بسم الله الرحمن الرحيم

Design for Al-Major Road in Dura

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جامعة بوليتكنك فلسطين
كلية الهندسة
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مشروع تصميم واعادة تأهيل شارع الطرامة

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المشرف
م.مصعب شاهين

بناء على توجيهات الأستاذ المشرف وبموافقة جميع أعضاء اللجنة الممتحنة تم تقديم هذا المشروع الى دائرة الهندسة المدنية والمعمارية في كلية الهندسة للوفاء الجزئي بمتطلبات الحصول على درجة البكالوريوس.

توقيع مشرف المشروع　　　　　　توقيع رئيس الدائرة
....　　　　　　...................................

May 2018

Abstract

Design for Al-Major Road in Dura

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This project aim to Rehabilitate the paved part and design the unpaved part for the road which is connect Hanne triangle with the main road near AL-majnoneh camp and it consist of two parts the first one paved road (one kilometer and 100 meters) and the other part is unpaved road (900 meters) with a width of 16m and This road from the second class , the design will consider the heavy load of trucks and this road is important because of Urbanization at that area .

The road will be observed by using the total station and the GPS , and then Count traffic on intersections , after that Calculate the volume of drilling and filling areas , and Studying the collection of surface water , Then design the pavement (asphalt layers) , and the horizontal and vertical alignments , then doing some laboratory tests on soil layers , after that Solving the problem of drainage and designing the traffic lights and arranging the poles on the road.

The Plans will be drawn up showing the location of the road, the horizontal and vertical alignments, the cross sections, also the water drainage plans, the quantities and the results of the laboratory tests.

الملخص

تصميم شارع الماجور في بلدة دورا

فريق العمل:

حسين ابو سعدة

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المشرف

م.مصعب شاهين

يهدف المشروع الى تصميم شارع الماجور الذي يربط مثلث حنينة بالشارع الرئيسي المجاور لمعسكر المجنونة المعبد (كيلو ومئة متر) وتوسعته وتصميم الجزء المتبقي الغير معبد (تسمعئة متر) بعرض 16 متر وهو شارع من الدرجة الثانية , وسيتم التصميم بمراعاة تحمل الشاحنات الثقيلة, والطريق مراد تصميمه وتعبيده من اجل تلبية احتياجات التوسع العمراني في تلك المنطقة , حيث تعتبر هذه الطريق هي المدخل الجنوبي للمدينة فبالتالي يتم تخفيف الضغط على المدخل الشمالي للمدينة, وسهولة وصول سكان هذه المنطقة الى بيتوهم في وقت قصير .

وسوف يتم رصد الطريق مساحياً بأستخدام جهازي تحديد الموقع عن طريق القمرالصناعي وجهاز المحطة الشاملة وجهاز الميزان (القامة) , وتصميم المنحنيات الافقية والراسية وطبقات الاسفلت وحساب مساحات الحجوم لكميات الحفر والردم ودراسة تجميع المياه السطحية , ومن ثم عمل فحوصات مخبرية على طبقات التربة وهي فحص نسبة تحمل كلفورنيا وحدي اللدونة والمرونة للتربة وعمل العد المروري على التقاطعات , وحل مشكلة تصريف المياه وعمل تصميم ل اشارات المرور وترتيب اعمدة الاضاءة على الطريق.

سوف يتم عمل مخططات توضح موقع الطريق ومخططات تبين المنحنيات الافقية والرأسية والمقاطع العرضية ومخططات العد المروري , بالاضافة الى جداول حساب كميات الحفر والردم و نتائج الفحوصات المخبرية للتربة.

الاهداء

الى الملجأ الأول والأخير,الى من سهرت لأجلي ومن أجلي, الى من كان دعائها للرحمن ينير دربي , الى موطني الصغير , الى أعظم انسان عندي ,الى حبيبتي وفؤادي

الـــــــــــــ أمي ـــــــــــــى

الى السند الذي لا يميل , الى الحبيب الذي ضحى, الى من أفنى عمره كي يراني أشرق وأزهر, الى من سعى جاهدا كي يرسم لي دربي , الى من يطمئن القلب لوجوده , الى الحصن الذي ألجأ اليه في ضعفي

الـــــــــــــ أبي ـــــــــــــى

الى من يسعدني وجودي معهم , الى من هم لي فرحا وبلسما وعمادا , الى الجدار الذي استند اليه , الى أعزائي في فوضى الوفاء التي نعيشها

الـــــــــــــ أخي وأخوتي ـــــــــــــى

الى من كانوا ظلي , وقاسموني الفرح والحزن , الى من لجأت إليهم في غربتي وأعطوني من رحيق وفائهم ما يسد رمقي الى عائلتي , الى صحبتي التى أكن كل التقدير لها

الـــــــــــــ اصدقائي ـــــــــــــى

شكر وتقدير

بعد رحلة بحث و جهد و اجتهاد تكللت بإنجاز هذا المشروع ، نحمد الله عز وجل على نعمه التي منَ بها علينا فهو العلي القدير، كما لا ننسى أن نتقدم بأرقى و أثمن عبارات الشكر و العرفان إلى القائمين على جامعة بوليتكنك و على رأسهم رئيس الجامعة و كل العاملين بها وبالخصوص كلية الهندسة ودائرة الهندسة المعمارية والمدنية. إلى الذين كانوا عونا لنا في مشروعنا هذا ونورا يضيء الظلمة التي كانت تقف أحيانا في طريقنا.

كما لا يسعنا إلا أن نخص بأسمى عبارات الشكر و التقدير للمهندس "مصعب شاهين" لما قدمه من جهد و نصح و معرفة طيلة انجاز هذا المشروع.

