Rehabilitation and design of Seventy Road in Jenin City

By

Mohammad Yasin Mahmud Abu Salah Osaid Ashqar

Supervisor: Eng. Nidal ABURAJAB

Submitted to the College of Engineering

in partial fulfillment of the requirements for the

Bachelor degree in Civil Engineering

Palestine Polytechnic University

Jan 2025

CERTIFICATION

Palestine Polytechnic University

Hebron – Palestine

Rehabilitation and design of Seventy Road in Jenin City

Prepared By:

Osaid .M Ashqar Mahmud .M Abu Salah Mohammad .M Yasin

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

Project Supervisors	**Department Chairman**
Name: ……………….	**Name: ………………….**

Jan-2025

الاهداء

أهدي مشروع تخرجي و تعبي خلال السنوات الدراسية كهدية متواضعة و بسيطة الى تلك المرأة العظيمة التي ربت وعلمت التي لطالما نظرت لعينيها لاستمد منها قوتي لإكمال مسيرتي العلمية تقف كلماتي عاجزه عن شكرك يا حبيبه الى أمي الحنونة و الغالية و الى الشخص الذي مسك بيدي بقوة منذ صغري لم يسمح ان أقع أبدا الى قدوتي الأولى ونبرآسي الذي ينير دربي الى من علمني ان المثابرة الى من أعطاني و لم يزل يعطيني بلا حدود الى من رفعت راسي عاليا افتخاراً به إليك يا من أفديك بروحي الى حبيبي و قدوتي الى ابي العزيز و الغالي وأهدي تخرجي إلى مصدر سعادتي اخواني و اخواتي الى كل أهلي و أصدقائي و أحبابي.

الشكر والتقدير

اللهم لك الحمد والشكر، لا نحصي ثناءً عليك أنت كما أثنيت على نفسك، ونصلي ونسلم على من لا نبي بعده، سيدنا محمد صلى الله عليه وسلم.

الشكر لله أولاً وآخراً ونحمده حمداً كثيراً، أن منحنا شرف حب العلم والمعرفة

وأنعم علينا بالجهد والوقت في رحلتنا العلمية، وشكري لسيد البشرية أفصح من نطق بالعربية وحثنا على العلم بأحاديثه التنويرية فللّه الحمد ولرسوله صلى الله عليه وسلم.

ونشكر جزيل الشكر لمن أرشدنا لوجهتنا الصحيحة وأنار دربنا ورسم طريقنا نحو معرفة الوصول الى مشارف نهاية هذه الطريق معلمنا الفاضل م. نضال أبو رجب.

كما نتقدم بخالص الشكر والتقدير إلى كافة الأساتذة في قسم الهندسة المدنية وكلية الهندسة.

وشكرنا موصول الى مكتب الميادين الهندسي الذي لم يبخل علينا بإمدادنا بالأجهزة المساحية التي لزمتنا لإنجاز هذا المشروع.

Rehabilitation and design of Seventy Road

Supervisor

Eng. Nidal Abu- ABURAJAB

Team

Osaid .M Ashqar Mahmud .M Abu Salah Mohammad .M Yasin

Abstract:

The project consists of designing and rehabilitating the road linking The Almania circle with the the bypass road (Seventy Road), starting from (the bypass road (Seventy Road) and ending with the bypass road (Seventy Road)in (Jenin City), which is affiliated to the Jenin Municipality, with a length of (1300) meters, the road will be design with a width of (17) meters, and the importance of this road is summarized in that it is considered a vital and commercial road in the region, and serves a large number of residents of the region and the governorate as a whole.

The road project includes the necessary surveying works, in addition to the engineering and construction design of the road, as well as the requirements of the road design, including quantities calculations (cut and fill), rainwater drainage, with a consideration of the safety and security rules of road users (pedestrians and vehicles).

إعادة تأهيل وتصميم شارع السبعين

بإشراف:

الدكتور نضال أبو رجب

الفريق:

محمد ياسين　　　محمود أبو صلاح　　　اسيد أشقر

الملخص:

المشروع عبارة عن تصميم وإعادة تأهيل الطريق الواصل بين دوار الألمانية والشارع الالتفافي لمدينة جنين بدءاً من (دوار الألمانية) وانتهاء بمفرق الشارع الالتفافي في مدينة جنين والتابع لبلدية جنين، ويعد طريق شرياني تجاري هام يربط بين المنطقة الصناعية والشرقية في مدينة جنين بطول (١٣٠٠) متر تقريبا، ويعتبر هذا الطريق حيويا حيث سنقوم بتصميم هذا الطريق هندسيا بعرض(١٧)متر، وتتلخص أهمية هذا الطريق في انه يعتبر طريق حيوي وتجاري في المنطقة، ويخدم عدد كبير من سكان المنطقة والمحافظة ككل.

يشمل تصميم مشروع الطريق على تنفيذ أعمال المساحة اللازمة وبالإضافة إلى تصميم الطريق هندسيا وإنشائيا، وكذلك متطلبات تصميم الطريق من حسابات الكميات الحفر والردم وتصريف مياه الأمطار وغيرها مع مراعاة قواعد الأمان والسلامة لمستخدمي الطريق من مشاة ومركبات.

Contents:

Table of Contents:

List Of Figure:

List Of Table:

Chapter one

Introduction

1.1 Overview

1.2 Project idea

1.3 Project area

1.4 Objectives and importance of the project

1.5 Search method

1.6 Project structure

1.7 Previous studies

1.8 Surveying equipment and software used

1.9 Project schedule

1.1 Overview

Roads serve as the backbone of a country, around which unity, growth, and development revolve. There is no doubt that a well-developed road network enables a nation to achieve its security, strategic, military, economic, cultural, social, and political goals and policies.

Road engineering encompasses surveying the area where a road will be constructed, studying its topography and geology, creating designs, and analyzing materials and their properties. Whether these roads connect cities, neighboring countries, or serve tourist, agricultural, or other areas, the goal is to arrive at an appropriate engineering design. This process involves determining the geometric dimensions of the entire road and arranging visual elements such as the path, sight distances, lane widths, and slopes.

The process of constructing any road begins with conducting a feasibility study, which means the extent of the benefit provided by the proposed road compared to the cost. To do this study, we need to estimate the number of vehicles (called traffic volume) that are expected to use the road. Several methods are used, including:

Estimation: This is the expected traffic volume according to previous experiences for areas similar in population density, standard of living, etc., as similar areas in terms of population are expected to produce similar traffic volumes.

1.2 Project idea

The idea of the project includes designing and rehabilitating the Seventy Road in Jenin city, starting from (Al-Almaniyah circle) and ending with the bypass road. The importance of this road is that it is vital and serves a large number of residents of the region, as the road connects the Al-Almaniyah neighborhood and the bypass road located in the city of Jenin, and the road is considered an alternative. On other main roads and helps relieve pressure on them. The project aims to develop a safe

1.3 Project area

The project is located in the city of Jenin in the northern West Bank, in the Al-Almaniyah neighborhood located east of the city of Jenin, with a length of approximately (1400) meters, as shown in the picture:

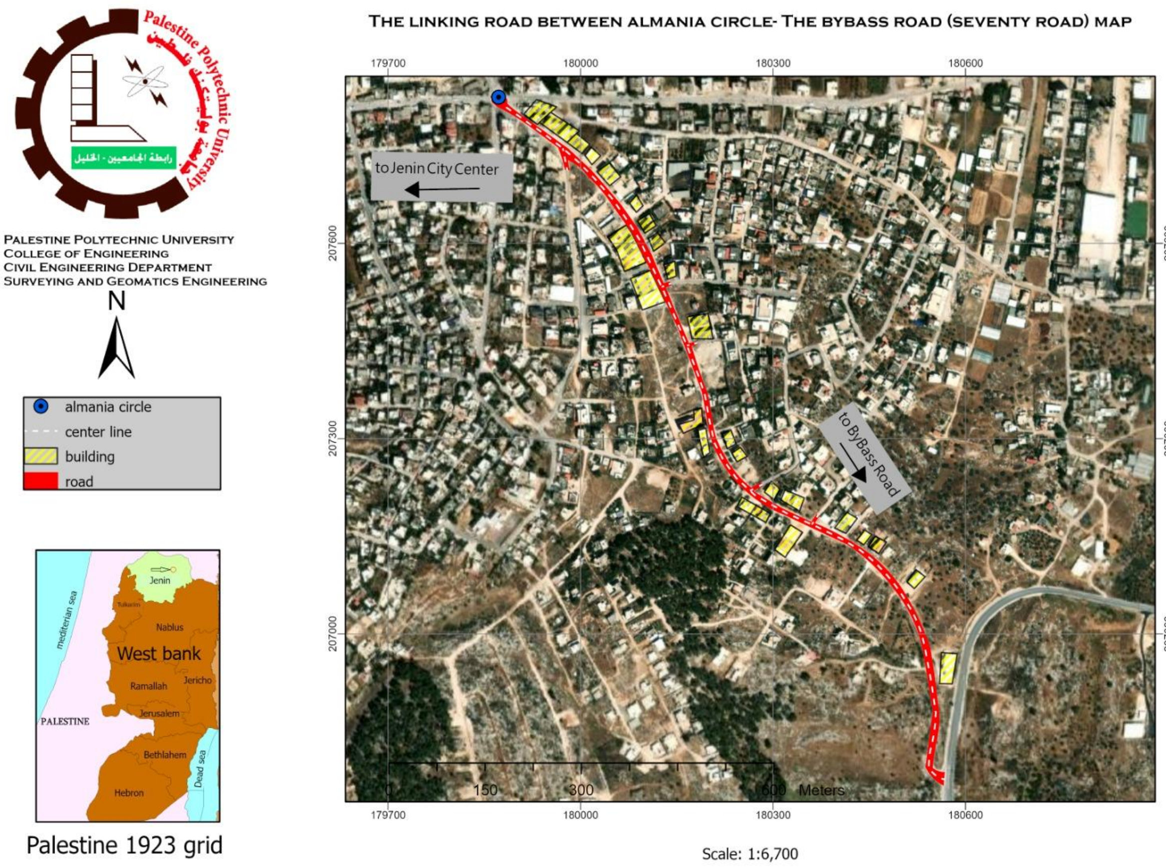


Figure 1.1: Project area

1.4 Objectives and importance of the project

- Enhancing the Area: The road's passage through an area makes it more vibrant and contributes to smooth traffic flow.
- Solving Traffic Crises: Addressing traffic congestion on main roads and finding alternative routes to alleviate pressure.
- Managing Rainwater: Designing side slopes for the road and creating drainage channels for rainwater and sanitary drainage based on engineering principles.
- Safety Considerations: Providing sidewalks, pedestrian crossings, lighting, and traffic signals as neede

1.5 Search method

- Research Topic Definition: Determine the subject of the research (Rehabilitation and design of Seventy Road in Jenin City and inquire about the topic from the supervisor.
- Work Area Identification: Define the work area and then conduct a survey visit to the site, gaining a comprehensive understanding of the project's nature, related issues, and crucial details for design and execution to achieve the best and most accurate results.
- Project Documentation: Write the project, adhering to the necessary principles and conditions in the introduction, discuss with the supervisor and consider their advice and opinion

1.6 Project structure

The graduation project includes several chapters that are being worked on, namely:

Chapter One: Overview.

It explains the research topic, importance, objectives, research method, research structure, equipment used, and project timeline.

Chapter Two: Surveying work.

This chapter contains surveying work, including a study of plans, reconnaissance work, and the initial surveying study, followed by the detailed raising stage, leading to the final surveying work, and learning about the satellite positioning system (GPS) and monitoring methods.

Chapter Three: Road problems and proposed solutions.

This chapter contains the problems encountered in the road and suggested solutions to them.

Chapter Four: Traffic volume and traffic signals.

This chapter contains a study of traffic volume through traffic counting, making the necessary calculations, traffic signals, and traffic safety.

Chapter Five: Laboratory Tests.

This chapter contains the results of soil testing and asphalt examination.

Chapter Six: Road Engineering Design.

This chapter covers the fundamentals of road engineering design, including the study of traffic volume, traffic composition, design speed, horizontal and vertical alignment, and road layers.

Chapter Seven: Road Construction Design.

This chapter focuses on the construction design of the road, considering pavement layer thicknesses and types of pavement to withstand the axle loads of vehicles traveling on this road.

Chapter Eight: Findings and Recommendations.

This chapter presents the findings and recommendations

1.7 Previous studies

Previous studies are considered as references, books, maps and plans that can be used in the design and planning process. Therefore, books that talk about road design and planning can be considered as previous studies of the road that we are working to rehabilitate in this project, and due to the abundance of books and literature in the field of road design, it has Several books and references have been relied upon that deal with the subject of roads, the most important of which are (Survey and Planning Curves) and (Cadastral Coverage of Roads), both of which are works by Dr. Youssef Siam. They deal with several topics, including horizontal planning and vertical planning, including horizontal and vertical curves, with an explanation of their types and Explain the laws related to them and explain that with some explained example, There are other books and references that were used, including road engineering, the surveying engineering book 1 and 2, and transportation and traffic engineering, which are considered compulsory courses in the field of surveying and geomatics at the university, in addition to some important sites on the Internet. We will work hard to benefit from these references in the good design of this book. The method is according to what was mentioned in these references

1.8 Surveying equipment and software used

1. We used a GPS device (Stonex S900A) (stonex data), (tripod) to stabilize the device while monitoring control points in a static manner.

Figure 1.2: type of the GPS device (Stonex S900A)

Figure 1.3: the tripod and data

2- Distance measuring tape

Figure 1.4: the measuring tape

3- Software (ArcGIS, Civil 3d)

Figure 1.5: the software used

1.9 Project schedule

Table 1-1 Shows a timeline for the project introduction

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Collect data about the project area																
Exploratory survey																
Field work																
Office work																
Starting drawing work																
Preparing the initial report for the project introduction																
Preparing the final report for the project introduction																

Chapter two

Surveying works

2.1 General introduction

2.2 Details of survey work

2.3 The initial survey stage

2.4 Detailed survey stage

2.5 Final survey work

2.6 Satellite Positioning System (GPS)

2.7 Survey methods

2.7.1 STATIC OBSERVATIONS

2.7.2 REAL TIME KINEMATIC " RTK " Method used to monitor the project

2.1 General introduction

When constructing and constructing the road, the basic objectives for which this road was built must be taken into account, the most important of which is the movement of users (vehicles and pedestrians) without any problems, reducing accidents and connecting areas by organizing movement on the road, whether for cars or people.

This can only be done by taking into account several things, such as the design speed, turns, intersections, traffic signals, and lanes. Without these things, the basic things desired from this road will not be achieved, and therefore they have the same importance as the road. The economic and social aspects must be taken into account, which will bring good returns to society. As a whole, therefore what is called the economic feasibility and importance that will be achieved through this work is done.

2.2 Details of survey work

This work takes place in four stages, the first stage is study plans, the second stage is exploratory work, the third stage is field work, and the fourth stage is office work as follows:

1. Study plans

These plans are obtained from official bodies such as municipalities and the academic supervisor. These plans are studied in order to get an idea of the nature of the area and the borders of the neighbors. It is possible to determine the route of the road and determine its location on maps. Make sure that it is not enough and you have to go to the field to find out the actual location.

2. Exploration work

1. The objective of this stage is to try to collect information about the area in which the road is intended to be reconstructed, by visiting the team to the road site and making a quick examination of the structure of the area, lines, telephone and electricity lines, and manholes.

3. Working in the field

The process begins with surveying the road details using a GPS device (STONEX S990A) and we used the RTK method to survey the road (mentioned below), from the center of the proposed road and then we monitor points to the left and right of the road. Details must also be taken into account such as buildings, fences, chains, electrical points, telephone points, and sections. Transverse every 10 meters and a sketch of the road, It was ensured that the device should be vertical and accurate so that we can obtain correct points and reduce errors as much as possible.

Steps to work in the field:

1 .Binding the device on the stand and binding the information collector on it

2. Connect the device to the Internet in order to establish a connection between the device (Receiver) and the Network of Bases (bases) and set the connection between the Receiver device and the information collector via Bluetooth technology.

3. Verify the connection and verify the accuracy given by the device.

4. The monitoring process began for all landmarks on the road to the right and left of the road, such as: existing asphalt, existing walls, electricity poles, communications poles, existing chains, fences, buildings, and signs.

5. A description was created within the device for each point that was monitored, and sketches were made for each complex area so that there would be no problem in connecting the points.

6. Ensure accuracy, signal strength, and number of satellites from time to time.

7. In places of tall buildings, two points were taken far from the building, and the measurement was made from the first point to the corner of the building and from the second point to the corner of the building in order to avoid errors resulting from the reflection of signals

8. Close the device and arrange it in its designated place in the box.

4. Office work

The Civil 3D software was utilized to connect the points as depicted in the diagram. Subsequently, we drew the buildings, profile, and contour lines for the area, as illustrated in the figure below. Afterward, we proceeded to design the road, incorporating features such as houses, trees, and curbs.

• Office work steps:-

1. The office work consisted of downloading the points in the form of CSV, and downloading them into the Civil 3D program.

2. Connect the dots and create colors and arrangements for the observed features.

3. Suggest an initial Center Line on the road to know the length of the road and identify problems on the road at each station on the road.

❖ It is very important to take into account when designing the road:

1- It must be economically feasible.

2- Make the most of it as much as possible.

- ❖ It is possible to summarize the most important surveying work that must be done to build the road :

1- Study previous plans for the area.

2- Exploration work.

3- Surveying work (preliminary, detailed, final). Therefore, it is necessary to know that engineering design is very important, as it will save time and effort and make road users safer.

2.3 The initial survey stage

At the beginning of this stage, the surveying team makes a “Control Point” in a static manner for 15 minutes for each point, revealing as much as possible all the points of the proposed way, as the goal behind making a “Control Point” that reveals the way points is to set coordinates and thus the locations of new points from Based on an old network of points whose coordinates are known accurately, such as a network of triangles, trigonometric surveying, or GPS points, thus, Control Point works contribute to condensing the networks of known points and making it easier to link other surveying works to the state’s general coordinate network

The following works were carried out :

1- Control Point distribution of the road, which begins with monitoring points via (STATIC) at lane change points.

2- surveying the existing road and all the existing details, including buildings, telephone and electricity poles, fences and chains.

3- Taking cross-sections at every 10 meters of the road to choose the appropriate levels and inclinations for design and implementation purposes to the right and left of the proposed project axis

❖ Table of control points coordinates:

Table 2-1 Table of control points coordinates

Point	Easting	`Northing	Elevation	Descrption
3000	179814.1292	207771.5749	144.0833	Control Point
4000	179883.784	207725.1299	145.307	Control Point
5000	179965.9031	207646.0896	147.1401	Control Point
6000	180045.7261	207525.3886	156.5064	Control Point
7000	180099.439	207398.7471	166.5294	Control Point
8000	180137.4934	207266.1694	176.6358	Control Point
9000	180171.3882	207207.0027	182.0695	Control Point
10000	180238.6615	207154.0436	188.4607	Control Point
11000	180329.7128	207113.9986	195.5712	Control Point
12000	180428.7514	207026.7274	203.3427	Control Point
13000	180466.3349	206945.9843	209.077	Control Point
14000	180482.1676	206856.1977	215.122	Control Point
15000	180477.2465	206783.34	218.3058	Control Point
16000	180476.1919	206755.4386	217.7583	Control Point
17000	180508.1404	206739.5588	217.3045	Control Point

❖ A picture showing the locations of control points :

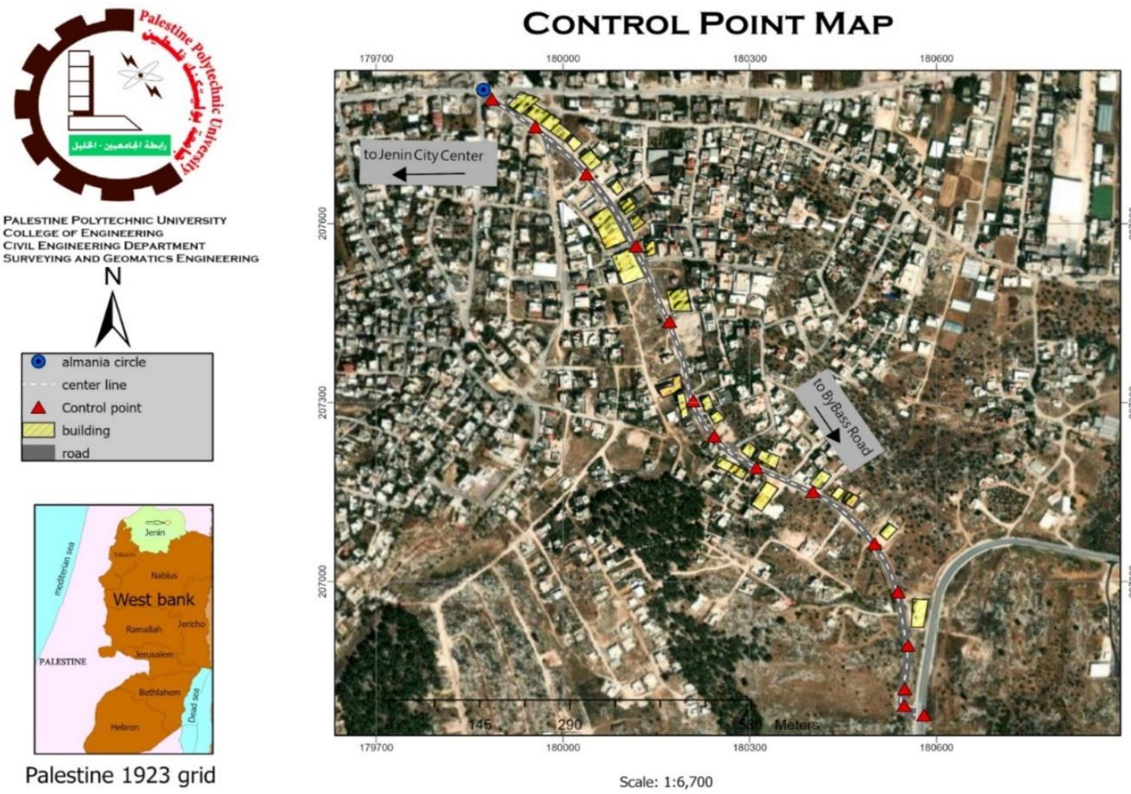


Figure 2.1: the locations of control points

2.4 Detailed survey stage

his is the initial stage in engineering project development. During this phase, surveying is conducted using various surveying instruments. This includes aerial surveying using photographs and ground surveying using GPS devices, which is the method employed in the project.

