# Palestine Polytechnic University

College of Engineering and Technology
Civil & Architecture Engineering Department

Project Title

# Infrastructure Evaluation Of The Hebron Old City and Re-Design part of it

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Hebron – Palestine

May-2014

## CERTIFICATION

Palestine Polytechnic University
(PPU)

Hebron – Palestine

The Project Entitled:

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BY


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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

May-2014

# اهداء

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

إلـــى.....

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

إلـــى....

انهار المحبة التي لا تنضب..........أمهاتنا الأحبة

إلـــى....

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

إلـــى....

كافة الأهل والأصدقاء

إلـــى....

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

إلـــى....

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

إلـــى....

من وصلت رائحة دمائهم الزكية الى السماء الندية .......شهداؤنا الابرار

فريق العمل

# ACKNOWLEDGMENT

We would like to thank and gratitude to Allah, the most merciful who granted us the ability and willing to start the project.

We thank the Palestine Polytechnic University, Department of Civil Engineering and Architecture, and extend our thanks and appreciation for each of the Hebron municipality, the Committee of Construction and the Meteorological Department for their efforts and support us in this project.

This project would not have been possible without the assistance of many individual. We are grateful to these people, who volunteered their time and volunteered their time and advice,
Specially Eng. Samah AL-Jbari, and all of who help us to finish this project.

Finally, our deep sense and sincere thanks to our parents, brothers and sisters for all patience, and for their endless support and encouragement.

This graduation project has been supported by the deanship of graduate studies and scientific research through "Distinguished Graduation Project Fund"

# Abstract

Infrastructure Evaluation of the Hebron Old City and Re-design Part of it

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Hebron Old City is the area that is located in the southern part of Hebron City it has a large religious and historical value and it has a big concern from the Palestinian authority and other Arab and foreign institutions.

This area is facing a problem in its infrastructure such as roads, networks, buildings, schools, Shops, these problems was raising in the last few years and they are accelerated to make the situation in this area very dangerous. So a study and evaluation for the current situation the existing infrastructure , problems analysis and solving it must be doing to sustain Hebron Old City in a good status.

The current study concern in studying and evaluating the main parts of infrastructure in the most important area in Hebron City which is the Old City then analyzing the problems and solving it through making a re-design for some parts that are deteriorated and by making complete design for other parts .

The results of the presents study show that the Hebron old city face an infrastructure problems caused by absence of important parts of physical infrastructure and by deterioration of other parts.

Project team concern with this area and the most important part of infrastructure will be designed which are : waste water collection system , storm water drainage system and re-design for the worst road in the Hebron old city .These parts of infrastructure reduce problems improve the life standards in the Hebron old city.

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# CHAPTER ONE

# INTRODUCTION

## 1.1 General

Infrastructure is the basic physical systems of a country's or community's, it is including roads ,utilities ,networks ,school ,building ,shops etc. These systems are considered as an essential part for enabling productivity and sustainability.

Developing infrastructure often requires large initial investment, high Engineering skills ,broad institutional cooperation and public and individual contribution .

Palestinian cities does not have a complete infrastructure, since it is now in a building ,rebuilding and reconstructure stage .At least many Palestinian cities does not have drainage system ,water network, highways, roads which have the most important part of infrastructure.

## 1.2 Problem Definition

Hebron city like most cities in Palestine have no complete infrastructure, the most important part of Hebron city is the old city which is located in the southern part of Hebron , this area has an important religious and historical value, so the Palestine authority and many foreign agency's give this area big concern.

Hebron old city which is located in the Sothern part of the city, it has the lowest elevation .Is suffering from a bad situation of its infrastructure there is no storm water collection system, bad condition of wastewater collection system , road deterioration and destoried buildings and shops.

During heavy rains in winter , rain water accumulates in the old city. it is the lowest lying area of the Hebron city whereas most residential areas located on surrounding slopes. Overflow water flood streets that storm water raises through the sewers casing sewage over flow from manholes and inlets in houses and streets. note that the system used in the old city is combined system which means making a wastewater and storm water drainage system working togather in the same pipe. this making the problem bigger and it's come to be really danger, that because the flooding of the drainage system impact on the quality of life in the old city , it prevent residents , visitors and shoppers from entering the old city, most shops in the old city is closed in this situation and the houses and shops foundation and walls are deteriorated and by the time it will be damaged.

Note that all quantity of storm water and wastewater which is collected from Hebron city is entering the old city that the systems are design by gravity from the highest point to the lowest and this duplicate the problem in the old city. Fig 1.1 and 1.2 show the situation in the old city in winter time.

Fig (1.1) Hebron old city in winter time.

Fig (1.2) Markets and shops in the Hebron old city in winter time.

## 1.3 Objectives and goals

The very crowded area and high population density, without expanding in the boundary of the old city, and the high pressure on the infrastructure networks make the old city in a serious environmental and infrastructure problems. to reduce these problems the project team looking to make an evaluation for the existing infrastructures and facilities of the Hebron old city.

The most important goal of the study is to evaluate and assess the situation of the existing infrastructure in the old city and then making a design or redesign for some part of it.

**The objectives can be explained as:-**

**1. Evaluate and assess the existing situation of the old city infrastructure:**

This will be done by making many visits to the old city to make a deep study for the existing situation, and by making a problem discussion with those who are living there and with those who serve that area like Hebron municipality and Hebron Rehabilitate Committee, also a review of previous studies, workshops conclusions, and taking an opinion of some people who are having a good vision for the Hebron Old City future situation .

These steps will be done by taking all of the infrastructure component into account, so that all networks such as water, wastewater, storm water, roads will be evaluated, a fast view of the cultural, economical, environmental aspects will discussed and the infrastructure network will having the main concern.

**2. Design and/or redesign of some parts of the old city infrastructure:**

After making an evaluation for the infrastructure in the old city, project team will take a decision by making a design and/ or a redesign for the worst part of infrastructure and giving their recommendation to give the old city good and complete facilities of infrastructure.

## 1.4 Importance of the project

It is simply known that the old part of any city is the most important part of it because old parts always having a historical worth and in many cases religious values, and this is concern as a worthy heredity

Hebron old city was built in the third millennium BC by the Canaanites. many civilizations were lived there like Turkish, Assyrians, Babylonians horsemen, Greeks, Romans, and Byzantines. Ibrahim mosque and Ibrahim Takia is located in that area. The special design of market place is seen in the old city , all of these things giving Hebron old city a great value , Palestinian authority, and many foreign agencies give this area big concern ,they looking after Hebron old city as a rudimental piece.

## 1.5 Methodology

1. Site visits to Hebron Old City , Hebron Rehabilitation Committee , and Hebron Municipality were done.
2. All needed maps and photos were obtained.
3. All previous studies , statistical studies for Old City were obtained.
4. quantities such as water consumption , waste water production , rain water depth were obtained.
5. Infrastructure evaluation will be done after study and discussion of the existing situation.
6. Design and / Redesign for some parts of infrastructure specially those which causes a big problem in the Old City will be done.
7. All calculations and drawings for the selected parts will be done.
8. Finalizing the project by writing a complete report showing the outcomes of evaluation and design.

## 1.6 Phases of the project

The project will consist of four phases as shown in the table 1.1

Table 1.1: Phases of the Project With Their Expected Duration.

| Title / (week ) | Duration/2014 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 9/13 | 10/13 | 11/13 | 12/13 | 01/14 | 02/14 | 03/14 | 04/14 | 05/14 |
| Data collection and survey | | | | | | | | | |
| Infrastructure evaluation | | | | | | | | | |
| Design and or re-design of some parts of infrastructure | | | | | | | | | |
| Writing the report and preparing maps | | | | | | | | | |

### 1.6.1 First Phase: Data collection and survey

In this phase available data information , maps , drawings , statistical studies and previous studies from different sources were collected through many visits to the Old City , Hebron Rehabilitation Committee , Hebron Municipality and Meteorological department.

This phase include the following tasks:-

1. Many visits to the Old City.
2. Collecting of maps and drawing.
3. Collecting of meteorological and hydraulic data.
4. Review the statistical data.
5. Review the previous studies.

### 1.6.2 Second Phase : Infrastructure Evaluation

After study the previous data in the first phase , an evaluation and assessment for the existing infrastructure will be done.

### 1.6.3 Third Phase : Design and/or-design of some parts of infrastructure

After making an evaluation of the infrastructure Old City decision will be of the infrast in the old city taken to make design or re-design for the worst part of infrastructure which cause a serious problem for that area.

In this phase calculations , analysis , design , drawing , profiles , maps will be prepare .

### 1.6.4 Fourth Phase : Writing the report

After finishing all of the above three phases , Project team will prepare a complete report.

## 1.7 Organization of the project

The project report will be prepared in accordance with the objectives and scope of work. The report will consist of six chapter . The first chapter entitled "*Introduction*" outlines the problem , project objectives , and phases of the project

Chapter two entitled "*Characteristic of the project area*" presents basic background data and information on the project area , water supply , waste water disposal and rain water quantities .

Chapter three entitled "*Infrastructure evaluation*" deals with an assessment of the existing infrastructure in the Old City through studying the current situation and discussing the problem.

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

Chapter five entitled "*Analysis and Design*" present the design calculation and maps of the part of infrastructure that the team will design it .

Chapter sex entitled "*Bill of quantity*".

Chapter seven entitled "*Conclusion and Recommendation*" discusses the conclusions of the study and show the recommended ideas and the future steps.

# CHAPTER TOW

# CHARACTERISTICS OF THE PROJECT AREA

## 2.1 General

In this chapter, the basic data of The Old city of Hebron will be discussed briefly. The location, topography, and climate. water consumption, wastewater production rainfall will be briefly presented.

## 2.2 Project Area

Hebron is one of the Palestinian cities. That is located in the heart of the southern part of the Palestine its latitude 31:31 north, longitude 35:8 east. It is the largest city in the West Bank, and it is traditionally the commercial hub of the southern part of West Bank see fig (2.1) .

The city of Hebron (al-Khalil in Arabic) is one of the oldest inhabited cities in the world, and its history dates back more than 4,000 years . Hebron is the fourth holiest city for Muslims after Mecca, Medina, and al-Quds. al-Ibrahim mosque, the Sanctuary of Abraham, the old city of Hebron is one of the ancient historical, religious, and heritage sites in Palestine .

The population of Hebron about a quarter million people. Lives in the city about ninety thousand. As for the area around the city of Hebron are "30" thirty square kilometers.

The old city of Hebron is located in the sothern part of Hebron city as shown in fig (2.2) it has area (42 km2 ) it has a population of 40000 that lives in many neighborhoods [3] .

The main old neighborhoods in Hebron old city are : the neighborhood of Sheikh Ali albakaa , Algazzazen neighborhood , neighborhood Alsoakna , Aljabari neighborhood, neighborhood Bany daar , Abu sninh Alakabh , Almuhtsbeen neighborhood , neighborhood Qaton , neighborhood Almsharqa , Alsahla neighborhood. See fig (2.3).

## 2.3 Meteorological Data

The hydrology of region depends primarily on its climate, and secondarily on its topography. Climate is largely dependent on geographical position of the earth surface; humidity, temperature, and wind. These factors are affecting evaporation and transpiration. So this study will include needed data about these factors, since they play big role in the determination of quantites that are needed for design .

The climate of Old city tends to be cold in winter and warm in summer. with limited amount of rain, the percentage of yearly rainfall about 500 mm, and relatively humid.

### 2.3.1 Rainfall

The average annual rainfall in Old city is about 471 mm ,Rainfall occurs between November and April while it has no rains in the summer season from June to September , the maximum annual rainfall in the period from 2003 to 2013 is 604mm. this was in year 2011/2012 .The annual rainfall during the period from ( 2003-2013) for Old city is shown in table(2.1).

Table (2.1): annual rainfall during the period (2003-2013) for Old city.[ 5 ]

| Year | 2003-2004 | 2004-2005 | 2005-2006 | 2006-2007 | 2007-2008 |
|---|---|---|---|---|---|
| Annual rainfall(mm) | 465.9 | 595.0 | 414.0 | 529.6 | 329.6 |
| Year | 2008-2009 | 2009-2010 | 2010-2011 | 2011-2012 | 2012-2013 |
| Annual rainfall(mm) | 409.2 | 470.0 | 438.0 | 604 | 454.7 |

### 2.3.2 Temperature

The temperature is characterized by considerable variation between summer and winter times. The mean temperature values at Hebron City are given in Table (2.2). The following mean and maximum value are shown:

- The mean maximum temperature: 20 $^{0}$C

- The mean minimum temperature: 11 $^0$C [ 5 ].

### 2.3.3 Relative Humidity

The relative humidity in Hebron City varies between 45-78%, it reaches the maximum value in January (78%) ; The relative humidity of Hebron City is shown in Table (2.2). [ 5 ]

Table (2.2): mean monthly minimum and maximum temperature(˚C) &mean monthly relative humidity (%) for the last 25 year . [ 5 ].

| Month | Maximum Temperature (˚C) | Minimum Temperature (˚C) | Relative Humidity (%) |
|---|---|---|---|
| **September** | 26.0 | 15.9 | 59.0 |
| **October** | 23.2 | 14.0 | 56.0 |
| **November** | 17.5 | 9.9 | 60.0 |
| **December** | 12.1 | 5.6 | 60.0 |
| **January** | 10.2 | 4.0 | 78.0 |
| **February** | 11.5 | 4.7 | 74.0 |
| **March** | 14.6 | 6.5 | 71.0 |
| **April** | 19.6 | 9.9 | 52.0 |
| **May** | 23.6 | 13.2 | 49.0 |
| **June** | 25.9 | 15.8 | 53.0 |
| **July** | 27.2 | 17.0 | 45.0 |
| **August** | 27.2 | 17.0 | 75.0 |

### 2.3.4 Wind

The average wind speed in Hebron is about 5.19 (Km/h), the maximum wind speed in the January is 6.93(km/h). The directions and velocities of wind vary depending on the season of the year. In Winter , the wind blows in the morning from the southwest.

In Summer , north easting wind blows all day long. According to data obtained from Meteorological station . [ 5]

## 2.4 Population

The ideal approach for the population forecasting is by the study and use of previous census records, which cover along period. The longer the period, and the more comprehensive the census data, the more accurate will be the results, which will be obtained. In the analysis of these data, demographical, economical and political factors should be considered in order to develop a method of forecasting which will predict the expected growth rate, future population and its distribution in the different zones of the area under consideration.

Prediction of the future population of Old town is very difficult due to the lack of reliable historic data, and the political uncertainties which will greatly influence future social and economic development. At the same time, the available data on past population growth do not constitute a reliable basis for projecting the future population growth in Old town .

In addition to the current setuation that most of the resedent of the Old city left it due to the bad condition and so they left their houses impty in some cases , some peoble from out side Hebron city come to site thes house and so this condition make the predction of future population very difficult.

The base for the forecasting is the 2007 population for Old town obtained from PCBS of 40000 inhabitants. The rate of population growth for the purpose of our study is 1.2%, it is based on a deep discussion with instituation that looking to and monitor the condition in the Old city like Hebron municipility and Hebron Rehabilitation committee.[ 4 ].

To calculate the population at the end of the design period (year 2038), a geometric increase is assumed, represented by the following equation:

$$P = P_{\circ} \ (1+R\ )^{n} \qquad (2.1)$$

Where, P is the future population , $P_{\circ}$ is the present population , r is the annual population growth rate, and n is the period of projection.

Using the above assumption and equation, Table (2.3) presents the population projection up to the design horizon of 2038. The data show that the population of Old town is estimated to be 57300 capita in year 2038.

Table (2.3): Population forecasts for Old town.

| Year | 2007 | 2017 | 2027 | 2038 |
| --- | --- | --- | --- | --- |
| Population | 40000 | 45100 | 50800 | 57300 |

## 2.5 Water Consumption

According to the water consumption data obtained from Hebron municipality, the current water consumption was 65 liters per capita per day, and the future water consumption is 120 liters per capita per day. [ 3 ]

## 2.6 Wastewater Quantity

Assumed that the wastewater generated from the individual in the city of Hebron equal to 80% of consumption , which is equivalent to 96 ( liters / capita / day) . The total output is equivalent to the default 15370 ($m^3$ / day) . As for the actual outflow ranges (approximately 11,000 to 12,000 $m^3$ / day). But in the winter ( rainy days ) outflow becomes approximately three times the daily amount .[ 3] .

# CHAPTER THREE

# INFRASTUCTURE EVALUATION

## 3.1 GENERAL

This chapter makes an evaluation of the Hebron Old City . This evaluation is depending on many factors such as location , population , economic condition , and infrastructure conditions .

To make this evaluation easer the following major topics will study for the Old City :

- General information that contain ; geographic location, historical background , and area at present.

- Demographic information that contains ; population , residential condition , and economic conditions.
- Infrastructure services that contain ; municipal services , organization , programs and activities.

## 3.2 General Information :

### 3.2.1 Geographic location :

The Old City of Hebron is located in the southern part of the city as shown in fig (3.1).

The Old City started from allocation called Bab Alzaweya and ended in allocation called Qaiton as shown in fig (3.2).

The Old City is the lowest part of the City , that the highest point in the Hebron City is Ras Aljoura which reach (1005 m) in its elevation and this is in the north part of City , elevation decreases until it reach the Old City that the lowest point in the Old City which called Qaiton has (875 m) in its elevation , note that the highest point in the Old City is in Bab Alzaweya which has (900 m) in its elevation this is shown in appendix C (c-1) .

### 3.2.2 History of the old city

The city was established in the third millennium BC by the Canaanites , Where the city suffered for many successive campaigns of invasion by the Assyrians, Babylonians horsemen , Greeks , Romans , and Byzantines , The city has opened by Islamic Arabs in the seventh century AD . Hebron is also venerated by Muslims for its association with Abraham and was traditionally viewed as one of the "four holy cities of Islam " To contain Islamic historical landmarks and relics as the existence of the Ibrahimi Mosque , the Takia Ibrahimeya and the sultan pool which shown in the fig (3.3).

### 3.2.3 present area:

The importance of the Old City do not stop at the borders of historical and archaeological significance, as the Old City occupies 20% of the area of the city of Hebron, an area of 42 square kilometers .

The Old City in the south-east of the city of Hebron , and bounded on the north Bab Alzawia , and in the south Al fahes where the Sahleh and shuhadaa street in the west , and keryat arbaa to the east. Hebron old city boundary is shown in fig (3.4)

### 3.2.4 population:

The population of the city of Hebron,200,000 people are concentrated in the following areas: the area of Ain Sarah, Bab Alzawiea ,and the Old City area ,Al Salam Street, and we are in our project that are focused on the preparation of the Old City with a population of approximately 40,000.[9]

The old City is one of the areas with relatively high population density in the city of Hebron, the reason for this is due to the special case that distinguish this region from the rest of the city where the old town suffer the practices of the Israeli occupation which prevents the urbanization

the following map well shown Densities of population in Hebron City .Figure (3.5).

The sanitary network of Hebron City is a combined system , that collect wastewater and storm water in the same pipe . This system in Hebron city running by gravity except in seven point that are : Ramah Suburb pump station , Beit Kahil pump station, Farsh Alhawa pump station , Haskah pump station , Alzyton suburb pump station , The central vegetable market pump station , nnkor pump station (Korea Center).

This locations used pump to raise the flow to the highest point , and then to run with the hole system by gravity . Appendix C (c-5)

This system is designed by Hebron Municipality Engineers since 1950 and now the municipality looking to make a new design that use a separated system , so as to make two networks , One for collect wastewater , the other for collect storm water . And this will be done in the coming years.

The system that is used in the Old City is a combined system also , but it used a Roman pipes that is situated in the Old City before hundreds of years

The fig (3.13) and appendix C (c-6) show the roman profile, this pipe has (2 m) in its diameter , it has the ability to dispose the wastewater for the hole City including the Old City in summer days.

But in winter a very big problem is raised because the quantity of flow is exceed its ability to dispose , and this causing an accumulation of polluted water in the Old City streets and it prevent tourists to enter the Old City . Fig (3.14),( 3.15) show the water accumulated in the Old City.

Fig 3.14 the water accumulated in the Old City.[ 3 ]

Fig 3.15 the water accumulated in the Old City.[ 3 ]

The accumulation of the polluted water causing a big environmental and health full problems.

In addition the system inlets in the Old City is closed due to the bad use of it, So that the population , put waste , stones and soil in this inlets , in the summer days and so it cannot worked especially in the winter as shown in fig (3.16) ,(3.17).

Fig 3.16the manholes in the Old City

Fig 3.17 the system inlets in the Old City

Also the closed iron gate that is located in the far away of the Old City makes the problem more complicated , it closed by Israeli occupation to prevent the Palestinian people to enter that area , this closed gate accumulate the water in many meters to make the problem so dangerous , as shown in fig (3.18).

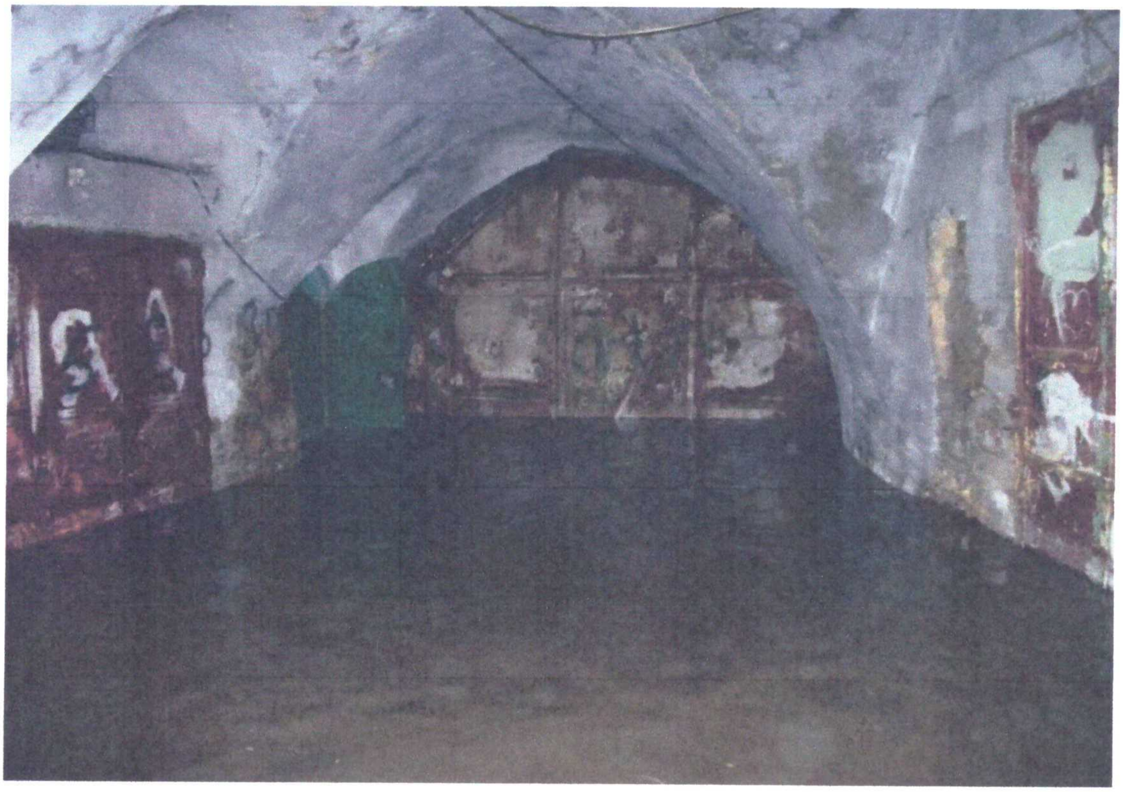


Fig 3.18 closed iron gate [ 3 ]

**Secondly** :- the roads in Old city is taking a special design ( Old city ) that use stone , berks , these roads is rehabilitate by Hebron rehabilitation committee to sustain its old style on the other hand some roads use asplulte in its design and this roads is in bad condition and so it needs to re-design .

**Thirdly :-** water network , electrical network and communication network are a new networks and they are is a good condition .

## 3.4 Next Step :

After studying , discussing , Analysing and Evaluating the situation of the Hebron Old city infrastructure project team take adecession to make a complete design for waste water collection system and storm water drainage system using a dry wither flow that means each system will done separately to prevent flooding in winter time and also to take benefits from rain water and finally to reduce pressure on the future treatmrnt plant that will be in the west of ytah city also project team will make a re-design for AL-Shalalh road that has a bad condition , this will be done next semester.

## 3.4 Roads Evaluation

According to our study of Hebron old city roads we classified it into three main types which are :-

1- Asphalt roads : Al-Shalaleh old road and Beer Alsaba road.

2- Stone roads : Al-Shalaleh new road ,Sowq Alkhawajat road , Beit Hadassah road , Sowq Askafa road , Sowq Aldjaj road and Sowq Allaban road.

3- Tile roads : Salah Aldin road and AlZaheda road.

All roads are good and has been rehabilitated expect Alshahaheh old road which our study focused in it.

The location of the roads and its names are illustrated in fig (3.19).

### 3.4.1 Roads pictures:

Fig 3.20 Sowq Askafah road "stone"

Fig 3.21 Shalalh road's new "stone"

Fig 3.22 Beit Hadassah road "stone"

Fig 3.23 Salah al-Din road, "tiling"

Fig 3.24 Shalalh road, the old "asphalt"

Fig 3.25 Sowq el-djaj road "stone"

Fig 3.26 Sowq Al-ban road "stone"

Fig 3.27 Sowq Khawagat road" stone"

Fig 3.28 AL-Zaheda road "tile"

Fig 3.29 Beersheba road "Asphalt"

### 3.4.2 Evaluation schedule :

| NAME | TYPE | Rating |
|---|---|---|
| Shalalh road, the old | asphalt | Bad need rehabilitation |
| Shalalh road's new | stone | Good "has been rehabilitated" |
| Sowq Khawagat road | stone | Good "has been rehabilitated" |
| Beit Hadassah road | stone | Good "has been rehabilitated" |
| Salah al-Din road | tile | Good "has been rehabilitated" |
| Sowq Askafah road | stone | Good "has been rehabilitated" |
| Sowq el-djaj road | stone | Good "has been rehabilitated" |
| Sowq Al-ban road | stone | Good "has been "rehabilitated |
| AL-Zaheda road | tile | Good "has been rehabilitated" |
| Beersheba road | Asphalt | Bad need rehabilitation |

# 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.[13]

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.[3]

### 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.[3]

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).[3]

**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.[7]

### 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.[7]

**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.[13]

### 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.[12]

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.

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. [12]

**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.[3]

**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 .[7]

### 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. [13]

**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.[3]

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.

## 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 :

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.[11]

### 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.[11]

**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. [10]

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:

$$C = \frac{\sum Ci.Ai}{\sum Ai} \qquad (4.4)$$

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 4.1 and Table 4.2).

Table 4.1: The Range of Coefficient With Respect to General Character of the Area[10]

| Description of Area | Runoff Coefficients |
|---|---|
| Business | |
| Down town<br>Neighborhood | 0.70 to 0.95<br>0.50 to 0.70 |
| Residential | |
| Single-Family<br>Multi-unit, detached<br>Multi-unit, attached | 0.30 to 0.50<br>0.40 to 0.60<br>0.60 to 0.75 |
| Residential (suburban) | 0.25 to 0.40 |
| Apartment | 0.50 to 0.70 |
| Industrial | |
| Light<br>Heavy | 0.50 to 0.80<br>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[10]

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

$$i\left(\frac{l}{s.ha}\right) = 166.7i\left[\frac{mm}{\min}\right] \quad (4.5)$$

### 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; $C = \dfrac{100\sqrt{R}}{m+\sqrt{R}}$.

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.[4]

Darcy-Weishbach formula states that

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

Where H: the pressure head loss ( mwc ).

L: the length of pipe (m).

D: the diameter of pipe (m)

$\lambda$ : the dimensionless friction factor generally varying between 0.02 to 0.075.

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

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

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

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 [10]

| **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 |
| **Material** | **Commonly Used Values of n** |

| | |
|---|---|
| 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%.[11]

## 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 :

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.[11]

**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.

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.

**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) [11]

| **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 |

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.[11]

6. Appurtenances

Storm Sewer appurtenances include manholes, inlets, outlets and outfall, and other Appropriate storm sewer appurtenances must be selected in design of storm water sewers. [10]

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:

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

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

$$Q = C.i.A \qquad (4.10)$$

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 Fig (4.1 and 4.2), one can design the drainage system.

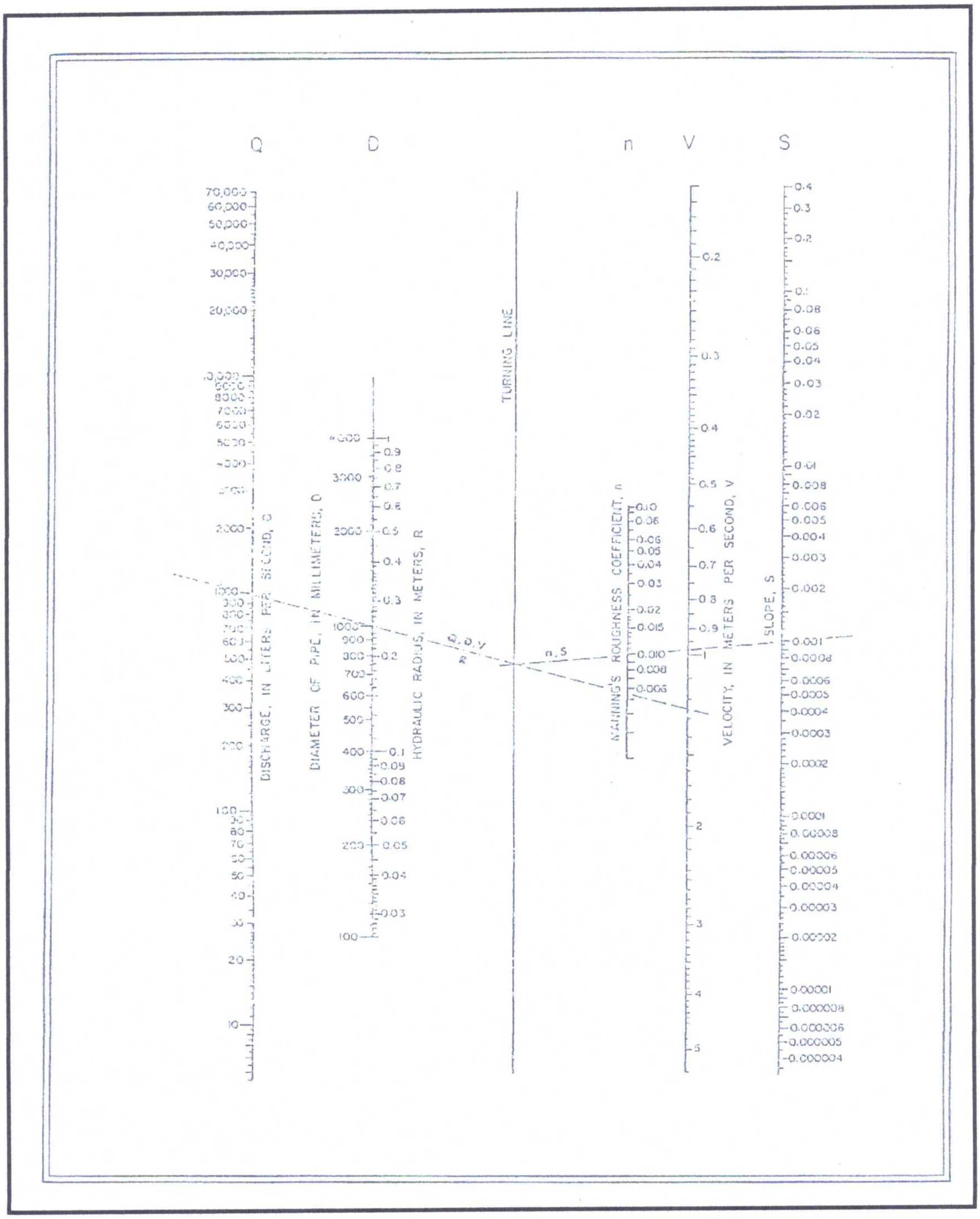



Fig 4.1 Nomo graph for solution of manning formula[11]

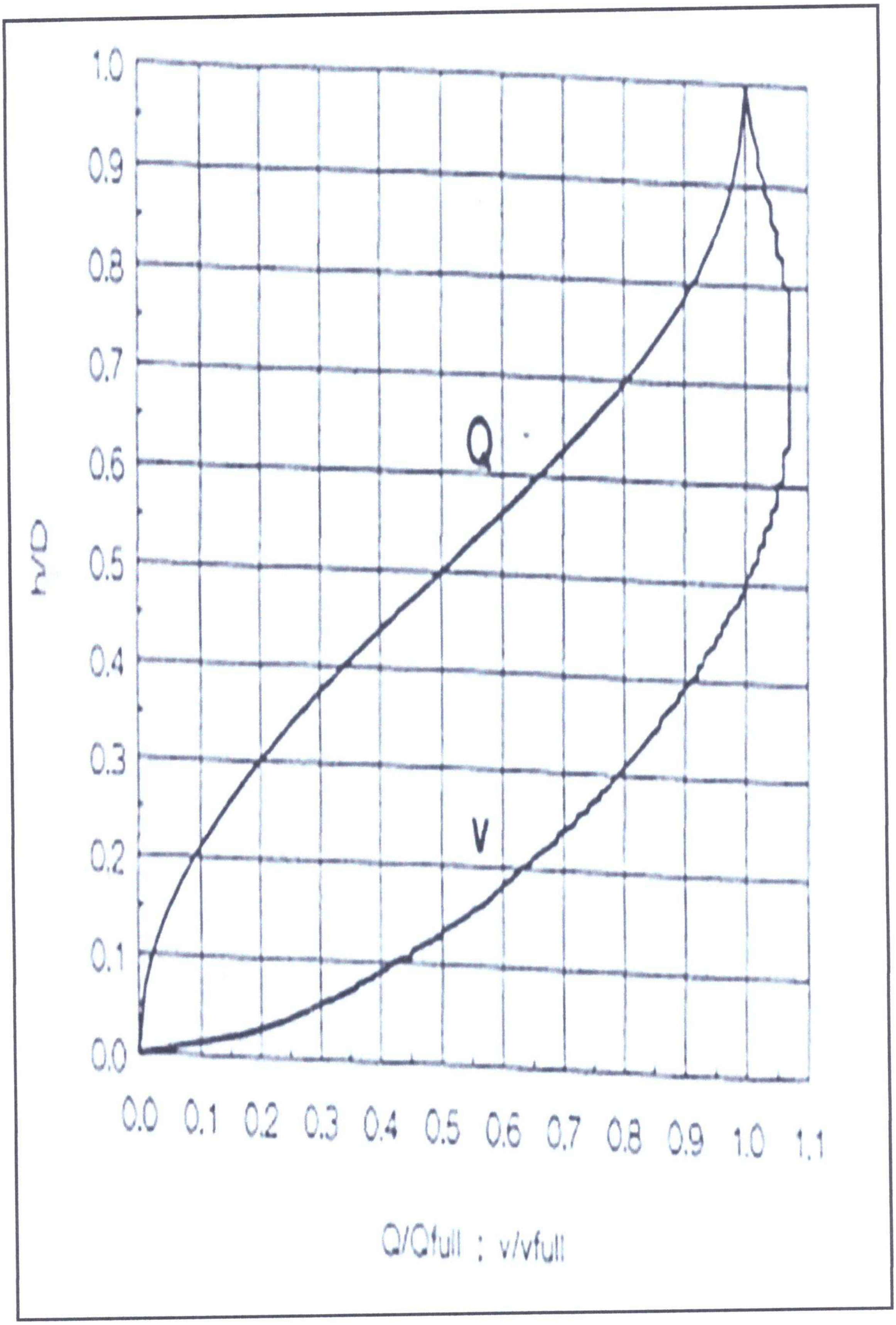



Fig 4.2 Hydraulic properties of circular sewer[11]

**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.[10]

## 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:

To redesign the AL_Shlaleh road, this requires field work and office work to redesign the road, 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. [4]

Traverse networks have the following advantages:

1. Little reconnaissance is required compared with that needed for an interconnected network of points.
2. Observations only involve three stations at a time so planning the task is simple.
3. 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.[4]

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.[4]

1. Link Traverse:

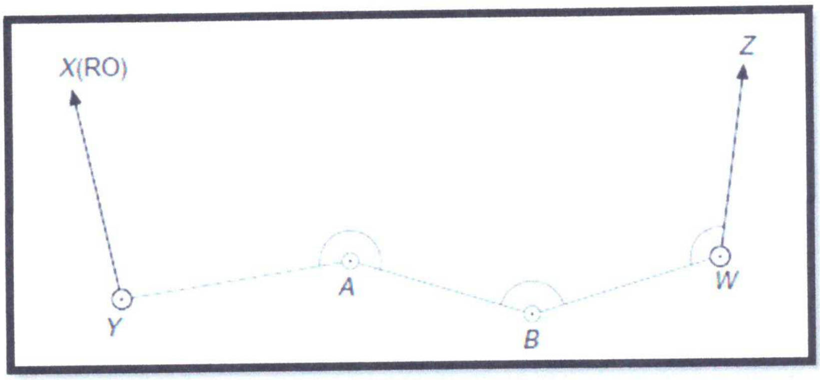



Fig 4.3: Link Traverse[4]

Fig (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.[1]

2. Loop Traverse:

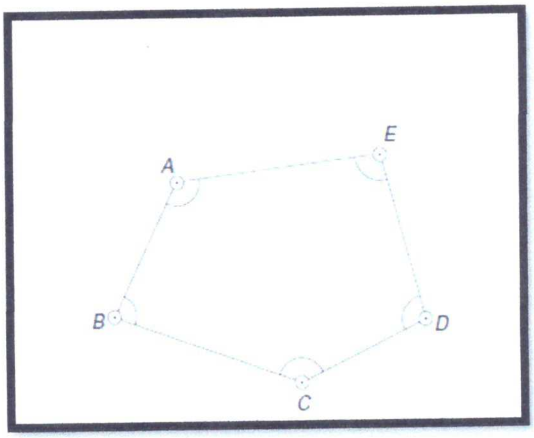



Fig 4.4.a : Loop Traverse(independent)

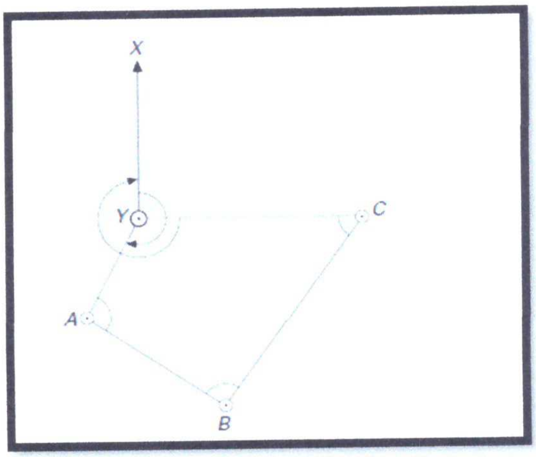



Fig 4.4.b: Loop Traverse(oriented)

Fig (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.[4]

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.[1]

3. Open(free) Traverse:

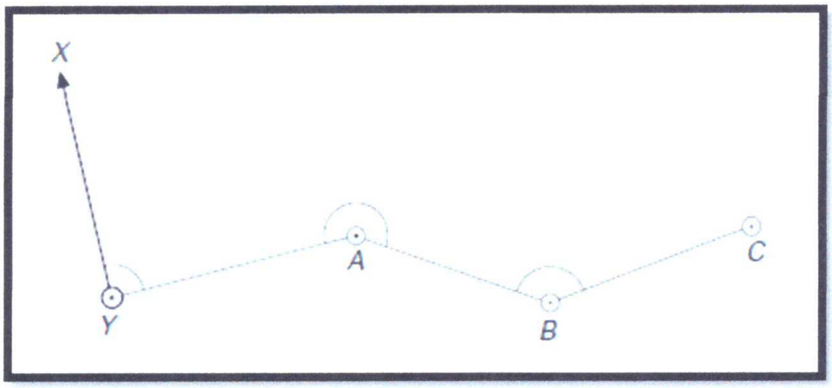



Fig 4.5: Open Traverse[4]

Fig (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.[4]

**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.

* Table 4.5 : Horizontal Control Accuracy Standards For Traverse(By The Federal Geodetic Control)[4]

| 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":

$$X = (J^T J)^{-1} J^T K \tag{4.11}$$

Where:

X: Unknown Matrix.

J: Jacobean Matrix.

K: Observation Matrix.

V: Variance Matrix.

And here are the matrices forms:

- The Jacobean Matrix:

$$J = \begin{bmatrix} \frac{\partial F_1}{\partial dx_1} & \frac{\partial F_1}{\partial dy_1} & \frac{\partial F_1}{\partial dx_2} & \frac{\partial F_1}{\partial dy_2} & \cdots\cdots\cdots\cdots & \frac{\partial F_1}{\partial dx_n} & \frac{\partial F_1}{\partial dy_n} \\ \frac{\partial F_2}{\partial dx_1} & \frac{\partial F_2}{\partial dy_1} & \frac{\partial F_2}{\partial dx_2} & \frac{\partial F_2}{\partial dy_2} & \cdots\cdots\cdots\cdots & \frac{\partial F_2}{\partial dx_n} & \frac{\partial F_2}{\partial dy_n} \\ & \vdots & & & & & \\ & \vdots & & & & & \\ \frac{\partial F_{m-1}}{\partial dx_1} & \frac{\partial F_{m-1}}{\partial dy_1} & \frac{\partial F_{m-1}}{\partial dx_2} & \frac{\partial F_{m-1}}{\partial dy_2} & \cdots\cdots\cdots\cdots & \frac{\partial F_{m-1}}{\partial dx_n} & \frac{\partial F_{m-1}}{\partial dy_n} \\ \frac{\partial F_m}{\partial dx_1} & \frac{\partial F_m}{\partial dy_1} & \frac{\partial F_m}{\partial dx_2} & \frac{\partial F_m}{\partial dy_2} & \cdots\cdots\cdots\cdots & \frac{\partial F_m}{\partial dx_n} & \frac{\partial F_m}{\partial dy_n} \end{bmatrix} \tag{4.12}$$

- Distance Observation Reduction:

$$F_{(x_i, y_i, x_j, y_j)} = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2} \tag{4.13}$$

- Linearization:

Taking the derivatives of last equation

$$\frac{\partial F}{\partial x_i} = \frac{x_i - x_j}{IJ} \tag{4.14}$$

$$\frac{\partial F}{\partial y_i} = \frac{y_i - y_j}{IJ} \tag{4.15}$$

$$\frac{\partial F}{\partial x_j} = \frac{x_j - x_i}{IJ} \tag{4.16}$$

$$\frac{\partial F}{\partial y_j} = \frac{y_j - y_i}{IJ} \tag{4.17}$$

- Angle Observation reduction:

$$\theta = Az_{IF} - Az_{IB} \tag{4.18}$$

$$\theta = \tan^{-1}\frac{x_f - x_i}{y_f - y_i} - \tan^{-1}\frac{x_b - x_i}{y_b - y_i} + D \tag{4.19}$$

- Taking the derivatives of the last equation:

$$\frac{\partial F}{\partial x_i} = \frac{y_i - y_b}{IB^2} - \frac{y_i - y_f}{IF^2} \tag{4.20}$$

$$\frac{\partial F}{\partial y_i} = \frac{x_b - x_i}{IB^2} - \frac{x_f - x_i}{IF^2} \tag{4.21}$$

- Observation matrix K:

$$K = \begin{bmatrix} F_1 - F_{1o} \\ F_2 - F_{2o} \\ \vdots \\ \vdots \\ \vdots \\ F_n - F_{no} \end{bmatrix} \tag{4.22}$$

- The weight Matrix W:

$$W=\begin{bmatrix} \sigma F_1{}^2 & & & & & \\ & \sigma F_2{}^2 & & & & \\ & & \sigma F_3{}^2 & & & \\ & & & \ddots & & \\ & & & & \ddots & \\ & & & & & \sigma F_n{}^2 \end{bmatrix} \quad (4.23)$$

- Unknown Matrix X:

$$X=\begin{bmatrix} dx_1 \\ dy_1 \\ dx_2 \\ dy_2 \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ dx_n \\ dy_n \end{bmatrix} \quad (4.24)$$

- Variance matrix V:

$$V=\begin{bmatrix} V1 \\ V2 \\ V3 \\ V4 \\ \vdots \\ \vdots \\ \vdots \\ \vdots \\ Vn \end{bmatrix} \quad (4.25)$$

- Corrected coordinates:
- $X = X_o + d_x$ (4.26)
- $Y = Y_o + d_y$ (4.27)

### B.4.3 The horizontal and vertical alignment of the Streets

#### B.4.3.1 Introduction

The horizontal alignment of the streets consists usually from straight parts and circular ones, so we must connect these parts together by using curves that transmit us from the straight parts to the circular ones in a gradual way to avoid sudden movement, so we can reduce street's dangers to the minimum level.

In order to achieve a balanced design of the street , we must take in response the basics of the geometrical design that give us continuous traffic flow at the design speed .we must also take in response the relation between the design speed , the radiuses of the curves, and other things.

**Centrifugal Force**

The transition of the vehicle from the straight part to the curved one will expose it to

a centrifugal force when it enters the curve, centrifugal force inversely proportional to the radius of the curve.

Figure (4.6) illustrates the forces acting on a vehicle of weight W as it is driven

round a highway bend of radius R. The angle of incline of the street (super elevation) is termed a. P denotes the side frictional force between the vehicle and the highway, and N the reaction to the weight of the vehicle normal to the surface of the highway. C is the centrifugal force acting horizontally on the vehicle and equals c =M * v2/R where M is the mass of the vehicle.

As all the forces in Fig (4.6) are in equilibrium, they can be resolved along

the angle of inclination of the street:

(Weight of vehicle resolved parallel to highway) + (Side friction factor)

= (Centrifugal force resolved parallel to highway)

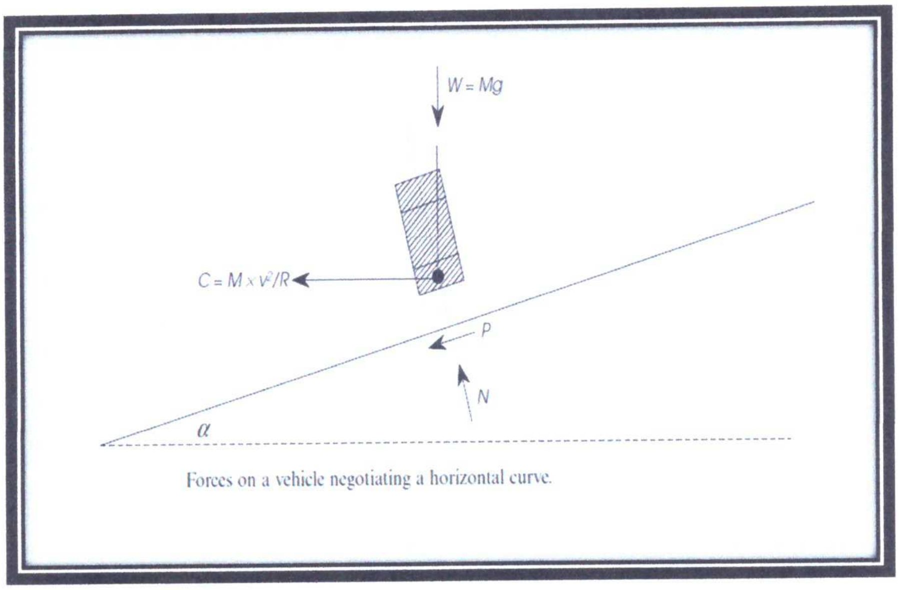



Fig 4.6 Force on vehicle negotiating a horizontal curve. [4]

$$p = \frac{m\ v^2}{R} \tag{4-28}$$

Where:

P : Centrifugal force.

m: vehicle's mass.

R: Curve's radius.

V: vehicle's velocity.

From the relation above it is clear that the centrifugal force inversely proportional to the radius of the curve , so when the vehicle is on the straight part of the street the radius is infinity consequently the centrifugal force (P) equals zero. To prevent the rapid change of the centrifugal force from zero to a large value we resort to the transition curve.[4]

### B.4.3.2 Super Elevation :

Super elevation is the banking (rotation) of a highway to counter some of the lateral force. As shown in fig (4.7), the banking causes a portion of the lateral acceleration to act normal (perpendicular) to the banked pavement. This is felt as a downward (with respect to the vehicle) force by the vehicle occupants. The remaining portion of the lateral force may act one of three ways depending on the banking and speed of the vehicle.[5]

• If the speed is balanced for the banking, the lateral force acting outward on the vehicle will be countered by the forces pushing the vehicle down the slope of the banking. The vehicle and occupants will experience a downward force (perpendicular to the street way) and the vehicle will travel around the curve with little steering input. This is a neutral or equilibrium condition.

• If the vehicle is traveling faster than the equilibrium speed, the resultant lateral force acts outward on the vehicle and occupants. At excessive speeds, the vehicle will skid or roll off the street.

• If the speed is lower than the equilibrium speed, the vehicle and occupants are forced

inward. Extreme banking can cause top heavy vehicles to rollover towards the inside of the curve. Additionally, icy conditions can cause the vehicle to slide down the banking, particularly when the tires are spinning to accelerate in stop and go traffic.

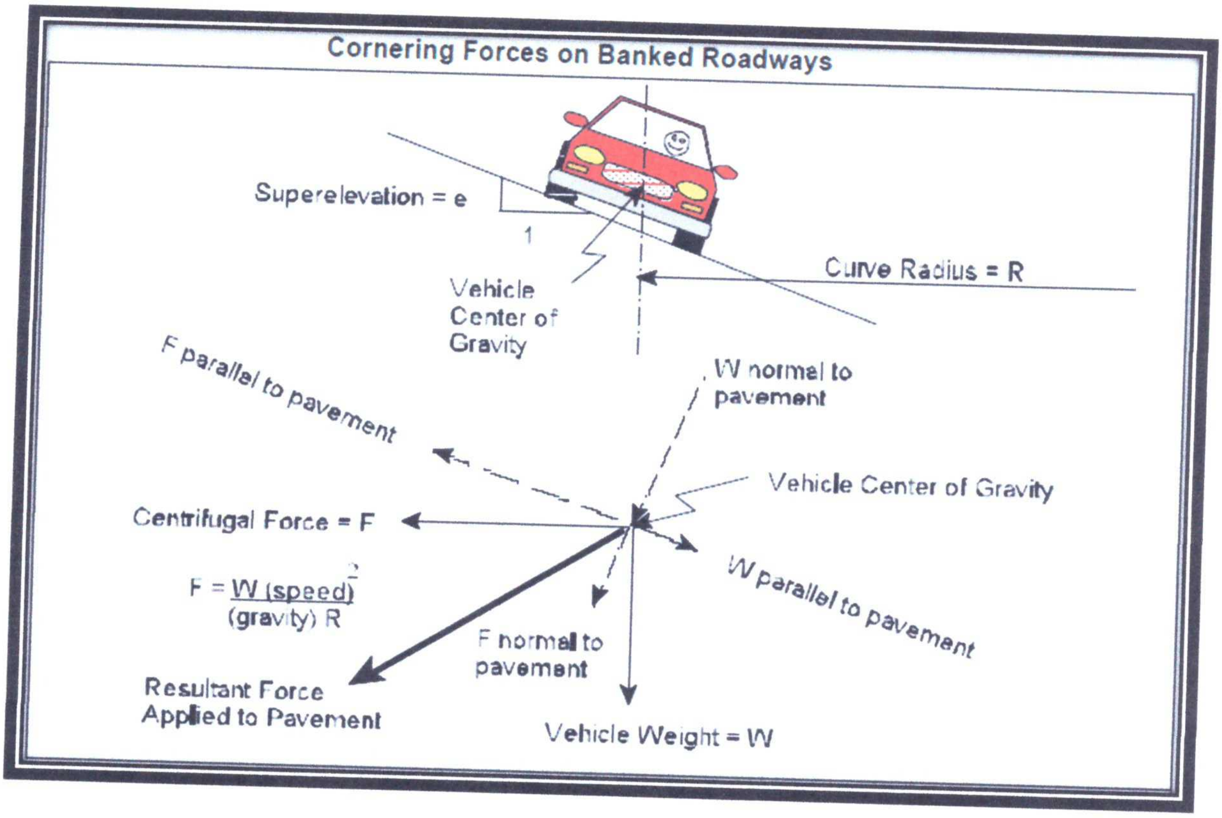



Fig 4.7 Centrifugal force.[4]

**Maximum super elevation rates :**

High rates of super elevation may cause slow moving vehicles to slide down the banking in snow and ice. High super elevation rates can be difficult to attain in urban settings due to closely spaced intersections, numerous driveways, and limited right of way. Maximum super elevation rates are chosen to limit the adverse effects of super elevation.[4]

**Five maximum super elevation rates are commonly used:**

1. Maximum super elevation rates of 4% and 6% are for urban areas.
2. Maximum super elevation rates of 6%and 8% are for areas that have frequent ice and snow.
3. Maximum super elevation rates of 10% and 12% in rural areas without ice or snow concerns represent a practical limit to accommodate occasional slow moving vehicles, construction equipment, and maintenance equipment.

**Horizontal curve sight distance:**

Once you have a radius that seems to connect the two previously disjointed sections of street way safely and comfortably, you need to make sure that you have provided an adequate stopping sight distance throughout your horizontal curve.

