then choose gravity pipe report and gravity node report. The required reports for this project are attached in appendix A page (190).

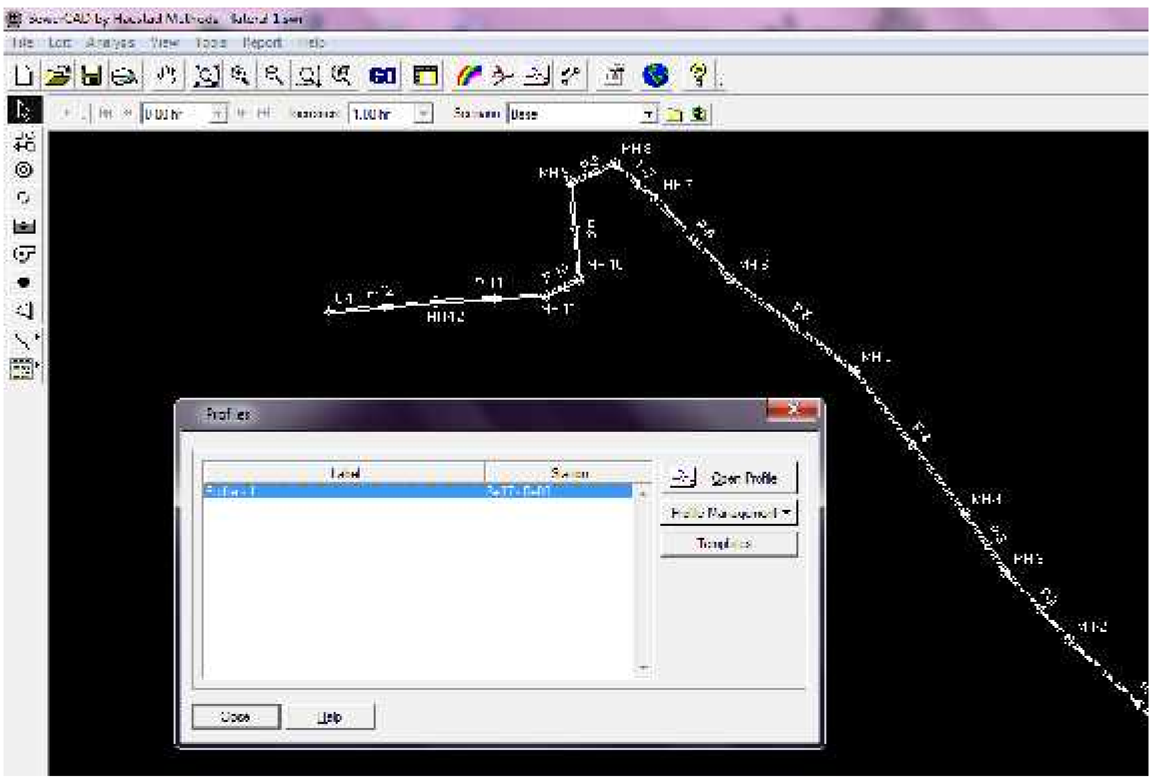


Figure (5.14) Creating Profile

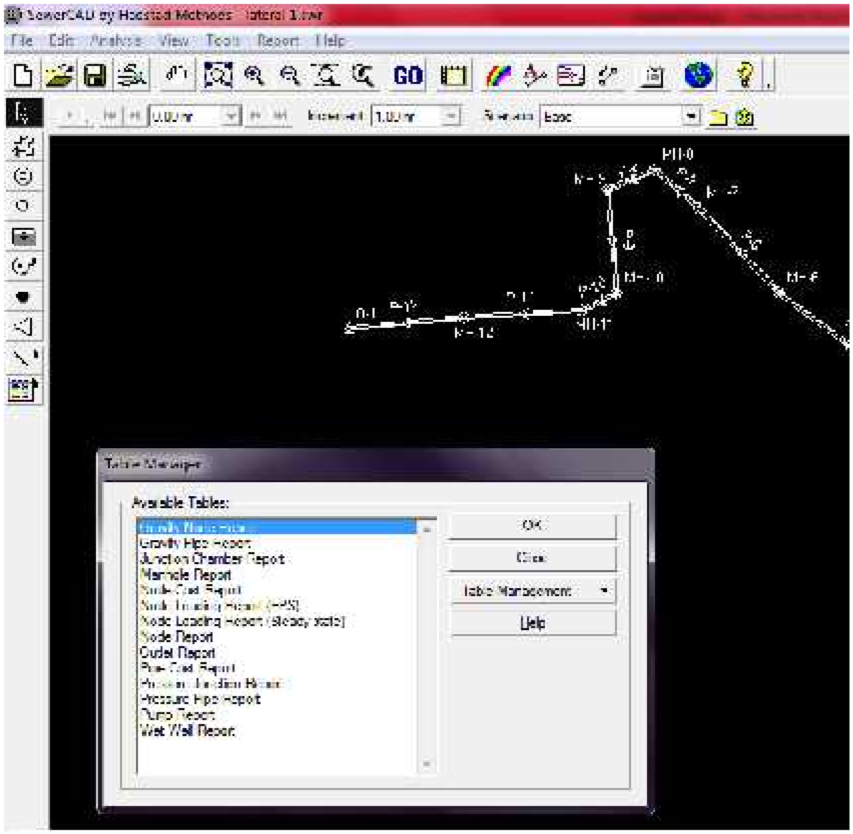


Figure (5.15) Creating Tables

5.2 Storm Water Drainage System

5.2.1 General:

In this section, design of storm water drainage system for the Al-Arroub, in order to solve the problem causes by the cumulative flooded storm water in the streets.

In this section, the layout of the system established will be presented followed by discussion of detailed design computations and the final design and profiles of the suggested storm water drainage system.

5.2.2 Layout of the System:

The first step in designing a storm water drainage system is to establish an overall system layout that includes a plan of the area, showing roads, streets, buildings, other utilities, and topography.

In suggesting the layout of storm water drainage system for the Al-Arroub camp area, the following basic steps were followed:

1. Obtain a topographic map of the area to be served.
2. Locate the catchment of the site and determine the area of this catchment.
3. Sketch in preliminary closed pipe system to serve the area.
4. Sewer layout is followed natural drainage ways so as to minimize excavation and pumping requirements.
5. Establish preliminary pipe diameter that can drain the required water runoff.
6. Revise the layout so as to optimize flow-carrying capacity at minimum cost.

The final layout of storm water drainage system for Al-Arroub camp is illustrated in drawing (D4, D5) in Appendix B.

5.2.3 Design Computation:

The detailed design of storm water sewers involves the selection of appropriate pipe diameters and slopes to transport the quantity of storm water from the surrounding and upstream areas to the next pipe in series, subject to the appropriate design constrains. The design computations and procedure for design storm water drainage system for Al-Arroub camp using sewerCAD is illustrated in the design example given below.

- **Design Example**: **Design a gravity flow storm water drainage pipe:**

Design a gravity flow storm water drainage pipe for the area AL-Arroub camp line1 shown in the accompanying (Figure 5.14). Assume that the following design criteria have been developed and adopted based on an analysis of local conditions and codes.

1. For weighted Runoff coefficient (C) use 0.3.
2. For Inlet time (Ti) use 5 minutes
3. For Concentration time (T_c) use equations

$$T_c = t_i + t_f \quad (4.5)$$

4. For Runoff rate depending on the formula:

$$Q = C.i.A \quad (4.3)$$

5. For Rainfall intensity use (Figure 5.16).

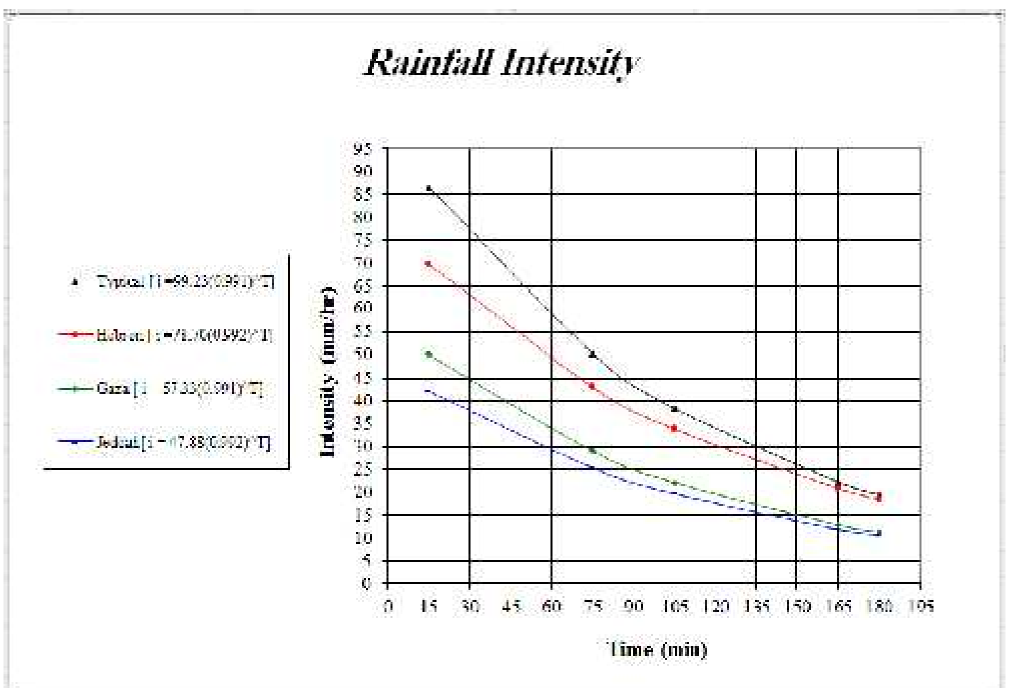


Figure 5.16 rainfall intensity

Solution:

1. Lay out the storm water sewer line. Draw a line to represent the proposed sewer (See Figure 5.17)
2. Locate and number the upper and lower points of the line.
3. The necessary computations for the storm water sewer shown in Figure presented in the (Table 5.2). The data in the table are calculated as follow:
4. The entries in columns 1 through 5 are used to identify the point locations, their numbers and the length between them.

a. The entries in columns 6and 7 represent tributary area; shows the partial sewered area in hectare.
b. The entries in columns 8 through 14 are used to calculate the design flow. Runoff coefficient (C) is entered in column 8.
c. The partial sewered area in hectare is multiplied by runoff coefficient (C) and the result is given in column 9
d. The cumulative multiplication of the sewered area in hectare is multiplied by runoff coefficient (C) are given in column 10.
e. The concentration time is shown in column 11
f. The rainfall intensity (mm/hr) is shown in column 12
g. The rainfall intensity (l/s.ha) is shown in column 13 its calculated by dividing column 12 over 60 minutes and then multiplying by 166.67
h. Column 14 shows run off rate (Q) which obtained by multiply column 10 by column 13
i. Column 15 shows (Qi) in (l/s) separately between two inlets.

A3 storm water line 1 fig(5.17)

WATER TABLE (5.2)

5. 2.4 SewerCAD program works:

To design the storm water network on sewerCAD program we repeat the same steps as sanitary design example, but in step of design constrains enter the specifications of storm water system design.

The profiles for storm water network are attached in appendix C, and the gravity pipe reports and gravity nod reports are attached in appendix A page (215).

5.3 Analysis and Adjust Traverse Network

5.3.1 General:

Traversing is one of the simplest and most popular methods of establishing control networks in engineering surveying. In underground mining it is the only method of control applicable whilst in civil engineering it lends itself ideally to control surveys where only a few intervisible points surrounding the site are required.

5.3.2 Traverse Adjustment:

This project used a link traverse, because it’s the most accurate traverse.

Link traverse adjustment:

A link traverse (Figure 5.18) commences from known stations, GPS.1and GPS.2, and connects to known stations GPS.3 and GPS.4.Stations GPS.1, GPS.2, GPS3 and GPS.4are usually fixed to a higher order of accuracy. Their values remain unaltered.

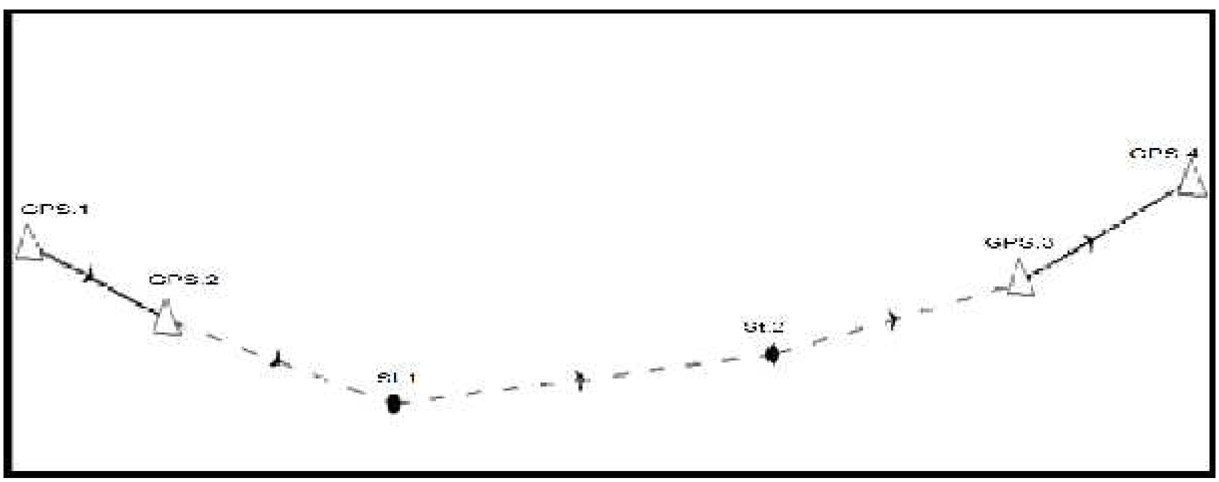


Figure (5.18) Link Traverse adjustments

Where:

GPS.1, GPS.2, GPS.3 and GPS.4 control point (Known Coordinates) (Trimble GPS) were used in readings of four control points (tow in the beginning and tow at the end of the traverse), then (Total Station) was used to measure horizontal distance and horizontal angle see figure (5.16).

5.3.3 Observations:

Table (5.3) show the observations of angles and distances that measured in project area, Were horizontal distances measured three times, and horizontal angles measured three times face right and three times face left to achieve high accuracy.

Table (5.3) Observations of Link Travers

F.R GPS2				
point	**Horizontal Angle d**	**'**	**"**	**Horizontal Distance m**
GPS.1	00	00	00	**118.436**
ST.1	174	13	41	**191.223**
GPS.1	359	59	52	**118.440**
ST.1	174	13	18	**191.219**
GPS.1	00	00	17	**118..437**
ST.1	**174**	**13**	**19**	**191.229**
F.L GPS2				
point	**Horizontal Angle d**	**'**	**"**	**Horizontal Distance m**
ST.1	354	13	30	**191.226**
GPS.1	180	00	11	**118.438**
ST.1	354	13	35	**191.225**
GPS.1	180	00	03	**118.437**
ST.1	354	13	55	**191.227**
GPS.1	**180**	**00**	**00**	**118.438**
F.R ST.1				
point	**Horizontal Angle d**	**'**	**"**	**Horizontal Distance m**
GPS.2	00	00	00	**191.262**
ST.2	145	01	42	**309.873**
GPS.2	359	59	45	**191.273**
ST.2	145	01	38	**309.861**
GPS.2	00	00	03	**191.254**
ST.2	**145**	**01**	**35**	**309.881**

F.L ST.1				
point	Horizontal Angle			Horizontal Distance
	d	'	"	m
ST.2	325	01	29	**309.897**
GPS.2	179	59	53	**191.254**
ST.2	325	01	38	**309.859**
GPS.2	179	59	21	**191.245**
ST.2	325	01	09	**309.876**
GPS.2	**179**	**59**	**12**	**191.244**

F.R ST.2				
point	Horizontal Angle			Horizontal Distance
	d	'	"	m
ST.1	00	00	00	**309.889**
GPS.3	174	07	28	**207.352**
ST.1	359	59	53	**309.888**
GPS.3	174	06	52	**207.359**
ST.1	359	59	59	**309.897**
GPS.3	**174**	**07**	**07**	**207.349**

F.L ST.2				
point	Horizontal Angle			Horizontal Distance
	d	'	"	m
GPS.3	354	06	31	**207.351**
ST.1	180	00	10	**309.897**
GPS.3	354	06	47	**207.313**
ST.1	179	59	40	**309.876**
GPS.3	354	06	59	**207.344**
ST.1	**179**	**59**	**58**	**309.894**

F.R GPS3				
point	Horizontal Angle			Horizontal Distance
	d	'	"	m
ST.2	00	00	00	**207.343**
GPS.4	169	00	55	**147.209**
ST.2	00	00	13	**207.340**
GPS.4	169	01	24	**147.215**
ST.2	00	00	00	**207.337**
GPS.4	**169**	**01**	**12**	**147.216**

F.L GPS3				
point	Horizontal Angle d	'	"	Horizontal Distance m
GPS.4	349	00	49	**147.212**
ST.2	179	59	54	**207.339**
GPS.4	349	01	54	**147.216**
ST.2	180	00	03	**207.329**
GPS.4	349	01	46	**147.213**
ST.2	**180**	**00**	**18**	**207.348**

Table (5.4) represents the average angels and average distances that's measured in field. The average and variance of horizontal angels and horizontal distances calculation are added in Appendix (A) page (219).

Table (5.4) Average Horizontal (Distances & Angles)

From	To	H.Angle			H.Distance
GPS2	GPS1	0	0	0	**118.438**
GPS2	1	174	13	29.1	**191.225**
1	GPS2	0	0	0	
1	2	145	01	48.33	**309.875**
2	1	0	0	0	
2	GPS3	174	07	0.67	**207.345**
GPS3	2	0	0	0	
GPS3	**GPS4**	**169**	**01**	**15.33**	**147.214**

5.3.4 Coordinates Determination for unknown stations before correction:

*** Coordinate calculation before correction:**

1. Azimuth calculation:

$$_{A,B} = \tan^{-1}\frac{\Delta E}{\Delta N} + C \qquad (5.1)$$

- Example:

$Az_{GPS.2-GPS.1} = \tan^{-1}\frac{X1-X2}{Y1-Y2} + K$

$= \tan^{-1}\frac{162681.28-162739.007}{114750.128-114646.713} = 330^o\ 49'\ 45.9''$

See appendix A page (230)

2. Uncorrected coordinate calculation :
   - Δ Easting = Horizontal Distance * Sin (Azimuth)
   - Δ Northing =Horizontal Distance * Cos (Azimuth)

Easting B (unknown) =Easting A (known) + Δ Easting.

Northing B (unknown) =Northing A (known) + ΔNorthing.

Example for station 1:

Δ Easting = 191.225 * Sin (145º 3' 15")

= 109.53 m

Δ Northing =191.225 * Cos (145º 3' 15")

= -157.17 m.

$X1_0$ =162739.0078+ 109.53

=162848.541 m.

$Y1_0$ =114646.713+ (-157.17)

=114489.967 m

See appendix A page (230).

5.3.5 Traverse Error Reduction:

There are many errors to reduce in traverse working. The traverse of this project is observed by total station Leica SET 630RK.

Errors in this instrument:

1- Distance error = ± (5 + 10ppm)

2- Angular error = ± 6"

*** Types of Errors:**

1. Instrument Centering error:

This error is a result of many factors like:

a. Instrument Quality.

b. Tripod Quality.

c. Observer skill.

2. Target Centering Error :

This error because the prism is not perpendicular on the ground and it's about 2mm, and corrected by this equation:

$$\sigma_D = \sqrt{(\sigma_i)^2 + (\sigma_t)^2 + a^2 + (D*bppm)^2} \quad (5.2)$$

Where:

σ_D : Distance Error

σ_i : Instrument Cantering Error

σ_t : Prism Error

a&b: Instrument Factor

Example on correct of distance errors:

The distance between GPS.2 and st1 equal (191.225).

$$\sigma_D = \sqrt{(\sigma_i)^2 + (\sigma_t)^2 + a^2 + (D*bppm)^2}$$

$$\sigma_D = \sqrt{(0.002)^2 + (0.002)^2 + (0.003)^2 + (191.225*0.00001)^2}$$

$= 0.005$ m

Table (5.5) average distance and the errors of each one

Line	Distance (m)	σ_D(m)
GPS2 –ST1	191.225	**.005**
ST1 –ST2	309.875	**.0052**
ST2 –GPS 3	**207.345**	**.0092**

3. Angels Reading Error:

This error is a result of tow possible factors:

a. Pointing Error.

b. Reading Error.

This error correct by this equation:

$$\sigma_{abr} = \pm \frac{2\sigma_{DIN}}{\sqrt{n}} \quad (5.3)$$

Where:

σ_{abr}: Is Pointing and Reading Error.

σ_{DIN}: Is Instrument Error.

n: Is reading repetition.

This value is usually be constant and equal:

$\sigma_{abr} = \pm \frac{2*6''}{\sqrt{3}}$ = 6.9".

5.3.6 Coordinate Error correction methods:

There are many methods for coordinate correction in traverse:

a. Least Square Method.

b. Linear and Angular Misclosure Method.

c. Compass Rule.

The method that will be use is least square method because it's more accurate than other methods, least square method correct the error for each coordinate and show the confidante level in traverse. The corrected coordinates are measured using least square by deferent ways:

1- Autodesk land desktop 2006 program.
2- Adjust program.
3- Manually.

The following table represents the corrected coordinates by different ways:

Table (5.6) Corrected coordinates

1.Autodesk 2006 method		
Station	Easting (m)	**Northing (m)**
St.1	162848.5251	**114490.0317**
St.2	163139.5154	**114383.7131**
2. Adjust program method		
Station	Easting (m)	**Northing (m)**
St.1	162,848.538	**114,489.972**
St.2	163,139.537	**114,383.693**
3.Manually		
Station	Easting (m)	**Northing (m)**
St.1	162848.3866	**114489.8549**
St.2	**163139.2937**	**114383.1096**

Coordinates in table (5.6) are corrected according to known coordinates taken by GPS, and table (5.7) represents the known coordinates.