كما نتقدم بالشكر الجزيل لكل من أسهم في تقديم يد العون لإنجاز هذا البحث ، و نخص بالذكر بلدية دورا ممثلة برئيسها واعضائها من مهندسين وعاملين, إلى من قدموا لنا المساعدات والتسهيلات والمعلومات ، فلهم منا كل الشكر فلولا وجودهم لما أحسسنا بمتعة العمل و حلاوة المشروع ، و لما وصلنا إلى ما وصلنا إليه فلهم منا كل الشكر.

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1. CHAPTER ONE

INTRODUCTION

.

The roads are one of the most important elements of communication, which have a great role in the development of different peoples, civilizations, and countries economic. As the creation of the road is highly efficient, and qualified this will directly improve countries economic by reducing the time to move from one place to another, and thus reduce the cost of mobility. In addition, roads play an essential role in our daily lives, where they are critical and indispensable; they help in the transport of the commercial goods, enable us to travel around the word and gain new experiences, and cultures. So roads must be well designed with the best possible quality, minimum cost, and maximum safety, the engineering design of the road is defined as the process of finding its geometric dimensions, the arrangement of its visual elements; as path, visibility distances, and the width of the lanes and slopes. [1]

1.1 About Dura

Dura is a Palestinian city that located in the southern of west bank, and it is one of the Hebron governorate west towns. It's bounded on the east by Yatta town, on the north by Ithna and Taffoh towns, and on the west by the green line, and on the south by Samoua and Dahreya town. This city population is around 55113, with annual growth rate of 3%. [2]

Figure 1-1 Dura city [2]

1.2 Work idea

The idea of our project is to construct and design the road "Wad al Majoor" of Dura city, this road connects the area of "Ahnina" Triangle with street No. 60 adjacent to "Al Majnona" camp. Our aim is to allow the people who lives in this area to enter and leave without the trouble and difficulties of traveling along far distances as the road that connect between "Dura" and "Al Fawwar". Where the road that we looking for is able to connect street No. 60 with "Ahnina" that connect Dura with other villages.

1.3 Work motivation

The aim of the road construction according to the engineering specifications, is to serve people and facilitating their movement to meet their needs, and connecting different regions of different structures. So the is a need to develop a model design that meet these purposes, especially as we have noticed that Dura lands are mostly reclaimed for agriculture with high speed chains.

Importance of our work:

- Serving the residential areas through which the street passes, to make it more dynamic, alive, and sophisticated.
- It gives advantages to our work according to the importance of this street, as it connects the southern area of Dora city with the rest of the neighboring villages.
- Addressing the problem of rainwater; by designing the lateral tendencies of the road, and building the drainage channels based on engineering rules.

1.4 Work region

The road that our project works on is located in the southern area of "Dura", specifically in the area of "Wadi Majour", where it connects the "Ahnina" triangle with street No.6 near to "Al Majnona" camp, the area of our work is as shown in following Figure 1.2 bellow:

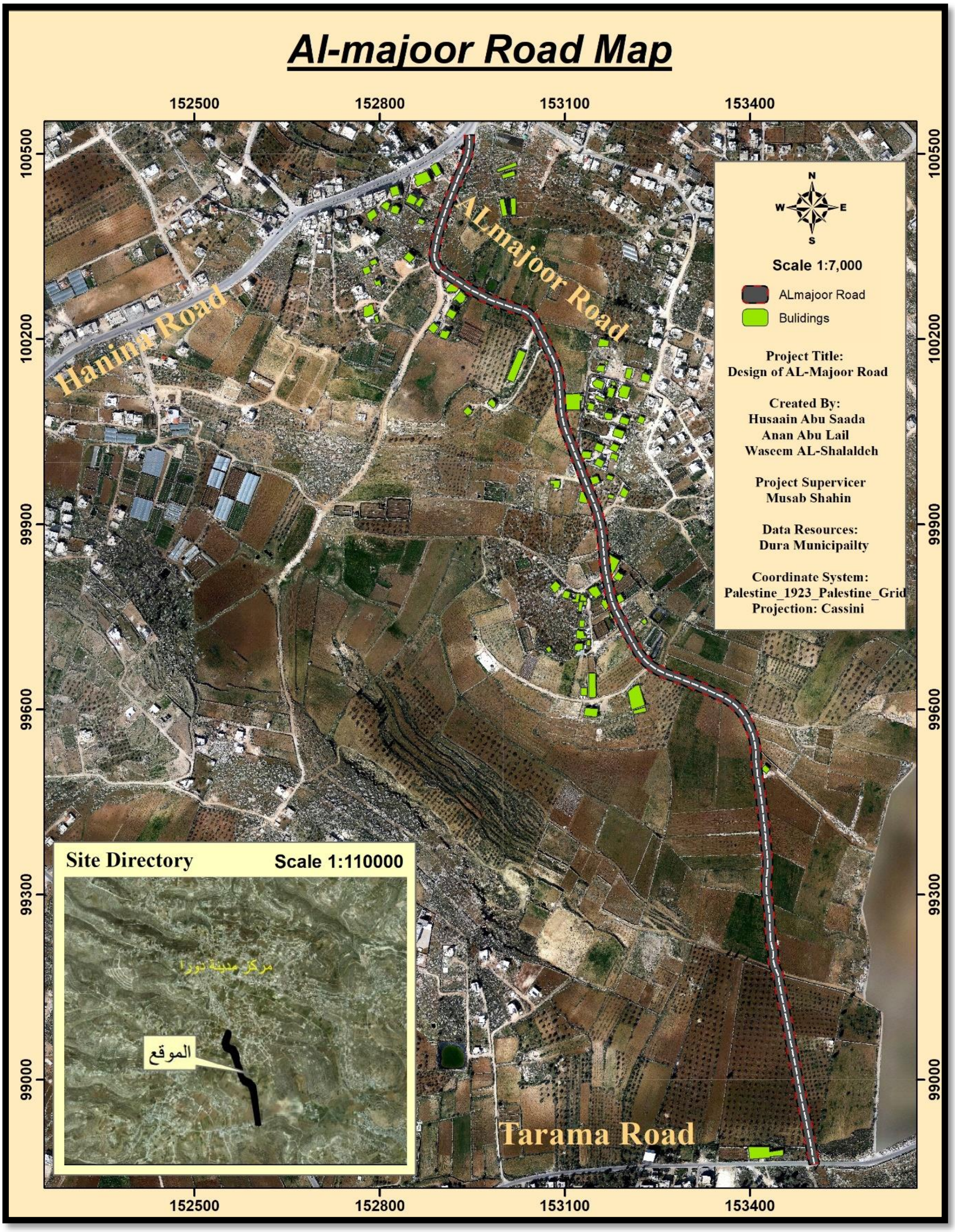

Figure 1-2 The region that we works on.

1.5 Work stages

Stage 1) Data Collection

In this step, the information about the street will be collected from the municipality and through number of site visiting to identify and recognize the nature of the road and its surrounding buildings, and the expected tendencies and the status of the current street.

Stage 2) Observation Step

In this step, the site will be observed using GPS (global positioning system) and total station, also the expected middle (center) point of the road will be observed, and monitor the changes about 12 meter to the right and left of the street, so to have a monitoring area of 24 meter; So we can change the center of the street to get the best 16 meters of width within the monitoring area.

Stage 3) Check the Observations

In this step, the data we gather from step 2 and step 1 will be analyzed, so that we can achieve the best horizontal and vertical design of the road, also that take into account neighboring houses, lands, and properties.

Stage 4) Design the Alignment

In this step, the horizontal and lateral tendencies will be designed, so that the water is easily and well drainage.

Stage 5) Calculation of quantities

In this step, the amount of drilling and landfilling that generated from our design will be calculated, then the road will be modified if possible to obtain the minimum amount of drilling and filling, (equal amount of drilling and filling).

Stage 6) Soil Test

In this step, the samples of soil will be obtained to conduct the necessary tests to know the soil bearing.

Stage 7) Intersections Study

In this step, the intersections over the road will be analyzed, and the best solutions with highest safety and easiness in the movement will be find according to engineering standards.

Stage 8) Traffic Study

In this step, the necessary services and equipment over the road will be analyzed such as lighting and traffic lights.

Stage 9) Sewage Network Study

In this step, the sewage network for the road will be designed, and the appropriate locations for the fountains will be selected.

Stage 10) Finishing the plans

In this step, all needed plans and designs that needed for the road will be created, such as horizontal and vertical designs, side tendencies schemes, quantity walls, design plans for the sewage network, soil testing reports, traffic signs schema, and the position of lighting columns.

Stage 11) Results and Recommendations

In this step, the documenting will be finalized, and the final results with further any recommendations will be discussed.

1.6 Work limitations

- The political and security conditions prevailing in the surrounding area, where our work will be close to "Al majnona" camp.
- The difficulties of obtaining the information from the official authorities during our work stage of data collection.
- The large number of details around the road, such as the chains and walls, that make our fieldwork, design, and monitoring more difficult.
- The lie of the road across some agricultural lands that may affect our survey work.

1.7 Used software and hardware

In our work we need the following hardware:

- GPS device.

In our work we need the following software:

- Civil 3D program(2016).
- AutoCad program(2007).
- Arc GIS 10.5 program .
- Microsoft office (2010).

1.8 Related work

There are a number of previous projects that related to road design and rehabilitation one of them is as follow:

- Majour street design project in 3024-2015 at Palestine Polytechnic university.

In our study we have to do two main points relating to the previous work:

  - Study the strengths and weaknesses of the previous project.
  - Preserve and keep the strengths of such projects, and addressing the weakness points as much as possible.

1.9 Work schedule

Week / Step	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Project selection and information collection	■	■													
Site detection and reconnaissance			■	■											
Field work				■	■	■	■	■	■	■					
Office work						■	■	■	■	■	■				
Preparing and studding of the plans									■	■	■	■			
Documentation										■	■	■	■	■	

Reviewing and printing															
Week Step	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Laboratory tests															
Design and calculation															
Preparing the first report for the project															
First Delivery(prototype)															
Final Delivery															
Offering the tender															

2. CHAPTER TWO
SURVEY WORK

2.1 General background

A branch of applied mathematics that is concerned with determining the area of any portion of the earth's surface, the lengths and directions of the bounding lines, and the contour of the surface and with accurately delineating the whole on paper.

when we want to design the road there's some woks should be done also, there's some data should be collected before starting design, in this chapter we will show the survey work and how it will be done also, we will talk about global navigation satellite system in general, we will show the devices which we used to Monitor the road, we will talk about some Monitoring methods and how we correct the data. [3]

2.2 Types of surveying

There are many types of disciplines in surveying and a surveyor during their career may decide to specialize in a particular discipline or may gain experience in all disciplines. [3]

Figure 2-1 Surveying workers. [3]

The main disciplines of surveying are:

1) Land surveying

Land surveying involves measuring and determining property boundaries, which are used as the basis for all property transactions including buying, selling, mortgaging and leasing. Due to the importance of having a secure and strong property market, in NSW a land surveyor needs to be registered to be able to carry out a land survey.