Sight distance can be the controlling aspect of horizontal curve design where obstructions are present near the inside of the curve. To determine the actual sight distance that you have provided, you need to consider that the driver can only see the portion of the street way ahead that is not hidden by the obstruction. In addition, at the instant the driver is in a position to see a hazard in the street way ahead, there should be a length of streetway between the vehicle and the hazard that is greater than or equal to the stopping sight distance. See fig (4.8) below.

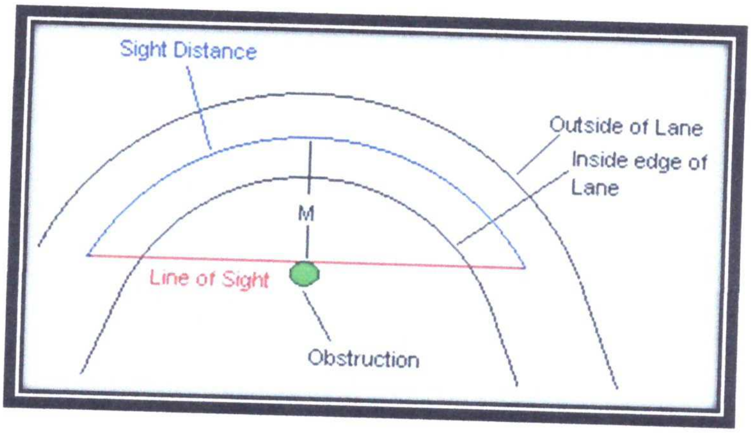



Fig 4.8: Sight Distance[5]

Because the sight obstructions for each curve will be different, no general method for calculating the sight distance has been developed. If you do have a specific obstruction in mind, however, there is an equation that might be helpful. This equation involves the stopping sight distance, the degree of the curve, and the location of the obstruction.

$$M = (5730/D)*(1 - \cos(SD/200)) \tag{4-29}$$

Where:

M = Distance from the center of the inside lane to the obstruction (ft.)
D = Degree of the curve. Where R = 5730/D
S = Stopping sight distance (ft)
R = Radius of the curve (ft)

Once your rough design has been adjusted to accommodate the sight distance restrictions, and you are satisfied with the aesthetic and financial consequences of your super elevation scheme, you can begin to polish your design into its final form.

### B.4.3.3 Horizontal and Vertical Curves:

In the geometric design of motorways, railways, pipelines, etc., the design and setting out of curves is an important aspect of the engineer's work.

The initial design is usually based on a series of straight sections whose positions are defined largely by the topography of the area. The intersections of pairs of straights are then connected by horizontal curves. In the vertical design, intersecting gradients are connected by curves in the vertical plane.

Curves can be listed under three main headings, as follows:

(1) Circular curves of constant radius.

(2) Transition curves of varying radius (spirals).

(3) Vertical curves of parabolic form.

**Horizontal circular Curves:**

The horizontal curves are defined by the radius of the curve or by the degree of it, and so we must choose the radius of the curve to coincide with the design speed of the street.

Horizontal curves are divided into four types as shown in the following fig:

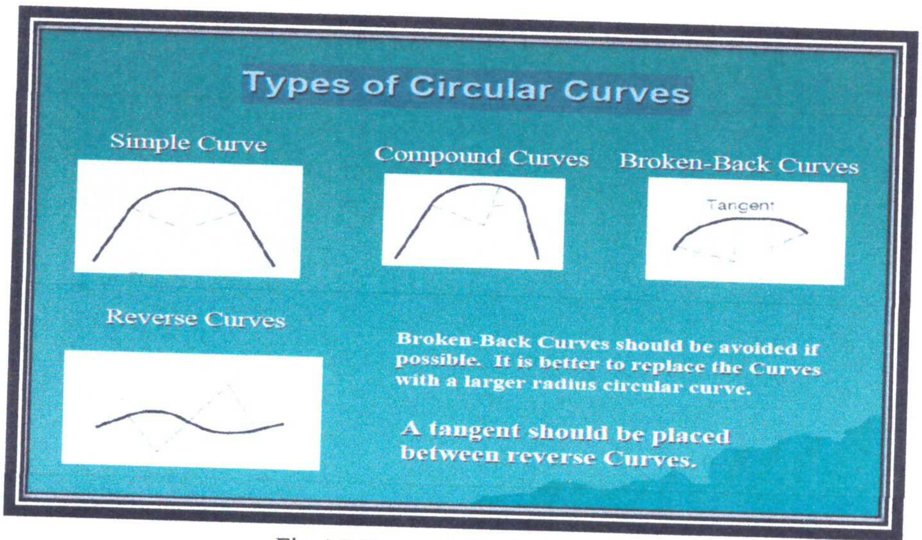



Fig 4.9 Types of circular curves[5]

**First: Simple circular curve**

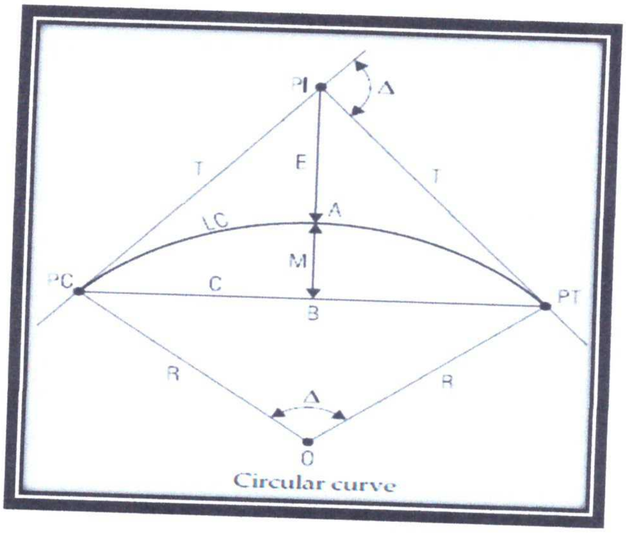



Fig 4.10 Circular curve[5]

A simple horizontal curve consists of a part of a circle tangent to two straight sections on the horizontal alignment. The radius of a curve preferably should be large enough that drivers do not feel compelled to slow their vehicles. Such a radius, however, is not always feasible, inasmuch as the alignment should blend harmoniously with the existing topography as much as possible and balance other design considerations, such as overall project economy, sight distance, and side friction.[5]

Super elevation, usually employed on curves with sharp curvature, also should be taken into account .A curve begins at a point designated point of curvature or PC. There, the curve is tangent to the straight section of the alignment, which is called a tangent Fig. (4.10). The curve ends at the point of tangency PT, where the curve is tangent to another straight section of the alignment. The angle D formed at PI, the point of intersection of the two tangents, is called the interior angle or intersection angle.

Using the radius and angle ( Δ ) we can calculate the elements of the simple circular curve from the following relations:

$$L = \frac{\pi \Delta R}{180} \qquad \text{.....(4-30)}$$

$$T = R\left(\tan\frac{\Delta}{2}\right) \qquad \text{(4-31)}$$

$$M = R\left(1 - \cos\frac{\Delta}{2}\right) \qquad \text{(4-32)}$$

$$E = R\left(\sec\frac{\Delta}{2} - 1\right) \qquad \text{(4-33)}$$

$$LC = 2R\left(\sin\frac{\Delta}{2}\right) \qquad \text{(4-34)}$$

Where:

T : Tangent length.

E : External distance.

M : Arc's arrow.

LC : Long string.

L : Curve's Length.

$\Delta$ : Angle of deviation of the two tangents.

Table 4-6 Maximum Curvature for Normal Crown section[5]

Maximum Curvature for Normal Crown Section*

| Design speed, mi/h | Average running speed, mi/h | Maximum degree of curve | Minimum curve radius, ft |
|---|---|---|---|
| 20 | 20 | 3° 23′ | 1,700 |
| 30 | 28 | 1° 43′ | 3,340 |
| 40 | 36 | 1° 02′ | 5,550 |
| 50 | 44 | 0° 41′ | 8,320 |
| 55 | 48 | 0° 35′ | 9,930 |
| 60 | 52 | 0° 29′ | 11,690 |
| 65 | 55 | 0° 26′ | 13,140 |
| 70 | 58 | 0° 23′ | 14,690 |

*Adapted from "A Policy on Geometric Design of Highways and Streets," American Association of State Highway and Transportation Officials.

**Second: Compound Circular curve**

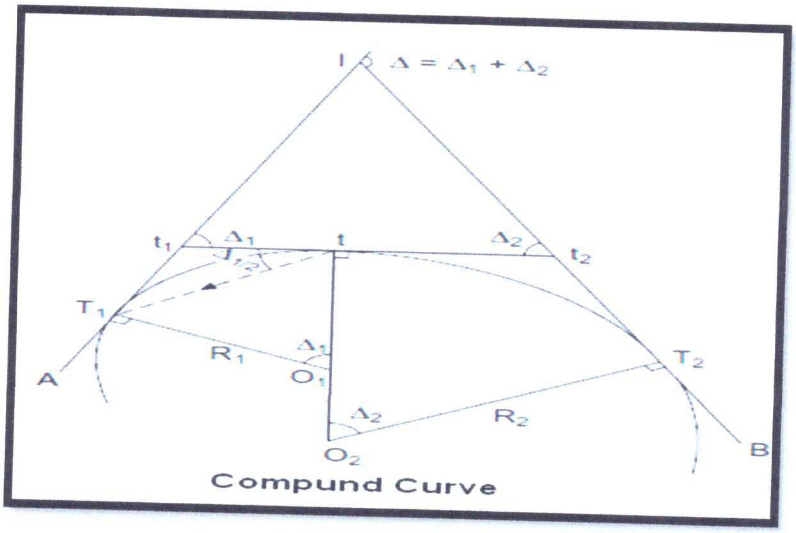



Fig 4.11 Compound curve[4]

The compound circular curve consist from two or more horizontal consecutive curves so that the second point of tangency of the first curve is the same as the first point of tangency of the second curve .This type of curves used to connect two straight lines by more than one circular curve , but under the following conditions:

1 - The radiuses of these curves are different.

2 - All the centers of these curves lie in the same side.

3 - The curves are contiguous at the points of connection between them.

**Third: Broken-back curve**

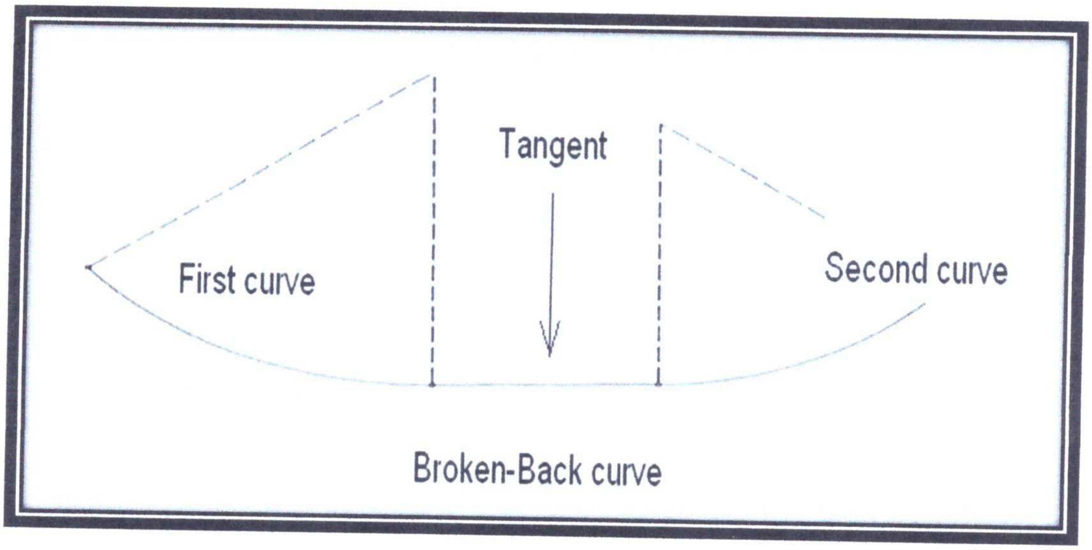



Fig 4.12 Broken-Back curve.[4]

This curve consists of two circular curves their centers lie in the same side and they are connected together by a common tangent it's length less than 30 m.

**Fourth: Reveres curve**

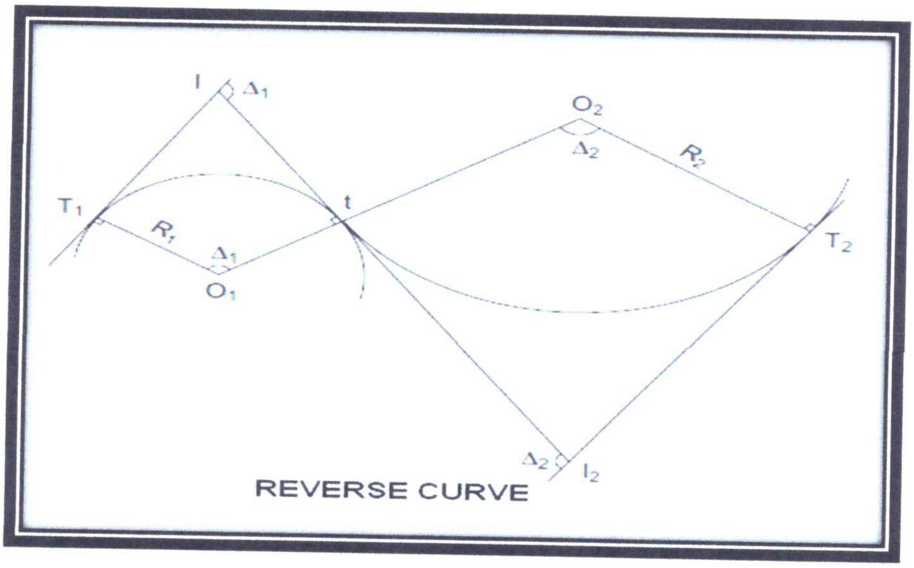



Fig 4.13 Reverse curve[4]

In this type of curves we connect the two straight lines by more than one circular curve under the following conditions:

1- The centers of the curves are not in the same side.
2- The radiuses of these curves may be equal or may be not .

3- The curves are contiguous at the points of connection between them.

**General notes about Horizontal alignment:**

In addition to the design elements in the horizontal alignment, there are some of the rules which are not restricted by any formula but they are of great importance to achieve safe ways .For example the excessive curvature, the wrong connection between curves and other problems. They all reduce the velocity and this will produce economical loss because of increasing the time of the trip and operating costs .So to avoid those bad things we must follow the following general steps:

a- To make the appropriate sight distance through the internal edge of the curve.

b- To make the appropriate drainage system for surface water.

c- Reducing as possible as we can from the earthworks.

d- Avoiding the short connecting curves, but using suitable transition curves.

e- To reduce the affects of the reveres curves if exist , we must increase the radius of the curve , decreasing the velocity , and put the required caution signs .

f- If there were obstructions for using one circular curve with a large radius , then we use a compound curve give us more reliability .

g- Super elevation should not exceed (12%) in all cases.

h- The preferable super elevation value is (6%).

i- The side friction should not exceed the maximum and allowable value of (16%).

j- Avoiding the use of reverse curves as possible as we can to avoid the following things:

- Sudden transition from a specific radius to another suddenly, leading to dangers especially if the driver does not give attention.
- Difficulty of dealing with the centrifugal force, because of the transition from the first curve to the second one with two cross slopes in different directions.

**Vertical Alignment :**

A vertical alignment defines the geometry of a highway in elevation, or profile. A vertical alignment can be represented by the highway centerline along a single tangent at a given grade, a vertical curve, or a combination of these.

**Vertical Curve and it's elements:**

These are used as a transition where the vertical alignment changes grade, or slope. Vertical curves are designed to blend as best as possible with the existing topography, consideration being given to the specified design speed, economy, and safety.

The tangents to a parabolic curve, known as grades, can affect traffic in many ways; for example ,they can influence the speed of large tractor-trailers and stopping sight distance.

Although a circular curve can be used for a vertical curve, common practice is to employ a parabolic curve. It is linked to a corresponding horizontal alignment by common stationing. Figure 8.1 shows a typical vertical curve and its constituent elements.[4]

A curve like the one shown in Fig. (4.14) is known as a crest vertical curve; that is, the curve crests like a hill. If the curve is concave, it is called a sag vertical curve; that is, the curve sags like a valley. As indicated in Fig. 8.1, the transition starts on a tangent at PVC, point of vertical curvature, and terminates on a second tangent at PVT, point of vertical tangency. The tangents, if extended, would meet at PVI.

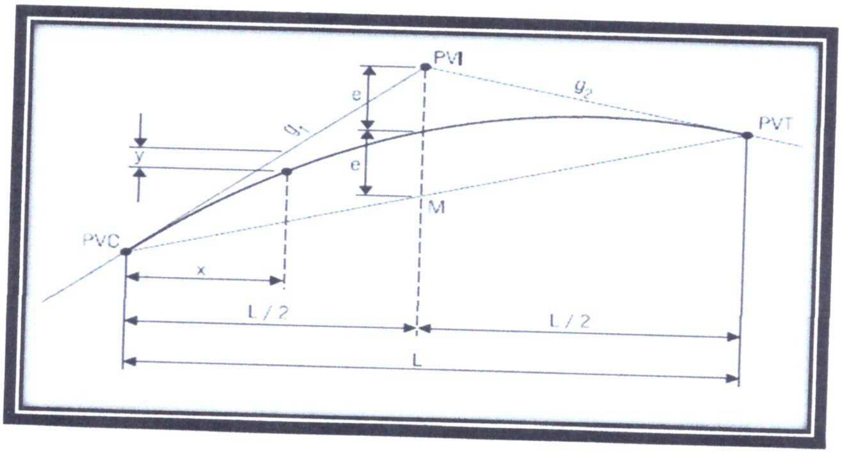



Fig 4.14 Parabolic Vertical curve.[4]

g1, g2 : the gradients.

BVC : the beginning of the vertical curve.

PI : intersection point.

EVC : the end of the vertical curve.

L : the length of the curve.

e : the external intermediate distance.

### B.4.3.4 Transition Curves

These curve types are used to connect curved and straight sections of highway.(They can also be used to ease the change between two circular curves where the difference in radius is large.) The purpose of transition curves is to permit the gradual introduction of centrifugal forces. Such forces are required in order to cause a vehicle to move round a circular arc rather than continue in a straight line. A finite quantity of time, long enough for the purposes of ease and safety, will be required by the driver to turn the steering heel. The vehicle will follow its own transition curve as the driver turns the steering wheel. The radial acceleration experienced by the vehicle travelling at a given velocity v changes from zero on the tangent to v2/R when on the circular arc. The form of the transition curve should be such that the radial acceleration is constant. The radius of curvature of a transition curve gradually decreases from infinity at the intersection of the tangent and the transition curve to the designated radius R at the intersection of the transition curve with the circular curve.[5]

Transition curves are normally of spiral or clothoid form:

$RL = A2$

Where:

A2 is a constant that controls the scale of the clothoid.

R is the radius of the horizontal curve.

L is the length of the clothoid.

Two formulae are required for the analysis of transition curves:

$$S = L2/24R \quad \text{.........} (4\text{-}35)$$

$$L = V^3/\,(3.6^3 * C * R \quad \text{.........} (4\text{-}36)$$

Where:

S : the shift (m)

L : the length of the transition curve (m)

R : the radius of the circular curve (m)

V : the design speed (km/hr)

C : the rate of change of radial acceleration (m/s3)

The value of C should be within the range 0.3 to 0.6. A value above 0.6 can result in instability in the vehicle while values less than 0.3 will lead to excessively long transition curves leading to general geometric difficulties. The design process usually commences with an initial value of 0.3 being utilized, with this value being increased gradually if necessary towards its upper ceiling.[4]

The length of transition should normally be limited to (24R)0.5 (TD 9/93),

thus:

$$L_{\text{max}} = \sqrt{24R} \quad \text{.........} (4\text{-}37)$$

Figure (4.7) illustrates the situation where transition curves are introduced between the tangents and a circular curve of radius R. Here, the circular curve.

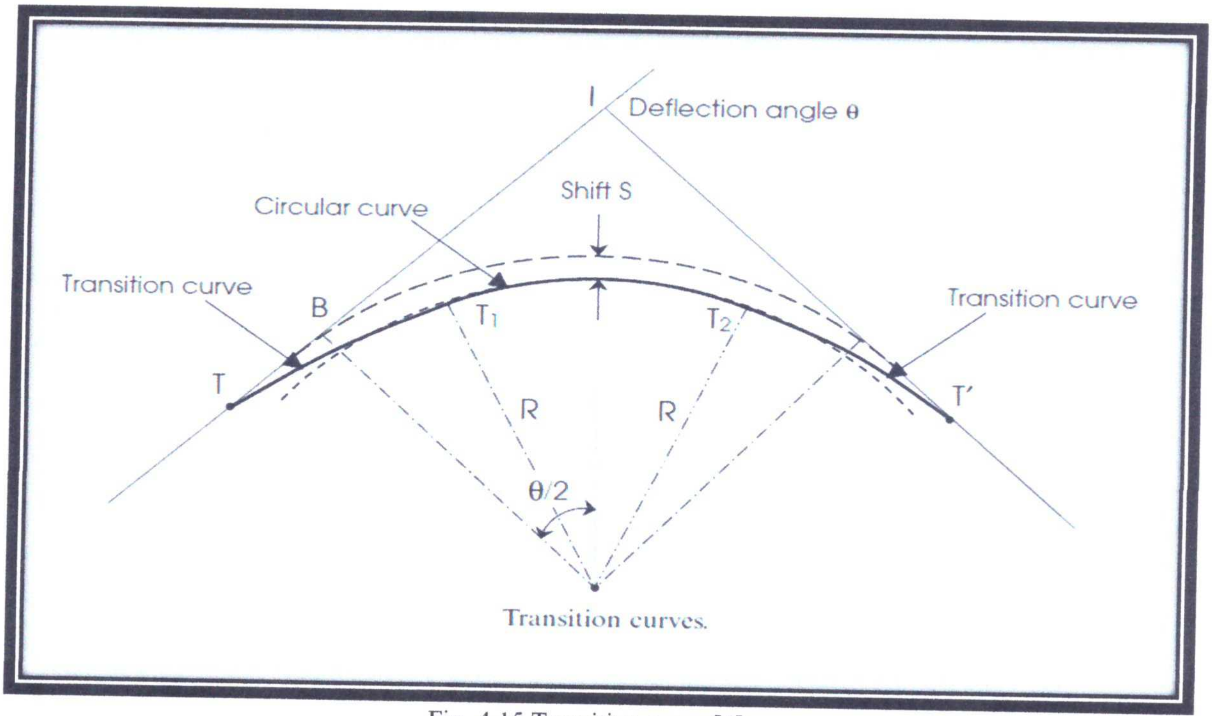



Fig 4.15 Transition curve.[4]

must be shifted inwards from its initial position by the value S so that the curves can meet tangentially. This is the same as having a circular curve of radius (R+ S) joining the tangents replaced by a circular curve (radius R) and two transition curves. The tangent points are, however, not the same. In the case of the circular curve of radius (R + S), the tangent occurs at B, while for the circular/transition curves, it occurs at T see Fig.( 4.15).

From the geometry of the above figure:

$$IB = (R + S)\ \tan(\theta/2) \qquad (4\text{-}38)$$

It has been proved that B is the mid-point of the transition.

Therefore:

$$BT = L/2 \qquad (4\text{-}39)$$

Combining these two equations, the length of the line IT is obtained:

$$IT = (R + S) \tan(\theta/2) + L/2 \quad (4\text{-}40)$$

If a series of angles and chord lengths are used, the spiral is the preferred form.

If, as is the case here, x and y co-ordinates are being used, then any point on the transition curve can be estimated using the following equations of the curve which takes the form of a cubic parabola (see Fig. 7.9):

$$y = L \quad (4.41)$$

$$x = y3 / 6RL \quad (4.42)$$

When y attains its maximum value of L (the length of the transition curve), then the maximum offset is calculated as follows:

$$x = L3 / 6RL = L2 / 6R \quad (4.43)$$

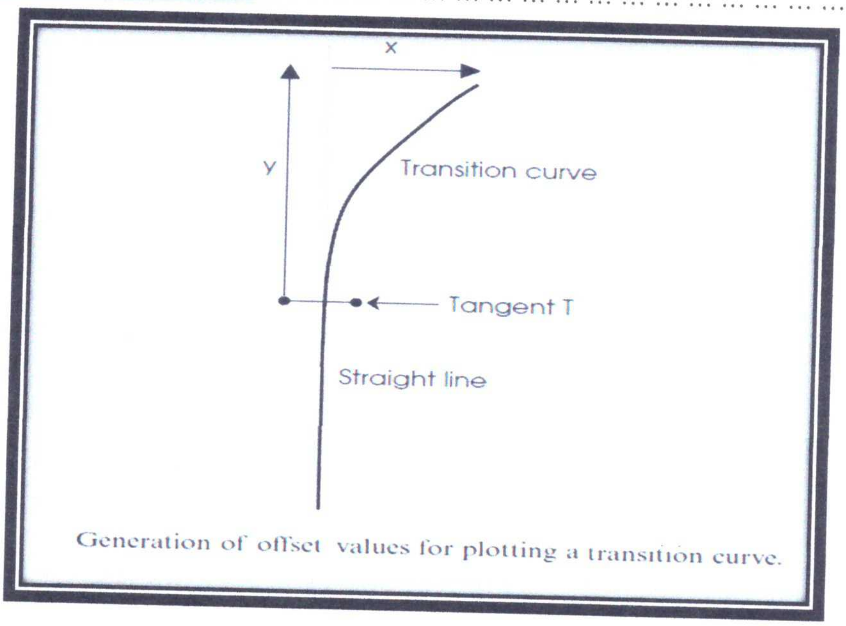



Fig 4.16 Generation of offset values for plotting a transition curve.[4]

### C.4.3 Intersections on the streets:

An intersection is the junction or crossing of two or more streets at the same or different elevations. When the streets are at the same level, the intersection is called an at-grade intersection. When the streets are at different elevations, the intersection is referred to as a grade separation when there is no connection between the intersecting streets or as an interchange when connecting streets, such as ramps or turning street ways, permit movement of vehicles between the intersecting streets.

Intersections should be kept simple so that necessary movements are obvious to drivers. Uniformity of intersections is important to avoid driver confusion. Factors to be considered for this purpose include design speed, intersection angles (90°is preferred), intersection curves, vehicle turning paths, streetway widths, and traffic control devices.

Intersection is an important part of the street, because the safety, velocity, affiance, operating costs they all depend on the intersection . It is not reasonable to design a highway which is wide with narrow intersections.[4]

### C.4.3.1 Horizontal and Vertical alignment at intersections :

Alignment geometries play a critical role in the design of an at-grade intersection. In the vertical plane, it is important that the profiles of the intersecting street ways be as flat as possible (preferably less than 3% through the intersection). Also, the horizontal alignment should be as straight as practical. Grade and curvature have considerable impact on sight distance at intersections, where it is desirable to have sight distances greater than specified minimum values. Adverse sight-distance conditions can be the source of accidents, because of driver inability to see other vehicles or discern the messages of traffic-control devices.[5]

### C.4.3.2 Types of intersections :

There are generally two types of intersections:

1-At-grade intersections.

2- Grade separated interchanges.

**At-grade intersections :**

The junction or crossing of two or more highways at a point of common elevation is called an atgrade intersection. Intersections of highways and railways at grade should be provided with protective and warning devices. Sight distance is an important design consideration when only advance warning of approaching trains and railway cross buck signs are installed.[5]

### Geometric Design of At-Grade Intersections:

Major influences on the geometric design of at grade intersections include human factors, traffic considerations, physical elements, and economic factors. The goal is to reduce or eliminate the potential for accidents involving vehicular, bicycle, or pedestrian traffic through the intersection. Also, natural transitional paths for traffic must be provided.[5]

### Human Factors:

Design of an intersection is affected by human factors, such as driving habits, the ability of drivers to make decisions, adequate advance warning to drivers regarding the presence of an intersection, driver decision and reaction time, and the presence of pedestrians at the intersection.[4]

### Traffic Considerations:

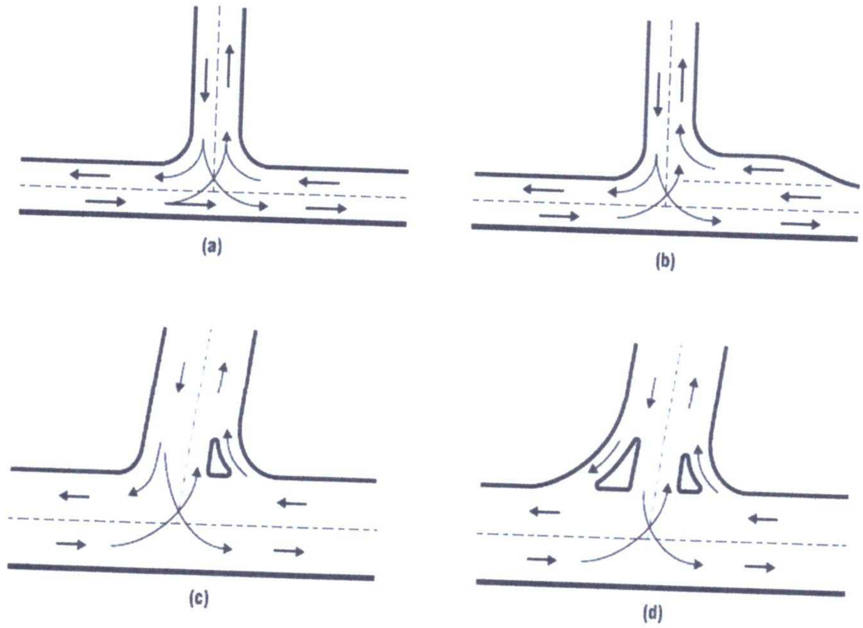
Traffic volume and movement impact the design of an at-grade intersection. Both the design and actual capacity of the intersecting highways should be taken into account. Also of concern are the design-hour turning movement and other movements, such as diverging, merging, weaving, and crossing. Other traffic criteria include vehicle size, speed and operating characteristics, transit involvement, and, if applicable, the history of accidents at the site.[4]

### Types of At-Grade Intersections:

Each highway that radiates from an intersection and forms part of it is known as an intersection leg. The intersection of two highways generally results in four legs. Intersections with more than four legs are not recommended.

### Three-Leg Intersections:

A three-leg intersection is formed when one highway starts or terminates at a junction with another highway Fig. (4.17). Unchannelized T intersections (Fig.4.17) are usually employed at the intersection of minor streets with more important highways at an angle not exceeding 30° from the normal. At times, a right-turn lane is provided on one side of the through highway Fig.( 4.17) this type of turn lane is used when right-turning traffic from the through highway is significant and left-turning traffic from the through highway is minor.

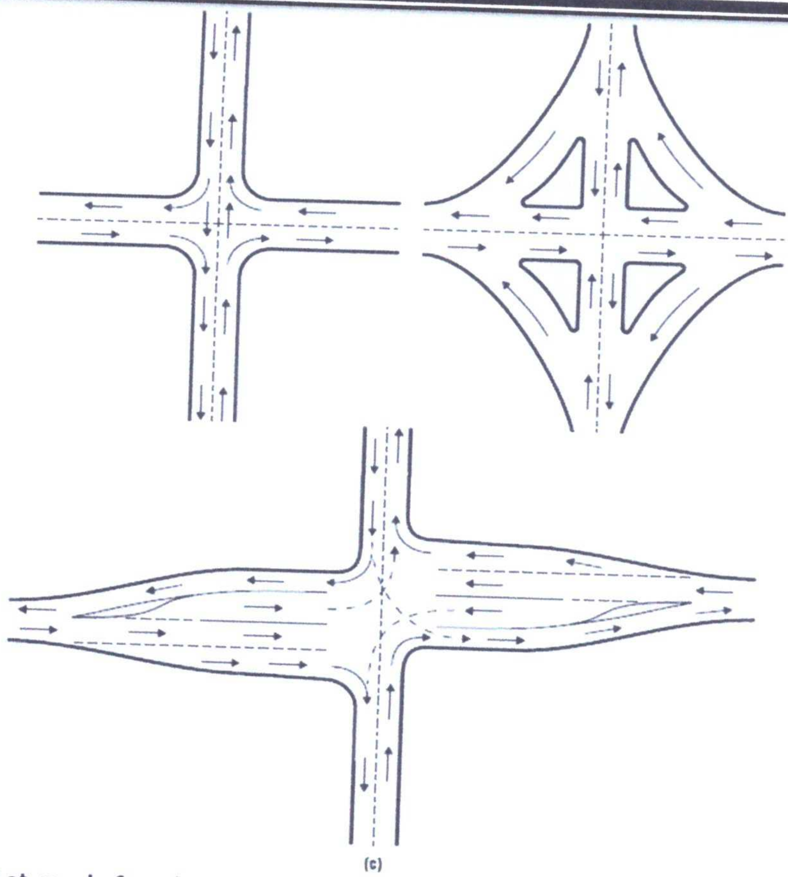



Types of at-grade T (three-leg) intersections: (a) unchannelized; (b) intersection with a rightturn lane; (c) intersection with a single-turning roadway; (d) channelized intersection with a pair of turning roadways.

Fig 4.17 Type of at-grade T(Three-leg) Intersections [5]

**Four-Leg Intersections :**

A four-leg intersection is formed when two highways cross at grade (Fig. 4.12). The design of four-leg intersections follows follows many of the general guidelines for three-leg intersections. As with T intersections, the street way intersection angle typically should not be more than 30° from the normal. Fig (4.18) shows a four-leg intersection of a through highway and a minor highway. The through highway is flared to provide additional capacity for through and turning movements. The flaring is provided through incorporation of parallel auxiliary lanes that are required for major highways requiring an uninterrupted flow capacity. Flaring may also be needed where cross traffic is sufficiently high to warrant signal control.




Types of at-grade four-leg intersections: (a) unchannelized; (b) channelized; (c) flared.

Fig 4.18 Types of at-grade four-leg intersections[5]

**Grade intersection (Interchanges):**

An interchange is a system of interconnecting street ways used in conjunction with one or more grade separations of highways (Fig. 16.26). It accommodates movement of traffic between two or more street ways at different elevations. In so doing, it eliminates grade crossings, which may be unsafe and are inefficient in accommodating both turning and through traffic .When highways carrying high volumes of traffic intersect each other, the greatest degree of safety, efficiency, and capacity is achieved with grade separations of the highways. There are in use numerous variations of the interchange types shown in Fig. (4.19). They vary in size and magnitude depending on the environment and scope of service for which they are intended. Design of an interchange is based on traffic volume, topography of the site, economic considerations, and environmental factors.[5]

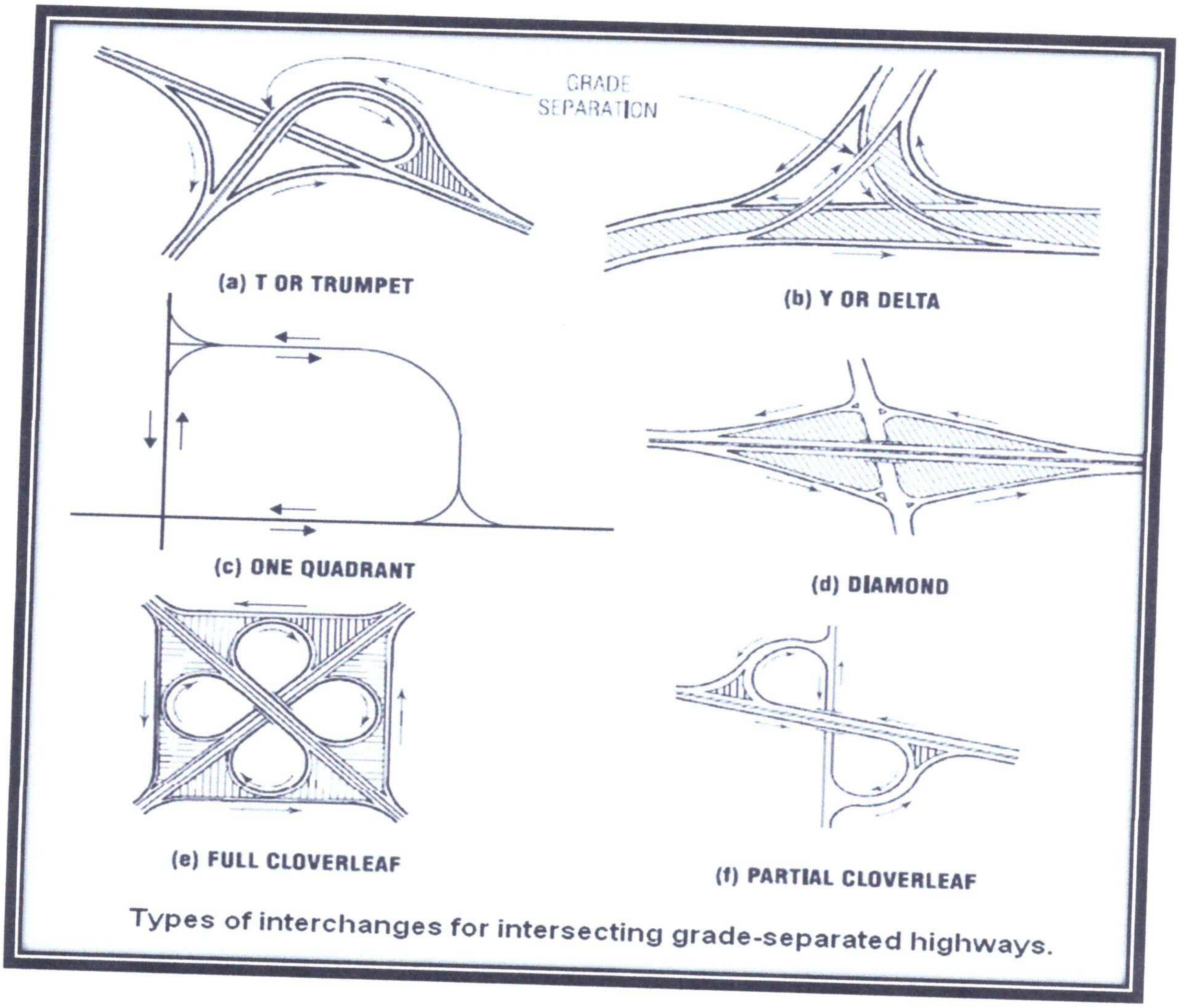



Fig 4.19 Types of interchanges for intersecting grade-separated highways.[5]

### C.4.3.3 Elements of intersection design:

**First : Traffic volume and pedestrian movement on the intersection.**

We must account for the pedestrian movement on the intersection as we must also make a full survey to determine traffic directions , volume , and vehicles .

**Second: Drivers behavior on the intersection.**

The behavior of the driver should be taken in consideration to design the intersection according to the behavior of 85% of the drivers, not according to the ideal driver.

**Fourth: The grade and the friction of the street at the intersections.**

It should, the radius at the intersection is very small which require a large slope, but it is difficult to make the appropriate slope without making sudden change in the slope of the street surface and because the distances are short large slopes are not used and instead of that the velocity is reduced depending on the side friction when turning over, and table (4.7) displays the slope of the street surface according to the velocity.

Table (4-7) The slope of the street surface according to the velocity[2]

| Turning over Speed (Km/h) | 65 | 5 | 48 | 40 | 32 | 25 |
|---|---|---|---|---|---|---|
| Friction Factor | 0.17 | 0.18 | 0.20 | 0.23 | 0.27 | 0.32 |
| Slope of the street Surface | 0.09 | 0.08 | 0.05 | 0.04 | 0.02 | 0 |
| Radius (m) | 140 | 100 | 75 | 50 | 30 | 15 |

**Fifth: The algebraic difference between two slopes.**

The algebraic difference between two slopes should not exceeds the allowable value, because the driver who drive his vehicle when it is inclined to the left , if he forced to incline to the right he will be exposed to a danger because of the difference between the two slopes , so the slopes should be reduced as possible as we can.

The algebraic difference between two slopes of the street surface defined as the summation of the two slopes if they are in different directions, and it should not exceed the values in the following table.

Table 4-8 The algebraic difference between two slopes of the street surface[4]

| Velocity (Km/h) | Algebraic Difference |
|---|---|
| 0.05-0.08 | 35 -25 |
| 0.05-0.06 | 48 - 40 |
| 0.04-0.04 | 55 and more |

**Sixth: Friction.**

The friction decrease with the increasing velocity , we should choose a suitable value for friction factor on the curve , the friction factor ranges from 0.16 to 0.32 according to the roughness of the surface.[5]

**Seventh: Velocity at the intersection .**

It is necessary to control the speed of the intersection, by placing signs or through narrow passages, as the thresholds that have been developed previously relied on the speed less than 15 km / h. However, the speed must be commensurate with the speed on the street to the intersection, where depends on the type of intersection and traffic volumes at the intersection, and to find a balance between speed and radius in addition to friction and slope street surface, is used the following equation:

$$\frac{V}{gR} = u + i \qquad \text{(4-44)}$$

Where :

V : vehicle speed km / hour.

g : gravity, $m/s^2$.

R : radius of the circle Surface.

u :coefficient of friction.

i : Slope of the street's surface .

**Eighth : The width of the lane which is specified for turning over.**

Must be introduced lane appropriate to allow vehicles to travel there with the survival of the vehicle away from the parties to pass a distance not less than 60 cm from each side, which controls the display lane vehicle size, type and volume of traffic and sharpness of the juncture, and there are three types of lanes allocated to the rotation, namely:

a- One lane which is not allowed to waive in it, and in this kind devoted to the movements of others are important, and a modest amount of traffic and short distances where the stops of a car is not possible.

b- One lane in one direction prevent the existence of a car and exceed it with the minimum velocity, and used to walk a moderate size, which requires only one leaked.

c- Two lanes in one or two direction with a heavy traffic.[4]

**Ninth: Stopping sight distance.**

The car which is approaching the intersection need to a distance vision before it is able to see the obstacle or danger and stop if it wishes, and we follow to find the distance the same methods used in the design of streets where the driver needed time to think and another to take action and use of brakes. Since the values of friction decreases with increasing speed, it will be considered a high coefficient of friction at low speed and low coefficient on high speed.

Table 4-9 Velocity versus sight distance.[4]

| Velocity (Km/H) | 65 | 60 | 50 | 40 | 30 | 25 |
|---|---|---|---|---|---|---|
| Sight Distance(m) | 85 | 75 | 65 | 50 | 34 | 24 |

**Tenth: Islands.**

An island is a defined area established between traffic lanes in channelized intersections to direct traffic into definite paths. It may consist of curbed medians or areas delineated by paint. In general, islands are provided in channelized intersections to separate and control the angle of conflicts in traffic movement, reduce excessive pavement areas, protect pedestrians and waiting areas for turning and crossing vehicles, and provide a location for traffic-control devices.[5]

An island may be curbed or uncurbed. It may be concrete, grass, or the same material as the traffic lanes. Islands may be used at intersections for the following reasons:

- Separation of conflicts.
- Control of angle of conflict.
- Reduction in excessive pavement areas.
- Favoring a predominant movement.
- Pedestrian protection.
- Protection and storage of vehicles.
- Location of traffic control devices.

The width of a median is the distance between the inside edges of the pavement.

The width depends upon the type of facility, topography, and available right-of-way. In rural areas with flat or rolling terrain, the desirable median width for freeways is 60 to 84 ft. Although the minimum median width is normally 40 ft, narrower medians may be used in rugged terrain. A constant-width median is not necessary, and in fact, variable-width medians and independent profiles may be used for the two streetways. Narrow medians with a barrier (barrier medians) are normally used in urban areas. Under normal design, the median width will vary depending on the width of the barrier and the shoulder width required .[5]

Medians are divided into types depending upon width and treatment of the applicable to urban areas, while wide, depressed medians apply to rural areas.

**Gradients:**

In vertical curve design the gradients are expressed as percentages, with a negative for a downgrade and a positive for an upgrade.

e.g. A downgrade of 1 in 20 = 5 in 100 = –5% = –g1%

An upgrade of 1 in 25 = 4 in 100 = +4% = +g2%

The angle of deflection of the two intersecting gradients is called the grade angle and equals A in Fig (4.20). The grade angle simply represents the change of grade through which the vertical curve deflects and is the algebraic difference of the two gradients

$A\% = (g1\% - g2\%)$ In the above example $A\% = (-5\% - 4\%) = -9\%$ (negative indicates a sag curve).

**Permissible approximations in vertical curve computation**

In civil engineering, street design is carried out in accordance with the following documents:

(1) Layouts of Streets in Rural Areas.

(2) Streets in Urban Areas.

(3) Motorway Design Memorandum.

The desirable maximum gradients for vertical curve design are:

Motorways 3%.

Dual carriageways 4%.

Single carriageways 6%.

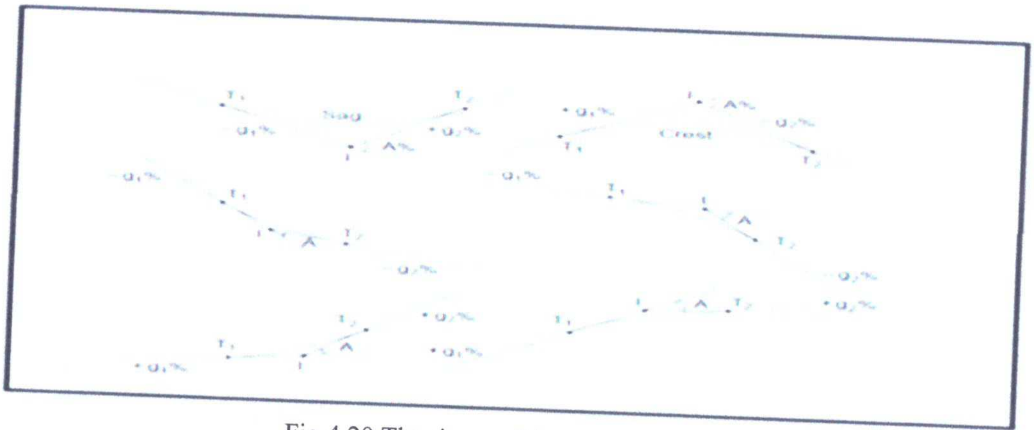


Fig 4.20 The six possible cases of gradiants.[2]

**The characteristics of the parabolic curve.**

The length of the curve equals the sum of the two tangents , so the front tangent $\ell 1$ and the back tangent $\ell 2$ :

$$L = \ell 2 + \ell 1 \quad \text{(4-45)}$$

$$y = ax2 \quad \text{(4-46)}$$

When the two tangents are in different directions:

$$e = \frac{g\,1 + qg\ \ 2}{400}\ell \quad \text{(4-47)}$$

When the two tangents are in the same direction:

$$e = \frac{g\,1 - \ g\ 2}{400}\ell \quad \text{(4-48)}$$

**Maximum vertical slopes in the streets**

The factors that controls the vertical curves:

1. Design Speed
2. Type of Topography in which the street pass through.
3. The length of the part which is under the vertical slope.

The following table shows the values of the vertical slopes taking in consideration the previous factors:

Table 4-10.The maximum slopes according to the topography of the land and the design speed.[5]

| DESIGN SPEED KPH | FLAT % | HILLY % | MOUNTAINOUS % |
|---|---|---|---|
| 50 | 6 | 8 | 9 |
| 65 | 5 | 7 | 8 |
| 80 | 4 | 5 | 7 |
| 90 | 3 | 4 | 6 |
| 100 | 3 | 4 | 6 |
| 110 | 3 | 4 | 5 |

| | | | |
|---|---|---|---|
| 120 | 3 | 4 | - |
| 130 | 3 | 4 | - |

**Factors involved in the selection of the length of vertical curve**

The main factors governing the selection and determine the lengths of vertical curve are as follow:

1- Stopping sight distance.

2- Comfort of the passengers.

**stopping sight distance**

This is the length of streetway needed between a vehicle and an arbitrary object (at some point down the street) to permit a driver to stop a vehicle safely before reaching the obstruction. This is not to be confused with passing sight distance, which AASHTO defines as the “length of streetway ahead visible to the driver. Table 4.5shows the parameters governing stopping sight distance on a crest vertical curve.

The minimum stopping sight distance is computed for a height of eye (driver eye height) of 3.50 ft and a height of object (obstruction in streetway) of 6 in. The stopping distance on a level streetway comprises the distance over which a vehicle moves during the brake reaction time, the time it takes a driver to apply the brakes on sighting an obstruction, and the distance over which the vehicle travels before coming to a complete stop (braking distance).Table 5.5 lists approximate stopping sight distances on a level streetway for various design speeds and wet pavements. If the vehicle is traveling uphill, the braking distance is less, because gravity aids in slowing the vehicle. For downhill

movement, braking distance is more. A general rule of thumb is that the longer a vertical curve, the larger the safe stopping sight distance may be. Long curves, however, may be too costly to construct. Therefore, a balance should be reached between economy and safety without jeopardizing safety.[5]

For crest vertical curves AASHTO defines the minimum length Lmin, ft, of crest vertical curves based on a required sight distance S, the height of the driver eye(H1), the height of the object above the street(H2) ft, as that given by Eq:

$$\text{Lmin} = \frac{A*S^2}{100((2H1)^{0.5}+(2H2)^{0.5})2} \quad (S<L) \qquad (4\text{-}49)$$

Also, for crest vertical curves:

$$\text{Lmin} = 25 - \frac{200((2H1)^{0.5}+(2H2)^{0.5})2}{A*S^2} \quad (S>L) \qquad (4\text{-}50)$$

For sag vertical curves AASHTO defines the minimum length Lmin, ft, of sag vertical curves:

$$\text{Lmin} = \frac{A*S^2}{120+3.5*S} \quad (S<L) \qquad (4\text{-}51)$$

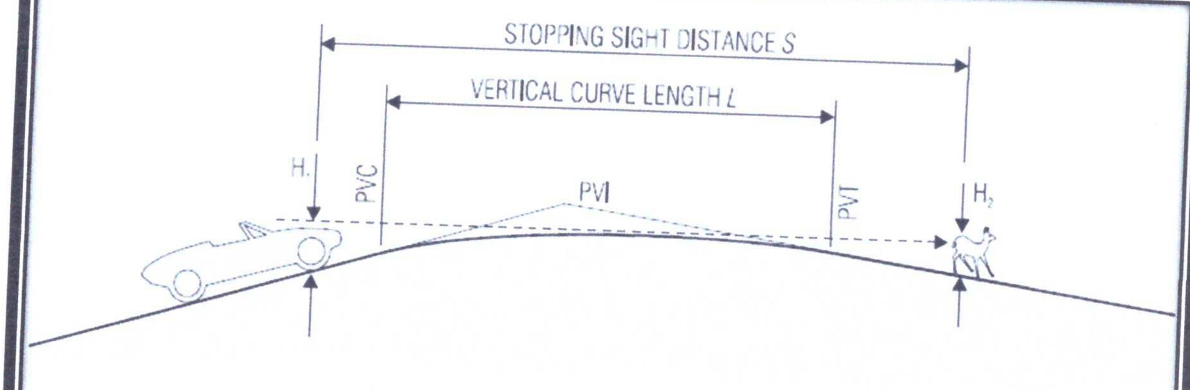
$$\text{Lmin} = 2S - \frac{120+3.5S}{A} \quad S>L) \qquad (4\text{-}52)$$

Table (4-11) Design controls for vertical curves based on stopping sight Distance.[5]

Design Controls for Vertical Curves Based on Stopping Sight Distance*

| Design speed, mi/h | Average speed for condition, mi/h | Coefficient of friction f | Stopping sight distance (rounded for design), ft | Rate of vertical curvature K, ft per percent of A: For crest curves, Computed | For crest curves, Rounded for design | For sag curves, Computed | For sag curves, Rounded for design |
|---|---|---|---|---|---|---|---|
| 20 | 20 – 20 | 0.40 | 125 – 125 | 8.6 – 8.6 | 10 – 10 | 14.7 – 14.7 | 20 – 20 |
| 25 | 24 – 25 | 0.38 | 150 – 150 | 14.4 – 16.1 | 20 – 20 | 21.7 – 23.5 | 30 – 30 |
| 30 | 28 – 30 | 0.35 | 200 – 200 | 23.7 – 28.8 | 30 – 30 | 30.8 – 35.3 | 40 – 40 |
| 35 | 32 – 35 | 0.34 | 225 – 250 | 35.7 – 46.4 | 40 – 50 | 40.8 – 48.6 | 50 – 50 |
| 40 | 36 – 40 | 0.32 | 275 – 325 | 53.6 – 73.9 | 60 – 80 | 53.4 – 65.6 | 60 – 70 |
| 45 | 40 – 45 | 0.31 | 325 – 400 | 76.4 – 110.2 | 80 – 120 | 67.0 – 84.2 | 70 – 90 |
| 50 | 44 – 50 | 0.30 | 400 – 475 | 106.6 – 160.0 | 110 – 160 | 82.5 – 105.6 | 90 – 110 |
| 55 | 48 – 55 | 0.30 | 450 – 550 | 140.4 – 217.6 | 150 – 220 | 97.6 – 126.7 | 100 – 130 |
| 60 | 52 – 60 | 0.29 | 525 – 650 | 189.2 – 302.2 | 190 – 310 | 116.7 – 153.4 | 120 – 160 |
| 65 | 55 – 65 | 0.29 | 550 – 725 | 227.1 – 394.3 | 230 – 400 | 129.9 – 178.6 | 130 – 180 |
| 70 | 58 – 70 | 0.28 | 625 – 850 | 282.8 – 530.9 | 290 – 540 | 147.7 – 211.3 | 150 – 220 |

* Adapted from "A Policy on Geometric Design of Highways and Streets," American Association of State Highway and Transportation Officials.