See appendix A page (232)

Table (5.7) known coordinates by GPS

Station	Easting (m)	Northing (m)
GPS. 1	162681.28	114750.128
GPS. 2	162739.007	114646.713
GPS.3	163340.474	114332.926
GPS.4	163487.363	114324.717

5. 3.7 Soil tests:

5.3.7.1 Proctor compaction Test

INTRODUCTION:
Compaction is one kind of densification that is realized by rearrangement of soil particles without outflow of water .It is realized by application of mechanic energy
It does not involved fluid flow, but with moisture changing altering.

COMPACTION EFFECT:

There are four factors affecting the extent of compaction:

1- Compaction effort.
2- Soil type and gradation.
3- Moisture content.
4- Dry unit weight (dry density).

OBJECTIVES:

The main purpose of conducting the compaction test is to determine the maximum dry unit weight of soil .After determine the maximum dry unit weight ,specification can be determined for field compaction of the soil. Soils are compacted for the following reasons:

1- To increase strength and stability
2- To decrease permeability
3- To enhance resistance to erosion
4- Decrease compressibility under load and minimize settlement.

EQUIPMENTS:

1- Compaction mold.
2- No.4 sieve
3- Standard Proctor hammer (5.5 Ib\24.5 N))
4- Balances (0.1 g sensitively).
5- Moisture cans.
6- Dry oven.
7- Graduated cylinder.
8- Mixing pan.
9- Straight edge.

PROCEDURE:

1- Obtain an air –dried soil in the mixing pan, break all the lumps so that its passes No.4 sieve.
2- Add approximate amount of water to increase the moisture content by about 5%.
3- Determine the weight of empty proctor mold without the base plate and collar (W1).
4- Place the first portion of the soil in the Proctor mold as explained a class and compact the layer applying 25 blows.

5- Scratch the layer with a spatula forming a grid to ensure uniformity in distribution of compaction energy to the subsequent layer .Place the second layer, apply 25 blows, place the last portion and apply 25 blows.
6- The final layer should ensure that the compacted soil is just above the rim of the compaction mold when the collar is still attached.
7- Determine the weight of the mold with the moist soil (W2).Extrude the sample and break it to collect the sample for water content determination preferably from the middle of the specimen.
8- Weight an empty moisture can (W3) and weight again with the moist soil obtained from the extrude sample in step 7 (W4), keep this can in the oven for water content determination.
9- After 24 hours recover the sample in the oven and determine the weight (W5).
10- Fill out the following table completely.

CALCULATION:

A. SUBGRADE LAYER:

1. Water Content for a given test:

$$Wc = \frac{\text{weight of water (gm)}}{\text{weight of dry soil (gm)}}$$

$$= \frac{W4-W5}{W5-W3} \qquad (5.4)$$

2. Moist unit weight for a given test:

$$\gamma\ moist = \frac{\text{weight of moist soil (gm)}}{\text{volume of mould}}$$

$$= \frac{W2-W1}{1/30} \qquad (5.5)$$

3. Dry unit weight for a given test:

$$\gamma\ dry = \frac{\gamma\ \text{moist}}{1+W\%} \qquad (5.6)$$

- Weigh of dry soil =5 kg.
- volume of mould = 944 cm^3

Table (5.8): Proctor test output.

TEST NUMBER	1	2	3	4	5
Wc %	5.8	8.9	11.7	14.6	18.5
W1(gm)	3319	3319	3319	3319	3319
W2(gm)	4864.3	5044.3	5121.7	5208	5161.6
W2-W1(gm)	1545.3	1725.3	1802.7	1889	1842.6
$\gamma\ moist$ (gm /cm³)	1.64	1.83	1.91	2	1.95
$\gamma\ dry$ (gm /cm³)	1.55	1.68	1.71	1.74	1.64

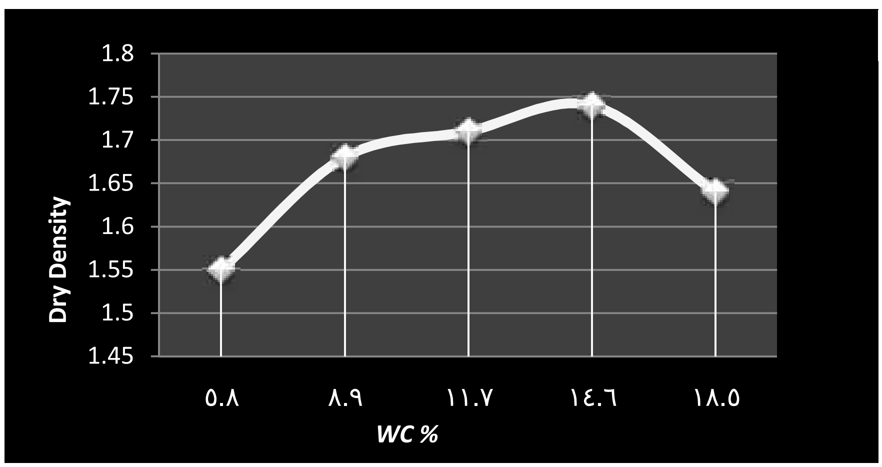


Figure (5.19): Relationship between water content and maximum dry density

- Maximum dry density = 1.73(gm /cm³)
- Optimum moisture content = 14 %

B. BASECOARSE LAYER:

Table (5.9): basecoarse layer tests output

TEST NUMBER	1	2	3	4
W %	9	11	15	19
W1(gm)	3323	3323	3323	3323
W2(gm)	5300.5	5379	5420	5384
W2-W1(gm)	1977.5	2056	2097	2061
W3(gm)	32	31	32.5	26
W4(gm)	185	203	226.5	211.5
W5(gm)	172.5	187	203.5	185.5
Wc%	8.9	10.2	13.5	16.3
$\gamma\ moist$ (gm /cm³)	2.09	2.18	2.22	2.18
$\gamma\ dry$ (gm /cm³)	1.91	1.97	1.95	1.87

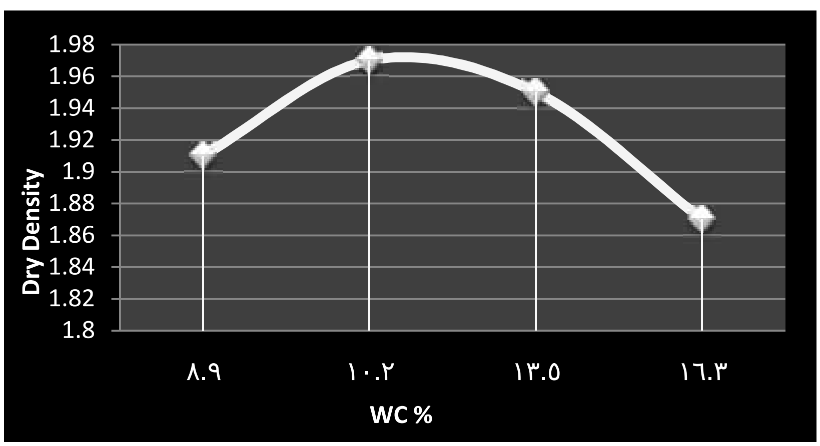


Figure (5.20) Relationship between Water Content and Maximum Dry Density

- Maximum dry density = 1.975(gm /cm³)
- Optimum moisture content = 10.3 %

5.3.7.2 California Bearing Ratio (CBR)

DEFINITION:

The California Bearing Ratio (CBR) test was developed by the California division of Highway as method of classifying and evaluating soil-sub grade and base course materials for flexible pavement. CBR test, an empirical test, has been used to determine the material properties for pavement design. Empirical tests measure the strength of the material and are not a true representation of the resilient modulus .It is penetration test wherein a standard piston, having an area of 3 in^2, is used to penetrate the soil at a standard rate of 1.25 mm\min .The pressure up to a penetration of 1.25 mm and it is ratio to the bearing value of a standard crushed rock is termed as the CBR.

OBJECTIVES:

The CBR test to determine the relative bearing ratio and expansion characteristic under known surcharge weights of base, sub-base and sub grade soils for the design of roads, pavement and runways .The CBR test is used extensively in selection of materials and control of sub grade to determine the CBR value of the sub grade soil.

EQUIPMENTS:

1. Loading machine –any compression machine can operate at constant rate of 1.25 mm per minute can be used.
2. Cylindrical moulds – moulds of 150 mm diameter and 175 mm height provided with a collar of about 50 mm length and detachable base.

PROCEDURE:

1. Take a sample of soil specimen.

2. Add water to the soil in the quantity such that optimum moisture content or field moisture content is reached.

3. Then soil and water are mixed thoroughly.

4. Spacer disc is placed over the base plate at the bottom of mould and a coarse filter paper is placed over the spacer disc.

5. The prepared soil water mix is divided into five. The mould is cleaned and oil is applied, then fill one fifth of the mould with the prepared soil.

6. Surcharge weight of 2.5 kg is placed on top surface of soil .Mould containing specimen is placed in piston on the testing machine .The penetration plunger is brought in contact with the soil and a load of 4 kg is applied so that contact between soil and plunger is established .Then dial reading are adjusted to zero .Load is applied such that penetration rate is 1.25 mm\min. Load at penetration of 0.5, 1, 1.5, 2, 2.5, 3,4,5,7.5,10 and 12.5mm are noted.

Table (5.10) Standard load value.

Penetration (mm)	Standard Load (kg)	Unit Standard Load (kg\cm^2)
2.5	1370	70.35
5	2055	105.53
7.5	2630	134
10.0	3180	162
12.5	3600	183

The specification for California Bearing Ratio for Roads Layers in Palestine and Jordan is mentioned in table (5.11):

Table (5.11) Standard CBR values in Palestine and Jordan

CBR%	Layers
8 at least	Sub Grade
40 at least	Sub-base course
80 at least	Base course

CALCULATION:

$$CBR = \frac{\text{load carries by specimen}}{\text{Load carries by standard specimen}} * 100\% \qquad (5.7)$$

A. CBR for Sub grade layer:

- Weight of empty mould =7712 gm
- Volume of mould =2124 cm^3
- Water content =14%

Table (5.12) Subgrade Penetration Standard Value

Penetration (mm)	Roving dial reading (1div =2.54 kg)
0.5	0
1	27
1.5	71
2	109
2.5	150
3	187
3.5	224
4	255
4.5	289
5	324
6	374
7	426
8	479
9	529
10	581
11	631

- California Bearing Ratio at 2.5 mm penetration =28%
- California Bearing Ratio at 5.0 mm penetration =40%

B. CBR for Base course layer:

Table (5.13) Base course Penetration standard Value

Penetration (mm)	Roving dial reading (1div =2.54 kg)
0.5	0
1	74
1.5	250
2	480
2.5	640
3	792
3.5	930
4	1030
4.5	1130
5	1227
5.5	1310
6	1382
6.5	1455
7	1527
7.5	1598
8	1665
8.5	1730

- California Bearing Ratio at 2.5 mm penetration =119%
- California Bearing Ratio at 5.0 mm penetration = 152%
- The used value of CBR is 100%.

5.3.8 Adjustment of Periodic Counts:

Expansion factors, used to adjust periodic counts, are determined either from continuous count stations or from control count stations.
Expansion factors from Continuous Count Stations. Hourly, daily, and monthly expansion factors can be determined using data obtained at continuous count stations.

1. Hourly Expansion Factor (HEF) is determined by the formula:

$$HEF = \frac{\text{total volume for 24-hr period}}{\text{volume for particular hour}} \quad (5.8)$$

These factors are used to expand counts of durations shorter than 24 hour to 24-hour volumes by multiplying the hourly volume for each hour during the count period by the HEF for that hour and finding the mean of these products.

Table (5.14) Hourly Expansion Factors for Rural Primary Road

Hour	HEF	Hour	HEF
6:00–7:00 a.m.	42	06:00–07 p.m	16.62
7:00–8:00 a.m.	29	07:00–08 p.m	17.49
8:00–9:00 a.m.	22.5	08:00–09 p.m	20.38
9:00–10:0 a.m	18.8	09:00–10 p.m	25.26
10:00–11 a.m	17.1	10:00–11 p.m	31.19
11:00–12 p.m	18.52	11:00–12 a.m	34.31
12:00–01 p.m	18.71	12:00–01 a.m	51.24
01:00–02 p.m	16.71	01:00–02 a.m	82.33
02:00–03 p.m	14.84	02:00–03 a.m	123.5
03:00–04 p.m	14.77	03:00–04 a.m	137.22

04:00–05 p.m	12.85	04:00–05 a.m	143.6
05:00–06 p.m	13.85	05:00–06 a.m	90.14

2. Daily expansion factor (DEF) is computed as:

$$DEF = \frac{\text{average total volume for week}}{\text{average volume for particular day}} \quad (5.9)$$

This factor is used to determine weekly volumes from counts of 24-hour duration by multiplying the 24-hour volume by the DEF.

Table (5.15) Daily Expansion Factor for Rural Primary Road

Days of weeks	DEF
Sunday	9.515
Monday	7.012
Tuesday	7.727
Wednesday	6.582
Thursday	7.012
Friday	5.724
Saturday	6.510

3. Monthly expansion factor (MEF) is computed as :

$$MEF = \frac{\text{AADT}}{\text{ADT for particular month}} \quad (5.10)$$

The AADT for a given year may be obtained from the ADT for a given month by multiplying this volume by the MEF.

Table (5.16) Daily Expansion Factor for Rural Primary Road

Month	MEF
January	1.756
February	1.975
March	1.635
April	1.481

May	1.394
June	0.948
July	0.578
August	0.521
September	0.6320
October	.948
November	1.185
December	1.354

- In these case the count of vehicle as shown: The data are collected on a Thursday during March.

Table (5.17) Vehicle number

Hours	Number of vehicle
10.00–11:00 a.m	75
11:00–12:00 a.m	81
12:00–01:00 p.m	73

- Estimate the 24-hr volume for Thursday using the factors given in Table (5.11)

$$ADT = \frac{75 * 17.1 + 81 * 34.31 + 73 * 18.71}{3} = 1833$$

- Adjust the 24-hr volume for Thursday to an average volume for the week using the factors given in Table (5.15)

Total 7-day volume $= 1382 * 7.012$

$= 12852$

$AWT = 9691\backslash 7$

$= 1452$

- Since the data were collected in March, use the factor shown for March in Table (5.16) to obtain the AADT.

$AADT = 1836 * 1.635$

$= 3002$

- Computation the numbers of lane:

$$Number\ of\ lane = \frac{AADT}{Saturation} \quad (5.12)$$

$$= \frac{2263}{1500}$$

$$= 2$$

- Then the number of lane in these case equal 2 lanes in two directions.

5.3.9 Structural Design of the Road

$$ESAL = f_d \times G_f \times AADT \times 365 \times N_i \times f_E \quad (5.13)$$

ESAL: Equivalent Accumulated 18,000 Ib Single Axle Load

F_{d}: design lane factor.

G_f: growth factor.

AADT: first year annual average daily traffic.

Ni: number of axles on each vehicle.

fe: load equivalency factor.

- We get fd from table(5.18)

Table (5.18) Percentage of Total Truck Traffic in Design Lane

Number Of Traffic Lanes (Two Directions)	Percentage Truck in Design Lane (%
2	50
4	45 (35-48)
6 or more	40 (25-48)

- Fd = 0.50 for Truck
- Fd = 0.10 for Passenger car

- We get Growth factor (Gjt)from table(5.19)

Table (5.19) Growth rate factor.

Design period years	Annual Growth Rate (%)							
	No. growth	2	4	5	6	7	8	**10**
1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	**1.0**
2	2.0	2.02	2.04	2.05	2.06	2.07	2.08	**2.10**
3	3.0	3.06	3.12	3.15	3.18	3.21	3.25	**3.31**
4	4.0	4.12	4.25	4.31	4.37	4.44	4.51	**4.64**
5	5.0	5.20	5.42	5.53	5.64	5.75	5.87	**6.11**
6	6.0	6.31	6.63	6.80	6.98	7.15	7.34	**7.72**
7	7.0	7.43	7.90	8.14	8.39	8.65	8.92	**9.49**
8	8.0	8.58	9.21	9.55	9.90	10.26	10.64	**11.44**
9	9.0	9.75	10.58	11.03	11.49	11.98	12.49	**13.58**

10	10.0	10.95	12.01	12.58	13.18	13.82	14.49	**15.94**
11	11.0	12.17	13.49	14.21	14.97	15.78	16.65	**18.53**
12	12.0	13.41	15.03	15.92	16.87	17.89	18.98	**21.38**
13	13.0	14.68	16.63	17.71	18.88	20.14	21.50	**24.52**
14	14.0	15.97	18.29	19.16	21.01	22.55	24.21	**27.97**
15	15.0	17.29	20.02	22.58	23.28	25.13	27.15	**31.77**
16	16.0	18.64	21.82	23.66	25.67	27.89	30.32	**35.95**
17	17.0	20.01	23.70	25.84	2.21	30.48	33.75	**40.55**
18	18.0	21.41	25.65	28.13	30.91	34.00	37.45	**45.60**
19	19.0	22.84	27.67	30.54	33.76	37.38	41.45	**51.16**
20	20.0	24.30	29.78	33.06	36.79	41.00	45.76	**57.28**
25	25.0	32.03	41.65	47.73	51.86	63.25	73.11	**98.35**
30	30.0	40.57	56.08	66.44	79.05	94.46	113.28	**164.49**
35	35.0	49.99	73.65	90.32	111.43	138.24	172.32	**271.02**

- Growth rate equal 5% for all vehicle.
- The design period 20 years.
- The Growth factor (Gjt) equal 33.06 from table (5.19).
- passenger car (1kips/axle) = 90%
- 2 single axle. unit truck (6 kips/axle) = 8%
- 3 single axle. unit truck (10 kips/axle) = 2%

- We get load equivalency factor for axle load (fE)from table(5.20)

Table (5.20) Axle load equivalent factor.

Gross Axle Load		Load Equivalency factor		Gross Axle Load		Load Equivalency factor	
KN	Ib	Single Axle	Tandem Axle	KN	Ib	Single Axle	**Tandem Axle**
4.45	1,000	0.00002		182.5	41,000	23.27	**2.29**
8.9	2,000	0.00018		187.0	42,000	25.64	**2.51**
13.35	3,000	0.00072		191.3	43,000	28.22	**2.75**
17.8	4,000	0.00209		195.7	44,000	31.00	**3.00**
22.25	5,000	0.00500		200.0	45,000	34.00	**3.27**
26.7	6,000	0.01043		204.5	46,000	37.24	**3.55**
31.15	7,000	0.01960		209.0	47,000	40.74	**3.85**
35.6	8,000	0.03430		213.5	48,000	44.50	**4.17**
40.0	9,000	0.0562		218.0	49,000	48.54	**4.51**
44.5	10,000	0.0877	0.00688	222.4	50,000	52.88	**4.86**
48.9	11,000	0.1311	0.01008	226.8	51,000		**5.23**
53.4	12,000	0.189	0.0144	231.3	52,000		**5.63**
57.8	13,000	0.264	0.0199	235.7	53,000		**6.04**
62.3	14,000	0.360	0.0270	240.2	54,000		**6.47**
66.7	15,000	0.478	0.0360	244.6	55,000		**6.93**
71.2	16,000	0.623	0.0472	249.0	56,000		**7.41**
75.6	17,000	0.796	0.0608	253.5	57,000		**7.92**
80.0	18,000	1.00	0.0773	258.0	58,000		**8.45**
84.5	19,000	1.24	0.0971	262.5	59,000		**9.01**
89.0	20,000	1.51	0.1206	267.0	60,000		**9.59**
93.4	21,000	1.83	0.148	271.3	61,000		**10.20**
97.8	22,000	2.18	0.180	275.8	62,000		**10.84**
102.3	23,000	2.58	0.217	280.2	63,000		**11.52**
106.8	24,000	3.03	0.260	284.5	64,000		**12.22**

111.2	25,000	3.53	0.308	289.0	65,000	**12.96**
115.6	26,000	4.09	0.364	293.5	66,000	**13.73**
120.0	27,000	4.71	0.426	298.0	67,000	**14.54**
124.5	28,000	5.39	0.495	302.5	68,000	**15.38**
129.0	29,000	6.14	0.572	307.0	69,000	**16.26**
133.5	30,000	6.97	0.658	311.5	70,000	**17.19**
138.0	31,000	7.88	0.753	316.0	71,000	**18.15**
142.3	32,000	8.88	0.857	320.0	72,000	**19.16**
146.8	33,000	9.98	0.971	325.0	73,000	**20.22**
151.2	34,000	11.18	1.095	329.0	74,000	**21.32**
155.7	35,000	12.5	1.23	333.5	75,000	**22.47**
160.0	36,000	13.93	1.38	338.0	76,000	**23.66**
164.5	37,000	15.50	1.53	342.5	77,000	**24.91**
169.0	38,000	12.20	1.70	347.0	78,000	**26.22**
173.5	39,000	19.06	1.89	351.5	79,000	**27.58**
178.0	40,000	21.08	2.08	365.0	80,000	**28.99**

- Load equivalency factor for Passenger cars (fEi (car)) = 0.00002
- Load equivalency factor for 2single axle (fEi (Truck)) = 0.01043
- Load equivalency factor for 3 single axle (fEi (Truck)) =0.0877
- ESAL (Passenger car)= 3002 * 0.90 * 365 * 0.00002 * 0.1* 33.06 * 2

  ESAL (Passenger car) =130.4

- ESAL (2 axles. single unit truck)= 3002* 0.08 * 365 * 0.01043 * 0.50 * 33.06 * 2

  ESAL (2 axles. single unit truck) =30226

- ESAL (3 axles. single unit truck)= 3002 *0 .02 * 365 * 0.0877 * 0.50 * 33.06 * 3

  ESAL (3 axles. single unit truck = 95307.53

- Total ESAL =125664.
- Design a flexible pavement for urban Local street using 1993 AASHTO, after take these information:
- ESAL equal 125664.
- Take a 1 day for water to remove.
- Saturation became during 30% of time.
- Materials:

1. Elastic modulus for HMA at 68ºF equal 450 ksi. Show figure (5.21)
2. CBR for base layer equal 100%, the value of resilient modulus equal 31 ksi. from chart (5.22)
3. CBR for subgrade layer equal 40% (from these value, subgrade layer can be used as sub base layer). Show figure (5.23)

The value of Mr for subgrade when CBR > 10 is calculated by

$Mr = 3000 * CBR^{0.65}$
$Mr = 3000 * 40^{0.65} = 32996$ psi

When Mr greater than 15000 psi it multiplied by adjustment factor equal 0.33.