Surveying includes:

1. Boundary surveying and surveying of natural and human features.
2. Elevation surveying for the project.

3- Comparison between observed elevations and contour line

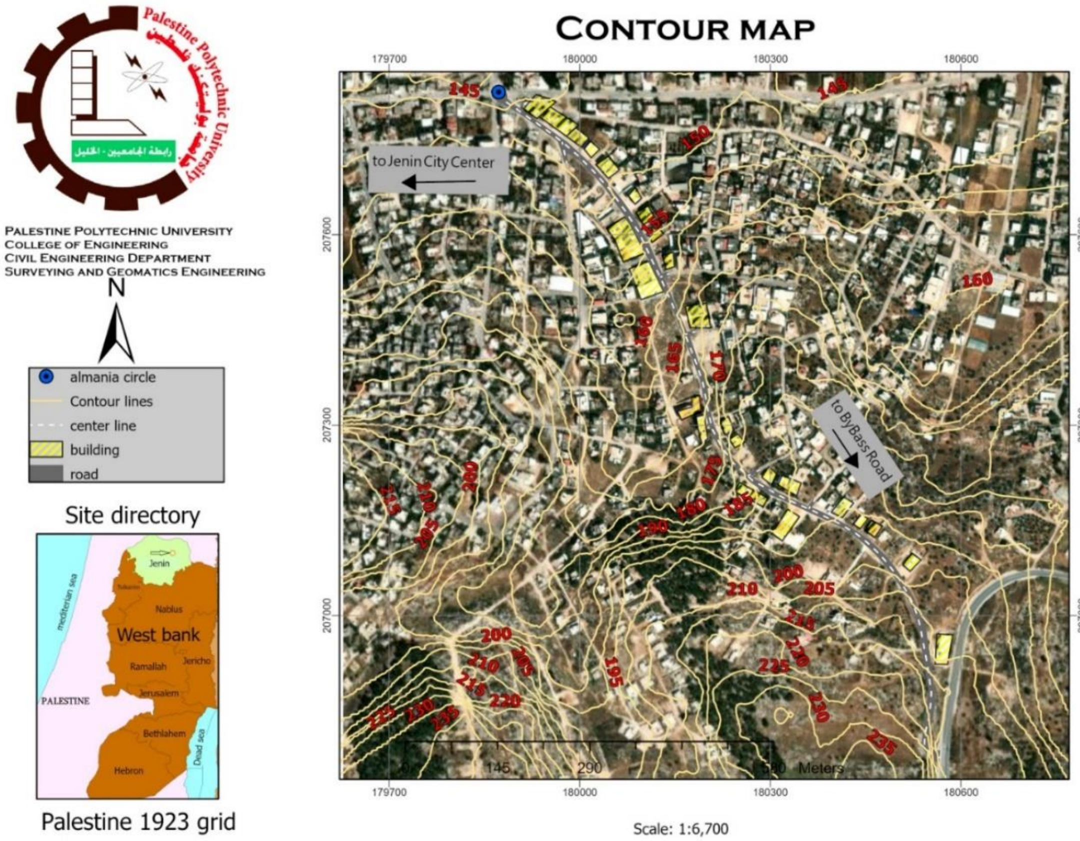


Figure 2.2: contour line map

2.5 Final survey work

After the initial plans are completed, the design team can use these plans and various spatial information to study and redesign the street.

This study usually includes drawing longitudinal sections of several paths for the purpose of estimating the amount of earthworks, such as excavation and backfilling, The designing team must also take into account the various environmental, social, economic and technical aspects that help in rehabilitating the road.

2.6 Satellite Positioning System (GPS)

The signals sent by satellites in the GPS system are very complex signals, as they use many techniques to form these signals and send them to ground receivers.

The reason for the complications in the signal structure of GPS satellites is that these signals must be sent from an altitude of about 20,200 km to the surface of the Earth. Therefore, if these signals are sent in the usual way for terrestrial systems, they will reach the Earth (if they do) with difficulty due to the noise sources present around the devices. Reception: Therefore, these devices will not be able to receive useful information from the satellites, and we will not be able to determine their required coordinates.

These receivers are widely used in military surveying work, where combat surveying areas are surveyed and the most important points of the world and their coordinates are determined, as well as in civil surveying in order to survey cities, lands, and various roads. This process is very necessary to build a new geographic system called the Geographic Information System, which has become very necessary in Various developed countries.

The accuracy and comprehensiveness of the surveying work must be such that it allows determining or choosing the axis of the best road that can pass through each path. In order to achieve this, it is usually done by measuring, calculating and correcting the coordinates of all points (Control Point).

2.7 Survey methods

2.7.1 : Static Observations

In this method, the GPS receiver is placed over the points to be surveying without moving the device for a certain period of time (in our project, the points were surveyed for 10 minutes). This method gives very high accuracy, and is used in the following :

1- Surveying geodetic networks

2- First-order triangle networks

3- Survey long lines

2.7.2 :Real Time Kinematic RTK Method used to monitor the project

This method has the advantage that it is possible to obtain the coordinates at the site on the data processor screen, and it is used in projects that do not require great accuracy (within a range of 3 cm).

Several methods are used to process the data in real time, including :

- **Correction factors based on the area covered (Area Correction Parameter (ACP) :**

In this method, a group of bases is distributed among points with known coordinates, such that each one exceeds a specific area. If the observer is present in the area covered by the base, corrections are sent to him from the nearest base, and the length of the base line is less than 30 km.

- **Virtual Reference Station (VRS) :**

This system uses a set of rules distributed over a network covering the area it serves. They are all connected to one server to which corrections are sent in real time. When the user begins monitoring, the first location is sent with an accuracy of up to 10 m. Then the corrections information from the rules is used and a mathematical approach is used. Relatively, the location is corrected and is considered the hypothetical station that the system begins to adopt and measure the length of the base line from and send the corrections to the user based on them. The benefit of this system lies in that it reduces the length of the base line, which reduces the error resulting from changes in the atmosphere.

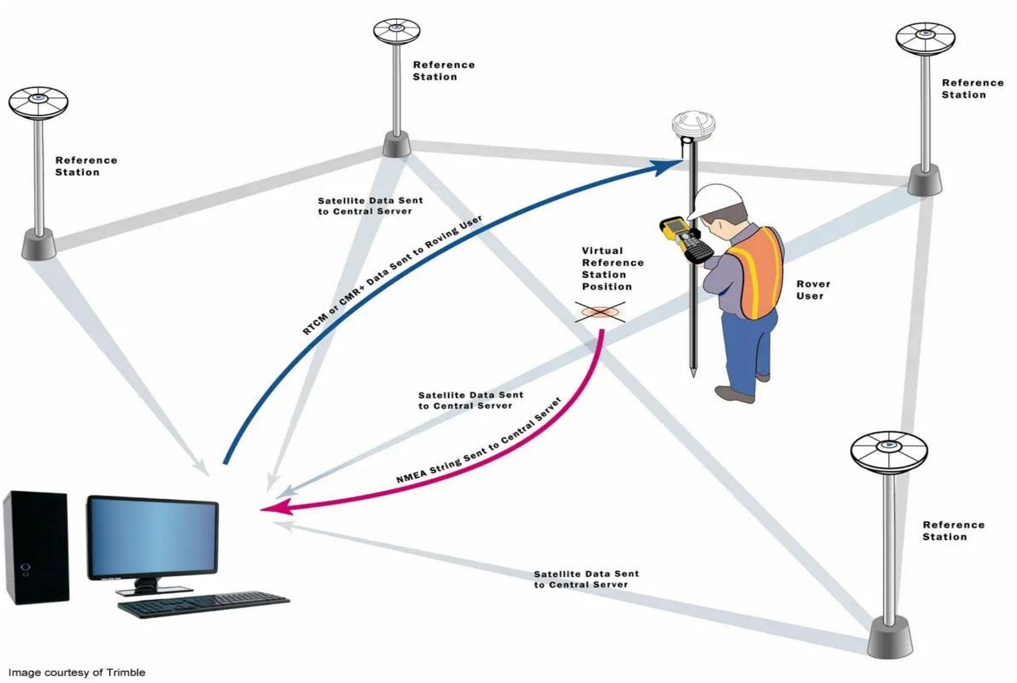


Figure 2.3: Virtual Reference Station (VRS)

Chapter Three

Road problems and their proposed solutions

3.1 General introduction

3.1.1 Types of roads

3.2 Special problems on the road and proposed solutions

3.2.1 Narrowness of the road

3.2.2 Poor drainage of rainwater from the surface

3.2.3 Cracks in the road surface

3.2.4 There are no sidewalks on the road

3.2.5 The desired goals of diagnosing problems and developing appropriate solutions to them

3.1 General introduction

"Developing appropriate solutions for existing road problems is an essential and necessary step to ensure safe and comfortable roads. Before implementing these solutions, a comprehensive assessment of the road is crucial to identify existing flaws and determine the best approaches to address these issues.

The Seventy Street in Jenin faces several challenges and obstacles that hinder the road redesign process and impact the structural planning. Therefore, it is essential to discuss these problems and work diligently to find solutions. Studying and identifying solutions for redesign obstacles are the initial steps toward creating a good road design, considering technical, construction, and traffic aspects, and ensuring long-term service for the area. After conducting a field visit and studying all engineering aspects, we will present these obstacles and problems along with explanations for each and possible suggestions for resolution".

3.1.1 Types of roads

Road Categories

There are two general categories of roads based on their locations :

Urban Roads: Urban roads are found within cities, towns, and villages (i.e., within the administrative boundaries of local authorities). These roads are classified into arterial roads, collector roads, and local roads. It’s worth noting that in urban areas, there are sometimes agricultural roads as well, which serve the agricultural lands in those areas. These roads are considered local roads, and there is no minimum width requirement for their right-of-way. However, it is preferable for the right-of-way width not to be less than 6 meters

Rural Roads: Rural roads are located outside the boundaries of cities and towns. The classification of these roads is based on what was adopted by the Supreme Planning Council in 1998 during session number 98/4 regarding the Palestinian regional road project and its accompanying regulations. This classification generally considers the network structure and the importance of the roads. Rural roads are further categorized into highways, main roads, regional roads, and local roads

aspects, we will present these obstacles and problems along with explanations for each and possible suggestions for resolution".

3.2 Poor drainage of rainwater from the surface

If we were to multiply examples of problems on any road, it would not require any effort. When examining any road, you find that it is filled with issues. This situation can result in significant human and material losses. After conducting a field visit and studying all engineering aspects, we will present these problems along with explanations for each and possible suggestions for resolution.

Key Road Problems:

1. Narrow Roads: Insufficient road width.
2. Poor Rainwater Drainage from the Surface: Inadequate drainage systems for rainwater .
3. Asphalt Cracks and Types: Cracks in the asphalt layer and their various types.
4. Lack of Sidewalks: Absence of sidewalks or pedestrian pathways.
5. Inadequate Lighting: Insufficient street lighting.
6. Missing Traffic Signs: Absence of proper traffic signs.

3.2.1 Narrowness of the road

Clarification of the problem :

The road under study has been observed to be narrow. Its current width is approximately 5 meters. This narrowness results in vehicles having to drive on the edges of the road when two vehicles meet, which can increase the risk for road users. This factor discourages citizens from using the road. Additionally, addressing this issue may require widening the curves

.

Figure 3.1: An image showing the narrowness of the road

3.2.2 Poor drainage of rainwater from the surface

Problem Description: The surface drainage encompasses all aspects related to removing rainwater from the road's vicinity. Proper design of the surface drainage system should align with the amount of rainfall that occurs on or near the road. When a well-designed rainwater drainage system is in place, it reduces damage to vehicles and minimizes the risk of future asphalt layer cracks.

Upon examining the road, differences in elevation become apparent from the beginning to the end. During winter, rainwater flows across the road, accumulating in lower-lying areas. Additionally, the lack of proper drainage infrastructure exacerbates the issue.

When examining the road, differences in elevation become apparent from the beginning to the end. During winter, rainwater flows across it, accumulating in lower-lying areas. Additionally, there is a lack of proper drainage infrastructure.

Figure 3.2: An image showing poor rainwater drainage

Proposed Solutions:

To address this problem, channels for water drainage should be constructed to align with the road's slope, ensuring that water does not accumulate in the middle of the road and affect the asphalt layers.

3.2.3 Cracks in the road surface

1. Alligator Cracking
2. Block Cracking
3. Edge Cracking

1. Alligator Cracks: These are interconnected and sequential cracks resembling alligator skin that occur on the road surface due to asphalt layer failure. These cracks begin beneath the asphalt layer and extend to the surface in the form of longitudinal cracks, eventually connecting at sharp angles. If left without maintenance, they can lead to potholes in the road.

Figure 3.3: An image showing alligator cracks

These road cracks occur due to one or more of the following reasons:

1. Weak Subbase and Subgrade Layers:
2. Poor materials used or aging over time weaken the subbase and subgrade layers.
3. Insufficient Pavement Thickness:
4. Inadequate thickness of pavement layers.
5. Poor Water Drainage in Soil Under the Path or Subgrade:
6. Inadequate drainage of rainwater from the surface and structure of the road, leading to ponding on the road or in ditches.
7. Increased Loads and Traffic Movement.

2. Block Cracking:

Block cracking appears as a pattern of roughly rectangular blocks, ranging in size from 30 cm to 3 meters.

Causes:

1. Thermal Expansion and Contraction:
2. Resulting from changes in ambient temperature.
3. Common in Older Asphalt Layers.

3. Edge Cracking:

Longitudinal cracks occur in the outer 0.3 to 0.6 meters of pavement, curving toward the pavement edge.

Causes:

1. Insufficient compaction at the road edge according to specifications for either the base layer or the subbase layer, or both.
2. Use of non-compliant fill materials in the base and subbase layers.
3. Discontinuity between old and new asphalt due to gradual or uneven welding execution.
4.

3.2.4 There are no sidewalks on the road

sidewalks or designated pedestrian spaces, which is a significant issue. Many pedestrians use this street to reach the Korean school, and they are forced to walk on the narrow road alongside vehicles. Improving the walking environment necessitates creating safer and convenient sidewalks for moving between stores, crossing roads, and intersections. A well-designed sidewalk would be comfortable, secure, and appealing for pedestrians, enhancing the overall appearance of the neighborhood and encouraging people to use it.

Proposed Solutions: Appropriate sidewalks will be designed on both sides of the road for pedestrians, with suitable width and using materials like stones or concrete. These sidewalks will be protected from water and erosion, look at fig 3.1.

3.2.5 The desired goals of diagnosing problems and developing

1. Extending the operational life of the road.
2. Reducing the cost of transportation on the road.
3. Ensuring the road surface in good operational condition.

Chapter Four

Traffic volume and traffic signals

4.1 Introduction

4.2 Traffic Volume

4.3 Current and future progress

4.4 Road age

4.5 Road capacity

4.6 Traffic counting

4.7 Traffic signals, traffic signals and lamp posts

4.1 Introduction

Traffic engineering is the science that studies and evaluates traffic movement for various modes of transportation. It involves examining the fundamental laws related to traffic flow and its generation, as well as the practical applications of this knowledge to achieve safe and efficient operations.

The field of traffic engineering encompasses both road engineering and traffic management. When designing and constructing roads for vehicle use, it is essential to incorporate regulatory measures to organize traffic flow. This ensures optimal performance and prevents accidents, ultimately achieving the road's intended purpose.

Traffic engineering covers several aspects, including traffic directions, lane markings, turning (both right and left), intersections, stopping points, and more. These elements are equally important as the road itself, so they must be considered during road design. Implementing these features during road construction ensures they become integral parts of the road infrastructure.

Signs, road markings, intersections, traffic lights, public parking areas, and designated stopping zones—all these elements are strategically placed to facilitate traffic movement. The road users play a crucial role in determining travel time, location, origin, and destination. These users can be pedestrians, cyclists, private vehicles, taxis, or heavy-duty trucks. Therefore, traffic planning heavily relies on understanding user behavior, preferences, and abilities.

Road users often seek shortcuts to save time and effort. When in a hurry, they may increase their vehicle speed, fully aware of the risks associated with high speeds—the primary cause of most fatal accidents. Pedestrians and cyclists, especially those who disregard traffic rules and crosswalks, also contribute significantly to accidents within urban areas.

In summary, traffic engineering aims to create a harmonious balance between road infrastructure, user behavior, and safety, ensuring efficient

4.2 Traffic Volume

Traffic volume is one of the essential factors to consider during road engineering design. It involves studying and estimating the volume of traffic on roads, taking into account the connections between different road segments. Traffic volume is measured by the number of vehicles passing through a specific point or station on the road during a certain time period. This is expressed as the Average Daily Traffic (ADT) or the Annual Average Daily Traffic (AADT)1.

Average Daily Traffic (ADT): ADT represents the total volume of traffic measured during a specific time period, which is more than one day but less than a year. It is calculated by dividing the total traffic volume by the number of days the survey was conducted. The unit of measurement is “vehicles per day.”

Annual Average Daily Traffic (AADT): AADT is the total volume of daily traffic over a year, divided by the number of days in that year. The unit of measurement remains “vehicles per day.”

Using the annual total traffic volume, we can analyze traffic growth trends, calculate accident rates, and estimate the economic impact on road users. The formula for traffic volume is:

$$\textbf{TRAFFIC VOLUME} = \frac{VEHICLE}{TIME} \quad \ldots \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation 1)}$$

Designing based on the average daily traffic volume alone, without considering peak hours, can lead to congestion during rush hours. Additionally, designing a road that is never congested is not economically feasible. Therefore, selecting the design traffic volume requires detailed and precise study.

Some of the main reasons for traffic-related issues include increased population density, higher vehicle ownership rates, and insufficient road space. The challenge lies in ensuring that the allocated space for traffic growth keeps pace with population increases

4.3 Current and future Traffic Volume

The volume of traffic increases day after day, and when planning the future road, the future volume of traffic on the road must be taken into account during the design, in order to avoid traffic congestion in the future, and in order for the road to fulfill the purpose for which it was designed, which is to accommodate the current and future traffic volume, so the following matters must be taken into consideration. Consideration:

1. Current Traffic: Accurate data on the current traffic volume is essential. This can be obtained by surveying the traffic on the existing road or the roads leading to the planned road.

2. Vehicle Usage: Consider the natural increase in the number of vehicles due to population growth, economic development, tourism, agriculture, and industry in the area.
3. Traffic Generated by Road Construction: Anticipate the traffic that will result from constructing the new road.

4.4 Road age

All factors related to increased traffic volume indicate that road planning and design cannot be based solely on the current traffic volume. Instead, the design should consider the road's future lifespan—for example, 10, 15, or 20 years—to accommodate traffic during that period. Afterward, the road becomes inadequate and requires rehabilitation. Designing a road for a short period leads to continuous rehabilitation needs, while designing for an extended timeframe significantly increases costs but reduces effort compared to short-term designs. Therefore, roads are often designed with a future lifespan of around 20 years.

4.5 Road capacity

Road capacity refers to the maximum number of vehicles that can reasonably be expected to pass through a road during a given time period under prevailing road and traffic conditions. It depends on traffic volume, traffic composition, driving speed, and the interactions experienced by traffic flow. Capacity is a fundamental consideration when designing the cross-sectional layout of a road to accommodate the expected design traffic volume. Table 4-1 illustrates capacity values for various types of roads according to AASHTO specifications.

Table 4-1 It shows the capacity values for some types of roads according to AASHTO specifications.

Capacity (private car/hour)	Road type
2000 (For each lane)	highway
3000 (Total in both directions)	Two lane road
4000 (Total in both directions)	Three lane road

Several factors influence road capacity:

1 . Horizontal and Vertical Planning:

Sharp horizontal curves and short vertical curves reduce road speed, leading to decreased capacity.

2 . Lane Width:

Narrow lanes and tight shoulders along the road decrease its capacity.

3 . Transport Vehicles:

The presence of commercial vehicles affects traffic flow and reduces road capacity.

4.6 Traffic counting

Road traffic calculation:

It is the process of collecting data on the number and type of vehicles that use a particular road or road network. This data is used to understand traffic patterns and identify congestion areas, as well as to inform transportation planning and policy decisions.

❖ There are many methods used to calculate road traffic, including:

1- Manual (this is the type that was used in the project): The simplest way to calculate traffic and includes physical monitoring and recording the number of vehicles passing through a specific location. This method is typically used for short periods of time, such as a few hours or a day, and is prone to errors due to possible human error or observer bias. However, manual counting can be useful in situations where other methods are impractical, such as in areas Remote or rural.

2- Video Analytics: It is a method of calculating traffic that uses video cameras to capture images of traffic and analyze the data using computer algorithms. This method can provide detailed information about traffic volume, speeds, and patterns, in addition to information about the type and size of vehicles. Video analytics can be used to calculate Traffic on both urban and rural roads, but requires the installation of cameras and the use of specialized software

There are many factors to consider when choosing a method for calculating traffic, including the type of data required, the accuracy required, resource availability, and cost. Traffic data is usually collected at regular intervals, such as hourly, daily, or weekly, and is used to understand traffic patterns. To determine trends over time, it is important to ensure that the data represents typical traffic conditions and is not affected by unusual events, such as road closures or special events.

Traffic data is used for a variety of purposes, including transportation planning, traffic engineering, and transportation research. It can help identify areas where traffic jams or congestion exist and inform decisions about infrastructure improvements or changes in transportation policies. It can also be used to evaluate the effectiveness of Transportation projects or policies and to evaluate the impact of new developments or changes in land use patterns.

❖ Traffic counting location:-

Figure 4.1: An image shows the location of the traffic count

The traffic count in this area was carried out during three periods over one day .

Each period lasted an hour with an interval of 15 minutes. The first count was done in the morning, the second during peak hours, and the third in peak hours in the evening.

- **The results of the morning period for Tuesday 2/4/2024 .:**

Table 4-2 shows the results of the traffic count during the morning period

Time (AM)	Cars	Trucks	Buses	Toatal
7:30-7:45	42	6	5	53
7:45 - 8:00	37	4	4	45
8:00 - 8:15	29	7	1	37
8:15 - 8:30	33	2	3	38
Sum	141	19	13	173

From the table, we note that the largest traffic volume recorded through the traffic count was at (7:45-7:30), where the number of vehicles reached 53 vehicles in a time period of 15 minutes.

❖ Calculating the flow rate in the morning:

Flow rate = largest traffic volume in 15 minutes x 4

Flow rate 53*4= 212 vehicles/hour.