Stopping sight distance on a crest vertical curve.

Fig 4.21 Stopping sight distance on a crest vertical curve.[5]

**Comfort of the passengers**

Where the vertical curves are designed on the basis of the provision of passenger comfort s the length of the curve is determined on the basis of centrifugal force which is equal to 0.6 m/s2.

**General considerations in the vertical deign**

1- In the case of several lanes (four lanes, for example, or above) and in one direction, the stopping sight distance criterion for the length of vertical curve ,the reason for that is not likely to face another car in the opposite direction to the direction of excess, while in the case of streets with two lanes With the possibility of abuse for a vehicle going the same direction at sites of vertical curves, the passing sight distance is considered the safe factor for determination of the curve length.

2- The use of the passing sight distance is considered the as a safe factor for determination of the curve length, will increase the length of the curve which often causes an increase in drilling work.

3- In planning we must avoid refracted longitudinal bending (two vertical curves in the same direction separated by a short tangent) especially in the concave curves where the full scene for two curves together Unacceptable. [5]

# CHAPTER FIVE
# ANALYSIS AND DESIGN

## 5.1 Design for Wastewater Collection System

### 5. 1.1General:

In this chapter, project team evaluate and design wastewater collection system for Old City, 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 to reduce the problems caused 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 will prepare.

### 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 a Topography map is shown in appendix C (c-6) 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 Old City, 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 Old City, the lowest point is in the closed gate.
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 Old Cityis illustrated in drawing (B-1, B-2) 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) .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 65 L/c.d in 2013and 120 L/c.d for the future in 2038 when the rate is 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 40000 while in the future "after 25 years" it is predicted to be equal 57300persons with growth rate reach to 1.2 %.
7. Peaking factor depending on the formula :

$$P_f = 1.5 + \left(\frac{2.5}{\sqrt{q}}\right) \quad (5.1)$$

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 (B-3).
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.

Table 5.1 Sanitary Sewer Quantity Calculation

## Sanitary Sewer Design Computations

Line Road No 1 - Part 1

| Line No | Location | | | Length | unit sewage | Tributary area | | Flow Rates | | | | | | Q max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Street Sewer Name | Upper Mh No | Lower Mh No | | | Incremental | Total | Industry | | | Infiltration | Total | Total | |
| | | | | | | | | Average | Peak Factor | Maximum | | Average | Maximum | |
| | | | | m | m | dounm | dounm | m³/day | | m³/day | m³/day | m³/day | m³/day | m³/day |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | road 1 | 1 | 2 | 36.6 | 1.4 | 50.16 | 50.16 | 12070.22 | 1.52 | 18380.00 | 1207.02 | 13277.25 | 19587.02 | 19587.02 |
| 2 | road 1 | 2 | 3 | 31 | 1.4 | 46.73 | 96.89 | 12205.87 | 1.52 | 18585.01 | 1220.59 | 13426.46 | 19805.59 | 218.57 |
| 3 | road 1 | 3 | 4 | 34.6 | 1.4 | 55.09 | 151.98 | 12418.64 | 1.52 | 18906.56 | 1241.86 | 13660.51 | 20148.42 | 342.83 |
| 4 | road 1 | 4 | 5 | 32.2 | 1.4 | 47.90 | 199.88 | 12698.47 | 1.52 | 19329.43 | 1269.85 | 13968.32 | 20599.28 | 450.85 |
| 5 | road 1 | 5 | 6 | 35.6 | 1.4 | 45.40 | 245.28 | 13041.87 | 1.52 | 19848.30 | 1304.19 | 14346.05 | 21152.49 | 553.21 |
| 6 | road 1 | 6 | 7 | 27.6 | 1.4 | 37.39 | 282.67 | 13437.60 | 1.52 | 20446.21 | 1343.76 | 14781.36 | 21789.97 | 637.48 |
| 7 | road 1 | 7 | 8 | 20.7 | 1.4 | 33.10 | 315.77 | 13879.68 | 1.52 | 21114.05 | 1387.97 | 15267.65 | 22502.02 | 712.05 |

### Design Assamptions and data

1) Water comnsumption is 120 l/d.d which 80% return to sewer

3) Infiltration is equal 10 % of the average industrial wastewater flow.

4) Minimum pipe diameter= 200 mm

5) Minimum velocity Vmin = 0.6 m/sec

6) Maximum velocity Vmax = 3 m/sec

7) Minimum slope Smin = 0.5 %

8) Maximum slope Smax = 15 %

9) Maximum manhole spacing = 60 m

10) Minimum depth of sew 1.5 m

11) Design depth of flow h 0.5

12) Maining coefficient r 0.01

### 5.1.4 SewerCAD program works:

a. Open SewerCAD,select file → import →DXF Background to import the DXF file, fig (5.1) below shows this step.

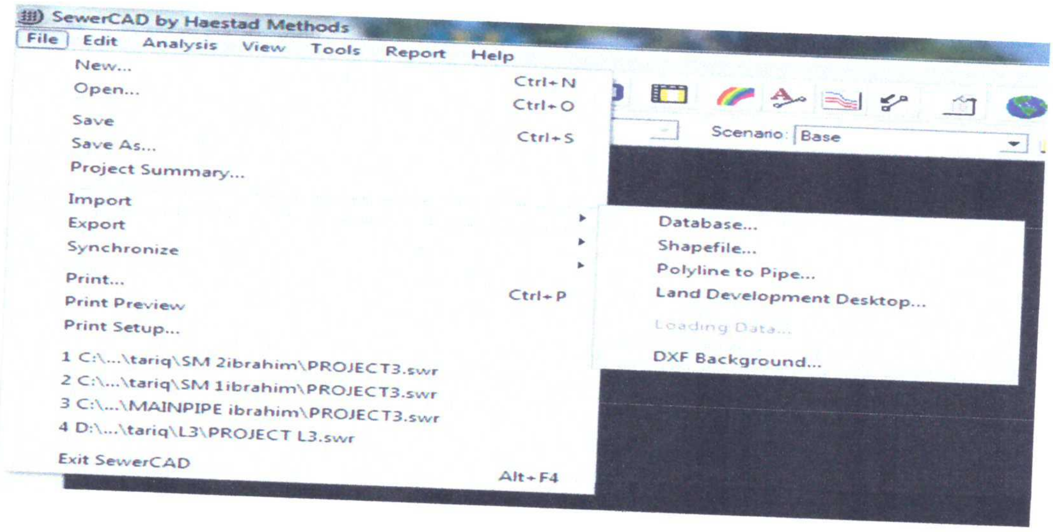



Fig 5.1 Importing DXF file

b. Specify file location isthen press open, fig (5.2) below shows this step. And fig (5.3) shows line (SL1).

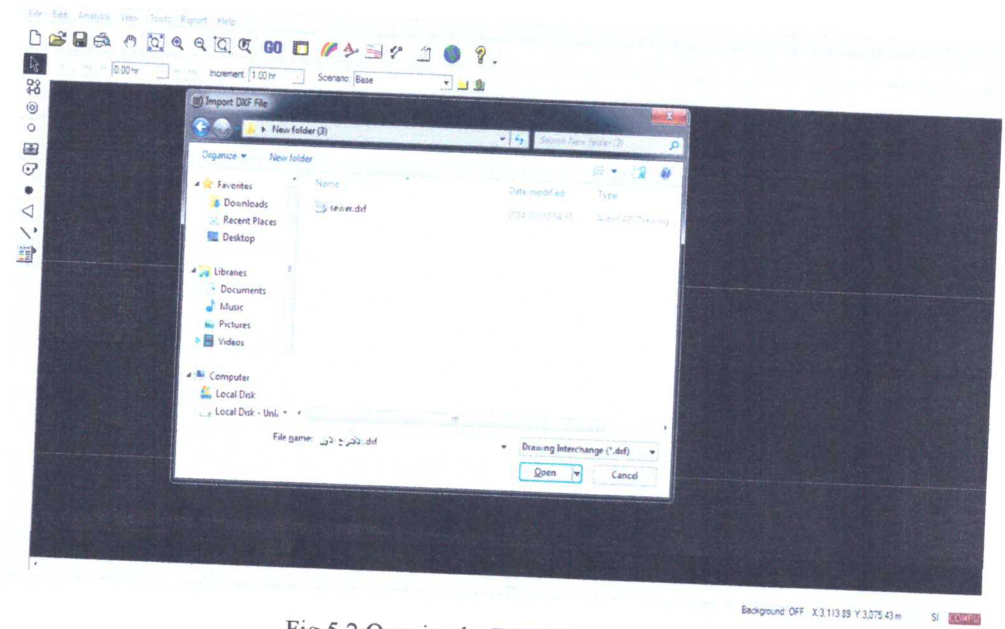



Fig 5.2 Openingthe DXF file.

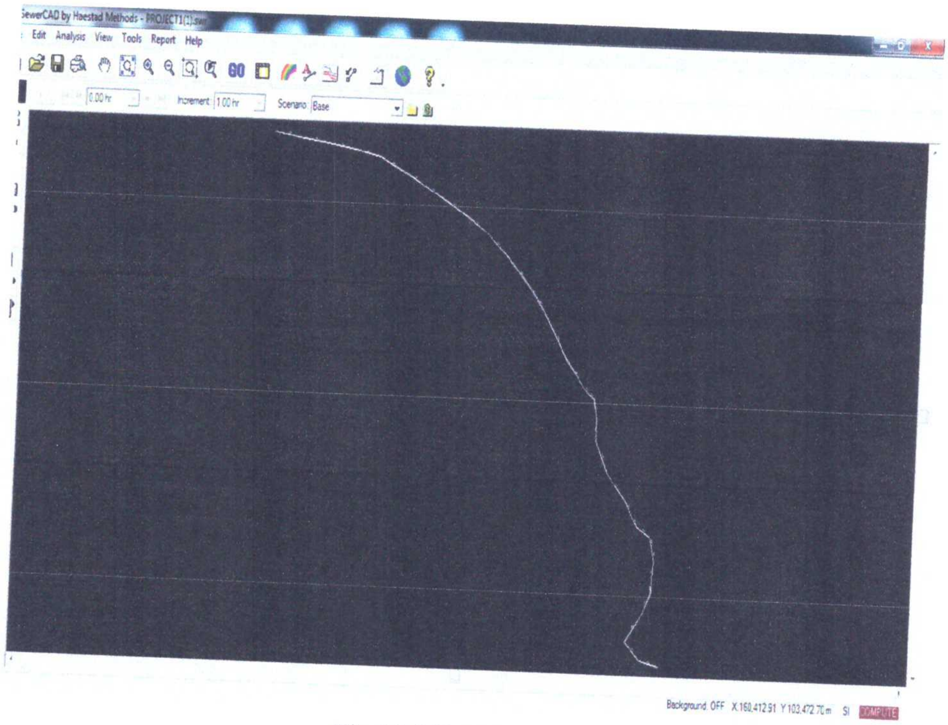



Fig 5.3 S1L1 Line.

c. Press pipe icon, a massage will appear tell youto create a project see fig (5.4).

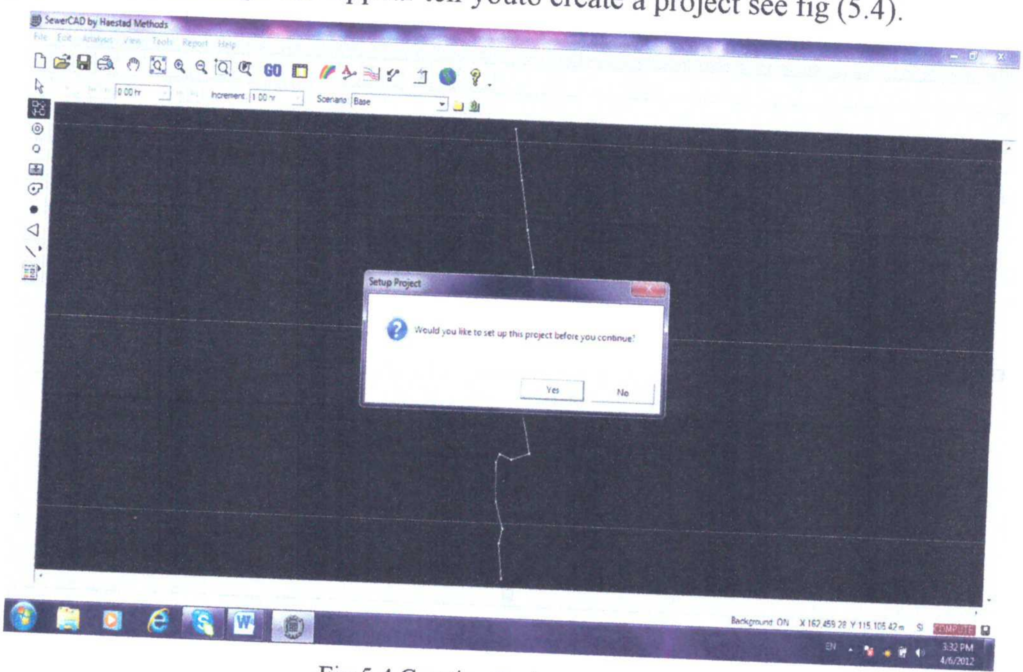



Fig 5.4 Creating Project

d. Press yes and define the project then press next twice, then select finish, the fig (5.5) below show this step.

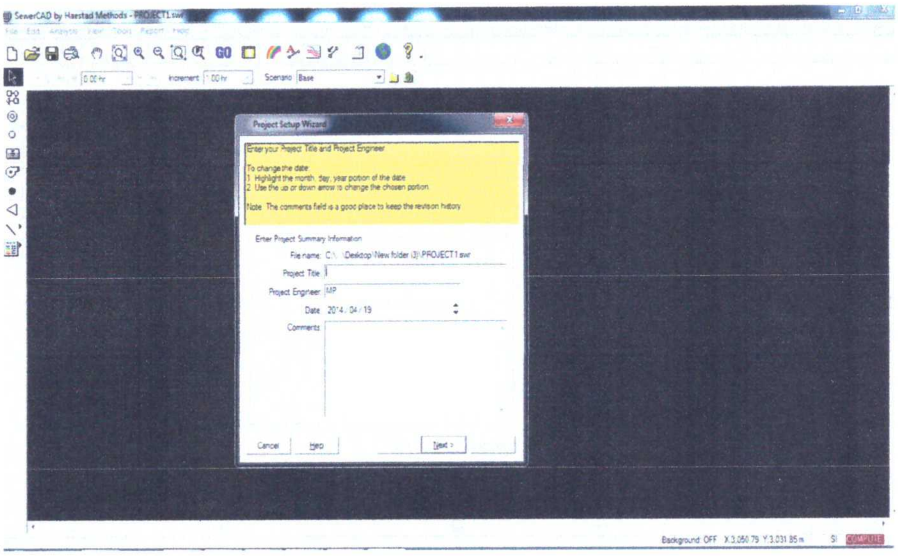



Fig 5.5 Defining the project

e. Press pipe icon and connect between manholes, fig (5.6) below shows the step.

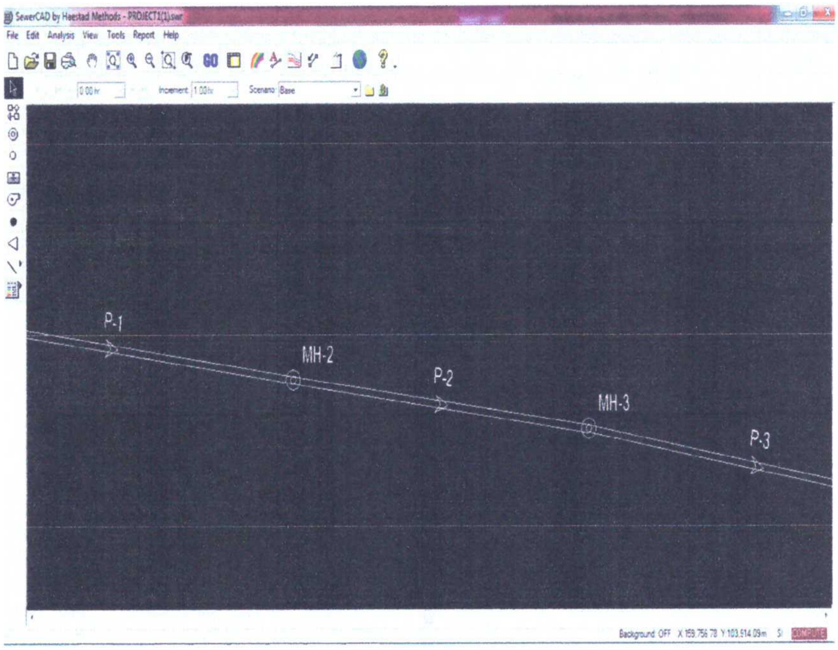



Fig 5.6 Creating a pipe network.

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 fig (5.7) below shows the step.

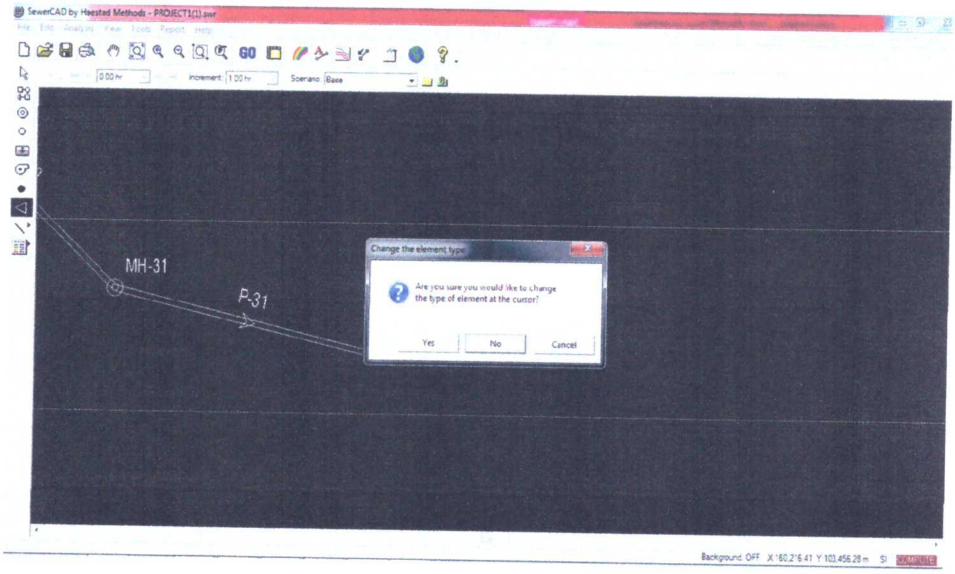



Fig 5.7 Creating outlet

g. Save your project, then select analysis → alternatives → physical properties → edit, then start editing gravity pipe, see fig (5.8).

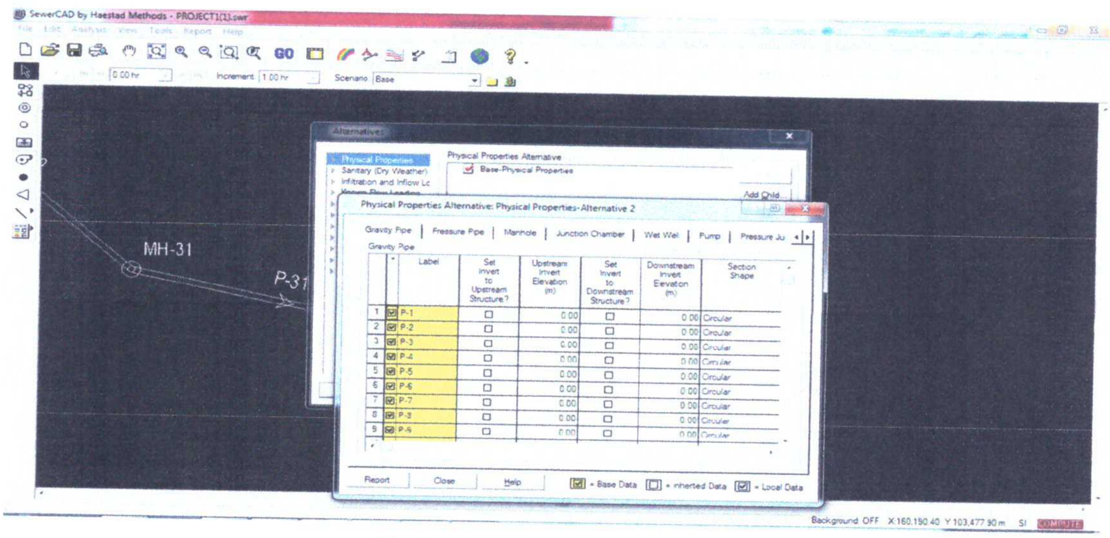



Fig 5.8 Editing design parameters

h. Select manhole to enter the ground elevations of manholes, then select out let to enter its elevation. Then press close. Fig (5.9) below shows the step.

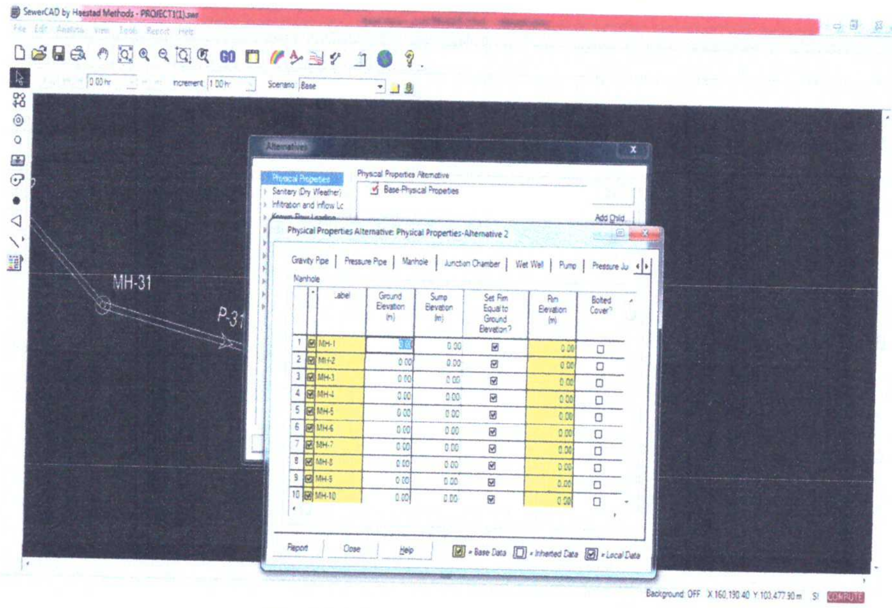



Fig 5.9 Editing design parameters

i. Select sanitary (dry weather) → edit → manhole to select the type of load and to enter the load for each manhole, fig (5.10) below shows the step.

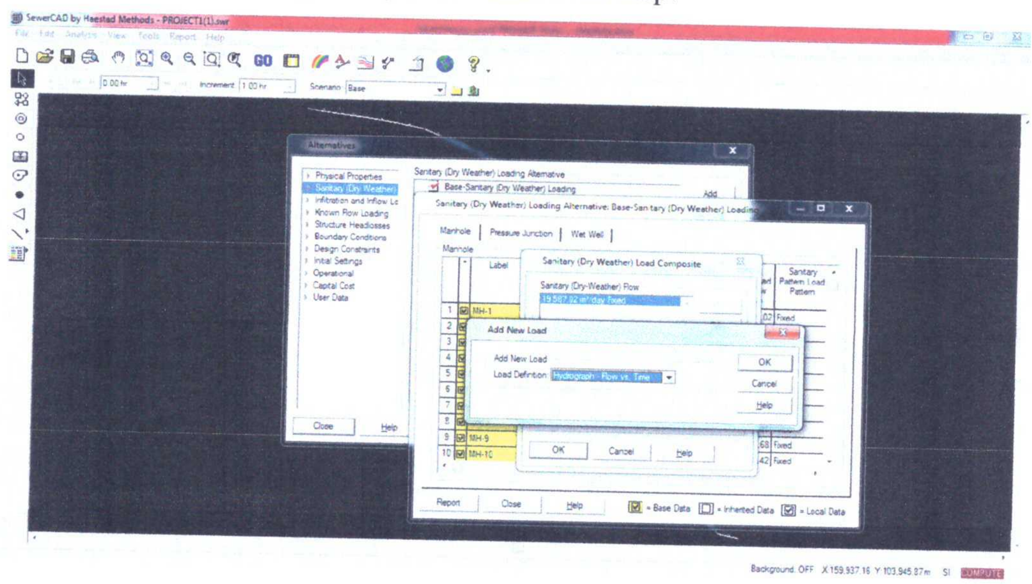


Fig 5.10 Editing design parameters

j. After doing this for each manhole press close, then select design constrains → edit to enter the design specifications, fig (5.11) below shows the step.

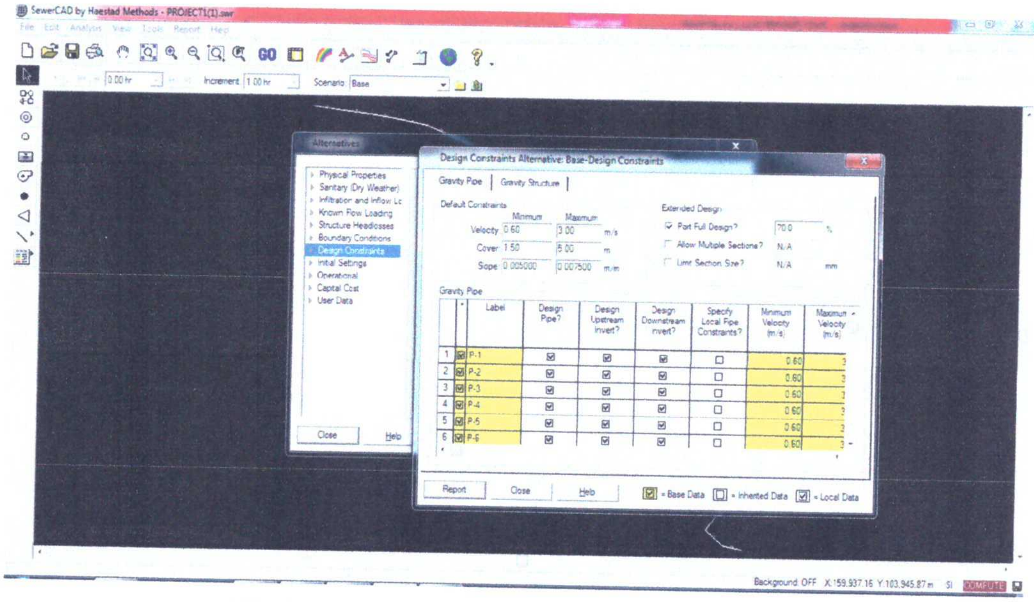


Fig 5.11 Editing design parameters

k. Last step press save, press GO button to start design then press on GO, fig (5.12) below shows the step.

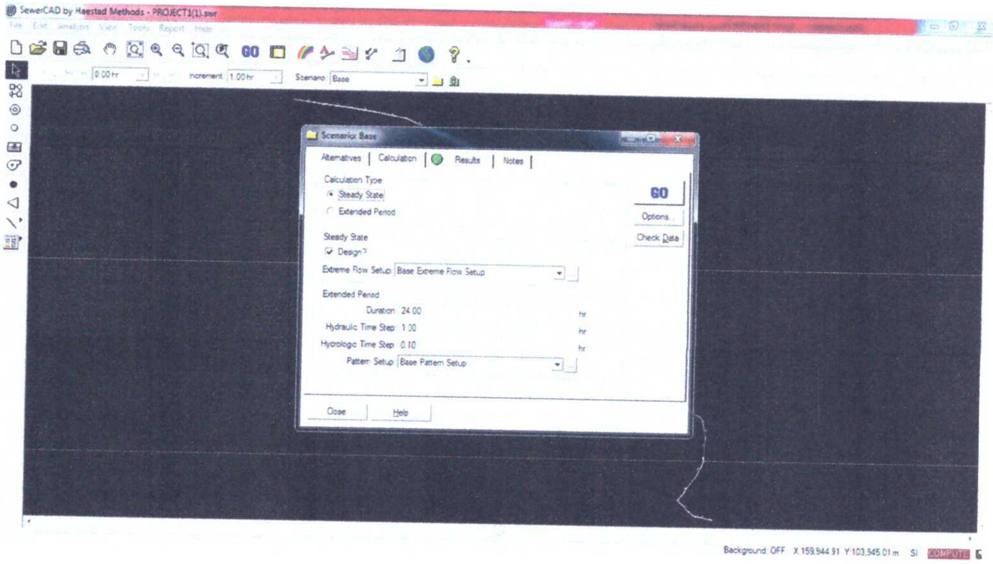


Fig 5.12 checking the design

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 (5.13), 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 fig (5.14), and then choose gravity pipe report and gravity node report. The required reports for this project are attached in appendix A page (173).

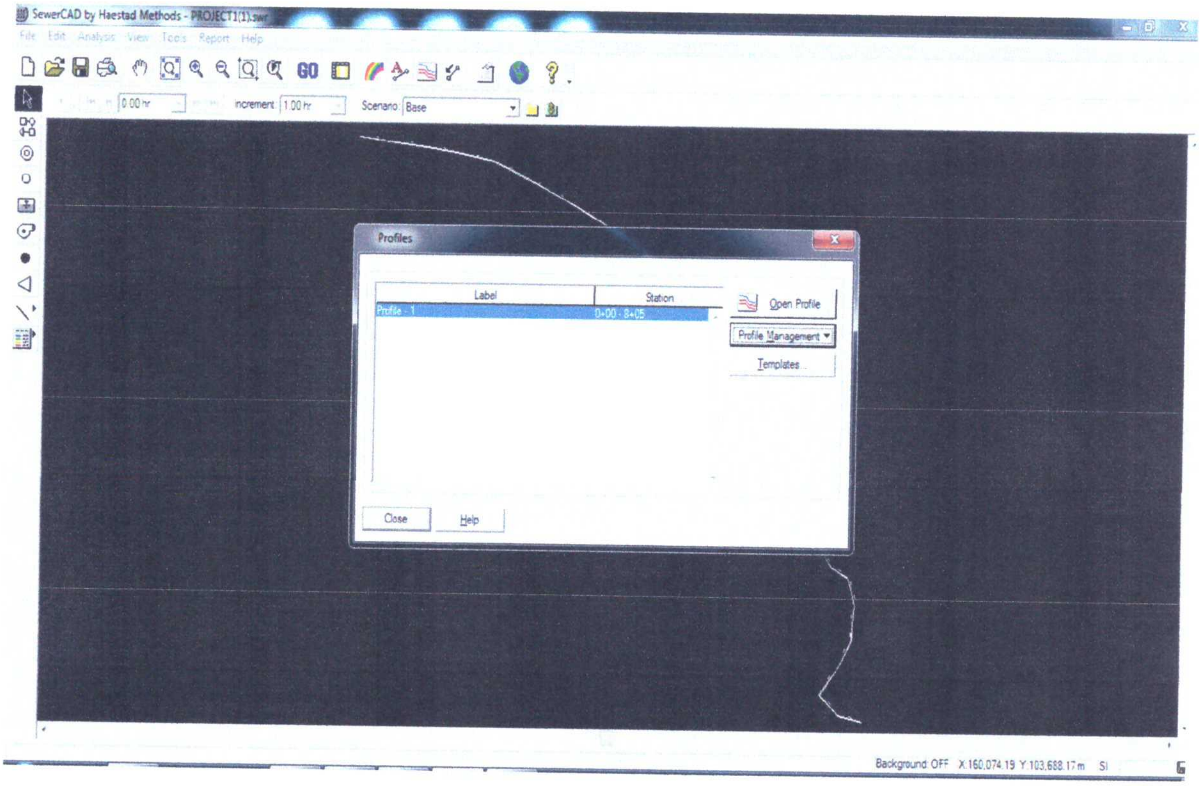



Fig 5.13 Creating Profile

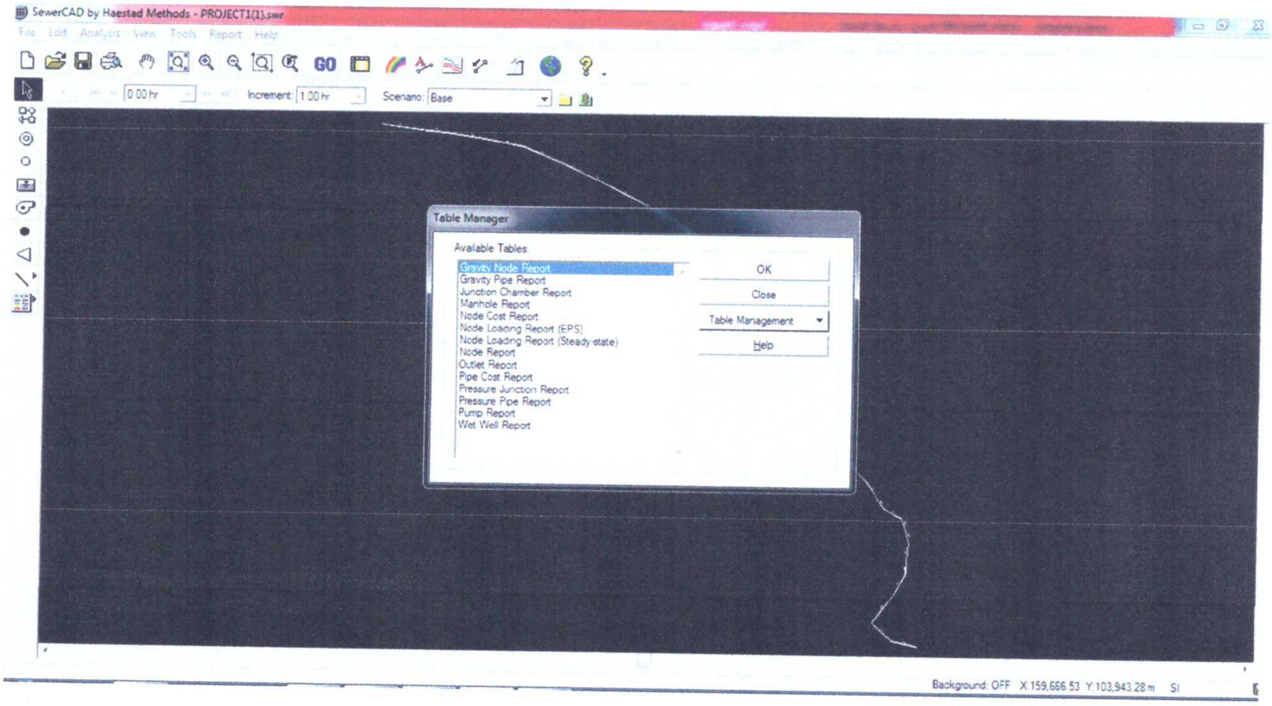
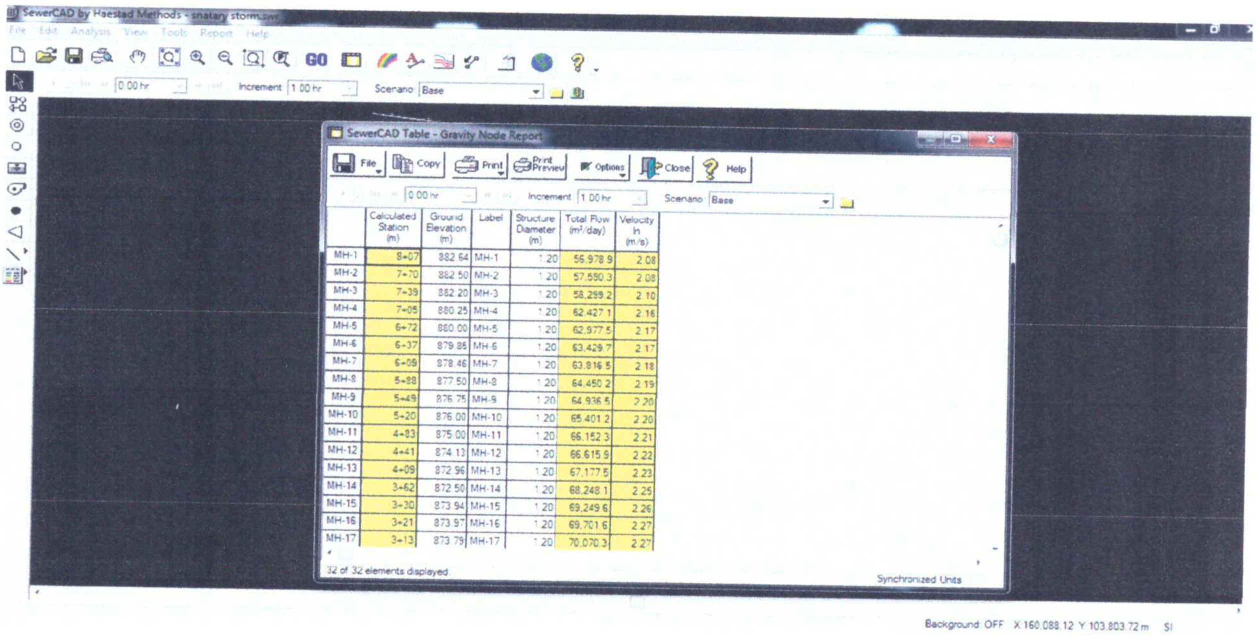



Fig 5.14 Creating Tables




| | Calculated Station (m) | Ground Elevation (m) | Label | Structure Diameter (m) | Total Flow (m³/day) | Velocity In (m/s) |
|---|---|---|---|---|---|---|
| MH-1 | 8+07 | 882.64 | MH-1 | 1.20 | 56,978.9 | 2.08 |
| MH-2 | 7+70 | 882.50 | MH-2 | 1.20 | 57,590.3 | 2.08 |
| MH-3 | 7+39 | 882.20 | MH-3 | 1.20 | 58,299.2 | 2.10 |
| MH-4 | 7+05 | 880.25 | MH-4 | 1.20 | 62,427.1 | 2.16 |
| MH-5 | 6+72 | 880.00 | MH-5 | 1.20 | 62,977.5 | 2.17 |
| MH-6 | 6+37 | 879.85 | MH-6 | 1.20 | 63,429.7 | 2.17 |
| MH-7 | 6+09 | 878.46 | MH-7 | 1.20 | 63,816.5 | 2.18 |
| MH-8 | 5+88 | 877.50 | MH-8 | 1.20 | 64,450.2 | 2.19 |
| MH-9 | 5+49 | 876.75 | MH-9 | 1.20 | 64,936.5 | 2.20 |
| MH-10 | 5+20 | 876.00 | MH-10 | 1.20 | 65,401.2 | 2.20 |
| MH-11 | 4+83 | 875.00 | MH-11 | 1.20 | 66,152.3 | 2.21 |
| MH-12 | 4+41 | 874.13 | MH-12 | 1.20 | 66,615.9 | 2.22 |
| MH-13 | 4+09 | 872.96 | MH-13 | 1.20 | 67,177.5 | 2.23 |
| MH-14 | 3+62 | 872.50 | MH-14 | 1.20 | 68,248.1 | 2.25 |
| MH-15 | 3+30 | 873.94 | MH-15 | 1.20 | 69,249.6 | 2.26 |
| MH-16 | 3+21 | 873.97 | MH-16 | 1.20 | 69,701.6 | 2.27 |
| MH-17 | 3+13 | 873.79 | MH-17 | 1.20 | 70,070.3 | 2.27 |

Fig 5.15 Example of Wastewater Table.

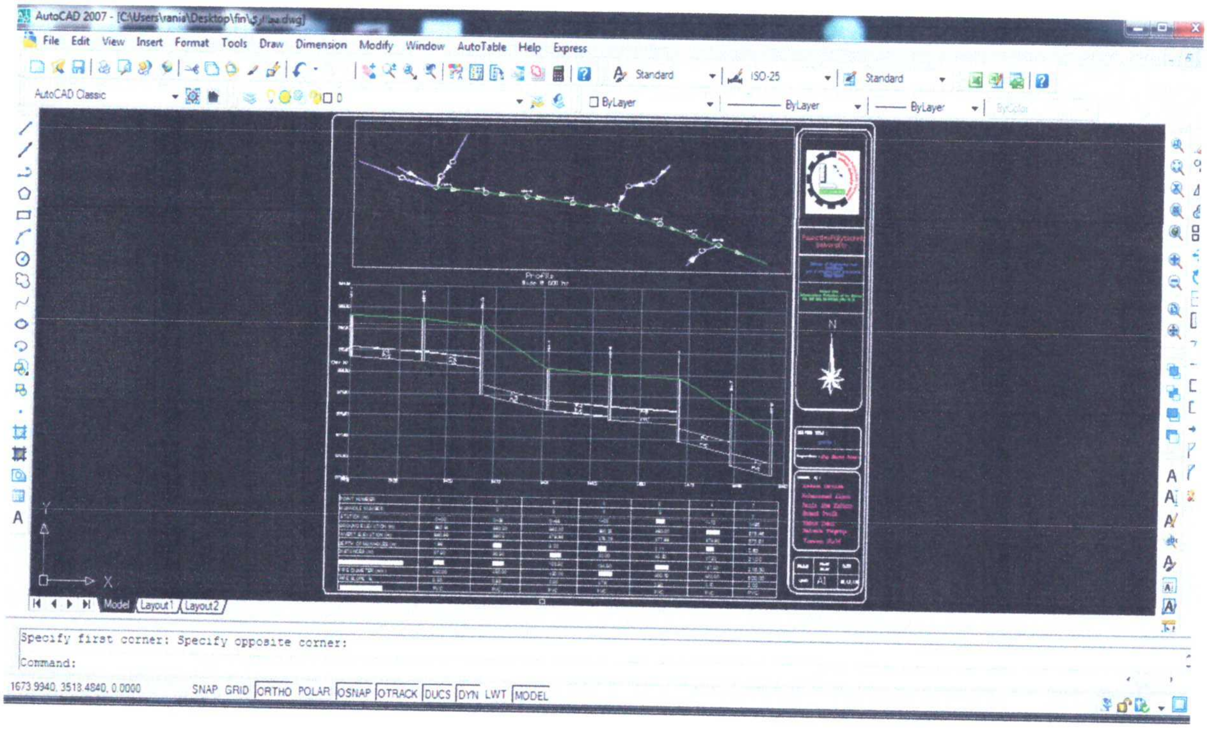


Fig 5.16 Example of Wastewater Profile.

The profiles for Wastewater network are attached in appendix B ,and the gravity pipe reports and gravity nod reports are attached in appendix A page (177).

## 5.2 Deign for Storm Water Drainage System

### 5.2.1 General:

In this section, design of storm water drainage system for the Old City, 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 will be.

### 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 Old City 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 stormwater drainage system for Hebron Old City illustrated in drawing (B-3, B-4) 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 Old City 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 Old City campline1 shown in the accompanying (B-6). 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 0.65.
2. For Inlet time (Ti) use 10 minutes

3. For Concentration time ($T_c$) use equations

$$T_c = t_i + t_f \quad (5.2)$$

4. For Runoff rate depending on the formula:

$$Q = C.i.A \quad (5.3)$$

5. For Rainfall intensity use Fig (5.17).

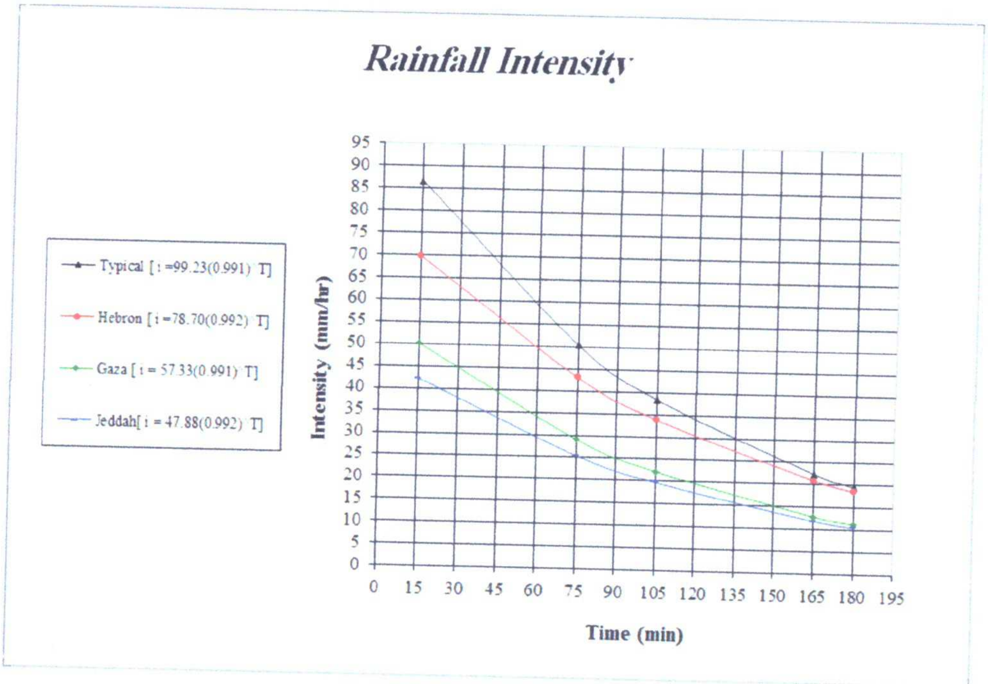



Fig 5.17 rainfall intensity

**Solution:**

1. Lay out the storm water sewer line. Draw a line to represent the proposed sewer see appendix C (c-7).
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 7represent 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 runoff rate (Q) which obtained by multiply column 10 by column 13

i. Column 15 shows (Qi) in (l/s) separately between two inlets.

Table 5.2 StormWater Quantity Calculation

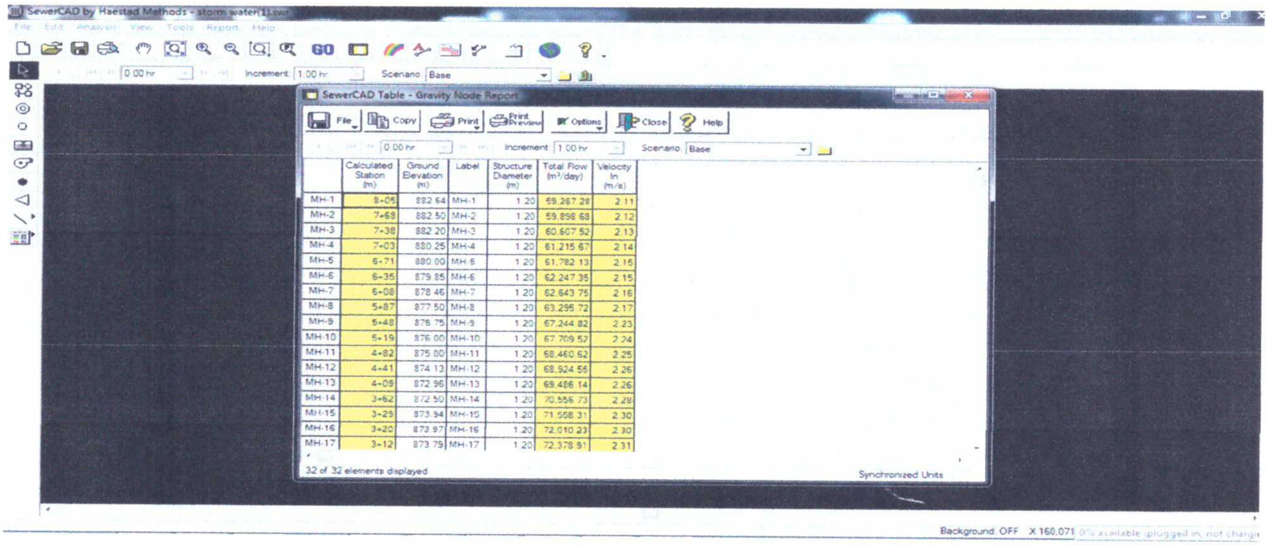
# StormWater Design Computations

## Line Road No 1 Part 1

| NUMBER | LOCATION | | | LENGTH | LENGTH COMULATIVE | AREA of Street and industry | C FACTOR Street and industry | C.A STREET | SUM(AC) COMULATIVE | Tc | ( i ) | Q | Qi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | LINE NAME | UPPER MH. NO. | LOWER MH. NO. | (m) | (m) | (ha) | | (ha) | (ha) | (min) | (l/s.ha) | (l/s) | (l/s) |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 14 | 15 | 16 | 17 | 18 |
| 1 | Road 1 P1 | 1 | 2 | 37.155 | 37.155 | 4.961 | 0.650 | 3.224 | 3.224 | 10.619 | 200.778 | 59287.279 | 59287.279 |
| 2 | Road 1 P1 | 2 | 3 | 30.545 | 67.700 | 4.724 | 0.650 | 3.071 | 6.295 | 11.128 | 199.958 | 59898.681 | 611.403 |
| 3 | Road 1 P1 | 3 | 4 | 34.594 | 102.295 | 5.524 | 0.650 | 3.591 | 9.886 | 11.705 | 199.035 | 60607.519 | 708.837 |
| 4 | Road 1 P1 | 4 | 5 | 32.123 | 134.418 | 4.787 | 0.650 | 3.111 | 12.997 | 12.240 | 198.181 | 61215.673 | 608.154 |
| 5 | Road 1 P1 | 5 | 6 | 34.200 | 168.618 | 4.509 | 0.650 | 2.931 | 15.928 | 12.810 | 197.275 | 61782.129 | 566.457 |
| 6 | Road 1 P1 | 6 | 7 | 27.695 | 196.312 | 3.733 | 0.650 | 2.426 | 18.354 | 13.272 | 196.545 | 62247.344 | 465.215 |
| 7 | Road 1 P1 | 7 | 8 | 20.718 | 217.030 | 3.1899 | 0.650 | 2.073 | 20.428 | 13.617 | 196.001 | 62643.748 | 396.404 |
| 8 | Road 1 P1 | 8 | 9 | 39.337 | 256.367 | 5.3104 | 0.650 | 3.452 | 23.880 | 14.273 | 194.971 | 63295.714 | 651.966 |

### 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.




| | Calculated Station (m) | Ground Elevation (m) | Label | Structure Diameter (m) | Total Flow (m³/day) | Velocity In (m/s) |
|---|---|---|---|---|---|---|
| MH-1 | 8+05 | 882.64 | MH-1 | 1.20 | 59,287.28 | 2.11 |
| MH-2 | 7+69 | 882.50 | MH-2 | 1.20 | 59,898.68 | 2.12 |
| MH-3 | 7+38 | 882.20 | MH-3 | 1.20 | 60,607.52 | 2.13 |
| MH-4 | 7+03 | 880.25 | MH-4 | 1.20 | 61,215.67 | 2.14 |
| MH-5 | 6+71 | 880.00 | MH-5 | 1.20 | 61,782.13 | 2.15 |
| MH-6 | 6+35 | 879.85 | MH-6 | 1.20 | 62,247.35 | 2.15 |
| MH-7 | 6+08 | 878.46 | MH-7 | 1.20 | 62,643.75 | 2.16 |
| MH-8 | 5+87 | 877.50 | MH-8 | 1.20 | 63,295.72 | 2.17 |
| MH-9 | 5+48 | 876.75 | MH-9 | 1.20 | 67,244.82 | 2.23 |
| MH-10 | 5+19 | 876.00 | MH-10 | 1.20 | 67,709.52 | 2.24 |
| MH-11 | 4+82 | 875.00 | MH-11 | 1.20 | 68,460.62 | 2.25 |
| MH-12 | 4+41 | 874.13 | MH-12 | 1.20 | 68,924.56 | 2.26 |
| MH-13 | 4+09 | 872.96 | MH-13 | 1.20 | 69,486.14 | 2.26 |
| MH-14 | 3+62 | 872.50 | MH-14 | 1.20 | 70,556.73 | 2.28 |
| MH-15 | 3+25 | 873.94 | MH-15 | 1.20 | 71,558.31 | 2.30 |
| MH-16 | 3+20 | 873.97 | MH-16 | 1.20 | 72,010.23 | 2.30 |
| MH-17 | 3+12 | 873.79 | MH-17 | 1.20 | 72,378.91 | 2.31 |

Fig 5.18 Example of storm water table.

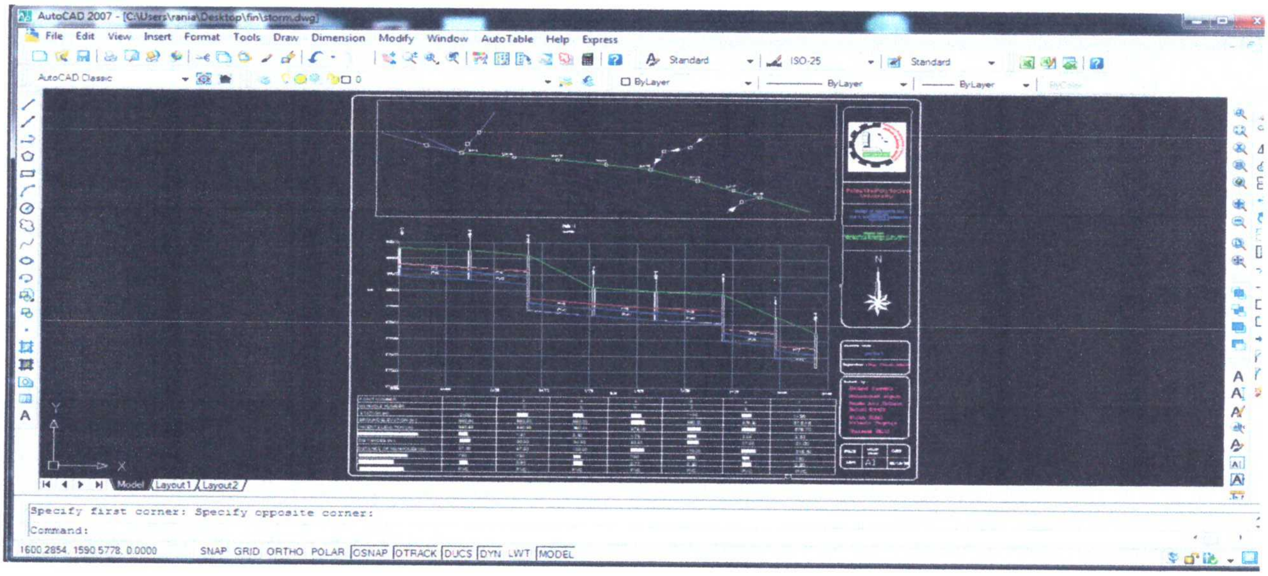


Fig 5.19 Example of storm water Profile.