Mr = 32996* 0.33 =10888.6 psi = 10.8 ksi

4. Standard deviation (So) equal 0.5.

Table (5.21) standard deviation

Pavement	*Standard Deviation, S_o*
Flexible pavements	0.40 –0.50
Rigid pavements	0.30 –0.40

5. The value of Δ PSI = pi-pt

pt: terminal serviceability index
pi: initial serviceability index

When pi equal 4.5, and pt equal 2.5

Δ PSI = 2

pt: terminal serviceability index

pi: initial serviceability index

5.3.10 Design the Thickness of Layers

Table (5.22) reliability level

Recommended Level of Reliability		
Functional Classification	*Urban*	*Rural*
Interstate and other freeways	85–99.9	80 –99
Other principal arterials	80 –99.9	75–95
Collectors	80 –95	75–95
Local	50 –80	50 –80

- The value of the Reliability equal 80

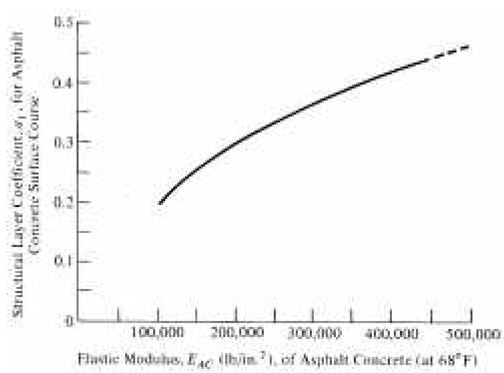


Figure (5.21) Charts for Estimating Structural Layer Coefficient of Dense-Graded/Asphalt

- Concrete Based on the Elastic (Resilient) Modulus for asphalt is 400ksi
- The value of Structure layer coefficient (a1) for Asphalt equal 0.44

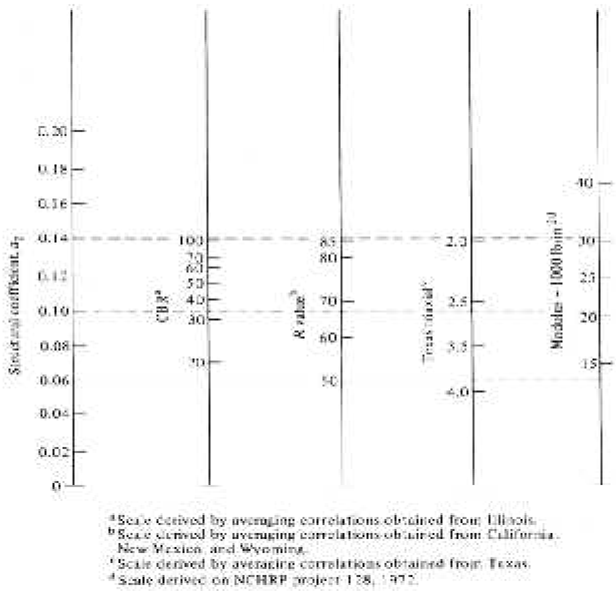


Figure (5.22) Variation in Granular Base Layer Coefficient, *a*2, with Various Subbase Strength Parameters

- The value of Structural coefficient (a2) for base layer equal 0.14

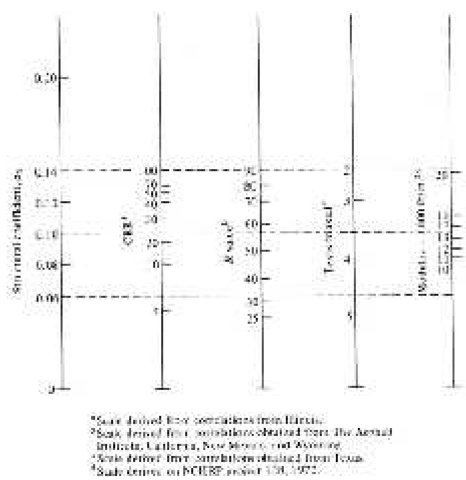


Figure (5.23) Variation in Granular Subgrade Layer Coefficient, *a*3, with Various Subgrade Strength Parameters

Table (5.23) Definition of Drainage Quality

Quality of Drainage	*Water Removed Within**
Excellent	2 hours
Good	1 day
Fair	1 week
Poor	1 month
Very poor	(water will not drain)

- The quality of drainage is good.

Table (5.24) Recommended *mi* Values

Quality of Drainage	*Percent of Time Pavement Structure Is Exposed to Moisture Levels Approaching Saturation*			
	Less than 1%	*1 to 5%*	*5 to 25%*	*Greater Than 25%*
Excellent	1.40 –1.35	1.35–1.30	1.30 –1.20	1.20
Good	1.35–1.25	1.25–1.15	1.15–1.00	1.00
Fair	1.25–1.15	1.15–1.05	1.00 –0.80	0.80
Poor	1.15–1.05	1.05–0.80	0.80 –0.60	0.60
Very poor	1.05–0.95	0.95–0.75	0.75–0.40	0.40

- at 30% of time pavement structure is exposed to moisture levels approaching saturation ,then the value of :

- mi = 1
- m1 = m2 =1.

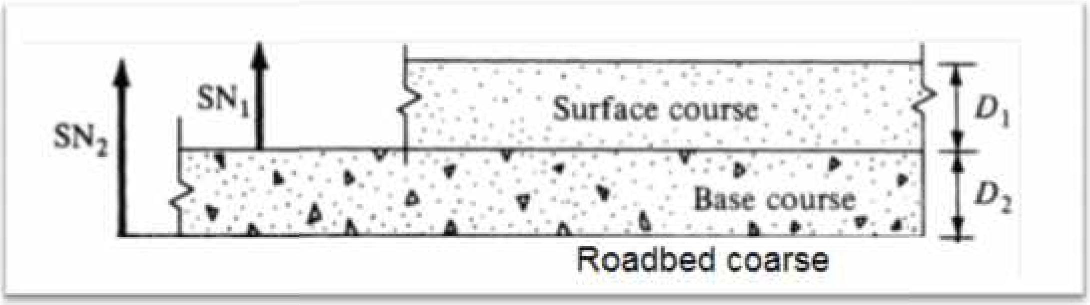


Figure (5.24) The structure number above each of two layers is determined from figure (5.25)

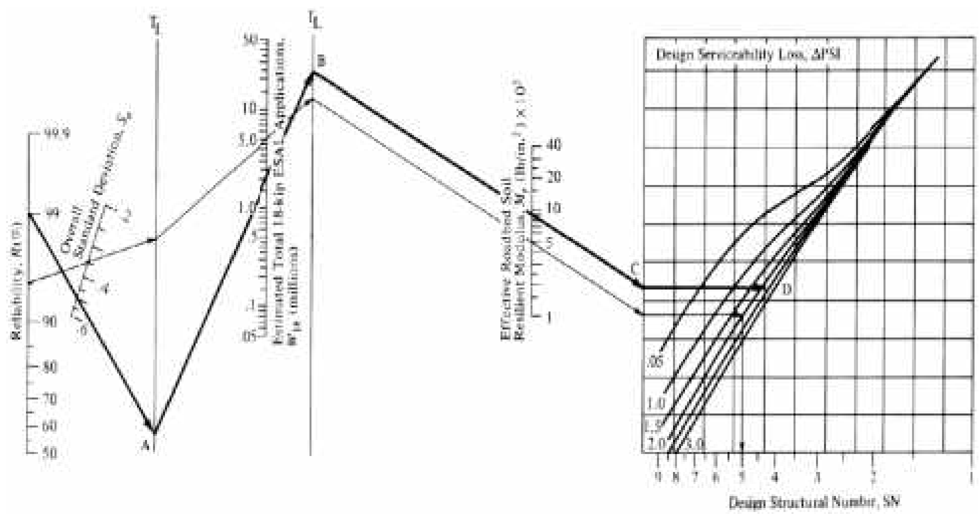


Figure (5.25) Design Chart for Flexible Pavements Based on Using Mean Values for each Input

- SN2 (above subgrade layer) = 2.89
- SN1 (above base layer)= 1.34

$D1 = \frac{SN1}{a1} = \frac{1.34}{0.44} = 3.05$

$D1^{*} = 4''$

$SN1^{*} = a1 * D1^{*} = 0.44 * 4 = 1.76$

$D2^{*} \geq \frac{SN2 - SN1^{*}}{a2 * m2}$

$D2^{*} \geq \frac{2.89 - 1.76}{0.14 * 1} = 8.07$

$D2^{*} = 10''$

$SN2^{*} = a1 * D1^{*} + a2 * m2 * D2^{*}$

$= 0.44 * 4 + 0.14 * 1 * 12 = 3.4$

- $SN2^{*} > SN2$
- Then the design is correct.

Table (5.25) HMA and Base Coarse layer thick

Layer	Thickness (in)
HMA surface	4
Base coarse	10

CHAPTER SIX

CONCLUSION

Conclusion

In the project an attempt is made to evaluate the existing infrastructure in the Palestinian camp and to design the most important part of the physical infrastructure. The main conclusion drawn from the present study are:-

1- The Palestinian refugees lived and still living in the camps , since 1948 , most of the situations in their regarding to the environmental issue , social issues and other issued needs to be looked and discussed carefully

2- All the camps have almost the same problems.

3- The water consumption in the camps is too little; it is ranged between (65 – 80) letters per capita per day.

4- Many camps have a part of infrastructure which is in very bad condition and on absenceof engineering standards, the others have no infrastructure.

5- A trial is made to design a wastewater collection system, storm water drainage system and road design which serve all of AL-Arroub camp.

6- The flow in wastewater collection system and storm water drainage system is going by gravity.

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CHAPTER SIX

BILL OF QUANTITIES

6.1 BILL OF QUANTITY FOR THE PROPOSED WASTEWATER COLLECTION SYSTEM

No.	EXCAVATION	UNIT	QTY	UNIT PRICE		TOTAL PRICE	
				$	C	$	C
A1	Excavation of pipes trench in all kind of soil for one pipe diameter 200mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	4190				
A2	Excavation of pipes trench in all kind of soil for one pipe diameter 250mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	944.5				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 300mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	80				
A4	Excavation of pipes trench in all kind of soil for one pipe diameter 375mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	69.5				

Sub-Total							
B	**PIPE WORK**						
B1	Supplying, storing and installing of uPVC	LM	5284				
Sub-Total							
C	**PIPE BEDDING AND BACKFILLING** **Dimension and material**						
C1	Supplying and embedment of sand for one pipe diameter 200mm, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	4190				
C2	Supplying and embedment of sand for one pipe diameter 250mm, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	944.5				
C3	Supplying and embedment of sand for one pipe diameter 300mm, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	80				

C4	Supplying and embedment of sand for one pipe diameter 375mm, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	69.5				
Sub-Total							
D	**MANHOLES, Details according to the drawing**						
D1	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1200mm, depth up to 1.00m.	NR	158				
D2	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1000mm, depth up to 2.5m.	NR	12				
Sub-Total							
E	**Concrete Surround**						
E1	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	5248				

Sub-Total							
F	**Air And Water Leakage Test**						
F1	Air leakage test for sewer pipe lines200,250,300,375,according to specifications, including for all temporary works.	LM	5248				
F2	Water leakage tests for manholes, depth up to 1.00 meter according to specifications.	NR	158				
F3	Water leakage test for manholes , depth up to 2.5 meter according to specification	NR	12				
Sub-Total							
G	**Survey work**						
G1	Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system	LM	5248				

6.2 BILL OF QUANTITY FOR THE PROPOSED STORM WATER DRAINAGE SYSTEM

No.	EXCAVATION	UNIT	QTY	UNIT PRICE		TOTAL PRICE	
				$	C	$	C
A1	Excavation of pipes trench in all kind of soil for one pipe diameter 250 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	103				
A2	Excavation of pipes trench in all kind of soil for one pipe diameter 300mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	40				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 375mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	388.5				
A4	Excavation of pipes trench in all kind of soil for one pipe diameter 450mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	336.5				

A5	Excavation of pipes trench in all kind of soil for one pipe diameter 600mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	319				
A6	Excavation of pipes trench in all kind of soil for one pipe diameter 750 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	917.5				
A7	Excavation of pipes trench in all kind of soil for one pipe diameter 900 mm depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	346				
Sub-Total							
B	**PIPE WORK**						
B1	Supplying, storing and installing of uPVC	LM	2450.5				
Sub-Total							
C	**PIPE BEDDING AND BACKFILLING** **Dimension and material**						

C1	Supplying and embedment of sand for one pipe diameter 250mm, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	103				
C2	Supplying and embedment of sand for one pipe diameter 300mm, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	40				
C3	Supplying and embedment of sand for one pipe diameter 375mm, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	388.5				
C4	Supplying and embedment of sand for one pipe diameter 450mm,depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	336.5				

C5	Supplying and embedment of sand for one pipe diameter 600mm,depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	319				
C6	Supplying and embedment of sand for one pipe diameter 750mm,depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	917.5				
C7	Supplying and embedment of sand for one pipe diameter 900mm,depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	346				
Sub-Total							
D	**MANHOLES, Details according to the drawing**						

D1	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1200mm, depth up to 1.00m.	NR	29				
D2	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1200mm, depth up to 2.5m.	NR	18				
Sub-Total							
E	**Concrete Surround**						
E1	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	2450.5				
Sub-Total							
F	**Air And Water Leakage Test**						
F1	Air leakage test for sewer pipe lines 250,300,375,450,600,750and900mm according to specifications, including for all temporary works.	LM	2450.5				
F2	Water leakage tests for manholes, depth up to 1.00 meter according to specifications.	NR	29				

F3	Water leakage test for manholes , depth up to 2.5 metera ccording to specification	NR	18				
Sub-Total							
G	**Survey work**						
G1	Topographicalsurvey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system	LM	2450.5				

6.3 BILL OF QUANTITY FOR THE MAIN ROAD

Cut and Fill Quantity

Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+020.00	0.00	2.18	0.00	0.00	0.00	0.00
0+040.00	0.00	2.45	0.03	46.23	0.03	46.23
0+060.00	0.02	1.92	0.26	43.66	0.29	89.89
0+080.00	0.09	1.57	1.09	34.89	1.38	124.78
0+100.00	0.02	1.57	1.09	31.39	2.47	156.17
0+120.00	0.01	3.09	0.37	46.59	2.84	202.76
0+140.00	0.00	3.30	0.14	63.91	2.98	266.67
0+160.00	0.00	2.14	0.04	54.35	3.02	321.01
0+180.00	0.60	0.85	6.07	29.90	9.10	350.91
0+200.00	1.63	0.08	22.38	9.37	31.47	360.28
0+220.00	1.88	0.07	35.14	1.52	66.61	361.80
0+240.00	0.56	0.44	24.39	5.07	91.00	366.87
0+260.00	0.44	1.38	10.05	18.20	101.05	385.07
0+280.00	0.00	2.78	4.45	41.67	105.50	426.73
0+300.00	0.04	2.63	0.41	54.03	105.91	480.77
0+320.00	0.00	3.13	0.41	57.30	106.32	538.07
0+340.00	0.00	2.96	0.00	60.73	106.32	598.80
0+360.00	0.00	3.46	0.00	64.24	106.32	663.04
0+380.00	0.00	4.30	0.00	77.60	106.32	740.65
0+400.00	0.00	4.72	0.00	90.22	106.32	830.87
			173			

Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+420.00	0.00	4.84	0.00	95.62	106.32	926.49
0+440.00	0.00	3.41	0.00	82.47	106.32	1008.96
0+460.00	0.19	1.51	1.90	49.16	108.22	1058.12
0+480.00	0.31	1.10	4.98	26.09	113.20	1084.20
0+500.00	1.07	0.01	13.78	11.09	126.98	1095.30
0+520.00	2.06	0.02	31.34	0.29	158.31	1095.59
0+540.00	3.26	0.00	53.27	0.23	211.58	1095.82
0+560.00	0.17	1.81	34.34	18.09	245.93	1113.91
0+580.00	0.00	4.95	1.72	67.64	247.64	1181.55
0+600.00	0.00	6.04	0.00	109.89	247.64	1291.44
0+620.00	0.00	5.26	0.00	112.93	247.64	1404.37
0+640.00	0.00	5.41	0.00	106.68	247.64	1511.05
0+660.00	0.00	5.99	0.00	114.01	247.64	1625.07
0+680.00	0.00	6.29	0.00	122.84	247.64	1747.91
0+700.00	0.00	5.81	0.00	121.09	247.64	1869.00
0+720.00	0.00	4.41	0.00	102.23	247.64	1971.23
0+740.00	0.00	3.48	0.00	78.84	247.64	2050.07
0+760.00	0.58	1.24	5.75	47.12	253.40	2097.19
0+780.00	0.70	1.24	12.72	24.77	266.11	2121.96
0+800.00	1.43	0.66	21.26	18.99	287.37	2140.95

174

Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+820.00	0.13	2.45	15.77	31.09	303.14	2172.05
0+840.00	0.01	3.64	1.43	60.87	304.57	2232.91
0+860.00	0.00	4.27	0.05	79.13	304.62	2312.05
0+880.00	0.00	4.61	0.00	88.87	304.62	2400.92
0+900.00	0.00	5.04	0.00	96.40	304.62	2497.32
0+920.00	0.00	4.86	0.00	99.04	304.62	2596.36
0+940.00	0.00	3.37	0.00	82.29	304.62	2678.66
0+960.00	0.07	1.75	0.66	51.18	305.28	2729.83
0+980.00	1.19	0.07	12.55	18.21	317.83	2748.04
1+000.00	4.43	0.00	56.32	0.74	374.15	2748.78
1+020.00	4.83	0.00	92.78	0.00	466.93	2748.78
1+040.00	2.18	0.01	70.02	0.10	536.95	2748.88

175

Pavement Quantity

Station	Area	Volume	Cumulative Volume
0+020.00	0.40	0.00	0.00
0+040.00	0.40	8.00	8.00
0+060.00	0.40	8.00	16.00
0+080.00	0.40	8.00	24.00
0+100.00	0.40	8.00	32.00
0+120.00	0.40	8.00	40.00
0+140.00	0.40	8.00	48.00
0+160.00	0.40	8.00	56.00
0+180.00	0.40	8.00	64.00
0+200.00	0.40	8.00	72.00
0+220.00	0.40	8.00	80.00
0+240.00	0.44	8.41	88.41
0+260.00	0.54	9.80	98.21
0+280.00	0.54	10.80	109.01
0+300.00	0.54	10.80	119.81
0+320.00	0.54	10.82	130.63
0+340.00	0.54	10.81	141.44
0+360.00	0.54	10.80	152.24
0+380.00	0.54	10.80	163.04
0+400.00	0.54	10.80	173.84
		176	

Station	Area	Volume	Cumulative Volume
0+420.00	0.54	10.80	184.64
0+440.00	0.54	10.80	195.44
0+460.00	0.54	10.80	206.24
0+480.00	0.54	10.80	217.04
0+500.00	0.54	10.80	227.84
0+520.00	0.56	10.96	238.80
0+540.00	0.99	15.43	254.23
0+560.00	1.06	20.45	274.68
0+580.00	1.08	21.39	296.07
0+600.00	0.80	18.79	314.86
0+620.00	0.54	13.40	328.26
0+640.00	0.54	10.80	339.06
0+660.00	0.54	10.80	349.86
0+680.00	0.54	10.80	360.66
0+700.00	0.54	10.80	371.46
0+720.00	0.54	10.80	382.26
0+740.00	0.54	10.80	393.06
0+760.00	0.54	10.80	403.86
0+780.00	0.54	10.80	414.66
0+800.00	0.54	10.80	425.46
		177	

Station	Area	Volume	Cumulative Volume
0+820.00	0.54	10.80	436.26
0+840.00	0.54	10.80	447.06
0+860.00	0.54	10.80	457.86
0+880.00	0.54	10.80	468.66
0+900.00	0.54	10.80	479.46
0+920.00	0.54	10.80	490.26
0+940.00	0.54	10.80	501.06
0+960.00	0.54	10.80	511.86
0+980.00	0.55	10.89	522.75
1+000.00	0.66	12.06	534.81
1+020.00	0.58	12.41	547.22
1+040.00	0.55	11.34	558.55
		178	

Base Quantity

Station	Area	Volume	Cumulative Volume
0+020.00	1.00	0.00	0.00
0+040.00	1.00	20.00	20.00
0+060.00	1.00	20.00	40.00
0+080.00	1.00	20.00	60.00
0+100.00	1.00	20.00	80.00
0+120.00	1.00	20.00	100.00
0+140.00	1.00	20.00	120.00
0+160.00	1.00	20.00	140.00
0+180.00	1.00	20.00	160.00
0+200.00	1.00	20.00	180.00
0+220.00	1.00	20.00	200.00
0+240.00	1.10	21.01	221.01
0+260.00	1.35	24.51	245.52
0+280.00	1.35	27.00	272.52
0+300.00	1.35	27.00	299.52
0+320.00	1.35	27.04	326.56
0+340.00	1.35	27.04	353.60
0+360.00	1.35	27.00	380.60
0+380.00	1.35	27.00	407.60
0+400.00	1.35	27.00	434.60
		179	