- **The results of the after noon period for Tuesday 2/4/2024 .:**

Table 4-3 shows the results of the traffic count during the after noon period

Time (AM)	Cars	Trucks	Buses	Toatal
11:00 - 11:15	65	15	3	83
11:15 - 11:30	60	9	2	71
11:30 - 11:45	55	18	4	77
11:45 - 12:00	77	13	2	92
Sum	257	55	11	323

From the table, we note that the largest traffic volume recorded through the traffic count was at (12:00-11:45), where the number of vehicles reached 92 vehicles in a time period of 15 minutes.

❖ Calculating the flow rate during the afternoon:

Flow rate = largest traffic volume in 15 minutes x 4

Flow rate 92*4= 368 vehicles/hour.

- **The results of the evening period for Tuesday 2/4/2024 .:**

Table 4-4 shows the results of the traffic count during the morning period

Time (PM)	Cars	Trucks	Buses	Toatal
3:00 - 3:15	46	4	2	52
3:15 - 3:30	53	5	1	59
3:30 - 3:45	38	8	1	47
3:45 - 4:00	35	10	0	45
Sum	172	27	4	203

Through the table, we note that the largest traffic volume recorded through the traffic count was at the time (3:15-3:30), where the number of vehicles reached 59 vehicles in a time period of 15 minutes.

- **Calculating the flow rate during the afternoon:**

Flow rate = largest traffic volume in 15 minutes x 4

Flow rate 95*4= 236 vehicles/hour.

• Calculation of the total traffic flow rate: 212+368+236 = 816 We divide the total by 3 816/3 = 272 vehicles/hour.

- **Calculation of the Peak Hour Factor (PHF) :**

- **PHF = V /Vt(60/t)………………………. (Equation number 2)**

V = Traffic volume during the three hours

V = 272 vehicles/hour

Vt = Maximum traffic flow during the time periods (t) in the three periods.

Vt = 92

PHF=272/(92*4)=0.73913

The value of the factor is 0.73913, which means that the traffic flow during the peak hour was regular, and that the demand for this section of the road was high throughout this hour.

Total number of vehicles = (Number of small cars *1 + Number of trucks *3 + Number of buses * 2.5) / Number of counting days.

Table 4-5 shows the total number of vehicles on the road.

Total number of cars	570
Total number of trucks	101
Total number of buses	28

- Number of cars = (570 * 1) /3 = 190 cars **(Equation number 3)**
- Number of trucks = (101* 3)/3 = 101 trucks **(Equation number 4)**
- Number of buses = (28 * 2.5) /3 = 23.33 buses **(Equation number 5)**
- Average total number of vehicles = (190 + 101 + 23.33) = 314.33 vehicles **(Equation number 6)**
- Average Daily Traffic (ADT) = 314.33* 24 = 7544 vehicles **(Equation number 7)**
- Average Annual Daily Traffic (AADT) = 7544* 50 = 365/ 1033 vehicles **(Equation number 8)**
- Average daily traffic after 20 years = 7544 * 2.5 = 18860 vehicle **(Equation number 9)**

4.7 Traffic signals, traffic signals and lamp posts

Traffic Lights: These are signal devices placed at road intersections or pedestrian crossings to regulate traffic flow and control it safely using colored lights according to a globally agreed-upon system. Traffic lights exist in many cities around the world. They illuminate in three main colors:

- Red Light: Indicates stop.
- Yellow Light: Warns drivers to prepare to move or clear the area.
- Green Light: Allows passage.

Figure 4.2: An image shows the traffic signal

❖ Streetlight Poles: Streetlight poles help improve safety and visibility by illuminating sidewalks and roads. They play a crucial role in enhancing safety for pedestrians, especially during low-light conditions. For single-lane roads, the streetlights should be positioned on the side of the road within the sidewalks. In the case of dual-lane roads, they can be placed in the median island.

❖ Traffic Signs and Guidance Panels: Traffic signs and guidance panels are used to inform people about locations, directions, whether to proceed or stop, and other matters that regulate pedestrian and vehicle movement. When designing and installing guidance panels, important considerations include:

1- Correct Placement: Ensure that the sign is positioned correctly based on the need, whether parallel or perpendicular to the curb.

2- Height Consideration: Use the average eye level as a standard for determining the height of guidance signs. The height should not be less than 2.1 meters to avoid obstructing pedestrians.

3- Clarity and Simplicity: Keep the content of the signs simple, clear, and directly meaningful.

4- Proper Installation and Maintenance: Ensure correct installation and periodic maintenance.

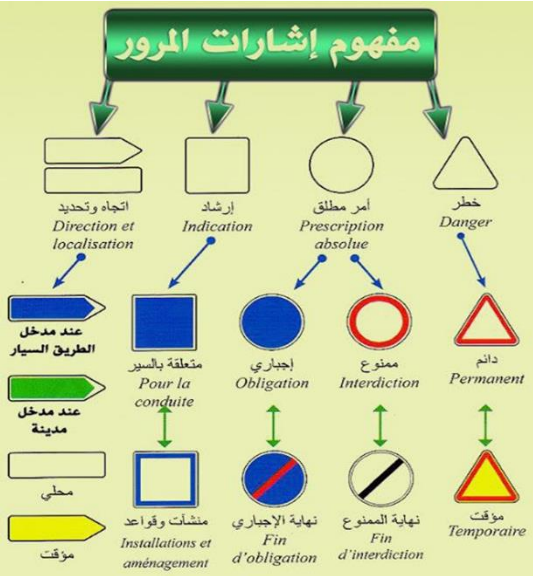


Figure 4.3: An image shows the types traffic signal

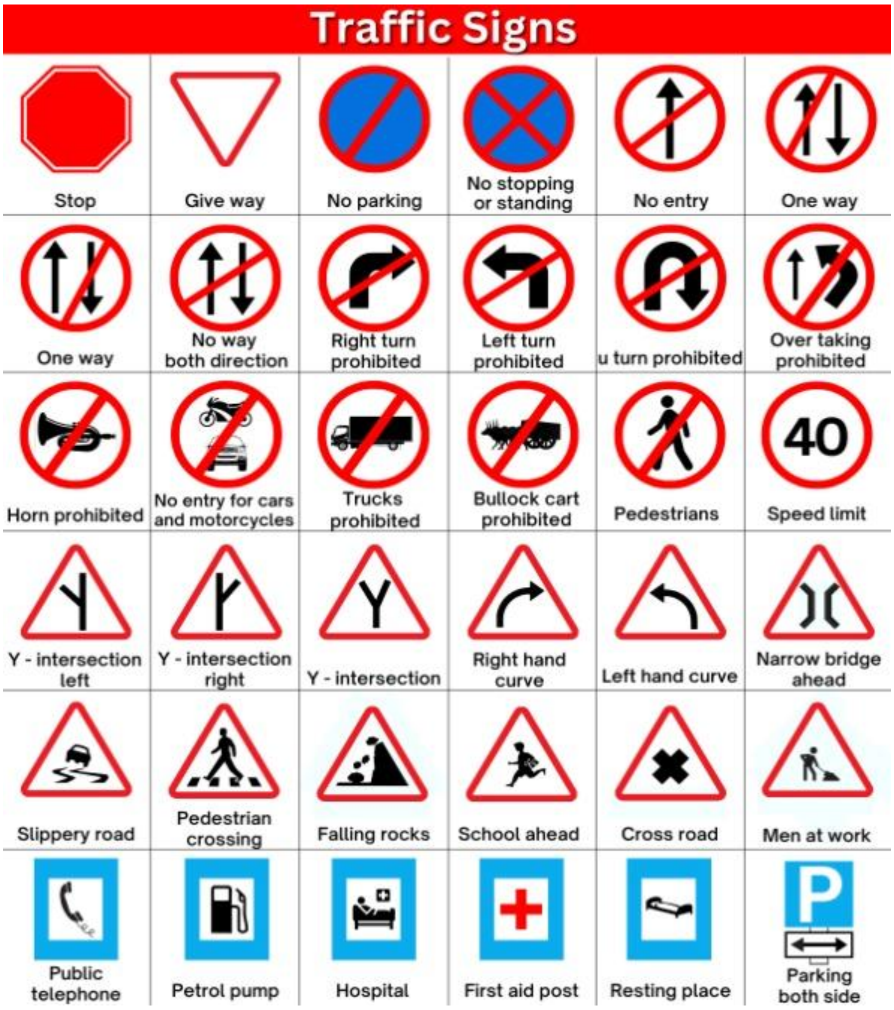


Figure 4.4: Traffic signal board

It is worth noting that all traffic signs are limited to a circle, a triangle, and a rectangle, and each of them expresses a specific thing about the road. Through this explanation, we have learned what traffic signs are and what they mean.

Table 4-6 shows the traffic signals that will be used on the road

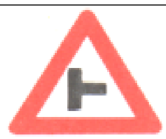
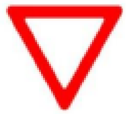
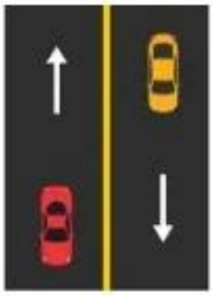
The meaning	Signal
Boys near the place	
Sharp turn to the left	
Intersection junction	
Intersection junction to the left	
Intersection junction to the right	
Give priority to the traffic in front of you	
No overtaking	
No overtaking for trucks over 4 tons	

Table 4-7 Shows the lines that will be used on the road

	CROSS IT WHEN IT IS SAFE AND COME BACK AFTER OVER TAKING
	DON NOT OVERTAKE
	CANNOT CROSS FOR OVER TAKING
	MOVE FORWARD SINCE PROHIBITED
	LANE TRAFFIC

Chapter Five

Laboratory tests

5.1 Introduction

5.2 Site Investigation

5.3 Sample Extraction And Packaging

5.4 Types Of Soil Samples

5.5 Laboratory Experiments

5.5.1 PROCTOR COMPACTION TEST

5.5.2 CALIFORNIA BEARING RATIO – CBR TEST

5.1 Introduction

Laboratory soil testing aims to identify its main physical,
chemical, and mechanical properties, which allows these characteristics to be considered when designing the road. The main objectives of soil testing can be summarized as follows:

1. The ability to accurately classify the soil.
2. Identify properties related to soil stability under load (Strength requirements) and its bearing capacity.
3. Study the effect of groundwater, if present, on soil behavior and understand the possibility of its level changing over time.
4. Examine the impact of surrounding weather conditions (rain, snow, temperature, etc.) on soil behavior.

5.2 Site Investigation

Soil tests conducted on_site and in the laboratory are part of a broader process called site inves tigation. This is a comprehensive task that includes several steps arranged as follows:

1. Collecting preliminary information about the site: Important details about the site and its surroundings, such as land and site layout plans, any available data on soil properties in a djacent areas, utility lines, and other information gathered from various sources.
2. Visiting the site: This follows the information gathering step and involves an initial visit to the site to understand its shape, topography, geology, and other characteristics.

5.3 Sample Extraction and Packaging

The first sample is taken directly from the ground
surface. Subsequent samples are taken at a rate of at least one sample per meter, as well as at soil layer changes. Samples are immediately sealed in airtight containers like plastic containers or bags and placed inside fabric bags, ensuring they are not compressed when placed in the bag. Each sample is then encased in an outer casing of the same dimensions, made of wood or similar material, to protect it during transport.

Sampling is one of the most critical stages of geotechnical work, no less important than the tests to be conducted on the samples. Hence, accuracy and caution are essential when taking and pack aging samples to ensure they represent the original soil nature. The quantity of samples must also be sufficient for the required tests.

5.4 Types of Soil Samples

The results of laboratory tests depend on the knowledge and skill of the site investigation team i n properly determining sampling locations and how representative the sample is of the soil layer it was taken from, along with accurate measurement, preservation,
and transport to the laboratory to maintain its natural properties.
The main types of soil samples extracted from the site are:

1. **Cohesionless Soil Sampling:** It is challenging to obtain undisturbed samples in cohesionless soils like sandy soils or soils with a high proportion of aggregate. Minimal disturbance samples are taken using thin-walled sampling tubes, and sometimes samples are taken by freezing the surrounding area.

   Due to the difficulty in obtaining good samples, some field tests are usually conducted on-site.

   Disturbed samples are taken either manually using hand digging tools like shovels or mechanically using automated drilling equipment at depths specified by the supervising engineer for tests such as unit weight, specific gravity, soil classification, mechanical analysis, California bearing ratio, and chemical tests in the laboratory.

2. **Disturbed Soil Sampling:** These samples have disturbed soil structure and changed mec hanical properties during sampling. They can be taken manually, and in cohesive soils, they can be taken during drilling with an auger. For rock, samples can be taken by rotary drilling.

3. **Undisturbed Soil Sampling:** These samples retain their original structure and properties. They can be obtained from cohesive soils by hand-
cutting to get a single mass using a cutting edge sampling tube. For rocky soils, continuo us samples are obtained at drilling depth using rotary drilling equipment.

4. **Rock Sampling:** When extracting rock samples, the same equipment used for soil sampli ng is used after replacing the drilling tools with rock tools. It is advisable to consult an expert in the geology of the area and the types of rocks present to determine the rock's str ength and durability and the need for sampling. For solid and cohesive rocks, cylindrical samples are taken for compression tests. For soft and friable rocks, samples are extracted after filling them with cement to bind the rock parts together. Cement can be used in adja cent drill holes to arrange fractures in the rock layers.

5.5 Laboratory Tests

5.5.1 Proctor Compaction Test

The purpose of this test is to determine the maximum soil
density and optimum water content in order to calculate the compaction ratio on_site for the material samples that will be used in road project layers.

Work Steps:

1. A 50 kg sample was collected from the site, then sieved through a 3/4 inch sieve to remove large gravel.
2. Weigh 7 kg of the sample for testing.
3. Add 5% of the sample's weight in water and mix the water thoroughly into the sample.
4. Prepare and set up the mold.
5. Place layers of the sample one after the other, compacting each with 56 blows from a standard hammer. Then level the surface, extract the sample, and weigh it inside a known -weight can for each attempt.
6. After preparing and filling the cans for each attempt, they are placed in an oven for 24 hours.
   Then, take the necessary readings to calculate the moisture content and soil density
7. Plot the relationship between moisture content and density, where the peak of the curve represents the maximum density and the optimum water content.

Calculations and Results:

1. Moisture content = weight of water / dry weight of sample.
2. Weight of water = weight of can with sample (wet) - weight of can with sample (dry).
3. Dry weight of sample = weight of can with sample (dry) - weight of can.
4. Wet density = wet weight of sample / sample volume, where the sample volume is the Proctor mold volume.
5. Dry density = wet density / (1 + moisture content).

Table (5-1) Moisture Content and Dry Density

Test no	1	2	3	4
Water added(cc)	400	120	120	120
Wt.of cylinder+wet soil(gm)	9465	9608	9784	9776
Wt.of cylinder(gm)	5092	5092	5092	5092
Wt.of wet soil(gm)	4373	4516	4692	4684
Wet density (gm/cc)	2.059	2.126	2.209	2.206

Table (5-2) Proctor Test Readings for Finding Moisture Content

Dish no.	4	A1	38	B12	A14	A2	9	C9
Wt of dish+wet soil (gm)	215.4	206.8	187.2	207.3	194.8	196.4	256.0	274.5
Wt of dish+dry soil(gm)	208.3	200.0	179.2	198.5	183.7	185.4	238.6	256.7
Wt of dish(gm)	30.3	30.3	31.6	41.4	29.1	31.9	26	32.4
Wt of water(gm)	7.1	6.8	8.0	8.8	11.0	11.0	17.4	17.8
Wt of dry soil(gm)	178.0	169.7	157.1	157.1	154.6	153.5	212.6	224.3
Moist content(%)	3.99	4.01	5.60	5.60	7.18	7.17	8.18	7.94
Ave. moist content(%)	4.0		5.51		7.18		8.06	
Dry density(gm/cm3)	1.980		2.015		2.061		2.041	

Table (5-3) Moisture Content

Test no	1	2	3	4
Moist content w/c(%)	4.0	5.51	7.18	8.06
Wet density (gm/cm3)	2.059	2.126	2.209	2.206
Dry density (gm/cm3)	1.980	2.015	2.061	2.041

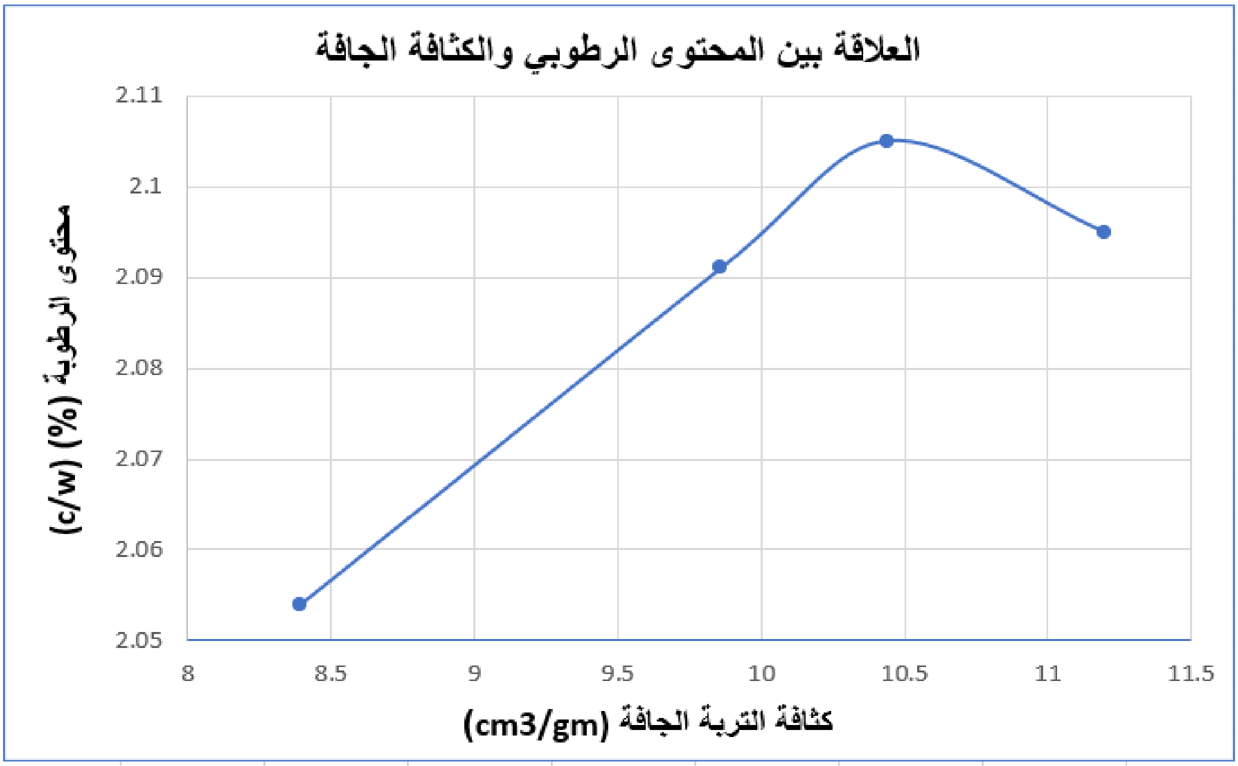


Figure (1-5): The Relationship Between Moisture Content and Dry Density

%7.18 = (o.m.c) Ideal amount of water (cm3/gm) 2.061 = Maximum dry density

5.5.2California Bearing Ratio (CBR Test)

The CBR test is one of the essential soil tests in road engineering. It aims to determine the soil's base layer or other layers making up a road, and to establish the_suitability as a base layer or sub specified layer thickness.

Work Steps:

1. Add the moisture content obtained from the previous test to the sample and mix it thorou ghly, then prepare the mold for placing the layers.
2. Add the sample layers, compacting each with 56 blows using a modified hammer, then le vel the surface.
3. Place the mold under the device, start it, and begin observing and recording the readings.

The table below shows the readings obtained when the CBR value is (2.5) mm and when it is (5) mm.

Table (5-4) The Relationship Between Stress and Penetration

Depth of penetration cm	**Standard resistance to penetration kg/cm2**	**No. 3**			
		Dial reading	Resist kg/cm2	Correct r kg/cm2	Cbr%
0		0	0.5		
05		90	11.6		
1		160	20.67		
1.5		240	31.01		
2		330	42.64		
2.5	70.35	420	54.26	54.26	77
3		530	68.48		
4		690	89.15		
5	105.35	775	100.13	100.13	95
6		904	116.80		
7		1075	138.88		
8		1189	153.62		
9		1351	174.55		
10		1469	189.79		

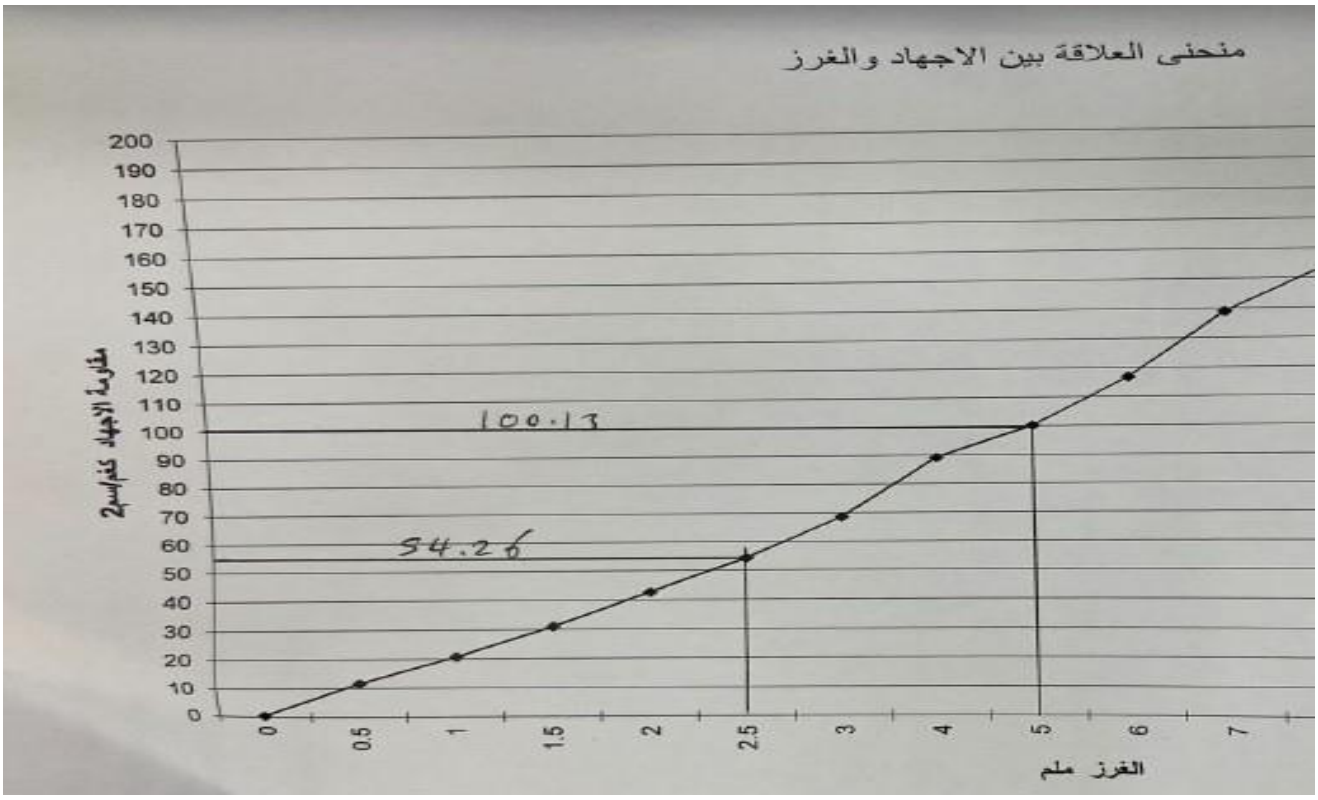


Figure (5-2): The Relationship Between Stress and Penetration

Figure (5-3): Explains laboratory experiments on soil

The principle of the test can be summarized as follows: A standard cylindrical tool (plunger) is driven into the sample at a specified rate. The relationship between the penetration force and the penetration value (distance) can be used to determine the CBR value.