2) Engineering surveying

Engineering surveyors are engaged in the construction industry and ensure construction works are built in the correct location and as per their design. They are generally found on construction sites setting out various types of works such as buildings, roads, bridges, tunnels and various other forms of infrastructure.

3) Mining surveying

Mining surveyors are involved in the development and construction of mining operations and can generally be found above and underground taking measurements to determine volumes and setting out new excavations and tunneling. Mining surveyors in NSW are registered due to many safety issues involved in mining including ensuring mining does not encroach upon hazardous areas and future subsidence.

4) Hydrographic surveying

Hydrographic surveying involves locating and measuring points under the sea and on the shore. There measurements are used to design infrastructure such as docks and jetties as well as ensuring ships have enough clearance from the sea bed to safely travel around the world. Using sonar scanners they are able to provide a picture of the sea bed without needing to get their feet wet and enabling the discovery of ship wrecks and other objects lost at sea.

5) Geodetic surveying

Geodetic surveyors are involved with undertaking very precise measurements to determine the shape and size of the world and track the movement of continents. Their measurements are used in the monitoring of sea level rise, earthquakes, and the tracking of satellites. Geodetic surveyors are involved in the development of co-ordinate systems and datum which are used in the productions of maps and plans.

6) Photogrammetry and remote sensing

Photogrammetry and remote sensing involves taking measurements of the world via photography or other wavelength bands such as infra-red or ultra-violet. Measurements may be sources from aerial photography or satellite imagery. Photogrammetry and remote sensing is used to map large areas and determine changes in the world over time.

2.3 The details of surveying work

This work done in four stages, first stage is the study plans, the second stage is the exploration work, third stage is the field work, and the fourth stage is the office work, that are as follow:

1) Study plans

These plans are obtained from official bodies such as municipalities. We got master plan for the area from Dura municipality. These plans are studied in order to get an idea for the nature of the area and the boundaries of neighbors. It is possible to identify and determine the route of the road and locate it on the maps, make sure that it's not enough and you have to go to the field to see the actual and the accurate location.

2) Exploration work

The aim of this stage is to try to draw the best route for the road, Which ensures the lowest cost and shortest path of the road, This is done by visiting the team to the road site and visually inspecting the area using maps and aerial photographs available to the area, and if the team doesn't have maps and aerial photographs they try to know about the area by asking the people in this area.

Figure 2-2 Exploration work stage.

3) The third stage: Fieldwork

We start observing the road by using the GPS device (Stonex s9i) and ,we used the RTK method (which mentioned below) , we start from the suggested center of the road then we take points at the left and the right of the road as needed for example : (L1 , L2 , C , R1 , R2) also , we have to observe the details such as the Buildings, fences ,chains , electric points , telephone points , manholes ...etc , and cross-sections each 10 meters and draw sketch for the road , then we make sure that the device should be vertical and accurate so we can get a good observation points , and reduce the errors as possible as , at the end we took some control points so we can go back by using total station whenever it needs.

Figure 2-3 Fieldwork stage.

4) Office work

We use civil 3d program to connect the points as the sketch shows and then we draw the buildings and the contour lines for the area as shown in the Figure below, Then we continue drawing the houses and the trees using GIS program, after that we exported the data as cad file to use it in civil 3d program to finish the plan.

2.4 Global Navigation Satellite System (GNSS)

GNSS (Global Navigation Satellite System) is a satellite system that is used to pinpoint the geographic location of a user's receiver anywhere in the world, Each of the GNSS systems employs a constellation of orbiting satellites working in conjunction with a network of ground stations, The USA's Global Positioning System (GPS) and Russia's Global Navigation Satellite System (GLONASS) are examples of GNSS. [4]

Figure 2-4 Office work stage. [4]

Components of GNSS [4]

1) **Space Segment:**

The space segment consists of GNSS satellites, orbiting about 20,000 km above the earth. Each GNSS has its own "constellation" of satellites, arranged in orbits to provide the desired coverage, as illustrated in Figure 2.5. where each satellite in a GNSS constellation broadcasts a signal that identifies it and provides its time, orbit and status.

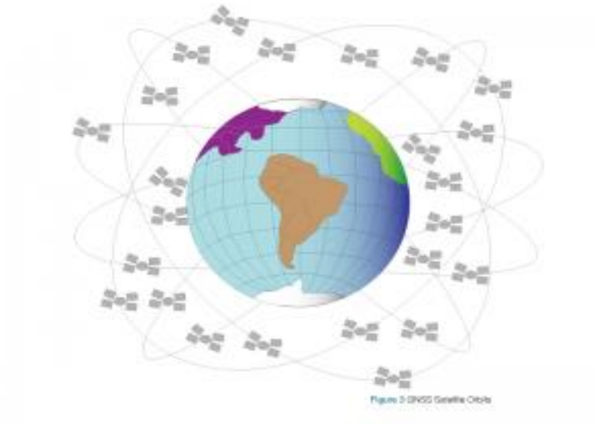

Figure 2-5 Space Segment. [4]

2) **Control Segment:**

The control segment comprises a ground-based network of master control stations, data uploading stations and monitor stations. In each GNSS system, the master control station adjusts the satellites' orbit parameters and onboard high-precision clocks when necessary to maintain accuracy.Monitor stations, usually installed over a broad geographic area, monitor the satellites' signals and status, and relay this information to the master control station. The master control station analyses the signals then transmits orbit and time corrections to the satellites through data uploading stations.

3) User Segment:

The user segment consists of equipment that processes the received signals from the GNSS satellites and uses them to derive and apply location and time information. The equipment ranges from smartphones and handheld receivers, to specialized receivers used for survey and mapping applications.