Station	Area	Volume	Cumulative Volume
0+420.00	1.35	27.00	461.60
0+440.00	1.35	27.00	488.60
0+460.00	1.35	27.00	515.60
0+480.00	1.35	27.00	542.60
0+500.00	1.35	27.00	569.60
0+520.00	1.39	27.41	597.01
0+540.00	2.47	38.56	635.57
0+560.00	2.65	51.13	686.70
0+580.00	2.70	53.46	740.17
0+600.00	2.00	46.98	787.15
0+620.00	1.35	33.49	820.64
0+640.00	1.35	27.00	847.64
0+660.00	1.35	27.00	874.64
0+680.00	1.35	27.00	901.64
0+700.00	1.35	27.00	928.64
0+720.00	1.35	27.00	955.64
0+740.00	1.35	27.00	982.64
0+760.00	1.35	27.00	1009.64
0+780.00	1.35	27.00	1036.64
0+800.00	1.35	27.00	1063.64
		180	

Station	Area	Volume	Cumulative Volume
0+820.00	1.35	27.00	1090.64
0+840.00	1.35	27.00	1117.64
0+860.00	1.35	27.00	1144.64
0+880.00	1.35	27.00	1171.64
0+900.00	1.35	27.00	1198.64
0+920.00	1.35	27.00	1225.64
0+940.00	1.35	27.00	1252.64
0+960.00	1.35	27.01	1279.65
0+980.00	1.37	27.22	1306.87
1+000.00	1.64	30.16	1337.02
1+020.00	1.46	31.02	1368.04
1+040.00	1.38	28.34	1396.38
		181	

Curb Stone Quantity

Station	Area	Volume	Cumulative Volume
0+020.00	0.15	0.00	0.00
0+040.00	0.05	2.01	2.01
0+060.00	0.15	2.01	4.02
0+080.00	0.05	2.01	6.03
0+100.00	0.15	2.01	8.05
0+120.00	0.05	2.01	10.06
0+140.00	0.15	2.01	12.07
0+160.00	0.05	2.01	14.08
0+180.00	0.15	2.01	16.09
0+200.00	0.05	2.01	18.10
0+220.00	0.15	2.01	20.11
0+240.00	0.07	2.23	22.34
0+260.00	0.15	2.23	24.57
0+280.00	0.05	2.01	26.58
0+300.00	0.15	2.01	28.60
0+320.00	0.05	2.01	30.61
0+340.00	0.15	2.01	32.62
0+360.00	0.15	2.97	35.59
0+380.00	0.15	2.97	38.57
0+400.00	0.15	2.97	41.54
		182	

Station	Area	Volume	Cumulative Volume
0+420.00	0.05	2.01	43.55
0+440.00	0.05	1.05	44.60
0+460.00	0.05	1.05	45.65
0+480.00	0.05	1.05	46.70
0+500.00	0.05	1.05	47.75
0+520.00	0.03	0.79	48.54
0+540.00	0.15	1.75	50.29
0+560.00	0.15	2.97	53.26
0+580.00	0.03	1.75	55.01
0+600.00	0.15	1.75	56.76
0+620.00	0.27	4.19	60.94
0+640.00	0.27	5.40	66.34
0+660.00	0.27	5.40	71.74
0+680.00	0.27	5.40	77.14
0+700.00	0.27	5.40	82.54
0+720.00	0.27	5.40	87.94
0+740.00	0.27	5.40	93.34
0+760.00	0.27	5.40	98.74
0+780.00	0.27	5.40	104.14
0+800.00	0.27	5.40	109.55
		183	

Station	Area	Volume	Cumulative Volume
0+820.00	0.27	5.40	114.95
0+840.00	0.27	5.40	120.35
0+860.00	0.27	5.40	125.75
0+880.00	0.27	5.40	131.15
0+900.00	0.27	5.40	136.55
0+920.00	0.27	5.40	141.95
0+940.00	0.27	5.40	147.35
0+960.00	0.05	3.23	150.57
0+980.00	0.15	2.01	152.58
1+000.00	0.15	2.97	155.56
1+020.00	0.15	2.98	158.54
1+040.00	0.07	2.24	160.77
		184	

Side Walk Quantity

Station	Area	Volume	Cumulative Volume
0+020.00	0.30	0.00	0.00
0+040.00	0.30	6.00	6.00
0+060.00	0.30	6.00	11.99
0+080.00	0.30	6.00	17.99
0+100.00	0.30	6.00	23.98
0+120.00	0.30	6.00	29.98
0+140.00	0.30	6.00	35.98
0+160.00	0.30	6.00	41.97
0+180.00	0.30	6.00	47.97
0+200.00	0.30	6.00	53.96
0+220.00	0.30	6.00	59.96
0+240.00	0.15	4.50	64.46
0+260.00	0.30	4.50	68.96
0+280.00	0.30	6.00	74.96
0+300.00	0.30	6.00	80.95
0+320.00	0.30	6.00	86.95
0+340.00	0.30	6.00	92.95
0+360.00	0.30	6.00	98.95
0+380.00	0.30	6.00	104.94
0+400.00	0.30	6.00	110.94
		185	

Station	Area	Volume	Cumulative Volume
0+420.00	0.30	6.00	116.94
0+440.00	0.30	6.00	122.93
0+460.00	0.30	6.00	128.93
0+480.00	0.30	6.00	134.92
0+500.00	0.30	6.00	140.92
0+520.00	0.15	4.50	145.42
0+540.00	0.30	4.50	149.91
0+560.00	0.30	6.00	155.91
0+580.00	0.15	4.50	160.41
0+600.00	0.30	4.50	164.90
0+620.00	0.30	6.00	170.90
0+640.00	0.30	6.00	176.90
0+660.00	0.30	6.00	182.89
0+680.00	0.30	6.00	188.89
0+700.00	0.30	6.00	194.88
0+720.00	0.30	6.00	200.88
0+740.00	0.30	6.00	206.88
0+760.00	0.30	6.00	212.87
0+780.00	0.30	6.00	218.87
0+800.00	0.30	6.00	224.86
		186	

Station	Area	Volume	Cumulative Volume
0+820.00	0.30	6.00	230.86
0+840.00	0.30	6.00	236.86
0+860.00	0.30	6.00	242.85
0+880.00	0.30	6.00	248.85
0+900.00	0.30	6.00	254.84
0+920.00	0.30	6.00	260.84
0+940.00	0.30	6.00	266.84
0+960.00	0.30	6.00	272.83
0+980.00	0.30	6.00	278.83
1+000.00	0.30	6.00	284.83
1+020.00	0.30	6.00	290.83
1+040.00	0.15	4.51	295.34
		187	

APPENDIX

(A)

- **WASTE WATER QUANTITY TABLES**
- **STORM WATER QUANTITY TABLE**
- **TRAVERSE ADJUSTMENT REPORTS**

First: Waste water quantity calculation

Example on calculation of waste water quantity for manhole number 1 to manhole number 2:

- Unit sewage = $waste\ water * Pop\ density$
- Waste water = 0.8* water consumption

= 0.8* 120/1000

* Waste water = 0.096 $\frac{m^3}{c.day}$

- Pop density = $\frac{population}{Area}$

- Population growth= 3.35 %

$$P_f = P_p\left(1 + \frac{r}{100}\right)^4$$

Pop 2011 = 10444$(1 + \frac{3.35}{100})^4$

Pop 2011= 11915person

Pop 2036 = 11915 $\left(1 + \frac{3.35}{100}\right)^{25}$

Pop 2036 =27155

- Area of camp = 426 dounum.

- Pop density = $\frac{27155}{426}$

- Pop density = 64c/donum

Unit sewage = 0.096 * 64 =6.11m^3/day.dounum

The incremental area is the expected area for each manhole.

Total area is the sum of all previous manholes area.

- Q Average = Unit sewage * Total Area

= 6.11 * 2.37

- Q Average = 14.48m^3/day

- Peak factor = $1.5 + \frac{2.5}{Qavg}$

Peak factor = $1.5 + \frac{2.5}{\sqrt{14.48}}$

Peak factor = 2.16

Peak factor should be less than 3

Maximum Q= Peak factor * Qavg

= 2.16*14.48
= 31.27 m^3/day

Infiltration = 0.1 * Qavg

= 0.1 * 14.48

Infiltration = 1.448m^3/day

Total Average = Infiltration + Qavg

= 1.448 + 14.48

Total Average = 15.92m^3/day

Total Max = Infiltration + Qmax

= 1.448 + 31.27

Total Max = 32.718m^3/day

Second: Storm water quantity calculation:

Example on calculation of waste water quantity for manhole number 1 to manhole number 2:

- **Pipe length =100 m.**
- **Tributary area = 4.83m^2.**
- **Runoff coefficient = 0.30.**
- **C.A= 1.45 ha.**
- **∑C.A= 1.45 ha.**
- **Concentration time (Tc) = ti +tf**
- **ti = 5 min.**
- **tf = $\frac{\text{Distance}}{\text{Velocity}}$.**

  tf =$\frac{100}{1*60}$ = 1.67 min.
- Tc = 5+1.67=6.67 min.
- Rain Fall intensity = 75$\frac{mm}{\text{hr}}$.
- Rain Fall intensity = 208.8$\frac{l}{\text{s.h}}$.
- Qmax =C.I.A

  Qmax = 0.3 * 208.8 *4.83

  =301.75$\frac{l}{s}$.

Third: Traverse adjustment

1. The average and variance for field observation (horizontal distances and angles):

A) Horizontal angles

F.R (ST.GPS2)

point	Horizontal Angle d ' "	Horizontal Distance m
GPS1	00 00 00	118.436
ST.1	174 13 41	191.223
GPS1	359 59 52	118.440
ST.1	174 13 18	191.219
GPS1	00 00 17	118..437
ST.1	174 13 19	191.229

F.L (ST. GPS2)

point	Horizontal Angle d ' "	Horizontal Distance m
ST.1	354 13 30	191.226
GPS1	180 00 11	118.438
ST.1	354 13 35	191.225
GPS1	180 00 03	118.437
ST.1	354 13 55	191.227
GPS1	180 00 00	118.438

- A.1.1Calculating of mean angles:

  Mean direction $= \frac{(Angle\ F.L - 180) + Angle\ F.R}{2}$.*

- $\overrightarrow{\text{GPS2 – GPS1 –ST1}}$

*First time:

$MD_{GPS2-GPS1}$ =00 00' 05.5"

$MD_{GPS2-ST1}$ = 174 13' 35.5"

Angle = 174 13' 35.5" – 00 00' 05.5"
= 174 13' 30"

*Second time:

$=\frac{(180\quad 00\quad 03-180\ \ 00\ \ 11)+354\ 13\ 35)-360}{2}$ = 00 00' 08.5" $=\frac{(354\quad 13\quad 35-180\ \ 00\ \ 00)+174\ \ 13\ \ 18}{2}$

= 174 13' 37"

Angle = 174 13' 37"– (00 00' 08.5")

= 174 13' 06.5"

*Third time:

$=\frac{(180\quad 00\quad 00-180\ \ 00\ \ 00)+00\ \ 00\ \ 17)}{2}$ = 00 00' 03.83"

$=\frac{(354\quad 13\quad 55-180\ \ 00\ \ 00)+174\ \ 13\ \ 19}{2}$ = 174 13' 37"

Angle = 174 13' 37" – 00 0' 00.5"

= 174 13' 28.5"

Mean angle $=\sum\frac{Anels}{n}$

Mean= $\frac{174\ \ 13'\ \ 06.5"+174\ \ 13'\ \ 30"+174\ \ 13'\ \ 28.5"}{3}$ = 174 13' 29.1"

- A.1.2 Calculating of variances:

V= mean – angle

V1= 29.1"- 30= --0.9"

Mean	Angle	V	V^2
174 13' 29.1"	174 13' 30"	-0.9"	**0.81**
174 13' 29.1"	174 13' 29"	0.1"	**0.01**
174 13' 29.1"	174 13' 28.5"	0.6"	**0.36**
∑			**1.180**

S= $\sqrt{\frac{\sum V^2}{n-1}}$

S= $\sqrt{\frac{1.180}{2}}$ = 0.768"

E95=1.96*S

E95=1.96*0.764 = 1.506

174 13' 29.1± 1.506

Range (174 13' 27.59" - 174 13' 30.61")

There is no reason to believe that any observation is a blunder or outlier.

F.R (ST.1)

point	Horizontal Angle d ' "	Horizontal Distance m
GPS2	00 00 00	191.262
ST.2	145 01 42	309.873
GPS.2	359 59 45	191.273
ST.2	145 01 38	309.861
GPS.2	00 00 03	191.254
ST.2	145 01 35	309.881

F.L (ST.1)

point	Horizontal Angle d ' "	Horizontal Distance m
ST.2	325 01 29	309.897
GPS.2	179 59 53	191.254
ST.2	325 01 38	309.859
GPS.2	179 59 21	191.245
ST.2	325 01 09	309.876
GPS.2	179 59 12	191.244

- A.2.1 Calculating of mean angles:
- $\overrightarrow{\text{GPS2 – ST2 –ST2}}$

***First time:**

MD st1 – GPS2= 00 00' 00"

MD st1 – st2 = 145 01' 35.5"

Angle = 145 01' 35.5"– 00 00' 00"

= 145 01' 35.5"

***Second time:**

MD st1 – st2 = - 00 00' 27"

MD st1 – GPS2 = 145 01' 38"

Angle = 145 01' 38"– (- 00 00' 27")

= 145 02' 05"

***Third time**:

MD st1 – GPS2 = - 00 00' 22.5"

MD st1 – st2 = 145 01' 22"

Angle = 145 00' 22" – (-00 00' 22.5")

= 145 01' 44.5"

Mean= $\sum \frac{Anels}{n}$

Mean= $\frac{174\ 13'\ 07.5" + 174\ 13'\ 06.5" + 174\ 13'\ 06"}{3}$ = 174 13' 06.67"

- A.2.2 Calculating of variances:

- V= mean – angle

145 01' 48.33"	145 01' 35.5"	12.83"	164.609
145 01' 48.33"	145 02' 05"	-16.67"	٢٧٧.٨٨٩
145 01' 48.33"	145 01' 44.5"	3.83"	14.669
∑			٤٥٧.١٦٧

- S = 15.119"
- E95=1.96*S
- E95=1.96*15.119 = 29.633
- 145 01' 48.33" ± 29.633
- Range (145 01' 18.697" - 145 02' 17.963")
- There is no reason to believe that any observation is a blunder or outlier

F.R (ST.2)

point	Horizontal Angle d ' "	Horizontal Distance m
ST.1	00 00 00	309.889
GPS.3	174 07 28	207.352
ST.1	359 59 53	309.888
GPS.3	174 06 52	207.359
ST.1	359 59 59	309.897
GPS.3	174 07 07	207.349

F.R (ST.2)

point	Horizontal Angle d ' "	Horizontal Distance m
GPS.3	354 06 31	207.351
ST.1	180 00 10	309.897
GPS.3	354 06 47	207.313
ST.1	179 59 40	309.876
GPS.3	354 06 59	207.344
ST.1	179 59 58	309.894

A.3.1 calculating of means angles:

- $\overrightarrow{\text{ST1 – ST2 –GPS3}}$

- MD st2– st1 = 00 00' 05"
- MD st2 – GPS2 = 174 06' 59.5"

Angle = 174 06' 59.5" – 00 00' 05"

= 174 06' 54.5"

***First time:**

- MD st2 – GPS2 = -00 00' 13.5"
- MD St2– st1 = 174 06' 49.5"

Angle = 174 06' 49.5" – (-00 00' 13.5")

= 174 07' 03"

***Second time:**

- MD st2 – GPS2 = - 00 00' 01.5"
- MD St2– st1 = 174 07' 03"

Angle = 174 07' 03" – (- 00 00' 01.5")

= 174 07' 04.5"

***Third time:**

- MD st2 – GPS2 = - 00 00' 01.5"
- MD St2– st1 = 174 07' 03"

Angle = 174 07' 03" – (- 00 00' 01.5")

= 174 07' 04.5".

Mean= = 174 07' 00.67" *

- **A.3.2 Calculating of variances:**

- V= mean – angle

Mean	Angle	V	
174 07' 00.67"	174 06' 54.5"	6.17"	**38.069**
174 07' 00.67"	174 07' 03"	-2.33"	**5.429**
174 07' 00.67"	174 07' 04.5	-3.83	**14.669**
∑			**58.167**

- S= = 5.39"
- E95=1.96*S
- E95=1.96*5.39 = 10.57"
- 174 07' 00.67"± 10.57"
- Range (174 06' 50.1" - 174 07' 11.24")
- There is no reason to believe that any observation is a blunder or outlier.

F.R (GPS.3)

point	Horizontal Angle d ' "	Horizontal Distance m
ST.2	00 00 00	**207.343**
GPS.4	169 00 55	**147.209**
ST.2	00 00 13	**207.340**
GPS.4	169 01 24	**147.215**
ST.2	00 00 00	**207.337**
GPS.4	**169 01 12**	**147.216**

F.R (GPS.3)

point	Horizontal Angle d ' "	Horizontal Distance m
GPS.4	349 00 49	**147.212**
ST.2	179 59 54	**207.339**
GPS.4	349 01 54	**147.216**
ST.2	180 00 03	**207.329**
GPS.4	349 01 46	**147.213**
ST.2	**180 00 18**	**207.348**

A.4.1 calculating of means angles:

- $\overrightarrow{\text{ST2 – GPS3 –GPS4}}$

***First time:**

- MD st2 – GPS2 = -00 00' 03"
- MD St2– st1 = 169 00' 52"

Angle = 169 00' 29.5" – (-00 00' 03")

= 169 00' 55"

***Firsttime:**

- MD st2 – GPS2 = -00 00' 03"
- MD St2– st1 = 169 00' 52"

Angle = 169 00' 29.5" – (-00 00' 03")

= 169 00' 55"

***Second time:**

- MD st2 – GPS2= 00 00' 08''
- MD St2– st1 = 169 01' 39''

Angle = 169 01' 16.5'' – 00 00' 08''

= 169 01' 31''

***Third time:**

- MD St2– st1= 00 00' 09''
- MD st2 – GPS2 = 169 01' 29''

Angle = 169 01' 06.5'' – 00 00' 09''

= 169 01' 20''

Mean= = 169 01' 15.33''

A.4.2 Calculating of variances:

V= mean – angle

Mean	Angle	V	
169 01' 15.33''	169 00' 55''	20.33''	**413.309**
169 01' 15.33''	169 01' 31''	-15.67''	**245.549**
169 01' 15.33''	169 01' 20''	-4.67''	**21.809**
∑			**680.667**

S = 18.45''

E95=1.96*S

E95=1.96*18.45 = 36.158''

169 01' 15.33'' ± 36.158''

Range (169 00' 39.17'' - 169 01' 51.49'')

There is no reason to believe that any observation is a blunder or outlier

B) Horizontal Distances:

- **B.1 Distance between GPS.1→GPS.2**

Mean= = 118.438 m

V= mean – distance

V= 118.438 – 118.436 = 0.002 m

Mean m	Distance m	V mm	mm
118.438	118.436	2	**4**
118.438	118.440	-2	**4**
118.438	118..437	1	**1**
118.438	118.438	0	**0.00**
118.438	118.437	1	**1**
118.438	118.438	0	**0.00**
∑			**10**

S = = 1.414 mm

E95=1.96*S

E95=1.96*1.29 = 2.772

118.438 ± 0.00277

Range (118.435 - 118.441)

There is no reason to believe that any observation is a blunder or outlier.

- **B.2 Distance between GPS.2→ST.1**

Mean= = 191.225 m

Mean m	Distance m	V mm	mm
191.225	191.223	2	**4**
191.225	191.219	6	**36**
191.225	191.229	-4	**16**
191.225	191.226	-1	**1**
191.225	191.225	0	**0**
191.225	191.227	-2	**4**
∑			**61**

S =   = 3.493 mm

E95=1.96*3.189 = 6.846

Range (191.218– 191.232)

There is no reason to believe that any observation is a blunder or outlier.

- **B.3Distance between ST.1→ST.2**

Mean=   = 309.875 m

Mean m	Distance m	V mm	mm
309.875	309.873	2	**4**
309.875	309.861	14	**196**
309.875	309.881	6-	**36**
309.875	309.897	-22	**484**
309.875	309.859	16	**256**
309.875	309.876	1-	**1**
∑			**977**

S =   = 13.979 mm

E95=1.96*12.761 = 27.398

Range (309.848– 309.902)

There is no reason to believe that any observation is a blunder or outlier.

- **B.4 Distance between ST.2→GPS.3**

Mean=   = 207.345 m

Mean m	Distance m	V mm	mm
207.345	207.352	-7	**49**
207.345	207.359	-14	**196**
207.345	207.349	-4	**16**
207.345	207.351	-6	**36**
207.345	207.313	32	**1024**
207.345	207.344	1	**1**
∑			**1322**

S = = 16.26 mm

E95=1.96*16.26=31.87

Range (207.313– 207.377)

There is no reason to believe that any observation is a blunder or outlier

- **B.5Distance between GPS.3 → GPS.4**

Mean= = 147.214m

Mean m	Distance m	V mm	mm
147.214	147.209	5	**25**
147.214	147.215	-1	**1**
147.214	147.216	-2	**4**
147.214	147.212	2	**4**
147.214	147.216	-2	**4**
147.214	147.213	1	**1**
∑			**39**

S = 2.793 mm

E95=1.96*2.793 = 5.474 mm

Range (147.209– 147.219)

There is no reason to believe that any observation is a blunder or outlier.