The CBR value is defined as the ratio between the loads required to penetrate the cylindrical plunger (with an area of 3 square inches) to a certain depth in a compacted soil sample with specific moisture and density, and the standard loads required to penetrate the plunger to the same depth in a standard crushed stone sample. Hence, the CBR is calculated as (load required for penetration / standard load for penetration in a standard sample) * 100%.

The table below shows some CBR values according to the Unified Soil Classification System (USCS) and the American Association of State Highway and Transportation Officials (AASHTO) system.

Table (5-5): California Bearing Ratio (CBR) Values According to the Unified Soil Classification System (USC) and AASHTO System

California Bearing Ratio (CBR)	Rating	Usage	According to Unified Soil Classification System (USC)	According to AASHTO System
(3-0)	Very Poor	Subgrade Layer	OH, CH, MH, OL	A5, A6, A7
(7-3)	Poor to Moderate	Subgrade Layer	OH, CH, MH, OL	A4, A5, A6, A7
(20-7)	Moderate	Sub-base Layer	OH, CL, ML, SC, SM, SP, GP	A2, A4, A6, A7
(50-20)	Good	Base Course	GM, GC, SW, SM, SP, GP	A-1-B, A-2-5, A3, A-2-6
50<	Excellent	Base Course	GW, GM	A-1-a, A-2-4, A4

Table (5-6): Required California Bearing Ratio (CBR) Specifications for Road Layers in Palestine and Jordan

Layer	California Ratio (%)
Subgrade Layer	Minimum 8%
Sub-base Course	Minimum 40%
Base Course	Minimum 80%

And because the California Bearing Ratio (CBR) in the Ain Nankar Street test at penetrations of 2.5 mm and 5 mm exceeds 80%, this soil is suitable to be used as a base layer.

Chapter Six

Road Engineering Design

6.1 Introduction

6.2 Fundamentals of Road Engineering Design

6.3 Horizontal and Vertical Planning

6.3.1 Horizontal Planning (HORIZONTAL ALIGNMENT)

6.3.2 Vertical Road Planning

6.4 Water Drainage

6.1 Introduction

Road engineering design is the process of determining the geometric dimensions of a road and arranging its constituent elements, such as alignment, sight distances, widths, and gradients. Roads must be classified as main, secondary, or local to establish design speed and ruling gradient after balancing factors such as the importance of the road, estimated traffic volume and characteristics, terrain, and available funds. Design speed and ruling gradient form the basis for setting minimum standards for both vertical and horizontal alignment. Thereafter, the designer, through trial and error, adjusts these standards or exceeds them to suit the terrain, producing a horizontal plan and longitudinal profile of the road.

Next, the details of geometric dimensions for single-level or multi-level intersections, service roads, and other features are determined. Finally, details of signs, markings, traffic signals, and other traffic control measures must be specified. Achieving a safe, smooth-flowing road requires aligning all elements with driver expectations to avoid sudden changes in design specifications. This guide aims to define the main design standards for urban roads to help designers and reviewers ensure that road engineering design meets the required standards.

Here's the translation with the necessary engineering context:

6.2 Principles of Road Engineering Design

Among the most important principles of road engineering design are:

1. Traffic Volume: This is the number of vehicles passing a certain point within a specified period of time.

2. Traffic Composition: This involves determining the percentage of trucks and taxis relative to the hourly traffic volume. It includes calculating the proportions of all vehicles expected to use the road (e.g., small cars, buses, commercial vehicles, heavy trucks).

3. Speed: The speed of the road is determined by a set of general factors in addition to the vehicle's capacity and the driver. These factors include:

3.1 Design Speed: This is the highest continuous speed at which a vehicle can travel safely on a major road under ideal weather conditions and low traffic density. It acts as a standard provided by the road and is a logical factor concerning the topography of the area. The design speed determines the horizontal and vertical curves of the road. It depends on the topography, the required road grade, traffic volume, economic considerations, and driver habits. Higher design speeds result in higher road capacity, wider and larger curve radii, gentler slopes, and longer sight distances for stopping and overtaking, though this requires more expenditure, especially in mountainous areas.

3.2 Running Speed: The running speed of a vehicle in a certain road section is the distance traveled divided by the travel time (only the vehicle's running time).

3.3 Average Spot Speed: This is the arithmetic mean of the speeds of all vehicles at a specific moment for all vehicles at a specific point in a small road section.

3.4 Design Speed Standards: The geometric design characteristics of the road must be compatible with the selected and anticipated design speed for environmental and topographical conditions. The designer must choose an appropriate design speed based on the planned road grade, topographical characteristics, traffic volume, and economic considerations.

Table (6-1) shows the design speed of urban roads

Road Type	Minimum Speed (km/h)	Desired Speed (km/h)
Local Road	30	50
Collector Road	50	60
General Arterial	80	100
Turbulence Horizon	70	90
Noticeable Turbulence	50	60
Expressway	90	120

- **The type of project road we have is a collector road (Collector) where the speed has been set at 50 km/h.**

3.5.Road Cross Section: The road cross section involves designing the different parts of the roa d section, depending on how the road is utilized. A road that accommodates a large number of ve hicles at high speeds requires a larger number of lanes and gentle or minimal longitudinal slopes. It also requires relatively larger radii compared to roads with fewer vehicles at lower speeds.

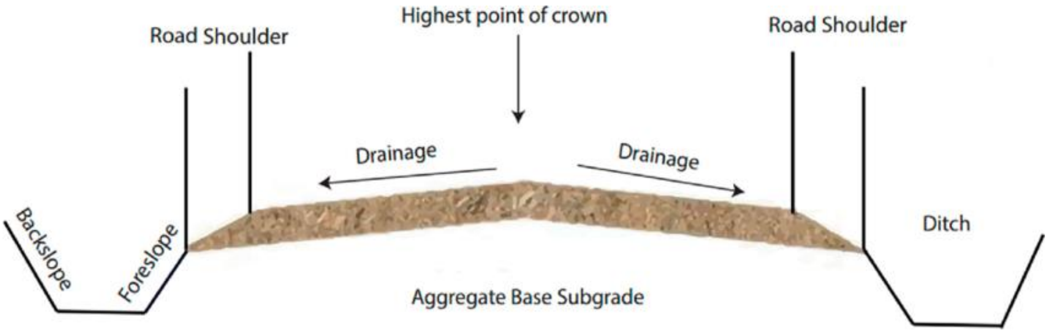


Figure (6-1) shows the cross-section of the road

3.6.Cross Slopes: Cross slopes are designed for the drainage of water on the road surface. These slopes should be constructed on both sides of the road axis and can be either uniform or curved in a parabolic sh ape. The slopes used in this project are 2%.

3.7.Longitudinal Slopes: In flat areas, the rainwater drainage system controls the levels. In areas where the water table is at the same level as the natural ground, the lower surface of the paveme nt should be at least 0.5 meters above the water level. In rocky areas, the design level should be s uch that the lower edge of the road shoulder is at least 0.3 meters above the rock level. This helps to avoid unnecessary rock excavation. A slope of 0.25% is considered the minimum gradient for rainwater drainage in the longitudinal direction of the road.

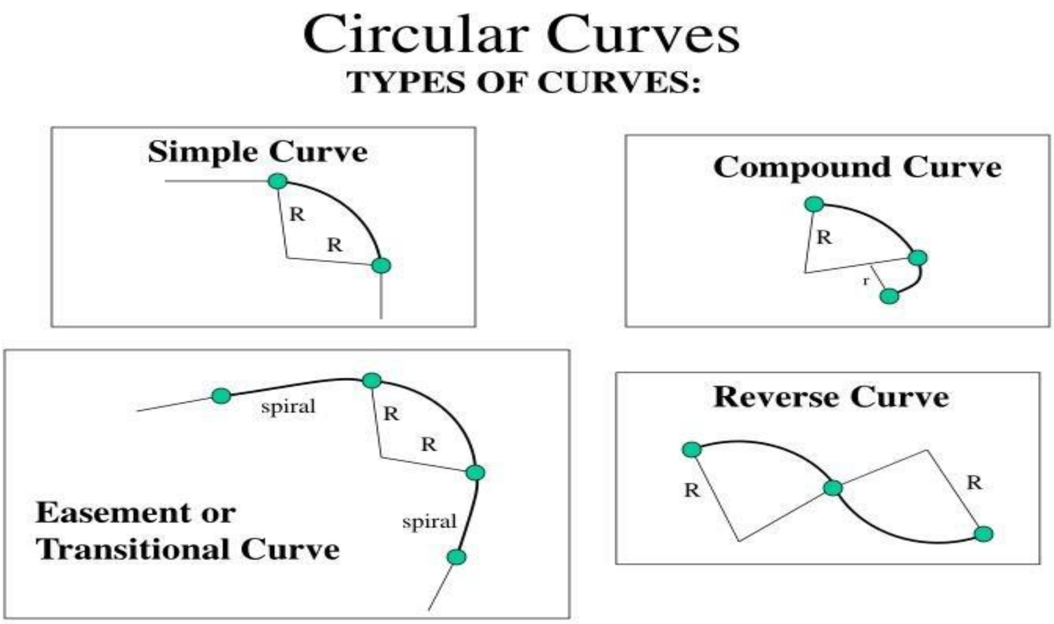
3.8 Sidewalks: Sidewalks are crucial for providing safety to pedestrians. The need for sidewalks increases near schools, hospitals, markets, and public places.

6.3Horizontal and Vertical Alignment

6.3.1 Horizontal Alignment

Types of Curves: There are multiple types of curves that can be used to connect intersecting straight lines, including:

Circular Curves: These are often used to create smooth transitions between straight sections of the road , Here we distinguish between the four types:



shows the types of circular curves Figure (6-2)

1. **Simple Circular Curves:** These are used to connect two straight lines that differ in direction with a single circular arc that touches both lines at the points of connection. This type was used in the project.

2. **Compound Circular Curves:** These connect two straight lines using more than one circular arc under the following conditions:

- The radii of these circular arcs (two or more) are different.
- The arcs are tangent at their points of connection.
- All centers of these circular arcs are on the same side.

3. **Broken_Back Circular Curves:** This term refers to a segment composed of two circular curves with centers on the same side, connected by a single, short tangent less than 30 meters in length.

4. **Reversed Circular Curves:** These connect two straight lines using more than one circular arc under the following conditions:

- The centers of curvature are not on the same side.
- The radio of these arcs may be equal or different.
- The arcs are tangent at their points of connection.

6.3.2 Vertical Road Alignment:

The vertical alignment of roads consists of a series of longitudinal slopes connected by vertical curves. The vertical alignment is influenced by factors such as safety, terrain, road grade, design speed, horizontal alignment, construction costs, vehicle characteristics, and rainwater drainage. The sight distance in all parts of the longitudinal section must meet the minimum stopping sight distance required for the design speed corresponding to the road grade.

When comparing alternative vertical alignments, they should be evaluated based on economic factors, the required service level, and traffic safety. Maximum gradient limits are

set to achieve economy and efficiency in road vehicle operation while keeping construction within reasonable limits. costs

1. Vertical Curves:

Vertical curves must be easy to use, safe, comfortable for operation, aesthetically pleasing, and sufficient for water drainage. The most important requirement for convex vertical curves is to provide adequate sight distances for the design speed. In all cases , the stopping sight distance should meet or exceed the minimum requirement.

6.4 Water Drainage:

Water is drained from the road surface by allowing it to flow along the road to the lowest poi nt, eliminating the need for a water drainage network due to the natural slope of the road surf ace.

Surface Water Collection: Rainwater on the pavement surface flows sideways due to the cross slope of the pavement layer. The amount of this slope depends on the type of pavement and the amount of rainfall, ranging from 4% to 6% for the road surface.

Water Drainage Requirements for Roads:

1. **Drainage from the Road Surface:** This is done by creating a cross slope on the road surface with a slope of 2%, increasing as the surface becomes rougher.
2. **Cutting the Road Off from Surface Water:** This prevents surface water from adjacent l ands from entering the road boundary.
3. **Preventing Water Infiltration:** Ensure that rainwater does not penetrate the road structure by making the road surface impervious.
4. **Preventing Surface Water Damage:** Ensure that surface water passing over the road and its side slopes does not create transverse potholes or soil erosion.
5. **Groundwater Level:** The groundwater level should not exceed a certain point relative to the lowest point of the pavement section, and the vertical distance between them should be at least 1.2 meters.

Chapter Seven

Structural Design of Roads

7.1 Introduction

7.2 Flexible Pavement

7.2.1 Components of Flexible Pavement

7.2.2 Principles on which Flexible Pavement Design is Based

7.2.3 Factors Affecting Flexible Pavement Design

7.3 Design of Flexible Pavement According to AASHTO System

7.1 Introduction

The structural design process of a road involves determining the thickness of pavement layers to withstand the axial loads of vehicles traveling on these roads. The main types of pavements are two: the first is rigid pavement, which consists of reinforced concrete slabs placed above the subgrade or subbase layer. The second, and more common type, is flexible pavement, which consists of several layers: the subbase, base course, and asphalt pavement layers. We will review the flexible pavement design method, which was used in the project.

7.2 Flexible Pavement

Flexible pavement is the pavement whose surface layer is made of asphalt concrete. The subbase and base course layers can be made of untreated materials like crushed stone and sand-gravel mixtures, or treated with asphalt binders. The treatment might be limited to the base course layer or extend to the subbase layer.

7.2.1 Components of Flexible Pavement

The following figure shows the layers of flexible pavement, which include the subgrade, subbase, base course, and finally the asphalt surface course.

Figure (7-1) shows the components of flexible pavement

1-Subgrade:

It represents the natural ground in the project area. Its bearing strength is tested, and if it does not pass the tests, soil that meets specifications can be brought from another location and compacted in the project area to form this layer. It forms the base on which the road rests.

2-Subbase:

This is the layer that is below the base course and above the natural ground. It consists of improved natural soil or gravel materials with specifications lower than those of the base course materials, as it is far from the impact of traffic and weather conditions.

3-Base Course:

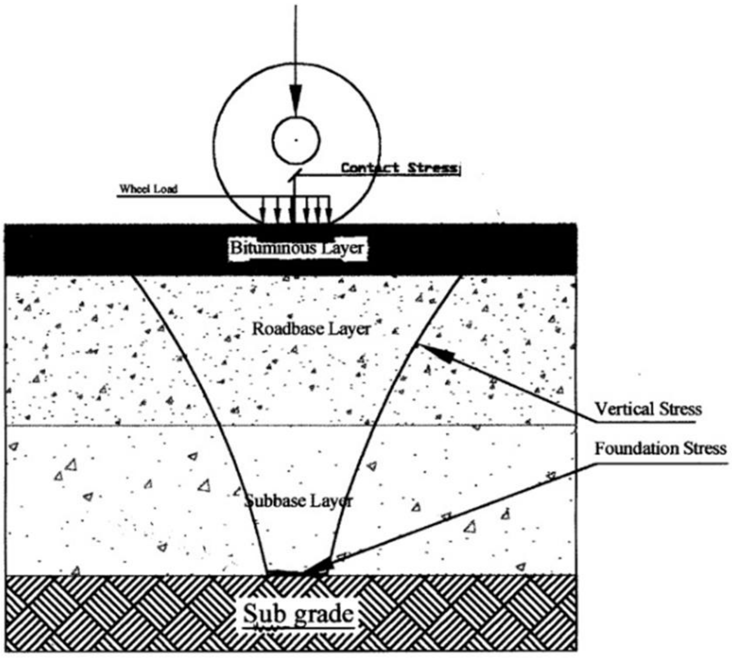
It is placed directly above the subbase layer or the natural ground if there is no subbase layer based on design requirements. It is usually made of base course material, and it may be executed in more than one layer if its thickness exceeds 20 cm.

4-Asphalt Surface Course:

It represents the surface that will be exposed to direct loads and weather conditions, protecting the other layers from weather factors. Its specifications vary according to the geographical area, as it is affected by weather conditions, especially temperature. It can also be executed in more than one layer.

7.2.2 Principles on which Flexible Pavement Design is Based

The load is transferred to the subgrade through a series of layers, and the flexible pavement distributes the load over a relatively smaller area of the underlying layer. The vehicle's tire represents the load that affects the layers, as illustrated in the following figure:



.Figure (7-2) shows how the load is distributed across the layers of flexible pavement

Since the initial installation cost of flexible pavement is very low, this is why this type of pavement is more common worldwide. However, flexible pavement requires routine maintenance and repairs every few years

7.2.3 Factors Affecting Flexible Pavement Design

- Traffic and Loading
- Environment
- Pavement Materials

7.3 Design of Flexible Pavement According to AASHTO System

The design is carried out according to the following steps:

1. Calculating the Equivalent Single Axle Load (ESAL): ESAL can be calculated using the equation:

   Equivalent Single Axle Load (ESAL) = AADT * 365 * Gf * T% * T.F * L.F .... Equation 1

   Where:

   - ESALS: number of repetitions of single axle load 18 kip (18000 lb) (80 KN).
   - AADT: average annual daily traffic for all axes.
   - Gf: growth factor in traffic volume.
   - T%: percent of trucks in the design lane.
   - T.F: truck factor.
   - L.F: axle load factor.

2. Calculating the value of Gf using the following formula:

   $$Gf = \frac{(1+r)^n - 1}{r}$$ .... Equation 2

   Where the road is designed for a lifespan of (20) years in the future, represented by (n), and an annual growth rate of (4%), represented by (r).

   Gf = 29.78

- **The T% factor was chosen from the following table.**

Table (7-1) shows the value of the T% factor.

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

The average annual daily traffic (AADT) was obtained from previous chapters and equals 1592 vehicles.

Then, we obtained the percentage of single, dual, and triple axles for vehicles on the road through traffic counting.

Table (7-2) shows the percentage and average number of vehicles per day.

متوسط عدد المركبات لكل ساعة			الايام
3-axle	2-axle	passenger	
101	28	570	Average
14.4492	4	81.545	النسبة المئوية من العدد الكلي

Then, we obtained the number of vehicles per axle type as follows:

Passenger cars = AADT * 94.6% = 1033.42 * 81.545% = 842.702 pc/day

Buses (2-axle) = AADT * 2.9% = 1033.42 * 4% = 41.3368 bus/day

Trucks (3-axle) = AADT * 2.5% = 1033.42 * 14.4492% = 149.33 truck/day

- To convert vehicle types to passenger cars for easier handling in calculations, refer to the following table:

Table (7-3) shows the vehicle weight in relation to the passenger car.

vehicle type	equivalency factor
(Pc)	1 pc
(Bus)	2 pc
(Trucks)	2.5 pc

- ❖ Passenger cars (10 kn/axle) = 842.702 pc
- ❖ Buses (2-axle) (100 kn/axle) = 2 * 46 = 82.6736 pc
- ❖ Trucks (3-axle) (110 kn/axle) = 2.5 * 40 = 373.3 pc

- After that, we converted the vehicle weights to standard loads according to the AASHTO system.

Table (7-4) shows the conversion of vehicle weights to standard loads.

GROSS AXLE		Load Equivalency factor	
KN	IB	SINGLE	TANDEM
10		0.0003135	
100		0.198089	
110		0.29419	

- Equivalent Single Axlel Load (ESAL) = AADT * 365 * Gf * T% * T.F * L.F

  1. ESAL (cars) = 842.702 * 29.78 * 0.45 * 0.0003135 * 365 * 2 = 2584.470

  2. ESAL (Buses) = 82.6736 * 29.78 * 0.45 * 0.198089 * 365 * 2 = 160209.1352

  3. ESAL (Trucks) = 373.3 * 29.78 * 0.45 * 0.29419 * 365 * 2 = 1074350.434

- Total ESAL = 1237144.039 (1.237144*10^6)

Calculation of Pavement Layer Thicknesses The goal of the design method used is to find pavement layers with a sufficient structural number to withstand the loads the road is subjected to.

- Reliability Factor (R): Reliability or dependability involves introducing a degree of certainty in the design process to ensure that the design choices can last throughout the pavement's design life. For any given level of reliability (R), the following table provides the proposed values for the reliability factor (R):

Table (7-5) shows the value of the reliability factor (R).

(R) :Proposed Reliability Values		Type of Road
(Rural)	(Urban)	
99.9-80	99.9-85	Expressway
95-75	90-80	Major
95-75	95-80	Collector
80-50	80-50	local

- We will choose a reliability factor value of 90 as shown in the table.
- The total standard deviation (S0) value is taken according to AASHTO as between (0.3 – 0.5), and we will adopt a value of (0.45) in the project.

3. Serviceability Loss (ΔPSI): It is the difference between the initial serviceability level (Initial PSI) and the final serviceability level (Final PSI).

a. Initial PSI = 4 – 4.5

b. Final PSI = 2.5

ΔPSI = Initial PSI - Final PSI = 4.5 – 2.5 = 2

- CBR for Base = 90%

- CBR for SubBase = 45%

- **Structure Layers Coefficients (a1, a2, a3):** This represents the relationship between the structural number and the thickness of the layer in inches, depending on the types of materials of the different pavement layers.