The profiles for storm water network are attached in appendix B ,and the gravity pipe reports and gravity nod reports are attached in appendix A page (185).

## 5.3 Traverse Network and Its Adjustment

### 5.3.1 General:

Traversing is one of the simplest and most popular methods of establishing control networks in engineering surveying. Using the technique of traversing, the relative position of the control points is fixed by measuring the horizontal angle at each point, between the adjacent stations, and the horizontal distance between consecutive pairs of stations.

Traverse networks have the following advantages:

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

(2) Observations only involve three stations at a time so planning the task is simple.

(3) Traversing may permit the control to follow the route of a highway, pipeline or tunnel, etc., with the minimum number of stations.

### 5.3.2 Types of traverse:

For the majority of traverses carried out today the field data would most probably be captured With a total station. The susceptibility 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 misclosure can be quantified and distributed throughout the network, to minimize the errors. Such a traverse is called a 'link' traverse.

Alternatively, the error vector can be obtained by completing the traverse back to its starting point. 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 (5.20) illustrates a typical link traverse commencing from the precisely coordinated point Y and closing onto point W, with terminal orienting bearing to points X and Z.

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.

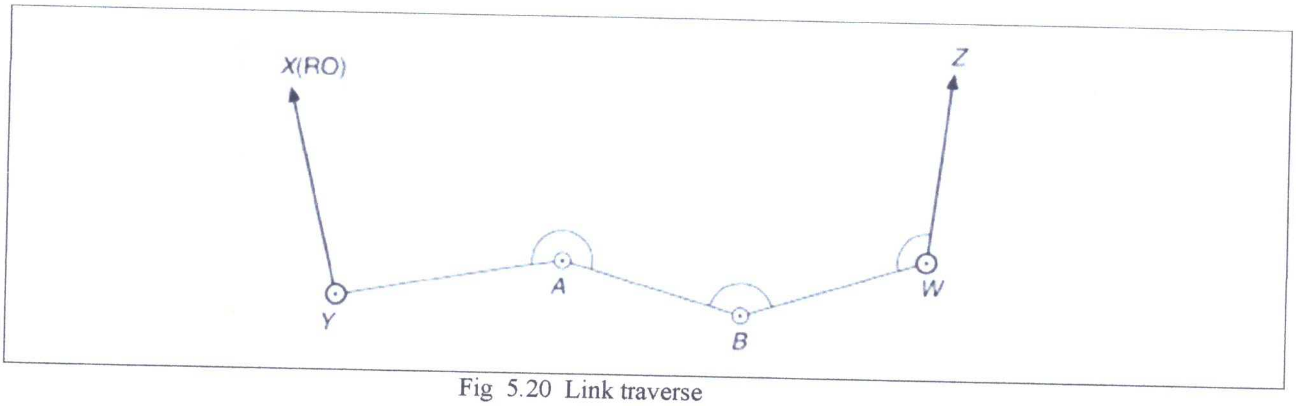



Fig 5.20 Link traverse

**2- Polygonal traverse**

Fig (5.21-a) and (5.21-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 external orientation is available, the control can only be used for independent sites and plans and cannot be directly connected to other survey systems.

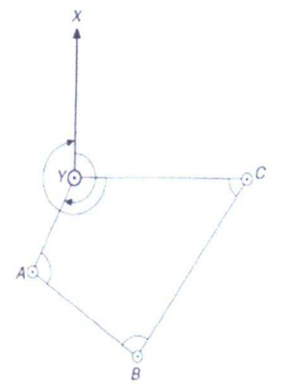



Fig 5. 21-a Loop traverse (oriented)

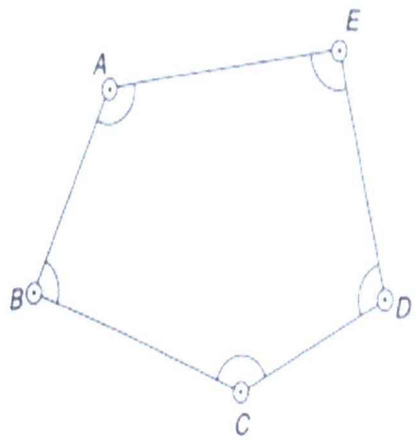



Fig 5.21-b Loop traverse (independent)

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.

### 3- Open or free traverse

Fig (5.22) 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 tunneling work because of the physical restriction on closure.

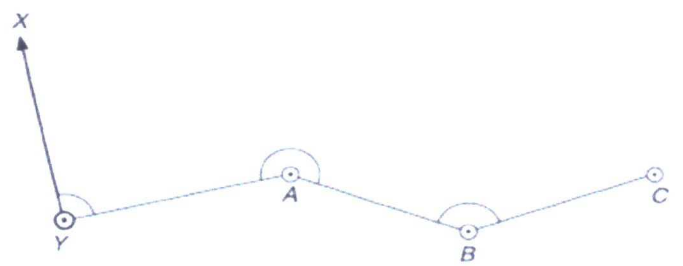



Fig 5.22 open/free traverse

In this project we used a link traverse, because it's the most accurate traverse.

### 5.3.3 Observations:

A link traverse Fig ( 5.23) start from known station 1000 , 2000 and ends in 6000 , and 7000 were taken by GPS.

Table show the observations of angles and distances that measured for traverse 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.

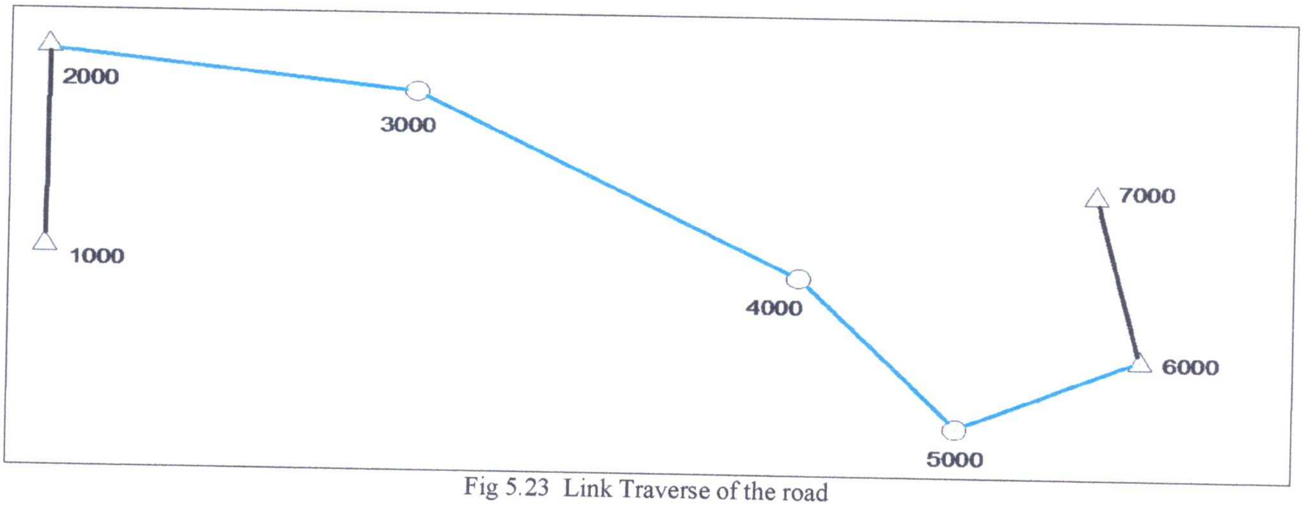



Fig 5.23 Link Traverse of the road

Table ( 5.3) observations of link traverse

**F.R.2000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 1000 | 00 00 00 | 100.328 |
| 3000 | 277 0٤ ١٥ | 154.233 |
| 1000 | 277 0٤ ١٥ | 100.330 |
| 3000 | 194 0٨ ٠٠ | 154.230 |
| 1000 | 194 0٨ ٠٠ | 100.324 |
| 3000 | 111 1٤ ٥٥ | 154.229 |

**F.L.2000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 3000 | 68 4٥ ٠٥ | 154.235 |
| 1000 | 14 ١٠ ٢0 | 100.323 |
| 3000 | 14 ١٠ ٢0 | 154.232 |
| 1000 | 97 0٧ ٤٠ | 100.324 |
| 3000 | 97 ٠٧ ٤٠ | 154.232 |
| 1000 | 180 04 00 | 100.322 |

**F.R.3000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 2000 | 00 00 00 | 154.240 |
| 4000 | 203 10 49 | 185.653 |
| 2000 | 203 10 49 | 154.230 |
| 4000 | 46 22 32 | 185.656 |
| 2000 | 46 22 32 | 154.228 |
| 4000 | 249 33 42 | 185.660 |

**F.L.3000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 4000 | 69 33 25 | 185.660 |
| 2000 | 226 22 50 | 154.232 |
| 4000 | 226 22 50 | 185.659 |
| 2000 | 23 11 18 | 154.233 |
| 4000 | 23 11 18 | 185.658 |
| 2000 | 179 59 44 | 154.233 |

**F.R.4000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 3000 | 00 00 00 | 185.654 |
| 5000 | 198 45 21 | 100.933 |
| 3000 | 198 45 21 | 185.656 |
| 5000 | 37 30 43 | 100.941 |
| 3000 | 37 30 43 | 185.655 |
| 5000 | 236 16 24 | 100.943 |

**F.L.4000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 5000 | 56 16 49 | 100.933 |
| 3000 | 217 31 27 | 185.658 |
| 5000 | 217 31 27 | 100.922 |
| 3000 | 18 45 50 | 185.655 |
| 5000 | 18 45 50 | 100.933 |
| 3000 | 180 00 13 | 185.660 |

**F.R.5000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 4000 | 00 00 00 | 100.922 |
| 6000 | 105 13 28 | 84.43 |
| 4000 | 105 13 28 | 100.914 |
| 6000 | 210 26 04 | 84.42 |
| 4000 | 210 26 04 | 100.917 |
| 6000 | 315 39 12 | 84.425 |

**F.L.5000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 6000 | 135 38 37 | 84.413 |
| 4000 | 30 25 45 | 100.923 |
| 6000 | 30 25 45 | 84.419 |
| 4000 | 285 12 23 | 100.928 |
| 6000 | 285 12 23 | 84.421 |
| 4000 | 179 59 23 | 100.917 |

**F.R.6000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 5000 | 00 00 00 | 84.419 |
| 7000 | 102 43 59 | 86.124 |
| 5000 | 102 43 59 | 84.420 |
| 7000 | 205 27 40 | 86.115 |
| 5000 | 205 27 40 | 84.425 |
| 7000 | 308 11 11 | 86.120 |

**F.L.6000**

| Point | Horizontal Angle | Horizontal Distance |
|---|---|---|
| 7000 | 128 11 06 | 86.130 |
| 5000 | 25 27 48 | 84.427 |
| 7000 | 25 27 48 | 86.125 |
| 5000 | 282 43 37 | 84.422 |
| 7000 | 282 43 37 | 86.122 |
| 5000 | 179 59 27 | 84.420 |

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

Table( 5.4) average horizontal distances and angles

| From | To | Horizontal Angle | Horizontal distance |
|---|---|---|---|
| 2000 | 1000 | 00 00 00 | 100.327 |
| 2000 | 3000 | 82 55 41.66 | 154.231 |
| 3000 | 2000 | 00 00 00 | |
| 3000 | 4000 | 156 48 46.2 | 185.658 |
| 4000 | 3000 | 00 00 00 | |
| 4000 | 5000 | 161 14 30 | 100.921 |
| 5000 | 4000 | 00 00 00 | |
| 5000 | 6000 | 254 46 55.6 | 84.422 |
| 6000 | 5000 | 00 00 00 | |
| 6000 | 7000 | 257 16 11.7 | ٨٦.١٢٢ |

### 5.3.4Coordinates determination for unknown stations before correction:

E3000=E2000+D 2000→3000Sin brg2000→3000=159708.277+154.2315 Sin97026' 1.86 = 159861.2122

N3000=N2000+D 2000→3000 Cos brg2000→3000= 103932.513+154.2315 Cos 97 26 1.86 =103912.5583

Where

E: Easting for unknown stations.

N: Northing for unknown stations.

D: Distance from station (known coordinates) to unknown stations .

brg: Bearing of the unknown stations.

For points 4000 , 5000 see Appendix A.

Table ( 5.5) shows the coordinates of control stations were taken by GPS instrument to tie the traverse to produce the most accurate solution. To compute the coordinates of remaining control stations (3000,4000, and 5000) you must observe the horizontal angles and distances and correct them from errors. Table (5.6) represents the horizontal angles before correction.

Table (5.5) Coordinates of control stations by GPS instrument

| ST | E | N | Z | ΔE | ΔN | ATAN | BRG |
|---|---|---|---|---|---|---|---|
| 1000 | 159707.643 | 103832.192 | 886.804 | -0.634 | -100.321 | 0.00632 | 180.3621 |
| 2000 | 159708.277 | 103932.513 | 883.172 | | | | |
| 6000 | 160162.758 | 103778.067 | 879.004 | 18.911 | -84.023 | -0.22138 | 167.3158 |
| 7000 | 160143.847 | 103862.09 | 884.247 | | | | |

Table (5.6) horizontal angles of the traverse

| station | degree | minute | Second | Angle (radian) |
|---|---|---|---|---|
| 3000 | 82 | 55 | 41.66 | 82.92823889 |
| 4000 | 156 | 48 | 46.2 | 156.8128333 |
| 5000 | 161 | 14 | 30 | 161.2416667 |
| 6000 | 254 | 46 | 55.6 | 254.7821111 |
| 7000 | 257 | 16 | 11.7 | 257.2699167 |

Indeed the horizontal angles are the base for the bearing of lines to compute the coordinates of control stations. Table (5.7) shows the bearing of lines before correction.

Example

Assume bearing of line AB = 40° 13′ 56′′, and the horizontal angle (A) = 120° 53′ 24′′ . compute the bearing of line AC.

Bearing AC = bearing AB + horizontal angle A

= 40° 13′ 56′′ + 120° 53 24 = 161° 7′ 20′′.

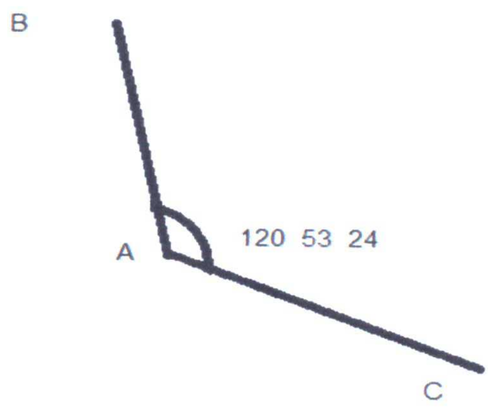



Table ( 5.7) Bearing of lines before correction

| From-To | Bearing | | | |
|---|---|---|---|---|
| 2000-3000 | 97.43384921 | | | |
| 3000-4000 | 120.6210159 | | | |
| 4000-5000 | 139.3793492 | | | |
| 5000-6000 | 64.5972381 | | | |

| | | | | |
|---|---|---|---|---|
| **6000-7000** | 167.3273214 | 167 | 19 | 38.35717232 |
| | 167.3158359 | 167 | 18 | 57.00909807 |
| | | | | |
| **ERROR** | -0.011485576 | -41.34807424 | | |
| **CORR** | 0.002297115 | | | |

In order to find the coordinates of unknown stations you must to correct the horizontal angle and bearing of the lines. Table(5.8) shows the correct bearing of lines and angles.

Table (5.8) correct bearing of line and angles

| **CORRECT ANGLE** | | | | | |
|---|---|---|---|---|---|
| **Station** | **Angle** | **Degree °** | **Minute ′** | **Second ″** | |
| **3000** | 82.930536 | 82 | 55 | 49.92961 | |
| **4000** | 156.8151304 | 156 | 48 | 54.46961 | |
| **5000** | 161.2439638 | 161 | 14 | 38.26961 | |
| **6000** | 254.7844082 | 254 | 47 | 3.869615 | |
| **7000** | 257.2722138 | 257 | 16 | 19.96961 | |
| **CORRECT BRG** | | | | | |
| **From-To** | **Bearing** | **Degree °** | **Minute ′** | **Second ″** | |
| **2000-3000** | 97.4315521 | 97 | 25 | 53.58756 | |
| **3000-4000** | 120.6164217 | 120 | 36 | 59.11794 | |
| **4000-5000** | 139.3724579 | 139 | 22 | 20.84833 | |
| **5000-6000** | 64.58804964 | 64 | 35 | 16.97871 | |
| **6000-7000** | 167.3158359 | 167 | 18 | 57.0091 | |

### 5.3.5 Traverse error reduction:

All surveying observations are subject to errors from varying sources. Although great care may be taken in observing the angle, these error sources will render inexact results. To appreciate fully the need for adjustments, surveyors must be able to identify the major observational error sources, know

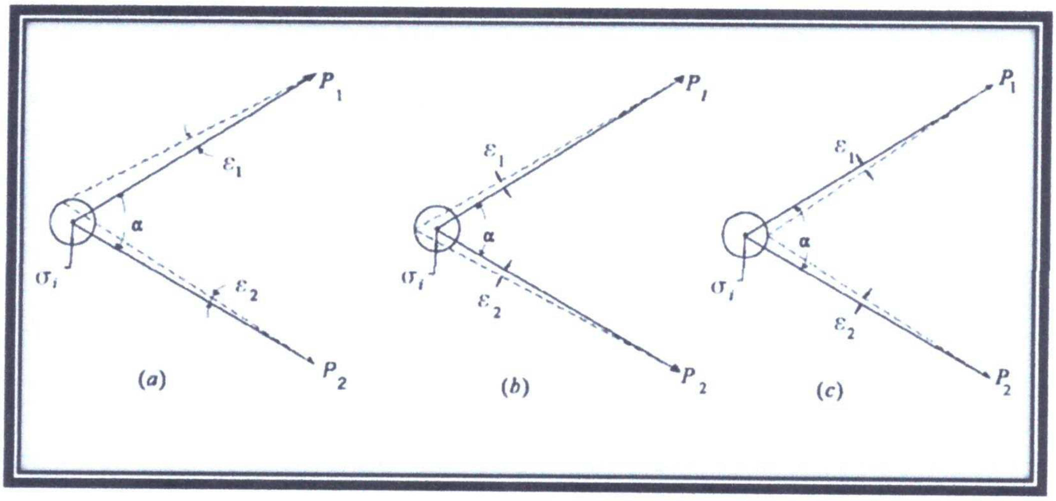



Fig 5.24 Error in angle due to error in instrument centering.

1. Target Centering Error :

This error because the prism is not perpendicular on the ground and it's about 2mm. This can be attributed to environmental conditions, optical plummet errors, quality of the optics, plumb bob centering error, personal abilities, and so on.

Fig (5.25) shown the angular error due to the centering error depends on the position of the target.

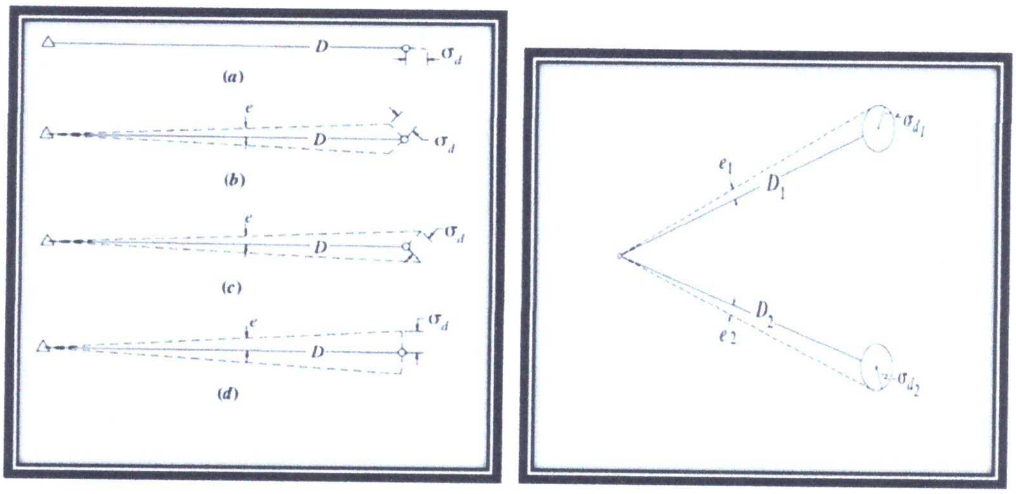



Fig 5.25 Error in angle due to target centering error.

Since two directions are required for each angle observation, the final equation is

$$\square\alpha t=\frac{\sqrt{D1^2+D2^2}}{D1*D2}\, 6t * \rho$$

Where :

6t:the angular error due to the target centering error.

D1&D2 :are the distances from the target to the instrument at stations 1 and 2.

$\rho$: row constant = 206264.

2. Point and reading errors.

With the introduction of electronic total station instruments, new standards were developed for estimating errors in angle observations.

This error correct by this equation:

$$\sigma_{abr} = \pm\frac{2\sigma_{DIN}}{\sqrt{n}}$$

Where:

$\sigma_{abr:}$ Is Pointing and Reading Error.

$\sigma_{DIN}$:Is Instrument Error.

n:Is reading repetition.

This value is usually be constant and equal:

$$\sigma_{abr} = \pm\frac{2*3"}{\sqrt{3}}= ٣.٤٦".$$

**4- Error in electronic distance observations.**

All EDM observations are subject to instrumental errors that manufacturers list as constant, a , and scalar, b , error. A typical specified accuracy is $\pm$(a + b ppm). In this expression, a is generally in the range 1 to 10 mm, and b is a scalar error that typically has the range 1 to 10 ppm. Other errors involved in electronic distance observations stem from the target and instrument centering errors. Since in any survey involving several stations these errors tend to be random Thus, the estimated error in an EDM observed distance is

$$\sigma_D = \sqrt{\sigma_i^2 + \sigma_t^2 + a^2 + (D \times b \text{ ppm})^2}$$

$$\sigma_D = \sqrt{(0.002)^2 + (0.002)^2 + (0.003)^2 + (154.2315 * 0.00001)^2}$$
$$= 0.0044 \text{ m}$$

Where:

6D= is the error in the observed distance D.

6i = the instrument centering error.

6 t= the reflector centering error.

And a and b the instrument's specified accuracy parameters.

Table (5.9) average distance and the errors of each one

| Line | Distance (m) | $\sigma_D$(m) |
|---|---|---|
| **2000-3000** | 154.2315 | 0.0044 |
| **3000-4000** | 185.6576 | 0.0045 |
| **4000-5000** | 100.9208 | 0.0028 |
| **5000-6000** | 84.42214 | 0.0028 |

### 5.3.6 Coordinate Error correction methods:

Table (5.10) correct coordinates for unknown control station

| COORDINATES CORRECTION | | | | |
|---|---|---|---|---|
| **FROM-TO** | **Bearing** | **Distance** | **ΔE** | **ΔN** |
| **2000-3000** | 1.700501379 | 154.2315 | 152.9359686 | -19.94856108 |
| **3000-4000** | 2.10515369 | 185.6576 | 159.7762054 | -94.55320519 |
| **4000-5000** | 2.432508276 | 100.9208 | 65.71348135 | -76.59468808 |
| **5000-6000** | 1.127274124 | 84.42214 | 76.25394413 | 36.22752719 |
| | SUM | 525.23204 | 454.6795996 | -154.8689272 |
| | | | | |
| | ΔE | 454.481 | | |
| | ΔN | -154.446 | | |
| | | | | |
| | ERROR E | 0.198599564 | | |
| | ERROR N | -0.422927154 | | |

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 Adjust program.

The table represents the corrected coordinates after the correction of bearings of lines traverse and its distance.

Table (5.11) final correct distances

| CORRECTION OF DISTANCES | | | | | |
|---|---|---|---|---|---|
| | | **E CORRECT** | **N CORRECT** | **ΔE** | **ΔN** |
| **2000-3000** | 154.2315 | -0.05831767 | 0.124190233 | 152.877651 | -19.8243708 |
| **3000-4000** | 185.6576 | -0.070200437 | 0.149495146 | 159.706005 | -94.40371 |
| **4000-5000** | 100.9208 | -0.038159947 | 0.08126341 | 65.6753214 | -76.5134247 |
| **5000-6000** | 84.42214 | -0.031921511 | 0.067978365 | 76.22202262 | 36.2955056 |
| | | -0.198599564 | 0.422927154 | 454.481 | -154.446 |

Table (5.12) final correct coordinates

| CORRECT COORDINATES. | | |
|---|---|---|
| **Station** | **Easting** | **Northing** |
| **2000** | 159708.277 | 103932.513 |
| **3000** | 159861.1547 | 103912.6886 |
| **4000** | 160020.8607 | 103818.2849 |
| **5000** | 160086.536 | 103741.7715 |
| **6000** | 160162.758 | 103778.067 |

## 5.4 The Structural design and Laboratory Tests

### 5.4.1 Introduction

The structural design of the road is to find the thickness of each of the sub base, the base course and the asphalt layers and to define their prosperities in order to carry loads of the vehicles travelling on it according to the laboratory tests and the traffic volume on it.

### 5.4.2 Laboratory Tests

Laboratory Tests includes several tests applied on the pavement layers of the road and the soil of the site.

The most important tests are:

1 - Compaction test.

2 - CBR test.

### 5.4.2.A Compaction test (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 involve fluid flow, but with moisture changing altering.

Objectives:

The chief purpose of running the compaction test is to determine the maximum dry unit weight of a soil. After determining this maximum dry unit weight, specifications can be determined for filed 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.

Standard Proctor Compaction Test Equipments:

1. Compaction mould.
2. Sieve No.4
3. Standard proctor hammer (5.5lb (24.5n)).
4. Balances (0.01 lb sensitivity and 0.1g sensitivity)
5. A large flat pan.
6. Jack.
7. Steel straight edge. Moisture cans.
8. Drying oven.
9. Plastic squeeze bottle with water.

## Procedure:

1. Obtain approximately 10lb (4.5kg) of air-dried in the mixing pan, break all the lumps so that it 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 mould without the base plate and the collar. W1,(lb).(Row #1 of the table).
4. Fix the collar and base plate .( ask your instruction regarding how to fill the mould and take the steps 5 and 6)
5. Place the first portion of the soil in the proctor mould and compact the layer applying 25 blows.
6. 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.

7. The final layer should ensure that the compacted soil is just above the rim of the compaction mould when the collar is still attached.
8. Detach the collar carefully without disturbing the compacted soil inside the mould and using a straight edge trim the excess soil leveling to the mould.
9. Determine the weight of the mould with the moist soil W2,(Ib). Extrude the sample and break it to collect the simple for water content determination preferably from the middle of the specimen.
10. Weigh an empty moisture can, W3,(g) and weigh again with the moist soil obtained from the extruded sample in step 9 , W4,(g) .Keep this can in the oven for water content determination.
11. Break the rest of the compacted soil with hand (visually ensure that it passes US Sieve No.4) .
12. Repeat steps 4 to 11 .During this process the weight W2 increases for some time with the increase in moisture and drops suddenly. Take two moisture increments after the weights starts reducing. Obtain at least 4 points to plot the dry unit weight, moisture content variation.
13. After 24 hrs recover the sample in the oven and determine the weight W5, (g).

Calculations and results:

The values of wet density, dry density and the other information about the base coarse layer appear in the tables (6-1), (6-2) respectively. And The optimum moisture content appears in the figure (6-1) such that:

The height of Proctor's template = 116.5 mm

The radius of the template = 152.4 mm

The volume of the template = $(r^2 * \pi) * \text{height}$

$V = (152.4^2 * \pi) * 116.5 = 2125 \ cm^3$ and this volume constant for all samples.

The weight of the empty template = 7749 g.

The compaction was applied on five layers, and each layer was hit 55 blows with the proctor's hammer.

Table (5-13) the values of wet density for base coarse samples

| Sample No. | Sample weight + Template(g) | Weight of the wet sample(g) | Volume of the sample ($cm^3$) | Wet density (g/$cm^3$) |
|---|---|---|---|---|
| 1 | 9608 | 4492 | Volume of the template = 2125 | 2.11 |
| 2 | 9910 | 4794 | | 2.25 |
| 3 | 10125 | 5009 | | 2.35 |
| 4 | 10114 | 4998 | | 2.35 |
| 5 | 10022 | 4906 | | 2.30 |

Table (5-14) the values of dry density and moisture content for base coarse samples

| Sample No. | Vine No. | Weight of empty Vine | Weight of the wet sample +vine (g) | Weight of the dry sample +vine (g) | Water weight (g) | Weight of the dry sample(g) | Moisture ratio (%) | Dry density (g/$cm^3$) |
|---|---|---|---|---|---|---|---|---|
| 1 | A2 | 31.85 | 307.85 | 298.60 | 9.25 | 266.75 | 3.5 | 2.05 |
| 2 | A7 | 31.45 | 304.80 | 291.40 | 13.40 | 259.95 | 5.16 | 2.15 |
| 3 | E12 | 32.80 | 276.05 | 259.20 | 16.85 | 226.40 | 7.44 | 2.20 |
| 4 | D4 | 31.70 | 300.50 | 278.60 | 21.90 | 246.90 | 8.90 | 2.16 |
| 5 | A11 | 29.15 | 239.95 | 219.30 | 20.65 | 190.15 | 10.90 | 2.09 |

From the results in tables (5-13), (5-15)

Wet density (1) = Weight of the wet sample / Volume of the sample

Wet density (1) = 4492/2125= 2.11 g/ $cm^3$

Moisture ratio (1) = Water weight / Weight of the dry sample

Moisture ratio (1) = 9.25 / 266.75= 3.5 %

Dry density (1) = Wet density / (1+ Moisture ratio)

Dry density (1) = 2.11 / (1+3.5) = 2.05 g/ $cm^3$

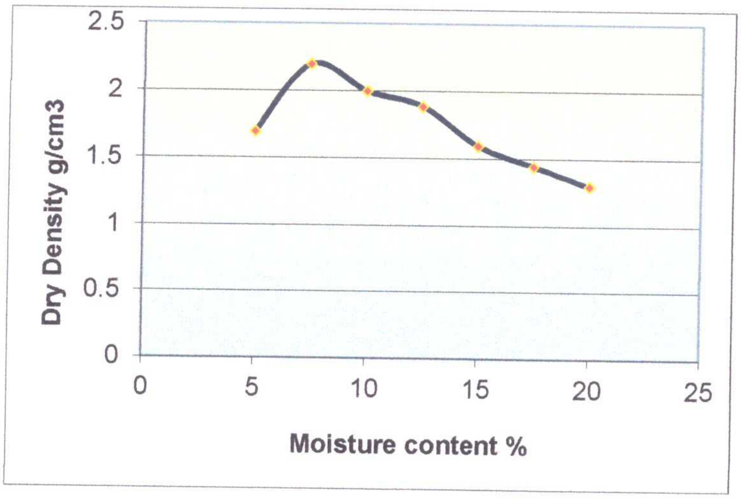



Fig 5-26 the relation between moisture ratio and dry density.

From the above figure we find that:

The maximum density = 2.2 g/ $cm^3$.

The optimum moisture content = 7.44 %.

The following table shows wet density for the soil samples:

Table (5-15) the values of wet density for soil samples

| Sample No. | Sample weight + Template(g) | Weight of the wet sample(g) | Volume of the sample (▯▯$^{▯}$) | Wet density (g/ ▯▯$^{▯}$) |
|---|---|---|---|---|
| 1 | 9433 | 4317 | Volume of the template = 2125 | 2.03 |
| 2 | 9625 | 4509 | | 2.12 |
| 3 | 9690 | 4574 | | 2.15 |
| 4 | 9545 | 4429 | | 2.08 |
| 5 | 9403 | 4287 | | 2.01 |

Table (5-16) the values of dry density and moisture ratio for soil samples

| Sample No. | Vine No. | Weight of empty Vine | Weight of the wet sample +vine (g) | Weight of the dry sample +vine (g) | Water weight (g) | Weight of the dry sample(g) | Moisture ratio (%) | Dry density (g/□□□) |
|---|---|---|---|---|---|---|---|---|
| 1 | A14 | 31.95 | 246.44 | 228.5 | 17.94 | 196.55 | 9.12 | 1.86 |
| 2 | B6 | 31.75 | 245.87 | 225.4 | 20.47 | 193.65 | 10.57 | 1.91 |
| 3 | C13 | 30.55 | 246.81 | 220.5 | 26.31 | 189.95 | 13.85 | 1.89 |
| 4 | A3 | 30.55 | 215.28 | 186.5 | 28.78 | 155.95 | 18.45 | 1.75 |
| 5 | 8 | 29 | 320.20 | 268.3 | 51.90 | 239.30 | 21.68 | 2.09 |

From the results in tables (5-15), (5-16)

Wet density (1) = Weight of the wet sample / Volume of the sample

Wet density (1) = 4317/2125= 2.03 g/ $cm^3$

Moisture ratio (1) = Water weight / Weight of the dry sample

Moisture ratio (1) = 17.94 / 196.55= 9.12 %

Dry density (1) = Wet density / (1+ Moisture ratio)

Dry density (1) = 2.03 / (1+9.12) = 1.86 g/ $cm^3$

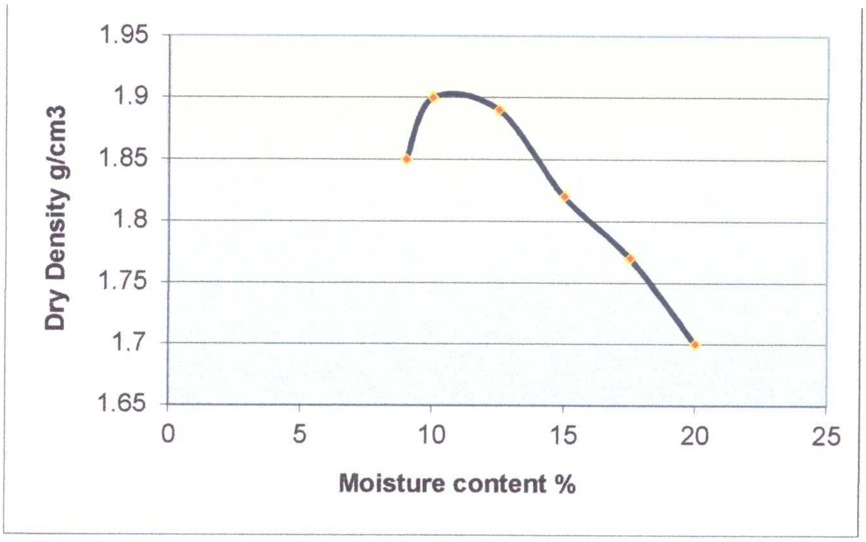



Fig 5-27 the relation between moisture ratio and dry density.

From the above figure we find that:

The maximum density = 1.91 g/ $cm^3$.

The optimum moisture content = 10.57 %.

### 5.4.2.B CBR Test

### Introduction

The CBR test is one of the most commonly used methods to evaluate the strength of a sub grade soil, sub base, and base course material for design of thickness for highways and airfield pavement.

### Definition of CBR:

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.
The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of subgrade soil for design of flexible pavement.
Tests are carried out on natural or compacted soils in water soaked or un-soaked conditions and the results so obtained are compared with the curves of standard test to have an idea of the soil strength of the subgrade soil.

### CBR Test PROCEDURE:

- Normally 3 specimens each of about 7 kg must be compacted so that their compacted densities range from 95% to 100% generally with 10, 30 and 65 blows.
- Weigh of empty mould.
- Add water to the first specimen (compact it in five layer by giving 10 blows per layer).

- After compaction, remove the collar and level the surface.
- Take sample for determination of moisture content.
- Weight of mould + compacted specimen.
- Place the mold in the soaking tank for four days (ignore this step in case of unsoaked **CBR**.
- Take other samples and apply different blows and repeat the whole process.
- After four days, measure the swell reading and find %age swell.
- Remove the mould from the tank and allow water to drain.
- Then place the specimen under the penetration piston and place surcharge load of 10lb.
- Apply the load and note the penetration load values.
- Draw the graphs between the penetration (in) and penetration load (in) and find the value of **CBR**.
- Draw the graph between the %age **CBR** and Dry Density, and find **CBR** at required degree of compaction.

## APPARATUS Used

- Three steel Moulds.
- Steel cutting collar
- Spacer Disc
- Surcharge weight
- Dial gauges
- IS sieves
- Penetration Plunger
- Loading Machine
- Miscellaneous Apparatus

Fig 5.28 the penetration device

## Results and Calculations

The California Bearing Ratio Test (CBR) = (Load causing 0.1'' penetration / Load causing the same penetration to a standard sample)*100%.

Table (5-17) Resistance to penetration relation CBR (55) for base coarse[1]

| Depth of Penetration (mm) | Standard Resistance To penetration (Kg/??) | Dial Reading (div.) | Resistance (Kg/??) |
|---|---|---|---|
| 0.5 | | 61 | 8.01 |
| 1 | | 120 | 15.75 |
| 1.5 | | 190 | 24.94 |
| 2 | | 275 | 36.09 |
| 2.5 | 49.22 | 375 | 49.22 |
| 3 | | 475 | 62.35 |
| 3.5 | | 580 | 76.13 |
| 4 | | 680 | 89.26 |
| 4.5 | | 780 | 102.38 |
| 5 | 114.20 | 870 | 114.20 |
| 5.5 | | 965 | 126.67 |
| 6 | | 1065 | 139.79 |
| 6.5 | | 1170 | 153.58 |
| 7 | | 1225 | 160.80 |
| 7.5 | | 1310 | 171.9587 |

| | | | |
|---|---|---|---|
| 8 | | 1375 | 180.491 |
| 8.5 | | 1445 | 189.6796 |
| 9 | | 1530 | 200.8372 |
| 9.5 | | 1615 | 211.99 |
| 10 | | 1690 | 221.84 |

Table (5-18) Resistance to penetration relation CBR (55) for soil[1]

| Depth of Penetration (mm) | Standard Resistance To penetration (Kg/ $cm^2$) | Dial Reading (div.) | Resistance (Kg/ $cm^2$) |
|---|---|---|---|
| 0.5 | | 30 | 3.94 |
| 1 | | 70 | 9.19 |
| 1.5 | | 100 | 13.13 |
| 2 | | 125 | 16.41 |
| 2.5 | 19.16 | 146 | 19.16 |
| 3 | | 165 | 21.66 |
| 3.5 | | 185 | 24.28 |
| 4 | | 200 | 26.25 |
| 4.5 | | 215 | 28.22 |
| 5 | 30.19 | 230 | 30.19 |
| 5.5 | | 245 | 32.16 |
| 6 | | 257 | 33.74 |
| 6.5 | | 271 | 35.57 |
| 7 | | 282 | 37.02 |
| 7.5 | | 292 | 38.33 |
| 8 | | 303 | 39.77 |
| 8.5 | | 314 | 41.22 |
| 9 | | 325 | 42.66 |
| 9.5 | | 335 | 43.97 |
| 10 | | 344 | 45.16 |

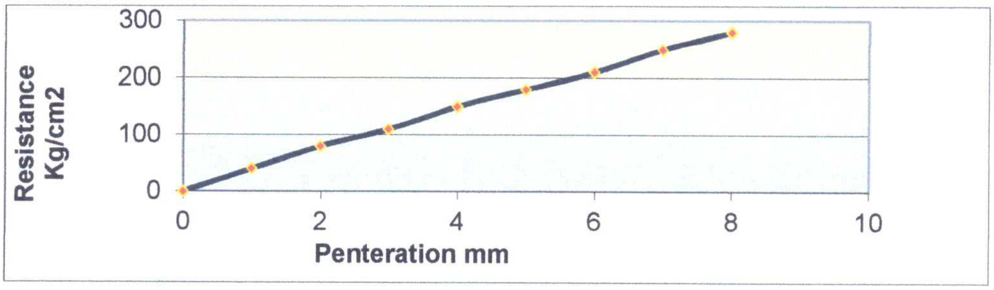



Fig 5.29 Resistance-Penetration Relationship[1]

| No. of blows | Dry Density | CBR at 2.5 | CBR at 5 |
|---|---|---|---|
| 55 | 2.07 | 49.22 | 144.20 |

From the previous figure we calculate the CBR at 95%density and that from the maximum value of the dry density.

### 5.4.3 Pavement

There are two main types of pavement:

1. Flexible pavement.
2. Rigid pavement.

### 5.4.3.A Flexible Pavement

Flexible pavements are so named because the total pavement structure deflects, or flexes, under loading. A flexible pavement structure is typically composed of several layers of material. Each layer receives the loads from the above layer, spreads them out, and then passes on these loads to the next layer below. Thus, the further down in the pavement structure a particular layer is, the fewer loads (in terms of force per area) it must carry see Fig (5.30).

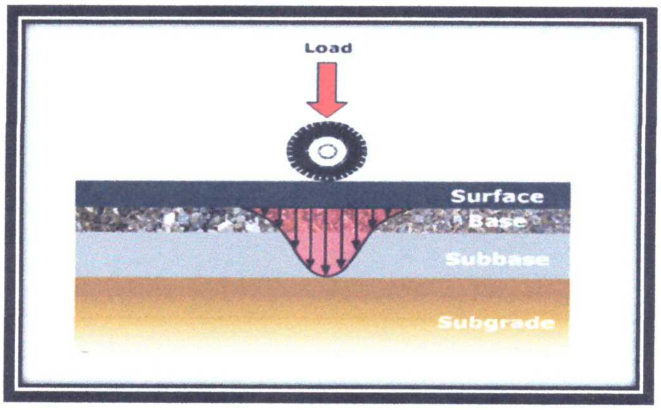



Fig 5.30 Flexible Pavement load distribution[1]

## General principles of flexible pavement design

In this design of flexible pavement, the pavement structure is usually considered as a multilayered elastic system, with the material in each layer characterized by certain physical properties that may include the modulus of elasticity, the resilient modulus, and the Poisson ratio. It is usually assumed that the subgrade layer is infinite in the both the horizontal and vertical direction, whereas the other layers are finite in the vertical direction and infinite in the horizontal direction.

The maximum vertical stresses are compressive and occur directly under the wheel load These decrease with increase in depth from the surface .The maximum horizontal stresses also occur directly under the wheel load but can be either tensile or compressive. When the load and pavement thickness are within certain ranges, horizontal compressive stresses will occur above the neutral axis, whereas horizontal tensile stresses will occur below the neutral axis .The temperature distribution within the pavement structure, will also have an effect on the magnitude of the stresses.

The design of the pavement is therefore generally based on strain criteria that limit both the horizontal and vertical strains below those that will cause excessive cracking and excessive permanent deformation. These criteria are considered in terms of repeated load applications, because the accumulated repetitions of traffic loads are of significant importance to the development of cracks and permanent deformation of the pavement.

## Design Procedure

The principle adopted in the design procedure is to determine the minimum thickness of the asphalt layer that will adequately withstand the stresses that develop for the two strain criteria discussed earlier that is , both the vertical compressive strain at the surface of the subgrade and the horizontal tensile strain at the bottom of the asphalt layer.[1]

## Structural components of a flexible pavement

Fig (5.31) shows the components of flexible pavement the subgrade or the prepared road bed , the subbase , the base and the wearing surface. The performance of the pavement depends on the satisfactory performance of each component, which requires proper evaluation of the properties of each component separately.

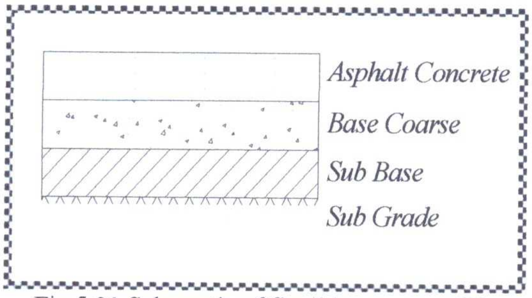



Fig 5.31 Schematic of flexible pavement[1]

### Sub grade(prepared road bed)

The sub grade is usually the natural material located along the horizontal alignment of the pavement and serves as the foundation of the pavement structure. The sub grade may also consist of a layer of selected borrow materials, well compacted prescribe specification. It may be necessary to treat the sub grade material to achieve certain strength properties required for the type of pavement being constructed. [1]

**Sub base Coarse**

Located immediately above the sub grade , the sub base components consists of materials of superior to that which generally is used for sub grade construction .The requirements of sub base materials are usually given in terms of the gradation , plastic characteristics , and strength . When the quality of the sub grade material meets the requirements of the sub base materials , the sub base component may be omitted .In case where suitable sub base materials is not readily available, the available material can be treated with other materials to achieve the necessary properties .This process of treating soil to improve their engineering properties is known as stabilization.

**Base Course**

The base course lies immediately above the sub base. It is placed immediately above the sub grade if a sub base course is not used. This course usually consists of granular materials such as crushed stone, crushed or uncrushed slag, crushed or uncrushed gravel, and sand. The specifications for base course materials usually include stricter requirements than those for sub base materials, particularly with respect to their plasticity, gradation, and strength. Materials that do not have the required properties can be used as base materials if they are properly stabilized with Portland cement, asphalt, or lime. In some cases, high-quality base course materials may also be treated with asphalt or Portland cement to improve the stiffness characteristics of heavy-duty pavements.[1]

**Surface Course**

The surface course is the upper course of the road pavement and is constructed immediately above the base course. The surface course in flexible pavements usually consists of a mixture of mineral aggregates and asphaltic materials. It should be capable of withstanding high tire pressures, resisting the abrasive forces due to traffic, providing a skid-resistant driving surface, and preventing the penetration of surface water into the underlying layers. The thickness of the wearing surface can vary from 3 in, to more than 6 in, depending on the expected traffic on the pavement.[1]

### 5.4.3.B Rigid Pavement

Rigid pavements are so named because the pavement structure deflects very little under loading due to the high modulus of elasticity of their surface course. A rigid pavement structure is typically composed of a PCC surface course built on top of either (1) the subgrade or (2) an underlying base course. Because of its relative rigidity, the pavement structure distributes loads over a wide area with only one, or at most two, structural layers see Fig ( 5.32).

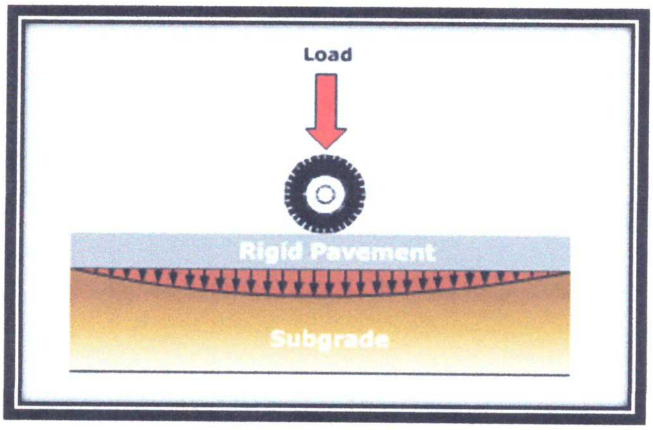



Figure (5.32) Rigid Pavement load distribution[1]

## Design of Rigid Pavements

Rigid highway pavements are normally constructed of Portland cement and may or may not have a base course between the sub grade and the concrete surface .When a base course is used in rigid pavement construction, it is usually referred to as a sub base course .It is common, however, for only the concrete surface to be referred to as the rigid pavement, even where there is a base course .In this text ,the terms "rigid pavement" and "concrete pavement "are synonymous. Rigid pavement have some flexural strength that permits them to sustain a beamlike action across minor irregularities in the underlying material. Thus the minor irregularities may not be reflected in the concrete pavement. Properly designed and constructed rigid pavement has long service lives and usually is less expensive to maintain than flexible pavements.

Thickness of highway concrete pavement normally ranges from 6 in to 13 in . Different types of rigid pavement are described later in this chapter .These pavement types usually are constructed to carry heavy traffic loads, although they have been used for residential and local roads.[1]

This section describes the typical rigid pavement structure consisting of:

- Surface course. This is the top layer, which consists of the PCC slab.
- Base course. This is the layer directly below the PCC layer and generally consists of aggregate or stabilized sub grade.
- Subbase course. This is the layer (or layers) under the base layer. A subbase is not always needed and therefore may often be omitted.

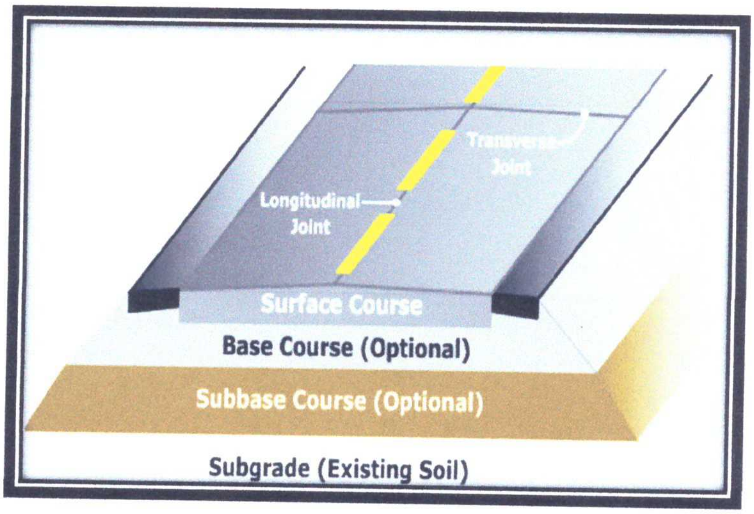



Figure (5.33) Basic Rigid Pavement Structure[1]

## Materials Used In Rigid Pavements

The Portland cement concrete commonly used for rigid pavements consists of Portland cement, coarse aggregate, fine aggregate, and water .Steel reinforcing rod may or may not be used, depending on the type of pavement being constructed. A description of the quality requirements for each of the basic materials is presented in the following paragraphs.

## Portland cement

Portland cement is manufactured by crushing and pulverizing a carefully prepared mix of limestone, marl, and clay or shale and by burning the mixture at a high temperature (about 2800°F) to form a clinker. The clinker is then allowed to cool, a small quantity of gypsum is added, and then the mixture is ground until more than 90 percent of the material passes the No.200 sieve. The main chemical constituents of the material are tricalcium silicate (C3S), dicalcium silicate (C2S), and tetracalcium alumino ferrite (C4AF).

Most highway agencies use either the American Society for Testing Materials (ASTM) specifications (ASTM Designation C150) or the American Association of State Highway and Transportation Officials (AASHTO) specifications (AASHTO Designation M85) for specifying Portland cement quality requirements used in their projects. The AASHTO specifications list five main types of Portland cement.[1]

Type I: is suitable for general concrete construction, where no special properties are required. A manufacturer will supply this type of cement when no specific type is requested.

Type II: is suitable for use in general concrete construction, where the concrete will be exposed to moderate action of sulphate or where moderate heat of hydration is required.

Type III: is suitable for concrete construction that requires a high concrete strength in a relatively short time. It is sometimes referred to as high early strength cement.

Types IV, V, and IV are similar to types I, II, and III, respectively, but contain a small amount (4 percent to 8 percent of total mix) of entrapped air. This is achieved during production by thoroughly mixing the cement with air-entraining agents and grinding the mixture. In addition to the properties listed for types I, II, and III, types IV, V, and VI are more resistant to calcium chloride and de-icing salts and are therefore more durable.

Type IV is suitable for projects where low heat of hydration is necessary, and type V is used in concrete construction projects where the concrete will be exposed to high sulphate action.

## Coarse Aggregates

The coarse aggregates used in Portland cement concrete are inert materials that do not react with cement and are usually comprised of crushed gravel, stone, or blast furnace slag. The coarse aggregates may be anyone of the three materials or else a combination of any two or all three. One of the major requirements for coarse aggregates used in Portland cement concrete is the gradation of the material. The material is well graded; with the maximum size specified .Material retained in a No.4 sieve is considered coarse aggregate.

## Fine Aggregates

Sand is mainly used as the fine aggregate in Portland cement concrete. Specifications for this material usually include grading requirements, soundness, and cleanliness. Standard specifications for the fine aggregates for Portland cement concrete (AASHTO Designation M6) give grading requirements normally adopted by state highway agencies.

## Water

The main water requirement stipulated is that the water used should also be suitable for drinking. This requires that the quantity of organic matter, oil, acids, and alkalies should not be greater than the allowable amount in drinking water.