Table shows the mean distances and angels

From	TO	H.Angle			H.Distance
GPS2	GPS1	0	0	0	**118.438**
GPS2	1	174	13	29.1	**191.225**
1	GPS2	0	0	0	
1	2	145	01	48.33	**309.875**
2	1	0	0	0	
2	GPS3	174	07	0.67	**207.345**
GPS3	2	0	0	0	
GPS3	**GPS4**	**169**	**01**	**15.33**	**147.214**

2. Azimuth for each line and initial coordinates for unknown points:

- $AZ = \tan^{-1}\frac{dx}{dy} + c$
- Az $_{GPS.2-GPS.1}$
- $\tan^{-1}\frac{X1-X2}{Y1-Y2} + c$

$=\tan^{-1}\frac{162681.28-162739.007}{114750.128-114646.713}+180$

= 330 49 45.9

- Az$_{GPS.2-ST.1}$=174 13 29.1-(360-330 49 45.9)

=145 3 15

- Az$_{ST.1GPS.2}$=Az$_{2-3}$+180

=325 03 15

- Az$_{ST.1-ST.2}$=145 01 48.33-(360-325 03 15)

=110 05 3.33

- Az$_{ST.2-ST.1}$=Az$_{3-4}$+180

=290 05 3.33

- Az$_{ST.2-GPS.3}$=$\tan^{-1}\frac{X5-X4}{Y5-Y4} + c$

$=\tan^{-1}\frac{163340.479-163139.572}{114332.962-114383.555}+180$

=104 08 40.19

- Az$_{GPS.3-ST.2}$=Az$_{4-5}$+180

=284 08 40.19

- Az$_{GPS.3-GPS.4}$=$\tan^{-1}\frac{X6-X5}{Y6-Y5} + c$

$=\tan^{-1}\frac{163487.363-163340.474}{114324.717-114332.926}+180$

=93 11 55.28

Line	Azimuth
L$_{GPS2-1}$	145 03 15
L$_{1-2}$	110 05 3.33

- $X1_{0} =$162739.0078+191.225*(sin Az_{GPS2-1}

=162848.541

- $Y1_{0}$ =114646.713+191.225*(CosAzGPS$_{2-1}$)

=114489.967

- $X2_{0}$=162848.541+309.875*(sin Az_{1-2})

=163139.572

- $Y2_{0}$=114489.976+309.875*(Cos Az_{1-2})

=114.383.555

3. The Corrected coordinates by different ways:

- **3.A Autodesk land desktop program least square report :**
  Angular error = 0-01-24
  Angular error/set = 0-00-21 Over
  Error North : 0.2379
  Error East : -0.1067
  Absolute error: 0.2607
  Error Direction: N 24-09-26 W
  Perimeter : 708.4450
  Precision : 1 in 2717.5944
  Number of sides: 3

SURVEY LEAST SQUARES CALCULATION

الأربعاءكانون الأول ١٤ ١٠:٥٩:٣٤ ٢٠١١

Project: traverse Al-Arroub

Input File:

Total # of Unknown Points: 2

Total # of Points : 6

Total # of Observations: 7

Degrees of Freedom : 3

Confidence Interval : 95%

Number of Iterations : 2

Chi Square Value : 60.09207

Goodness of Fit Test : Fails at the 5% Level

Standard Deviation of Unit Weight: 4.47557

****
OBSERVATIONS
****

Type	Pnt1	Pnt2	Pnt3	Measured	StdDev	Adjusted	Resid
DIST	2	3		191.2250	0.016	191.1629	-0.0621*
ANG	1	2	3	174-13-29.10	17.900	174-13-03.13	-25.97
ANG	4	5	6	169-01-15.30	15.300	169-00-56.29	-19.01
DIST	4	5		207.3450	0.016	207.2769	-0.0681*
ANG	3	4	5	174-07-00.70	10.700	174-06-44.48	-16.22
DIST	3	4		309.8750	0.017	309.8047	-0.0703*
ANG	2	3	4	145-01-48.30	10.900	145-01-25.43	-22.87

****
ADJUSTED COORDINATES
****
Std Deviations are at 95% Confidence Level

Point#	Northing	Easting	StdDevNth	StdDevEst
3	114490.0317	162848.5251	0.216	0.210
4	114383.7131	163139.5154	0.157	0.250

****
2D LEAST SQUARES ERROR ANALYSIS
****
Semi-Axes are at 95% Confidence Level

Point#	Semi-Major Axis	Semi-Minor Axis	Axis Azimuth
3	0.268513	0.137829	136-22-23
4	0.259546	0.140384	108-53-1

3.B Adjust Computation program

3.B.1 Matrices report :

J and K MATRICES -- Iteration: 1

~~~~~~~~~~~~~~~

0.572802	-0.819694	0.000000	0.000000	-0.000013
-0.939188	0.343403	0.939188	-0.343403	-0.000066
0.000000	0.000000	-0.969683	0.244368	0.161725
-884.162723	-617.852320	0.000000	0.000000	-0.086249
1112.744958	1243.012229	-228.582234	-625.159909	-0.569503
-228.582234	-625.159909	471.867102	1590.543712	204.408564
0.000000	0.000000	-243.284868	-965.383802	-120.088555

X MATRIX -- Iteration: 1

~~~~~~~~~~~~~~~

1 -0.003239
2 0.005121
3 -0.034656
4 0.137750

J and K MATRICES -- Iteration: 2

~~~~~~~~~~~~~~~

0.572803	-0.819693	0.000000	0.000000	0.006040
-0.939314	0.343058	0.939314	-0.343058	0.074965
0.000000	0.000000	-0.969535	0.244953	0.094420
-884.189811	-617.873166	0.000000	0.000000	0.214239
1112.597744	1243.268409	-228.407934	-625.395243	74.880908
-228.407934	-625.395243	472.196304	1590.318551	4.148216
0.000000	0.000000	-243.788370	-964.923307	4.420893
~~~~~~~~~~~~~~~

X MATRIX -- Iteration: 2
~~~~~~~~~~~~~~
1 0.000001
2 -0.000001
3 0.000023
4 0.000010

INVERSE MATRIX
~~~~~~~~~~~~~~

0.00000568	-0.00000690	0.00000359	-0.00000296
-0.00000690	0.00001071	-0.00000446	0.00000458
0.00000359	-0.00000446	0.00010523	-0.00002975
-0.00000296	0.00000458	-0.00002975	0.00001886

3.B.2 Adjust report :

----
travers AL-ARROUB

Number of Control Stations - 4

Number of Unknown Stations - 2

Number of Distance observations - 3

Number of Angle observations - 4

Number of Azimuth observations - 0

****
Initial approximations for unknown stations
****

Station	X	Y
1	162,848.541	114,489.967
2	163,139.572	114,383.555

Control Stations
~~~~~~~~~~~~~~~~

Station	X	Y
A	162,681.280	114,750.128
B	162,739.007	114,646.713
C	163,340.474	114,332.926
D	163,487.363	114,324.717

****
Distance Observations
****

Station Occupied	Station Sighted	Distance	S
B	1	191.225	0.004
1	2	309.875	0.014
2	C	207.345	0.016

****
Angle Observations
****

Station Backsighted	Station Occupied	Station Foresighted	Angle	S
A	B	1	174°13'29"	1"
B	1	2	145°01'48"	15"
1	2	C	174°07'01"	5"
2	C	D	169°01'15"	18"
~~~~~~~~~~~~~~~~

Notice: Matrices are written to the file C:\Users\DANDRA\Desktop\New folder\New Text Document.MAT

****
Adjusted stations
****

					Standard error ellipse computed		
Station	X	Y	Sx	Sy	Su	Sv	t
1	162,848.538	114,489.972	0.0132	0.0181	0.0218	0.0051	145.02°
2	163,139.537	114,383.693	0.0566	0.0240	0.0591	0.0171	107.28°

****
Adjusted Distance Observations
****

Station Occupied	Station Sighted	Distance	V	S	Std.Res.	Red.#
B	1	191.219	-0.0060	0.0218	-8.873	0.029
1	2	309.800	-0.0749	0.0586	-8.215	0.425
2	C	207.251	-0.0944	0.0590	-7.930	0.554

****
Adjusted Angle Observations
****

Station Backsighted	Station Occupied	Station Foresighted	Angle	V	S"	Std.Res.	Red.#
A	B	1	174°13'29"	-0.2"	5.5	-2.4	0.008
B	1	2	145°00'33"	-74.9"	14.2	-5.1	0.971
1	2	C	174°06'57"	-4.1"	27.0	-3.9	0.044
2	C	D	169°01'11"	-4.4"	17.3	-0.3	0.970

****
Adjustment Statistics
****
Iterations = 2
Redundancies = 3

Reference Variance = 30.497
Reference So = ±5.5

Failed to pass X^2 test at 95.0% significance level!
X^2 lower value = 0.22
X^2 upper value = 9.35
Possible blunder in observations with Std.Res.> 18
Convergence!

- **3.C Manually least square:**

Calculation of unknowns coordinates:

X= $J^T.W.J^{-1} * J^T.W.K$

- **First iteration:**

Calculating the Jacobian matrix:

$$J= \begin{matrix} \frac{\partial F_1}{\partial x_1} & \frac{\partial F_1}{\partial y_1} & \frac{\partial F_1}{\partial x_2} & \frac{\partial F_1}{\partial y_2} \\ \frac{\partial F_2}{\partial x_1} & \frac{\partial F_2}{\partial y_1} & \frac{\partial F_2}{\partial x_2} & \frac{\partial F_2}{\partial y_2} \\ \frac{\partial F_3}{\partial x_1} & \frac{\partial F_3}{\partial y_1} & \frac{\partial F_3}{\partial x_2} & \frac{\partial F_3}{\partial y_2} \\ \rho\frac{\partial \theta_1}{\partial x_1} & \frac{\partial \theta_1}{\partial y_1} & \frac{\partial \theta_1}{\partial x_2} & \frac{\partial \theta_1}{\partial y_2} \\ \rho\frac{\partial \theta_2}{\partial x_1} & \frac{\partial \theta_2}{\partial y_1} & \frac{\partial \theta_2}{\partial x_2} & \frac{\partial \theta_2}{\partial y_2} \\ \rho\frac{\partial \theta_3}{\partial x_1} & \frac{\partial \theta_3}{\partial y_1} & \frac{\partial \theta_3}{\partial x_2} & \frac{\partial \theta_3}{\partial y_2} \\ \rho\frac{\partial \theta_4}{\partial x_1} & \frac{\partial \theta_4}{\partial y_1} & \frac{\partial \theta_4}{\partial x_2} & \frac{\partial \theta_4}{\partial y_2} \end{matrix}$$

Example of distance derivation at J matrix:

$$\frac{\partial F1}{\partial x_1} = \frac{x_1 - x_{gps2}}{l1gps2} \frac{\partial F1}{\partial y_1} = \frac{y_1 - y_{gps2}}{l1gps2} \frac{\partial F1}{\partial x_2} = \frac{x_1 - x_{gps2}}{l1gps2} \frac{\partial F1}{\partial y_2} = \frac{y_1 - gps2}{l1gps2}$$

$$\frac{\partial F1}{\partial x_1} = \frac{162848.541 - 162739.009}{191.225} = 0.573$$

$$\frac{\partial F1}{\partial y_1} = \frac{114489.967 - 114646.713}{191.225} = -0.82$$

$$\frac{\partial F1}{\partial x_2} = 0$$

$$\frac{\partial F1}{\partial y_2} = 0$$

Example of angle derivation at J matrix:

$$\theta_1 = 360 - AZ_{gps2\,gps1} - AZ_{gps2\,1}$$

$$\frac{\partial \theta_1}{\partial x_1} = -\tan^{-1}\frac{x_{gps1} - x_{gps2}}{y_{gps1} - y_{gps2}} + \tan^{-1}\frac{x_1 - x_{gps2}}{y_1 - y_{gps2}}$$

$$= \frac{y_1 - y_{gps2}}{l_{1gps2}{}^2}\,\partial x_1 + \frac{x_{gps2} - x_1}{l_{1gps2}{}^2}\,\partial y_1$$

$$= \rho \quad \frac{114489.967 - 114646.713}{191.225^2} + \frac{162739.007 - 162848.541}{191.225^2}$$

$$\frac{\partial \theta_1}{\partial x_1} = -0.00429$$

$$\frac{\partial \theta_1}{\partial y_1} = -0.002995$$

$$J = \begin{vmatrix} 0.573 & -0.82 & 0 & 0 \\ -0.939 & 0.343 & 0.939 & -0.343 \\ 0 & 0 & -0.969 & 0.244 \\ -0.00429 & -0.002995 & 0 & 0 \\ 0.005395 & 0.006026 & -0.001108 & -0.003031 \\ -0.001108 & -0.003031 & 0.002286 & 0.007704 \\ 0 & 0 & -0.001177 & -0.004673 \end{vmatrix}$$

$$J^T = \begin{vmatrix} 0.573 & -0.939 & 0 & 0.00429 & 0.005395 & -0.00111 & 0 \\ -0.82 & 0.343 & 0 & -0.003 & 0.006026 & -0.00303 & 0 \\ 0 & 0.939 & -0.969 & 0 & -0.00111 & 0.002286 & -0.00118 \\ 0 & -0.343 & 0.244 & 0 & -0.00303 & 0.007704 & -0.00467 \end{vmatrix}$$

W=

111111	0	0	0	0	0	0
0	5102	0	0	0	0	0
0	0	3906	0	0	0	0
0	0	0	0.000008	0	0	0
0	0	0	0	0.00000002	0	0
0	0	0	0	0	0.00000002	0
0	0	0	0	0	0	0.00000001

$$l\ th = \sqrt{\Delta x^2 + \Delta y^2}$$

$$K = \begin{array}{c} l_{gps2\,1}(m) - l_{gps2\,1}(th) \\ l_{1\,2}(m) - l_{1\,2}(th) \\ l_{2\,gps3}(m) - l_{2\,gps3} \\ \emptyset_1\ m\ - \emptyset_1\ th \\ \emptyset_2\ m\ - \emptyset_2\ th \\ \emptyset_3\ m\ - \emptyset_3\ th \\ \emptyset_4\ m\ - \emptyset_4\ th \end{array}$$

$$K = \begin{array}{c} 191.225 - 191.225 \\ 309.875 - 309.875 \\ 207.345 - 207.183 \\ 147\ 13\ 29.1 - 147\ 13\ 29.1 \\ 145\ 01\ 48.33 - 145\ 01\ 48.33 \\ 174\ 07\ 00.67 - 174\ 03\ 36.86 \\ 169\ 01\ 15.33 - 169\ 03\ 15.09 \end{array}$$

k=

0
0
0.162
0
0
0.000988
-0.000581

The resulted matrix represents the differences in unknown pointes coordinates:

X=

-0.16015625
-0.11206055
-0.27441406
-0.42578125

The new coordinates of Unknown points is:

Point#	X initial	Y initial	X corrected	Y corrected
1	162848.541	114489.967	162848.3808	114489.8549
2	163139.5782	114383.555	163139.2976	114383.1292

- **Second iteration:**

Repeating the previous steps using the corrected coordinates resulted in from first iteration:

$$k' = \begin{vmatrix} 0 \\ -0.001 \\ -0.001 \\ -0.001 \\ 0 \\ 0.004 \\ -0.003 \end{vmatrix}$$

The resulted X matrix is:

$$X' = \begin{vmatrix} 0.00580502 \\ 0.00405693 \\ 0.00390625 \\ 0.01961136 \end{vmatrix}$$

The new coordinates of Unknown points is:

Point#	X initial	Y initial	X corrected	Y corrected
1	162848.3808	114489.8549	162848.3866	**114489.859**
2	**163139.2976**	**114383.1292**	**163139.2937**	**114383.1096**

Palestine Polytechnic University

Arroub Main Street

Hebron, Arroub camp

Points Report

Total COGO Points: 454

Number	Northing (m)	Easting (m)	Elevation (m)	Description
9	114384.323	163118.043	826.716	HOS1
11	114388.474	163118.608	826.714	AS
12	114391.667	163134.403	826.804	CW
13	114390.953	163134.330	826.650	AS
14	114383.107	163135.873	826.494	AS+C
15	114390.202	163140.511	826.758	CW
16	114372.381	163143.525	826.738	HOS2
101	114768.240	162677.712	832.803	AS+HOS1
102	114762.599	162680.807	832.815	AS+HOS2
104	114761.339	162680.825	832.761	HOS1
105	114760.701	162680.678	832.730	AS+C
106	114758.974	162681.004	832.701	AS+C
107	114748.269	162687.748	832.696	HOS2
108	114749.540	162686.091	832.569	AS+C
109	114764.816	162672.942	832.781	AS+HOS1
111	114752.231	162679.636	832.698	AS+HOS

113	114751.616	162678.675	832.708	GATE
114	114747.708	162680.657	832.652	GATE+CW
115	114743.836	162682.197	832.609	CW+GATE
116	114739.487	162684.253	832.547	GATE+CW
117	114739.913	162684.776	832.484	AS
118	114747.386	162688.250	832.719	HOS1
120	114740.339	162692.083	832.540	HOS2
121	114739.732	162691.454	832.406	AS
123	114733.265	162695.638	832.411	HOS1
124	114733.634	162694.939	832.287	AS+C
126	114732.802	162687.386	832.236	CW2
127	114727.568	162690.512	832.303	HOS2
129	114724.921	162693.178	832.137	AS+C
130	114721.810	162693.730	832.128	HOS1
131	114720.976	162701.510	832.077	AS+C
133	114707.727	162709.435	831.871	HOS2
134	114717.169	162697.074	832.339	HOS
135	114717.801	162697.892	832.161	HOS
136	114714.247	162699.998	832.140	HOS2
137	114714.444	162700.354	831.935	AS+C
138	114713.322	162698.235	831.800	HOS1
139	114702.995	162704.200	831.764	HOS2
141	114700.767	162706.561	831.674	HOS1
142	114705.478	162710.241	831.715	AS+C

143	114707.430	162709.884	831.709	HOS1
144	114700.382	162713.926	831.717	HOS2
145	114700.374	162713.931	831.718	HOS2
146	114696.723	162715.130	831.565	AS+C
147	114688.889	162711.569	831.453	HOS2
148	114689.503	162712.432	831.609	HOS1
149	114694.119	162711.062	831.513	AS
150	114685.574	162715.503	831.432	HOS2
151	114692.048	162718.280	831.457	HOS1
152	114684.159	162723.443	831.380	HOS2
153	114684.360	162721.793	831.393	AS
156	114681.496	162724.720	831.365	HOS1
157	114666.815	162733.731	831.012	HOS2
158	114675.578	162720.749	831.276	HOS1
159	114669.515	162724.212	831.190	HOS2
160	114668.434	162722.296	831.190	HOS1
161	114659.877	162727.401	831.153	HOS2
163	114661.180	162735.541	831.022	AS+C
166	114657.753	162727.292	831.489	AS+HOS1
167	114653.285	162730.494	831.550	HOS+HOS
168	114661.987	162737.728	831.488	HOS1
169	114659.107	162737.468	831.329	AS+C
170	114647.150	162747.344	831.067	HOS2
171	114645.372	162746.525	830.982	AS+HOS1

172	114640.948	162749.231	830.947	HOS2
173	114649.875	162733.341	831.319	HOS2+HOS1
174	114639.295	162741.313	831.059	AS+HOS2
176	114660.994	162729.406	831.423	AS
177	114633.599	162747.203	830.811	AS+HOS
178	114632.978	162746.161	830.905	HOS
179	114637.156	162753.723	830.890	HOS+HOS
181	114642.201	162750.777	830.913	HOS
182	114636.295	162747.940	830.777	HH
183	114637.515	162754.114	830.863	HOS2
185	114623.885	162752.531	830.550	HOS2
189	114627.607	162757.446	830.586	AS+C
190	114630.657	162758.192	830.855	HOS2+CW2
191	114626.248	162760.633	830.635	HOS1+CW2
192	114620.937	162762.526	830.526	AS+C
193	114618.477	162758.072	830.368	AS+C
195	114617.984	162757.615	830.517	HOS+HOS
196	114619.232	162764.988	830.484	HOS+HOS
198	114609.778	162761.628	830.127	HOS
199	114610.201	162762.594	830.125	AS+C
200	114608.663	162761.085	830.114	HOS1
201	114612.639	162767.843	830.174	AS+C
202	114614.923	162768.283	830.376	HOS2+HOS1
204	114605.299	162772.758	829.954	AS+CW2

205	114608.905	162770.267	830.101	CW1
207	114606.217	162774.529	829.990	HOS
208	114600.809	162769.258	829.953	AS+C+CW1
211	114601.025	162776.315	829.887	AS
212	114600.828	162776.099	829.771	AS
213	114600.496	162778.601	829.938	HOS 1
214	114599.000	162777.016	829.740	AS+C
216	114597.884	162771.195	829.829	CW2
217	114596.895	162770.025	830.060	HOS
219	114596.933	162770.130	830.027	HOS1
220	114597.246	162771.862	829.824	AS
221	114596.218	162770.147	829.822	AS+CW
222	114596.049	162778.879	829.702	AS+C
223	114588.599	162783.761	829.487	AS+C
224	114589.537	162784.808	829.644	HOS1
228	114577.552	162781.615	829.400	AS+CW
229	114583.815	162786.973	829.500	AS+C
230	114584.745	162788.314	829.633	HOS1
232	114576.524	162793.571	829.450	HOS2
233	114574.243	162793.540	829.400	AS
234	114574.864	162794.414	829.350	HOS1
237	114572.940	162780.130	829.320	GATE+CW
238	114568.914	162778.326	829.300	GATE+CW
239	114567.575	162777.842	829.280	CULVE

240	114565.883	162777.360	829.260	CW
243	114562.357	162779.595	829.250	CWA
245	114557.215	162783.749	829.250	CUL
246	114554.177	162782.411	829.200	CW1
247	114557.119	162781.309	829.230	AS
248	114560.859	162779.533	829.200	AS
249	114564.931	162782.629	829.300	AS
250	114572.202	162784.217	829.350	AS
251	114568.324	162797.388	829.400	AS
252	114565.335	162800.587	829.350	HOS2
253	114562.209	162801.422	829.310	AS+C
254	114563.138	162802.725	829.300	HOS 1
255	114555.595	162799.921	829.270	AS+C
256	114555.184	162799.230	829.260	HOS1
257	114560.466	162796.693	829.300	AS
260	114561.521	162795.515	829.280	AS
261	114562.266	162793.562	829.270	AS
262	114560.208	162788.544	829.320	AS
263	114557.822	162789.426	829.240	CW2
264	114556.792	162805.263	829.260	AS+C
265	114553.869	162807.141	828.992	AS+C
266	114553.876	162807.364	829.230	HOS1+HOS2
267	114550.269	162810.114	829.230	HOS1+HOS2
270	114548.422	162812.279	829.210	HOS1