Basic GNSS Concepts [4]

1) Satellites:

GNSS satellites orbit the earth. The satellites know their orbit ephemerides (the parameters that define their orbit) and the time very, very accurately. Ground-based control stations adjust the satellites' ephemerides and time, when necessary.

2) Propagation:

GNSS satellites regularly broadcast their ephemerides and time, as well as their status. GNSS radio signals pass through layers of the atmosphere to the user equipment.

3) Reception:

GNSS user equipment receives the signals from multiple GNSS satellites then, for each satellite, recovers the information that was transmitted and determines the time of propagation, the time it takes the signals to travel from the satellite to the receiver.

4) Computation:

GNSS user equipment uses the recovered information to compute time and position.

5) Application:

GNSS user equipment provides the computed position and time to the end user application, for example, navigation, surveying or mapping.

Methods of surveying using GPS

Real time kinematic refers to a stop-and-go method where the coordinates of points are available in real time. In this method, a radio communication link is maintained between the base receiver and the rover, and the base receiver supplies the pseudo-range and carrier phase measurements to the rover which in turn computes its position and display the coordinates. The rover keeps updating coordinates as it moves as long as the lock on satellites is maintained. [5]

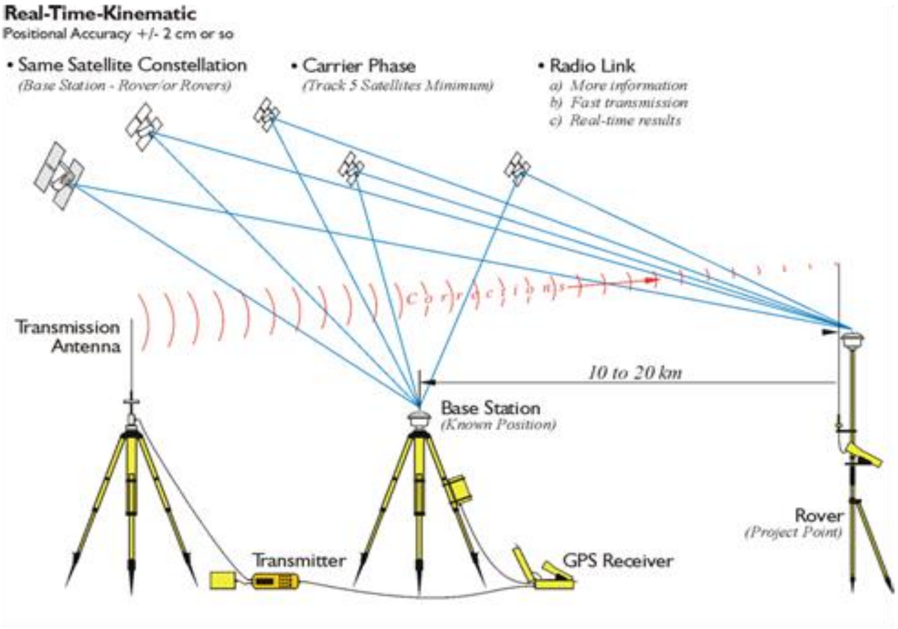

Figure 2-6 Real time kinematic. [5]

Static GPS survey procedures allow various systematic errors to be resolved when high-accuracy positioning is required. Static procedures are used to produce baselines between stationary GPS units by recording data over an extended period of time during which the satellite geometry changes. In this method, each receiver at each point logs data continuously for a pre-planned length of time. [5]

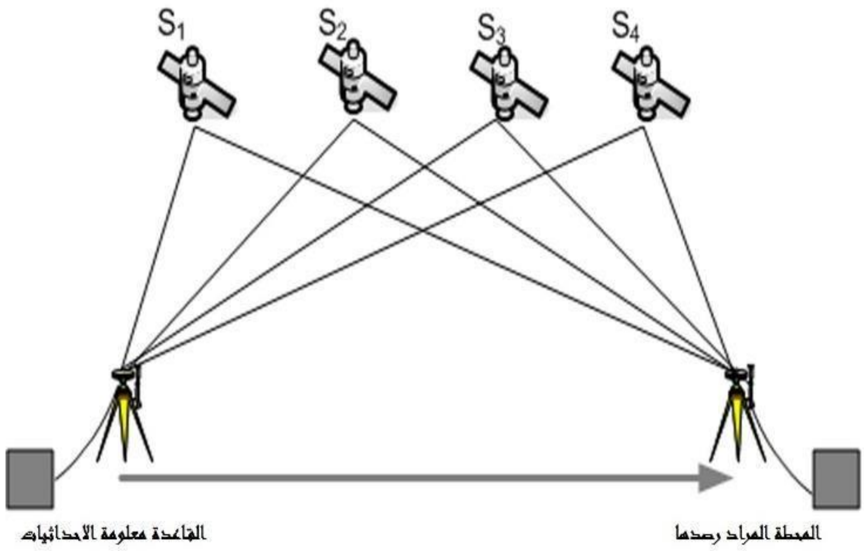

Figure 2-7 Static GPS survey. [5]

Correction the observations

In every time you observe a point the device calculate the coordinates, and this coordinates have some errors which may give a wrong location for the point , this errors result from some sources, such as ionosphere, troposphere, location of the satellites (DOP) and the errors of human, the GPS device have an error of (6-8) meters when it's calculate the point location without correction, but we can reduce the error , the correction concept is that there's some devices locate on a known coordinate points , which calculate the errors continuously and send it to the data collector so the data collect give us the corrected coordinates . [4]