## Reinforcing Steel

Steel reinforcing may be used in concrete pavements to reduce the amount of cracking that occurs, as a load transfer mechanism at joints, or as a means of tying two slabs together.
Steel reinforcement used to control cracking is usually referred to as temperature steel whereas steel rods used as load transfer mechanisms are known as dowel bars, and those used to connect two slabs together are known as tie bars.[1]

## Types of rigid highway pavement

Rigid highway pavements can be divided into three general types: plain concrete pavements, simply reinforced concrete pavements, and continuously reinforced concrete pavements. The definition of each pavement type is related to the amount of reinforcement used.

1-Plain Concrete Pavement

Plain concrete pavement has no temperature steel or dowels for load transfer. However, steel tie bars are often used to provide a hinge effect at longitudinal joints and to prevent the opening of these joints. Plain concrete pavements are used mainly on low-volume "highways or when cement-stabilized soils are used as sub base. Joints are placed at relatively shorter distances (10 to 20 ft) than with the other types of concrete pavements to reduce the amount of cracking. In some cases, the transverse joints of plain concrete pavements are skewed about 4 to 5 ft in plan, such that only one wheel of a vehicle passes through the joint at a time. This helps to provide a smoother ride.

2- Simply Reinforced Concrete Pavement

Simply reinforced concrete pavements have dowels for the transfer of traffic loads across joints, with these joints spaced at larger distances, ranging from 30 to 100 ft. Temperature steel is used throughout the slab, with the amount dependent on the length of the slab. Tie bars are also commonly used at longitudinal joints.

3-Continuously Reinforced Concrete Pavement

Continuously reinforced concrete pavements have no transverse joints, except onstruction joints or expansion joints when they are necessary at specific positions, such as at bridges. These pavements have a relatively high percentage of steel, with the minimum usually at 0.6 percent of the cross section of the slab. They also contain tie bars across the longitudinal joints.[1]

## Asphalt Institute Method for calculating loads and layers thickness

In the Asphalt Institute design method, the pavement is represented as a multilayered elastic system. The wheel load W is assumed to be applied through the tire as a uniform vertical pressure $p0$ , which is then spread by the different components of the pavement structure and eventually applied to subgrade as a much lower stress $p1$.Experince , established theory and test data are then used two specific stress-strain conditions.

So now we will calculate the ESAL (Equivalent Accumulated 18,000 Ib Single Axel Load)

ESAL = $fd * Gf *$ AADT* 365 * $Ni * fE$............................(5.4)

Where:

ESAL : Equivalent Accumulated 18,000 Ib Single Axel Load.

Fd: design lane factor.

Gf : Growth factor.

AADT: First year annual average daily traffic.

Ni : Number of axels on each vehicle.

fE : Load equivalency factor.

The value of (fd) is obtained from the table (5.19):

Table (5.19) Percentage of vehicle in the design lane.

| Number of Traffic lanes (Two Directions) | Percentage of vehicle in the design lane (%) |
|---|---|
| 2 | 50 |
| 4 | 45(35-48) |
| 6 or more | 40(25-48) |

The value of Growth factor ($Gf$) is obtained from the table (5.20):

Table (5.20) Growth 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 |

As we know the design of any road is on the ground that the validity of the road is usually taken for 20 years in the future, and the expected annual increase of 4%,so the value of (Gf) is =29.78%.

The value of Growth factor is obtained from the table of AADT:

Passenger cars ( 10 kN / axle) = 59%

Axle single-unit busses ( 100 kN / axle) = 8%

Axle single-unit trucks (110 kN / axle) = 33%

After the weights of vehicles are converted to standard loads which obtained from the following table as follows:

Load equivalency factor for a cars (fE(car)) = 0.0003135 (single axle)

Load equivalency factor for a busses (fE(bus)) = 0.198089 (tandem axle)

Load equivalency factor for a trucks (fE(truck)) = 0.29419 (tandem axle)

Axle single-unit busses ( 100 kN / axle) = 8%

Axle single-unit trucks (110 kN / axle) = 33%

After the weights of vehicles are converted to standard loads which obtained from the following table as follows:

Load equivalency factor for a cars (fE(car)) = 0.0003135 (single axle)

Load equivalency factor for a busses (fE(bus)) = 0.198089 (tandem axle)

Load equivalency factor for a trucks (fE(truck)) = 0.29419 (tandem axle)

Table (5.21) Load Equivalency factor[1]

| **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 | 0.0068 | 222.4 | 50,000 | 52.88 | 4.86 |
| 48.9 | 11,000 | 0.1311 | 0.0100 | 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 |

And then calculates the value of (ESAL) for each type of vehicle types according to the equation, and then combine the three values to get Total ESAL as follows:

$$ESAL_{car} = 0.5 \times 29.78 \times 400 \times 0.59 \times 365 \times 2 \times 0.0003135 = 0.008237 \times 10^6$$

$$ESAL_{car} = 0.5 \times 29.78 \times 400 \times 0.59 \times 365 \times 2 \times 0.0003135 = 0.008237 \times 10^6$$

$$ESAL_{car} = 0.5 \times 29.78 \times 400 \times 0.59 \times 365 \times 2 \times 0.0003135 = 0.008237 \times 10^6$$

Table (5.22) California rate and type of each layer of the pavement

| Layer | CBR(Kentuky) | Substance used |
|---|---|---|
| Asphalt | ......... | Plant Mix. |
| Base Coarse | 28.9 | Crushed Stone |
| Sub Base | 20.8 | Sandy Gravel |
| Sub Grade | 12.9 | ......... |

The layers of the flexible pavement are calculated as follows:

$$SN = a_1D_1 + a_2D_2 + a_3D_3 \quad \text{.............................................(5.5)}$$

Where:

- SN: Structural Number.
- a1,a2,a3: layer coefficients representative of surface, base course, and sub base
- D1, D2, D3: actual thickness, of surface, base course, and sub base.

The Regional factor is calculated from the equation:

$$R = \frac{N_d}{12} \times R_d + \frac{N_s}{12} \times R_s \quad \text{.........................................(5.6)}$$

where:

- R: Regional Factor
- Nd : Number of dry months in a year
- Rd: Regional Factor for soils dry

- Ns: Number of saturated months in a year
- Rs: Regional Factor for soils saturated

Table (5.23) Regional Factor

| case | Suggested Regional Factor |
|---|---|
| Roadbed soil frozen 5in or more | 0.2 –1.0 |
| Roadbed soils dry | 0.3 – 1.5 |
| Roadbed soils saturated | 4.0 – 5.0 |

In Hebron 4 months of the year are saturated and 8 months are dry so R value in Hebron

$$R = \frac{8}{12} \times 0.9 + \frac{4}{12} \times 4.5 = 2.1$$

The process of calculating SN is as follows:

1. By determining the value of CBR the corresponding (S-soil support value) for each layer is determined.

(S-soil support value) = 7.5

(S-soil support value) = 7.1

(S-soil support value) = 6.5

2. Appoint the values of (S-soil support value) and concluded with the point set on the scale of( ESAL = 4238) and then extend the line on the straight path to get ranking (SN-structural Number) as follows:

(SN-structural Number) = 1.75

(SN-structural Number) = 2.7

(SN-structural Number) = 2.9

3. Then reach these points with the point set on the scale of (Regional Number) and then extend the line on the straight path to find that the SN scale at a certain point so SN values are as follows:

SN1 = 3.45 (from enter CBR for base course in chart)

SN2 = 2.8 (from enter CBR for sub base course in chart)

SN3 = 3.2 (from enter CBR sub grade in chart)

4. The values of (a1,a2,a3)are obtained from the following tables:

Table (5.24) Layer coefficient for asphalt

| Case of the Pavement | a1 suggested |
|---|---|
| Road mix (low stability) | 0.2 |
| Plant mix (high stability) | 0.44 |
| Sand Asphalt | 0.40 |

Table (5-25) Layer coefficient for base course

| Case of the base course | a2 suggested |
|---|---|
| Sandy gravel | 0.07 |
| Crushed stone | 0.14 |
| Cement-treated(650psi or more) | 0.23 |
| Cement-treated(400-650psi) | 0.20 |
| Cement-treated(400 or less) | 0.15 |
| Coarse –graded bituminous-treated | 0.34 |
| Sand asphalt | 0.30 |
| Lime - treated | 0.15-0.30 |

From the previous tables

$a1 = 0.44$

$a2 = 0.14$

The thickness of the first layer (the pavement layer) is calculated as follow:

$SN1 = a1\ D1 \rightarrow 1.3 = 0.44D1 \rightarrow D1 = 3in = 3*2.54 = 7.62cm.$

Take ($D1 = 7.5cm$).

$SN1= (7.5/2.54)*0.44= 1.3$ in.

The thickness of the second layer (the base curse layer)

$SN2 = SN1 + a1\ D1 \rightarrow 2.8 = 2.1 + 0.14D2$

$\rightarrow D2 = 5\ in = 5*2.54 = 12.7\ cm.$

Take ($D2 = 20$ cm).

The thickness of the third layer (the sub base layer)

$SN3 = SN2 + a3\ D3 \rightarrow 3.9 = 3.58 + 0.11D3$

$\rightarrow D3 = 2.91\ in = 2.91\cdot 2.54 = 7.39\ cm.$

Take ($D2 = 20$ cm).

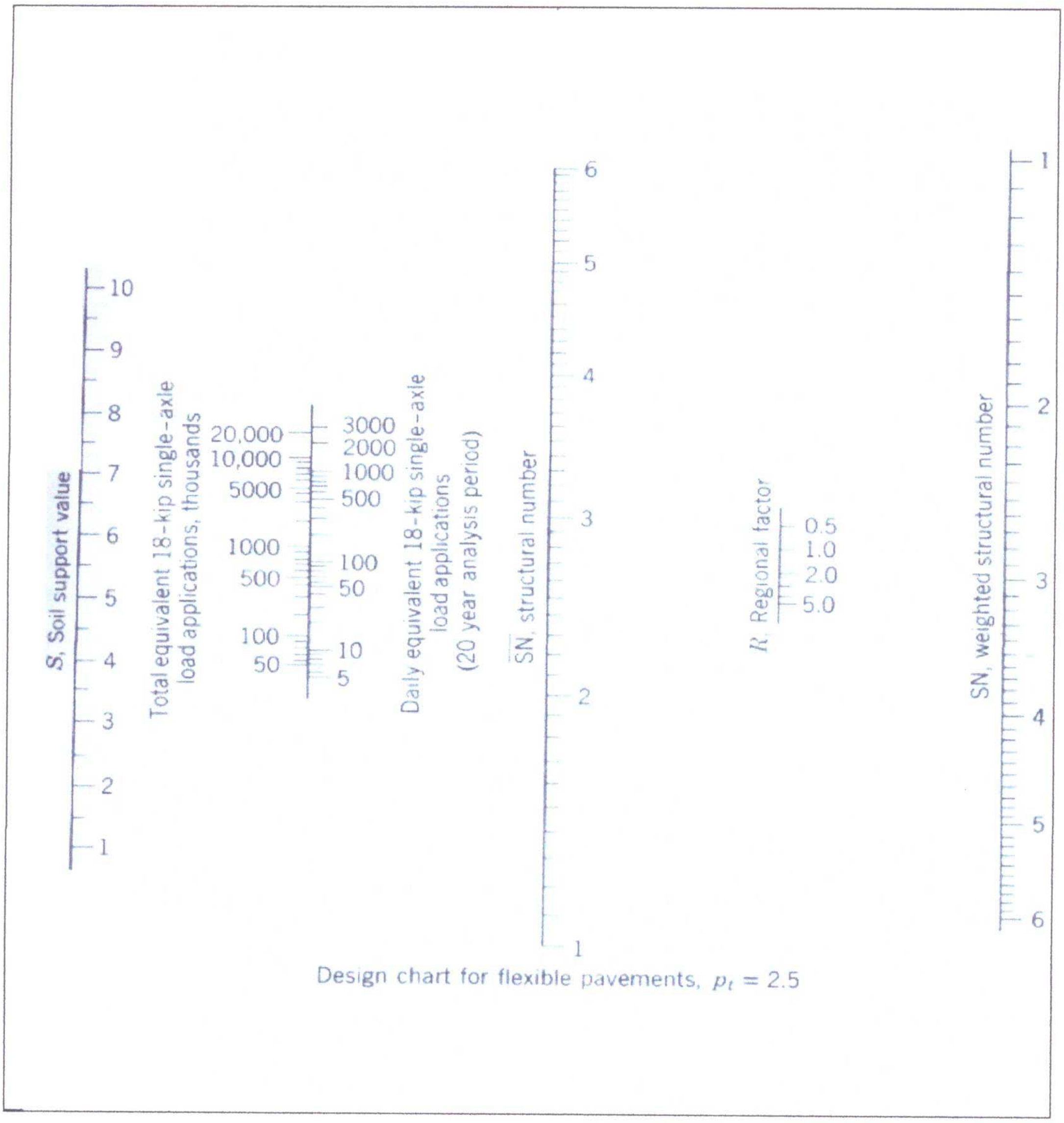



Fig 5.34 (AASHTO flexible-pavement design)

### 5.4.4 Final Results

After working according to the AASHTO, and taking in considerations all the factors affecting the design the layers of the pavement and after making calculations we obtain the following results:

Table (5.26) shows layer's thickness

| **Layer** | **Thickness(cm)** |
|---|---|
| asphalt | 7.5 |
| Base course | 20 |
| Sub base | 20 |

# CHAPTER SEX

# BILL OF QUANTIT

## 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 18 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site | LM | 135 | | | | |
| A2 | Excavation of pipes trench in all kind of soil for one pipe diameter 24 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site | LM | 523 | | | | |
| A3 | Excavation of pipes trench in all kind of soil for one pipe diameter 30 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site | LM | 147 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **Sub-Total** | | | | | | |
| B | **PIPE WORK** | | | | | | |
| B1 | Supplying, storing and installing of uPVC | LM | 805 | | | | |
| | **Sub-Total** | | | | | | |
| C | **PIPE BEDDING AND BACKFILLING** **Dimension and material** | | | | | | |
| C1 | Supplying and embedment of sand for one pipe diameter 18 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site. | LM | 135 | | | | |
| C2 | Supplying and embedment of sand for one pipe diameter 24 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site. | LM | 523 | | | | |
| C3 | Supplying and embedment of sand for one pipe diameter 30 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site. | LM | 147 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **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 | 31 | | | | |
| **Sub-Total** | | | | | | | |
| E | **Concrete Surround** | | | | | | |
| E1 | Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe. | LM | 805 | | | | |
| **Sub-Total** | | | | | | | |
| F | **Air And Water Leakage Test** | | | | | | |
| F1 | Air leakage test for sewer pipe lines 18 , 24 and 30 inch according to specifications, including for all t emporary works. | LM | 805 | | | | |
| F2 | Water leakage tests for manholes, depth up to 1.00 meter according to specifications. | NR | 31 | | | | |
| **Sub-Total** | | | | | | | |

| G | Survey work | | | | | | |
|---|---|---|---|---|---|---|---|
| G1 | Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system | LM | 805 | | | | |

## 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 30 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site | LM | 805 | | | | |
| Sub-Total | | | | | | | |
| B | **PIPE WORK** | | | | | | |
| B1 | Supplying, storing and installing of uPVC | LM | 805 | | | | |
| Sub-Total | | | | | | | |
| C | **PIPE BEDDING AND BACKFILLING**<br>**Dimension and material** | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C1 | Supplying and embedment of sand for one pipe diameter 30 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site. | LM | 805 | | | | |
| **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 | 31 | | | | |
| **Sub-Total** | | | | | | | |
| E | **Concrete Surround** | | | | | | |
| E1 | Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe. | LM | 805 | | | | |
| **Sub-Total** | | | | | | | |
| F | **Air And Water Leakage Test** | | | | | | |
| F1 | Air leakage test for sewer pipe lines 30 inch according to specifications, including for all temporary works. | LM | 805 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| F2 | Water leakage tests for manholes, depth up to 1.00 meter according to specifications. | NR | 31 | | | | |
| **Sub-Total** | | | | | | | |
| **G** | **Survey work** | | | | | | |
| G1 | Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system | LM | 805 | | | | |

cut and fill

## Total Volume Table

| Station | Fill Area | Cut Area | Fill Volume | Cut Volume | Cumulative Fill Vol | Cumulative Cut Vol |
|---|---|---|---|---|---|---|
| 0+000.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0+020.00 | 3.37 | 0.00 | 33.70 | 0.00 | 33.70 | 0.00 |
| 0+040.00 | 4.48 | 0.00 | 78.53 | 0.00 | 112.23 | 0.00 |
| 0+060.00 | 5.30 | 0.26 | 97.81 | 2.64 | 210.04 | 2.64 |
| 0+070.00 | 6.03 | 0.40 | 55.60 | 3.37 | 265.64 | 6.01 |
| 0+080.00 | 5.83 | 0.74 | 57.96 | 5.83 | 323.60 | 11.85 |
| 0+090.00 | 5.89 | 0.46 | 57.33 | 6.13 | 380.93 | 17.98 |
| 0+100.00 | 5.20 | 0.17 | 55.44 | 3.11 | 436.37 | 21.09 |
| 0+120.00 | 4.82 | 0.00 | 100.18 | 1.66 | 536.55 | 22.75 |
| 0+140.00 | 3.15 | 0.00 | 79.73 | 0.00 | 616.28 | 22.75 |
| 0+150.00 | 4.86 | 0.01 | 40.07 | 0.06 | 656.35 | 22.81 |
| 0+160.00 | 9.74 | 0.00 | 73.70 | 0.05 | 730.06 | 22.86 |
| 0+170.00 | 9.71 | 0.20 | 97.78 | 0.95 | 827.83 | 23.81 |
| 0+180.00 | 2.93 | 13.70 | 63.01 | 71.13 | 890.85 | 94.94 |
| 0+200.00 | 9.09 | 1.41 | 120.25 | 151.08 | 1011.10 | 246.03 |
| 0+220.00 | 6.12 | 0.06 | 152.12 | 14.73 | 1163.22 | 260.75 |
| 0+240.00 | 0.00 | 7.66 | 61.20 | 77.24 | 1224.41 | 338.00 |
| 0+260.00 | 1.74 | 6.68 | 17.22 | 143.63 | 1241.64 | 481.63 |
| 0+270.00 | 6.79 | 0.00 | 41.78 | 33.48 | 1283.42 | 515.10 |
| 0+280.00 | 7.30 | 0.66 | 70.48 | 3.30 | 1353.90 | 518.40 |

Total Volume Table

| Station | Fill Area | Cut Area | Fill Volume | Cut Volume | Cumulative Fill Vol | Cumulative Cut Vol |
|---|---|---|---|---|---|---|
| 0+300.00 | 9.53 | 0.00 | 168.36 | 6.59 | 1522.26 | 525.00 |
| 0+320.00 | 6.77 | 0.00 | 163.04 | 0.00 | 1685.30 | 525.00 |
| 0+330.00 | 7.11 | 0.00 | 69.60 | 0.00 | 1754.89 | 525.00 |
| 0+340.00 | 4.36 | 0.00 | 57.21 | 0.00 | 1812.11 | 525.00 |
| 0+350.00 | 4.19 | 0.30 | 42.71 | 1.44 | 1854.81 | 526.43 |
| 0+360.00 | 5.28 | 0.00 | 47.39 | 1.44 | 1902.20 | 527.87 |
| 0+380.00 | 4.79 | 0.00 | 100.70 | 0.00 | 2002.90 | 527.87 |
| 0+400.00 | 3.79 | 0.00 | 85.72 | 0.00 | 2088.62 | 527.87 |
| 0+410.00 | 3.87 | 0.00 | 38.04 | 0.00 | 2126.66 | 527.87 |
| 0+420.00 | 2.69 | 0.00 | 32.63 | 0.00 | 2159.30 | 527.87 |
| 0+440.00 | 3.26 | 0.00 | 59.33 | 0.00 | 2218.62 | 527.87 |
| 0+460.00 | 3.04 | 0.00 | 63.05 | 0.00 | 2281.67 | 527.87 |
| 0+480.00 | 2.01 | 0.00 | 50.57 | 0.00 | 2332.24 | 527.87 |
| 0+500.00 | 1.57 | 0.00 | 35.80 | 0.00 | 2368.04 | 527.87 |
| 0+512.34 | 0.00 | 0.00 | 9.66 | 0.00 | 2377.70 | 527.87 |

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Material Table

| Station | Area | Volume | Cumulative Volume |
|---|---|---|---|
| 0+000.00 | 0.36 | 0.00 | 0.00 |
| 0+020.00 | 0.36 | 7.20 | 7.20 |
| 0+040.00 | 0.36 | 7.20 | 14.40 |
| 0+060.00 | 0.36 | 7.20 | 21.60 |
| 0+070.00 | 0.36 | 3.60 | 25.20 |
| 0+080.00 | 0.36 | 3.60 | 28.80 |
| 0+090.00 | 0.36 | 3.60 | 32.40 |
| 0+100.00 | 0.36 | 3.60 | 36.00 |
| 0+120.00 | 0.36 | 7.20 | 43.20 |
| 0+140.00 | 0.36 | 7.20 | 50.40 |
| 0+150.00 | 0.36 | 3.60 | 54.00 |
| 0+160.00 | 0.36 | 3.60 | 57.60 |
| 0+170.00 | 0.36 | 3.60 | 61.20 |
| 0+180.00 | 0.36 | 3.60 | 64.80 |
| 0+200.00 | 0.36 | 7.20 | 72.00 |
| 0+220.00 | 0.36 | 7.20 | 79.20 |
| 0+240.00 | 0.36 | 7.20 | 86.40 |
| 0+260.00 | 0.36 | 7.20 | 93.60 |
| 0+270.00 | 0.36 | 3.60 | 97.20 |
| 0+280.00 | 0.36 | 3.60 | 100.80 |

| Material Table | | | |
|---|---|---|---|
| Station | Area | Volume | Cumulative Volume |
| 0+300.00 | 0.36 | 7.20 | 108.00 |
| 0+320.00 | 0.36 | 7.20 | 115.20 |
| 0+330.00 | 0.36 | 3.60 | 118.80 |
| 0+340.00 | 0.36 | 3.60 | 122.40 |
| 0+350.00 | 0.36 | 3.60 | 126.00 |
| 0+360.00 | 0.36 | 3.60 | 129.60 |
| 0+380.00 | 0.36 | 7.20 | 136.80 |
| 0+400.00 | 0.36 | 7.20 | 144.00 |
| 0+410.00 | 0.36 | 3.60 | 147.60 |
| 0+420.00 | 0.36 | 3.60 | 151.20 |
| 0+440.00 | 0.36 | 7.20 | 158.40 |
| 0+460.00 | 0.36 | 7.20 | 165.60 |
| 0+480.00 | 0.36 | 7.20 | 172.80 |
| 0+500.00 | 0.36 | 7.20 | 180.00 |
| 0+512.34 | 0.36 | 4.44 | 184.44 |

base

| Material Table | | | |
|---|---|---|---|
| Station | Area | Volume | Cumulative Volume |
| 0+000.00 | 0.72 | 0.00 | 0.00 |
| 0+020.00 | 0.72 | 14.40 | 14.40 |
| 0+040.00 | 0.72 | 14.40 | 28.80 |
| 0+060.00 | 0.72 | 14.40 | 43.20 |
| 0+070.00 | 0.72 | 7.20 | 50.40 |
| 0+080.00 | 0.72 | 7.20 | 57.60 |
| 0+090.00 | 0.72 | 7.20 | 64.80 |
| 0+100.00 | 0.72 | 7.20 | 72.00 |
| 0+120.00 | 0.72 | 14.40 | 86.40 |
| 0+140.00 | 0.72 | 14.40 | 100.80 |
| 0+150.00 | 0.72 | 7.20 | 108.00 |
| 0+160.00 | 0.72 | 7.20 | 115.20 |
| 0+170.00 | 0.72 | 7.20 | 122.40 |
| 0+180.00 | 0.72 | 7.20 | 129.60 |
| 0+200.00 | 0.72 | 14.40 | 144.00 |
| 0+220.00 | 0.72 | 14.40 | 158.40 |
| 0+240.00 | 0.72 | 14.40 | 172.80 |
| 0+260.00 | 0.72 | 14.40 | 187.20 |
| 0+270.00 | 0.72 | 7.20 | 194.40 |
| 0+280.00 | 0.72 | 7.20 | 201.60 |

| Material Table | | | |
|---|---|---|---|
| Station | Area | Volume | Cumulative Volume |
| 0+300.00 | 0.72 | 14.40 | 216.00 |
| 0+320.00 | 0.72 | 14.40 | 230.40 |
| 0+330.00 | 0.72 | 7.20 | 237.60 |
| 0+340.00 | 0.72 | 7.20 | 244.80 |
| 0+350.00 | 0.72 | 7.20 | 252.00 |
| 0+360.00 | 0.72 | 7.20 | 259.20 |
| 0+380.00 | 0.72 | 14.40 | 273.60 |
| 0+400.00 | 0.72 | 14.40 | 288.00 |
| 0+410.00 | 0.72 | 7.20 | 295.20 |
| 0+420.00 | 0.72 | 7.20 | 302.40 |
| 0+440.00 | 0.72 | 14.40 | 316.80 |
| 0+460.00 | 0.72 | 14.40 | 331.20 |
| 0+480.00 | 0.72 | 14.40 | 345.60 |
| 0+500.00 | 0.72 | 14.40 | 360.00 |
| 0+512.34 | 0.72 | 8.88 | 368.88 |

pavment
2

## Material Table

| Station | Area | Volume | Cumulative Volume |
|---|---|---|---|
| 0+000.00 | 0.18 | 0.00 | 0.00 |
| 0+020.00 | 0.18 | 3.60 | 3.60 |
| 0+040.00 | 0.18 | 3.60 | 7.20 |
| 0+060.00 | 0.18 | 3.60 | 10.80 |
| 0+070.00 | 0.18 | 1.80 | 12.60 |
| 0+080.00 | 0.18 | 1.80 | 14.40 |
| 0+090.00 | 0.18 | 1.80 | 16.20 |
| 0+100.00 | 0.18 | 1.80 | 18.00 |
| 0+120.00 | 0.18 | 3.60 | 21.60 |
| 0+140.00 | 0.18 | 3.60 | 25.20 |
| 0+150.00 | 0.18 | 1.80 | 27.00 |
| 0+160.00 | 0.18 | 1.80 | 28.80 |
| 0+170.00 | 0.18 | 1.80 | 30.60 |
| 0+180.00 | 0.18 | 1.80 | 32.40 |
| 0+200.00 | 0.18 | 3.60 | 36.00 |
| 0+220.00 | 0.18 | 3.60 | 39.60 |
| 0+240.00 | 0.18 | 3.60 | 43.20 |
| 0+260.00 | 0.18 | 3.60 | 46.80 |
| 0+270.00 | 0.18 | 1.80 | 48.60 |
| 0+280.00 | 0.18 | 1.80 | 50.40 |

| Material Table | | | |
|---|---|---|---|
| Station | Area | Volume | Cumulative Volume |
| 0+300.00 | 0.18 | 3.60 | 54.00 |
| 0+320.00 | 0.18 | 3.60 | 57.60 |
| 0+330.00 | 0.18 | 1.80 | 59.40 |
| 0+340.00 | 0.18 | 1.80 | 61.20 |
| 0+350.00 | 0.18 | 1.80 | 63.00 |
| 0+360.00 | 0.18 | 1.80 | 64.80 |
| 0+380.00 | 0.18 | 3.60 | 68.40 |
| 0+400.00 | 0.18 | 3.60 | 72.00 |
| 0+410.00 | 0.18 | 1.80 | 73.80 |
| 0+420.00 | 0.18 | 1.80 | 75.60 |
| 0+440.00 | 0.18 | 3.60 | 79.20 |
| 0+460.00 | 0.18 | 3.60 | 82.80 |
| 0+480.00 | 0.18 | 3.60 | 86.40 |
| 0+500.00 | 0.18 | 3.60 | 90.00 |
| 0+512.34 | 0.18 | 2.22 | 92.22 |

curb

| Material Table | | | |
|---|---|---|---|
| Station | Area | Volume | Cumulative Volume |
| 0+000.00 | 0.46 | 0.00 | 0.00 |
| 0+020.00 | 0.46 | 9.26 | 9.26 |
| 0+040.00 | 0.46 | 9.26 | 18.53 |
| 0+060.00 | 0.46 | 9.26 | 27.79 |
| 0+070.00 | 0.46 | 4.63 | 32.42 |
| 0+080.00 | 0.46 | 4.63 | 37.06 |
| 0+090.00 | 0.46 | 4.63 | 41.69 |
| 0+100.00 | 0.46 | 4.63 | 46.32 |
| 0+120.00 | 0.46 | 9.26 | 55.58 |
| 0+140.00 | 0.46 | 9.26 | 64.85 |
| 0+150.00 | 0.46 | 4.63 | 69.48 |
| 0+160.00 | 0.46 | 4.63 | 74.11 |
| 0+170.00 | 0.46 | 4.63 | 78.74 |
| 0+180.00 | 0.46 | 4.63 | 83.38 |
| 0+200.00 | 0.46 | 9.26 | 92.64 |
| 0+220.00 | 0.46 | 9.26 | 101.90 |
| 0+240.00 | 0.46 | 9.26 | 111.17 |
| 0+260.00 | 0.46 | 9.26 | 120.43 |
| 0+270.00 | 0.46 | 4.63 | 125.06 |
| 0+280.00 | 0.46 | 4.63 | 129.70 |

sub base

| Material Table | | | |
|---|---|---|---|
| Station | Area | Volume | Cumulative Volume |
| 0+000.00 | 0.00 | 0.00 | 0.00 |
| 0+020.00 | 0.00 | 0.00 | 0.00 |
| 0+040.00 | 0.00 | 0.00 | 0.00 |
| 0+060.00 | 0.26 | 2.64 | 2.64 |
| 0+070.00 | 0.40 | 3.37 | 6.01 |
| 0+080.00 | 0.74 | 5.83 | 11.85 |
| 0+090.00 | 0.46 | 6.13 | 17.98 |
| 0+100.00 | 0.17 | 3.11 | 21.09 |
| 0+120.00 | 0.00 | 1.66 | 22.75 |
| 0+140.00 | 0.00 | 0.00 | 22.75 |
| 0+150.00 | 0.01 | 0.06 | 22.81 |
| 0+160.00 | 0.00 | 0.05 | 22.86 |
| 0+170.00 | 0.20 | 0.95 | 23.81 |
| 0+180.00 | 13.70 | 71.13 | 94.94 |
| 0+200.00 | 1.41 | 151.08 | 246.03 |
| 0+220.00 | 0.06 | 14.73 | 260.75 |
| 0+240.00 | 7.66 | 77.24 | 338.00 |
| 0+260.00 | 6.68 | 143.63 | 481.63 |
| 0+270.00 | 0.00 | 33.48 | 515.10 |
| 0+280.00 | 0.66 | 3.30 | 518.40 |

| Material Table | | | |
|---|---|---|---|
| Station | Area | Volume | Cumulative Volume |
| 0+300.00 | 0.00 | 6.59 | 525.00 |
| 0+320.00 | 0.00 | 0.00 | 525.00 |
| 0+330.00 | 0.00 | 0.00 | 525.00 |
| 0+340.00 | 0.00 | 0.00 | 525.00 |
| 0+350.00 | 0.30 | 1.44 | 526.43 |
| 0+360.00 | 0.00 | 1.44 | 527.87 |
| 0+380.00 | 0.00 | 0.00 | 527.87 |
| 0+400.00 | 0.00 | 0.00 | 527.87 |
| 0+410.00 | 0.00 | 0.00 | 527.87 |
| 0+420.00 | 0.00 | 0.00 | 527.87 |
| 0+440.00 | 0.00 | 0.00 | 527.87 |
| 0+460.00 | 0.00 | 0.00 | 527.87 |
| 0+480.00 | 0.00 | 0.00 | 527.87 |
| 0+500.00 | 0.00 | 0.00 | 527.87 |
| 0+512.34 | 0.00 | 0.00 | 527.87 |

# CHAPTER 7

# CONCLUSIONS AND RECOMMENDATIONS

## CONCLUSIONS

This project is made to evaluate the existing infrastructure in the Hebron Old City and to design the most important part of the physical infrastructure parts.

The main conclusions are :-

1. Hebron Old City in the current situation faces a trouble and critical problems.
2. Population density in the Hebron Old City is related due to the political state and this causes many problem for the design .
3. The water consumption is too little . It is about 65 L /c.d , this figure is under living standard.
4. Hebron Old City having an infrastructure so bad condition special for the most important part of infrastructure that are waste water collection system , storm water drainage system and roads network .
5. Complete design for new waste water collection system and storm water drainage system were done to cover all the study area . and redesign for the worst road were made , which was Al Shalala street , section (B-21) in appendix B shown the location of waste water and storm water pipe.
6. The flow in waste water and storm water system is gowing by gravity.
7. A redesign of the streets of the Hebron Old City because of their age and lack of Preference side which leads to the accumulation of water in.

## RECOMMENDATIONS

1. Hebron old city is an important area which need to study more and more , high attention is needed from all organizations to solve problems.
2. Physical infrastructure were studied in this project but there was a wode range of conditions that must studied like environmental , educational , economical and cultural condition.

3. We recommend the Department of Civil Engineering and Architecture in Palestine Polytechnic University subtracting the road design projects, We also recommend Hebron Municipality to complete the work to complete a study of the area and the rehabilitation of the street as it is located within the municipal boundaries

# 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 = $(waste\ water * avg\ no\ of\ floor * no\ of\ houses * avg\ no\ of person)/area.$

- Waste water = 0.8* water consumption

  = 0.8* 120/1000

* Waste water = 0.096 $m^3/_{c.\,day}$

- $avg\ no\ of\ floor = 2.$

- $no\ of\ houses$=996.

- $avg\ no\ of person = 8.$

- Area of old city = 1093.22 dounum.

Unit sewage = 0.096 *14.58=1.4$m^3/day$.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

  = 1.4 * 50.16

- Q Average 70.22+12000=

  12070.22 $m^3/day$

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

Peak factor = $1.5 + \frac{2.5}{\sqrt{12070.22}}$

Peak factor= 1.52

Peak factor should be less than 3

Maximum Q= Peak factor * Qavg

= 1.52*12070.22
= 18380 $m^3/day$

Infiltration = 0.1 * Qavg

= 0.1 * 12070.22

Infiltration = 1207.022 $m^3/day$

Total Average = Infiltration + Qavg

= 1207.022 + 12070.22

Total Average = 13277.25$m^3/day$

Total Max = Infiltration + Qmax

=1207.022 + 18380

Total Max = 19587.02$m^3/day$

# Sanitary Sewer Design Computations

## Line Road No 1 - Part 1

| Line No | Location | | | Length | unit sewage | Tributary area | | Flow Rates | | | | | | Q max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Street Sewer Name | Upper Mh No | Lower Mh No | | | Incremental | Total | Industry Average | Industry Peak Factor | Industry Maximum | Infiltration | Total Average | Total Maximum | |
| | | | | m | m | dounm | dounm | m³/day | | m³/day | m³/day | m³/day | m³/day | m³/day |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | road 1 | 1 | 2 | 36.6 | 1.4 | 50.16 | 50.16 | 12070.22 | 1.52 | 18380.00 | 1207.02 | 13277.25 | 19587.02 | 19587.02 |
| 2 | road 1 | 2 | 3 | 31 | 1.4 | 46.73 | 96.89 | 12205.87 | 1.52 | 18585.01 | 1220.59 | 13426.46 | 19805.59 | 218.57 |
| 3 | road 1 | 3 | 4 | 34.6 | 1.4 | 55.09 | 151.98 | 12418.64 | 1.52 | 18906.56 | 1241.86 | 13660.51 | 20148.42 | 342.83 |
| 4 | road 1 | 4 | 5 | 32.2 | 1.4 | 47.90 | 199.88 | 12698.47 | 1.52 | 19329.43 | 1269.85 | 13968.32 | 20599.28 | 450.85 |
| 5 | road 1 | 5 | 6 | 35.6 | 1.4 | 45.40 | 245.28 | 13041.87 | 1.52 | 19848.30 | 1304.19 | 14346.05 | 21152.49 | 553.21 |
| 6 | road 1 | 6 | 7 | 27.6 | 1.4 | 37.39 | 282.67 | 13437.60 | 1.52 | 20446.21 | 1343.76 | 14781.36 | 21789.97 | 637.48 |
| 7 | road 1 | 7 | 8 | 20.7 | 1.4 | 33.10 | 315.77 | 13879.68 | 1.52 | 21114.05 | 1387.97 | 15267.65 | 22502.02 | 712.05 |

### Design Assamptions and data

1) Water comnsumption is 120 l/d.d which 80% return to sewer

3) Infiltration is equal 10 % of the average industrial wastewater flow.

4) Minimum pipe diameter= 200 mm

5) Minimum velocity Vmin = 0.6 m/sec

6) Maximum velocity Vmax = 3 m/sec

7) Minimum slope Smin = 0.5 %

8) Maximum slope Smax = 15 %

9) Maximum manhole spacing = 60 m

10) Minimum depth of sew 1.5 m

11) Design depth of flow h 0.5

12) Maining coefficient r 0.01

# Sanitary Sewer Design Computations

Line Roac No 1 - Part 2

| Line No | Location | | | Length | unit sewage | Tributary area | | Flow Rates | | | | | | Q max |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Street Sewer Name | Upper Mh No | Lower Mh No | | | Incrementa | Total | Industry | | | Infiltration | Total | | |
| | | | | | | | | Average | Peak Factor | Maximum | | Average | Maximum | |
| | | | | m | m | dounm | dounm | m³/day | | m³/day | m³/day | m³/day | m³/day | m³/day |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | road 1 | 8 | 9 | 39.4 | 1.4 | 53.08 | 368.84 | 14396.06 | 1.52 | 21894.04 | 1439.61 | 15835.66 | 23333.65 | 831.63 |
| 2 | road 1 | 9 | 10 | 28.8 | 1.4 | 40.88 | 409.72 | 14969.66 | 1.52 | 22760.36 | 1496.97 | 16466.62 | 24257.33 | 923.68 |
| 3 | road 1 | 10 | 11 | 36.9 | 1.4 | 40.31 | 450.02 | 15599.69 | 1.52 | 23711.78 | 1559.97 | 17159.66 | 25271.75 | 1014.42 |
| 4 | road 1 | 11 | 12 | 41.8 | 1.4 | 63.97 | 513.99 | 16319.28 | 1.52 | 24798.29 | 1631.93 | 17951.21 | 26430.22 | 1158.47 |
| 5 | road 1 | 12 | 13 | 31.9 | 1.4 | 49.83 | 563.82 | 17108.63 | 1.52 | 25989.95 | 1710.86 | 18819.49 | 27700.81 | 1270.59 |
| 6 | road 1 | 13 | 14 | 47 | 1.4 | 90.71 | 654.53 | 18024.97 | 1.52 | 27373.10 | 1802.50 | 19827.47 | 29175.59 | 1474.78 |
| 7 | road 1 | 14 | 15 | 32.8 | 1.4 | 82.53 | 737.06 | 19056.85 | 1.52 | 28930.40 | 1905.69 | 20962.54 | 30836.08 | 1660.49 |
| 8 | road 1 | 15 | 16 | 8.8 | 1.4 | 37.88 | 774.94 | 20141.77 | 1.52 | 30567.45 | 2014.18 | 22155.94 | 32581.63 | 1745.55 |

## Design Assamptions and data

| | | | | |
|---|---|---|---|---|
| 1) Water comnsumption is | 120 | m3/d.d which 80% return to sewer | 7) Minimum slope Smin = | 0.5 % |
| | | | 8) Maximum slope Smax = | 15 % |
| 3) Infiltration is equal | 10 | % of the average industrial wastewater flow. | 9) Maximum manhole spacing = | 60 m |
| 4) Minimum pipe diameter= | 200 | mm | 10) Minimum depth of sew | 1.5 m |
| 5) Minimum velocity Vmin = | 0.6 | m/sec | 11) Design depth of flow h | 0.5 |
| 6) Maximum velocity Vmax = | 3 | m/sec | 12) Maining coefficient r | 0.01 |

# Sanitary Sewer Design Computations

Line Roac No 1 - Part 3

| Line No | Location: Street Sewer Name | Location: Upper Mh No | Location: Lower Mh No | Length m | unit sewage m | Tributary area: Incrementa dounm | Tributary area: Total dounm | Flow Rates: Industry Average m³/day | Industry Peak Factor | Industry Maximum m³/day | Infiltration m³/day | Total Average m³/day | Total Maximum m³/day | Q max m³/day |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | road 1 | 16 | 2 | 8.17 | 1.4 | 32.43 | 807.37 | 21272.09 | 1.52 | 32272.76 | 2127.21 | 23399.30 | 34399.96 | 1818.33 |
| 2 | road 1 | 17 | 18 | 18.4 | 1.4 | 40.51 | 847.88 | 22459.12 | 1.52 | 34063.34 | 2245.91 | 24705.03 | 36309.25 | 1909.29 |
| 3 | road 1 | 18 | 19 | 20 | 1.4 | 32.62 | 880.50 | 23691.82 | 1.52 | 35922.53 | 2369.18 | 26061.00 | 38291.72 | 1982.46 |
| 4 | road 1 | 19 | 20 | 33.1 | 1.4 | 37.20 | 917.70 | 24976.60 | 1.52 | 37860.00 | 2497.66 | 27474.26 | 40357.66 | 2065.94 |
| 5 | road 1 | 20 | 21 | 33.2 | 1.4 | 27.53 | 945.23 | 26299.92 | 1.52 | 39855.31 | 2629.99 | 28929.91 | 42485.31 | 2127.65 |
| 6 | road 1 | 21 | 22 | 17.9 | 1.4 | 15.25 | 960.48 | 27644.59 | 1.52 | 41882.56 | 2764.46 | 30409.05 | 44647.02 | 2161.71 |
| 7 | road 1 | 22 | 23 | 12.5 | 1.4 | 15.67 | 976.15 | 29011.20 | 1.51 | 43942.62 | 2901.12 | 31912.32 | 46843.74 | 2196.73 |
| 8 | road 1 | 23 | 24 | 19.3 | 1.4 | 20.00 | 996.15 | 30405.81 | 1.51 | 46044.65 | 3040.58 | 33446.40 | 49085.23 | 2241.49 |

## Design Assamptions and data

1) Water comnsumption is 120 m3/d.d which 80% return to sewer

3) Infiltration is equal 10 % of the average industrial wastewater flow.

4) Minimum pipe diameter= 200 mm

5) Minimum velocity Vmin = 0.6 m/sec

6) Maximum velocity Vmax = 3 m/sec

7) Minimum slope Smin = 0.5 %

8) Maximum slope Smax = 15 %

9) Maximum manhole spacing = 60 m

10) Minimum depth of sew 1.5 m

11) Design depth of flow h 0.5

12) Maining coefficient r 0.01

# Sanitary Sewer Design Computations

| Line Road No 1 - Part 4 | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Line No | Location | | | Length | unit sewage | Tributary area | | Flow Rates | | | | | | Q max |
| | Street Sewer Name | Upper Mh No | Lower Mh No | | | Incremental | Total | Industry Average | Industry Peak Factor | Industry Maximum | Infiltration | Total Average | Total Maximum | |
| | | | | m | m | dounm | dounm | m³/day | | m³/day | m³/day | m³/day | m³/day | m³/day |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| 1 | road 1 | 24 | 25 | 19.3 | 1.4 | 12.33 | 1008.48 | 31817.68 | 1.51 | 48172.46 | 3181.77 | 34999.45 | 51354.23 | 2269.00 |
| 2 | road 1 | 25 | 26 | 8.72 | 1.4 | 9.71 | 1018.19 | 33243.15 | 1.51 | 50320.54 | 3324.31 | 36567.46 | 53644.85 | 2290.63 |
| 3 | road 1 | 26 | 27 | 13.6 | 1.4 | 10.21 | 1028.40 | 34682.91 | 1.51 | 52489.95 | 3468.29 | 38151.20 | 55958.24 | 2313.38 |
| 4 | road 1 | 27 | 28 | 18.1 | 1.4 | 9.13 | 1037.53 | 36135.45 | 1.51 | 54678.41 | 3613.55 | 39749.00 | 58291.95 | 2333.72 |
| 5 | road 1 | 28 | 29 | 11.9 | 1.4 | 9.84 | 1047.37 | 37601.77 | 1.51 | 56887.43 | 3760.18 | 41361.94 | 60647.61 | 2355.66 |
| 6 | road 1 | 29 | 30 | 19.3 | 1.4 | 13.91 | 1061.28 | 39087.56 | 1.51 | 59125.60 | 3908.76 | 42996.32 | 63034.36 | 2386.75 |
| 7 | road 1 | 30 | 31 | 35.5 | 1.4 | 17.50 | 1078.78 | 40597.85 | 1.51 | 61400.50 | 4059.79 | 44657.64 | 65460.29 | 2425.93 |
| 8 | road 1 | 31 | 32 | 25.1 | 1.4 | 14.44 | 1093.22 | 42128.36 | 1.51 | 63705.67 | 4212.84 | 46341.20 | 67918.51 | 2458.22 |

**Design Assamptions and data**

1) Water comnsumption is 120 m3/d.d which 80% return to sewer
3) Infiltration is equal 10 % of the average industrial wastewater flow.
4) Minimum pipe diameter= 200 mm
5) Minimum velocity Vmin = 0.6 m/sec
6) Maximum velocity Vmax = 3 m/sec
7) Minimum slope Smin = 0.5 %
8) Maximum slope Smax = 15 %
9) Maximum manhole spacing = 60 m
10) Minimum depth of sew 1.5 m
11) Design depth of flow h 0.5
12) Maining coefficient r 0.01

| Gravity Node Report | | | | | |
|---|---|---|---|---|---|
| Label | Calculated Station (m) | Ground Elevation (m) | Structure Diameter (m) | Total Flow ($m^2$/day) | Velocity In (m/s) |
| MH-1 | 8+05 | 882.64 | 1.2 | 19,587.02 | 1.76 |
| MH-2 | 7+68 | 882.5 | 1.2 | 19,805.59 | 1.77 |
| MH-3 | 7+37 | 882.2 | 1.2 | 20,148.42 | 1.79 |
| MH-4 | 7+03 | 880.25 | 1.2 | 20,599.27 | 1.81 |
| MH-5 | 6+71 | 880 | 1.2 | 21,152.48 | 1.58 |
| MH-6 | 6+35 | 879.85 | 1.2 | 21,789.96 | 1.6 |
| MH-7 | 6+08 | 878.46 | 1.2 | 22,502.01 | 1.61 |
| MH-8 | 5+87 | 877.5 | 1.2 | 23,333.64 | 1.63 |
| MH-9 | 5+47 | 876.75 | 1.2 | 24,257.32 | 1.66 |
| MH-10 | 5+19 | 876 | 1.2 | 25,271.74 | 1.68 |
| MH-11 | 4+82 | 875 | 1.2 | 26,430.21 | 1.71 |
| MH-12 | 4+40 | 874.13 | 1.2 | 27,700.80 | 1.74 |
| MH-13 | 4+08 | 872.96 | 1.2 | 29,175.58 | 1.78 |
| MH-14 | 3+61 | 872.5 | 1.2 | 30,836.07 | 1.81 |
| MH-15 | 3+28 | 873.94 | 1.2 | 32,581.62 | 1.86 |
| MH-16 | 3+19 | 873.97 | 1.2 | 34,399.95 | 1.9 |
| MH-17 | 3+11 | 873.79 | 1.2 | 36,309.24 | 1.94 |
| MH-18 | 2+93 | 872.5 | 1.2 | 38,291.70 | 1.99 |
| MH-19 | 2+73 | 872.35 | 1.2 | 40,357.64 | 2.04 |
| MH-20 | 2+40 | 871.2 | 1.2 | 42,485.29 | 2.09 |
| MH-21 | 2+06 | 870.6 | 1.2 | 44,647.00 | 2.14 |
| MH-22 | 1+88 | 870.2 | 1.2 | 46,843.73 | 2.2 |
| MH-23 | 1+76 | 869.9 | 1.2 | 49,085.22 | 2.26 |
| MH-24 | 1+57 | 869.54 | 1.2 | 51,354.22 | 2.32 |
| MH-25 | 1+48 | 868.86 | 1.2 | 53,644.85 | 2.03 |
| MH-26 | 1+34 | 868.1 | 1.2 | 55,958.23 | 2.06 |
| MH-27 | 1+16 | 867.7 | 1.2 | 58,291.95 | 2.09 |
| MH-28 | 1+04 | 867 | 1.2 | 60,647.61 | 2.13 |
| MH-29 | 0+85 | 866.4 | 1.2 | 63,034.36 | 2.17 |
| MH-30 | 0+50 | 867.02 | 1.2 | 65,460.29 | 2.2 |
| MH-31 | 0+25 | 865.33 | 1.2 | 67,918.51 | 2.24 |

| Gravity pipe Report | | | | |
|---|---|---|---|---|
| Label | Upstream Node | Downstream Node | Section Size Description | Section Shape |
| P-1 | MH-1 | MH-2 | 450 mm | Circular |
| P-2 | MH-2 | MH-3 | 450 mm | Circular |
| P-3 | MH-3 | MH-4 | 450 mm | Circular |
| P-4 | MH-4 | MH-5 | 450 mm | Circular |
| P-5 | MH-5 | MH-6 | 600 mm | Circular |
| P-6 | MH-6 | MH-7 | 600 mm | Circular |
| P-7 | MH-7 | MH-8 | 600 mm | Circular |
| P-8 | MH-8 | MH-9 | 600 mm | Circular |
| P-9 | MH-9 | MH-10 | 600 mm | Circular |
| P-10 | MH-10 | MH-11 | 600 mm | Circular |
| P-11 | MH-11 | MH-12 | 600 mm | Circular |
| P-12 | MH-12 | MH-13 | 600 mm | Circular |
| P-13 | MH-13 | MH-14 | 600 mm | Circular |
| P-14 | MH-14 | MH-15 | 600 mm | Circular |
| P-15 | MH-15 | MH-16 | 600 mm | Circular |
| P-16 | MH-16 | MH-17 | 600 mm | Circular |
| P-17 | MH-17 | MH-18 | 600 mm | Circular |
| P-18 | MH-18 | MH-19 | 600 mm | Circular |
| P-19 | MH-19 | MH-20 | 600 mm | Circular |
| P-20 | MH-20 | MH-21 | 600 mm | Circular |
| P-21 | MH-21 | MH-22 | 600 mm | Circular |
| P-22 | MH-22 | MH-23 | 600 mm | Circular |
| P-23 | MH-23 | MH-24 | 600 mm | Circular |
| P-24 | MH-24 | MH-25 | 600 mm | Circular |
| P-25 | MH-25 | MH-26 | 750 mm | Circular |
| P-26 | MH-26 | MH-27 | 750 mm | Circular |
| P-27 | MH-27 | MH-28 | 750 mm | Circular |
| P-28 | MH-28 | MH-29 | 750 mm | Circular |
| P-29 | MH-29 | MH-30 | 750 mm | Circular |
| P-30 | MH-30 | MH-31 | 750 mm | Circular |

| Gravity Manhole Report | | | | |
|---|---|---|---|---|
| Label | Calculated Station (m) | X (m) | Y (m) | Ground Elevation (m) |
| MH-1 | 8+05 | 159,710.82 | 103,934.98 | 882.64 |
| MH-2 | 7+68 | 159,747.93 | 103,930.47 | 882.5 |
| MH-3 | 7+37 | 159,778.02 | 103,926.94 | 882.2 |
| MH-4 | 7+03 | 159,812.24 | 103,921.49 | 880.25 |
| MH-5 | 6+71 | 159,843.87 | 103,915.52 | 880 |
| MH-6 | 6+35 | 159,876.73 | 103,901.74 | 879.85 |
| MH-7 | 6+08 | 159,901.90 | 103,890.24 | 878.46 |
| MH-8 | 5+87 | 159,920.79 | 103,881.49 | 877.5 |
| MH-9 | 5+47 | 159,956.10 | 103,864.02 | 876.75 |
| MH-10 | 5+19 | 159,980.66 | 103,849.56 | 876 |
| MH-11 | 4+82 | 160,010.19 | 103,826.91 | 875 |
| MH-12 | 4+40 | 160,040.65 | 103,798.33 | 874.13 |
| MH-13 | 4+08 | 160,061.20 | 103,774.10 | 872.96 |
| MH-14 | 3+61 | 160,087.90 | 103,735.41 | 872.5 |
| MH-15 | 3+28 | 160,109.88 | 103,711.19 | 873.94 |
| MH-16 | 3+19 | 160,116.45 | 103,705.06 | 873.97 |
| MH-17 | 3+11 | 160,123.25 | 103,700.86 | 873.79 |
| MH-18 | 2+93 | 160,127.68 | 103,682.90 | 872.5 |
| MH-19 | 2+73 | 160,128.02 | 103,662.99 | 872.35 |
| MH-20 | 2+40 | 160,142.93 | 103,633.32 | 871.2 |
| MH-21 | 2+06 | 160,166.37 | 103,609.47 | 870.6 |
| MH-22 | 1+88 | 160,176.17 | 103,594.41 | 870.2 |
| MH-23 | 1+76 | 160,183.53 | 103,584.15 | 869.9 |
| MH-24 | 1+57 | 160,200.47 | 103,575.10 | 869.54 |
| MH-25 | 1+48 | 160,203.18 | 103,566.61 | 868.86 |
| MH-26 | 1+34 | 160,206.45 | 103,553.54 | 868.1 |
| MH-27 | 1+16 | 160,204.72 | 103,535.66 | 867.7 |
| MH-28 | 1+04 | 160,204.42 | 103,523.75 | 867 |
| MH-29 | 0+85 | 160,195.40 | 103,506.55 | 866.4 |
| MH-30 | 0+50 | 160,173.99 | 103,478.64 | 867.02 |
| MH-31 | 0+25 | 160,192.55 | 103,461.63 | 865.33 |

## Second: Storm water quantity calculation:

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

- **Pipe length =37.155 m.**
- **Tributary area =4.961 ha**
- **Runoff coefficient = 0.65.**
- **C.A= 3.22 ha.**
- **∑C.A= 3.22 ha.**
- **Concentration time (Tc) = ti +tf**
- **ti = 10 min.**
- **tf =** $\frac{\text{Distance}}{\text{Velocity}}$ **.**

  **tf =** $\frac{37.155}{1*60}$ **= 0.62 min.**
- Tc =10+0.62=10.62 min.
- Rain Fall intensity = $72\frac{mm}{hr}$.
- Rain Fall intensity = $200.778\frac{l}{s.h}$.
- Qmax =C.I.A

  Qmax = 0.65 * 200.778 *4.961

  $=647.439\frac{l}{s}$.