272	114542.410	162806.272	829.202	HOS2
274	114540.305	162817.754	829.180	HOS2
275	114539.692	162816.794	829.179	HOS1
276	114539.242	162816.087	829.180	AS+C
277	114538.253	162809.742	829.190	AS+C
278	114537.596	162808.963	829.184	HOS1+HOS2
279	114534.909	162812.140	829.170	AS+C
282	114531.513	162814.220	829.155	AS+C
284	114453.983	162952.675	827.965	AS+C
288	114455.159	162948.794	828.052	HOS2
290	114458.264	162939.851	828.200	AS+C
291	114461.076	162933.748	828.250	HOS1
293	114463.458	162926.272	828.300	AS+C
296	114467.756	162919.741	828.350	HOS2
297	114467.525	162918.557	828.360	HOS1
298	114468.320	162913.727	828.390	AS+C
300	114472.103	162906.159	828.450	HOS2
301	114472.382	162905.251	828.452	HOS1
303	114470.353	162904.502	828.450	AS+C
304	114474.086	162900.251	828.480	HOS+HOS
306	114475.429	162891.379	828.540	AS+C
307	114477.268	162891.531	828.550	HOS1+HOS2
309	114479.874	162880.437	828.620	AS+C
310	114482.396	162877.918	828.640	HOS+HOS

311	114484.411	162870.701	828.690	AS+C
312	114487.615	162866.064	828.720	HOS+HOS
313	114487.862	162864.764	828.730	AS+C
314	114489.942	162861.565	828.760	AS+HOS1
316	114492.147	162856.340	828.791	AS+C
317	114493.078	162857.207	828.785	HOS2
318	114496.595	162851.658	828.840	HOS+HOS
319	114495.079	162850.617	828.840	AS+C
320	114498.085	162848.644	828.860	HOS
321	114499.807	162844.475	828.896	AS+C
322	114505.927	162840.684	828.940	HOS1
324	114504.681	162839.503	828.940	HOS2
325	114509.924	162835.531	828.980	HOS1
326	114509.408	162834.672	828.980	AS+C
328	114514.279	162832.000	829.026	HOS2
329	114513.871	162831.441	829.030	AS+C
331	114521.675	162828.477	829.210	HOS
332	114522.294	162827.836	829.210	HOS
333	114527.412	162824.602	829.130	HOS
334	114529.181	162820.846	829.231	AS+C
335	114529.212	162823.655	829.140	HOS
336	114534.245	162811.281	829.170	HOS2
337	114533.711	162810.499	829.167	HOS1
338	114531.661	162813.892	829.158	AS+C

339	114530.362	162812.468	829.150	HOS
340	114530.806	162812.872	829.150	HOS1
342	114520.766	162819.366	829.116	HOS2
343	114521.311	162819.819	829.120	AS +C
344	114520.056	162818.847	830.289	BRX1
346	114514.091	162823.272	829.049	BRX2
347	114514.780	162824.443	829.050	AS+C
348	114512.961	162825.033	829.040	AS+C
349	114511.764	162824.055	829.030	HOS1
350	114501.267	162834.218	828.953	AS+C
351	114501.235	162834.257	828.954	HOS 2
352	114500.126	162835.280	828.940	HOS1
353	114497.332	162838.454	828.910	HOS2
354	114497.001	162838.214	828.907	HOS1
355	114495.277	162841.301	828.890	AS+C
356	114494.795	162840.971	828.887	HOS2
357	114494.408	162840.703	828.886	HOS 1
359	114489.458	162847.262	828.850	HOS2
361	114486.365	162856.297	828.780	AS+C
362	114485.600	162855.754	828.775	HOS1
364	114480.423	162866.293	828.710	HOS2
365	114480.380	162866.290	828.710	HOS1
366	114479.481	162869.693	828.680	AS+C
367	114474.879	162877.099	828.630	HOS2

369	114474.745	162879.799	828.622	HOS1
370	114475.338	162880.978	828.610	AS+C
371	114472.726	162884.642	828.580	HOS+HOS
372	114469.898	162892.050	828.520	HOS2
373	114470.288	162892.292	828.520	AS+C
374	114468.405	162896.226	828.500	HOS1
375	114466.822	162899.418	828.729	HOS2
376	114466.820	162899.417	828.470	HOS1
377	114464.842	162904.819	828.425	HOS2
378	114464.842	162904.819	828.440	HOS1
380	114463.721	162908.183	828.410	HOS2
383	114463.435	162909.226	828.400	HOS1
384	114462.486	162912.822	828.380	AS+C
385	114458.830	162916.719	828.350	HOS+HOS
387	114455.525	162930.628	828.253	HOS2
388	114454.860	162930.705	828.250	HOS1
391	114451.798	162943.073	828.180	AS+C
392	114450.620	162943.587	828.170	HOS2
395	114448.412	162949.858	827.868	AS+C
396	114447.816	162949.599	828.000	HOS2
397	114444.950	162957.917	827.917	HOS2
400	114441.158	162972.023	827.401	AS+C
402	114439.805	162970.990	827.401	HOS
403	114436.379	162982.122	827.336	HOS2

405	114436.028	162983.047	827.276	HOS1
406	114432.426	162992.243	827.181	HOS2
407	114432.349	162992.770	827.194	HOS1
408	114430.848	163002.793	826.924	AS+C
409	114429.644	163003.181	827.348	HOS2
410	114429.255	163002.973	827.129	HOS1
411	114427.044	163013.508	826.797	AS+C
412	114425.662	163012.864	826.845	HOS+HOS
413	114424.479	163019.952	826.629	AS+C
414	114417.127	163035.724	826.445	HOS2
415	114416.343	163038.087	826.374	AS
416	114426.631	163037.675	826.797	CW1
417	114424.851	163039.416	826.520	AS
418	114419.063	163055.571	826.498	AS
419	114405.266	163046.715	826.654	HOS1
420	114401.176	163055.274	826.876	HOS2
421	114402.920	163056.259	826.876	HOS2
422	114400.873	163080.530	826.624	AS
424	114400.344	163061.913	826.932	HOS
425	114400.117	163072.233	826.688	HOS1
427	114413.059	163076.985	826.865	CW
428	114411.884	163077.321	826.703	AS
430	114409.026	163086.112	826.844	AS
431	114409.883	163086.421	826.999	CW+GATE

432	114407.904	163092.283	827.110	GATE+CW
433	114406.855	163092.172	826.879	AS
434	114397.514	163075.972	826.683	HOS2
435	114398.551	163076.829	826.683	HOS1
436	114394.530	163083.402	826.838	HOS2
438	114396.440	163093.512	826.753	AS
439	114402.760	163104.222	826.922	AS
440	114400.068	163112.043	826.912	AS
442	114400.039	163112.013	826.913	CW
444	114392.760	163104.939	826.775	AS
445	114391.241	163104.226	826.805	CWA
446	114387.079	163114.264	827.147	CWA
448	114396.730	163118.007	826.951	CW
449	114396.047	163117.830	826.817	AS
454	114454.184	162953.137	827.886	HOS1
455	114453.110	162953.564	827.904	C
456	114448.475	162964.453	827.704	C
457	114447.782	162966.361	827.670	C
458	114446.639	162974.746	827.760	HOS2
459	114445.512	162974.440	827.545	AS+C
460	114444.340	162981.317	827.394	CW
461	114442.701	162986.678	827.265	CW2
462	114441.622	162985.680	827.227	AS
464	114441.843	162989.548	827.315	HOS1

465	114439.242	162996.640	827.330	HOS2
466	114436.619	162999.473	827.001	AS
467	114438.682	163000.782	827.268	HOS 2
468	114435.764	163007.889	826.926	HOS+HOS
469	114432.549	163010.702	826.824	AS
470	114432.817	163011.097	826.939	HOS+HOS
471	114429.544	163020.478	826.691	HOS
472	114430.366	163020.977	826.699	HOS2
473	114429.726	163023.523	826.739	HOS1
474	114428.119	163023.730	826.650	AS
475	114426.706	163032.665	826.746	HOS
480	114411.826	163050.717	826.311	CS
481	114404.797	163069.676	826.581	CS
482	114398.236	163087.941	826.738	CS
484	114379.106	163147.934	826.430	CS
486	114386.544	163153.610	826.641	CW
487	114385.217	163157.187	826.569	CS
488	114385.890	163157.978	826.665	CW2
489	114383.964	163164.466	826.569	AS
491	114375.285	163159.636	826.332	CS
493	114376.346	163149.672	826.121	CW1
497	114369.460	163171.996	826.602	CW2
499	114386.227	163166.281	826.862	HOS1
500	114384.436	163170.029	826.896	HOS2

503	114381.966	163174.528	826.806	CWA
505	114379.292	163178.759	826.408	AS
506	114383.963	163178.265	826.653	HOS1
509	114368.476	163174.801	826.348	CW1
510	114365.670	163188.819	826.012	CS
511	114364.089	163188.310	826.105	CW
512	114375.007	163192.151	826.257	AS
513	114375.995	163202.342	826.480	HOS2
515	114371.468	163204.342	826.215	CWA
516	114370.683	163203.964	825.991	CS
517	114370.165	163204.719	825.889	CS
518	114368.255	163211.445	825.718	CS
519	114369.016	163212.950	825.904	CW
520	114359.231	163208.364	825.628	CS
521	114357.665	163207.797	825.465	CW2
522	114357.248	163211.497	825.596	HOS1
523	114355.307	163221.137	825.307	CS
524	114353.766	163221.247	825.845	HOS2
525	114364.425	163225.047	825.371	CS
526	114365.299	163226.365	825.575	CW2
528	114364.521	163229.573	825.501	CW1
529	114360.004	163240.483	824.972	CS
530	114361.264	163240.567	825.141	CW2
531	114359.689	163240.492	824.913	HOS1

532	114358.501	163246.677	824.702	HOS2
533	114352.883	163223.447	825.132	HOS1
534	114354.002	163225.308	825.216	CS
535	114350.936	163235.086	824.983	CS
536	114349.556	163236.060	824.786	HOS2
537	114349.609	163240.733	824.872	CWA
538	114350.264	163241.377	824.795	CS
539	114347.504	163252.581	824.400	CS
540	114346.481	163253.021	824.177	CW2
541	114346.028	163254.912	824.104	CW1
542	114346.588	163255.444	823.993	CS
544	114355.491	163256.402	824.480	AS+BARAX
545	114353.530	163260.734	824.265	CS
546	114354.484	163260.691	824.095	BARAX
548	114350.778	163270.013	823.962	CS
549	114343.484	163268.214	823.841	CS
551	114342.080	163273.331	823.831	CS
552	114341.202	163273.719	823.937	CW2
553	114340.964	163277.379	823.648	CS
554	114339.637	163278.848	823.843	CW2
555	114339.234	163284.396	823.476	CS
559	114348.269	163281.397	823.606	AS
560	114350.924	163281.406	823.637	HOS1
562	114336.209	163295.702	823.172	CS

563	114334.856	163295.870	823.004	CW2
564	114339.055	163278.791	823.963	CW1
565	114344.324	163294.172	823.188	AS
566	114344.837	163301.320	823.138	HOS1
567	114342.739	163300.800	823.081	CS+HOS1
568	114341.798	163301.650	823.113	CS
569	114333.884	163299.287	822.773	CW1
570	114335.122	163300.488	823.062	CS
571	114340.115	163309.618	823.007	CS
572	114340.926	163309.262	823.218	HOS2
573	114340.443	163311.688	823.058	HOS1
574	114338.356	163325.645	822.798	CS
575	114339.108	163326.313	822.847	HOS2
576	114331.786	163314.590	822.941	CS
577	114331.922	163317.842	822.928	CS
579	114328.835	163317.320	823.118	CW2
580	114328.258	163317.099	823.098	HOS1
581	114326.334	163325.765	822.512	HOS2
582	114329.780	163328.410	822.711	AS+C
584	114330.850	163318.054	823.047	CW1
585	114338.079	163329.347	822.760	HOS1
587	114337.902	163336.673	822.684	HOS
588	114338.966	163336.785	822.808	HOS
589	114338.520	163344.918	822.754	HOS2

590	114338.154	163344.940	822.709	HOS1
591	114337.638	163349.846	822.549	HOS2
592	114330.619	163342.092	822.535	AS+HOS1
593	114329.562	163334.433	822.626	AS
594	114337.530	163341.346	822.556	AS+C
595	114336.478	163350.471	822.362	AS+C
597	114337.468	163351.818	822.442	HOS1
598	114329.879	163351.856	822.201	HOS+HOS
599	114329.210	163357.953	822.161	HOS2
600	114328.620	163357.884	822.141	HOS1
602	114326.495	163367.727	821.987	HOS2
603	114327.882	163367.729	821.987	AS
604	114335.893	163368.316	821.973	HOS+HOS
605	114333.497	163385.211	821.872	HOS2
606	114327.763	163380.455	821.609	AS
608	114333.373	163385.446	821.842	HOS1
609	114332.276	163390.839	821.437	HOS2
612	114332.777	163400.284	821.303	AS+CW1
613	114331.641	163414.216	820.839	CW
616	114327.159	163381.940	821.550	CS
617	114324.329	163380.692	821.587	HOS1
618	114324.873	163399.265	821.133	CS
619	114320.700	163400.184	821.091	HOS2
620	114322.634	163400.930	821.090	HOS1

621	114320.976	163409.097	820.889	HOS2
622	114323.467	163409.585	820.867	AS
624	114323.106	163412.674	820.818	CW>
625	114322.674	163419.419	820.522	CW+GATE
626	114322.492	163422.669	820.440	GATE+CW
628	114336.875	163441.415	819.982	CW2
629	114330.035	163439.909	819.983	CW1
633	114320.773	163445.973	819.593	CW2+GATE
634	114320.518	163449.725	819.526	GATE+CW1
635	114326.638	163455.229	819.411	CW
636	114323.248	163423.196	820.392	AS
637	114321.565	163442.807	819.692	AS
638	114327.656	163444.381	819.772	AS
639	114326.205	163456.166	819.348	AS
640	114320.631	163456.969	819.202	AS+C
641	114319.836	163459.930	819.094	CW
645	114317.990	163476.432	818.287	AS+C
646	114316.950	163477.782	818.379	CW+GATE
647	114316.453	163480.733	818.146	GATE+CW
648	114314.513	163492.209	817.731	CW2+BARAX1
649	114312.378	163501.899	817.415	BARAX2
651	114311.879	163508.539	817.263	AS+C
652	114323.180	163492.155	817.845	AS
654	114324.170	163487.547	818.041	CW

655	114323.206	163499.377	817.576	CW2
658	114322.682	163501.814	817.406	AS
659	114325.871	163503.328	817.534	AS
660	114325.697	163507.768	817.521	AS
661	114320.709	163507.304	817.407	AS
662	114318.312	163510.092	817.299	AS+C
663	114317.700	163512.354	817.225	C
664	114320.447	163510.630	817.542	HOS1
665	114309.362	163518.981	817.202	BARX
666	114309.907	163519.200	817.009	AS
667	114314.459	163521.171	817.032	AS+C
669	114317.166	163520.391	817.149	HOS2+CW
670	114314.844	163526.070	817.010	CW2
672	114312.233	163531.302	816.861	AS+C
673	114307.504	163530.537	816.692	AS
674	114306.827	163531.043	816.853	CW
675	114305.109	163532.453	816.593	CWA
677	114306.157	163533.938	816.515	AS
678	114303.359	163534.654	816.402	AS
679	114299.676	163533.432	816.291	AS
681	114300.624	163545.537	816.614	CS
682	114296.953	163543.654	816.323	CS
684	114311.683	163536.838	817.058	CW1
686	114310.610	163536.124	816.820	AS+C

687	114306.966	163546.644	817.081	AS+C
688	114309.102	163544.504	817.109	CW2
689	114304.845	163553.710	817.383	AS+C
690	114299.708	163552.218	817.584	AS
691	114300.269	163546.433	817.021	CW1
692	114298.637	163558.802	817.747	CW2

Alignment Curve Report

Tangent Data

Length:	17.470	Course:	N 57° 15' 11.0345" E

Alignment: CL-ALIGMENIT

Description:

Tangent Data

Length:	56.117	Course:	S 27° 25' 58.8491" E

Circular Curve Data

Delta:	06° 21' 28.8043"	Type:	LEFT
Radius:	800.000		
Length:	88.774	Tangent:	44.433
Mid-Ord:	1.231	External:	1.233
Chord:	88.729	Course:	S 30° 36' 43.2512" E

Tangent Data

Length:	71.559	Course:	S 33° 47' 27.6534" E

Circular Curve Data

Delta:	02° 28' 46.8647"	Type:	RIGHT

Radius:	893.148		
Length:	38.654	Tangent:	19.330
Mid-Ord:	0.209	External:	0.209
Chord:	38.651	Course:	S 32° 33' 04.2210" E

Tangent Data

Length:	36.777	Course:	S 31° 18' 40.7886" E

Circular Curve Data

Delta:	33° 08' 38.9904"	Type:	LEFT
Radius:	76.015		
Length:	43.973	Tangent:	22.621
Mid-Ord:	3.158	External:	3.294
Chord:	43.362	Course:	S 47° 53' 00.2838" E

Circular Curve Data

Delta:	05° 46' 34.0314"	Type:	LEFT
Radius:	559.683		
Length:	56.423	Tangent:	28.235
Mid-Ord:	0.711	External:	0.712
Chord:	56.399	Course:	S 67° 20' 36.7947" E

Tangent Data

Length:	155.057	Course:	S 70° 13' 53.8104" E

Circular Curve Data

Delta:	04° 52' 31.7612"	Type:	LEFT
Radius:	2522.109		
Length:	214.615	Tangent:	107.372
Mid-Ord:	2.282	External:	2.285
Chord:	214.550	Course:	S 72° 40' 09.6910" E

Tangent Data

Length:	40.771	Course:	S 75° 06' 25.5716" E

Circular Curve Data

Delta:	14° 09' 34.9260"	Type:	LEFT
Radius:	150.000		
Length:	37.070	Tangent:	18.630
Mid-Ord:	1.144	External:	1.152
Chord:	36.976	Course:	S 82° 11' 13.0346" E

Circular Curve Data

Delta:	08° 39' 27.5822"	Type:	RIGHT
Radius:	250.000		
Length:	37.776	Tangent:	18.924
Mid-Ord:	0.713	External:	0.715
Chord:	37.740	Course:	S 84° 56' 16.7065" E

Circular Curve Data

Delta:	04° 39' 29.4010"	Type:	LEFT
Radius:	281.217		
Length:	22.863	Tangent:	11.438
Mid-Ord:	0.232	External:	0.233
Chord:	22.857	Course:	S 82° 56' 17.6159" E

Tangent Data

Length:	61.027	Course:	S 85° 16' 02.3164" E

Circular Curve Data

Delta:	13° 00' 50.7242"	Type:	RIGHT
Radius:	389.824		
Length:	88.544	Tangent:	44.463
Mid-Ord:	2.511	External:	2.528
Chord:	88.354	Course:	S 78° 45' 36.9544" E

Alignment: Intersection - (1) - NW - Quadrant

Description:

Circular Curve Data

Delta:	00° 38' 29.4148"	Type:	RIGHT
Radius:	891.148		
Length:	9.978	Tangent:	4.989
Mid-Ord:	0.014	External:	0.014
Chord:	9.978	Course:	S 33° 18' 21.0386" E

Circular Curve Data

Delta:	90° 14' 17.3657"	Type:	RIGHT
Radius:	1.000		
Length:	1.575	Tangent:	1.004
Mid-Ord:	0.294	External:	0.417
Chord:	1.417	Course:	S 12° 08' 02.3516" W

Tangent Data

Length:	10.000	Course:	S 57° 15' 11.0345" W

Alignment PI Station Report

Alignment Name: CL-ALIGMENIT
Station Range: Start: 0+000.00, End: 1+050.00

PI Station	Northing	Easting	Distance	Direction
0+000.00	114,766.5280m	162,675.3267m		
			100.550m	S27° 25' 59"E
0+100.55	114,677.2852m	162,721.6510m		
			135.322m	S33° 47' 28"E
0+235.78	114,564.8231m	162,796.9122m		
			78.728m	S31° 18' 41"E
0+314.50	114,497.5613m	162,837.8263m		
			50.856m	S64° 27' 20"E
0+364.09	114,475.6315m	162,883.7114m		
			290.664m	S70° 13' 54"E
0+654.71	114,377.3235m	163,157.2458m		
			166.773m	S75° 06' 26"E
0+821.35	114,334.4607m	163,318.4164m		
			37.554m	S89° 16' 00"E
0+858.71	114,333.9801m	163,355.9673m		
			30.362m	S80° 36' 33"E
0+889.00	114,329.0260m	163,385.9223m		
			116.929m	S85° 16' 02"E

1+005.92	114,319.3786m	163,502.4523m		
			44.463m	S72° 15' 12"E
1+050.00	114,305.8256m	163,544.7999m		