3. CHAPTER THREE
TRAFFIC ENGINEERING STUDIES

3.1 Volume studies [6]

Traffic volume studies are conducted to collect data on the number of vehicles and or pedestrians that pass a point on a highway facility during a specified time period. This time period varies from as little as 15 minutes to as much as a year depending on the anticipated use of the data. The data collected also may be put into subclasses which may include directional movement, occupancy rates, vehicle classification, and pedestrian age. Traffic volume studies are usually conducted when certain volume characteristics are needed, some of which follow:

1) Average Annual Daily Traffic (AADT)

Is the average of 24-hour counts collected every day of the year. AADTs are used in several traffic and transportation analyses for:

a) Estimation of highway user revenues.

b) Computation of crash rates in terms of number of crashes per 100 million vehicle miles

c) Establishment of traffic volume trends.

d) Evaluation of the economic feasibility of highway projects.

e) Development of freeway and major arterial street systems.

f) Development of improvement and maintenance programs

2) Average Daily Traffic (ADT)

Is the average of 24-hour counts collected over a number of days greater than one but less than a year, ADTs may be used for:

a) Planning of highway activities.

b) Measurement of current demand.

c) Evaluation of existing traffic flow

3) Peak Hour Volume (PHV)

Is the maximum number of vehicles that pass a point on a highway during a period of 60 consecutive minutes? PHVs are used for:

a) Functional classification of highways.
b) Design of the geometric characteristics of a highway, for example, number of lanes, intersection signalization, or channelization.
c) Capacity analysis.
d) Development of programs related to traffic operations, for example, one-way street systems or traffic routing.
e) Development of parking regulations

4) Vehicle Classification (VC)

records volume with respect to the type of vehicles, for example, passenger cars, two-axle trucks, or three-axle trucks. VC is used in:

a) Design of geometric characteristics, with particular reference to turning-radii requirements, maximum grades, lane widths, and so forth.
b) Capacity analyses, with respect to passenger-car equivalents of trucks.
c) Adjustment of traffic counts obtained by machines.
d) Structural design of highway pavements, bridges, and so forth.

5) Vehicle Miles of Travel (VMT)

Is a measure of travel along a section of road. It is the product of the traffic volume (that is, average weekday volume or ADT) and the length of roadway in miles to which the volume is applicable. VMTs are used mainly as a base for allocating resources for maintenance and improvement of highways.

3.2 Methods of conducting volume counts [6]

Traffic volume counts are conducted using two basic methods: manual and automatic. A description of each counting method follows.

Manual Method

Manual counting involves one or more persons recording observed vehicles using a counter. With this type of counter, both the turning movements at the intersection and the types of vehicles can be recorded. Note that in general, the inclusion of pickups and light trucks with four tires in the category of passenger cars does not create any significant deficiencies in the data collected, since the performance characteristics of these vehicles are similar to those of passenger cars. In some instances, however, a more detailed breakdown of commercial vehicles may be required which would necessitate the collection of data according to number of axles and/or weight. However, the degree of truck classification usually depends on the anticipated use of the data collected.

Figure 3.1 shows the TDC-12 electronic manual counter which may be used to conduct manual traffic volume counts at an intersection. The TDC-12 electronic manual counter, produced by Jamar Technologies, is powered by four AA batteries, which can be supplemented by an external power supply to extend the life of the batteries. Several buttons are provided, each of which can be used to record volume data for different movements and different types of vehicles. The data for each movement can be recorded in 1, 5, 15, 30, or 60 minute intervals, although the default value is 15 minutes.

Figure 3-1 Traffic Data Collector TDC-12 Hooked to a Computer.

The recorded data can be viewed as data collection proceeds by using either the status screen which indicates the current time and amount of time left in the interval, or a TAB key which shows totals for each of the primary movements. The stored data either can be extracted manually or transferred to a computer through a serial port. An associated software (PETRAPro) can be used to read, edit, store, or print a variety of reports and graphs. Figure 4.7 shows the hook-up of the equipment to a PC for data transmittal.

The main disadvantages of the manual count method are that 1) it is labor intensive and therefore can be expensive, 2) it is subject to the limitations of human factors, and 3) it cannot be used for long periods of counting.

Automatic Method

Automatic counters can be classified into two general categories: those that require the laying of detectors (surface or subsurface), and those that do not require the laying of detectors. Automatic counters that require the laying of surface detectors (such as pneumatic road tubes) or subsurface detectors (noninvasive, such as magnetic or electric contact devices) on the road, detect the passing vehicle and transmit the information to a recorder, which is connected to the detector at the side of the road.

Figure 3.2 shows an example setup of a surface detector using pneumatic road tubes. An example of counters using pneumatic road tubes as detectors is the Apollo Counter/Classifier manufactured by Diamond Traffic Products. An example of counters using magnetic detectors is the 3M Canoga C800 Vehicle Detector System.

Figure 3-2 A Sensor Setup of a Surface Detector Using Pneumatic Road Tube

3.3 Urban transportation planning [6]

Urban transportation planning involves the evaluation and selection of highway or transit facilities to serve present and future land uses. For example, the construction of a new shopping center, airport, or convention center will require additional transportation services. Also, new residential development, office space, and industrial parks will generate additional traffic, requiring the creation or expansion of roads and transit services.

The process must also consider other proposed developments and improvements that will occur within the planning period. The urban transportation planning process has been enhanced through the efforts of the Federal Highway Administration and the Federal Transit Administration of the U.S. Department of Transportation by the preparation of manuals and computer programs that assist in organizing data and forecasting travel flows.