# StormWater Design Computations

## Line Road No 1 Part 1

| NUMBER | LOCATION: LINE NAME | LOCATION: UPPER MH. NO. | LOCATION: LOWER MH. NO. | LENGTH (m) | LENGTH COMULATIVE (m) | AREA of Street and industry (ha) | C FACTOR Street and industry | C.A STREET (ha) | SUM(AC) COMULATIVE (ha) | Tc (min) | ( i ) (l/s.ha) | Q (l/s) | Qi (l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 14 | 15 | 16 | 17 | 18 |
| 1 | Road 1 P1 | 1 | 2 | 37.155 | 37.155 | 4.961 | 0.650 | 3.224 | 3.224 | 10.619 | 200.778 | 59287.279 | 59287.279 |
| 2 | Road 1 P1 | 2 | 3 | 30.545 | 67.700 | 4.724 | 0.650 | 3.071 | 6.295 | 11.128 | 199.958 | 59898.681 | 611.403 |
| 3 | Road 1 P1 | 3 | 4 | 34.594 | 102.295 | 5.524 | 0.650 | 3.591 | 9.886 | 11.705 | 199.035 | 60607.519 | 708.837 |
| 4 | Road 1 P1 | 4 | 5 | 32.123 | 134.418 | 4.787 | 0.650 | 3.111 | 12.997 | 12.240 | 198.181 | 61215.673 | 608.154 |
| 5 | Road 1 P1 | 5 | 6 | 34.200 | 168.618 | 4.509 | 0.650 | 2.931 | 15.928 | 12.810 | 197.275 | 61782.129 | 566.457 |
| 6 | Road 1 P1 | 6 | 7 | 27.695 | 196.312 | 3.733 | 0.650 | 2.426 | 18.354 | 13.272 | 196.545 | 62247.344 | 465.215 |
| 7 | Road 1 P1 | 7 | 8 | 20.718 | 217.030 | 3.1899 | 0.650 | 2.073 | 20.428 | 13.617 | 196.001 | 62643.748 | 396.404 |
| 8 | Road 1 P1 | 8 | 9 | 39.337 | 256.367 | 5.3104 | 0.650 | 3.452 | 23.880 | 14.273 | 194.971 | 63295.714 | 651.966 |

# StormWater Design Computations

## Line Road No 1 Part 2

| NUMBER | LOCATION LINE NAME | UPPER MH. NO. | LOWER MH. NO. | LENGTH (m) | LENGTH COMULATIVE (m) | AREA of Street and industry (ha) | C FACTOR Street and industry | C.A STREET (ha) | SUM(AC) COMULATIVE (ha) | Tc (min) | ( i ) (l/s.ha) | Q (l/s) | Qi (l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 14 | 15 | 16 | 17 | 18 |
| 9 | Road 1 P1 | 9 | 10 | 28.603 | 284.970 | 4.098 | 0.650 | 2.664 | 44.304 | 14.749 | 194.226 | 67244.823 | 3949.109 |
| 10 | Road 1 P1 | 10 | 11 | 35.997 | 320.966 | 4.028 | 0.650 | 2.618 | 46.922 | 15.349 | 193.293 | 67709.523 | 464.700 |
| 11 | Road 1 P1 | 11 | 12 | 39.570 | 360.537 | 6.393 | 0.650 | 4.156 | 51.077 | 16.009 | 192.271 | 68460.618 | 751.094 |
| 12 | Road 1 P1 | 12 | 13 | 28.822 | 389.359 | 4.028 | 0.650 | 2.618 | 53.696 | 16.489 | 191.531 | 68924.252 | 463.635 |
| 13 | Road 1 P1 | 13 | 14 | 40.270 | 429.629 | 4.982 | 0.650 | 3.238 | 56.934 | 17.160 | 190.501 | 69485.834 | 561.582 |
| 14 | Road 1 P1 | 14 | 15 | 32.834 | 462.463 | 9.070 | 0.650 | 5.895 | 62.829 | 17.708 | 189.666 | 70556.427 | 1070.593 |
| 15 | Road 1 P1 | 15 | 16 | 8.7818 | 471.245 | 8.2475 | 0.650 | 5.361 | 68.190 | 17.854 | 189.443 | 71558.006 | 1001.578 |
| 16 | Road 1 P1 | 16 | 17 | 7.881 | 479.126 | 3.7847 | 0.650 | 2.460 | 70.650 | 17.985 | 189.243 | 72009.933 | 451.927 |

# StormWater Design Computations

## Line Road No 1 Part 3

| NUMBER | LOCATION: LINE NAME | LOCATION: UPPER MH. NO. | LOCATION: LOWER MH. NO. | LENGTH (m) | LENGTH COMULATIVE (m) | AREA of Street and industry (ha) | C FACTOR Street and industry | C.A STREET (ha) | SUM(AC) COMULATIVE (ha) | Tc (min) | ( i ) (l/s.ha) | Q (l/s) | Qi (l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 14 | 15 | 16 | 17 | 18 |
| 17 | Road 1 P1 | 17 | 18 | 16.224 | 495.350 | 3.240 | 0.650 | 2.106 | 72.756 | 18.256 | 188.832 | 72378.614 | 368.681 |
| 18 | Road 1 P1 | 18 | 19 | 15.170 | 510.521 | 4.011 | 0.650 | 2.607 | 75.364 | 18.509 | 188.449 | 72842.106 | 463.492 |
| 19 | Road 1 P1 | 19 | 20 | 31.906 | 542.427 | 3.266 | 0.650 | 2.123 | 77.486 | 19.040 | 187.646 | 73179.891 | 337.785 |
| 20 | Road 1 P1 | 20 | 21 | 33.142 | 575.569 | 3.714 | 0.650 | 2.414 | 79.900 | 19.593 | 186.816 | 73566.541 | 386.650 |
| 21 | Road 1 P1 | 21 | 22 | 17.739 | 593.307 | 2.745 | 0.650 | 1.784 | 81.685 | 19.888 | 186.372 | 73863.696 | 297.155 |
| 22 | Road 1 P1 | 22 | 23 | 12.646 | 605.953 | 1.525 | 0.650 | 0.991 | 82.676 | 20.099 | 186.057 | 74022.387 | 158.691 |
| 23 | Road 1 P1 | 23 | 24 | 18.1846 | 624.138 | 1.5749 | 0.650 | 1.024 | 83.700 | 20.402 | 185.605 | 74174.987 | 152.600 |
| 24 | Road 1 P1 | 24 | 25 | 7.926 | 632.064 | 1.2315 | 0.650 | 0.800 | 84.500 | 20.534 | 185.408 | 74306.927 | 131.940 |

# StormWater Design Computations

## Line Road No 1 Part 4

| NUMBER | LOCATION: LINE NAME | LOCATION: UPPER MH. NO. | LOCATION: LOWER MH. NO. | LENGTH (m) | LENGTH COMULATIVE (m) | AREA of Street and industry (ha) | C FACTOR Street and industry | C.A STREET (ha) | SUM(AC) COMULATIVE (ha) | Tc (min) | ( i ) (l/s.ha) | Q (l/s) | Qi (l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 9 | 11 | 14 | 15 | 16 | 17 | 18 |
| 25 | Road 1 P1 | 25 | 26 | 12.052 | 644.116 | 0.970 | 0.650 | 0.631 | 85.131 | 20.735 | 185.109 | 74398.344 | 91.417 |
| 26 | Road 1 P1 | 26 | 27 | 12.160 | 656.276 | 1.020 | 0.650 | 0.663 | 85.794 | 20.938 | 184.808 | 74495.277 | 96.932 |
| 27 | Road 1 P1 | 27 | 28 | 8.687 | 664.962 | 0.913 | 0.650 | 0.593 | 86.387 | 21.083 | 184.593 | 74586.336 | 91.060 |
| 28 | Road 1 P1 | 28 | 29 | 6.716 | 671.678 | 0.985 | 0.650 | 0.640 | 87.027 | 21.195 | 184.427 | 74690.050 | 103.714 |
| 29 | Road 1 P1 | 29 | 30 | 6.491 | 678.169 | 1.388 | 0.650 | 0.902 | 87.929 | 21.303 | 184.267 | 74842.307 | 152.258 |
| 30 | Road 1 P1 | 30 | 31 | 24.974 | 703.143 | 1.749 | 0.650 | 1.137 | 89.066 | 21.719 | 183.652 | 74997.013 | 154.706 |
| 31 | Road 1 P1 | 31 | 32 | 20.0891 | 723.232 | 1.4418 | 0.650 | 0.937 | 90.003 | 22.054 | 183.159 | 75124.734 | 127.721 |

| Gravity Node Report | | | | | |
|---|---|---|---|---|---|
| Label | Calculated Station (m) | Ground Elevation (m) | Structure Diameter (m) | Total Flow ($m^2$/day) | Velocity In (m/s) |
| MH-1 | 8+05 | 882.64 | 1.2 | 59,287.28 | 2.11 |
| MH-2 | 7+68 | 882.5 | 1.2 | 59,898.68 | 2.12 |
| MH-3 | 7+38 | 882.2 | 1.2 | 60,607.52 | 2.13 |
| MH-4 | 7+03 | 880.25 | 1.2 | 61,215.67 | 2.14 |
| MH-5 | 6+71 | 880 | 1.2 | 61,782.13 | 2.15 |
| MH-6 | 6+35 | 879.85 | 1.2 | 62,247.35 | 2.15 |
| MH-7 | 6+08 | 878.46 | 1.2 | 62,643.75 | 2.16 |
| MH-8 | 5+87 | 877.5 | 1.2 | 63,295.72 | 2.17 |
| MH-9 | 5+48 | 876.75 | 1.2 | 67,244.82 | 2.23 |
| MH-10 | 5+19 | 876 | 1.2 | 67,709.52 | 2.24 |
| MH-11 | 4+82 | 875 | 1.2 | 68,460.62 | 2.25 |
| MH-12 | 4+41 | 874.13 | 1.2 | 68,924.55 | 2.26 |
| MH-13 | 4+09 | 872.96 | 1.2 | 69,486.14 | 2.26 |
| MH-14 | 3+62 | 872.5 | 1.2 | 70,556.73 | 2.28 |
| MH-15 | 3+29 | 873.94 | 1.2 | 71,558.31 | 2.3 |
| MH-16 | 3+20 | 873.97 | 1.2 | 72,010.23 | 2.3 |
| MH-17 | 3+12 | 873.79 | 1.2 | 72,378.91 | 2.31 |
| MH-18 | 2+93 | 872.5 | 1.2 | 72,842.41 | 2.32 |
| MH-19 | 2+73 | 872.35 | 1.2 | 73,180.19 | 2.32 |
| MH-20 | 2+40 | 871.2 | 1.2 | 73,566.84 | 2.33 |
| MH-21 | 2+07 | 870.6 | 1.2 | 73,864.00 | 2.33 |
| MH-22 | 1+89 | 870.2 | 1.2 | 74,022.69 | 2.33 |
| MH-23 | 1+76 | 869.9 | 1.2 | 74,175.29 | 2.34 |
| MH-24 | 1+57 | 869.54 | 1.2 | 74,307.23 | 2.34 |
| MH-25 | 1+48 | 868.86 | 1.2 | 74,398.64 | 2.34 |
| MH-26 | 1+35 | 868.1 | 1.2 | 74,495.58 | 2.34 |
| MH-27 | 1+17 | 867.7 | 1.2 | 74,586.64 | 2.34 |
| MH-28 | 1+05 | 867 | 1.2 | 74,690.35 | 2.35 |
| MH-29 | 0+85 | 866.4 | 1.2 | 74,842.61 | 2.35 |
| MH-30 | 0+50 | 867.02 | 1.2 | 74,997.31 | 2.35 |
| MH-31 | 0+25 | 865.33 | 1.2 | 75,125.04 | 2.35 |

| Gravity Pipe Report | | | | |
|---|---|---|---|---|
| Label | Upstream Node | Downstream Node | Section Size Description | Section Shape |
| P-1 | MH-1 | MH-2 | 750 mm | Circular |
| P-2 | MH-2 | MH-3 | 750 mm | Circular |
| P-3 | MH-3 | MH-4 | 750 mm | Circular |
| P-4 | MH-4 | MH-5 | 750 mm | Circular |
| P-5 | MH-5 | MH-6 | 750 mm | Circular |
| P-6 | MH-6 | MH-7 | 750 mm | Circular |
| P-7 | MH-7 | MH-8 | 750 mm | Circular |
| P-8 | MH-8 | MH-9 | 750 mm | Circular |
| P-9 | MH-9 | MH-10 | 750 mm | Circular |
| P-10 | MH-10 | MH-11 | 750 mm | Circular |
| P-11 | MH-11 | MH-12 | 750 mm | Circular |
| P-12 | MH-12 | MH-13 | 750 mm | Circular |
| P-13 | MH-13 | MH-14 | 750 mm | Circular |
| P-14 | MH-14 | MH-15 | 750 mm | Circular |
| P-15 | MH-15 | MH-16 | 750 mm | Circular |
| P-16 | MH-16 | MH-17 | 750 mm | Circular |
| P-17 | MH-17 | MH-18 | 750 mm | Circular |
| P-18 | MH-18 | MH-19 | 750 mm | Circular |
| P-19 | MH-19 | MH-20 | 750 mm | Circular |
| P-20 | MH-20 | MH-21 | 750 mm | Circular |
| P-21 | MH-21 | MH-22 | 750 mm | Circular |
| P-22 | MH-22 | MH-23 | 750 mm | Circular |
| P-23 | MH-23 | MH-24 | 750 mm | Circular |
| P-24 | MH-24 | MH-25 | 750 mm | Circular |
| P-25 | MH-25 | MH-26 | 750 mm | Circular |
| P-26 | MH-26 | MH-27 | 750 mm | Circular |
| P-27 | MH-27 | MH-28 | 750 mm | Circular |
| P-28 | MH-28 | MH-29 | 750 mm | Circular |
| P-29 | MH-29 | MH-30 | 750 mm | Circular |
| P-30 | MH-30 | MH-31 | 750 mm | Circular |

| Gravity Manhole Report | | | | |
|---|---|---|---|---|
| Label | Calculated Station (m) | X (m) | Y (m) | Ground Elevation (m) |
| MH-1 | 8+05 | 159,710.80 | 103,934.96 | 882.64 |
| MH-2 | 7+68 | 159,747.77 | 103,930.48 | 882.5 |
| MH-3 | 7+38 | 159,777.91 | 103,926.96 | 882.2 |
| MH-4 | 7+03 | 159,812.09 | 103,921.51 | 880.25 |
| MH-5 | 6+71 | 159,843.88 | 103,915.56 | 880 |
| MH-6 | 6+35 | 159,876.70 | 103,901.74 | 879.85 |
| MH-7 | 6+08 | 159,901.81 | 103,890.27 | 878.46 |
| MH-8 | 5+87 | 159,920.82 | 103,881.48 | 877.5 |
| MH-9 | 5+48 | 159,955.97 | 103,864.12 | 876.75 |
| MH-10 | 5+19 | 159,980.61 | 103,849.54 | 876 |
| MH-11 | 4+82 | 160,010.07 | 103,826.96 | 875 |
| MH-12 | 4+41 | 160,040.52 | 103,798.41 | 874.13 |
| MH-13 | 4+09 | 160,061.22 | 103,774.11 | 872.96 |
| MH-14 | 3+62 | 160,087.79 | 103,735.53 | 872.5 |
| MH-15 | 3+29 | 160,109.82 | 103,711.23 | 873.94 |
| MH-16 | 3+20 | 160,116.26 | 103,705.31 | 873.97 |
| MH-17 | 3+12 | 160,123.33 | 103,700.82 | 873.79 |
| MH-18 | 2+93 | 160,127.71 | 103,682.86 | 872.5 |
| MH-19 | 2+73 | 160,128.02 | 103,662.99 | 872.35 |
| MH-20 | 2+40 | 160,142.88 | 103,633.42 | 871.2 |
| MH-21 | 2+07 | 160,166.30 | 103,609.57 | 870.6 |
| MH-22 | 1+89 | 160,176.02 | 103,594.52 | 870.2 |
| MH-23 | 1+76 | 160,183.51 | 103,584.20 | 869.9 |
| MH-24 | 1+57 | 160,200.45 | 103,575.15 | 869.54 |
| MH-25 | 1+48 | 160,203.09 | 103,566.83 | 868.86 |
| MH-26 | 1+35 | 160,206.40 | 103,553.61 | 868.1 |
| MH-27 | 1+17 | 160,204.70 | 103,535.62 | 867.7 |
| MH-28 | 1+05 | 160,204.42 | 103,523.79 | 867 |
| MH-29 | 0+85 | 160,195.47 | 103,506.73 | 866.4 |
| MH-30 | 0+50 | 160,173.96 | 103,478.60 | 867.02 |
| MH-31 | 0+25 | 160,192.50 | 103,461.68 | 865.33 |

**Alignment PI station Report :**

| PI Station | Northing | Easting | Distance | Direction |
|---|---|---|---|---|
| 0+000.00 | 103,946.8984m | 159,685.7729m | | |
| | | | 76.393m | S82° 26' 48"E |
| 0+076.39 | 103,936.8564m | 159,761.5033m | | |
| | | | 90.181m | S74° 10' 45"E |
| 0+166.52 | 103,912.2704m | 159,848.2682m | | |
| | | | 38.796m | S64° 50' 24"E |
| 0+205.25 | 103,895.7766m | 159,883.3830m | | |
| | | | 55.002m | S65° 46' 40"E |
| 0+260.25 | 103,873.2106m | 159,933.5427m | | |
| | | | 82.394m | S59° 59' 48"E |
| 0+342.62 | 103,832.0094m | 160,004.8956m | | |
| | | | 68.249m | S46° 36' 18"E |
| 0+410.66 | 103,785.1204m | 160,054.4879m | | |
| | | | 101.787m | S35° 45' 49"E |
| 0+512.34 | 103,702.5269m | 160,113.9768m | | |

**Alignment Curve Report :**

| Tangent Data | | | |
|---|---|---|---|
| **Length:** | 61.939 | Course: | S 82° 26' 47.5048" E |

| Circular Curve Data | | | |
|---|---|---|---|
| **Delta:** | **08° 16' 02.3632"** | **Type:** | **RIGHT** |
| **Radius:** | 200 | | |
| **Length:** | 28.858 | Tangent: | 14.454 |
| **Mid-Ord:** | 0.52 | External: | 0.522 |
| **Chord:** | 28.833 | Course: | S 78° 18' 46.3232" E |

| Tangent Data | | | |
|---|---|---|---|
| **Length:** | 58.986 | Course: | S 74° 10' 45.1416" E |

| Circular Curve Data | | | |
|---|---|---|---|
| **Delta:** | **09° 20' 21.3245"** | **Type:** | **RIGHT** |
| **Radius:** | 204.95 | | |
| **Length:** | 33.407 | Tangent: | 16.741 |
| **Mid-Ord:** | 0.68 | External: | 0.683 |
| **Chord:** | 33.37 | Course: | S 69° 30' 34.4794" E |

| Tangent Data | | | |
|---|---|---|---|
| **Length:** | 20.418 | Course: | S 64° 50' 23.8171" E |

| Circular Curve Data | | | |
|---|---|---|---|
| **Delta:** | **00° 56' 16.5674"** | **Type:** | **LEFT** |
| **Radius:** | 200 | | |
| **Length:** | 3.274 | Tangent: | 1.637 |
| **Mid-Ord:** | 0.007 | External: | 0.007 |
| **Chord:** | 3.274 | Course: | S 65° 18' 32.1008" E |

| Tangent Data | | | |
|---|---|---|---|
| **Length:** | 43.266 | Course: | S 65° 46' 40.3845" E |

| Circular Curve Data | | | |
|---|---|---|---|
| **Delta:** | **05° 46' 52.4906"** | **Type:** | **RIGHT** |
| **Radius:** | 200 | | |
| **Length:** | 20.18 | Tangent: | 10.099 |
| **Mid-Ord:** | 0.254 | External: | 0.255 |

| | | | |
|---|---|---|---|
| **Chord:** | 20.172 | Course: | S 62° 53' 14.1392" E |

| Tangent Data | | | |
|---|---|---|---|
| **Length:** | 48.815 | Course: | S 59° 59' 47.8939" E |

| Circular Curve Data | | | |
|---|---|---|---|
| **Delta:** | **13° 23' 30.1939"** | **Type:** | **RIGHT** |
| **Radius:** | 200 | | |
| **Length:** | 46.746 | Tangent: | 23.48 |
| **Mid-Ord:** | 1.364 | External: | 1.374 |
| **Chord:** | 46.64 | Course: | S 53° 18' 02.7970" E |

| Tangent Data | | | |
|---|---|---|---|
| **Length:** | 26.862 | Course: | S 46° 36' 17.7000" E |

| Circular Curve Data | | | |
|---|---|---|---|
| **Delta:** | **10° 50' 28.2127"** | **Type:** | **RIGHT** |
| **Radius:** | 188.721 | | |
| **Length:** | 35.709 | Tangent: | 17.908 |
| **Mid-Ord:** | 0.844 | External: | 0.848 |
| **Chord:** | 35.655 | Course: | S 41° 11' 03.5937" E |

| Tangent Data | | | |
|---|---|---|---|
| **Length:** | 83.879 | Course: | S 35° 45' 49.4873" E |

| Station | Cut Area (Sq.M.) | Cut Volume (Cu.M.) | Reusable Volume (Cu.M.) | Fill Area (Sq.M.) | Fill Volume (Cu.M.) | Cum. Cut Vol. (Cu.M.) | Cum. Reusable Vol. (Cu.M.) | Cum. Fill Vol. (Cu.M.) | Cum. Net Vol. (Cu.M.) |
|---|---|---|---|---|---|---|---|---|---|
| 0+000.00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0+020.00 | 0 | 0 | 0 | 3.37 | 33.7 | 0 | 33.7 | 33.7 | -33.7 |
| 0+040.00 | 0 | 0 | 0 | 4.48 | 78.53 | 0 | 112.23 | 112.23 | -112.23 |
| 0+060.00 | 0.26 | 2.64 | 2.64 | 5.3 | 97.81 | 2.64 | 210.04 | 210.04 | -207.4 |
| 0+070.00 | 0.4 | 3.37 | 3.37 | 6.03 | 55.6 | 6.01 | 265.64 | 265.64 | -259.62 |
| 0+080.00 | 0.74 | 5.83 | 5.83 | 5.83 | 57.96 | 11.85 | 323.6 | 323.6 | -311.75 |
| 0+090.00 | 0.46 | 6.13 | 6.13 | 5.89 | 57.33 | 17.98 | 380.93 | 380.93 | -362.95 |
| 0+100.00 | 0.17 | 3.11 | 3.11 | 5.2 | 55.44 | 21.09 | 436.37 | 436.37 | -415.28 |
| 0+120.00 | 0 | 1.66 | 1.66 | 4.82 | 100.18 | 22.75 | 536.55 | 536.55 | -513.8 |
| 0+140.00 | 0 | 0 | 0 | 3.15 | 79.73 | 22.75 | 616.28 | 616.28 | -593.53 |
| 0+150.00 | 0.01 | 0.06 | 0.06 | 4.86 | 40.07 | 22.81 | 656.35 | 656.35 | -633.55 |
| 0+160.00 | 0 | 0.05 | 0.05 | 9.74 | 73.7 | 22.86 | 730.06 | 730.06 | -707.2 |
| 0+170.00 | 0.2 | 0.95 | 0.95 | 9.71 | 97.78 | 23.81 | 827.83 | 827.83 | -804.02 |
| 0+180.00 | 13.7 | 71.13 | 71.13 | 2.93 | 63.01 | 94.94 | 890.85 | 890.85 | -795.91 |
| 0+200.00 | 1.41 | 151.08 | 151.08 | 9.09 | 120.25 | 246.03 | 1,011.10 | 1,011.10 | -765.07 |
| 0+220.00 | 0.06 | 14.73 | 14.73 | 6.12 | 152.12 | 260.75 | 1,163.22 | 1,163.22 | -902.46 |
| 0+240.00 | 7.66 | 77.24 | 77.24 | 0 | 61.2 | 338 | 1,224.41 | 1,224.41 | -886.42 |
| 0+260.00 | 6.68 | 143.63 | 143.63 | 1.74 | 17.22 | 481.63 | 1,241.64 | 1,241.64 | -760.01 |
| 0+270.00 | 0 | 33.48 | 33.48 | 6.79 | 41.78 | 515.1 | 1,283.42 | 1,283.42 | -768.32 |
| 0+280.00 | 0.66 | 3.3 | 3.3 | 7.3 | 70.48 | 518.4 | 1,353.90 | 1,353.90 | -835.5 |
| 0+300.00 | 0 | 6.59 | 6.59 | 9.53 | 168.36 | 525 | 1,522.26 | 1,522.26 | -997.26 |
| 0+320.00 | 0 | 0 | 0 | 6.77 | 163.04 | 525 | 1,685.30 | 1,685.30 | -1,160.30 |
| 0+330.00 | 0 | 0 | 0 | 7.11 | 69.6 | 525 | 1,754.89 | 1,754.89 | -1,229.90 |
| 0+340.00 | 0 | 0 | 0 | 4.36 | 57.21 | 525 | 1,812.11 | 1,812.11 | -1,287.11 |
| 0+350.00 | 0.3 | 1.44 | 1.44 | 4.19 | 42.71 | 526.43 | 1,854.81 | 1,854.81 | -1,328.38 |
| 0+360.00 | 0 | 1.44 | 1.44 | 5.28 | 47.39 | 527.87 | 1,902.20 | 1,902.20 | -1,374.33 |
| 0+380.00 | 0 | 0 | 0 | 4.79 | 100.7 | 527.87 | 2,002.90 | 2,002.90 | -1,475.03 |
| 0+400.00 | 0 | 0 | 0 | 3.79 | 85.72 | 527.87 | 2,088.62 | 2,088.62 | -1,560.75 |
| 0+410.00 | 0 | 0 | 0 | 3.87 | 38.04 | 527.87 | 2,126.66 | 2,126.66 | -1,598.80 |
| 0+420.00 | 0 | 0 | 0 | 2.69 | 32.63 | 527.87 | 2,159.30 | 2,159.30 | -1,631.43 |
| 0+440.00 | 0 | 0 | 0 | 3.26 | 59.33 | 527.87 | 2,218.62 | 2,218.62 | -1,690.75 |
| 0+460.00 | 0 | 0 | 0 | 3.04 | 63.05 | 527.87 | 2,281.67 | 2,281.67 | -1,753.80 |
| 0+480.00 | 0 | 0 | 0 | 2.01 | 50.57 | 527.87 | 2,332.24 | 2,332.24 | -1,804.37 |
| 0+500.00 | 0 | 0 | 0 | 1.57 | 35.8 | 527.87 | 2,368.04 | 2,368.04 | -1,840.17 |
| 0+512.34 | 0 | 0 | 0 | 0 | 9.66 | 527.87 | 2,377.70 | 2,377.70 | -1,849.83 |

## Corridor section point report

Corridor Name: Corridor - (1)
Description:
Base Alignment Name: Alignment - (1)
Station Range: Start: 0+000.00, End: 0+512.34

CHAINAGE 0+000.00

| POINT | X | Y | Z | OFFSET | STRING CUT |
|---|---|---|---|---|---|
| 1 | 159,686.35 | 103,951.29 | 884.5644 | -4.425m | Ditch_Out |
| 2 | 159,686.33 | 103,951.14 | 884.5644 | -4.275m | Top_Curb |
| 3 | 159,686.33 | 103,951.09 | 884.4144 | -4.225m | Flowline_Gutter |
| 4 | 159,686.28 | 103,950.69 | 884.2474 | -3.825m | ETW_Base |
| 5 | 159,686.28 | 103,950.69 | 884.4224 | -3.825m | ETW |
| 6 | 159,686.28 | 103,950.69 | 883.9474 | -3.825m | ETW_Sub |
| 7 | 159,686.28 | 103,950.69 | 884.3474 | -3.825m | ETW_Pave2 |
| 8 | 159,686.28 | 103,950.69 | 884.3724 | -3.825m | ETW_Pave1 |
| 9 | 159,685.80 | 103,947.12 | 884.3184 | -0.225m | Crown_Pave1 |
| 10 | 159,685.80 | 103,947.12 | 884.4184 | -0.225m | Back_Curb |
| 11 | 159,685.80 | 103,947.12 | 884.1934 | -0.225m | Crown_Base |
| 12 | 159,685.80 | 103,947.12 | 883.8934 | -0.225m | Crown_Sub |
| 13 | 159,685.80 | 103,947.12 | 884.2934 | -0.225m | Crown_Pave2 |
| 14 | 159,685.80 | 103,947.12 | 884.3684 | -0.225m | Crown |
| 15 | 159,685.77 | 103,946.90 | 883.9684 | -0.000m | Bottom_Curb |
| 16 | 159,685.77 | 103,946.90 | 884.4184 | -0.000m | Top_Curb |
| 17 | 159,685.77 | 103,946.90 | 884.4184 | 0.001m | Top_Curb |
| 18 | 159,685.77 | 103,946.90 | 883.9684 | 0.001m | Bottom_Curb |
| 19 | 159,685.74 | 103,946.67 | 884.2934 | 0.226m | Crown_Pave2 |
| 20 | 159,685.74 | 103,946.67 | 884.3684 | 0.226m | Crown |
| 21 | 159,685.74 | 103,946.67 | 884.4184 | 0.226m | Back_Curb |
| 22 | 159,685.74 | 103,946.67 | 883.8934 | 0.226m | Crown_Sub |
| 23 | 159,685.74 | 103,946.67 | 884.1934 | 0.226m | Crown_Base |
| 24 | 159,685.74 | 103,946.67 | 884.3184 | 0.226m | Crown_Pave1 |
| 25 | 159,685.27 | 103,943.11 | 884.4224 | 3.826m | ETW |
| 26 | 159,685.27 | 103,943.11 | 884.3474 | 3.826m | ETW_Pave2 |
| 27 | 159,685.27 | 103,943.11 | 884.2474 | 3.826m | ETW_Base |
| 28 | 159,685.27 | 103,943.11 | 883.9474 | 3.826m | ETW_Sub |
| 29 | 159,685.27 | 103,943.11 | 884.3724 | 3.826m | ETW_Pave1 |
| 30 | 159,685.22 | 103,942.71 | 884.4144 | 4.226m | Flowline_Gutter |
| 31 | 159,685.21 | 103,942.66 | 884.5644 | 4.276m | Top_Curb |
| 32 | 159,685.19 | 103,942.51 | 884.5644 | 4.426m | Hinge |
| 33 | 159,684.78 | 103,939.38 | 884.0388 | 7.580m | Daylight |

CHAINAGE 0+025.00

CHAINAGE 0+050.00

CHAINAGE 0+075.00

CHAINAGE 0+100.00

| POINT | X | Y | Z | OFFSET | STRING CUT |
|---|---|---|---|---|---|
| 1 | 159,785.54 | 103,934.92 | 880.8199 | -4.692m | Daylight |
| 2 | 159,785.47 | 103,934.66 | 880.7754 | -4.425m | Ditch_Out |
| 3 | 159,785.43 | 103,934.52 | 880.7754 | -4.275m | Top_Curb |
| 4 | 159,785.42 | 103,934.47 | 880.6254 | -4.225m | Flowline_Gutter |
| 5 | 159,785.31 | 103,934.09 | 880.6334 | -3.825m | Flange |
| 6 | 159,785.31 | 103,934.09 | 880.5584 | -3.825m | ETW_Pave2 |
| 7 | 159,785.31 | 103,934.09 | 880.5834 | -3.825m | ETW_Pave1 |
| 8 | 159,785.31 | 103,934.09 | 880.1584 | -3.825m | ETW_Sub |
| 9 | 159,785.31 | 103,934.09 | 880.4584 | -3.825m | ETW_Base |
| 10 | 159,784.33 | 103,930.62 | 880.5794 | -0.225m | Crown |
| 11 | 159,784.33 | 103,930.62 | 880.5294 | -0.225m | Crown_Pave1 |
| 12 | 159,784.33 | 103,930.62 | 880.6294 | -0.225m | Back_Curb |
| 13 | 159,784.33 | 103,930.62 | 880.5044 | -0.225m | Crown_Pave2 |
| 14 | 159,784.33 | 103,930.62 | 880.1044 | -0.225m | Crown_Sub |
| 15 | 159,784.33 | 103,930.62 | 880.4044 | -0.225m | Crown_Base |
| 16 | 159,784.26 | 103,930.41 | 880.1794 | -0.000m | Bottom_Curb |
| 17 | 159,784.26 | 103,930.41 | 880.6294 | -0.000m | Top_Curb |
| 18 | 159,784.26 | 103,930.41 | 880.6294 | 0.001m | Top_Curb |
| 19 | 159,784.26 | 103,930.41 | 880.1794 | 0.001m | Bottom_Curb |
| 20 | 159,784.20 | 103,930.19 | 880.5294 | 0.226m | Crown_Pave1 |
| 21 | 159,784.20 | 103,930.19 | 880.5044 | 0.226m | Crown_Pave2 |
| 22 | 159,784.20 | 103,930.19 | 880.1044 | 0.226m | Crown_Sub |
| 23 | 159,784.20 | 103,930.19 | 880.5794 | 0.226m | Crown |
| 24 | 159,784.20 | 103,930.19 | 880.4044 | 0.226m | Crown_Base |
| 25 | 159,784.20 | 103,930.19 | 880.6294 | 0.226m | Back_Curb |
| 26 | 159,783.22 | 103,926.73 | 880.6334 | 3.826m | ETW |
| 27 | 159,783.22 | 103,926.73 | 880.4584 | 3.826m | ETW_Base |
| 28 | 159,783.22 | 103,926.73 | 880.5584 | 3.826m | ETW_Pave2 |
| 29 | 159,783.22 | 103,926.73 | 880.5834 | 3.826m | ETW_Pave1 |
| 30 | 159,783.22 | 103,926.73 | 880.1584 | 3.826m | ETW_Sub |
| 31 | 159,783.11 | 103,926.34 | 880.6254 | 4.226m | Flowline_Gutter |
| 32 | 159,783.10 | 103,926.29 | 880.7754 | 4.276m | Top_Curb |
| 33 | 159,783.06 | 103,926.15 | 880.7754 | 4.426m | Back_Curb |
| 34 | 159,781.67 | 103,921.27 | 879.9296 | 9.500m | Daylight |

CHAINAGE 0+125.00

CHAINAGE 0+150.00

CHAINAGE 0+175.00

CHAINAGE 0+200.00

| POINT | X | Y | Z | OFFSET | STRING CUT |
|---|---|---|---|---|---|
| 1 | 159,882.21 | 103,905.61 | 879.053 | -8.405m | Daylight |
| 2 | 159,880.52 | 103,902.01 | 877.0629 | -4.425m | Ditch_Out |
| 3 | 159,880.45 | 103,901.88 | 877.0629 | -4.275m | Top_Curb |
| 4 | 159,880.43 | 103,901.83 | 876.9129 | -4.225m | Flowline_Gutter |
| 5 | 159,880.26 | 103,901.47 | 876.9209 | -3.825m | Flange |
| 6 | 159,880.26 | 103,901.47 | 876.8459 | -3.825m | ETW_Pave2 |
| 7 | 159,880.26 | 103,901.47 | 876.8709 | -3.825m | ETW_Pave1 |
| 8 | 159,880.26 | 103,901.47 | 876.4459 | -3.825m | ETW_Sub |
| 9 | 159,880.26 | 103,901.47 | 876.7459 | -3.825m | ETW_Base |
| 10 | 159,878.73 | 103,898.21 | 876.8669 | -0.225m | Crown |
| 11 | 159,878.73 | 103,898.21 | 876.8169 | -0.225m | Crown_Pave1 |
| 12 | 159,878.73 | 103,898.21 | 876.9169 | -0.225m | Back_Curb |
| 13 | 159,878.73 | 103,898.21 | 876.7919 | -0.225m | Crown_Pave2 |
| 14 | 159,878.73 | 103,898.21 | 876.3919 | -0.225m | Crown_Sub |
| 15 | 159,878.73 | 103,898.21 | 876.6919 | -0.225m | Crown_Base |
| 16 | 159,878.64 | 103,898.01 | 876.4669 | -0.000m | Bottom_Curb |
| 17 | 159,878.64 | 103,898.01 | 876.9169 | -0.000m | Top_Curb |
| 18 | 159,878.63 | 103,898.01 | 876.9169 | 0.001m | Top_Curb |
| 19 | 159,878.63 | 103,898.01 | 876.4669 | 0.001m | Bottom_Curb |
| 20 | 159,878.54 | 103,897.80 | 876.8169 | 0.226m | Crown_Pave1 |
| 21 | 159,878.54 | 103,897.80 | 876.7919 | 0.226m | Crown_Pave2 |
| 22 | 159,878.54 | 103,897.80 | 876.3919 | 0.226m | Crown_Sub |
| 23 | 159,878.54 | 103,897.80 | 876.8669 | 0.226m | Crown |
| 24 | 159,878.54 | 103,897.80 | 876.6919 | 0.226m | Crown_Base |
| 25 | 159,878.54 | 103,897.80 | 876.9169 | 0.226m | Back_Curb |
| 26 | 159,877.01 | 103,894.54 | 876.9209 | 3.826m | ETW |
| 27 | 159,877.01 | 103,894.54 | 876.7459 | 3.826m | ETW_Base |
| 28 | 159,877.01 | 103,894.54 | 876.8459 | 3.826m | ETW_Pave2 |
| 29 | 159,877.01 | 103,894.54 | 876.8709 | 3.826m | ETW_Pave1 |
| 30 | 159,877.01 | 103,894.54 | 876.4459 | 3.826m | ETW_Sub |
| 31 | 159,876.84 | 103,894.18 | 876.9129 | 4.226m | Flowline_Gutter |
| 32 | 159,876.82 | 103,894.14 | 877.0629 | 4.276m | Top_Curb |
| 33 | 159,876.75 | 103,894.00 | 877.0629 | 4.426m | Back_Curb |
| 34 | 159,874.31 | 103,888.80 | 875.6259 | 10.174m | Daylight |

CHAINAGE 0+225.00

CHAINAGE 0+250.00

CHAINAGE 0+275.00

CHAINAGE 0+300.00

| POINT | X | Y | Z | OFFSET | STRING CUT |
|---|---|---|---|---|---|
| 1 | 159,971.56 | 103,859.51 | 874.8279 | -7.147m | Daylight |
| 2 | 159,970.20 | 103,857.16 | 875.2815 | -4.425m | Back_Curb |
| 3 | 159,970.12 | 103,857.03 | 875.2815 | -4.275m | Top_Curb |
| 4 | 159,970.10 | 103,856.98 | 875.1315 | -4.225m | Flowline_Gutter |
| 5 | 159,969.90 | 103,856.64 | 875.1395 | -3.825m | ETW |
| 6 | 159,969.90 | 103,856.64 | 875.0645 | -3.825m | ETW_Pave2 |
| 7 | 159,969.90 | 103,856.64 | 874.6645 | -3.825m | ETW_Sub |
| 8 | 159,969.90 | 103,856.64 | 875.0895 | -3.825m | ETW_Pave1 |
| 9 | 159,969.90 | 103,856.64 | 874.9645 | -3.825m | ETW_Base |
| 10 | 159,968.10 | 103,853.52 | 875.0855 | -0.225m | Crown |
| 11 | 159,968.10 | 103,853.52 | 875.0355 | -0.225m | Crown_Pave1 |
| 12 | 159,968.10 | 103,853.52 | 875.1355 | -0.225m | Back_Curb |
| 13 | 159,968.10 | 103,853.52 | 875.0105 | -0.225m | Crown_Pave2 |
| 14 | 159,968.10 | 103,853.52 | 874.9105 | -0.225m | Crown_Base |
| 15 | 159,968.10 | 103,853.52 | 874.6105 | -0.225m | Crown_Sub |
| 16 | 159,967.98 | 103,853.32 | 874.6855 | -0.000m | Bottom_Curb |
| 17 | 159,967.98 | 103,853.32 | 875.1355 | -0.000m | Top_Curb |
| 18 | 159,967.98 | 103,853.32 | 875.1355 | 0.001m | Top_Curb |
| 19 | 159,967.98 | 103,853.32 | 874.6855 | 0.001m | Bottom_Curb |
| 20 | 159,967.87 | 103,853.13 | 875.0355 | 0.226m | Crown_Pave1 |
| 21 | 159,967.87 | 103,853.13 | 875.0105 | 0.226m | Crown_Pave2 |
| 22 | 159,967.87 | 103,853.13 | 874.6105 | 0.226m | Crown_Sub |
| 23 | 159,967.87 | 103,853.13 | 875.0855 | 0.226m | Crown |
| 24 | 159,967.87 | 103,853.13 | 874.9105 | 0.226m | Crown_Base |
| 25 | 159,967.87 | 103,853.13 | 875.1355 | 0.226m | Back_Curb |
| 26 | 159,966.07 | 103,850.01 | 875.1395 | 3.826m | ETW |
| 27 | 159,966.07 | 103,850.01 | 874.9645 | 3.826m | ETW_Base |
| 28 | 159,966.07 | 103,850.01 | 875.0645 | 3.826m | ETW_Pave2 |
| 29 | 159,966.07 | 103,850.01 | 875.0895 | 3.826m | ETW_Pave1 |
| 30 | 159,966.07 | 103,850.01 | 874.6645 | 3.826m | ETW_Sub |
| 31 | 159,965.87 | 103,849.66 | 875.1315 | 4.226m | Flowline_Gutter |
| 32 | 159,965.85 | 103,849.62 | 875.2815 | 4.276m | Top_Curb |
| 33 | 159,965.77 | 103,849.49 | 875.2815 | 4.426m | Back_Curb |
| 34 | 159,963.89 | 103,846.24 | 874.6549 | 8.185m | Daylight |

CHAINAGE 0+325.00

CHAINAGE 0+350.00

CHAINAGE 0+375.00

CHAINAGE 0+400.00

| POINT | X | Y | Z | OFFSET | STRING CUT |
|---|---|---|---|---|---|
| 1 | 160,051.15 | 103,796.76 | 872.7444 | -6.307m | Daylight |
| 2 | 160,049.81 | 103,795.44 | 873.0581 | -4.425m | Back_Curb |
| 3 | 160,049.70 | 103,795.34 | 873.0581 | -4.275m | Top_Curb |
| 4 | 160,049.66 | 103,795.30 | 872.9081 | -4.225m | Flowline_Gutter |
| 5 | 160,049.38 | 103,795.02 | 872.9161 | -3.825m | ETW |
| 6 | 160,049.38 | 103,795.02 | 872.8411 | -3.825m | ETW_Pave2 |
| 7 | 160,049.38 | 103,795.02 | 872.4411 | -3.825m | ETW_Sub |
| 8 | 160,049.38 | 103,795.02 | 872.8661 | -3.825m | ETW_Pave1 |
| 9 | 160,049.38 | 103,795.02 | 872.7411 | -3.825m | ETW_Base |
| 10 | 160,046.81 | 103,792.50 | 872.8621 | -0.225m | Crown |
| 11 | 160,046.81 | 103,792.50 | 872.8121 | -0.225m | Crown_Pave1 |
| 12 | 160,046.81 | 103,792.50 | 872.9121 | -0.225m | Back_Curb |
| 13 | 160,046.81 | 103,792.50 | 872.7871 | -0.225m | Crown_Pave2 |
| 14 | 160,046.81 | 103,792.50 | 872.6871 | -0.225m | Crown_Base |
| 15 | 160,046.81 | 103,792.50 | 872.3871 | -0.225m | Crown_Sub |
| 16 | 160,046.65 | 103,792.34 | 872.4621 | -0.000m | Bottom_Curb |
| 17 | 160,046.65 | 103,792.34 | 872.9121 | -0.000m | Top_Curb |
| 18 | 160,046.64 | 103,792.34 | 872.9121 | 0.001m | Top_Curb |
| 19 | 160,046.64 | 103,792.34 | 872.4621 | 0.001m | Bottom_Curb |
| 20 | 160,046.48 | 103,792.19 | 872.8121 | 0.226m | Crown_Pave1 |
| 21 | 160,046.48 | 103,792.19 | 872.7871 | 0.226m | Crown_Pave2 |
| 22 | 160,046.48 | 103,792.19 | 872.3871 | 0.226m | Crown_Sub |
| 23 | 160,046.48 | 103,792.19 | 872.8621 | 0.226m | Crown |
| 24 | 160,046.48 | 103,792.19 | 872.6871 | 0.226m | Crown_Base |
| 25 | 160,046.48 | 103,792.19 | 872.9121 | 0.226m | Back_Curb |
| 26 | 160,043.91 | 103,789.67 | 872.9161 | 3.826m | ETW |
| 27 | 160,043.91 | 103,789.67 | 872.7411 | 3.826m | ETW_Base |
| 28 | 160,043.91 | 103,789.67 | 872.8411 | 3.826m | ETW_Pave2 |
| 29 | 160,043.91 | 103,789.67 | 872.8661 | 3.826m | ETW_Pave1 |
| 30 | 160,043.91 | 103,789.67 | 872.4411 | 3.826m | ETW_Sub |
| 31 | 160,043.63 | 103,789.39 | 872.9081 | 4.226m | Flowline_Gutter |
| 32 | 160,043.59 | 103,789.35 | 873.0581 | 4.276m | Top_Curb |
| 33 | 160,043.48 | 103,789.25 | 873.0581 | 4.426m | Back_Curb |
| 34 | 160,041.22 | 103,787.03 | 872.5288 | 7.601m | Daylight |