Profile PVI Station & Curve Report

Vertical Alignment: Layout (4)
Station Range: Start: 0+000.00, End: 1+050.00

PVI	Station	Grade Out (%)	Curve Length
0.00	0+000.00	-1.56%	
1.00	0+093.71	-1.22%	25.675m
	Vertical Curve Information:(sag curve) PVC Station: 0+080.87 Elevation: 831.529m PVI Station: 0+093.71 Elevation: 831.329m PVT Station: 0+106.55 Elevation: 831.172m Low Point: 0+106.55 Elevation: 831.172m Grade in(%): -1.56% Grade out(%): -1.22% Change(%): 0.34% K: 75.8080437209665 Curve Length: 25.675m Headlight Distance:		
2.00	0+277.97	-0.86%	30.255m
	Vertical Curve Information:(sag curve) PVC Station: 0+262.85 Elevation: 829.260m PVI Station: 0+277.97 Elevation: 829.075m PVT Station: 0+293.10 Elevation: 828.946m Low Point: 0+293.10 Elevation: 828.946m Grade in(%): -1.22% Grade out(%): -0.86% Change(%): 0.37% K: 82.263873729204 Curve Length: 30.255m Headlight Distance:		

3.00	0+464.14	-0.71%	86.251m

Vertical Curve Information:(sag curve)

PVC Station:	0+421.01	Elevation:	827.852m
PVI Station:	0+464.14	Elevation:	827.484m
PVT Station:	0+507.27	Elevation:	827.177m
Low Point:	0+507.27	Elevation:	827.177m
Grade in(%):	-0.86%	Grade out(%):	-0.71%
Change(%):	0.14%	K:	599.221054055856
Curve Length:	86.251m		
Headlight Distance:			

4.00	0+692.14	-2.33%	97.536m

Vertical Curve Information:(crest curve)

PVC Station:	0+643.37	Elevation:	826.209m
PVI Station:	0+692.14	Elevation:	825.862m
PVT Station:	0+740.91	Elevation:	824.725m
High Point:	0+643.37	Elevation:	826.209m
Grade in(%):	-0.71%	Grade out(%):	-2.33%
Change(%):	1.62%	K:	60.1595702244714
Curve Length:	97.536m		

5.00	0+866.79	-2.66%	34.341m

Vertical Curve Information:(crest curve)

PVC Station:	0+849.62	Elevation:	822.189m
PVI Station:	0+866.79	Elevation:	821.789m
PVT Station:	0+883.96	Elevation:	821.332m
High Point:	0+849.62	Elevation:	822.189m
Grade in(%):	-2.33%	Grade out(%):	-2.66%
Change(%):	0.33%	K:	104.606423308956
Curve Length:	34.341m		

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Corridor Section Points Report

Corridor Name: Corridor - (2)
Base Alignment Name: CL-ALIGMENIT
Station Range: Start: 0+000.00, End: 1+050.00

CHAINAGE 0+000.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	162,678.6121	114,768.2334	832.9514	-3.702m	Ditch_Out
2	162,677.2808	114,767.5423	832.9514	-2.202m	Back_Curb
3	162,677.1477	114,767.4732	832.9514	-2.052m	Top_Curb
4	162,677.1106	114,767.4540	832.7514	-2.010m	Flowline_Gutter
5	162,677.1018	114,767.4494	832.7520	-2.000m	Flange
6	162,677.1018	114,767.4494	832.4020	-2.000m	ETW_Sub
7	162,677.1018	114,767.4494	832.6520	-2.000m	ETW_Pave1
8	162,673.5516	114,765.6065	832.6520	2.000m	ETW_Pave1
9	162,673.5516	114,765.6065	832.4020	2.000m	ETW_Base
10	162,673.5516	114,765.6065	832.7520	2.000m	ETW
11	162,673.5427	114,765.6019	832.7514	2.010m	Flowline_Gutter
12	162,673.5057	114,765.5827	832.9514	2.052m	Top_Curb
13	162,673.3725	114,765.5136	832.9514	2.202m	Back_Curb
14	162,672.0412	114,764.8225	832.9514	3.702m	Ditch_Out

CHAINAGE 0+025.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	162,690.0840	114,746.0208	832.5116	-3.650m	Sidewalk_Out
2	162,688.7527	114,745.3297	832.5116	-2.150m	Top_Curb

3	162,688.6195	114,745.2606	832.3616	-2.000m	Flowline_Gutter
4	162,688.6195	114,745.2606	832.2616	-2.000m	ETW_Pave1
5	162,688.6195	114,745.2606	832.0116	-2.000m	ETW_Sub
6	162,688.6195	114,745.2606	832.3616	-2.000m	Flange
7	162,685.0693	114,743.4178	832.0116	2.000m	ETW_Base
8	162,685.0693	114,743.4178	832.3616	2.000m	ETW
9	162,685.0693	114,743.4178	832.2616	2.000m	ETW_Pave1
10	162,685.0693	114,743.4178	832.3616	2.000m	Flowline_Gutter
11	162,684.9362	114,743.3487	832.5116	2.150m	Sidewalk_In
12	162,683.6049	114,742.6576	832.5116	3.650m	Ditch_Out
13	162,683.4047	114,742.5537	832.5680	3.876m	Daylight

CHAINAGE 0+050.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,701.6477	114,723.8559	832.1706	-3.702m	Ditch_Out
2	162,700.3163	114,723.1648	832.1706	-2.202m	Sidewalk_In
3	162,700.1832	114,723.0957	832.1706	-2.052m	Top_Curb
4	162,700.1462	114,723.0765	831.9706	-2.010m	Flowline_Gutter
5	162,700.1373	114,723.0719	831.6212	-2.000m	ETW_Sub
6	162,700.1373	114,723.0719	831.9712	-2.000m	Flange
7	162,700.1373	114,723.0719	831.8712	-2.000m	ETW_Pave1
8	162,696.5871	114,721.2290	831.9712	2.000m	Flange
9	162,696.5871	114,721.2290	831.6212	2.000m	ETW_Base
10	162,696.5871	114,721.2290	831.8712	2.000m	ETW_Pave1
11	162,696.5783	114,721.2244	831.9706	2.010m	Flowline_Gutter

12	162,696.5412	114,721.2052	832.1706	2.052m	Top_Curb
13	162,696.4081	114,721.1361	832.1706	2.202m	Sidewalk_In
14	162,695.0768	114,720.4450	832.1706	3.702m	Hinge
15	162,695.0271	114,720.4192	832.1566	3.758m	Daylight

CHAINAGE 0+075.00

CHAINAGE 0+100.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	162,725.7319	114,680.2826	831.3856	-3.805m	Daylight
2	162,725.6426	114,680.2298	831.4115	-3.702m	Hinge
3	162,724.3512	114,679.4668	831.4115	-2.202m	Back_Curb
4	162,724.2221	114,679.3905	831.4115	-2.052m	Top_Curb
5	162,724.1862	114,679.3693	831.2115	-2.010m	Flowline_Gutter
6	162,724.1775	114,679.3642	830.8621	-2.000m	ETW_Sub
7	162,724.1775	114,679.3642	831.2121	-2.000m	Flange
8	162,724.1775	114,679.3642	831.1121	-2.000m	ETW_Pave1
9	162,720.7337	114,677.3295	830.8621	2.000m	ETW_Base
10	162,720.7337	114,677.3295	831.2121	2.000m	ETW
11	162,720.7337	114,677.3295	831.1121	2.000m	ETW_Pave1
12	162,720.7251	114,677.3244	831.2115	2.010m	Flowline_Gutter
13	162,720.6892	114,677.3032	831.4115	2.052m	Top_Curb
14	162,720.5601	114,677.2269	831.4115	2.202m	Back_Curb
15	162,719.2686	114,676.4639	831.4115	3.702m	Hinge
16	162,718.8445	114,676.2133	831.2884	4.194m	Daylight

CHAINAGE 0+125.00

CHAINAGE 0+150.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	162,752.7346	114,638.4750	830.8998	-4.248m	Daylight
2	162,752.2377	114,638.1425	830.7504	-3.650m	Ditch_Out
3	162,750.9911	114,637.3083	830.7504	-2.150m	Top_Curb
4	162,750.8665	114,637.2249	830.6004	-2.000m	Flowline_Gutter
5	162,750.8665	114,637.2249	830.5004	-2.000m	ETW_Pave1
6	162,750.8665	114,637.2249	830.2504	-2.000m	ETW_Sub
7	162,750.8665	114,637.2249	830.6004	-2.000m	Flange
8	162,747.5422	114,635.0002	830.6004	2.000m	Flange
9	162,747.5422	114,635.0002	830.2504	2.000m	ETW_Base
10	162,747.5422	114,635.0002	830.5004	2.000m	ETW_Pave1
11	162,747.5422	114,635.0002	830.6004	2.000m	Flowline_Gutter
12	162,747.4175	114,634.9168	830.7504	2.150m	Sidewalk_In
13	162,746.1709	114,634.0825	830.7504	3.650m	Ditch_Out
14	162,745.5996	114,633.7002	830.9222	4.337m	Daylight

CHAINAGE 0+175.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	162,766.3760	114,617.5224	830.4366	-3.932m	Daylight
2	162,766.1848	114,617.3945	830.4941	-3.702m	Hinge
3	162,764.9382	114,616.5602	830.4941	-2.202m	Back_Curb

4	162,764.8136	114,616.4768	830.4941	-2.052m	Top_Curb
5	162,764.7789	114,616.4536	830.2941	-2.010m	Flowline_Gutter
6	162,764.7706	114,616.4481	829.9447	-2.000m	ETW_Sub
7	162,764.7706	114,616.4481	830.2947	-2.000m	Flange
8	162,764.7706	114,616.4481	830.1947	-2.000m	ETW_Pave1
9	162,761.4463	114,614.2234	829.9447	2.000m	ETW_Base
10	162,761.4463	114,614.2234	830.2947	2.000m	ETW
11	162,761.4463	114,614.2234	830.1947	2.000m	ETW_Pave1
12	162,761.4380	114,614.2178	830.2941	2.010m	Flowline_Gutter
13	162,761.4034	114,614.1946	830.4941	2.052m	Top_Curb
14	162,761.2787	114,614.1112	830.4941	2.202m	Back_Curb
15	162,760.0321	114,613.2770	830.4941	3.702m	Hinge
16	162,759.2959	114,612.7843	830.2726	4.588m	Daylight

CHAINAGE 0+200.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,780.7189	114,597.0393	829.8690	-4.460m	Daylight
2	162,780.0460	114,596.5889	830.1389	-3.650m	Hinge
3	162,778.7994	114,595.7547	830.1389	-2.150m	Top_Curb
4	162,778.6747	114,595.6713	829.9889	-2.000m	Flowline_Gutter
5	162,778.6747	114,595.6713	829.6389	-2.000m	ETW_Sub
6	162,778.6747	114,595.6713	829.9889	-2.000m	Flange
7	162,778.6747	114,595.6713	829.8889	-2.000m	ETW_Pave1
8	162,775.3505	114,593.4466	829.6389	2.000m	ETW_Base

9	162,775.3505	114,593.4466	829.9889	2.000m	ETW
10	162,775.3505	114,593.4466	829.8889	2.000m	ETW_Pave1
11	162,775.3504	114,593.4466	829.9889	2.000m	Flowline_Gutter
12	162,775.2258	114,593.3632	830.1389	2.150m	Top_Curb
13	162,773.9792	114,592.5289	830.1389	3.650m	Hinge
14	162,772.5857	114,591.5964	829.7198	5.327m	Daylight

CHAINAGE 0+225.00

CHAINAGE 0+250.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	162,808.0403	114,554.9705	829.5629	-4.402m	Ditch_Out
2	162,806.7633	114,554.1836	829.5629	-2.902m	Sidewalk_In
3	162,806.6356	114,554.1049	829.5629	-2.752m	Top_Curb
4	162,806.6001	114,554.0831	829.3629	-2.710m	Flowline_Gutter
5	162,806.5916	114,554.0778	829.0135	-2.700m	ETW_Sub
6	162,806.5916	114,554.0778	829.3635	-2.700m	Flange
7	162,806.5916	114,554.0778	829.2635	-2.700m	ETW_Pave1
8	162,801.9941	114,551.2452	829.3635	2.700m	Flange
9	162,801.9941	114,551.2452	829.0135	2.700m	ETW_Base
10	162,801.9941	114,551.2452	829.2635	2.700m	ETW_Pave1
11	162,801.9856	114,551.2399	829.3629	2.710m	Flowline_Gutter
12	162,801.9501	114,551.2181	829.5629	2.752m	Top_Curb
13	162,801.8224	114,551.1394	829.5629	2.902m	Sidewalk_In

14	162,800.5454	114,550.3525	829.5629	4.402m	Hinge
15	162,799.3998	114,549.6467	829.2266	5.747m	Daylight

CHAINAGE 0+275.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,821.1829	114,533.6736	829.1593	-4.548m	Daylight
2	162,821.0139	114,533.5708	829.2087	-4.350m	Hinge
3	162,819.7324	114,532.7913	829.2087	-2.850m	Top_Curb
4	162,819.6043	114,532.7134	829.0587	-2.700m	Flowline_Gutter
5	162,819.6043	114,532.7134	828.7087	-2.700m	ETW_Sub
6	162,819.6043	114,532.7134	829.0587	-2.700m	Flange
7	162,819.6043	114,532.7134	828.9587	-2.700m	ETW_Pave1
8	162,817.2975	114,531.3102	828.7627	0.000m	ETW_Base
9	162,817.2975	114,531.3102	829.1127	0.000m	ETW
10	162,817.2975	114,531.3102	829.0127	0.000m	ETW_Pave1
11	162,814.9907	114,529.9070	829.0657	2.700m	Flange
12	162,814.9907	114,529.9070	829.0657	2.700m	Flowline_Gutter
13	162,814.8626	114,529.8291	829.2157	2.850m	Top_Curb
14	162,813.5810	114,529.0496	829.2157	4.350m	Hinge
15	162,813.4443	114,528.9664	829.1757	4.510m	Daylight

CHAINAGE 0+300.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,834.2204	114,512.9211	829.0329	-4.494m	Daylight
2	162,834.1471	114,512.8649	829.0098	-4.402m	Ditch_Out

3	162,832.9559	114,511.9532	829.0098	-2.902m	Back_Curb
4	162,832.8368	114,511.8621	829.0098	-2.752m	Top_Curb
5	162,832.8037	114,511.8367	828.8098	-2.710m	Flowline_Gutter
6	162,832.7958	114,511.8306	828.4604	-2.700m	ETW_Sub
7	162,832.7958	114,511.8306	828.8104	-2.700m	Flange
8	162,832.7958	114,511.8306	828.7104	-2.700m	ETW_Pave1
9	162,828.5077	114,508.5485	828.9638	2.700m	ETW
10	162,828.5077	114,508.5485	828.6138	2.700m	ETW_Base
11	162,828.5077	114,508.5485	828.8638	2.700m	ETW_Pave1
12	162,828.4998	114,508.5424	828.9632	2.710m	Flowline_Gutter
13	162,828.4666	114,508.5171	829.1632	2.752m	Top_Curb
14	162,828.3475	114,508.4259	829.1632	2.902m	Back_Curb
15	162,827.1564	114,507.5142	829.1632	4.402m	Ditch_Out

CHAINAGE 0+325.00

CHAINAGE 0+350.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	162,872.8717	114,485.8872	828.6050	-4.402m	Ditch_Out
2	162,872.2593	114,484.5179	828.6050	-2.902m	Back_Curb
3	162,872.1981	114,484.3809	828.6050	-2.752m	Top_Curb
4	162,872.1811	114,484.3429	828.4050	-2.710m	Flowline_Gutter
5	162,872.1770	114,484.3338	828.4056	-2.700m	Flange
6	162,872.1770	114,484.3338	828.0556	-2.700m	ETW_Sub

7	162,872.1770	114,484.3338	828.3056	-2.700m	ETW_Pave1
8	162,869.9723	114,479.4043	828.3285	2.700m	ETW_Pave1
9	162,869.9723	114,479.4043	828.0785	2.700m	ETW_Base
10	162,869.9723	114,479.4043	828.4285	2.700m	ETW
11	162,869.9682	114,479.3952	828.4279	2.710m	Flowline_Gutter
12	162,869.9512	114,479.3571	828.6279	2.752m	Top_Curb
13	162,869.8900	114,479.2202	828.6279	2.902m	Back_Curb
14	162,869.2776	114,477.8509	828.6279	4.402m	Ditch_Out

CHAINAGE 0+375.00

CHAINAGE 0+400.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,919.0391	114,467.6120	828.1775	-4.402m	Ditch_Out
2	162,918.5318	114,466.2004	828.1775	-2.902m	Back_Curb
3	162,918.4811	114,466.0593	828.1775	-2.752m	Top_Curb
4	162,918.4670	114,466.0200	827.9775	-2.710m	Flowline_Gutter
5	162,918.4636	114,466.0106	827.9781	-2.700m	Flange
6	162,918.4636	114,466.0106	827.6281	-2.700m	ETW_Sub
7	162,918.4636	114,466.0106	827.8781	-2.700m	ETW_Pave1
8	162,916.6372	114,460.9289	827.8781	2.700m	ETW_Pave1
9	162,916.6372	114,460.9289	827.6281	2.700m	ETW_Base
10	162,916.6372	114,460.9289	827.9781	2.700m	ETW
11	162,916.6338	114,460.9194	827.9775	2.710m	Flowline_Gutter

12	162,916.6197	114,460.8802	828.1775	2.752m	Top_Curb
13	162,916.5690	114,460.7390	828.1775	2.902m	Back_Curb
14	162,916.0617	114,459.3274	828.1775	4.402m	Ditch_Out

CHAINAGE 0+425.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,942.5483	114,459.1079	827.9143	-4.350m	Sidewalk_Out
2	162,942.0410	114,457.6963	827.9143	-2.850m	Top_Curb
3	162,941.9903	114,457.5552	827.7643	-2.700m	Flowline_Gutter
4	162,941.9903	114,457.5552	827.7643	-2.700m	Flange
5	162,941.9903	114,457.5552	827.6643	-2.700m	ETW_Pave1
6	162,941.9903	114,457.5552	827.4143	-2.700m	ETW_Base
7	162,941.0771	114,455.0143	827.7183	0.000m	ETW_Pave1
8	162,941.0771	114,455.0143	827.4683	0.000m	ETW_Sub
9	162,941.0771	114,455.0143	827.8183	0.000m	ETW
10	162,940.1639	114,452.4734	827.7643	2.700m	Flange
11	162,940.1639	114,452.4734	827.7643	2.700m	Flowline_Gutter
12	162,940.1132	114,452.3322	827.9143	2.850m	Top_Curb
13	162,939.6058	114,450.9206	827.9143	4.350m	Ditch_Out

CHAINAGE 0+450.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,966.0750	114,450.6525	827.7005	-4.350m	Sidewalk_Out
2	162,965.5677	114,449.2408	827.7005	-2.850m	Top_Curb

3	162,965.5170	114,449.0997	827.5505	-2.700m	Flowline_Gutter
4	162,965.5170	114,449.0997	827.5505	-2.700m	Flange
5	162,965.5170	114,449.0997	827.4505	-2.700m	ETW_Pave1
6	162,965.5170	114,449.0997	827.2005	-2.700m	ETW_Base
7	162,964.6038	114,446.5588	827.5045	0.000m	ETW_Pave1
8	162,964.6038	114,446.5588	827.2545	0.000m	ETW_Sub
9	162,964.6038	114,446.5588	827.6045	0.000m	ETW
10	162,963.6906	114,444.0179	827.5505	2.700m	Flange
11	162,963.6906	114,444.0179	827.5505	2.700m	Flowline_Gutter
12	162,963.6399	114,443.8768	827.7005	2.850m	Top_Curb
13	162,963.1325	114,442.4652	827.7005	4.350m	Ditch_Out

CHAINAGE 0+475.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	162,989.6017	114,442.1970	827.5024	-4.350m	Sidewalk_Out
2	162,989.0944	114,440.7854	827.5024	-2.850m	Top_Curb
3	162,989.0437	114,440.6442	827.3524	-2.700m	Flowline_Gutter
4	162,989.0437	114,440.6442	827.3524	-2.700m	Flange
5	162,989.0437	114,440.6442	827.2524	-2.700m	ETW_Pave1
6	162,989.0437	114,440.6442	827.0024	-2.700m	ETW_Base
7	162,988.1305	114,438.1033	827.3064	0.000m	ETW_Pave1
8	162,988.1305	114,438.1033	827.0564	0.000m	ETW_Sub
9	162,988.1305	114,438.1033	827.4064	0.000m	ETW
10	162,987.2173	114,435.5625	827.3524	2.700m	Flange

11	162,987.2173	114,435.5625	827.3524	2.700m	Flowline_Gutter
12	162,987.1665	114,435.4213	827.5024	2.850m	Top_Curb
13	162,986.6592	114,434.0097	827.5024	4.350m	Ditch_Out

CHAINAGE 0+500.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	163,013.3898	114,434.4687	827.0671	-5.123m	Daylight
2	163,013.1284	114,433.7415	827.3246	-4.350m	Sidewalk_Out
3	163,012.6211	114,432.3299	827.3246	-2.850m	Top_Curb
4	163,012.5703	114,432.1888	827.1746	-2.700m	Flowline_Gutter
5	163,012.5703	114,432.1888	826.8246	-2.700m	ETW_Base
6	163,012.5703	114,432.1888	827.1746	-2.700m	Flange
7	163,012.5703	114,432.1888	827.0746	-2.700m	ETW_Pave1
8	163,011.6572	114,429.6479	826.8786	0.000m	ETW_Base
9	163,011.6572	114,429.6479	827.2286	0.000m	ETW
10	163,011.6572	114,429.6479	827.1286	0.000m	ETW_Pave1
11	163,010.7440	114,427.1070	827.1746	2.700m	Flange
12	163,010.7440	114,427.1070	827.1746	2.700m	Flowline_Gutter
13	163,010.6932	114,426.9658	827.3246	2.850m	Top_Curb
14	163,010.1859	114,425.5542	827.3246	4.350m	Ditch_Out

CHAINAGE 0+525.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	163,036.9239	114,426.0340	826.6871	-5.145m	Daylight