  - **a1:** Symbol for the wearing surface layer.
  - **a2:** Symbol for the base layer.
  - **a3:** Symbol for the subbase layer.

- It represents the relative capacity of the material used in each pavement layer.
- Based on the above, the MR value for each layer will be adopted as follows:
  - Surface layer: 4.5 * 10^5 PSI
  - Base layer: 29 * 10^3 PSI
  - Subbase layer: 17 * 10^3 PSI

The following table shows the modulus of elasticity for the asphalt layer and the strength coefficient of the layer:

Table (7-6) illustrates the Structure Layers Coefficients (a1).

التماسك Hveem	معامل قوة الطبقة الاسفلتية	ثبات مارشال (رطل)	معامل المرونة (رطل /بوصة ٢)
80	0.22	500	125000
95	0.25	750	150000
120	0.3	975	200000
130	0.33	1200	250000
155	0.36	1400	300000
175	0.39	1600	350000
190	0.42	1900	400000

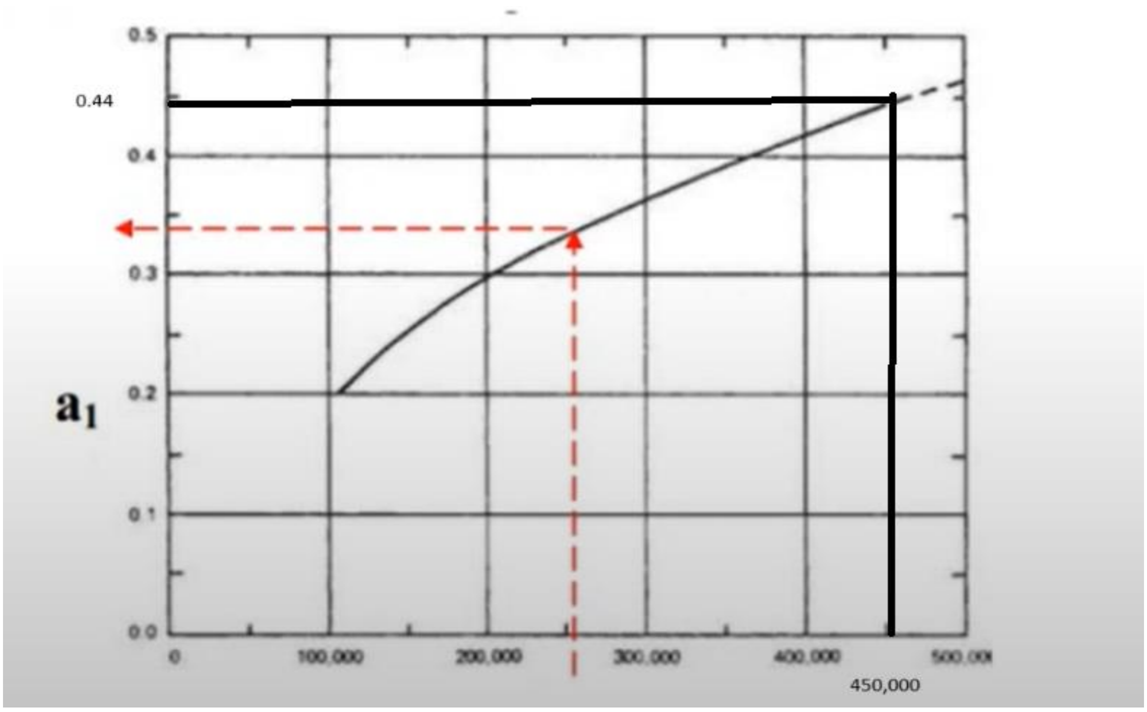


Figure (7-3) illustrates the Surface Layers Coefficients (a1).

The value of (a2) is = 0.13

This value was obtained from the following figure:

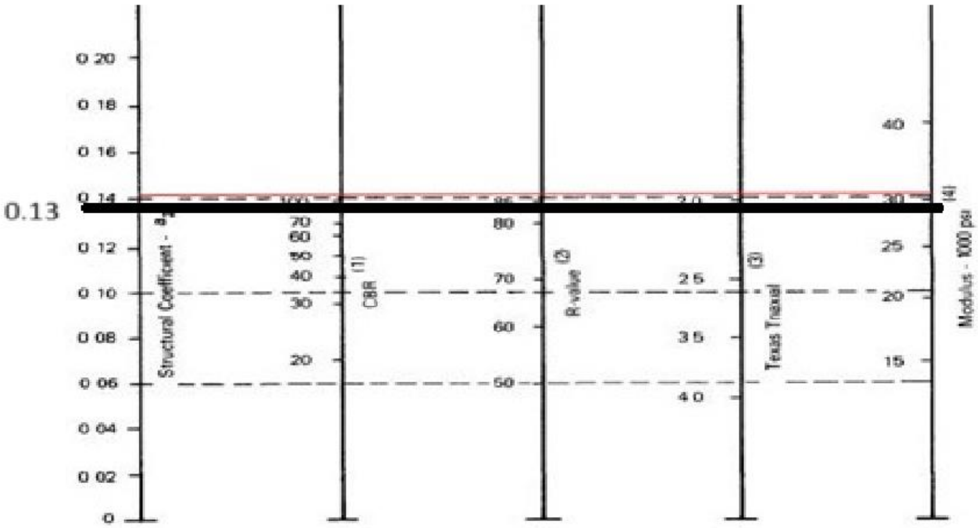


Figure (7-4) illustrates the Base Course Layers Coefficients (a2).

The value of (a3) is = 0.123.

This value was obtained from the following figure:

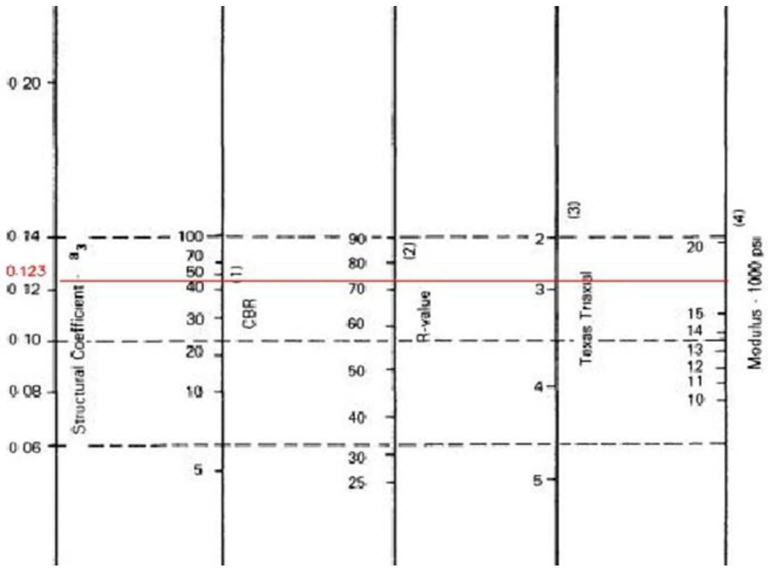


Figure (7-5) illustrates the Subbase Course Layers Coefficients (a3).

The Structural Number (SN):
It is a value that represents the pavement's rigidity and serves as an indicative number derived from the analysis of traffic, subgrade soil, and environmental factors. We determined the Structural Number using the following figure:

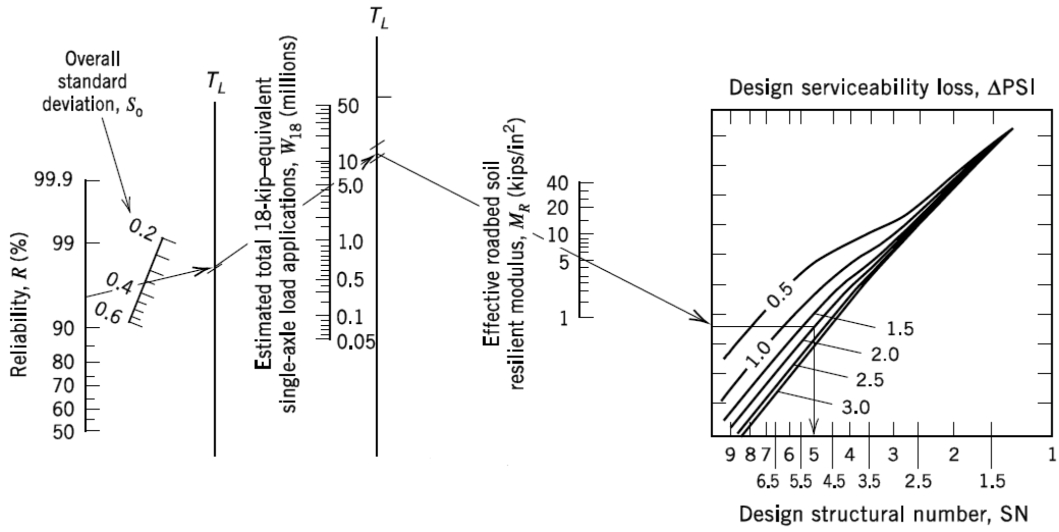


Figure (7-6) Surface Structure Number

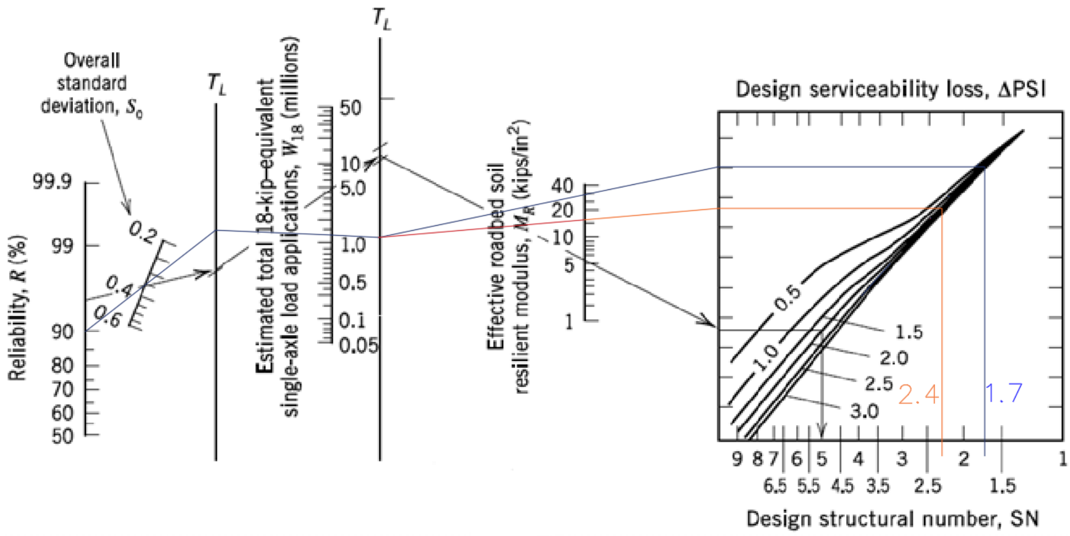


Figure (7-6) Value Surface Structure Number 1&2

Water Drainage Coefficients (m_2, m_3):
These coefficients reflect the ability of the base and sub-base layers to drain rainwater. They are estimated based on the water drainage rate of each layer. The following table illustrates the values of these coefficients:

Values of Water Drainage Coefficients: Table (7-7)

مناطق زراعية (Rural Region)	مناطق حضرية (Urban Region)	كفاءة التصريف (Drainge Coeficient)
1	1.15 – 1.25	جيدGOOD
0.6	1.05 – 0.80	ضعيفةpoor

- **After collecting this data, we proceed to calculate the road layers :-**

a. Reliability (R) = 90%

b. Overall satandard deviation (S_0) = 0.45

c. ESAL Total = 522999.082 = 1237144.039 (1.237144*10^6)

d. ΔPSI = 2

e. MR1 = 4.5 * 10^5 PSI

f. MR2 = 29*10^3 PSI

g. MR3 = 17*10^3 PSI

h. SN1 = 1.7

i. SN2 = 2.4

- **From the following equations, we deduce the thickness of each layer:**

$SN1 = a_1 d_1$
$SN2 = a_1 d_1 + a_2 d_2 m_2$

Where :

D_1 = Asphaltic concrete thickness.

D_2 = Base Course thickness.

SN1 = Structure Number for Asphaltic concrete Layer.

SN1 = Structure Number for Base Course.

- **Calculation :**

$SN1 = a_1d_1$

$1.7 = 0.44 * d1$

$D_1 = 3.8636$ in = 9.813 cm = 10 cm

$SN2 = a_1d_1 + a_2d_2m_2$

$2.4 = 1.7 + (0.13 * 0.8 * d2)$

$D_2 = 6.73$ in = 17.096 cm = 17 cm.

Accordingly, the thicknesses are rounded up to the nearest higher value to comply with the specifications. Based on a review of some road projects, the recommended layer thicknesses are as shown in the following table:

Table (7-8): Layer Thicknesses for the Project

Pavement	Layers Thickness (cm)
طبقة الاسفلت (Asphalt Layer)	10 cm
طبقة الأساس (Base Course Layer)	17 cm

Chapter Eight

Results and Recommendations

8.1 Introduction

8.2 Results

8.3 The project cost

8.4 Recommendations

8.1 Introduction

When undertaking any task, whether it is engineering-related or not, it ultimately produces final outcomes that define the objectives for which the task was carried out, whether positive or negative.

This chapter discusses a set of findings obtained from the design process of this road and includes a series of recommendations aimed at ensuring a favorable impression during the implementation of this project.

8.2 Results

After completing the full survey and designing this road, several results have been reached, the most important of which are:

1. Fully raising the road and obtaining detailed plans for it.
2. Preparing all horizontal and vertical designs and all necessary information for their implementation, and preparing related maps.
3. The implementation of this road is important as it connects the cities of Hebron and Dura, and it is considered an arterial road for the time and effort it saves for users.
4. The importance of studying road design and linking it with other landmarks.
5. Handling rainwater by draining it towards the valley through the natural slopes of the road surface, with rainwater being drained using drains at the end of the road.
6. The result was an engineering design based on (2011 AASHTO) specifications with a design speed of ٥٠ km/h.
7. The layer results after performing all necessary calculations were as follows:

- Asphalt layer: 10 cm
- Base course layer: 17 cm

8. The design was carried out using Civil 3D software, with the results output on the attached plans, The quantities were as follows:

Calculating the project cost is essential to determine the cost of any project since cost is important to know the amount needed to execute this project and to provide the funding party with all the costs to be covered for the project. In this chapter, the cost of each pavement layer along the road length will be calculated, as well as the excavation and filling.

Quantity Calculation:

1. Calculating the Volume of Asphalt and Base Course Layers:

- **Volume of the Asphalt Layer:** Volume of the Asphalt Layer = Road Area × Layer Thickness
  Volume of the Asphalt Layer = 19208 × 0.10 = 1920.8 m^3

- **Volume of the Base Course Layer:** Volume of the Base Course Layer = Road Area × Layer Thickness
  Volume of the Base Course Layer = 19208 × 0.17 = 3265.36 m^3

2. Calculating the Volume of Excavation and Backfill for the Road (from the tables):

- Volume of Excavation = 6030 m^3

- Volume of Backfill = 4788 m^3

8.3 Project Cost

Table (8-1): Material Cost for the Project

Description	Unit	Price
Excavation	m^3	7
Backfilling	m^3	6
Asphalt	m^3	40
Base course	m^3	7
Sidewalks	m^3	35
Curbe stone	m^3	13
Road paint	m^3	8
Traffic sign	m^3	110
Lighting poles	m^3	88
Manholes	m^3	220

Cost Calculation:

1. **Cost for the Asphalt Layer:** Cost for the Asphalt Layer = 1920.8 × 40 = 76,832 USD
2. **Cost for the Base Course Layer:** Cost for the Base Course Layer = 3265.36 × 7 = 22,857.52 USD
3. **Excavation Cost:** Excavation Cost = 6030 × 7 = 42,210 USD
4. **Backfill Cost:** Backfill Cost = 4788 × 6 = 28,728 USD
5. **Manhole Cost** = Quantity * Unit Cost
   Manhole Cost = 50 * 220 = 11,000 USD
6. **Curb Cost** = Road Curb Area * Cost per Meter
   Curb Cost = 4884 * 13 = 63,492 USD
7. **Sidewalk Cost** = Road Sidewalk Area * Cost per Square Meter
   Sidewalk Cost = 1924 * 35 = 67,340 USD
8. **Lighting Pole Cost** = Quantity * Unit Cost
   Lighting Pole Cost = 42 * 1200 = 50,400 USD
9. **Road Painting Cost** = Area * Cost per Square Meter
   Road Painting Cost = 950 * 8 = 7,600 USD
10. **Traffic Sign Cost** = Quantity * Unit Cost
    Traffic Sign Cost = 25 * 110 = 2,750 USD

Table (8-2): Final project cost Table

Description	Unit	Price	Quantity	Cost
Excavation	m^3	7	6030	42210
Backfilling	m^3	6	4788	28728
Asphalt	m^3	40	1702	68080
Base course	m^3	7	2893	20251
Sidewalks	m^2	35	1924	67340
Curbe stone	m	13	2884	37492
Road paint	m^2	8	950	7600
Traffic sign	**Number**	110	25	2750
Lighting poles	**Number**	800	42	33600
Manholes	**Number**	220	50	11000
Pipes	**Number**	90	49	4410
Total Cost				323461

Final cost of the project =323,461USD

8.4 Recommendations

1. The compaction should be done properly and in thin layers.
2. Vehicles should not be allowed to drive on the asphalt layer before 24 hours have passed since it was laid, to prevent the layer from collapsing.
3. Communicate with the Jenin Municipality during the project execution for any consultation they may require.
4. Invite the university to organize training courses for students to reach a higher level, especially in terms of technology and modern programs.
5. Ensure the existence of joint projects between different departments in the College of Engineering to achieve proper integration.

References

[1] دراسة مقارنة عملية بين طريقة الرصد الحقلية الثابتة وطريقة إعادة التمركز في نظام تعيين المواضع " ,عيسى .م الشاملGPS," Tishreen University Journal-Engineering Sciences Series, vol. 31, no. 3, 2009.

[2] Mannering, Fred L., and Scott S. Washburn. Principles of highway engineering and traffic analysis. John Wiley & Sons, 2020.

[3] Maadani, Omran, and AO Abd El Halim. "AASHTO pavement design guides." Journal of Cold Regions Engineering 31.3.

[4] E. S. P. Roger P. Roess, William R. McShane, Traffic Engineering, Fourth Edition ed. pearson, 2011.

[5] دولة فلسطين وزارة النقل والمواصلات .دليل السلامة المرورية على الطرق في فلسطين .,ع .ف .م .د , 2013, p. 182.

[6] Das, Braja M., and Khaled Sobhan. "Principles of geotechnical engineering." (2012).

[7] University of Memphis, *Geometric Design of Highways and Streets*. Memphis, TN: Dept. of Civil Engineering, 2023.

Appendix:

a) Ground Control Point (GCP) coordinates report

PointID	Name	Code	Role	x	y	h
1	1	cp	Survey	207771.579	179814.1213	144.0893
2	2	cp	Survey	207771.575	179814.1292	144.0833
3	3	cp	Survey	207725.13	179883.784	145.307
4	4	cp	Survey	207646.09	179965.9031	147.1401
5	5	cp	Survey	207525.389	180045.7261	156.5064
6	6	cp	Survey	207398.747	180099.439	166.5294
7	7	cp	Survey	207266.169	180137.4934	176.6358
8	8	cp	Survey	207207.003	180171.3882	182.0695
9	9	cp	Survey	207154.044	180238.6615	188.4607
10	10	cp	Survey	207113.999	180329.7128	195.5712
11	11	cp	Survey	207026.727	180428.7514	203.3427
12	12	cp	Survey	206945.984	180466.3349	209.077
13	13	cp	Survey	206856.198	180482.1676	215.122
14	14	cp	Survey	206783.34	180477.2465	218.3058
15	15	cp	Survey	206755.439	180476.1919	217.7583
16	16	cp	Survey	206739.559	180508.1404	217.3045

Name	B	L	H.1	WGS84 X	WGS84 Y	WGS84 Z
1	032d27m50.1898410000s	035d18m52.5927735000s	164.697	4395542	3113900.1	3404038.4
2	032d27m50.1897240000s	035d18m52.5930750000s	164.691	4395542	3113900.1	3404038.4
3	032d27m48.6796485000s	035d18m55.2584145000s	165.914	4395522.9	3113972	3403999.8
4	032d27m46.1110065000s	035d18m58.3996980000s	167.746	4395511.4	3114064.3	3403934
5	032d27m42.1900005000s	035d19m01.4513250000s	177.111	4395524.7	3114171.4	3403837.2
6	032d27m38.0770305000s	035d19m03.5028795000s	187.133	4395556.1	3114259.3	3403735.6
7	032d27m33.7718835000s	035d19m04.9545810000s	197.238	4395599.2	3114336.4	3403629.2
8	032d27m31.8499980000s	035d19m06.2499810000s	202.671	4395609.4	3114385	3403582.1
9	032d27m30.1284615000s	035d19m08.8236555000s	209.061	4395598.1	3114459.4	3403540.8
10	032d27m28.8253035000s	035d19m12.3082725000s	216.171	4395568	3114549.6	3403510.7
11	032d27m25.9887435000s	035d19m16.0967085000s	223.941	4395554.4	3114661.2	3403441.2
12	032d27m23.3662635000s	035d19m17.5323390000s	229.674	4395572	3114719.7	3403376.1
13	032d27m20.4509805000s	035d19m18.1347705000s	235.718	4395606.4	3114763.3	3403303.6
14	032d27m18.0859965000s	035d19m17.9432850000s	238.902	4395643.4	3114783.4	3403243.8
15	032d27m17.1802800000s	035d19m17.9017350000s	238.354	4395655.9	3114790.9	3403220
16	032d27m16.6636365000s	035d19m19.1242980000s	237.9	4395644.1	3114821.7	3403206.3

Name	BaseStation	BaseLatitude	BaseLongitude	BaseAltitude
1	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
2	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
3	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
4	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
5	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
6	RTCM-Ref 1004	032d29m44.9216386402s	035d21m01.6090797711s	233.747
7	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
8	RTCM-Ref 1004	032d29m44.9216386402s	035d21m01.6090797711s	233.747
9	RTCM-Ref 1004	032d29m44.9216386402s	035d21m01.6090797711s	233.747
10	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
11	RTCM-Ref 1004	032d29m44.9216386402s	035d21m01.6090797711s	233.747
12	RTCM-Ref 1004	032d29m44.9216386402s	035d21m01.6090797711s	233.747
13	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
14	RTCM-Ref 1004	032d29m44.9216386402s	035d21m01.6090797711s	233.747
15	RTCM-Ref 1004	032d29m44.9216354400s	035d21m01.6090797600s	233.747
16	RTCM-Ref 1004	032d29m44.9216386402s	035d21m01.6090797711s	233.747