CHAINAGE 0+425.00

CHAINAGE 0+450.00

CHAINAGE 0+475.00

CHAINAGE 0+500.00

| POINT | X | Y | Z | OFFSET | STRING CUT |
|---|---|---|---|---|---|
| 1 | 160,111.53 | 103,715.97 | 870.9584 | -5.876m | Daylight |
| 2 | 160,110.36 | 103,715.13 | 871.2003 | -4.425m | Back_Curb |
| 3 | 160,110.23 | 103,715.04 | 871.2003 | -4.275m | Top_Curb |
| 4 | 160,110.19 | 103,715.01 | 871.0503 | -4.225m | Flowline_Gutter |
| 5 | 160,109.87 | 103,714.78 | 871.0583 | -3.825m | ETW |
| 6 | 160,109.87 | 103,714.78 | 870.9833 | -3.825m | ETW_Pave2 |
| 7 | 160,109.87 | 103,714.78 | 870.5833 | -3.825m | ETW_Sub |
| 8 | 160,109.87 | 103,714.78 | 871.0083 | -3.825m | ETW_Pave1 |
| 9 | 160,109.87 | 103,714.78 | 870.8833 | -3.825m | ETW_Base |
| 10 | 160,106.95 | 103,712.67 | 871.0043 | -0.225m | Crown |
| 11 | 160,106.95 | 103,712.67 | 870.9543 | -0.225m | Crown_Pave1 |
| 12 | 160,106.95 | 103,712.67 | 871.0543 | -0.225m | Back_Curb |
| 13 | 160,106.95 | 103,712.67 | 870.9293 | -0.225m | Crown_Pave2 |
| 14 | 160,106.95 | 103,712.67 | 870.8293 | -0.225m | Crown_Base |
| 15 | 160,106.95 | 103,712.67 | 870.5293 | -0.225m | Crown_Sub |
| 16 | 160,106.77 | 103,712.54 | 870.6043 | -0.000m | Bottom_Curb |
| 17 | 160,106.76 | 103,712.54 | 871.0543 | -0.000m | Top_Curb |
| 18 | 160,106.76 | 103,712.54 | 871.0543 | 0.001m | Top_Curb |
| 19 | 160,106.76 | 103,712.54 | 870.6043 | 0.001m | Bottom_Curb |
| 20 | 160,106.58 | 103,712.41 | 870.9543 | 0.226m | Crown_Pave1 |
| 21 | 160,106.58 | 103,712.41 | 870.9293 | 0.226m | Crown_Pave2 |
| 22 | 160,106.58 | 103,712.41 | 870.5293 | 0.226m | Crown_Sub |
| 23 | 160,106.58 | 103,712.41 | 871.0043 | 0.226m | Crown |
| 24 | 160,106.58 | 103,712.41 | 870.8293 | 0.226m | Crown_Base |
| 25 | 160,106.58 | 103,712.41 | 871.0543 | 0.226m | Back_Curb |
| 26 | 160,103.66 | 103,710.30 | 871.0583 | 3.826m | ETW |
| 27 | 160,103.66 | 103,710.30 | 870.8833 | 3.826m | ETW_Base |
| 28 | 160,103.66 | 103,710.30 | 870.9833 | 3.826m | ETW_Pave2 |
| 29 | 160,103.66 | 103,710.30 | 871.0083 | 3.826m | ETW_Pave1 |
| 30 | 160,103.66 | 103,710.30 | 870.5833 | 3.826m | ETW_Sub |
| 31 | 160,103.34 | 103,710.07 | 871.0503 | 4.226m | Flowline_Gutter |
| 32 | 160,103.30 | 103,710.04 | 871.2003 | 4.276m | Top_Curb |
| 33 | 160,103.17 | 103,709.95 | 871.2003 | 4.426m | Back_Curb |
| 34 | 160,102.67 | 103,709.59 | 871.0959 | 5.052m | Daylight |

| # | " | ' | Ang.deg | Ang.deg2 | Des | Ang.rad | AZ.rad | E=E+DsinAz | N=N+DcosAz |
|---|---|---|---|---|---|---|---|---|---|
| st2000 | | | | | | | 3.147912200 | **159708.277** | **103932.513** |
| bs | | | | | | | **Az=180 21 43.5"** | | |
| st1000 | | | | | | | | **159707.643** | **103832.192** |
| 1 | 5 | 38 | 1 | 1.6347222 | 45.635 | 0.0285 | 3.176443485 | 159706.6869 | 103886.906 |
| 2 | 20 | 18 | 355 | 355.30556 | 42.59 | 6.2013 | 9.349163995 | 159711.4943 | 103890.045 |
| 3 | 33 | 30 | 348 | 348.50917 | 43.013 | 6.0826 | 9.230544632 | 159716.5791 | 103890.309 |
| 4 | 34 | 32 | 9 | 9.5427778 | 15.434 | 0.1666 | 3.314465092 | 159705.6222 | 103917.309 |
| 5 | 46 | 55 | 349 | 349.92944 | 15.567 | 6.1074 | 9.255333155 | 159710.9021 | 103917.169 |
| 6 | 29 | 51 | 334 | 334.85806 | 18.021 | 5.8444 | 8.992287796 | 159715.8302 | 103916.151 |
| 7 | 49 | 36 | 329 | 329.61361 | 15.974 | 5.7528 | 8.900754973 | 159716.2699 | 103918.682 |
| 8 | 17 | 11 | 323 | 323.18806 | 14.93 | 5.6407 | 8.788607873 | 159717.1472 | 103920.504 |
| 9 | 34 | 45 | 315 | 315.75944 | 14.238 | 5.511 | 8.658954150 | 159718.1458 | 103922.25 |
| 10 | 4 | 35 | 307 | 307.58444 | 13.901 | 5.3684 | 8.516273483 | 159719.2391 | 103923.965 |
| 11 | 0 | 20 | 299 | 299.33333 | 14.052 | 5.2244 | 8.372264428 | 159720.4836 | 103925.552 |
| 12 | 58 | 35 | 291 | 291.59944 | 14.708 | 5.0894 | 8.237282603 | 159721.9177 | 103927.012 |
| 13 | 36 | 42 | 285 | 285.71 | 15.967 | 4.9866 | 8.134492406 | 159723.6199 | 103928.093 |
| 14 | 14 | 9 | 282 | 282.15389 | 17.715 | 4.9245 | 8.072426558 | 159725.571 | 103928.674 |
| 15 | 32 | 36 | 279 | 279.60889 | 19.598 | 4.8801 | 8.028007929 | 159727.579 | 103929.12 |
| 16 | 11 | 52 | 277 | 277.86972 | 22.579 | 4.8497 | 7.997653744 | 159730.6234 | 103929.28 |
| 17 | 59 | 36 | 268 | 268.61639 | 23.457 | 4.6882 | 7.836152611 | 159731.7303 | 103932.931 |
| 18 | 20 | 7 | 258 | 258.12222 | 25.9 | 4.5051 | 7.652994850 | 159733.6556 | 103937.684 |
| 19 | 42 | 56 | 251 | 251.945 | 24.317 | 4.3973 | 7.545181984 | 159731.4438 | 103939.903 |
| 20 | 57 | 41 | 254 | 254.69917 | 23.524 | 4.4453 | 7.593251260 | 159731.0059 | 103938.577 |
| 21 | 35 | 31 | 239 | 239.52639 | 23.313 | 4.1805 | 7.328436332 | 159728.4439 | 103944.209 |
| 22 | 17 | 7 | 231 | 231.12139 | 24.664 | 4.0338 | 7.181741408 | 159727.5748 | 103947.872 |
| 23 | 56 | 24 | 224 | 224.41556 | 27.206 | 3.9168 | 7.064702537 | 159727.4397 | 103951.825 |
| 24 | 32 | 14 | 217 | 217.24222 | 34.006 | 3.7916 | 6.939504252 | 159729.0276 | 103959.454 |
| 25 | 54 | 6 | 208 | 208.115 | 31.515 | 3.6323 | 6.780204173 | 159723.3036 | 103960.215 |
| 26 | 48 | 44 | 198 | 198.74667 | 30.664 | 3.4688 | 6.616695911 | 159718.3152 | 103961.487 |
| 27 | 7 | 3 | 198 | 198.05194 | 25.998 | 3.4567 | 6.604570721 | 159716.4893 | 103957.18 |
| 28 | 27 | 15 | 197 | 197.2575 | 23.431 | 3.4428 | 6.590705049 | 159715.3695 | 103954.845 |
| 29 | 58 | 52 | 194 | 194.88278 | 20.428 | 3.4013 | 6.549258328 | 159713.6484 | 103952.222 |
| 30 | 12 | 26 | 191 | 191.43667 | 18.463 | 3.3412 | 6.489112342 | 159712.0522 | 103950.586 |
| 31 | 54 | 55 | 185 | 185.93167 | 16.6 | 3.2451 | 6.393031967 | 159710.0968 | 103949.013 |
| 32 | 23 | 14 | 187 | 187.23972 | 15.202 | 3.2679 | 6.415861843 | 159710.288 | 103947.581 |
| 33 | 25 | 30 | 170 | 170.50694 | 14.769 | 2.9759 | 6.123819778 | 159705.9333 | 103947.095 |
| 34 | 58 | 39 | 160 | 160.66611 | 15.006 | 2.8042 | 5.952064835 | 159703.3985 | 103946.704 |
| 35 | 39 | 19 | 153 | 153.3275 | 15.733 | 2.6761 | 5.823981909 | 159701.3036 | 103946.616 |
| 36 | 15 | 23 | 144 | 144.3875 | 18.093 | 2.52 | 5.667949474 | 159697.8346 | 103947.288 |
| 37 | 42 | 6 | 136 | 136.11167 | 25.562 | 2.3756 | 5.523508934 | 159690.6728 | 103951.047 |
| 38 | 45 | 8 | 103 | 103.14583 | 26.245 | 1.8002 | 4.948146601 | 159682.758 | 103938.643 |
| 39 | 15 | 11 | 66 | 66.1875 | 9.642 | 1.1552 | 4.303101999 | 159699.4314 | 103928.676 |
| 40 | 25 | 47 | 49 | 49.790278 | 8.832 | 0.869 | 4.016916483 | 159701.4962 | 103926.854 |
| 41 | 55 | 41 | 30 | 30.698611 | 9.373 | 0.5358 | 3.683704040 | 159703.441 | 103924.484 |
| 42 | 12 | 44 | 17 | 17.736667 | 11.31 | 0.3096 | 3.457475432 | 159704.7635 | 103921.763 |
| 43 | 37 | 55 | 9 | 9.9269444 | 14.925 | 0.1733 | 3.321170065 | 159705.6112 | 103917.828 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 44 | 57 | 3 | 346 | 346.06583 | 10.461 | 6.04 | 9.187900420 | 159710.7319 | 103922.344 |
| 45 | 40 | 58 | 338 | 338.97778 | 10.832 | 5.9163 | 9.064190513 | 159712.0988 | 103922.378 |
| 46 | 31 | 23 | 347 | 347.39194 | 12.876 | 6.0631 | 9.211045425 | 159711.0081 | 103919.93 |
| 47 | 8 | 56 | 213 | 213.93556 | 17.066 | 3.7339 | 6.881792032 | 159717.8936 | 103946.612 |
| 48 | 11 | 46 | 219 | 219.76972 | 17.863 | 3.8357 | 6.983617449 | 159719.7906 | 103946.17 |
| 49 | 38 | 42 | 213 | 213.71056 | 21.565 | 3.73 | 6.877865041 | 159720.3587 | 103950.376 |
| 50 | 20 | 0 | 125 | 125.00556 | 10.556 | 2.1818 | 5.329670728 | 159699.6691 | 103938.623 |
| 51 | 52 | 16 | 118 | 118.28111 | 10.384 | 2.0644 | 5.212307032 | 159699.1638 | 103937.491 |
| 52 | 30 | 20 | 118 | 118.34167 | 19.239 | 2.0655 | 5.213363926 | 159691.4022 | 103941.753 |
| 53 | 0 | 50 | 121 | 121.83333 | 19.508 | 2.1264 | 5.274305005 | 159691.7686 | 103942.907 |
| 54 | 25 | 59 | 117 | 117.99028 | 27.226 | 2.0593 | 5.207231033 | 159684.3169 | 103945.442 |
| 55 | 10 | 52 | 121 | 121.86944 | 26.761 | 2.127 | 5.274935263 | 159685.6399 | 103946.786 |
| 56 | 18 | 16 | 158 | 158.27167 | 3.921 | 2.7624 | 5.910273896 | 159706.8485 | 103936.165 |
| 57 | 40 | 59 | 132 | 132.99444 | 2.229 | 2.3212 | 5.469103142 | 159706.6563 | 103934.043 |
| 58 | 55 | 6 | 63 | 63.115278 | 0.966 | 1.1016 | 4.249481606 | 159707.4127 | 103932.082 |
| 59 | 9 | 39 | 342 | 342.6525 | 2.069 | 5.9804 | 9.128326515 | 159708.8814 | 103930.534 |
| 60 | 5 | 1 | 318 | 318.01806 | 3.81 | 5.5505 | 8.698374350 | 159710.8075 | 103929.665 |
| 61 | 49 | 6 | 301 | 301.11361 | 5.417 | 5.2554 | 8.403336136 | 159712.897 | 103929.685 |
| 62 | 43 | 6 | 287 | 287.11194 | 6.846 | 5.011 | 8.158960952 | 159714.8071 | 103930.457 |
| 63 | 16 | 20 | 237 | 237.33778 | 8.006 | 4.1423 | 7.290237862 | 159715.0442 | 103936.791 |
| 64 | 31 | 18 | 260 | 260.30861 | 8.899 | 4.5432 | 7.691154535 | 159717.0583 | 103933.956 |
| 65 | 26 | 59 | 247 | 247.99056 | 9.416 | 4.3283 | 7.476163908 | 159717.0289 | 103935.986 |
| 66 | 34 | 37 | 227 | 227.62611 | 9.411 | 3.9728 | 7.120737302 | 159715.2694 | 103938.812 |
| 67 | 41 | 56 | 214 | 214.94472 | 8.946 | 3.7515 | 6.899405313 | 159713.4474 | 103939.814 |
| 68 | 58 | 59 | 201 | 201.99944 | 8.119 | 3.5256 | 6.673467593 | 159711.3659 | 103940.021 |
| 69 | 30 | 7 | 188 | 188.125 | 6.923 | 3.2834 | 6.431312855 | 159709.2987 | 103939.36 |
| 70 | 11 | 57 | 166 | 166.95306 | 4.798 | 2.9139 | 6.061792716 | 159707.2234 | 103937.194 |
| 71 | 14 | 52 | 344 | 344.87056 | 5.527 | 6.0191 | 9.167038888 | 159709.6858 | 103927.169 |
| 72 | 36 | 53 | 9 | 9.8933333 | 17.342 | 0.1727 | 3.320583441 | 159705.1895 | 103915.448 |
| 73 | 35 | 59 | 6 | 6.9930556 | 17.228 | 0.1221 | 3.269964044 | 159706.0715 | 103915.427 |
| 74 | 29 | 12 | 3 | 3.2080556 | 27.726 | 0.056 | 3.203903332 | 159706.5505 | 103904.841 |
| 75 | 6 | 49 | 337 | 337.81833 | 19.038 | 5.896 | 9.04395439 | 159715.3531 | 103914.839 |
| 76 | 20 | 22 | 279 | 279.37222 | 40.593 | 4.876 | 8.023877316 | 159748.2856 | 103925.65 |
| 77 | 33 | 1 | 274 | 274.02583 | 40.593 | 4.7827 | 7.930565227 | 159748.751 | 103929.407 |
| 78 | 17 | 12 | 268 | 268.20472 | 41.148 | 4.6811 | 7.828967672 | 159749.4121 | 103933.542 |
| 79 | 0 | 39 | 265 | 265.65 | 36.883 | 4.6365 | 7.784379358 | 159745.0707 | 103935.078 |
| 80 | 31 | 57 | 261 | 261.95861 | 33.293 | 4.572 | 7.719952468 | 159741.2714 | 103936.962 |
| 81 | 50 | 7 | 258 | 258.13056 | 27.318 | 4.5052 | 7.653140294 | 159735.0459 | 103937.963 |
| 82 | 37 | 43 | 271 | 271.72694 | 62.8 | 4.7425 | 7.890442047 | 159771.0353 | 103930.224 |
| 83 | 33 | 4 | 275 | 275.07583 | 61.807 | 4.801 | 7.948891184 | 159769.8058 | 103926.656 |
| 84 | 24 | 2 | 276 | 276.04 | 62.574 | 4.8178 | 7.965719067 | 159770.4608 | 103925.536 |
| 85 | 20 | 50 | 277 | 277.83889 | 62.849 | 4.8492 | 7.997115601 | 159770.4833 | 103923.548 |
| 86 | 19 | 32 | 278 | 278.53861 | 62.789 | 4.8614 | 8.009328058 | 159770.3099 | 103922.798 |
| 87 | 19 | 24 | 279 | 279.40528 | 62.305 | 4.8765 | 8.024454245 | 159769.6789 | 103921.943 |
| 88 | 57 | 50 | 279 | 279.84917 | 56.924 | 4.8843 | 8.032201567 | 159764.2994 | 103922.422 |
| 89 | 41 | 1 | 278 | 278.02806 | 80.097 | 4.8525 | 8.000417182 | 159787.5168 | 103920.826 |
| 90 | 15 | 41 | 275 | 275.6875 | 79.764 | 4.8117 | 7.959566782 | 159787.5968 | 103924.107 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 91 | 21 | 4 | 273 | 273.0725 | 80.178 | 4.766 | 7.913926422 | 159788.311 | 103927.71 |
| 92 | 37 | 4 | 272 | 272.07694 | 71.778 | 4.7486 | 7.896550699 | 159779.99 | 103929.458 |
| 93 | 12 | 2 | 274 | 274.03667 | 97.18 | 4.7828 | 7.930754305 | 159805.1707 | 103925.06 |
| 94 | 11 | 50 | 273 | 273.83639 | 97.111 | 4.7793 | 7.927258798 | 159805.1274 | 103925.403 |
| 95 | 0 | 3 | 276 | 276.05 | 96.713 | 4.818 | 7.9658936 | 159804.385 | 103921.712 |
| 96 | 55 | 16 | 278 | 278.28194 | 96.455 | 4.8569 | 8.004848379 | 159803.6364 | 103918.016 |
| 97 | 4 | 35 | 278 | 278.58444 | 112.88 | 4.8622 | 8.010128 | 159819.7837 | 103914.959 |
| 98 | 10 | 2 | 277 | 277.03611 | 112.96 | 4.8352 | 7.983104486 | 159820.2966 | 103917.968 |
| 99 | 16 | 43 | 274 | 274.72111 | 114.053 | 4.7948 | 7.942700114 | 159821.8814 | 103922.408 |
| 100 | 42 | 15 | 275 | 275.26167 | 127.627 | 4.8042 | 7.952134588 | 159835.2897 | 103920.006 |
| 101 | 25 | 10 | 277 | 277.17361 | 126.549 | 4.8376 | 7.985504314 | 159833.733 | 103915.917 |
| 102 | 0 | 1 | 279 | 279.01667 | 125.567 | 4.8698 | 8.017671701 | 159832.1655 | 103912.051 |
| 103 | 30 | 41 | 8 | 8.6916667 | 26.221 | 0.1517 | 4.993042288 | 159835.9596 | 103919.951 |
| 104 | 50 | 44 | 7 | 7.7472222 | 30.872 | 0.1352 | 4.976558623 | 159831.3537 | 103920.75 |
| 105 | 50 | 45 | 28 | 28.763889 | 20.346 | 0.502 | 5.343368654 | 159844.7263 | 103924.691 |
| 106 | 35 | 55 | 28 | 28.926389 | 20.431 | 0.5049 | 5.346204814 | 159844.6919 | 103924.788 |
| 107 | 50 | 49 | 24 | 24.830556 | 20.395 | 0.4334 | 5.274719037 | 159843.9002 | 103923.562 |
| 108 | 55 | 18 | 15 | 15.315278 | 21.532 | 0.2673 | 5.108646110 | 159841.2912 | 103920.999 |
| 109 | 55 | 38 | 15 | 15.648611 | 21.583 | 0.2731 | 5.114463874 | 159841.2929 | 103921.135 |
| 110 | 50 | 30 | 356 | 356.51389 | 24.331 | 6.2223 | 11.063685277 | 159836.8801 | 103914.345 |
| 111 | 40 | 19 | 349 | 349.32778 | 26.125 | 6.0969 | 10.938263978 | 159835.0726 | 103911.192 |
| 112 | 35 | 14 | 344 | 344.24306 | 21.646 | 6.0082 | 10.849518834 | 159839.7392 | 103909.538 |
| 113 | 40 | 59 | 339 | 339.99444 | 20.036 | 5.934 | 10.775366581 | 159841.6025 | 103908.312 |
| 114 | 30 | 23 | 334 | 334.39167 | 19.213 | 5.8362 | 10.677579662 | 159842.905 | 103906.681 |
| 115 | 35 | 38 | 329 | 329.64306 | 19.202 | 5.7534 | 10.594700763 | 159843.475 | 103905.196 |
| 116 | 30 | 5 | 339 | 339.09167 | 21.878 | 5.9183 | 10.759610136 | 159839.883 | 103907.574 |
| 117 | 45 | 6 | 328 | 328.1125 | 20.614 | 5.7266 | 10.567987529 | 159842.3966 | 103904.14 |
| 118 | 40 | 34 | 326 | 326.57778 | 19.502 | 5.6999 | 10.541201573 | 159843.6314 | 103904.129 |
| 119 | 20 | 59 | 321 | 321.98889 | 20.431 | 5.6198 | 10.461110353 | 159843.573 | 103902.281 |
| 120 | 45 | 53 | 318 | 318.89583 | 17.765 | 5.5658 | 10.407126350 | 159846.3777 | 103902.828 |
| 121 | 20 | 44 | 314 | 314.73889 | 16.754 | 5.4932 | 10.334573982 | 159847.9295 | 103902.403 |
| 122 | 5 | 54 | 307 | 307.90139 | 16.777 | 5.3739 | 10.215237095 | 159849.2317 | 103900.886 |
| 123 | 55 | 38 | 368 | 368.64861 | 15.022 | 6.4341 | 11.275476134 | 159846.7173 | 103916.839 |
| 124 | 20 | 2 | 309 | 309.03889 | 13.952 | 5.3937 | 10.235090215 | 159851.0464 | 103903.072 |
| 125 | 0 | 51 | 306 | 306.85 | 12.512 | 5.3555 | 10.196886897 | 159852.4257 | 103903.724 |
| 126 | 30 | 57 | 303 | 303.95833 | 11.447 | 5.3051 | 10.146417793 | 159853.5926 | 103904.095 |
| 127 | 0 | 1 | 8 | 8.0166667 | 10.513 | 0.1399 | 4.981261315 | 159851.0194 | 103915.481 |
| 128 | 30 | 14 | 13 | 13.241667 | 11.716 | 0.2311 | 5.072454769 | 159850.19 | 103916.817 |
| 129 | 35 | 19 | 16 | 16.326389 | 12.782 | 0.2849 | 5.126293328 | 159849.452 | 103917.829 |
| 130 | 10 | 53 | 3 | 3.8861111 | 8.092 | 0.0678 | 4.909169521 | 159853.2189 | 103914.271 |
| 131 | 30 | 37 | 327 | 327.625 | 8.733 | 5.7181 | 10.559479049 | 159853.239 | 103909 |
| 132 | 30 | 19 | 278 | 278.325 | 10.25 | 4.8577 | 9.699031728 | 159858.3787 | 103902.822 |
| 133 | 35 | 9 | 361 | 361.15972 | 11.034 | 6.3034 | 11.144770365 | 159850.2433 | 103914.329 |
| 134 | 45 | 52 | 269 | 269.87917 | 14.133 | 4.7103 | 9.551624128 | 159859.3668 | 103898.669 |
| 135 | 10 | 14 | 244 | 244.23611 | 13.51 | 4.2627 | 9.104068378 | 159865.4136 | 103899.867 |
| 136 | 0 | 35 | 249 | 249.58333 | 16.392 | 4.3561 | 9.197395012 | 159864.8499 | 103896.719 |
| 137 | 0 | 32 | 234 | 234.53333 | 16.247 | 4.0934 | 8.934722959 | 159868.8017 | 103898.354 |

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|---|---|---|---|---|---|---|---|---|---|
| 138 | 40 | 58 | 225 | 225.97778 | 13.907 | 3.9441 | 8.785400346 | 159869.453 | 103901.529 |
| 139 | 45 | 32 | 221 | 221.54583 | 23.795 | 3.8667 | 8.708048323 | 159876.7862 | 103894.748 |
| 140 | 25 | 59 | 222 | 222.99028 | 27.432 | 3.8919 | 8.733258634 | 159878.6483 | 103891.558 |
| 141 | 40 | 31 | 222 | 222.52778 | 26.091 | 3.8838 | 8.725186486 | 159877.9548 | 103892.726 |
| 142 | 30 | 9 | 226 | 226.15833 | 25.259 | 3.9472 | 8.788551634 | 159876.1627 | 103892.372 |
| 143 | 5 | 45 | 227 | 227.75139 | 26.242 | 3.975 | 8.816355699 | 159876.1539 | 103891.156 |
| 144 | 25 | 12 | 229 | 229.20694 | 23.119 | 4.0004 | 8.841759936 | 159873.8828 | 103893.389 |
| 145 | 10 | 57 | 218 | 218.95278 | 26.666 | 3.8214 | 8.662790966 | 159879.5638 | 103893.397 |
| 146 | 15 | 50 | 216 | 216.8375 | 29.507 | 3.7845 | 8.625872404 | 159882.2992 | 103892.108 |
| 147 | 55 | 2 | 209 | 209.04861 | 27.909 | 3.6486 | 8.489930648 | 159883.6077 | 103896.112 |
| 148 | 30 | 9 | 214 | 214.15833 | 20.45 | 3.7378 | 8.579112124 | 159876.4597 | 103899.125 |
| 149 | 10 | 31 | 214 | 214.51944 | 33.667 | 3.7441 | 8.585414702 | 159886.2103 | 103890.201 |
| 150 | 45 | 17 | 212 | 212.29583 | 40.621 | 3.7053 | 8.546605367 | 159892.4155 | 103886.75 |
| 151 | 5 | 16 | 211 | 211.26806 | 43.679 | 3.6873 | 8.528667261 | 159895.2638 | 103885.404 |
| 152 | 50 | 34 | 210 | 210.58056 | 47.773 | 3.6753 | 8.516668122 | 159898.8162 | 103883.297 |
| 153 | 35 | 51 | 209 | 209.85972 | 52.39 | 3.6627 | 8.504087207 | 159902.8582 | 103880.978 |
| 154 | 5 | 33 | 209 | 209.55139 | 53.82 | 3.6574 | 8.498705775 | 159904.1712 | 103880.344 |
| 155 | 45 | 44 | 209 | 209.74583 | 56.009 | 3.6608 | 8.502099471 | 159905.8063 | 103878.877 |
| 156 | 50 | 43 | 209 | 209.73056 | 56.58 | 3.6605 | 8.501832823 | 159906.2706 | 103878.544 |
| 157 | 50 | 25 | 208 | 208.43056 | 61.236 | 3.6378 | 8.479143543 | 159910.809 | 103876.852 |
| 158 | 50 | 34 | 205 | 205.58056 | 61.146 | 3.5881 | 8.429401660 | 159912.454 | 103879.414 |
| 159 | 50 | 8 | 204 | 204.14722 | 58.769 | 3.563 | 8.404385274 | 159911.2443 | 103881.951 |
| 160 | 0 | 36 | 204 | 204.6 | 50.681 | 3.5709 | 8.412287737 | 159904.14 | 103885.84 |
| 161 | 5 | 16 | 208 | 208.26806 | 61.21 | 3.635 | 8.476307383 | 159910.8894 | 103877.008 |
| 162 | 15 | 34 | 206 | 206.57083 | 67.915 | 3.6053 | 8.446685267 | 159917.4857 | 103874.751 |
| 163 | 0 | 55 | 205 | 205.91667 | 71.396 | 3.5939 | 8.435267905 | 159920.8244 | 103873.485 |
| 164 | 25 | 23 | 207 | 207.39028 | 69.447 | 3.6196 | 8.460987271 | 159918.1957 | 103873.075 |
| 165 | 15 | 39 | 206 | 206.65417 | 73.003 | 3.6068 | 8.448139708 | 159921.6465 | 103871.821 |
| 166 | 35 | 35 | 205 | 205.59306 | 73.502 | 3.5883 | 8.429619826 | 159922.8115 | 103872.676 |
| 167 | 30 | 11 | 205 | 205.19167 | 76.225 | 3.5813 | 8.422614268 | 159925.3848 | 103871.643 |
| 168 | 55 | 30 | 205 | 205.51528 | 81.003 | 3.5869 | 8.428262347 | 159929.1635 | 103868.685 |
| 169 | 35 | 32 | 204 | 204.54306 | 80.75 | 3.5699 | 8.411293869 | 159929.6856 | 103869.979 |
| 170 | 50 | 11 | 204 | 204.19722 | 84.006 | 3.5639 | 8.405257938 | 159932.7158 | 103868.688 |
| 171 | 0 | 1 | 205 | 205.01667 | 84.315 | 3.5782 | 8.419559942 | 159932.3401 | 103867.504 |
| 172 | 15 | 3 | 204 | 204.05417 | 85.475 | 3.5614 | 8.402761148 | 159934.0787 | 103868.101 |
| 173 | 50 | 42 | 203 | 203.71389 | 89.518 | 3.5555 | 8.396822180 | 159937.804 | 103866.446 |
| 174 | 30 | 59 | 201 | 201.99167 | 87.341 | 3.5254 | 8.366763732 | 159937.2622 | 103869.839 |
| 175 | 20 | 38 | 202 | 202.63889 | 77.181 | 3.5367 | 8.378059891 | 159927.9769 | 103874.066 |
| 176 | 5 | 26 | 203 | 203.43472 | 93.994 | 3.5506 | 8.391949803 | 159941.8722 | 103864.527 |
| 177 | 30 | 24 | 202 | 202.40833 | 98.156 | 3.5327 | 8.374035937 | 159946.3337 | 103863.912 |
| 178 | 45 | 14 | 203 | 203.24583 | 98.608 | 3.5473 | 8.388653070 | 159946.0006 | 103862.442 |
| 179 | 0 | 17 | 203 | 203.28333 | 104.528 | 3.548 | 8.389307568 | 159951.0595 | 103859.367 |
| 180 | 35 | 38 | 201 | 201.64306 | 103.035 | 3.5193 | 8.360679320 | 159951.2435 | 103862.686 |
| 181 | 25 | 24 | 203 | 203.40694 | 107.257 | 3.5501 | 8.391464989 | 159953.2884 | 103857.776 |
| 182 | 35 | 22 | 203 | 203.37639 | 111.227 | 3.5496 | 8.390931694 | 159956.729 | 103855.794 |
| 183 | 15 | 25 | 203 | 203.42083 | 113.903 | 3.5504 | 8.391707396 | 159958.9832 | 103854.349 |
| 184 | 40 | 27 | 203 | 203.46111 | 115 | 3.5511 | 8.392410376 | 159959.884 | 103853.718 |

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|---|---|---|---|---|---|---|---|---|---|
| 185 | 10 | 54 | 201 | 201.90278 | 118.213 | 3.5239 | 8.365212328 | 159964.2533 | 103854.853 |
| 186 | 50 | 31 | 201 | 201.53056 | 109.582 | 3.5174 | 8.358715825 | 159957.0722 | 103859.698 |
| 187 | 32 | 15 | 359 | 359.25889 | 126.419 | 6.2703 | 11.8438809 | 160002.9409 | 103836.606 |
| 188 | 20 | 49 | 358 | 358.82222 | 125.93 | 6.2626 | 11.83625963 | 160002.5467 | 103835.602 |
| 189 | 29 | 23 | 358 | 358.39139 | 125.917 | 6.2551 | 11.82874017 | 160001.8523 | 103834.958 |
| 190 | 10 | 9 | 358 | 358.15278 | 125.185 | 6.2509 | 11.82457562 | 160001.9595 | 103834.065 |
| 191 | 37 | 17 | 354 | 354.29361 | 124.866 | 6.1836 | 11.75722046 | 159996.1704 | 103827.943 |
| 192 | 53 | 16 | 354 | 354.28139 | 124.899 | 6.1834 | 11.75700714 | 159996.1281 | 103827.947 |
| 193 | 18 | 54 | 358 | 358.905 | 118.197 | 6.2641 | 11.83770438 | 160007.8316 | 103829.954 |
| 194 | 12 | 19 | 354 | 354.32 | 113.175 | 6.1841 | 11.75768103 | 160004.6671 | 103819.913 |
| 195 | 41 | 34 | 353 | 353.57806 | 112.786 | 6.1711 | 11.74473166 | 160003.947 | 103818.581 |
| 196 | 48 | 0 | 355 | 355.01333 | 109.037 | 6.1962 | 11.76978198 | 160008.5772 | 103818.005 |
| 197 | 18 | 39 | 356 | 356.655 | 108.497 | 6.2248 | 11.79843447 | 160011.1683 | 103819.818 |
| 198 | 49 | 44 | 0 | 0.7469444 | 101.5 | 0.013 | 5.586667066 | 160021.4186 | 103819.63 |
| 199 | 32 | 41 | 359 | 359.69222 | 100.949 | 6.2778 | 11.851444 | 160020.3577 | 103818.002 |
| 200 | 46 | 17 | 357 | 357.29611 | 100.051 | 6.236 | 11.80962397 | 160017.845 | 103814.516 |
| 201 | 31 | 53 | 354 | 354.89194 | 99.916 | 6.194 | 11.76766335 | 160014.9507 | 103811.476 |
| 202 | 51 | 51 | 354 | 354.86417 | 99.885 | 6.1935 | 11.76717853 | 160014.9391 | 103811.42 |
| 203 | 34 | 22 | 353 | 353.37611 | 99.118 | 6.1676 | 11.74120706 | 160013.7181 | 103809.017 |
| 204 | 33 | 8 | 359 | 359.1425 | 96.816 | 6.2682 | 11.84184953 | 160022.3686 | 103814.269 |
| 205 | 46 | 0 | 1 | 1.0127778 | 96.736 | 0.0177 | 5.591306733 | 160024.8199 | 103816.263 |
| 206 | 0 | 57 | 355 | 355.95 | 87.038 | 6.2125 | 11.7861299 | 160025.3091 | 103803.633 |
| 207 | 25 | 28 | 0 | 0.4736111 | 83.832 | 0.0083 | 5.581896499 | 160032.4474 | 103805.82 |
| 208 | 27 | 14 | 1 | 1.2408333 | 76.45 | 0.0217 | 5.595287053 | 160037.9968 | 103800.835 |
| 209 | 4 | 44 | 2 | 2.7344444 | 72.879 | 0.0477 | 5.621355485 | 160041.7474 | 103799.263 |
| 210 | 30 | 26 | 1 | 1.4416667 | 72.426 | 0.0252 | 5.598792256 | 160040.7481 | 103797.887 |
| 211 | 8 | 31 | 358 | 358.51889 | 71.685 | 6.2573 | 11.83096547 | 160038.4434 | 103794.93 |
| 212 | 22 | 49 | 354 | 354.82278 | 73.464 | 6.1928 | 11.76645616 | 160033.8405 | 103792.959 |
| 213 | 15 | 58 | 354 | 354.97083 | 74.982 | 6.1954 | 11.76904022 | 160032.8869 | 103794.155 |
| 214 | 0 | 58 | 354 | 354.96667 | 73.211 | 6.1953 | 11.76896749 | 160034.1503 | 103792.914 |
| 215 | 26 | 1 | 353 | 353.02389 | 71.812 | 6.1614 | 11.73505963 | 160033.4802 | 103790.166 |
| 216 | 26 | 1 | 353 | 353.02389 | 71.882 | 6.1614 | 11.73505963 | 160033.4285 | 103790.213 |
| 217 | 30 | 29 | 353 | 353.49167 | 69.239 | 6.1696 | 11.74322389 | 160035.7638 | 103788.848 |
| 218 | 28 | 12 | 353 | 353.20778 | 67.386 | 6.1646 | 11.73826909 | 160036.8962 | 103787.343 |
| 219 | 11 | 1 | 353 | 353.01972 | 66.91 | 6.1614 | 11.7349869 | 160037.0986 | 103786.859 |
| 220 | 31 | 3 | 353 | 353.05861 | 66.841 | 6.162 | 11.73566564 | 160037.1801 | 103786.846 |
| 221 | 13 | 45 | 354 | 354.75361 | 66.091 | 6.1916 | 11.76524897 | 160039.0736 | 103787.764 |
| 221 | 14 | 41 | 354 | 354.68722 | 66.066 | 6.1905 | 11.76409027 | 160039.0383 | 103787.692 |
| 221 | 52 | 27 | 354 | 354.46444 | 68.842 | 6.1866 | 11.76020206 | 160036.8569 | 103789.429 |
| 221 | 0 | 32 | 0 | 0.5333333 | 67.874 | 0.0093 | 5.582938849 | 160042.7976 | 103793.674 |
| 221 | 49 | 11 | 3 | 3.1969444 | 67.957 | 0.0558 | 5.629427633 | 160045.2064 | 103795.716 |
| 221 | 6 | 32 | 354 | 354.535 | 68.812 | 6.1878 | 11.76143349 | 160036.9372 | 103789.469 |
| 221 | 0 | 38 | 351 | 351.63333 | 54.534 | 6.1372 | 11.71078985 | 160045.3655 | 103777.534 |
| 221 | 4 | 4 | 354 | 354.06778 | 53.739 | 6.1796 | 11.75327892 | 160047.4992 | 103778.704 |
| 221 | 25 | 8 | 354 | 354.14028 | 53.786 | 6.1809 | 11.75454429 | 160047.5118 | 103778.786 |
| 221 | 41 | 14 | 358 | 358.24472 | 53.731 | 6.2525 | 11.82618036 | 160050.2983 | 103781.443 |
| 221 | 35 | 22 | 2 | 2.3763889 | 53.689 | 0.0415 | 5.615106236 | 160053.2768 | 103783.918 |

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|---|---|---|---|---|---|---|---|---|---|
| 221 | 14 | 29 | 2 | 2.4872222 | 53.719 | 0.0434 | 5.617040643 | 160053.3398 | 103784.006 |
| 221 | 13 | 20 | 4 | 4.3369444 | 52.173 | 0.0757 | 5.649324386 | 160055.636 | 103783.81 |
| 235 | 19 | 19 | 5 | 5.3219444 | 44.579 | 0.0929 | 5.666515879 | 160060.755 | 103778.139 |
| 236 | 8 | 27 | 5 | 5.4522222 | 41.024 | 0.0952 | 5.668789655 | 160062.8871 | 103775.293 |
| 237 | 21 | 8 | 3 | 3.1391667 | 40.602 | 0.0548 | 5.62841922 | 160061.8104 | 103773.977 |
| 238 | 38 | 22 | 1 | 1.3772222 | 41.135 | 0.024 | 5.597667488 | 160060.4945 | 103773.614 |
| 239 | 43 | 21 | 358 | 358.36194 | 41.056 | 6.2546 | 11.82822627 | 160058.9087 | 103772.141 |
| 240 | 50 | 8 | 353 | 353.14722 | 41.412 | 6.1636 | 11.7372122 | 160056.0003 | 103769.745 |
| 241 | 31 | 3 | 353 | 353.05861 | 41.445 | 6.162 | 11.73566564 | 160055.9327 | 103769.72 |
| 242 | 54 | 41 | 359 | 359.69833 | 42.14 | 6.2779 | 11.85155066 | 160058.914 | 103773.596 |
| 243 | 11 | 4 | 351 | 351.06972 | 45.942 | 6.1273 | 11.70095298 | 160051.5573 | 103771.557 |
| 244 | 29 | 49 | 3 | 3.8247222 | 35.647 | 0.0668 | 5.640384422 | 160065.1678 | 103770.304 |
| 245 | 44 | 41 | 354 | 354.69556 | 30.473 | 6.1906 | 11.76423571 | 160064.6307 | 103762.956 |
| 246 | 43 | 50 | 350 | 350.84528 | 28.467 | 6.1234 | 11.69703569 | 160064.7901 | 103760.142 |
| 247 | 13 | 58 | 350 | 350.97028 | 28.717 | 6.1256 | 11.69921735 | 160064.6396 | 103760.351 |
| 248 | 52 | 59 | 1 | 1.9977778 | 27.624 | 0.0349 | 5.608498226 | 160069.2806 | 103763.343 |
| 249 | 1 | 55 | 1 | 1.9169444 | 27.316 | 0.0335 | 5.607087418 | 160069.4429 | 103763.079 |
| 250 | 28 | 13 | 3 | 3.2244444 | 27.479 | 0.0563 | 5.629907598 | 160069.8345 | 103763.592 |
| 251 | 4 | 20 | 3 | 3.3344444 | 27.486 | 0.0582 | 5.63182746 | 160069.8722 | 103763.63 |
| 252 | 37 | 46 | 5 | 5.7769444 | 27.284 | 0.1008 | 5.674457127 | 160070.9343 | 103764.155 |
| 253 | 13 | 7 | 4 | 4.1202778 | 24.63 | 0.0719 | 5.645542839 | 160071.8737 | 103761.562 |
| 254 | 55 | 51 | 3 | 3.8652778 | 23.566 | 0.0675 | 5.64109225 | 160072.423 | 103760.644 |
| 255 | 28 | 28 | 4 | 4.4744444 | 16.954 | 0.0781 | 5.651724214 | 160076.5276 | 103755.456 |
| 256 | 33 | 13 | 6 | 6.2258333 | 15.949 | 0.1087 | 5.682291716 | 160077.5188 | 103754.927 |
| 257 | 55 | 57 | 1 | 1.9652778 | 13.704 | 0.0343 | 5.607930994 | 160077.9697 | 103752.468 |
| 258 | 22 | 4 | 10 | 10.072778 | 8.2 | 0.1758 | 5.749433563 | 160082.3641 | 103748.831 |
| 259 | 16 | 41 | 355 | 355.68778 | 8.452 | 6.2079 | 11.78155326 | 160080.563 | 103747.751 |
| 260 | 38 | 27 | 355 | 355.46056 | 8.497 | 6.204 | 11.77758748 | 160080.5074 | 103747.759 |
| 261 | 44 | 20 | 351 | 351.34556 | 8.567 | 6.1321 | 11.70576718 | 160080.0402 | 103747.357 |
| 262 | 19 | 17 | 333 | 333.28861 | 10.025 | 5.817 | 11.39061405 | 160077.2831 | 103745.63 |
| 263 | 12 | 32 | 317 | 317.53667 | 12.739 | 5.5421 | 11.11569076 | 160073.8888 | 103743.298 |
| 264 | 15 | 23 | 317 | 317.3875 | 12.761 | 5.5395 | 11.11308731 | 160073.863 | 103743.268 |
| 265 | 38 | 28 | 313 | 313.47722 | 14.636 | 5.4712 | 11.04484008 | 160071.9178 | 103742.492 |
| 266 | 38 | 44 | 322 | 322.74389 | 14.515 | 5.6329 | 11.20657393 | 160072.3429 | 103744.811 |
| 267 | 18 | 24 | 323 | 323.405 | 16.164 | 5.6445 | 11.21811249 | 160070.7706 | 103745.339 |
| 268 | 38 | 29 | 322 | 322.49389 | 16.627 | 5.6286 | 11.2022106 | 160070.2627 | 103745.183 |
| 269 | 32 | 55 | 339 | 339.92556 | 21.145 | 5.9328 | 11.50645058 | 160068.0909 | 103752.11 |
| 270 | 55 | 31 | 341 | 341.53194 | 22.338 | 5.9609 | 11.53448736 | 160067.364 | 103753.235 |
| 271 | 43 | 17 | 302 | 302.29528 | 12.192 | 5.276 | 10.84967834 | 160074.4735 | 103739.999 |
| 272 | 14 | 38 | 292 | 292.63722 | 10.092 | 5.1075 | 10.68111347 | 160076.9389 | 103738.65 |
| 273 | 58 | 39 | 287 | 287.66611 | 10.841 | 5.0207 | 10.59435121 | 160076.5559 | 103737.538 |
| 274 | 17 | 25 | 289 | 289.42139 | 10.275 | 5.0514 | 10.62498659 | 160076.9585 | 103738.05 |
| 275 | 27 | 40 | 282 | 282.67417 | 10.363 | 4.9336 | 10.50722534 | 160077.3843 | 103736.91 |
| 276 | 1 | 52 | 275 | 275.86694 | 11.227 | 4.8148 | 10.3884169 | 160077.3156 | 103735.366 |
| 277 | 54 | 27 | 273 | 273.465 | 12.416 | 4.7729 | 10.34649506 | 160076.6449 | 103734.267 |
| 278 | 55 | 21 | 275 | 275.36528 | 13.46 | 4.806 | 10.37966117 | 160075.5493 | 103733.996 |
| 279 | 7 | 4 | 281 | 281.06861 | 12.14 | 4.9056 | 10.47920311 | 160075.9789 | 103735.778 |

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|---|---|---|---|---|---|---|---|---|---|
| 280 | 19 | 47 | 289 | 289.78861 | 8.589 | 5.0578 | 10.63139582 | 160078.5103 | 103738.712 |
| 281 | 45 | 44 | 283 | 283.74583 | 6.519 | 4.9523 | 10.52592946 | 160080.7228 | 103738.821 |
| 282 | 25 | 32 | 304 | 304.54028 | 4.07 | 5.3152 | 10.88886098 | 160082.4892 | 103741.338 |
| 283 | 31 | 39 | 331 | 331.65861 | 3.201 | 5.7885 | 11.36216518 | 160083.5477 | 103742.919 |
| 284 | 25 | 18 | 328 | 328.30694 | 1.63 | 5.73 | 11.30366756 | 160084.9828 | 103742.266 |
| 285 | 35 | 53 | 345 | 345.89306 | 1.494 | 6.037 | 11.61060311 | 160085.3158 | 103742.634 |
| 286 | 16 | 14 | 78 | 78.237778 | 0.988 | 1.3655 | 6.939137248 | 160087.1386 | 103742.554 |
| 287 | 8 | 10 | 316 | 316.16889 | 2.122 | 5.5182 | 11.09181853 | 160084.4238 | 103741.975 |
| 288 | 15 | 1 | 287 | 287.02083 | 1.456 | 5.0095 | 10.58308899 | 160085.2021 | 103741.188 |
| 289 | 30 | 50 | 236 | 236.84167 | 1.153 | 4.1337 | 9.707297315 | 160086.2146 | 103740.664 |
| 290 | 44 | 29 | 200 | 200.49556 | 1.277 | 3.4993 | 9.072938006 | 160086.9761 | 103740.573 |
| 291 | 18 | 24 | 159 | 159.405 | 1.556 | 2.7821 | 8.35577252 | 160087.9002 | 103741.023 |
| 292 | 31 | 23 | 159 | 159.39194 | 1.498 | 2.7819 | 8.355544658 | 160087.8495 | 103741.051 |
| 293 | 1 | 47 | 122 | 122.78361 | 1.456 | 2.143 | 7.716608707 | 160087.9783 | 103741.971 |
| 294 | 34 | 34 | 118 | 118.57611 | 2.279 | 2.0695 | 7.643173979 | 160088.7645 | 103742.248 |
| 295 | 0 | 4 | 104 | 104.06667 | 4.102 | 1.8163 | 7.389936401 | 160090.2042 | 103743.607 |
| 296 | 6 | 37 | 118 | 118.61833 | 4.203 | 2.0703 | 7.643910896 | 160090.6466 | 103742.648 |
| 297 | 39 | 37 | 100 | 100.6275 | 6.088 | 1.7563 | 7.329911619 | 160091.8069 | 103744.818 |
| 298 | 57 | 29 | 103 | 103.49917 | 9.973 | 1.8064 | 7.380031657 | 160095.4097 | 103746.323 |
| 299 | 39 | 57 | 103 | 103.96083 | 9.989 | 1.8145 | 7.388089261 | 160095.4604 | 103746.259 |
| 300 | 40 | 52 | 119 | 119.87778 | 10.636 | 2.0923 | 7.665892348 | 160096.9844 | 103743.76 |
| 301 | 38 | 6 | 130 | 130.11056 | 11.907 | 2.2709 | 7.844488012 | 160098.4425 | 103741.885 |
| 302 | 59 | 16 | 130 | 130.28306 | 11.94 | 2.2739 | 7.847498705 | 160098.4757 | 103741.849 |
| 303 | 6 | 31 | 136 | 136.51833 | 11.592 | 2.3827 | 7.956324832 | 160098.0673 | 103740.587 |
| 304 | 37 | 59 | 138 | 138.99361 | 11.574 | 2.4259 | 7.999526579 | 160097.9876 | 103740.093 |
| 305 | 33 | 4 | 156 | 156.07583 | 7.64 | 2.724 | 8.2976676 | 160093.4363 | 103738.492 |
| 306 | 2 | 56 | 154 | 154.93389 | 5.621 | 2.7041 | 8.27773691 | 160091.6598 | 103739.46 |
| 307 | 43 | 53 | 168 | 168.89528 | 7.214 | 2.9478 | 8.521409114 | 160092.202 | 103737.306 |
| 308 | 40 | 15 | 173 | 173.26111 | 7.171 | 3.024 | 8.597607281 | 160091.814 | 103736.917 |
| 309 | 52 | 19 | 177 | 177.33111 | 7.403 | 3.095 | 8.668642181 | 160091.6153 | 103736.386 |
| 310 | 15 | 7 | 179 | 179.12083 | 8.272 | 3.1262 | 8.699878727 | 160092.0208 | 103735.579 |
| 311 | 19 | 40 | 173 | 173.67194 | 7.912 | 3.0311 | 8.604777675 | 160092.3208 | 103736.374 |
| 312 | 33 | 14 | 182 | 182.2425 | 6.558 | 3.1807 | 8.754362088 | 160090.6106 | 103736.633 |
| 313 | 6 | 39 | 122 | 122.65167 | 15.607 | 2.1407 | 7.714305842 | 160101.991 | 103743.944 |
| 314 | 6 | 50 | 118 | 118.835 | 16.823 | 2.0741 | 7.647692443 | 160103.0023 | 103745.217 |
| 315 | 33 | 56 | 118 | 118.9425 | 16.843 | 2.0759 | 7.649568672 | 160103.0283 | 103745.191 |
| 316 | 38 | 40 | 119 | 119.67722 | 20.885 | 2.0888 | 7.662391993 | 160107.0389 | 103745.748 |
| 317 | 42 | 52 | 119 | 119.87833 | 20.862 | 2.0923 | 7.665902044 | 160107.0301 | 103745.672 |
| 318 | 23 | 46 | 119 | 119.77306 | 25.723 | 2.0904 | 7.664064601 | 160111.7965 | 103746.627 |
| 319 | 44 | 34 | 118 | 118.57889 | 25.477 | 2.0696 | 7.64322246 | 160111.4493 | 103747.101 |
| 320 | 39 | 15 | 115 | 115.26083 | 25.831 | 2.0117 | 7.585311466 | 160111.4403 | 103748.628 |
| 321 | 41 | 6 | 107 | 107.11139 | 23.985 | 1.8694 | 7.443076828 | 160108.5245 | 103751.352 |
| 322 | 30 | 22 | 99 | 99.375 | 23.253 | 1.7344 | 7.30805137 | 160106.4091 | 103753.845 |
| 323 | 35 | 15 | 99 | 99.259722 | 23.265 | 1.7324 | 7.306039393 | 160106.395 | 103753.891 |
| 324 | 47 | 11 | 97 | 97.196389 | 22.773 | 1.6964 | 7.270027433 | 160105.5353 | 103754.327 |
| 325 | 38 | 12 | 96 | 96.210556 | 22.676 | 1.6792 | 7.252821396 | 160105.2364 | 103754.597 |
| 326 | 10 | 22 | 98 | 98.369444 | 21.855 | 1.7169 | 7.290501115 | 160105.0122 | 103753.445 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 374 | 0 | 21 | 159 | 159.35 | 38.865 | 2.7812 | 5.41294378 | 159991.149 | 103843.303 |
| 375 | 5 | 36 | 151 | 151.60139 | 37.963 | 2.6459 | 5.277705004 | 159988.804 | 103838.585 |
| 376 | 30 | 41 | 145 | 145.69167 | 38.326 | 2.5428 | 5.174560893 | 159986.5556 | 103835.338 |
| 377 | 35 | 50 | 150 | 150.84306 | 47.92 | 2.6327 | 5.26446959 | 159980.0599 | 103843.381 |
| 378 | 5 | 41 | 145 | 145.68472 | 56.459 | 2.5427 | 5.17443969 | 159970.322 | 103843.417 |
| 379 | 20 | 9 | 147 | 147.15556 | 54.416 | 2.5683 | 5.200110574 | 159972.7895 | 103843.749 |
| 380 | 20 | 18 | 148 | 148.30556 | 52.751 | 2.5884 | 5.22018186 | 159974.7658 | 103843.899 |
| 381 | 40 | 24 | 148 | 148.41111 | 52.732 | 2.5903 | 5.222024152 | 159974.8297 | 103843.975 |
| 382 | 40 | 40 | 152 | 152.67778 | 52.301 | 2.6647 | 5.296491534 | 159977.2308 | 103847.09 |
| 383 | 40 | 7 | 158 | 158.12778 | 50.654 | 2.7599 | 5.391611978 | 159981.4488 | 103850.069 |
| 384 | 15 | 23 | 149 | 149.3875 | 70.128 | 2.6073 | 5.239065353 | 159960.2363 | 103853.5 |
| 385 | 30 | 18 | 149 | 149.30833 | 68.983 | 2.6059 | 5.237683634 | 159961.1782 | 103852.842 |
| 386 | 55 | 23 | 148 | 148.39861 | 67.736 | 2.59 | 5.221805986 | 159961.7252 | 103851.282 |
| 387 | 55 | 1 | 147 | 147.03194 | 67.631 | 2.5662 | 5.197953153 | 159961.047 | 103849.813 |
| 388 | 30 | 50 | 145 | 145.84167 | 68.916 | 2.5454 | 5.177178887 | 159959.2556 | 103849.139 |
| 389 | 10 | 39 | 145 | 145.65278 | 66.018 | 2.5421 | 5.173882154 | 159961.7489 | 103847.646 |
| 390 | 25 | 45 | 146 | 146.75694 | 65.351 | 2.5614 | 5.193153498 | 159962.9178 | 103848.471 |
| 391 | 55 | 36 | 157 | 157.61528 | 66.088 | 2.7509 | 5.382667166 | 159969.0709 | 103859.303 |
| 392 | 35 | 26 | 157 | 157.44306 | 67.091 | 2.7479 | 5.379661321 | 159968.1599 | 103859.768 |
| 393 | 40 | 30 | 155 | 155.51111 | 67.87 | 2.7142 | 5.345942529 | 159966.1623 | 103858.429 |
| 394 | 15 | 0 | 153 | 153.00417 | 68.267 | 2.6704 | 5.302188095 | 159964.1272 | 103856.219 |
| 395 | 35 | 26 | 154 | 154.44306 | 87.664 | 2.6955 | 5.327301443 | 159949.2546 | 103868.821 |
| 396 | 0 | 29 | 154 | 154.48333 | 87.741 | 2.6962 | 5.328004423 | 159949.2274 | 103868.916 |
| 397 | 10 | 54 | 153 | 153.90278 | 96.337 | 2.6861 | 5.317871817 | 159941.6498 | 103873.08 |
| 398 | 5 | 9 | 155 | 155.15139 | 95.07 | 2.7079 | 5.339664192 | 159943.8892 | 103874.049 |
| 399 | 10 | 23 | 151 | 151.38611 | 95.92 | 2.6422 | 5.273947698 | 159939.6715 | 103869.327 |
| 400 | 30 | 46 | 150 | 150.775 | 87.577 | 2.6315 | 5.263281797 | 159946.2401 | 103864.091 |
| 401 | 40 | 25 | 154 | 154.42778 | 102.889 | 2.6953 | 5.327034796 | 159936.8027 | 103877.582 |
| 402 | 35 | 6 | 153 | 153.10972 | 102.767 | 2.6723 | 5.304030387 | 159935.5614 | 103875.565 |
| 403 | 25 | 48 | 153 | 153.80694 | 116.252 | 2.6844 | 5.31619921 | 159925.1646 | 103884.255 |
| 404 | 30 | 31 | 151 | 151.525 | 119.697 | 2.6446 | 5.276371766 | 159919.7008 | 103882.234 |
| 405 | 20 | 13 | 151 | 151.22222 | 123.615 | 2.6393 | 5.271087297 | 159916.0419 | 103883.775 |
| 406 | 5 | 11 | 151 | 151.18472 | 131.042 | 2.6387 | 5.270432798 | 159909.6987 | 103887.639 |
| 407 | 25 | 8 | 151 | 151.14028 | 133.121 | 2.6379 | 5.269657097 | 159907.8805 | 103888.653 |
| 408 | 15 | 38 | 146 | 146.6375 | 42.052 | 2.5593 | 5.191068799 | 159983.5352 | 103837.618 |
| 409 | 11 | 5 | 272 | 272.08639 | 14.199 | 4.7488 | 7.380564953 | 160033.498 | 103824.723 |
| 410 | 20 | 5 | 252 | 252.08889 | 13.363 | 4.3998 | 7.031542736 | 160029.9534 | 103828.041 |
| 411 | 50 | 32 | 152 | 152.54722 | 109.517 | 2.6625 | 5.29421291 | 159929.3634 | 103878.434 |
| 412 | 40 | 43 | 149 | 149.72778 | 103.407 | 2.6132 | 5.245004321 | 159931.7774 | 103870.758 |
| 413 | 15 | 6 | 205 | 205.10417 | 14.887 | 3.5797 | 5.682735806 | 159923.3283 | 103883.013 |
| 414 | 35 | 11 | 205 | 205.19306 | 17.7 | 3.5813 | 5.68428721 | 159921.7616 | 103885.349 |
| 415 | 5 | 9 | 202 | 202.15139 | 17.541 | 3.5282 | 5.631200112 | 159921.0964 | 103884.673 |
| 416 | 30 | 20 | 188 | 188.34167 | 28.202 | 3.2872 | 5.39017499 | 159909.7714 | 103888.414 |
| 417 | 30 | 35 | 182 | 182.59167 | 47.815 | 3.1868 | 5.289818558 | 159891.677 | 103896.831 |
| 418 | 45 | 27 | 180 | 180.4625 | 66.308 | 3.1497 | 5.252657589 | 159874.8759 | 103904.836 |
| 419 | 10 | 15 | 179 | 179.25278 | 81.289 | 3.1286 | 5.231543954 | 159861.1614 | 103911.061 |
| 420 | 5 | 56 | 203 | 203.93472 | 11.851 | 3.5593 | 5.66232515 | 159924.8456 | 103880.369 |

| " | ' | Ang. deg | الوصف | Ang.deg2 | Ang.rad | elevation station | ارتفاع الجهاز | ارتفاع العاكس | elevation |
|---|---|---|---|---|---|---|---|---|---|
| 54 | 58 | 90 | inlet بجانب رصيف | 90.9816667 | 1.5879296 | 883.172 | 1.57 | 1.65 | 882.31 |
| 3 | 53 | 90 | center منهل | 90.8841667 | 1.5862279 | 883.172 | 1.57 | 1.65 | 882.435 |
| 11 | 53 | 90 | inlet بجانب رصيف | 90.8863889 | 1.5862667 | 883.172 | 1.57 | 1.65 | 882.427 |
| 26 | 29 | 91 | رصيف | 91.4905556 | 1.5968114 | 883.172 | 1.57 | 1.65 | 882.69 |
| 59 | 53 | 91 | center line | 91.8997222 | 1.6039527 | 883.172 | 1.57 | 1.65 | 882.576 |
| 8 | 2 | 92 | رصيف | 92.0355556 | 1.6063235 | 883.172 | 1.57 | 1.65 | 882.451 |
| 21 | 37 | 92 | رصيف | 92.6225 | 1.6165676 | 883.172 | 1.57 | 1.65 | 882.36 |
| 28 | 51 | 92 | رصيف | 92.8577778 | 1.620674 | 883.172 | 1.57 | 1.65 | 882.347 |
| 14 | 10 | 93 | رصيف | 93.1705556 | 1.626133 | 883.172 | 1.57 | 1.65 | 882.303 |
| 56 | 33 | 93 | رصيف | 93.5655556 | 1.633027 | 883.172 | 1.57 | 1.65 | 882.226 |
| 13 | 44 | 93 | رصيف | 93.7369444 | 1.6360183 | 883.172 | 1.57 | 1.65 | 882.174 |
| 56 | 39 | 93 | رصيف | 93.6655556 | 1.6347723 | 883.172 | 1.57 | 1.65 | 882.15 |
| 24 | 28 | 93 | رصيف | 93.4733333 | 1.6314174 | 883.172 | 1.57 | 1.65 | 882.123 |
| 40 | 31 | 93 | رصيف | 93.5277778 | 1.6323677 | 883.172 | 1.57 | 1.65 | 882 |
| 30 | 29 | 93 | رصيف | 93.4916667 | 1.6317374 | 883.172 | 1.57 | 1.65 | 881.896 |
| 21 | 37 | 93 | رصيف | 93.6225 | 1.6340209 | 883.172 | 1.57 | 1.65 | 881.663 |
| 43 | 10 | 93 | center line | 93.1786111 | 1.6262736 | 883.172 | 1.57 | 1.65 | 881.789 |
| 29 | 40 | 92 | رصيف | 92.6747222 | 1.617479 | 883.172 | 1.57 | 1.65 | 881.882 |
| 11 | 26 | 92 | رصيف | 92.4363889 | 1.6133193 | 883.172 | 1.57 | 1.65 | 882.057 |
| 58 | 57 | 91 | رصيف | 91.9661111 | 1.6051114 | 883.172 | 1.57 | 1.65 | 882.284 |
| 54 | 29 | 91 | رصيف | 91.4983333 | 1.5969472 | 883.172 | 1.57 | 1.65 | 882.482 |
| 37 | 21 | 90 | رصيف | 90.3602778 | 1.5770844 | 883.172 | 1.57 | 1.65 | 882.937 |
| 12 | 49 | 88 | رصيف | 88.82 | 1.5502014 | 883.172 | 1.57 | 1.65 | 883.652 |
| 40 | 28 | 87 | رصيف | 87.4777778 | 1.5267752 | 883.172 | 1.57 | 1.65 | 884.59 |
| 18 | 35 | 87 | center line | 87.5883333 | 1.5287048 | 883.172 | 1.57 | 1.65 | 884.419 |
| 3 | 37 | 87 | رصيف | 87.6175 | 1.5292139 | 883.172 | 1.57 | 1.65 | 884.368 |
| 11 | 55 | 87 | رصيف | 87.9197222 | 1.5344886 | 883.172 | 1.57 | 1.65 | 884.036 |
| 57 | 6 | 88 | رصيف | 88.1158333 | 1.5379114 | 883.172 | 1.57 | 1.65 | 883.863 |
| 31 | 26 | 88 | رصيف | 88.4419444 | 1.5436031 | 883.172 | 1.57 | 1.65 | 883.648 |
| 49 | 36 | 88 | رصيف | 88.6136111 | 1.5465993 | 883.172 | 1.57 | 1.65 | 883.539 |
| 57 | 48 | 88 | رصيف | 88.8158333 | 1.5501287 | 883.172 | 1.57 | 1.65 | 883.435 |
| 38 | 50 | 88 | رصيف | 88.8438889 | 1.5506184 | 883.172 | 1.57 | 1.65 | 883.399 |
| 10 | 48 | 88 | رصيف | 88.8027778 | 1.5499009 | 883.172 | 1.57 | 1.65 | 883.401 |
| 49 | 40 | 88 | رصيف | 88.6802778 | 1.5477628 | 883.172 | 1.57 | 1.65 | 883.438 |
| 1 | 33 | 88 | رصيف | 88.5502778 | 1.5454939 | 883.172 | 1.57 | 1.65 | 883.49 |
| 43 | 25 | 88 | رصيف | 88.4286111 | 1.5433704 | 883.172 | 1.57 | 1.65 | 883.588 |
| 27 | 54 | 87 | رصيف | 87.9075 | 1.5342753 | 883.172 | 1.57 | 1.65 | 884.026 |
| 44 | 48 | 87 | رصيف | 87.8122222 | 1.5326124 | 883.172 | 1.57 | 1.65 | 884.095 |
| 34 | 18 | 89 | رصيف | 89.3094444 | 1.5587439 | 883.172 | 1.57 | 1.65 | 883.208 |
| 13 | 55 | 89 | رصيف | 89.9202778 | 1.5694049 | 883.172 | 1.57 | 1.65 | 883.104 |