2	163,036.5404	114,424.9668	826.9706	-4.011m	Hinge
3	163,036.5404	114,424.9668	826.8706	-4.011m	ETW_Pave1
4	163,036.5404	114,424.9668	826.6206	-4.011m	ETW_Sub
5	163,034.1853	114,418.4141	826.9918	2.952m	Flange
6	163,034.1853	114,418.4141	826.6418	2.952m	ETW_Sub
7	163,034.1853	114,418.4141	826.8918	2.952m	ETW_Pave1
8	163,034.1853	114,418.4141	826.9918	2.952m	Flowline_Gutter
9	163,034.1346	114,418.2729	827.1418	3.102m	Top_Curb
10	163,033.6273	114,416.8613	827.1418	4.602m	Sidewalk_Out
11	163,032.9603	114,415.0056	826.6488	6.574m	Daylight

CHAINAGE 0+550.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	163,060.8924	114,418.8281	826.9771	-6.469m	Ditch_Out
2	163,060.3866	114,417.4160	826.9771	-4.969m	Sidewalk_In
3	163,060.3360	114,417.2748	826.9771	-4.819m	Top_Curb
4	163,060.3219	114,417.2355	826.7771	-4.777m	Flowline_Gutter
5	163,060.3186	114,417.2261	826.4277	-4.767m	ETW_Sub
6	163,060.3186	114,417.2261	826.7777	-4.767m	Flange
7	163,060.3186	114,417.2261	826.6777	-4.767m	ETW_Pave1
8	163,056.7718	114,407.3247	826.7581	5.750m	Flange
9	163,056.7718	114,407.3247	826.4081	5.750m	ETW_Base
10	163,056.7718	114,407.3247	826.6581	5.750m	ETW_Pave1
11	163,056.7685	114,407.3153	826.7575	5.760m	Flowline_Gutter

12	163,056.7544	114,407.2760	826.9575	5.802m	Top_Curb
13	163,056.7038	114,407.1348	826.9575	5.952m	Sidewalk_In
14	163,056.1980	114,405.7227	826.9575	7.452m	Hinge
15	163,056.0019	114,405.1752	826.8121	8.034m	Daylight

CHAINAGE 0+575.00

CHAINAGE 0+600.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	163,108.0642	114,402.6483	826.6180	-6.650m	Ditch_Out
2	163,107.5865	114,401.2264	826.6180	-5.150m	Sidewalk_In
3	163,107.5387	114,401.0842	826.6180	-5.000m	Top_Curb
4	163,107.5254	114,401.0447	826.4180	-4.958m	Flowline_Gutter
5	163,107.5222	114,401.0352	826.3186	-4.948m	ETW_Pave1
6	163,107.5222	114,401.0352	826.0686	-4.948m	ETW_Sub
7	163,107.5222	114,401.0352	826.4186	-4.948m	Flange
8	163,104.9751	114,393.4542	826.1065	3.049m	ETW_Base
9	163,104.9751	114,393.4542	826.4565	3.049m	ETW
10	163,104.9751	114,393.4542	826.3565	3.049m	ETW_Pave1
11	163,104.9719	114,393.4447	826.4559	3.059m	Flowline_Gutter
12	163,104.9586	114,393.4052	826.6559	3.101m	Top_Curb
13	163,104.9108	114,393.2630	826.6559	3.251m	Sidewalk_In
14	163,104.4331	114,391.8411	826.6559	4.751m	Ditch_Out
15	163,104.2441	114,391.2787	826.8043	5.344m	Daylight

CHAINAGE 0+625.00

CHAINAGE 0+650.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,155.4328	114,387.0535	826.7283	-6.460m	Daylight
2	163,154.9031	114,385.3670	826.2863	-4.692m	Ditch_Out
3	163,154.4536	114,383.9359	826.2863	-3.192m	Sidewalk_In
4	163,154.4087	114,383.7928	826.2863	-3.042m	Top_Curb
5	163,154.3962	114,383.7530	826.0863	-3.000m	Flowline_Gutter
6	163,154.3063	114,383.4668	825.7543	-2.700m	ETW_Sub
7	163,154.3063	114,383.4668	826.1043	-2.700m	Flange
8	163,154.3063	114,383.4668	826.0043	-2.700m	ETW_Pave1
9	163,152.6882	114,378.3149	825.7543	2.700m	ETW_Base
10	163,152.6882	114,378.3149	826.1043	2.700m	ETW
11	163,152.6882	114,378.3149	826.0043	2.700m	ETW_Pave1
12	163,152.5983	114,378.0287	826.0863	3.000m	Flowline_Gutter
13	163,152.5858	114,377.9889	826.2863	3.042m	Top_Curb
14	163,152.5409	114,377.8458	826.2863	3.192m	Back_Curb
15	163,152.0914	114,376.4147	826.2863	4.692m	Hinge
16	163,151.9674	114,376.0198	826.1828	5.106m	Daylight

CHAINAGE 0+675.00

CHAINAGE 0+700.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,203.2549	114,372.9129	826.1959	-6.804m	Daylight
2	163,202.6620	114,370.8857	825.6679	-4.692m	Ditch_Out
3	163,202.2410	114,369.4460	825.6679	-3.192m	Back_Curb
4	163,202.1989	114,369.3020	825.6679	-3.042m	Top_Curb
5	163,202.1872	114,369.2620	825.4679	-3.000m	Flowline_Gutter
6	163,202.1030	114,368.9740	825.3859	-2.700m	ETW_Pave1
7	163,202.1030	114,368.9740	825.1359	-2.700m	ETW_Sub
8	163,202.1030	114,368.9740	825.4859	-2.700m	Flange
9	163,200.5874	114,363.7911	825.4859	2.700m	Flange
10	163,200.5874	114,363.7911	825.1359	2.700m	ETW_Base
11	163,200.5874	114,363.7911	825.3859	2.700m	ETW_Pave1
12	163,200.5032	114,363.5031	825.4679	3.000m	Flowline_Gutter
13	163,200.4915	114,363.4631	825.6679	3.042m	Top_Curb
14	163,200.4494	114,363.3192	825.6679	3.192m	Sidewalk_In
15	163,200.0284	114,361.8794	825.6679	4.692m	Ditch_Out
16	163,199.9366	114,361.5655	825.7497	5.019m	Daylight

CHAINAGE 0+725.00

CHAINAGE 0+750.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,250.7617	114,357.5864	824.7010	-4.933m	Daylight
2	163,250.6987	114,357.3540	824.6408	-4.692m	Ditch_Out
3	163,250.3063	114,355.9062	824.6408	-3.192m	Sidewalk_In
4	163,250.2671	114,355.7614	824.6408	-3.042m	Top_Curb
5	163,250.2562	114,355.7212	824.4408	-3.000m	Flowline_Gutter
6	163,250.1777	114,355.4316	824.1088	-2.700m	ETW_Sub
7	163,250.1777	114,355.4316	824.4588	-2.700m	Flange
8	163,250.1777	114,355.4316	824.3588	-2.700m	ETW_Pave1
9	163,248.7651	114,350.2197	824.1088	2.700m	ETW_Base
10	163,248.7651	114,350.2197	824.4588	2.700m	ETW
11	163,248.7651	114,350.2197	824.3588	2.700m	ETW_Pave1
12	163,248.6866	114,349.9301	824.4408	3.000m	Flowline_Gutter
13	163,248.6757	114,349.8899	824.6408	3.042m	Top_Curb
14	163,248.6365	114,349.7451	824.6408	3.192m	Back_Curb
15	163,248.2441	114,348.2973	824.6408	4.692m	Hinge
16	163,248.1109	114,347.8057	824.4710	5.201m	Daylight

CHAINAGE 0+775.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,275.1193	114,351.9945	823.7763	-5.817m	Daylight
2	163,274.8301	114,350.9071	824.0577	-4.692m	Hinge
3	163,274.4446	114,349.4575	824.0577	-3.192m	Back_Curb

4	163,274.4060	114,349.3125	824.0577	-3.042m	Top_Curb
5	163,274.3953	114,349.2722	823.8577	-3.000m	Flowline_Gutter
6	163,274.3182	114,348.9823	823.5257	-2.700m	ETW_Sub
7	163,274.3182	114,348.9823	823.8757	-2.700m	Flange
8	163,274.3182	114,348.9823	823.7757	-2.700m	ETW_Pave1
9	163,272.9303	114,343.7637	823.5257	2.700m	ETW_Base
10	163,272.9303	114,343.7637	823.8757	2.700m	ETW
11	163,272.9303	114,343.7637	823.7757	2.700m	ETW_Pave1
12	163,272.8532	114,343.4738	823.8577	3.000m	Flowline_Gutter
13	163,272.8425	114,343.4335	824.0577	3.042m	Top_Curb
14	163,272.8040	114,343.2885	824.0577	3.192m	Back_Curb
15	163,272.4184	114,341.8389	824.0577	4.692m	Hinge
16	163,272.3164	114,341.4551	823.9584	5.089m	Daylight

CHAINAGE 0+800.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	163,299.2148	114,345.3260	823.1834	-5.565m	Daylight
2	163,298.9903	114,344.4818	823.4746	-4.692m	Hinge
3	163,298.6048	114,343.0321	823.4746	-3.192m	Back_Curb
4	163,298.5662	114,342.8872	823.4746	-3.042m	Top_Curb
5	163,298.5555	114,342.8469	823.2746	-3.000m	Flowline_Gutter
6	163,298.4784	114,342.5570	822.9426	-2.700m	ETW_Sub
7	163,298.4784	114,342.5570	823.2926	-2.700m	Flange

8	163,298.4784	114,342.5570	823.1926	-2.700m	ETW_Pave1
9	163,297.0905	114,337.3384	823.0239	2.700m	ETW_Base
10	163,297.0905	114,337.3384	823.3739	2.700m	ETW
11	163,297.0905	114,337.3384	823.2739	2.700m	ETW_Pave1
12	163,297.0134	114,337.0484	823.3559	3.000m	Flowline_Gutter
13	163,297.0027	114,337.0081	823.5559	3.042m	Top_Curb
14	163,296.9642	114,336.8632	823.5559	3.192m	Back_Curb
15	163,296.5786	114,335.4136	823.5559	4.692m	Hinge
16	163,296.2979	114,334.3580	823.2828	5.784m	Daylight

CHAINAGE 0+825.00

CHAINAGE 0+850.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,347.5008	114,338.5681	822.4164	-4.692m	Ditch_Out
2	163,347.4204	114,337.0703	822.4164	-3.192m	Sidewalk_In
3	163,347.4124	114,336.9205	822.4164	-3.042m	Top_Curb
4	163,347.4101	114,336.8789	822.2164	-3.000m	Flowline_Gutter
5	163,347.3940	114,336.5793	821.8844	-2.700m	ETW_Sub
6	163,347.3940	114,336.5793	822.2344	-2.700m	Flange
7	163,347.3940	114,336.5793	822.1344	-2.700m	ETW_Pave1
8	163,347.1045	114,331.1871	822.1264	2.700m	Flange
9	163,347.1045	114,331.1871	821.7764	2.700m	ETW_Base
10	163,347.1045	114,331.1871	822.0264	2.700m	ETW_Pave1

11	163,347.0884	114,330.8875	822.1084	3.000m	Flowline_Gutter
12	163,347.0862	114,330.8459	822.3084	3.042m	Top_Curb
13	163,347.0782	114,330.6961	822.3084	3.192m	Sidewalk_In
14	163,346.9977	114,329.1982	822.3084	4.692m	Hinge
15	163,346.9874	114,329.0061	822.2602	4.884m	Daylight

CHAINAGE 0+875.00

CHAINAGE 0+900.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,397.2885	114,332.7931	821.0331	-4.692m	Ditch_Out
2	163,397.1625	114,331.2984	821.0331	-3.192m	Sidewalk_In
3	163,397.1499	114,331.1489	821.0331	-3.042m	Top_Curb
4	163,397.1464	114,331.1074	820.8331	-3.000m	Flowline_Gutter
5	163,397.1212	114,330.8084	820.7511	-2.700m	ETW_Pave1
6	163,397.1212	114,330.8084	820.5011	-2.700m	ETW_Sub
7	163,397.1212	114,330.8084	820.8511	-2.700m	Flange
8	163,396.6674	114,325.4275	820.5946	2.700m	ETW_Base
9	163,396.6674	114,325.4275	820.9446	2.700m	ETW
10	163,396.6674	114,325.4275	820.8446	2.700m	ETW_Pave1
11	163,396.6422	114,325.1286	820.9266	3.000m	Flowline_Gutter
12	163,396.6387	114,325.0870	821.1266	3.042m	Top_Curb
13	163,396.6261	114,324.9376	821.1266	3.192m	Sidewalk_In

14	163,396.5001	114,323.4429	821.1266	4.692m	Ditch_Out
15	163,396.4775	114,323.1756	821.1936	4.960m	Daylight

CHAINAGE 0+925.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	163,422.2589	114,331.4884	820.5580	-5.452m	Daylight
2	163,422.1961	114,330.7307	820.3679	-4.692m	Ditch_Out
3	163,422.0724	114,329.2358	820.3679	-3.192m	Back_Curb
4	163,422.0600	114,329.0863	820.3679	-3.042m	Top_Curb
5	163,422.0566	114,329.0447	820.1679	-3.000m	Flowline_Gutter
6	163,422.0318	114,328.7458	820.0859	-2.700m	ETW_Pave1
7	163,422.0318	114,328.7458	819.8359	-2.700m	ETW_Sub
8	163,422.0318	114,328.7458	820.1859	-2.700m	Flange
9	163,421.5863	114,323.3642	820.1859	2.700m	Flange
10	163,421.5863	114,323.3642	819.8359	2.700m	ETW_Base
11	163,421.5863	114,323.3642	820.0859	2.700m	ETW_Pave1
12	163,421.5615	114,323.0652	820.1679	3.000m	Flowline_Gutter
13	163,421.5581	114,323.0236	820.3679	3.042m	Top_Curb
14	163,421.5457	114,322.8742	820.3679	3.192m	Sidewalk_In
15	163,421.4219	114,321.3793	820.3679	4.692m	Ditch_Out
16	163,421.3919	114,321.0170	820.4588	5.055m	Daylight

CHAINAGE 0+950.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,447.1004	114,328.5419	819.6957	-4.565m	Daylight
2	163,447.0915	114,328.4339	819.6686	-4.457m	Ditch_Out
3	163,446.9678	114,326.9390	819.6686	-2.957m	Sidewalk_In
4	163,446.9554	114,326.7896	819.5186	-2.807m	Flowline_Gutter
5	163,446.9554	114,326.7896	819.1686	-2.807m	ETW_Sub
6	163,446.9554	114,326.7896	819.5186	-2.807m	Flange
7	163,446.9554	114,326.7896	819.4186	-2.807m	ETW_Pave1
8	163,446.7238	114,323.9923	819.5748	0.000m	ETW
9	163,446.7238	114,323.9923	819.2248	0.000m	ETW_Base
10	163,446.7238	114,323.9923	819.4748	0.000m	ETW_Pave1
11	163,446.4924	114,321.1977	819.5187	2.804m	Flange
12	163,446.4924	114,321.1977	819.5187	2.804m	Flowline_Gutter
13	163,446.4801	114,321.0482	819.6687	2.954m	Top_Curb
14	163,446.3563	114,319.5533	819.6687	4.454m	Ditch_Out

CHAINAGE 0+975.00

CHAINAGE 1+000.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	163,497.5793	114,324.7630	817.7002	-6.902m	Daylight
2	163,497.3388	114,323.4522	818.3665	-5.569m	Sidewalk_Out
3	163,497.0681	114,321.9769	818.3665	-4.069m	Sidewalk_In
4	163,497.0410	114,321.8293	818.3665	-3.919m	Top_Curb

5	163,497.0335	114,321.7883	818.1665	-3.877m	Flowline_Gutter
6	163,497.0317	114,321.7785	818.1671	-3.867m	Flange
7	163,497.0317	114,321.7785	817.8171	-3.867m	ETW_Sub
8	163,497.0317	114,321.7785	818.0671	-3.867m	ETW_Pave1
9	163,495.8458	114,315.3159	818.0904	2.703m	ETW_Pave1
10	163,495.8458	114,315.3159	817.8404	2.703m	ETW_Base
11	163,495.8458	114,315.3159	818.1904	2.703m	ETW
12	163,495.8440	114,315.3061	818.1898	2.713m	Flowline_Gutter
13	163,495.8365	114,315.2651	818.3898	2.755m	Top_Curb
14	163,495.8094	114,315.1175	818.3898	2.905m	Back_Curb
15	163,495.5387	114,313.6422	818.3898	4.405m	Ditch_Out

CHAINAGE 1+025.00

Station and Curve

Tangent Data

Description	PT Station	Northing	Easting
Start:	0+00.000	114766.528	162675.327
End:	0+56.117	114716.722	162701.180

Tangent Data

Parameter	Value	Parameter	Value
Length:	56.117	Course:	S 27° 25' 58.8491" E

Curve Point Data

Description	Station	Northing	Easting
PC:	0+56.117	114716.722	162701.180
RP:		115085.291	163411.220
PT:	1+44.891	114640.358	162746.363

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	06° 21' 28.8043"	Type:	LEFT
Radius:	800.000		
Length:	88.774	Tangent:	44.433
Mid-Ord:	1.231	External:	1.233
Chord:	88.729	Course:	S 30° 36' 43.2512" E

Tangent Data

Description	PT Station	Northing	Easting
Start:	1+44.891	114640.358	162746.363
End:	2+16.450	114580.888	162786.161

Tangent Data

Parameter	Value	Parameter	Value
Length:	71.559	Course:	S 33° 47' 27.6534" E

Curve Point Data

Description	Station	Northing	Easting
PC:	2+16.450	114580.888	162786.161
RP:		114084.150	162043.892
PT:	2+55.104	114548.308	162806.958

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	02° 28' 46.8647"	Type:	RIGHT
Radius:	893.148		
Length:	38.654	Tangent:	19.330
Mid-Ord:	0.209	External:	0.209
Chord:	38.651	Course:	S 32° 33' 04.2210" E

Tangent Data

Description	PT Station	Northing	Easting
Start:	2+55.104	114548.308	162806.958
End:	2+91.881	114516.888	162826.071

Tangent Data

Parameter	Value	Parameter	Value
Length:	36.777	Course:	S 31° 18' 40.7886" E

Curve Point Data

Description	Station	Northing	Easting
PC:	2+91.881	114516.888	162826.071
RP:		114556.392	162891.015
PCC:	3+35.854	114487.807	162858.236

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	33° 08' 38.9904"	Type:	LEFT
Radius:	76.015		
Length:	43.973	Tangent:	22.621
Mid-Ord:	3.158	External:	3.294
Chord:	43.362	Course:	S 47° 53' 00.2838" E

Curve Point Data

Description	Station	Northing	Easting
PCC:	3+35.854	114487.807	162858.236
RP:		114992.781	163099.578
PT:	3+92.277	114466.082	162910.283

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	05° 46' 34.0314"	Type:	LEFT
Radius:	559.683		

Length:	56.423	Tangent:	28.235
Mid-Ord:	0.711	External:	0.712
Chord:	56.399	Course:	S 67° 20' 36.7947" E

Tangent Data

Description	PT Station	Northing	Easting
Start:	3+92.277	114466.082	162910.283
End:	5+47.334	114413.639	163056.201

Tangent Data

Parameter	Value	Parameter	Value
Length:	155.057	Course:	S 70° 13' 53.8104" E

Curve Point Data

Description	Station	Northing	Easting
PC:	5+47.334	114413.639	163056.201
RP:		116787.114	163909.226
PT:	7+61.948	114349.727	163261.011

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	04° 52' 31.7612"	Type:	LEFT
Radius:	2522.109		
Length:	214.615	Tangent:	107.372

Mid-Ord:	2.282	External:	2.285
Chord:	214.550	Course:	S 72° 40' 09.6910" E

Tangent Data

Description	PT Station	Northing	Easting
Start:	7+61.948	114349.727	163261.011
End:	8+02.719	114339.249	163300.412

Tangent Data

Parameter	Value	Parameter	Value
Length:	40.771	Course:	S 75° 06' 25.5716" E

Curve Point Data

Description	Station	Northing	Easting
PC:	8+02.719	114339.249	163300.412
RP:		114484.210	163338.964
PCC:	8+39.789	114334.222	163337.045

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	14° 09' 34.9260"	Type:	LEFT
Radius:	150.000		
Length:	37.070	Tangent:	18.630
Mid-Ord:	1.144	External:	1.152

Chord:	36.976	Course:	S 82° 11' 13.0346" E

Curve Point Data

Description	Station	Northing	Easting
PCC:	8+39.789	114334.222	163337.045
RP:		114084.243	163333.846
PCC:	8+77.565	114330.892	163374.638

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	08° 39' 27.5822"	Type:	RIGHT
Radius:	250.000		
Length:	37.776	Tangent:	18.924
Mid-Ord:	0.713	External:	0.715
Chord:	37.740	Course:	S 84° 56' 16.7065" E

Curve Point Data

Description	Station	Northing	Easting
PCC:	8+77.565	114330.892	163374.638
RP:		114608.340	163420.524
PT:	9+00.428	114328.082	163397.321

Circular Curve Data

Parameter	Value	Parameter	Value

Delta:	04° 39' 29.4010"	Type:	LEFT
Radius:	281.217		
Length:	22.863	Tangent:	11.438
Mid-Ord:	0.232	External:	0.233
Chord:	22.857	Course:	S 82° 56' 17.6159" E

Tangent Data

Description	PT Station	Northing	Easting
Start:	9+00.428	114328.082	163397.321
End:	9+61.456	114323.047	163458.140

Tangent Data

Parameter	Value	Parameter	Value
Length:	61.027	Course:	S 85° 16' 02.3164" E

Curve Point Data

Description	Station	Northing	Easting
PC:	9+61.456	114323.047	163458.140
RP:		113934.552	163425.977
PT:	10+50.000	114305.826	163544.800

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	13° 00' 50.7242"	Type:	RIGHT

Radius:	389.824		
Length:	88.544	Tangent:	44.463
Mid-Ord:	2.511	External:	2.528
Chord:	88.354	Course:	S 78° 45' 36.9544" E