Name	Antenna Height	Corrected Antenna Height	Survey Method	Epoch
1	1.5	1.5701	Pole to ARP	20
2	1.5	1.5701	Pole to ARP	20
3	1.5	1.5701	Pole to ARP	10
4	1.5	1.5701	Pole to ARP	10
5	1.5	1.5701	Pole to ARP	10
6	1.42	1.4901	Pole to ARP	10
7	1.5	1.5701	Pole to ARP	10
8	1.46	1.5301	Pole to ARP	10
9	1.54	1.6101	Pole to ARP	10
10	1.46	1.5301	Pole to ARP	10
11	1.5	1.5701	Pole to ARP	10
12	1.48	1.5501	Pole to ARP	10
13	1.36	1.4301	Pole to ARP	10
14	1.36	1.4301	Pole to ARP	10
15	1.39	1.4601	Pole to ARP	10
16	1.45	1.5201	Pole to ARP	10

Name	StartTime	EndTime	PDOP	HDOP	VDOP
1	25/03/24 09:47	25/03/24 10:02	1.205	0.6	1.01
2	25/03/24 10:05	25/03/24 10:20	1.17	0.6	1
3	25/03/24 10:26	25/03/24 10:41	1.1	0.6	0.9
4	25/03/24 10:48	25/03/24 11:03	1	0.57	0.9
5	25/03/24 11:10	25/03/24 11:25	1.2	0.6	1.1
6	25/03/24 11:31	25/03/24 11:46	1	0.5	0.8
7	25/03/24 11:53	25/03/24 12:08	1.2	0.7	1
8	25/03/24 12:15	25/03/24 12:30	1.03	0.6	0.9
9	25/03/24 12:38	25/03/24 12:53	1.1	0.6	0.9
10	25/03/24 01:01	25/03/24 01:16	1.1	0.6	1
11	25/03/24 01:24	25/03/24 01:39	0.91	0.52	0.8
12	25/03/24 01:48	25/03/24 02:03	0.92	0.52	0.8
13	26/03/24 02:11	26/03/24 02:26	1.04	0.6	0.91
14	26/03/24 02:36	26/03/24 02:51	1.1	0.6	0.9
15	26/03/24 03:03	26/03/24 03:18	1	0.5	0.8
16	26/03/24 03:29	26/03/24 03:44	1.1	0.6	0.9

Name	Observed Satellite Num	Used Satellite Num	Solve Status	RMS	HRMS	VRMS	Elevmask
1	28	25	FIXED	0.0199	0.0141	0.014	10
2	28	25	FIXED	0.0179	0.0141	0.011	10
3	26	25	FIXED	0.0192	0.0141	0.013	10
4	30	28	FIXED	0.0173	0.0141	0.01	10
5	23	23	FIXED	0.0245	0.0141	0.02	10
6	29	29	FIXED	0.0173	0.0141	0.01	10
7	22	22	FIXED	0.0245	0.0141	0.02	10
8	29	27	FIXED	0.0185	0.0141	0.012	10
9	27	27	FIXED	0.0173	0.0141	0.01	10
10	28	28	FIXED	0.0173	0.0141	0.01	10
11	29	30	FIXED	0.0173	0.0141	0.01	10
12	29	29	FIXED	0.0213	0.0141	0.016	10
13	31	27	FIXED	0.0179	0.0141	0.011	10
14	30	27	FIXED	0.0173	0.0141	0.01	10
15	33	30	FIXED	0.0173	0.0141	0.01	10
16	31	28	FIXED	0.0192	0.0141	0.013	10

b) pictures taken from the project area

c) Cut and Fill Quantity Table

Total Volume Table						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+000.00	0.06	4.92	0.00	0.00	0.00	0.00
0+020.00	2.88	4.04	29.38	89.62	29.38	89.62
0+040.00	2.44	8.41	53.17	124.46	82.55	214.08
0+060.00	0.00	12.67	24.39	210.76	106.94	424.84
0+070.00	0.00	10.71	0.00	116.76	106.94	541.61
0+080.00	0.00	9.01	0.00	98.60	106.94	640.20
0+090.00	0.72	6.07	3.70	75.25	110.64	715.45
0+100.00	2.81	4.47	18.09	52.45	128.73	767.90
0+110.00	4.99	1.59	39.68	30.26	168.41	798.15
0+120.00	2.06	1.25	35.59	14.21	204.00	812.36
0+140.00	7.90	0.29	99.68	15.45	303.67	827.81
0+150.00	8.27	0.00	80.86	1.46	384.53	829.27
0+160.00	7.16	0.00	77.57	0.00	462.10	829.27
0+180.00	8.71	0.00	158.77	0.00	620.87	829.27
0+200.00	6.07	0.00	147.83	0.00	768.70	829.27
0+220.00	3.68	0.07	97.54	0.71	866.24	829.98
0+240.00	6.93	0.00	106.57	0.72	972.81	830.70
0+250.00	7.28	0.00	72.44	0.02	1045.25	830.72
0+260.00	3.28	0.35	53.92	1.80	1099.17	832.52
0+270.00	0.94	1.20	21.39	7.92	1120.57	840.43
0+280.00	0.55	1.79	7.41	15.15	1127.97	855.58
0+300.00	0.05	3.52	6.03	53.08	1134.00	908.67
0+320.00	0.01	6.99	0.59	105.64	1134.59	1014.31
0+340.00	0.00	7.53	0.06	145.82	1134.65	1160.13
0+360.00	2.14	6.37	21.37	138.99	1156.02	1299.13
0+380.00	3.97	6.97	61.05	133.41	1217.08	1432.53
0+400.00	2.27	5.89	62.36	128.68	1279.43	1561.21
0+420.00	0.67	5.62	29.39	115.12	1308.82	1676.33
0+440.00	0.72	5.99	13.80	116.59	1322.62	1792.92
0+460.00	0.23	3.41	9.53	94.00	1332.15	1886.92

Total Volume Table						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+480.00	2.45	0.37	26.86	37.73	1359.01	1924.66
0+500.00	5.58	0.00	80.34	3.67	1439.34	1928.33
0+520.00	5.39	0.00	109.47	0.00	1548.82	1928.33
0+530.00	4.92	0.00	51.44	0.00	1600.26	1928.33
0+540.00	3.46	0.01	41.98	0.05	1642.24	1928.37
0+550.00	4.81	0.00	41.37	0.05	1683.61	1928.42
0+560.00	4.04	0.71	44.24	3.57	1727.85	1931.99
0+580.00	0.17	4.02	42.28	47.16	1770.13	1979.15
0+590.00	0.03	8.87	1.00	64.21	1771.14	2043.36
0+600.00	0.00	6.12	0.17	75.02	1771.31	2118.38
0+610.00	0.01	4.76	0.04	54.49	1771.36	2172.87
0+620.00	0.25	5.83	1.33	52.84	1772.69	2225.71
0+630.00	0.10	7.46	1.87	65.56	1774.56	2291.27
0+640.00	0.00	9.20	0.55	81.96	1775.11	2373.24
0+660.00	2.44	10.17	24.77	193.47	1799.88	2566.71
0+670.00	3.78	7.88	32.03	90.35	1831.91	2657.06
0+680.00	1.92	5.18	29.28	65.82	1861.19	2722.88
0+690.00	0.06	9.73	10.02	75.38	1871.22	2798.26
0+700.00	0.50	9.23	2.64	95.56	1873.86	2893.82
0+710.00	0.00	10.00	2.33	96.39	1876.19	2990.20
0+720.00	1.24	6.10	6.36	80.42	1882.55	3070.62
0+730.00	4.60	5.58	29.71	58.31	1912.26	3128.93
0+740.00	4.39	5.54	45.78	55.40	1958.04	3184.33
0+750.00	2.28	7.27	34.01	63.81	1992.05	3248.14
0+760.00	1.63	9.70	20.19	84.42	2012.24	3332.55
0+770.00	0.97	8.96	13.51	92.69	2025.75	3425.24
0+780.00	0.24	9.38	6.32	91.21	2032.07	3516.46
0+800.00	0.33	8.01	5.78	173.92	2037.85	3690.38
0+820.00	0.05	6.39	3.83	144.33	2041.69	3834.71
0+840.00	0.00	7.58	0.52	139.66	2042.20	3974.36

Total Volume Table						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+850.00	0.00	6.45	0.00	70.67	2042.20	4045.04
0+860.00	0.06	5.44	0.29	59.97	2042.49	4105.01
0+880.00	1.32	2.29	13.63	77.58	2056.12	4182.60
0+890.00	1.57	1.06	14.13	16.99	2070.25	4199.59
0+900.00	3.22	0.63	23.55	8.66	2093.80	4208.25
0+920.00	9.22	0.00	124.43	6.32	2218.23	4214.57
0+930.00	11.73	0.00	104.45	0.00	2322.68	4214.57
0+940.00	14.22	0.00	129.40	0.00	2452.09	4214.57
0+960.00	15.81	0.00	300.31	0.00	2752.39	4214.57
0+970.00	13.77	0.00	148.15	0.00	2900.54	4214.57
0+980.00	11.78	0.00	127.54	0.00	3028.08	4214.57
0+990.00	11.34	0.00	115.08	0.00	3143.16	4214.57
1+000.00	11.85	0.00	115.66	0.00	3258.83	4214.57
1+010.00	12.28	0.00	120.96	0.00	3379.79	4214.57
1+020.00	13.38	0.00	128.30	0.00	3508.09	4214.57
1+030.00	14.38	0.00	139.11	0.00	3647.21	4214.57
1+040.00	14.24	0.00	143.12	0.00	3790.32	4214.57
1+060.00	14.34	0.00	286.51	0.00	4076.83	4214.57
1+070.00	12.94	0.00	137.49	0.00	4214.32	4214.57
1+080.00	10.25	0.00	116.81	0.00	4331.13	4214.57
1+090.00	8.54	0.00	94.40	0.00	4425.53	4214.57
1+100.00	7.51	0.00	80.67	0.00	4506.19	4214.57
1+120.00	5.68	0.02	131.90	0.23	4638.09	4214.80
1+130.00	5.40	0.00	55.90	0.12	4693.99	4214.91
1+140.00	2.25	1.36	39.09	6.68	4733.08	4221.59
1+160.00	1.30	5.36	35.48	67.22	4768.56	4288.81
1+180.00	0.10	7.41	14.22	127.00	4782.78	4415.82
1+190.00	0.03	9.85	0.65	85.20	4783.42	4501.02
1+200.00	0.09	10.78	0.60	101.79	4784.02	4602.80
1+210.00	0.00	10.65	0.46	106.25	4784.48	4709.05

Total Volume Table						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
1+220.00	0.00	12.50	0.01	115.62	4784.49	4824.67
1+230.00	0.00	15.99	0.01	142.59	4784.49	4967.26
1+240.00	0.00	19.29	0.00	176.41	4784.49	5143.68
1+250.00	0.00	20.66	0.01	200.17	4784.50	5343.85
1+260.00	0.00	14.54	0.01	176.40	4784.51	5520.25
1+270.00	0.00	7.33	0.00	118.05	4784.51	5638.30
1+280.00	0.00	3.79	0.00	74.21	4784.51	5712.51
1+300.00	0.00	0.00	0.00	38.14	4784.51	5750.65
1+309.95	0.00	0.00	0.00	0.00	4784.51	5750.65

d) Materials Quantity Table

base table			
Station	Area	Volume	Cumulative Volume
0+000.00	2.21	0.00	0.00
0+020.00	2.21	44.20	44.20
0+040.00	2.21	44.20	88.40
0+060.00	2.35	45.56	133.96
0+070.00	2.21	22.78	156.74
0+080.00	2.21	22.10	178.84
0+090.00	2.21	22.10	200.94
0+100.00	2.35	22.78	223.72
0+110.00	2.21	22.78	246.50
0+120.00	2.21	22.10	268.60
0+140.00	2.21	44.20	312.80
0+150.00	2.21	22.10	334.90
0+160.00	2.21	22.10	357.00
0+180.00	2.35	45.56	402.56
0+200.00	2.21	45.56	448.12
0+220.00	2.21	44.20	492.32
0+240.00	2.35	45.56	537.88
0+250.00	2.35	23.46	561.34
0+260.00	2.21	22.78	584.12
0+270.00	2.21	22.10	606.22
0+280.00	2.21	22.10	628.32
0+300.00	2.21	44.20	672.52
0+320.00	2.21	44.20	716.72
0+340.00	2.21	44.20	760.92
0+360.00	2.35	45.56	806.48

base table			
Station	Area	Volume	Cumulative Volume
0+380.00	2.21	45.56	852.04
0+400.00	2.21	44.20	896.24
0+420.00	2.21	44.20	940.44
0+440.00	2.21	44.20	984.64
0+460.00	2.35	45.56	1030.20
0+480.00	2.21	45.56	1075.76
0+500.00	2.21	44.20	1119.96
0+520.00	2.21	44.20	1164.16
0+530.00	2.21	22.10	1186.26
0+540.00	2.21	22.10	1208.36
0+550.00	2.21	22.10	1230.46
0+560.00	2.21	22.10	1252.56
0+580.00	2.21	44.20	1296.76
0+590.00	2.21	22.10	1318.86
0+600.00	2.21	22.10	1340.96
0+610.00	2.21	22.10	1363.06
0+620.00	2.21	22.10	1385.16
0+630.00	2.35	22.78	1407.94
0+640.00	2.21	22.78	1430.72
0+660.00	2.21	44.20	1474.92
0+670.00	2.21	22.10	1497.02
0+680.00	2.21	22.10	1519.12
0+690.00	2.21	22.10	1541.22
0+700.00	2.21	22.10	1563.32
0+710.00	2.35	22.78	1586.10

base table			
Station	Area	Volume	Cumulative Volume
0+720.00	2.21	22.78	1608.88
0+730.00	2.21	22.10	1630.98
0+740.00	2.21	22.10	1653.08
0+750.00	2.21	22.10	1675.18
0+760.00	2.21	22.10	1697.28
0+770.00	2.21	22.10	1719.38
0+780.00	2.21	22.10	1741.48
0+800.00	2.21	44.20	1785.68
0+820.00	2.35	45.56	1831.24
0+840.00	2.21	45.56	1876.80
0+850.00	2.21	22.10	1898.90
0+860.00	2.21	22.10	1921.00
0+880.00	2.21	44.20	1965.20
0+890.00	2.21	22.10	1987.30
0+900.00	2.21	22.10	2009.40
0+920.00	2.21	44.20	2053.60
0+930.00	2.21	22.10	2075.70
0+940.00	2.21	22.10	2097.80
0+960.00	2.21	44.20	2142.00
0+970.00	2.21	22.10	2164.10
0+980.00	2.21	22.10	2186.20
0+990.00	2.21	22.10	2208.30
1+000.00	2.21	22.10	2230.40
1+010.00	2.21	22.10	2252.50
1+020.00	2.21	22.10	2274.60

base table			
Station	Area	Volume	Cumulative Volume
1+030.00	2.21	22.10	2296.70
1+040.00	2.21	22.10	2318.80
1+060.00	2.21	44.20	2363.00
1+070.00	2.21	22.10	2385.10
1+080.00	2.21	22.10	2407.20
1+090.00	2.21	22.10	2429.30
1+100.00	2.21	22.10	2451.40
1+120.00	2.35	45.56	2496.96
1+130.00	2.21	22.78	2519.74
1+140.00	2.21	22.10	2541.84
1+160.00	2.21	44.20	2586.04
1+180.00	2.21	44.20	2630.24
1+190.00	2.21	22.10	2652.34
1+200.00	2.21	22.10	2674.44
1+210.00	2.21	22.10	2696.54
1+220.00	2.21	22.10	2718.64
1+230.00	2.21	22.10	2740.74
1+240.00	2.21	22.10	2762.84
1+250.00	2.35	22.78	2785.62
1+260.00	2.35	23.46	2809.08
1+270.00	1.17	18.34	2827.42
1+280.00	1.17	14.60	2842.02
1+300.00	0.00	11.78	2853.80
1+309.95	0.00	0.00	2853.80

pavment table			
Station	Area	Volume	Cumulative Volume
0+000.00	1.30	0.00	0.00
0+020.00	1.30	26.00	26.00
0+040.00	1.30	26.00	52.00
0+060.00	1.38	26.80	78.80
0+070.00	1.30	13.40	92.20
0+080.00	1.30	13.00	105.20
0+090.00	1.30	13.00	118.20
0+100.00	1.38	13.40	131.60
0+110.00	1.30	13.40	145.00
0+120.00	1.30	13.00	158.00
0+140.00	1.30	26.00	184.00
0+150.00	1.30	13.00	197.00
0+160.00	1.30	13.00	210.00
0+180.00	1.38	26.80	236.80
0+200.00	1.30	26.80	263.60
0+220.00	1.30	26.00	289.60
0+240.00	1.38	26.80	316.40
0+250.00	1.38	13.80	330.20
0+260.00	1.30	13.40	343.60
0+270.00	1.30	13.00	356.60
0+280.00	1.30	13.00	369.60
0+300.00	1.30	26.00	395.60
0+320.00	1.30	26.00	421.60
0+340.00	1.30	26.00	447.60
0+360.00	1.38	26.80	474.40

pavment table			
Station	Area	Volume	Cumulative Volume
0+380.00	1.30	26.80	501.20
0+400.00	1.30	26.00	527.20
0+420.00	1.30	26.00	553.20
0+440.00	1.30	26.00	579.20
0+460.00	1.38	26.80	606.00
0+480.00	1.30	26.80	632.80
0+500.00	1.30	26.00	658.80
0+520.00	1.30	26.00	684.80
0+530.00	1.30	13.00	697.80
0+540.00	1.30	13.00	710.80
0+550.00	1.30	13.00	723.80
0+560.00	1.30	13.00	736.80
0+580.00	1.30	26.00	762.80
0+590.00	1.30	13.00	775.80
0+600.00	1.30	13.00	788.80
0+610.00	1.30	13.00	801.80
0+620.00	1.30	13.00	814.80
0+630.00	1.38	13.40	828.20
0+640.00	1.30	13.40	841.60
0+660.00	1.30	26.00	867.60
0+670.00	1.30	13.00	880.60
0+680.00	1.30	13.00	893.60
0+690.00	1.30	13.00	906.60
0+700.00	1.30	13.00	919.60
0+710.00	1.38	13.40	933.00

curb			
Station	Area	Volume	Cumulative Volume
0+000.00	0.16	0.00	0.00
0+020.00	0.16	3.13	3.13
0+040.00	0.16	3.13	6.26
0+060.00	0.08	2.35	8.60
0+070.00	0.16	1.17	9.78
0+080.00	0.16	1.56	11.34
0+090.00	0.16	1.56	12.90
0+100.00	0.08	1.17	14.08
0+110.00	0.16	1.17	15.25
0+120.00	0.16	1.56	16.81
0+140.00	0.16	3.13	19.94
0+150.00	0.16	1.56	21.51
0+160.00	0.16	1.56	23.07
0+180.00	0.08	2.35	25.42
0+200.00	0.16	2.35	27.76
0+220.00	0.16	3.13	30.89
0+240.00	0.08	2.35	33.24
0+250.00	0.08	0.78	34.02
0+260.00	0.16	1.17	35.19
0+270.00	0.16	1.56	36.75
0+280.00	0.16	1.56	38.32
0+300.00	0.16	3.13	41.45
0+320.00	0.16	3.13	44.57
0+340.00	0.16	3.13	47.70
0+360.00	0.08	2.35	50.05

curb			
Station	Area	Volume	Cumulative Volume
0+380.00	0.16	2.35	52.39
0+400.00	0.16	3.13	55.52
0+420.00	0.16	3.13	58.65
0+440.00	0.16	3.13	61.78
0+460.00	0.08	2.35	64.12
0+480.00	0.16	2.35	66.47
0+500.00	0.16	3.13	69.60
0+520.00	0.16	3.13	72.73
0+530.00	0.16	1.56	74.29
0+540.00	0.16	1.56	75.85
0+550.00	0.16	1.56	77.42
0+560.00	0.16	1.56	78.98
0+580.00	0.16	3.13	82.11
0+590.00	0.16	1.56	83.67
0+600.00	0.16	1.56	85.24
0+610.00	0.16	1.56	86.80
0+620.00	0.16	1.56	88.37
0+630.00	0.08	1.17	89.54
0+640.00	0.16	1.17	90.71
0+660.00	0.16	3.13	93.84
0+670.00	0.16	1.56	95.40
0+680.00	0.16	1.56	96.97
0+690.00	0.16	1.56	98.53
0+700.00	0.16	1.56	100.10
0+710.00	0.08	1.17	101.27

pavment table			
Station	Area	Volume	Cumulative Volume
0+720.00	1.30	13.40	946.40
0+730.00	1.30	13.00	959.40
0+740.00	1.30	13.00	972.40
0+750.00	1.30	13.00	985.40
0+760.00	1.30	13.00	998.40
0+770.00	1.30	13.00	1011.40
0+780.00	1.30	13.00	1024.40
0+800.00	1.30	26.00	1050.40
0+820.00	1.38	26.80	1077.20
0+840.00	1.30	26.80	1104.00
0+850.00	1.30	13.00	1117.00
0+860.00	1.30	13.00	1130.00
0+880.00	1.30	26.00	1156.00
0+890.00	1.30	13.00	1169.00
0+900.00	1.30	13.00	1182.00
0+920.00	1.30	26.00	1208.00
0+930.00	1.30	13.00	1221.00
0+940.00	1.30	13.00	1234.00
0+960.00	1.30	26.00	1260.00
0+970.00	1.30	13.00	1273.00
0+980.00	1.30	13.00	1286.00
0+990.00	1.30	13.00	1299.00
1+000.00	1.30	13.00	1312.00
1+010.00	1.30	13.00	1325.00
1+020.00	1.30	13.00	1338.00