Urban transportation planning is concerned with two separate time horizons. The first is a short-term emphasis intended to select projects that can be implemented within a one- to three-year period. These projects are designed to provide better management of existing facilities by making them as efficient as possible. The second time horizon deals with the long-range transportation needs of an area and identifies the projects to be constructed over a 20-year period. Short-term projects involve programs such as traffic signal timing to improve flow, car and van pooling to reduce congestion, park-and-ride fringe parking lots to increase transit ridership, and transit improvements. Long-term projects involve programs such as adding new highway elements, additional bus lines or freeway lanes, rapid transit systems and extensions, or access roads to airports or shopping malls.

3.4 Traffic counting

Counting should done in different hours in different days, so our counting had been done in two days, which is Saturday and Sunday from 8 am until 3 pm in both two sides.

Method of counting

We count each car that passes in our road as intervals of 15 minutes and then we made a table of it according to type of vehicles as the picture shows and from this counting we can calculate the peak-hour factor (PHV) ,average annual daily traffic (AADT) and peak hour (PH).

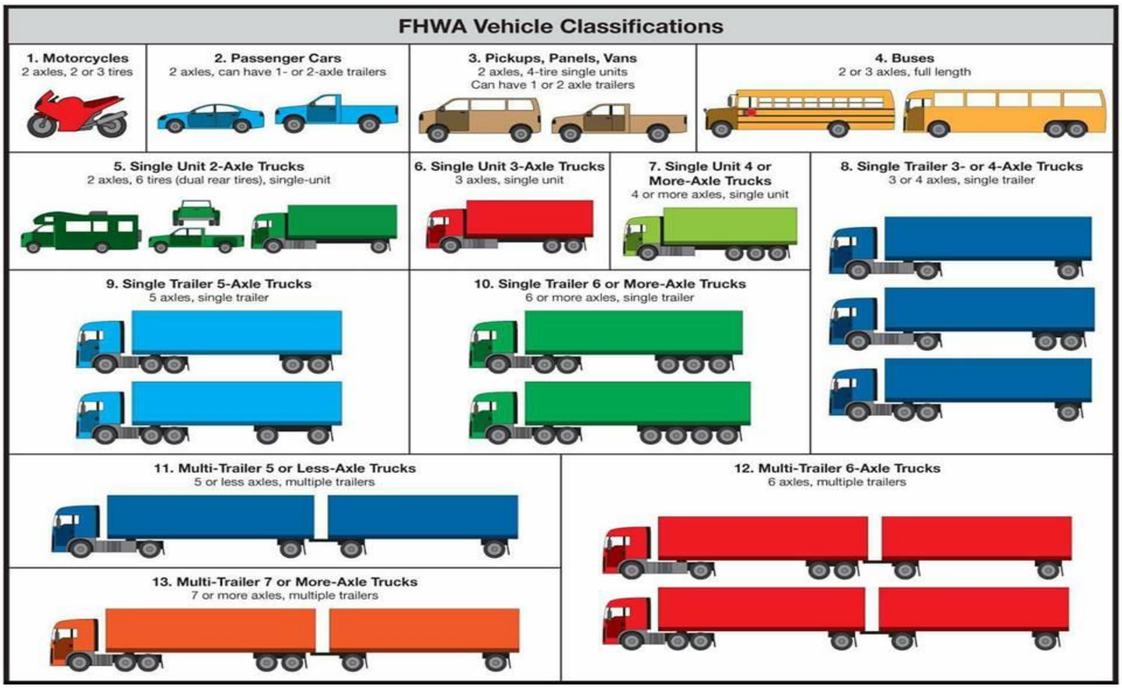

Figure 3-3 Vehicle Classifation

The relationship between the hourly volume and the maximum rate of flow within the hour is defined by the peak-hour factor, as follows:

$$PHF = \frac{\text{hourly volume}}{\text{max.rate of flow}} \quad \text{Equation (3.1)}$$

For standard 15-minute analysis period, this becomes:

$$PHF = \frac{v}{4 * Vm15} \quad \text{Equation (3.2)}$$

Where: V= hourly volume, vehs

Vml5 = maximum 15-minute volume within the hour, vehs

PHF - peak-hour factor

These figures shows the relationship between the number of vehicles and the time in each all days of counting.