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|---|---|---|---|---|---|---|---|---|---|
| 1 | 36 | 90 | رصيف | 90.6002778 | 1.5812732 | 883.172 | 1.57 | 1.65 | 882.994 |
| 37 | 15 | 91 | رصيف | 91.2602778 | 1.5927923 | 883.172 | 1.57 | 1.65 | 882.843 |
| 41 | 27 | 91 | رصيف | 91.4613889 | 1.5963024 | 883.172 | 1.57 | 1.65 | 882.711 |
| 40 | 23 | 92 | جزير ١ | 92.3944444 | 1.6125873 | 883.172 | 1.57 | 1.65 | 882.655 |
| 16 | 29 | 92 | جزير ١ | 92.4877778 | 1.6142162 | 883.172 | 1.57 | 1.65 | 882.621 |
| 41 | 3 | 92 | جزير ١ | 92.0613889 | 1.6067744 | 883.172 | 1.57 | 1.65 | 882.629 |
| 32 | 25 | 89 | جزيرة٢ | 89.4255556 | 1.5607704 | 883.172 | 1.57 | 1.65 | 883.263 |
| 21 | 34 | 89 | جزيرة٢ | 89.5725 | 1.563335 | 883.172 | 1.57 | 1.65 | 883.225 |
| 29 | 48 | 88 | جزير٢ | 88.8080556 | 1.549993 | 883.172 | 1.57 | 1.65 | 883.541 |
| 21 | 31 | 88 | جزيرة وسطية | 88.5225 | 1.5450091 | 883.172 | 1.57 | 1.65 | 883.364 |
| 8 | 2 | 88 | جزيرة وسطية | 88.0355556 | 1.5365103 | 883.172 | 1.57 | 1.65 | 883.448 |
| 9 | 44 | 87 | جزيرة وسطية | 87.7358333 | 1.5312792 | 883.172 | 1.57 | 1.65 | 883.853 |
| 40 | 57 | 87 | جزيرة وسطية | 87.9611111 | 1.535211 | 883.172 | 1.57 | 1.65 | 883.786 |
| 3 | 26 | 87 | جزيرة وسطية | 87.4341667 | 1.5260141 | 883.172 | 1.57 | 1.65 | 884.312 |
| 18 | 41 | 87 | جزيرة وسطية | 87.6883333 | 1.5304501 | 883.172 | 1.57 | 1.65 | 884.172 |
| 53 | 13 | 89 | دوار | 89.2313889 | 1.5573815 | 883.172 | 1.57 | 1.65 | 883.145 |
| 43 | 54 | 89 | دوار | 89.9119444 | 1.5692595 | 883.172 | 1.57 | 1.65 | 883.095 |
| 33 | 34 | 92 | دوار | 92.5758333 | 1.6157531 | 883.172 | 1.57 | 1.65 | 883.049 |
| 50 | 33 | 94 | دوار | 94.5638889 | 1.6504512 | 883.172 | 1.57 | 1.65 | 882.927 |
| 21 | 19 | 94 | دوار | 94.3225 | 1.6462382 | 883.172 | 1.57 | 1.65 | 882.804 |
| 30 | 8 | 94 | دوار | 94.1416667 | 1.643082 | 883.172 | 1.57 | 1.65 | 882.7 |
| 37 | 57 | 93 | دوار | 93.9602778 | 1.6399162 | 883.172 | 1.57 | 1.65 | 882.618 |
| 53 | 30 | 93 | دوار | 93.5147222 | 1.6321398 | 883.172 | 1.57 | 1.65 | 882.6 |
| 13 | 32 | 92 | دوار | 92.5369444 | 1.6150744 | 883.172 | 1.57 | 1.65 | 882.698 |
| 57 | 5 | 92 | دوار | 92.0991667 | 1.6074337 | 883.172 | 1.57 | 1.65 | 882.747 |
| 26 | 2 | 91 | دوار | 91.0405556 | 1.5889574 | 883.172 | 1.57 | 1.65 | 882.921 |
| 34 | 29 | 90 | دوار | 90.4927778 | 1.5793969 | 883.172 | 1.57 | 1.65 | 883.015 |
| 29 | 3 | 90 | دوار | 90.0580556 | 1.5718096 | 883.172 | 1.57 | 1.65 | 883.084 |
| 47 | 50 | 89 | دوار | 89.8463889 | 1.5681153 | 883.172 | 1.57 | 1.65 | 883.111 |
| 32 | 19 | 89 | دوار | 89.3255556 | 1.5590251 | 883.172 | 1.57 | 1.65 | 883.148 |
| 57 | 7 | 93 | منهل | 93.1325 | 1.6254688 | 883.172 | 1.57 | 1.65 | 882.79 |
| 50 | 8 | 91 | منهل | 91.1472222 | 1.5908191 | 883.172 | 1.57 | 1.65 | 882.745 |
| 39 | 35 | 91 | inlet | 91.5941667 | 1.5986198 | 883.172 | 1.57 | 1.65 | 882.613 |
| 25 | 17 | 91 | inlet | 91.2902778 | 1.5933159 | 883.172 | 1.57 | 1.65 | 882.468 |
| 11 | 0 | 92 | inlet | 92.0030556 | 1.6057562 | 883.172 | 1.57 | 1.65 | 882.426 |
| 19 | 9 | 93 | رصيف | 93.1552778 | 1.6258663 | 883.172 | 1.57 | 1.65 | 880.854 |
| 44 | 3 | 93 | center line | 93.0622222 | 1.6242422 | 883.172 | 1.57 | 1.65 | 880.92 |
| 2 | 55 | 92 | رصيف | 92.9172222 | 1.6217115 | 883.172 | 1.57 | 1.65 | 880.995 |
| 36 | 39 | 92 | منهل | 92.66 | 1.6172221 | 883.172 | 1.57 | 1.65 | 881.378 |
| 40 | 27 | 92 | منهل | 92.4611111 | 1.6137508 | 883.172 | 1.57 | 1.65 | 881.661 |
| 45 | 14 | 92 | منهل | 92.2458333 | 1.6099935 | 883.172 | 1.57 | 1.65 | 882.021 |
| 41 | 35 | 92 | رصيف | 92.5947222 | 1.6160828 | 883.172 | 1.57 | 1.65 | 880.246 |
| 38 | 40 | 92 | center line | 92.6772222 | 1.6175227 | 883.172 | 1.57 | 1.65 | 880.202 |
| 34 | 41 | 92 | منهل | 92.6927778 | 1.6177942 | 883.172 | 1.57 | 1.65 | 880.149 |
| 19 | 40 | 92 | منهل | 92.6719444 | 1.6174306 | 883.172 | 1.57 | 1.65 | 880.159 |
| 45 | 38 | 92 | رصيف | 92.6458333 | 1.6169748 | 883.172 | 1.57 | 1.65 | 880.19 |
| 6 | 32 | 92 | منهل | 92.535 | 1.6150404 | 883.172 | 1.57 | 1.65 | 880.334 |

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|---|---|---|---|---|---|---|---|---|---|
| 39 | 39 | 92 | منهل | 92.6608333 | 1.6172366 | 883.172 | 1.57 | 1.65 | 880.447 |
| 26 | 23 | 92 | رصيف | 92.3905556 | 1.6125194 | 883.172 | 1.57 | 1.65 | 879.748 |
| 36 | 24 | 92 | center line | 92.41 | 1.6128588 | 883.172 | 1.57 | 1.65 | 879.735 |
| 8 | 19 | 92 | رصيف | 92.3188889 | 1.6112686 | 883.172 | 1.57 | 1.65 | 879.845 |
| 42 | 22 | 92 | منهل | 92.3783333 | 1.6123061 | 883.172 | 1.57 | 1.65 | 880.111 |
| 24 | 11 | 92 | رصيف | 92.19 | 1.609019 | 883.172 | 1.57 | 1.65 | 879.376 |
| 9 | 8 | 92 | عمود كهرباء | 92.1358333 | 1.6080737 | 883.172 | 1.57 | 1.65 | 879.47 |
| 29 | 13 | 92 | center line | 92.2247222 | 1.6096251 | 883.172 | 1.57 | 1.65 | 879.335 |
| 22 | 13 | 92 | رصيف | 92.2227778 | 1.6095911 | 883.172 | 1.57 | 1.65 | 879.348 |
| 53 | 4 | 92 | رصيف | 92.0813889 | 1.6071234 | 883.172 | 1.57 | 1.65 | 878.99 |
| 50 | 4 | 92 | center line | 92.0805556 | 1.6071089 | 883.172 | 1.57 | 1.65 | 878.988 |
| 36 | 2 | 92 | رصيف | 92.0433333 | 1.6064592 | 883.172 | 1.57 | 1.65 | 879.023 |
| 4 | 58 | 91 | رصيف | 91.9677778 | 1.6051405 | 883.172 | 1.57 | 1.65 | 878.707 |
| 27 | 0 | 92 | center line | 92.0075 | 1.6058338 | 883.172 | 1.57 | 1.65 | 878.656 |
| 55 | 1 | 92 | رصيف | 92.0319444 | 1.6062604 | 883.172 | 1.57 | 1.65 | 878.637 |
| 25 | 54 | 100 | رصيف | 100.906944 | 1.7611584 | 882.513 | 1.57 | 1.65 | 877.38 |
| 15 | 4 | 99 | رصيف | 99.0708333 | 1.7291122 | 882.513 | 1.57 | 1.65 | 877.504 |
| 50 | 0 | 104 | رصيف | 104.013889 | 1.8153848 | 882.513 | 1.57 | 1.65 | 877.355 |
| 55 | 28 | 103 | رصيف | 103.481944 | 1.8061006 | 882.513 | 1.57 | 1.65 | 877.535 |
| 30 | 44 | 99 | رصيف | 99.7416667 | 1.7408205 | 882.513 | 1.57 | 1.65 | 877.932 |
| 5 | 43 | 99 | رصيف | 99.7180556 | 1.7404084 | 882.513 | 1.57 | 2.65 | 877.745 |
| 15 | 40 | 99 | رصيف | 99.6708333 | 1.7395842 | 882.513 | 1.57 | 2.65 | 877.755 |
| 40 | 26 | 100 | center line | 100.444444 | 1.7530863 | 882.513 | 1.57 | 2.65 | 877.298 |
| 40 | 43 | 99 | رصيف | 99.7277778 | 1.7405781 | 882.513 | 1.57 | 2.3 | 877.304 |
| 15 | 58 | 101 | رصيف | 101.970833 | 1.7797268 | 882.513 | 1.57 | 2.3 | 877.844 |
| 45 | 11 | 103 | رصيف | 103.195833 | 1.8011071 | 882.513 | 1.57 | 1.65 | 877.735 |
| 40 | 7 | 104 | رصيف | 104.127778 | 1.8173726 | 882.513 | 1.57 | 1.65 | 877.597 |
| 40 | 17 | 104 | رصيف | 104.294444 | 1.8202814 | 882.513 | 1.57 | 1.65 | 877.54 |
| 0 | 51 | 101 | زاوية مبنى | 101.85 | 1.7776178 | 882.513 | 1.57 | 1.65 | 877.843 |
| 45 | 54 | 102 | زاوية مبنى | 102.9125 | 1.796162 | 882.513 | 1.57 | 1.65 | 877.707 |
| 40 | 4 | 104 | رصيف | 104.077778 | 1.8164999 | 882.513 | 1.57 | 1.65 | 877.542 |
| 50 | 20 | 103 | رصيف | 103.347222 | 1.8037493 | 882.513 | 1.57 | 1.65 | 877.586 |
| 40 | 31 | 105 | center line | 105.527778 | 1.8418072 | 882.513 | 1.57 | 1.65 | 877.497 |
| 10 | 36 | 106 | منهل | 106.602778 | 1.8605695 | 882.513 | 1.57 | 1.65 | 877.438 |
| 15 | 29 | 108 | زاوية مبنى | 108.4875 | 1.8934641 | 882.513 | 1.57 | 1.65 | 876.824 |
| 55 | 49 | 110 | كوربة | 110.831944 | 1.9343823 | 882.513 | 1.57 | 1.65 | 876.717 |
| 10 | 19 | 112 | رصيف | 112.319444 | 1.9603441 | 882.513 | 1.57 | 1.65 | 876.705 |
| 50 | 45 | 114 | رصيف | 114.763889 | 2.0030077 | 882.513 | 1.57 | 1.65 | 876.661 |
| 0 | 56 | 116 | رصيف | 116.933333 | 2.0408717 | 882.513 | 1.57 | 1.65 | 876.617 |
| 55 | 38 | 118 | رصيف | 118.648611 | 2.0708089 | 882.513 | 1.57 | 1.65 | 876.69 |
| 20 | 53 | 114 | رصيف | 114.888889 | 2.0051894 | 882.513 | 1.57 | 1.65 | 876.997 |
| 40 | 31 | 112 | رصيف | 112.527778 | 1.9639802 | 882.513 | 1.57 | 1.65 | 877.131 |
| 10 | 43 | 124 | رصيف | 124.719444 | 2.1767649 | 882.513 | 1.57 | 1.65 | 876.826 |
| 0 | 30 | 123 | center line | 123.5 | 2.1554816 | 882.513 | 1.57 | 1.65 | 876.653 |
| 30 | 46 | 119 | رصيف | 119.775 | 2.0904681 | 882.513 | 1.57 | 1.65 | 876.569 |
| 25 | 15 | 118 | رصيف | 118.256944 | 2.063973 | 882.513 | 1.57 | 1.65 | 876.502 |
| 35 | 12 | 112 | مبنى | 112.209722 | 1.9584291 | 882.513 | 1.57 | 1.65 | 876.663 |

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|---|---|---|---|---|---|---|---|---|---|
| 25 | 9 | 114 | رصيف | 114.156944 | 1.9924145 | 882.513 | 1.57 | 1.65 | 876.374 |
| 30 | 3 | 110 | مبنى | 110.058333 | 1.9208803 | 882.513 | 1.57 | 1.65 | 876.448 |
| 30 | 44 | 110 | رصيف | 110.741667 | 1.9328067 | 882.513 | 1.57 | 1.65 | 876.28 |
| 45 | 49 | 113 | رصيف | 113.829167 | 1.9866937 | 882.513 | 1.57 | 1.65 | 876.291 |
| 0 | 37 | 104 | رصيف | 104.616667 | 1.8259053 | 882.513 | 1.57 | 1.65 | 876.227 |
| 30 | 52 | 101 | رصيف | 101.875 | 1.7780542 | 882.513 | 1.57 | 1.65 | 876.665 |
| 10 | 16 | 102 | منهل | 102.269444 | 1.7849385 | 882.513 | 1.57 | 3.5 | 874.909 |
| 10 | 8 | 101 | inlet | 101.136111 | 1.7651581 | 882.513 | 1.57 | 3.5 | 875.611 |
| 50 | 42 | 100 | منهل | 100.713889 | 1.757789 | 882.513 | 1.57 | 3.5 | 875.618 |
| 35 | 15 | 101 | زاوية مبنى | 101.259722 | 1.7673156 | 882.513 | 1.57 | 3.5 | 875.98 |
| 40 | 18 | 100 | رصيف | 100.311111 | 1.7507592 | 882.513 | 1.57 | 3.5 | 875.732 |
| 25 | 30 | 99 | رصيف | 99.5069444 | 1.7367238 | 882.513 | 1.57 | 3.5 | 875.642 |
| 55 | 57 | 99 | center line | 99.9652778 | 1.7447232 | 882.513 | 1.57 | 3.5 | 875.679 |
| 20 | 34 | 102 | center line | 102.572222 | 1.790223 | 882.513 | 1.57 | 3.5 | 876.022 |
| 0 | 19 | 98 | رصيف | 98.3166667 | 1.7159495 | 882.513 | 1.57 | 3.65 | 875.512 |
| 45 | 7 | 97 | رصيف | 97.1291667 | 1.6952238 | 882.513 | 1.57 | 3.65 | 875.352 |
| 55 | 42 | 96 | رصيف | 96.7152778 | 1.688 | 882.513 | 1.57 | 3.65 | 875.29 |
| 50 | 14 | 96 | رصيف | 96.2472222 | 1.6798309 | 882.513 | 1.57 | 1.65 | 877.203 |
| 45 | 47 | 95 | رصيف | 95.7958333 | 1.6719527 | 882.513 | 1.57 | 1.65 | 877.115 |
| 35 | 42 | 95 | رصيف | 95.7097222 | 1.6704498 | 882.513 | 1.57 | 1.65 | 877.052 |
| 10 | 31 | 95 | رصيف | 95.5194444 | 1.6671288 | 882.513 | 1.57 | 1.65 | 877.021 |
| 50 | 30 | 95 | رصيف | 95.5138889 | 1.6670318 | 882.513 | 1.57 | 1.65 | 876.971 |
| 5 | 10 | 95 | منهل | 95.1680556 | 1.6609959 | 882.513 | 1.57 | 1.65 | 876.895 |
| 35 | 10 | 95 | منهل | 95.1763889 | 1.6611414 | 882.513 | 1.57 | 3.65 | 874.894 |
| 5 | 17 | 95 | center line | 95.2847222 | 1.6630321 | 882.513 | 1.57 | 1.65 | 876.997 |
| 40 | 55 | 95 | center line | 95.9277778 | 1.6742556 | 882.513 | 1.57 | 1.65 | 877.171 |
| 35 | 10 | 95 | stars | 95.1763889 | 1.6611414 | 882.513 | 1.57 | 1.65 | 876.888 |
| 45 | 50 | 94 | رصيف | 94.8458333 | 1.6553721 | 882.513 | 1.57 | 1.65 | 876.675 |
| 15 | 41 | 94 | رصيف | 94.6875 | 1.6526086 | 882.513 | 1.57 | 1.65 | 876.579 |
| 55 | 37 | 94 | مبنى | 94.6319444 | 1.651639 | 882.513 | 1.57 | 1.65 | 876.806 |
| 40 | 33 | 94 | مبنى | 94.5611111 | 1.6504027 | 882.513 | 1.57 | 1.65 | 876.609 |
| 5 | 36 | 94 | رصيف | 94.6013889 | 1.6511057 | 882.513 | 1.57 | 1.65 | 876.517 |
| 20 | 32 | 94 | رصيف | 94.5388889 | 1.6500149 | 882.513 | 1.57 | 1.65 | 876.382 |
| 5 | 20 | 94 | مبنى | 94.3347222 | 1.6464515 | 882.513 | 1.57 | 1.65 | 876.293 |
| 40 | 24 | 94 | رصيف | 94.4111111 | 1.6477847 | 882.513 | 1.57 | 1.65 | 876.204 |
| 25 | 26 | 94 | رصيف | 94.4402778 | 1.6482938 | 882.513 | 1.57 | 3.5 | 874.06 |
| 20 | 29 | 94 | مبنى | 94.4888889 | 1.6491422 | 882.513 | 1.57 | 3.5 | 873.964 |
| 10 | 41 | 94 | رصيف | 94.6861111 | 1.6525844 | 882.513 | 1.57 | 1.65 | 875.427 |
| 0 | 34 | 94 | رصيف | 94.5666667 | 1.6504997 | 882.513 | 1.57 | 1.65 | 875.283 |
| 35 | 37 | 94 | center line | 94.6263889 | 1.651542 | 882.513 | 1.57 | 1.65 | 875.365 |
| 15 | 56 | 94 | center line | 94.9375 | 1.656972 | 882.513 | 1.57 | 1.65 | 875.765 |
| 15 | 30 | 94 | رصيف | 94.5041667 | 1.6494089 | 882.513 | 1.57 | 1.65 | 875.029 |
| 40 | 22 | 94 | منهل | 94.3777778 | 1.647203 | 882.513 | 1.57 | 1.65 | 874.919 |
| 35 | 22 | 94 | رصيف | 94.3763889 | 1.6471787 | 882.513 | 1.57 | 1.65 | 874.886 |
| 10 | 15 | 94 | رصيف | 94.2527778 | 1.6450213 | 882.513 | 1.57 | 1.65 | 874.66 |
| 0 | 16 | 94 | center line | 94.2666667 | 1.6452637 | 882.513 | 1.57 | 1.65 | 874.746 |
| 5 | 11 | 94 | رصيف | 94.1847222 | 1.6438335 | 882.513 | 1.57 | 1.65 | 874.585 |

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|---|---|---|---|---|---|---|---|---|---|
| 40 | 5 | 94 | رصيف | 94.0944444 | 1.6422579 | 882.513 | 1.57 | 1.65 | 874.471 |
| 10 | 50 | 93 | رصيف | 93.8361111 | 1.6377491 | 882.513 | 1.57 | 1.65 | 874.795 |
| 10 | 50 | 93 | رصيف | 93.8361111 | 1.6377491 | 882.513 | 1.57 | 1.65 | 874.722 |
| 45 | 6 | 94 | center line | 94.1125 | 1.642573 | 882.513 | 1.57 | 1.65 | 873.933 |
| 5 | 15 | 94 | center line | 94.2513889 | 1.6449971 | 882.513 | 1.57 | 1.65 | 874.287 |
| 45 | 51 | 88 | مبنى | 88.8625 | 1.5509432 | 871.565 | 1.61 | 1.65 | 874.035 |
| 57 | 52 | 88 | رصيف | 88.8825 | 1.5512923 | 871.565 | 1.61 | 1.65 | 873.981 |
| 4 | 56 | 88 | رصيف | 88.9344444 | 1.5521989 | 871.565 | 1.61 | 1.65 | 873.867 |
| 47 | 56 | 88 | center line | 88.9463889 | 1.5524073 | 871.565 | 1.61 | 1.65 | 873.827 |
| 48 | 56 | 88 | رصيف | 88.9466667 | 1.5524122 | 871.565 | 1.61 | 1.65 | 873.821 |
| 54 | 53 | 88 | اعلى رصيف | 88.8983333 | 1.5515686 | 871.565 | 1.61 | 1.65 | 873.927 |
| 20 | 54 | 88 | رصيف | 88.9055556 | 1.5516947 | 871.565 | 1.61 | 1.65 | 873.783 |
| 51 | 51 | 88 | رصيف | 88.8641667 | 1.5509723 | 871.565 | 1.61 | 1.65 | 873.769 |
| 51 | 52 | 88 | مبنى | 88.8808333 | 1.5512632 | 871.565 | 1.61 | 1.65 | 873.728 |
| 37 | 0 | 89 | رصيف | 89.0102778 | 1.5535224 | 871.565 | 1.61 | 1.65 | 873.409 |
| 0 | 58 | 88 | center line | 88.9666667 | 1.5527613 | 871.565 | 1.61 | 1.65 | 873.482 |
| 59 | 56 | 88 | مبنى | 88.9497222 | 1.5524655 | 871.565 | 1.61 | 1.65 | 873.386 |
| 0 | 57 | 88 | رصيف | 88.95 | 1.5524704 | 871.565 | 1.61 | 1.65 | 873.375 |
| 3 | 59 | 88 | center line | 88.9841667 | 1.5530667 | 871.565 | 1.61 | 1.65 | 873.299 |
| 3 | 59 | 88 | رصيف | 88.9841667 | 1.5530667 | 871.565 | 1.61 | 1.65 | 873.297 |
| 38 | 55 | 88 | اعلى رصيف | 88.9272222 | 1.5520728 | 871.565 | 1.61 | 1.65 | 873.395 |
| 40 | 22 | 89 | زاوية مبنى | 89.3777778 | 1.5599365 | 871.565 | 1.61 | 1.65 | 872.601 |
| 7 | 58 | 88 | منهل | 88.9686111 | 1.5527952 | 871.565 | 1.61 | 1.65 | 873.268 |
| 50 | 55 | 88 | زاوية مبنى | 88.9305556 | 1.552131 | 871.565 | 1.61 | 1.65 | 873.331 |
| 45 | 0 | 89 | منهل | 89.0125 | 1.5535612 | 871.565 | 1.61 | 1.65 | 873.025 |
| 37 | 0 | 89 | منهل | 89.0102778 | 1.5535224 | 871.565 | 1.61 | 1.65 | 872.973 |
| 26 | 56 | 88 | اعلى رصيف | 88.9405556 | 1.5523055 | 871.565 | 1.61 | 1.65 | 872.939 |
| 26 | 56 | 88 | زاوية مبنى | 88.9405556 | 1.5523055 | 871.565 | 1.61 | 1.65 | 872.873 |
| 9 | 4 | 89 | رصيف | 89.0691667 | 1.5545502 | 871.565 | 1.61 | 1.65 | 872.702 |
| 16 | 6 | 89 | center line | 89.1044444 | 1.5551659 | 871.565 | 1.61 | 1.65 | 872.646 |
| 32 | 58 | 88 | رصيف | 88.9755556 | 1.5529164 | 871.565 | 1.61 | 1.65 | 872.839 |
| 0 | 3 | 89 | رصيف | 89.05 | 1.5542157 | 871.565 | 1.61 | 1.65 | 872.768 |
| 29 | 3 | 89 | مدخل | 89.0580556 | 1.5543563 | 871.565 | 1.61 | 1.65 | 872.729 |
| 20 | 8 | 89 | مدخل | 89.1388889 | 1.5557671 | 871.565 | 1.61 | 1.65 | 872.604 |
| 22 | 56 | 88 | مدخل | 88.9394444 | 1.5522861 | 871.565 | 1.61 | 1.65 | 872.856 |
| 20 | 7 | 89 | منهل | 89.1222222 | 1.5554762 | 871.565 | 1.61 | 1.65 | 872.586 |
| 20 | 7 | 89 | منهل | 89.1222222 | 1.5554762 | 871.565 | 1.61 | 1.65 | 872.557 |
| 20 | 7 | 89 | زاوية مبنى | 89.1222222 | 1.5554762 | 871.565 | 1.61 | 1.65 | 872.55 |
| 44 | 1 | 89 | دخلة | 89.0288889 | 1.5538472 | 871.565 | 1.61 | 1.65 | 872.658 |
| 30 | 5 | 89 | رصيف | 89.0916667 | 1.5549429 | 871.565 | 1.61 | 1.65 | 872.573 |
| 37 | 0 | 89 | اعلى رصيف | 89.0102778 | 1.5535224 | 871.565 | 1.61 | 1.65 | 872.666 |
| 35 | 4 | 89 | مدخل | 89.0763889 | 1.5546763 | 871.565 | 1.61 | 1.65 | 872.635 |
| 37 | 4 | 89 | منهل | 89.0769444 | 1.554686 | 871.565 | 1.61 | 1.65 | 872.619 |
| 41 | 0 | 89 | زاوية مبنى | 89.0113889 | 1.5535418 | 871.565 | 1.61 | 1.65 | 872.698 |
| 46 | 4 | 89 | st 1100 | 89.0794444 | 1.5547296 | 871.565 | 1.61 | 1.65 | 872.631 |
| 22 | 8 | 89 | زاوية مبنى | 89.1394444 | 1.5557768 | 871.565 | 1.61 | 1.65 | 872.344 |
| 47 | 2 | 89 | اعلى رصيف | 89.0463889 | 1.5541527 | 871.565 | 1.61 | 1.65 | 872.419 |

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|---|---|---|---|---|---|---|---|---|---|
| 23 | 10 | 89 | رصيف | 89.1730556 | 1.5563634 | 871.565 | 1.61 | 1.65 | 872.301 |
| 23 | 10 | 89 | center line | 89.1730556 | 1.5563634 | 871.565 | 1.61 | 1.65 | 872.301 |
| 24 | 10 | 89 | رصيف | 89.1733333 | 1.5563683 | 871.565 | 1.61 | 1.65 | 872.3 |
| 4 | 3 | 89 | اعلى رصيف | 89.0511111 | 1.5542351 | 871.565 | 1.61 | 1.65 | 872.415 |
| 4 | 5 | 89 | زاوية مبنى | 89.0844444 | 1.5548169 | 871.565 | 1.61 | 1.65 | 872.359 |
| 35 | 9 | 89 | زاوية مبنى | 89.1597222 | 1.5561307 | 871.565 | 1.61 | 1.65 | 872.179 |
| 13 | 6 | 89 | زاوية مبنى | 89.1036111 | 1.5551514 | 871.565 | 1.61 | 1.65 | 872.167 |
| 37 | 14 | 89 | رصيف | 89.2436111 | 1.5575949 | 871.565 | 1.61 | 1.65 | 872.061 |
| 16 | 13 | 89 | منهل | 89.2211111 | 1.5572022 | 871.565 | 1.61 | 1.65 | 872.084 |
| 11 | 14 | 89 | center line | 89.2363889 | 1.5574688 | 871.565 | 1.61 | 1.65 | 872.072 |
| 10 | 14 | 89 | رصيف | 89.2361111 | 1.557464 | 871.565 | 1.61 | 1.65 | 872.077 |
| 29 | 6 | 89 | اعلى رصيف | 89.1080556 | 1.555229 | 871.565 | 1.61 | 1.65 | 872.17 |
| 37 | 28 | 88 | زاوية مبنى | 88.4769444 | 1.544214 | 871.565 | 1.61 | 2 | 872.295 |
| 54 | 8 | 89 | منهل | 89.1483333 | 1.5559319 | 871.565 | 1.61 | 1.55 | 872.308 |
| 33 | 8 | 89 | عمود كهرباء | 89.1425 | 1.5558301 | 871.565 | 1.61 | 1.65 | 872.059 |
| 50 | 22 | 89 | منهل | 89.3805556 | 1.559985 | 871.565 | 1.61 | 1.65 | 871.854 |
| 21 | 42 | 89 | inlet angle 1 | 89.7058333 | 1.5656621 | 871.565 | 1.61 | 1.65 | 871.671 |
| 20 | 42 | 89 | inlet angle 2 | 89.7055556 | 1.5656573 | 871.565 | 1.61 | 1.65 | 871.673 |
| 56 | 38 | 89 | inlet angle 3 | 89.6488889 | 1.5646683 | 871.565 | 1.61 | 1.65 | 871.694 |
| 56 | 38 | 89 | inlet angle 4 | 89.6488889 | 1.5646683 | 871.565 | 1.61 | 1.65 | 871.692 |
| 6 | 34 | 89 | اسفل رصيف | 89.5683333 | 1.5632623 | 871.565 | 1.61 | 1.65 | 871.732 |
| 26 | 14 | 89 | اعلى رصيف | 89.2405556 | 1.5575415 | 871.565 | 1.61 | 1.65 | 871.889 |
| 25 | 14 | 89 | زاوية مبنى | 89.2402778 | 1.5575367 | 871.565 | 1.61 | 1.65 | 871.887 |
| 2 | 18 | 89 | منهل كهرباء | 89.3005556 | 1.5585887 | 871.565 | 1.61 | 1.65 | 871.826 |
| 0 | 18 | 89 | منهل كهرباء | 89.3 | 1.558579 | 871.565 | 1.61 | 1.65 | 871.813 |
| 10 | 25 | 89 | منهل كهرباء | 89.4194444 | 1.5606637 | 871.565 | 1.61 | 1.65 | 871.697 |
| 19 | 23 | 89 | منهل | 89.3886111 | 1.5601256 | 871.565 | 1.61 | 1.65 | 871.695 |
| 24 | 24 | 89 | منهل كهرباء | 89.4066667 | 1.5604407 | 871.565 | 1.61 | 1.65 | 871.667 |
| 38 | 19 | 89 | زاوية مبنى | 89.3272222 | 1.5590541 | 871.565 | 1.61 | 1.65 | 871.621 |
| 32 | 42 | 89 | اعلى رصيف | 89.7088889 | 1.5657155 | 871.565 | 1.61 | 1.65 | 871.568 |
| 12 | 38 | 90 | اسفل رصيف | 90.6366667 | 1.5819083 | 871.565 | 1.61 | 1.65 | 871.431 |
| 44 | 42 | 90 | منهل | 90.7122222 | 1.5832269 | 871.565 | 1.61 | 1.65 | 871.419 |
| 40 | 33 | 90 | center line | 90.5611111 | 1.5805896 | 871.565 | 1.61 | 1.65 | 871.427 |
| 14 | 38 | 90 | اسفل رصيف | 90.6372222 | 1.581918 | 871.565 | 1.61 | 1.65 | 871.383 |
| 45 | 58 | 89 | اعلى رصيف | 89.9791667 | 1.5704327 | 871.565 | 1.61 | 1.65 | 871.53 |
| 38 | 49 | 89 | زاوية مبنى | 89.8272222 | 1.5677808 | 871.565 | 1.61 | 1.65 | 871.569 |
| 34 | 49 | 89 | منهل كهرباء | 89.8261111 | 1.5677614 | 871.565 | 1.61 | 1.65 | 871.569 |
| 55 | 39 | 89 | منهل | 89.6652778 | 1.5649543 | 871.565 | 1.61 | 1.65 | 871.619 |
| 16 | 42 | 89 | مبنى | 89.7044444 | 1.5656379 | 871.565 | 1.61 | 1.65 | 871.611 |
| 24 | 31 | 89 | منهل كهرباء | 89.5233333 | 1.5624769 | 871.565 | 1.61 | 1.65 | 871.701 |
| 30 | 31 | 89 | منهل | 89.525 | 1.562506 | 871.565 | 1.61 | 1.65 | 871.71 |
| 52 | 11 | 90 | منهل | 90.1977778 | 1.5742482 | 871.565 | 1.61 | 1.65 | 871.483 |
| 19 | 27 | 91 | inlet | 91.4552778 | 1.5961957 | 871.565 | 1.61 | 1.65 | 871.269 |
| 55 | 24 | 90 | منهل | 90.4152778 | 1.5780443 | 871.565 | 1.61 | 1.65 | 871.446 |
| 4 | 24 | 91 | رصيف | 91.4011111 | 1.5952503 | 871.565 | 1.61 | 1.65 | 871.274 |
| 14 | 17 | 91 | رصيف | 91.2872222 | 1.5932626 | 871.565 | 1.61 | 1.65 | 871.292 |
| 37 | 19 | 91 | رصيف | 91.3269444 | 1.5939559 | 871.565 | 1.61 | 1.65 | 871.265 |

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|---|---|---|---|---|---|---|---|---|---|
| 51 | 8 | 91 | رصيف | 91.1475 | 1.590824 | 871.565 | 1.61 | 1.65 | 871.276 |
| 25 | 0 | 91 | زاوية مبنى | 91.0069444 | 1.5883708 | 871.565 | 1.61 | 1.65 | 871.288 |
| 33 | 28 | 90 | زاوية مبنى | 90.4758333 | 1.5791012 | 871.565 | 1.61 | 1.65 | 871.424 |
| 9 | 29 | 91 | منهل كهرباء | 91.4858333 | 1.596729 | 871.565 | 1.61 | 1.65 | 871.302 |
| 5 | 53 | 91 | منهل | 91.8847222 | 1.6036909 | 871.565 | 1.61 | 1.65 | 871.31 |
| 42 | 35 | 92 | منهل كهرباء | 92.595 | 1.6160876 | 871.565 | 1.61 | 1.65 | 871.341 |
| 48 | 36 | 93 | inlet | 93.6133333 | 1.6338609 | 871.565 | 1.61 | 1.65 | 871.323 |
| 37 | 0 | 92 | منهل كهرباء | 92.0102778 | 1.6058823 | 871.565 | 1.61 | 1.65 | 871.468 |
| 54 | 27 | 91 | عمود كهرباء | 91.465 | 1.5963654 | 871.565 | 1.61 | 1.65 | 871.487 |
| 32 | 10 | 92 | زاوية مبنى | 92.1755556 | 1.6087669 | 871.565 | 1.61 | 1.65 | 871.487 |
| 32 | 10 | 95 | رصيف | 95.1755556 | 1.6611268 | 871.565 | 1.61 | 1.65 | 871.333 |
| 16 | 34 | 98 | رصيف | 98.5711111 | 1.7203904 | 871.565 | 1.61 | 1.65 | 871.306 |
| 7 | 37 | 101 | رصيف | 101.618611 | 1.7735793 | 871.565 | 1.61 | 1.65 | 871.288 |
| 3 | 29 | 100 | رصيف | 100.484167 | 1.7537796 | 871.565 | 1.61 | 1.65 | 871.289 |
| 12 | 18 | 97 | اسفل رصيف | 97.3033333 | 1.6982635 | 871.565 | 1.61 | 1.65 | 871.326 |
| 50 | 30 | 92 | اعلى رصيف | 92.5138889 | 1.614672 | 871.565 | 1.61 | 1.65 | 871.459 |
| 18 | 19 | 91 | منهل | 91.3216667 | 1.5938638 | 871.565 | 1.61 | 1.65 | 871.491 |
| 18 | 29 | 90 | عمود كهرباء | 90.4883333 | 1.5793194 | 871.565 | 1.61 | 1.65 | 871.506 |
| 47 | 36 | 88 | منهل | 88.6130556 | 1.5465896 | 871.565 | 1.61 | 1.65 | 871.624 |
| 58 | 37 | 91 | inlet | 91.6327778 | 1.5992937 | 871.565 | 1.61 | 1.65 | 871.405 |
| 50 | 11 | 88 | منهل | 88.1972222 | 1.5393319 | 871.565 | 1.61 | 1.65 | 871.717 |
| 15 | 4 | 88 | اعلى رصيف | 88.0708333 | 1.537126 | 871.565 | 1.61 | 1.65 | 871.861 |
| 12 | 2 | 89 | اسفل رصيف | 89.0366667 | 1.553983 | 871.565 | 1.61 | 1.65 | 871.693 |
| 16 | 51 | 88 | منهل cente+ line | 88.8544444 | 1.5508026 | 871.565 | 1.61 | 1.65 | 871.738 |
| 51 | 7 | 89 | اسفل رصيف | 89.1308333 | 1.5556265 | 871.565 | 1.61 | 1.65 | 871.706 |
| 26 | 22 | 88 | اعلى رصيف | 88.3738889 | 1.5424153 | 871.565 | 1.61 | 1.65 | 871.864 |
| 15 | 30 | 88 | منهل كهرباء | 88.5041667 | 1.5446891 | 871.565 | 1.61 | 1.65 | 871.828 |
| 35 | 31 | 88 | زاوية مبنى | 88.5263889 | 1.545077 | 871.565 | 1.61 | 1.65 | 871.823 |
| 41 | 52 | 90 | inlet | 90.8780556 | 1.5861213 | 871.565 | 1.61 | 1.65 | 871.408 |
| 41 | 23 | 91 | منهل | 91.3947222 | 1.5951388 | 871.565 | 1.61 | 1.65 | 871.388 |
| 41 | 23 | 91 | رصيف | 91.3947222 | 1.5951388 | 871.565 | 1.61 | 1.65 | 871.349 |
| 42 | 23 | 91 | رصيف | 91.395 | 1.5951437 | 871.565 | 1.61 | 1.65 | 871.35 |
| 43 | 23 | 91 | رصيف | 91.3952778 | 1.5951485 | 871.565 | 1.61 | 1.65 | 871.345 |
| 55 | 12 | 91 | نهاية الرصيف | 91.2152778 | 1.5920069 | 871.565 | 1.61 | 1.65 | 871.35 |
| 38 | 17 | 90 | منهل | 90.2938889 | 1.5759257 | 871.565 | 1.61 | 1.65 | 871.484 |
| 10 | 36 | 91 | منهل كهرباء | 91.6027778 | 1.5987701 | 871.565 | 1.61 | 1.65 | 871.342 |
| 51 | 53 | 87 | زاوية مبنى | 87.8975 | 1.5341008 | 871.565 | 1.61 | 1.65 | 872.098 |
| 30 | 24 | 88 | اسفل رصيف | 88.4083333 | 1.5430165 | 871.565 | 1.61 | 1.65 | 871.992 |
| 36 | 50 | 87 | اعلى رصيف | 87.8433333 | 1.5331554 | 871.565 | 1.61 | 1.65 | 872.159 |
| 37 | 6 | 88 | اسفل رصيف | 88.1102778 | 1.5378145 | 871.565 | 1.61 | 1.65 | 872.214 |
| 5 | 40 | 87 | اعلى رصيف | 87.6680556 | 1.5300962 | 871.565 | 1.61 | 1.65 | 872.375 |
| 9 | 22 | 87 | زاوية مبنى | 87.3691667 | 1.5248796 | 871.565 | 1.61 | 1.65 | 872.707 |
| 33 | 24 | 87 | منهل كهرباء | 87.4091667 | 1.5255778 | 871.565 | 1.61 | 1.65 | 872.678 |
| 22 | 49 | 87 | اسفل رصيف | 87.8227778 | 1.5327966 | 871.565 | 1.61 | 1.65 | 872.507 |
| 2 | 44 | 87 | منهل cente+ line | 87.7338889 | 1.5312452 | 871.565 | 1.61 | 1.65 | 872.474 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 17 | 56 | 87 | اسفل رصيف | 87.9380556 | 1.5348086 | 871.565 | 1.61 | 1.65 | 872.362 |
| 20 | 32 | 87 | اعلى رصيف | 87.5388889 | 1.5278418 | 871.565 | 1.61 | 1.65 | 872.525 |
| 54 | 28 | 87 | منهل كهرباء | 87.4816667 | 1.5268431 | 871.565 | 1.61 | 1.65 | 872.527 |
| 54 | 28 | 87 | مبنى | 87.4816667 | 1.5268431 | 871.565 | 1.61 | 1.65 | 872.522 |
| 14 | 33 | 87 | عمود كهرباء | 87.5538889 | 1.5281036 | 871.565 | 1.61 | 1.65 | 872.459 |
| 47 | 43 | 90 | مبنى | 90.7297222 | 1.5835324 | 871.565 | 1.61 | 1.65 | 871.278 |
| 50 | 34 | 90 | مبنى | 90.5805556 | 1.5809289 | 871.565 | 1.61 | 1.65 | 871.29 |
| 19 | 44 | 90 | منهل | 90.7386111 | 1.5836875 | 871.565 | 1.61 | 1.65 | 871.263 |
| 9 | 49 | 90 | منهل | 90.8191667 | 1.5850935 | 871.565 | 1.61 | 1.65 | 871.243 |
| 23 | 6 | 91 | inlet | 91.1063889 | 1.5901065 | 871.565 | 1.61 | 1.65 | 871.195 |
| 21 | 6 | 91 | منهل | 91.1058333 | 1.5900968 | 871.565 | 1.61 | 1.65 | 871.213 |
| 27 | 3 | 91 | منهل | 91.0575 | 1.5892532 | 871.565 | 1.61 | 1.65 | 871.252 |
| 16 | 52 | 90 | نقطة جيش | 90.8711111 | 1.5860001 | 871.565 | 1.61 | 1.65 | 871.297 |
| 35 | 38 | 90 | نقطة جيش | 90.6430556 | 1.5820198 | 871.565 | 1.61 | 1.65 | 871.335 |
| 43 | 55 | 90 | نقطة جيش | 90.9286111 | 1.5870036 | 871.565 | 1.61 | 1.65 | 871.296 |
| 33 | 51 | 90 | نقطة جيش | 90.8591667 | 1.5857916 | 871.565 | 1.61 | 1.65 | 871.31 |
| 11 | 7 | 91 | inlet | 91.1197222 | 1.5903392 | 871.565 | 1.61 | 1.65 | 871.287 |
| 10 | 7 | 91 | منهل | 91.1194444 | 1.5903343 | 871.565 | 1.61 | 1.65 | 871.283 |
| 6 | 7 | 91 | منهل | 91.1183333 | 1.5903149 | 871.565 | 1.61 | 1.65 | 871.179 |
| 30 | 57 | 90 | منهل | 90.9583333 | 1.5875224 | 871.565 | 1.61 | 1.65 | 871.154 |
| 12 | 59 | 90 | منهل | 90.9866667 | 1.5880169 | 871.565 | 1.61 | 1.65 | 871.075 |
| 0 | 56 | 90 | منهل | 90.9333333 | 1.5870861 | 871.565 | 1.61 | 1.65 | 870.866 |
| 15 | 57 | 90 | inlet | 90.9541667 | 1.5874497 | 871.565 | 1.61 | 1.65 | 870.808 |
| 39 | 57 | 90 | منهل | 90.9608333 | 1.587566 | 871.565 | 1.61 | 1.65 | 870.768 |
| 22 | 58 | 90 | زاوية مبنى | 90.9727778 | 1.5877745 | 871.565 | 1.61 | 1.65 | 870.716 |
| 55 | 24 | 91 | مبنى | 91.4152778 | 1.5954976 | 871.565 | 1.61 | 1.65 | 870.287 |
| 49 | 48 | 89 | زاوية مبنى | 89.8136111 | 1.5675432 | 871.565 | 1.61 | 1.65 | 871.644 |
| 9 | 46 | 90 | مبنى | 90.7691667 | 1.5842208 | 871.565 | 1.61 | 1.65 | 871.212 |
| 9 | 46 | 90 | مبنى | 90.7691667 | 1.5842208 | 871.565 | 1.61 | 1.65 | 871.161 |
| 56 | 4 | 91 | زاوية مبنى | 91.0822222 | 1.5896847 | 871.565 | 1.61 | 1.65 | 871.35 |
| 38 | 14 | 92 | RL | 92.2438889 | 1.6099596 | 871.565 | 1.61 | 1.65 | 871.298 |
| 17 | 35 | 90 | بناء جيش | 90.5880556 | 1.5810598 | 871.565 | 1.61 | 1.65 | 871.357 |
| 36 | 27 | 89 | مبنى اخر الدخلة | 89.46 | 1.5613715 | 872.63068 | 1.615 | 1.65 | 872.809 |
| 33 | 59 | 88 | مبنى اخر الدخلة | 88.9925 | 1.5532121 | 872.63068 | 1.615 | 1.65 | 873.136 |
| 18 | 44 | 92 | منهل دخلة | 92.7383333 | 1.6185893 | 872.63068 | 1.615 | 1.65 | 872.453 |
| 10 | 33 | 93 | منهل دخلة | 93.5527778 | 1.632804 | 872.63068 | 1.615 | 1.65 | 872.446 |
| 30 | 58 | 93 | inlet | 93.975 | 1.6401732 | 872.63068 | 1.615 | 1.65 | 872.349 |
| 21 | 20 | 89 | اخر دخلة بناء | 89.3391667 | 1.5592626 | 872.63068 | 1.615 | 1.65 | 873.031 |
| 55 | 39 | 89 | اخر دخلة بناء | 89.6652778 | 1.5649543 | 872.63068 | 1.615 | 1.65 | 872.817 |
| 29 | 12 | 90 | زاوية مبنى | 90.2080556 | 1.5744276 | 872.63068 | 1.615 | 1.65 | 872.455 |
| 32 | 6 | 91 | زاوية مبنى | 91.1088889 | 1.5901501 | 872.63068 | 1.615 | 1.65 | 871.86 |
| 38 | 9 | 91 | منهل | 91.1605556 | 1.5910518 | 872.63068 | 1.615 | 1.65 | 871.786 |
| 47 | 57 | 90 | RL | 90.9630556 | 1.5876048 | 872.63068 | 1.615 | 1.65 | 870.796 |
| 30 | 58 | 90 | st 1200 | 90.975 | 1.5878133 | 872.63068 | 1.615 | 1.65 | 870.828 |
| 1 | 59 | 88 | مبنى | 88.9836111 | 1.553057 | 870.82772 | 1.615 | 1.65 | 871.158 |
| 0 | 46 | 88 | مبنى | 88.7666667 | 1.5492706 | 870.82772 | 1.615 | 1.65 | 871.024 |
| 20 | 47 | 88 | منهل | 88.7888889 | 1.5496585 | 870.82772 | 1.615 | 1.65 | 871.001 |



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|---|---|---|---|---|---|---|---|---|---|
| 20 | 56 | 87 | رصيف | 87.9388889 | 1.5348232 | 873.167 | 1.56 | 1.65 | 877.018 |
| 45 | 47 | 87 | st 1800 | 87.7958333 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 55 | 49 | 87 | مبنى | 87.8319444 | 1.5329566 | 877.05703 | 1.56 | 1.65 | 878.035 |
| 10 | 22 | 88 | اعلى رصيف | 88.3694444 | 1.5423378 | 877.05703 | 1.56 | 1.65 | 878.328 |
| 0 | 50 | 86 | رصيف | 86.8333333 | 1.5155276 | 877.05703 | 1.56 | 1.65 | 880.636 |
| 45 | 8 | 87 | رصيف | 87.1458333 | 1.5209817 | 877.05703 | 1.56 | 3.55 | 879.12 |
| 50 | 1 | 88 | رصيف | 88.0305556 | 1.536423 | 877.05703 | 1.56 | 1.65 | 877.375 |
| 0 | 47 | 90 | رصيف | 90.7833333 | 1.5844681 | 877.05703 | 1.56 | 1.65 | 876.884 |
| 25 | 12 | 92 | رصيف | 92.2069444 | 1.6093148 | 877.05703 | 1.56 | 1.65 | 876.184 |
| 45 | 3 | 93 | رصيف | 93.0625 | 1.624247 | 877.05703 | 1.56 | 1.65 | 876.511 |