pavment table			
Station	Area	Volume	Cumulative Volume
1+030.00	1.30	13.00	1351.00
1+040.00	1.30	13.00	1364.00
1+060.00	1.30	26.00	1390.00
1+070.00	1.30	13.00	1403.00
1+080.00	1.30	13.00	1416.00
1+090.00	1.30	13.00	1429.00
1+100.00	1.30	13.00	1442.00
1+120.00	1.38	26.80	1468.80
1+130.00	1.30	13.40	1482.20
1+140.00	1.30	13.00	1495.20
1+160.00	1.30	26.00	1521.20
1+180.00	1.30	26.00	1547.20
1+190.00	1.30	13.00	1560.20
1+200.00	1.30	13.00	1573.20
1+210.00	1.30	13.00	1586.20
1+220.00	1.30	13.00	1599.20
1+230.00	1.30	13.00	1612.20
1+240.00	1.30	13.00	1625.20
1+250.00	1.38	13.40	1638.60
1+260.00	1.38	13.80	1652.40
1+270.00	0.69	10.79	1663.19
1+280.00	0.69	8.59	1671.78
1+300.00	0.00	6.93	1678.71
1+309.95	0.00	0.00	1678.71

curb			
Station	Area	Volume	Cumulative Volume
0+720.00	0.16	1.17	102.44
0+730.00	0.16	1.56	104.01
0+740.00	0.16	1.56	105.57
0+750.00	0.16	1.56	107.13
0+760.00	0.16	1.56	108.70
0+770.00	0.16	1.56	110.26
0+780.00	0.16	1.56	111.83
0+800.00	0.16	3.13	114.95
0+820.00	0.08	2.35	117.30
0+840.00	0.16	2.35	119.65
0+850.00	0.16	1.56	121.21
0+860.00	0.16	1.56	122.77
0+880.00	0.16	3.13	125.90
0+890.00	0.16	1.56	127.47
0+900.00	0.16	1.56	129.03
0+920.00	0.16	3.13	132.16
0+930.00	0.16	1.56	133.72
0+940.00	0.16	1.56	135.29
0+960.00	0.16	3.13	138.41
0+970.00	0.16	1.56	139.98
0+980.00	0.16	1.56	141.54
0+990.00	0.16	1.56	143.11
1+000.00	0.16	1.56	144.67
1+010.00	0.16	1.56	146.23
1+020.00	0.16	1.56	147.80

curb			
Station	Area	Volume	Cumulative Volume
1+030.00	0.16	1.56	149.36
1+040.00	0.16	1.56	150.93
1+060.00	0.16	3.13	154.05
1+070.00	0.16	1.56	155.62
1+080.00	0.16	1.56	157.18
1+090.00	0.16	1.56	158.75
1+100.00	0.16	1.56	160.31
1+120.00	0.08	2.35	162.66
1+130.00	0.16	1.17	163.83
1+140.00	0.16	1.56	165.39
1+160.00	0.16	3.13	168.52
1+180.00	0.16	3.13	171.65
1+190.00	0.16	1.56	173.21
1+200.00	0.16	1.56	174.78
1+210.00	0.16	1.56	176.34
1+220.00	0.16	1.56	177.91
1+230.00	0.16	1.56	179.47
1+240.00	0.16	1.56	181.03
1+250.00	0.08	1.17	182.21
1+260.00	0.08	0.78	182.99
1+270.00	0.04	0.64	183.63
1+280.00	0.04	0.58	184.21
1+300.00	0.00	0.39	184.61
1+309.95	0.00	0.00	184.61

side walk			
Station	Area	Volume	Cumulative Volume
0+000.00	0.71	0.00	0.00
0+020.00	0.72	14.30	14.30
0+040.00	0.72	14.30	28.60
0+060.00	0.71	14.30	42.90
0+070.00	0.72	7.15	50.05
0+080.00	0.71	7.15	57.20
0+090.00	0.72	7.15	64.35
0+100.00	0.71	7.15	71.50
0+110.00	0.72	7.15	78.65
0+120.00	0.72	7.15	85.80
0+140.00	0.71	14.30	100.10
0+150.00	0.71	7.15	107.25
0+160.00	0.71	7.15	114.40
0+180.00	0.72	14.30	128.70
0+200.00	0.72	14.30	143.00
0+220.00	0.72	14.30	157.30
0+240.00	0.71	14.30	171.60
0+250.00	0.71	7.15	178.75
0+260.00	0.71	7.15	185.90
0+270.00	0.71	7.15	193.05
0+280.00	0.71	7.15	200.20
0+300.00	0.71	14.30	214.50
0+320.00	0.71	14.30	228.80
0+340.00	0.72	14.30	243.10
0+360.00	0.72	14.30	257.40

side walk			
Station	Area	Volume	Cumulative Volume
0+380.00	0.72	14.30	271.70
0+400.00	0.72	14.30	286.00
0+420.00	0.72	14.30	300.30
0+440.00	0.71	14.30	314.60
0+460.00	0.72	14.30	328.90
0+480.00	0.71	14.30	343.20
0+500.00	0.72	14.30	357.50
0+520.00	0.72	14.30	371.80
0+530.00	0.72	7.15	378.95
0+540.00	0.72	7.15	386.10
0+550.00	0.72	7.15	393.25
0+560.00	0.71	7.15	400.40
0+580.00	0.72	14.30	414.70
0+590.00	0.72	7.15	421.85
0+600.00	0.71	7.15	429.00
0+610.00	0.71	7.15	436.15
0+620.00	0.72	7.15	443.30
0+630.00	0.71	7.15	450.45
0+640.00	0.72	7.15	457.60
0+660.00	0.72	14.30	471.90
0+670.00	0.72	7.15	479.05
0+680.00	0.71	7.15	486.20
0+690.00	0.71	7.15	493.35
0+700.00	0.72	7.15	500.50
0+710.00	0.72	7.15	507.65

side walk			
Station	Area	Volume	Cumulative Volume
0+720.00	0.71	7.15	514.80
0+730.00	0.71	7.15	521.95
0+740.00	0.72	7.15	529.10
0+750.00	0.72	7.15	536.25
0+760.00	0.72	7.15	543.40
0+770.00	0.72	7.15	550.55
0+780.00	0.72	7.15	557.70
0+800.00	0.71	14.30	572.00
0+820.00	0.71	14.30	586.30
0+840.00	0.72	14.30	600.60
0+850.00	0.71	7.15	607.75
0+860.00	0.71	7.15	614.90
0+880.00	0.72	14.30	629.20
0+890.00	0.71	7.15	636.35
0+900.00	0.72	7.15	643.50
0+920.00	0.71	14.30	657.80
0+930.00	0.72	7.15	664.95
0+940.00	0.72	7.15	672.10
0+960.00	0.71	14.30	686.40
0+970.00	0.72	7.15	693.55
0+980.00	0.71	7.15	700.70
0+990.00	0.72	7.15	707.85
1+000.00	0.72	7.15	715.00
1+010.00	0.71	7.15	722.15
1+020.00	0.71	7.15	729.30

side walk			
Station	Area	Volume	Cumulative Volume
1+030.00	0.72	7.15	736.45
1+040.00	0.71	7.15	743.60
1+060.00	0.72	14.30	757.90
1+070.00	0.71	7.15	765.05
1+080.00	0.72	7.15	772.20
1+090.00	0.71	7.15	779.35
1+100.00	0.71	7.15	786.50
1+120.00	0.72	14.30	800.80
1+130.00	0.71	7.15	807.95
1+140.00	0.72	7.15	815.10
1+160.00	0.72	14.30	829.40
1+180.00	0.71	14.30	843.70
1+190.00	0.72	7.15	850.85
1+200.00	0.72	7.15	858.00
1+210.00	0.71	7.15	865.15
1+220.00	0.71	7.15	872.30
1+230.00	0.71	7.15	879.45
1+240.00	0.71	7.15	886.60
1+250.00	0.71	7.15	893.75
1+260.00	0.72	7.15	900.90
1+270.00	0.36	5.88	906.78
1+280.00	0.36	5.55	912.33
1+300.00	0.00	3.61	915.94
1+309.95	0.00	0.00	915.94

e) T-section Quantity Table

T – SECTION CUT AND FILL						
Station	Fill Area	Cut Area	Fill Volume	Cut Volume	Cumulative Fill Vol	Cumulative Cut Vol
0+000.00	0.24	4.63	0.00	0.00	0.00	0.00
0+010.00	0.00	6.22	1.68	66.44	1.68	66.44
0+020.00	0.00	6.12	0.00	78.36	1.68	144.80
0+024.56	0.00	6.48	0.00	33.26	1.68	178.06

Pavement			
Station	Area	Volume	Cumulative Volume
0+000.00	2.00	0.00	0.00
0+010.00	2.00	26.43	26.43
0+020.00	1.55	24.85	51.28
0+024.56	1.45	8.70	59.98

Base			
Station	Area	Volume	Cumulative Volume
0+000.00	3.40	0.00	0.00
0+010.00	3.40	44.93	44.93
0+020.00	2.64	42.25	87.17
0+024.56	2.46	14.79	101.96

curb			
Station	Area	Volume	Cumulative Volume
0+000.00	0.04	0.00	0.00
0+010.00	0.04	0.39	0.39
0+020.00	0.04	0.39	0.78
0+024.56	0.04	0.18	0.96

side walk			
Station	Area	Volume	Cumulative Volume
0+000.00	0.36	0.00	0.00
0+010.00	0.36	3.47	3.47
0+020.00	0.36	3.43	6.91
0+024.56	0.37	1.60	8.51

T – section L cut and fill						
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+010.00	0.09	4.90	0.41	44.41	0.41	44.41
0+017.21	0.00	5.04	0.30	57.01	0.71	101.42

Pavement			
Station	Area	Volume	Cumulative Volume
−0+000.00	0.00	0.00	0.00
0+010.00	2.00	19.07	19.07
0+017.21	1.33	21.44	40.51

Base			
Station	Area	Volume	Cumulative Volume
−0+000.00	0.00	0.00	0.00
0+010.00	3.40	32.42	32.42
0+017.21	2.26	36.45	68.87

curb			
Station	Area	Volume	Cumulative Volume
−0+000.00	0.00	0.00	0.00
0+010.00	0.04	0.19	0.19
0+017.21	0.04	0.28	0.47

side walk			
Station	Area	Volume	Cumulative Volume
−0+000.00	0.00	0.00	0.00
0+010.00	0.36	1.64	1.64
0+017.21	0.36	2.39	4.04

f) Pipe Network Description Table

STRUCTURE TABLE			
STRUCTURE NAME:	DETAILS:	PIPES IN:	PIPES OUT
Structure – (308)	1200 mm RIM − 201.98 SUMP = 198.36 INV OUT − 198.357		Pipe – (296), 500 mm REINFORCED CONCRETE INV OUT −198.36
Structure – (309)	1200 mm RIM = 199.54 SUMP − 195.81 INV IN = 195.911 INV OUT − 195.811	Pipe – (296), 500 mm REINFORCED CONCRETE INV IN −195.91	Pipe – (297), 500 mm REINFORCED CONCRETE INV OUT −195.81
Structure – (364)	300 mm RIM − 197.90 SUMP = 193.58 INV IN − 193.576	Pipe – (351), 250 mm REINFORCED CONCRETE INV IN −193.58	
Structure – (310)	1200 mm RIM = 197.42 SUMP − 193.70 INV IN = 193.797 INV OUT − 193.697 INV OUT = 193.697	Pipe – (297), 500 mm REINFORCED CONCRETE INV IN −193.80	Pipe – (298), 500 mm REINFORCED CONCRETE INV OUT −193.70 Pipe – (351), 250 mm REINFORCED CONCRETE INV OUT =193.70
Structure – (311)	1200 mm RIM − 195.12 SUMP = 191.39 INV IN − 191.494 INV OUT = 191.394	Pipe – (298), 500 mm REINFORCED CONCRETE INV IN −191.49	Pipe – (299), 500 mm REINFORCED CONCRETE INV OUT −191.39
Structure – (363)	300 mm RIM = 193.55 SUMP − 188.22 INV IN = 188.221	Pipe – (350), 250 mm REINFORCED CONCRETE INV IN =188.22	
Structure – (312)	1200 mm RIM − 192.16 SUMP = 188.44 INV IN − 188.537 INV OUT = 188.437 INV OUT − 188.437	Pipe – (299), 500 mm REINFORCED CONCRETE INV IN =188.54	Pipe – (300), 500 mm REINFORCED CONCRETE INV OUT =188.44 Pipe – (350), 250 mm REINFORCED CONCRETE INV OUT −188.44
Structure – (313)	1200 mm RIM − 190.82 SUMP = 187.10 INV IN − 187.200 INV OUT − 187.100	Pipe – (300), 500 mm REINFORCED CONCRETE INV IN −187.20	Pipe – (301), 500 mm REINFORCED CONCRETE INV OUT −187.10
Structure – (362)	300 mm RIM − 190.29 SUMP = 184.63 INV IN − 184.629	Pipe – (349), 250 mm REINFORCED CONCRETE INV IN −184.63	
Structure – (314)	1200 mm RIM = 188.61 SUMP − 184.88 INV IN = 184.980 INV OUT − 184.880 INV OUT = 184.880	Pipe – (301), 500 mm REINFORCED CONCRETE INV IN −184.98	Pipe – (302), 500 mm REINFORCED CONCRETE INV OUT =184.88 Pipe – (349), 250 mm REINFORCED CONCRETE INV OUT =184.88
Structure – (361)	300 mm RIM = 188.00 SUMP − 182.71 INV IN − 182.708	Pipe – (348), 250 mm REINFORCED CONCRETE INV IN −182.71	
Structure – (315)	1200 mm RIM − 186.64 SUMP = 182.92 INV IN − 183.018 INV OUT = 182.918 INV OUT − 182.918	Pipe – (302), 500 mm REINFORCED CONCRETE INV IN =183.02	Pipe – (303), 500 mm REINFORCED CONCRETE INV OUT =182.92 Pipe – (348), 250 mm REINFORCED CONCRETE INV OUT −182.92

Structure – (360)	300 mm RIM = 186.26 SUMP = 181.20 INV IN = 181.196	Pipe – (347), 250 mm REINFORCED CONCRETE INV IN =181.20	
Structure – (316)	1200 mm RIM = 185.10 SUMP = 181.38 INV IN = 181.480 INV OUT = 181.380 INV OUT = 181.380	Pipe – (303), 500 mm REINFORCED CONCRETE INV IN =181.48	Pipe – (304), 500 mm REINFORCED CONCRETE INV OUT =181.38 Pipe – (347), 250 mm REINFORCED CONCRETE INV OUT =181.38
Structure – (317)	1200 mm RIM = 183.25 SUMP = 179.52 INV IN = 179.622 INV OUT = 179.522	Pipe – (304), 500 mm REINFORCED CONCRETE INV IN =179.62	Pipe – (305), 500 mm REINFORCED CONCRETE INV OUT =179.52
Structure – (318)	1200 mm RIM = 181.00 SUMP = 177.28 INV IN = 177.380 INV OUT = 177.280	Pipe – (305), 500 mm REINFORCED CONCRETE INV IN =177.38	Pipe – (306), 500 mm REINFORCED CONCRETE INV OUT =177.28
Structure – (319)	1200 mm RIM = 179.38 SUMP = 175.66 INV IN = 175.757 INV OUT = 175.657	Pipe – (306), 500 mm REINFORCED CONCRETE INV IN =175.76	Pipe – (307), 500 mm REINFORCED CONCRETE INV OUT =175.66
Structure – (320)	1200 mm RIM = 178.19 SUMP = 174.47 INV IN = 174.566 INV OUT = 174.466	Pipe – (307), 500 mm REINFORCED CONCRETE INV IN =174.57	Pipe – (308), 500 mm REINFORCED CONCRETE INV OUT =174.47
Structure – (359)	300 mm RIM = 176.90 SUMP = 171.83 INV IN = 171.825	Pipe – (346), 250 mm REINFORCED CONCRETE INV IN =171.83	
Structure – (321)	1200 mm RIM = 175.74 SUMP = 172.01 INV IN = 172.112 INV OUT = 172.012 INV OUT = 172.012	Pipe – (308), 500 mm REINFORCED CONCRETE INV IN =172.11	Pipe – (309), 500 mm REINFORCED CONCRETE INV OUT =172.01 Pipe – (346), 250 mm REINFORCED CONCRETE INV OUT =172.01
Structure – (358)	300 mm RIM = 174.21 SUMP = 169.58 INV IN = 169.585	Pipe – (345), 250 mm REINFORCED CONCRETE INV IN =169.58	
Structure – (322)	1200 mm RIM = 173.45 SUMP = 169.73 INV IN = 169.829 INV OUT = 169.729 INV OUT = 169.729	Pipe – (309), 500 mm REINFORCED CONCRETE INV IN =169.83	Pipe – (310), 500 mm REINFORCED CONCRETE INV OUT =169.73 Pipe – (345), 250 mm REINFORCED CONCRETE INV OUT =169.73
Structure – (323)	1200 mm RIM = 172.09 SUMP = 168.37 INV IN = 168.469 INV OUT = 168.369	Pipe – (310), 500 mm REINFORCED CONCRETE INV IN =168.47	Pipe – (311), 500 mm REINFORCED CONCRETE INV OUT =168.37
Structure – (324)	1200 mm RIM = 169.85 SUMP = 166.13 INV IN = 166.227 INV OUT = 166.127	Pipe – (311), 500 mm REINFORCED CONCRETE INV IN =166.23	Pipe – (312), 500 mm REINFORCED CONCRETE INV OUT =166.13
Structure – (325)	1200 mm RIM = 167.88 SUMP = 164.15 INV IN = 164.250 INV OUT = 164.150	Pipe – (312), 500 mm REINFORCED CONCRETE INV IN =164.25	Pipe – (313), 500 mm REINFORCED CONCRETE INV OUT =164.15

STRUCTURE TABLE			
STRUCTURE NAME:	DETAILS:	PIPES IN:	PIPES OUT
Structure – (326)	1200 mm RIM = 167.14 SUMP = 163.41 INV IN = 163.512 INV OUT = 163.412	Pipe – (313), 500 mm REINFORCED CONCRETE INV IN =163.51	Pipe – (314), 500 mm REINFORCED CONCRETE INV OUT =163.41
Structure – (327)	1200 mm RIM = 164.59 SUMP = 160.86 INV IN = 160.965 INV OUT = 160.865	Pipe – (314), 500 mm REINFORCED CONCRETE INV IN =160.96	Pipe – (315), 500 mm REINFORCED CONCRETE INV OUT =160.86
Structure – (328)	1200 mm RIM = 162.43 SUMP = 158.70 INV IN = 158.803 INV OUT = 158.703	Pipe – (315), 500 mm REINFORCED CONCRETE INV IN =158.80	Pipe – (316), 500 mm REINFORCED CONCRETE INV OUT =158.70
Structure – (357)	300 mm RIM = 160.64 SUMP = 156.21 INV IN = 156.210	Pipe – (344), 250 mm REINFORCED CONCRETE INV IN =156.21	
Structure – (329)	1200 mm RIM = 160.06 SUMP = 156.34 INV IN = 156.436 INV OUT = 156.336 INV OUT = 156.336	Pipe – (316), 500 mm REINFORCED CONCRETE INV IN =156.44	Pipe – (317), 500 mm REINFORCED CONCRETE INV OUT =156.34 Pipe – (344), 250 mm REINFORCED CONCRETE INV OUT =156.34
Structure – (330)	1200 mm RIM = 158.93 SUMP = 155.20 INV IN = 155.305 INV OUT = 155.205	Pipe – (317), 500 mm REINFORCED CONCRETE INV IN =155.30	Pipe – (318), 500 mm REINFORCED CONCRETE INV OUT =155.20
Structure – (331)	1200 mm RIM = 156.76 SUMP = 153.03 INV IN = 153.130 INV OUT = 153.030	Pipe – (318), 500 mm REINFORCED CONCRETE INV IN =153.13	Pipe – (319), 500 mm REINFORCED CONCRETE INV OUT =153.03
Structure – (356)	300 mm RIM = 155.04 SUMP = 150.64 INV IN = 150.637	Pipe – (343), 250 mm REINFORCED CONCRETE INV IN =150.64	
Structure – (332)	1200 mm RIM = 154.49 SUMP = 150.77 INV IN = 150.866 INV OUT = 150.766 INV OUT = 150.766	Pipe – (319), 500 mm REINFORCED CONCRETE INV IN =150.87	Pipe – (320), 500 mm REINFORCED CONCRETE INV OUT =150.77 Pipe – (343), 250 mm REINFORCED CONCRETE INV OUT =150.77
Structure – (355)	300 mm RIM = 153.19 SUMP = 148.55 INV IN = 148.554	Pipe – (342), 250 mm REINFORCED CONCRETE INV IN =148.55	
Structure – (333)	1200 mm RIM = 152.43 SUMP = 148.71 INV IN = 148.807 INV OUT = 148.707 INV OUT = 148.707	Pipe – (320), 500 mm REINFORCED CONCRETE INV IN =148.81	Pipe – (321), 500 mm REINFORCED CONCRETE INV OUT =148.71 Pipe – (342), 250 mm REINFORCED CONCRETE INV OUT =148.71
Structure – (354)	300 mm RIM = 151.09 SUMP = 146.76 INV IN = 146.755	Pipe – (341), 250 mm REINFORCED CONCRETE INV IN =146.76	

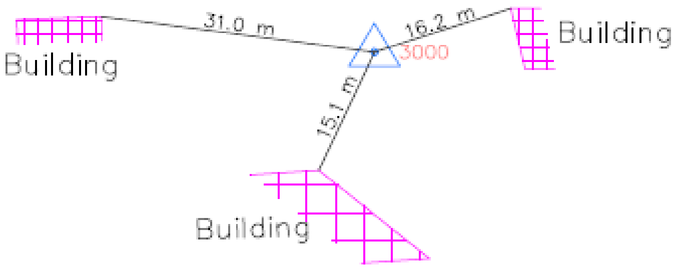
Structure – (334)	RIM = 150.63 SUMP = 146.89 INV IN = 146.987 INV OUT = 146.887 INV OUT = 146.887	Pipe – (321), 500 mm REINFORCED CONCRETE INV IN =146.99	Pipe – (322), 500 mm REINFORCED CONCRETE INV OUT =146.89 Pipe – (341), 250 mm REINFORCED CONCRETE INV OUT =146.89
Structure – (335)	1200 mm RIM = 149.98 SUMP = 146.26 INV IN = 146.357 INV OUT = 146.257	Pipe – (322), 500 mm REINFORCED CONCRETE INV IN =146.36	Pipe – (323), 500 mm REINFORCED CONCRETE INV OUT =146.26
Structure – (336)	1200 mm RIM = 148.60 SUMP = 144.87 INV IN = 144.972 INV OUT = 144.872	Pipe – (323), 500 mm REINFORCED CONCRETE INV IN =144.97	Pipe – (324), 500 mm REINFORCED CONCRETE INV OUT =144.87
Structure – (353)	300 mm RIM = 147.61 SUMP = 143.35 INV IN = 143.347	Pipe – (340), 250 mm REINFORCED CONCRETE INV IN =143.35	
Structure – (337)	1200 mm RIM = 147.23 SUMP = 143.50 INV IN = 143.598 INV OUT = 143.498 INV OUT = 143.498	Pipe – (324), 500 mm REINFORCED CONCRETE INV IN =143.60	Pipe – (325), 500 mm REINFORCED CONCRETE INV OUT =143.50 Pipe – (340), 250 mm REINFORCED CONCRETE INV OUT =143.50
Structure – (352)	300 mm RIM = 146.50 SUMP = 142.36 INV IN = 142.363	Pipe – (339), 250 mm REINFORCED CONCRETE INV IN =142.36	
Structure – (338)	1200 mm RIM = 146.24 SUMP = 142.51 INV IN = 142.606 INV OUT = 142.506 INV OUT = 142.506	Pipe – (325), 500 mm REINFORCED CONCRETE INV IN =142.61	Pipe – (326), 500 mm REINFORCED CONCRETE INV OUT =142.51 Pipe – (339), 250 mm REINFORCED CONCRETE INV OUT =142.51
Structure – (351)	300 mm RIM = 145.76 SUMP = 141.75 INV IN = 141.754	Pipe – (338), 250 mm REINFORCED CONCRETE INV IN =141.75	
Structure – (339)	1200 mm RIM = 145.61 SUMP = 141.89 INV IN = 141.989 INV OUT = 141.889 INV OUT = 141.889	Pipe – (326), 500 mm REINFORCED CONCRETE INV IN =141.99	Pipe – (327), 500 mm REINFORCED CONCRETE INV OUT =141.89 Pipe – (338), 250 mm REINFORCED CONCRETE INV OUT =141.89
Structure – (340)	1200 mm RIM = 145.26 SUMP = 141.50 INV IN = 141.604 INV OUT = 141.504	Pipe – (327), 500 mm REINFORCED CONCRETE INV IN =141.60	Pipe – (328), 500 mm REINFORCED CONCRETE INV OUT =141.50
Structure – (350)	300 mm RIM = 145.05 SUMP = 140.91 INV IN = 140.909	Pipe – (337), 250 mm REINFORCED CONCRETE INV IN =140.91	
Structure – (341)	1200 mm RIM = 144.92 SUMP = 141.06 INV IN = 141.164 INV OUT = 141.064 INV OUT = 141.064	Pipe – (328), 500 mm REINFORCED CONCRETE INV IN =141.16	Pipe – (329), 500 mm REINFORCED CONCRETE INV OUT =141.06 Pipe – (337), 250 mm REINFORCED CONCRETE INV OUT =141.06
Structure – (342)	1200 mm RIM = 144.75 SUMP = 140.90 INV IN = 140.899	Pipe – (329), 500 mm REINFORCED CONCRETE INV IN =140.90	

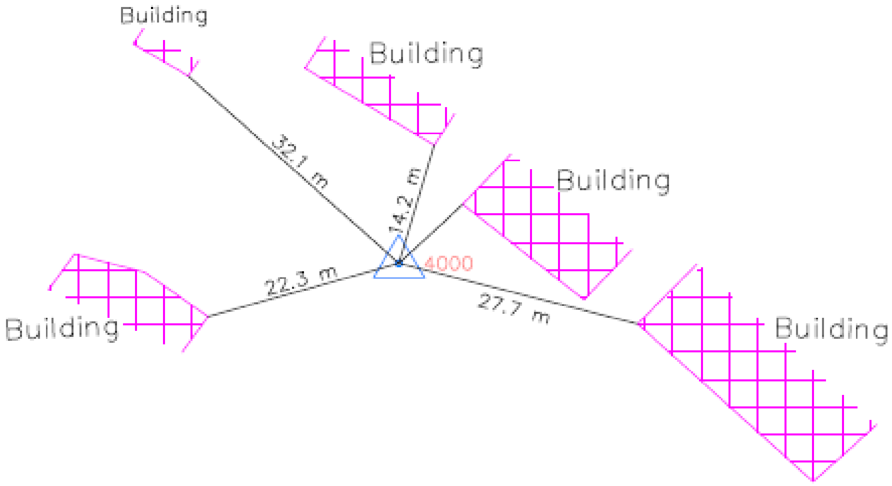
g) Pipe Material Table

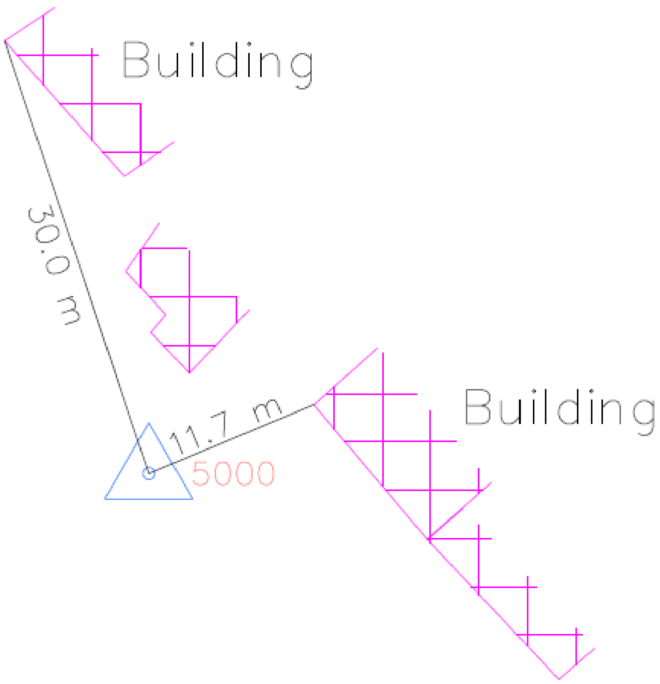
Pipe Table				
NAME	SIZE	LENGTH	SLOPE	MATERIAL
Pipe – (296)	500 mm	37.5 m	6.52%	Reinforced Concrete
Pipe – (297)	500 mm	31.6 m	6.38%	Reinforced Concrete
Pipe – (298)	500 mm	33.1 m	6.66%	Reinforced Concrete
Pipe – (299)	500 mm	41.1 m	6.94%	Reinforced Concrete
Pipe – (300)	500 mm	20.8 m	5.96%	Reinforced Concrete
Pipe – (301)	500 mm	30.9 m	6.86%	Reinforced Concrete
Pipe – (302)	500 mm	27.2 m	6.85%	Reinforced Concrete
Pipe – (303)	500 mm	21.2 m	6.79%	Reinforced Concrete
Pipe – (304)	500 mm	26.4 m	6.67%	Reinforced Concrete
Pipe – (305)	500 mm	31.1 m	6.88%	Reinforced Concrete
Pipe – (306)	500 mm	22.5 m	6.76%	Reinforced Concrete
Pipe – (307)	500 mm	19.1 m	5.70%	Reinforced Concrete
Pipe – (308)	500 mm	32.8 m	7.17%	Reinforced Concrete
Pipe – (309)	500 mm	30.7 m	7.10%	Reinforced Concrete
Pipe – (310)	500 mm	21.2 m	5.96%	Reinforced Concrete
Pipe – (311)	500 mm	30.2 m	7.11%	Reinforced Concrete
Pipe – (312)	500 mm	26.9 m	6.97%	Reinforced Concrete
Pipe – (313)	500 mm	14.3 m	4.46%	Reinforced Concrete
Pipe – (314)	500 mm	34.8 m	7.04%	Reinforced Concrete
Pipe – (315)	500 mm	29.7 m	6.95%	Reinforced Concrete
Pipe – (316)	500 mm	32.2 m	7.03%	Reinforced Concrete
Pipe – (317)	500 mm	18.4 m	5.61%	Reinforced Concrete
Pipe – (318)	500 mm	29.6 m	7.00%	Reinforced Concrete
Pipe – (319)	500 mm	30.9 m	7.01%	Reinforced Concrete
Pipe – (320)	500 mm	31.3 m	6.26%	Reinforced Concrete

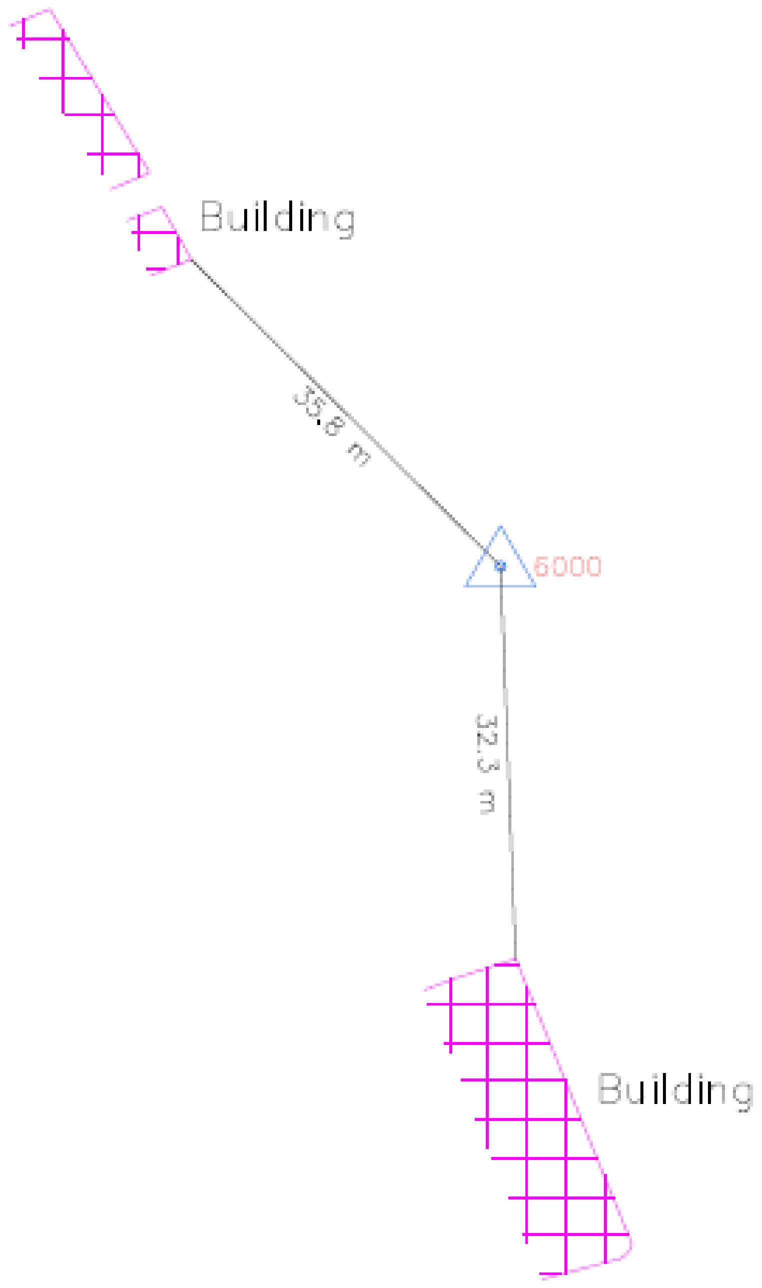
Pipe Table				
NAME	SIZE	LENGTH	SLOPE	MATERIAL
Pipe – (321)	500 mm	30.7 m	5.59%	Reinforced Concrete
Pipe – (322)	500 mm	15.9 m	3.32%	Reinforced Concrete
Pipe – (323)	500 mm	29.9 m	4.30%	Reinforced Concrete
Pipe – (324)	500 mm	36.9 m	3.45%	Reinforced Concrete
Pipe – (325)	500 mm	35.3 m	2.53%	Reinforced Concrete
Pipe – (326)	500 mm	31.9 m	1.62%	Reinforced Concrete
Pipe – (327)	500 mm	28.4 m	1.00%	Reinforced Concrete
Pipe – (328)	500 mm	34.0 m	1.00%	Reinforced Concrete
Pipe – (329)	500 mm	16.5 m	1.00%	Reinforced Concrete
Pipe – (337)	250 mm	15.5 m	1.00%	Reinforced Concrete
Pipe – (338)	250 mm	13.5 m	1.00%	Reinforced Concrete
Pipe – (339)	250 mm	14.3 m	1.00%	Reinforced Concrete
Pipe – (340)	250 mm	15.1 m	1.00%	Reinforced Concrete
Pipe – (341)	250 mm	13.2 m	1.00%	Reinforced Concrete
Pipe – (342)	250 mm	15.3 m	1.00%	Reinforced Concrete
Pipe – (343)	250 mm	12.9 m	1.00%	Reinforced Concrete
Pipe – (344)	250 mm	12.6 m	1.00%	Reinforced Concrete
Pipe – (345)	250 mm	14.5 m	1.00%	Reinforced Concrete
Pipe – (346)	250 mm	18.7 m	1.00%	Reinforced Concrete
Pipe – (347)	250 mm	18.4 m	1.00%	Reinforced Concrete
Pipe – (348)	250 mm	21.0 m	1.00%	Reinforced Concrete
Pipe – (349)	250 mm	25.1 m	1.00%	Reinforced Concrete
Pipe – (350)	250 mm	21.7 m	1.00%	Reinforced Concrete
Pipe – (351)	250 mm	12.2 m	1.00%	Reinforced Concrete

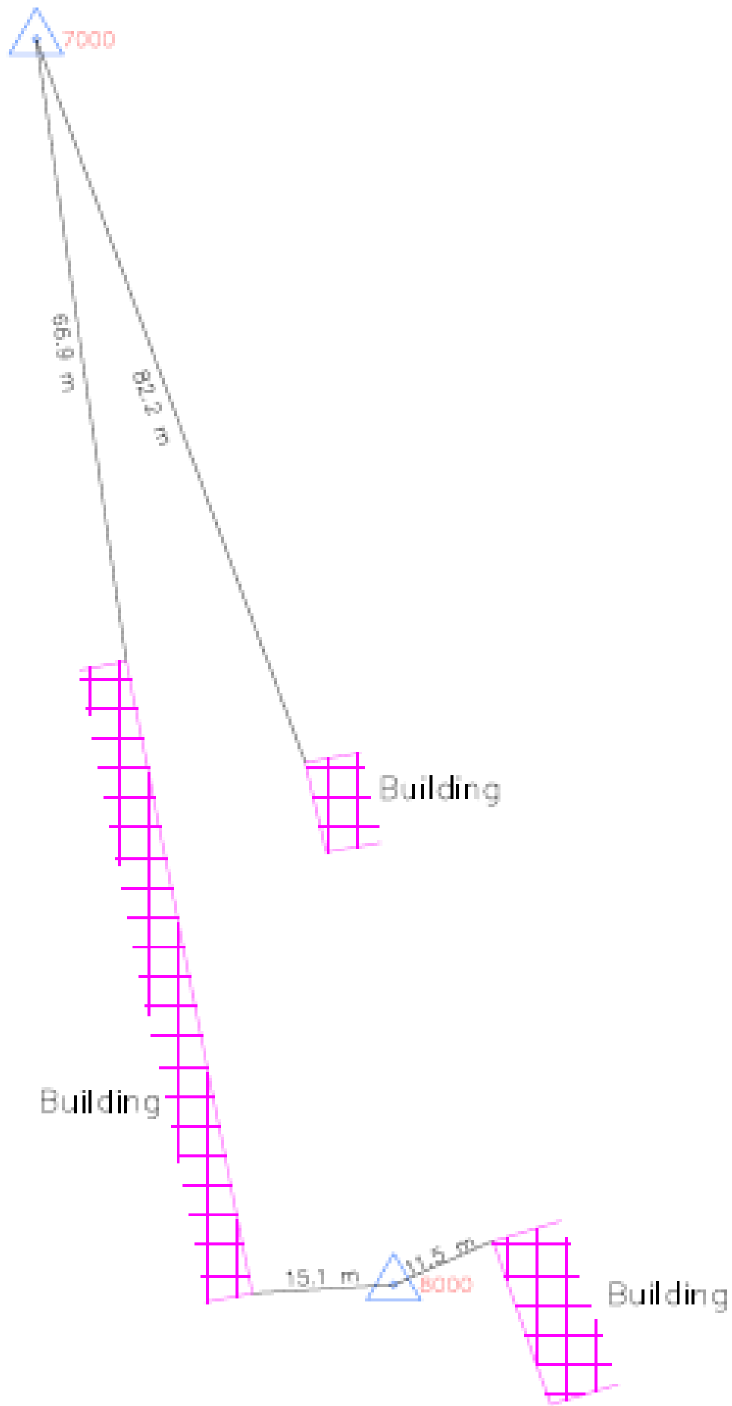
h) Sketch of control point

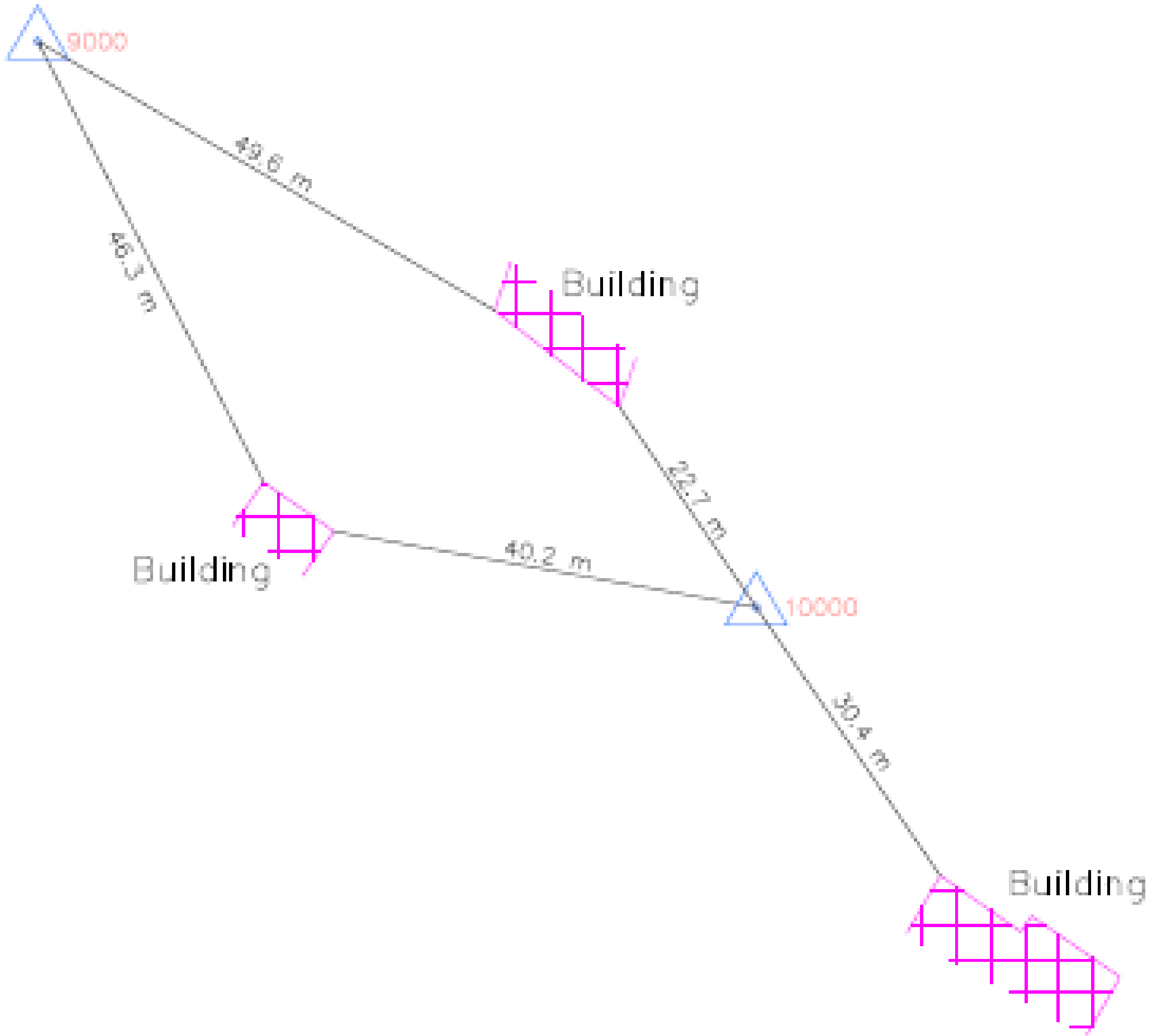


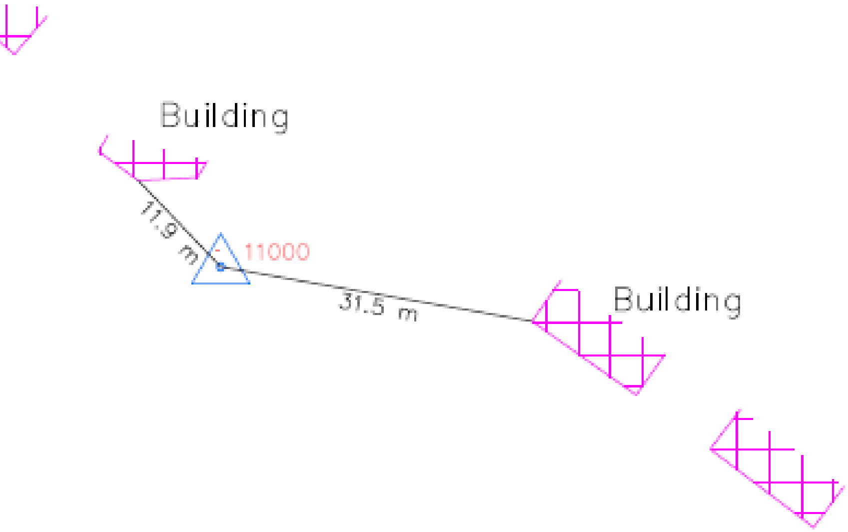


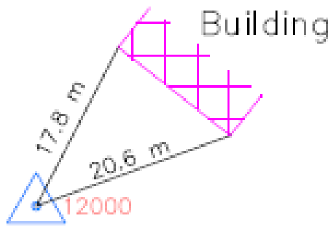



Building
35.8 m
6000
32.3 m
Building


7000
66.9 m
82.2 m
Building
Building
15.1 m
11.5 m
8000
Building


9000
49.6 m
46.3 m
Building
Building
22.7 m
40.2 m
10000
30.4 m
Building


Building
11.9 m
11000
31.5 m
Building


Building
17.8 m
20.6 m
12000