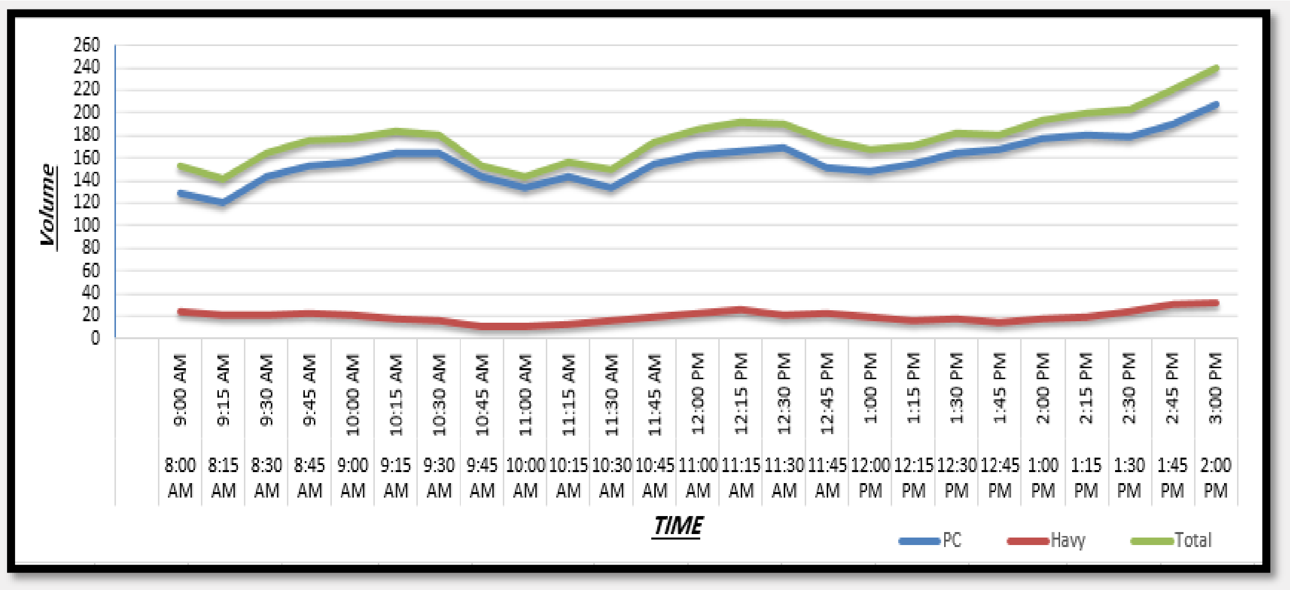

Figure 3-4 the relationship between the number of vehicles (volume) and the time for the first day.

And from the figure we can see that the hour between 2:00 and 3:00 give the highest flow of vehicles and it's the peak hour.

Table 3-1 The volume of traffic and flow rate for 15 min in peak hour

IN										
Day	Time		Vehicle Tybe							
	From	To	Motor Cycles	passenger Cars	Van	Buses	Single Unit 2,3,4 Axle	Single Trailer 3,4,5,6 Axle	Multi Trailer 5,6,7 Axle
Sat 10/3	14:00	14:15	0	53	1	2	3	0	0
	14:15	14:30	0	47	4	3	2	0	0
	14:30	14:45	1	46	1	1	5	1	0
	14:45	15:00	0	62	1	1	5	0	0
Percent %			0.004	0.87	0.03	0.03	0.062	0.004	0

$$PHF = \frac{v}{4*Vm15}$$

$$PHF = \frac{239}{4*69} = 0.87$$ Equation (3.3)

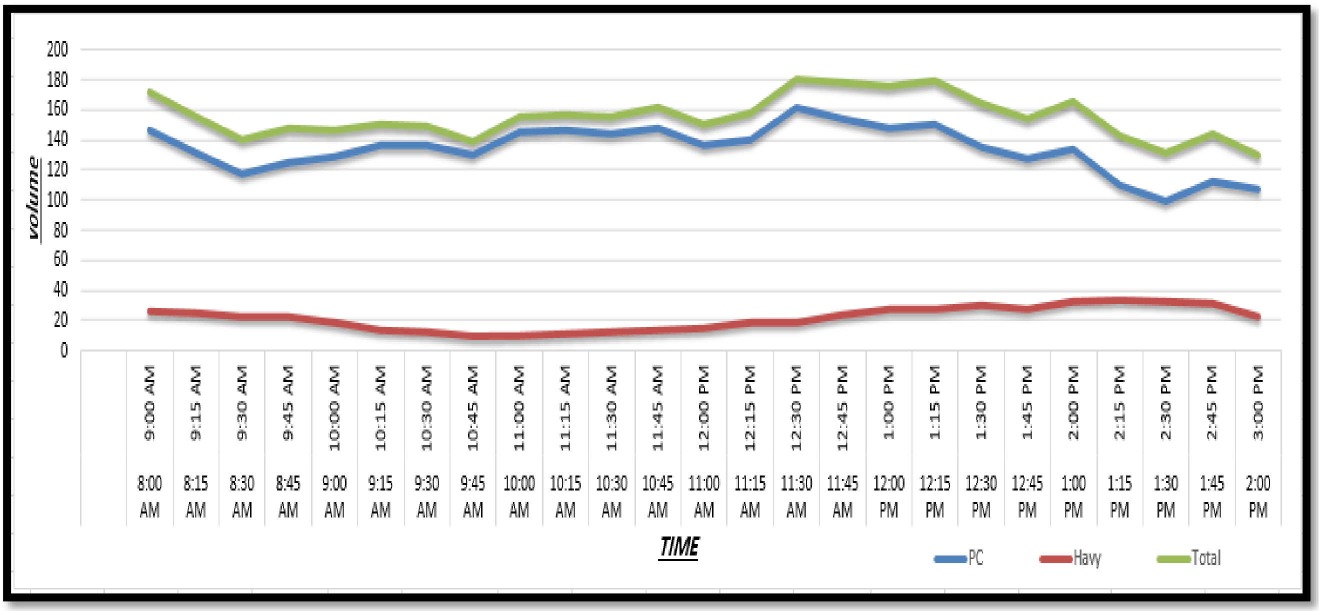

Figure 3-5 The relationship between the number of vehicles (volume) and the time for the first day

And from the figure we can see that the hour between 12:30 and 1:30 give the highest flow of vehicles and it's the peak hour.

Table 3-2 The volume of traffic and flow rate for 15 min in peak hour

OUT										
Day	Time		Vehicle Tybe							
	From	To	Motor Cycles	passenger Cars	Van	Buses	Single Unit 2,3,4 Axle	Single Trailer 3,4,5,6 Axle	Multi Trailer 5,6,7 Axle
Sat 10/3	12:30	12:45	0	44	1	0	2	0	0
	12:45	13:00	0	32	1	1	2	0	0
	13:00	13:15	0	47	1	2	4	1	0
	13:15	13:30	0	43	1	2	6	0	1
Percent %			0	0.87	0.02	0.03	0.07	0.005	0.005

$$\mathrm{PHF} = \frac{v}{4*Vm15}$$

$$\mathrm{PHF} = \frac{183}{4*55} = 0.87$$ Equation (3.4)

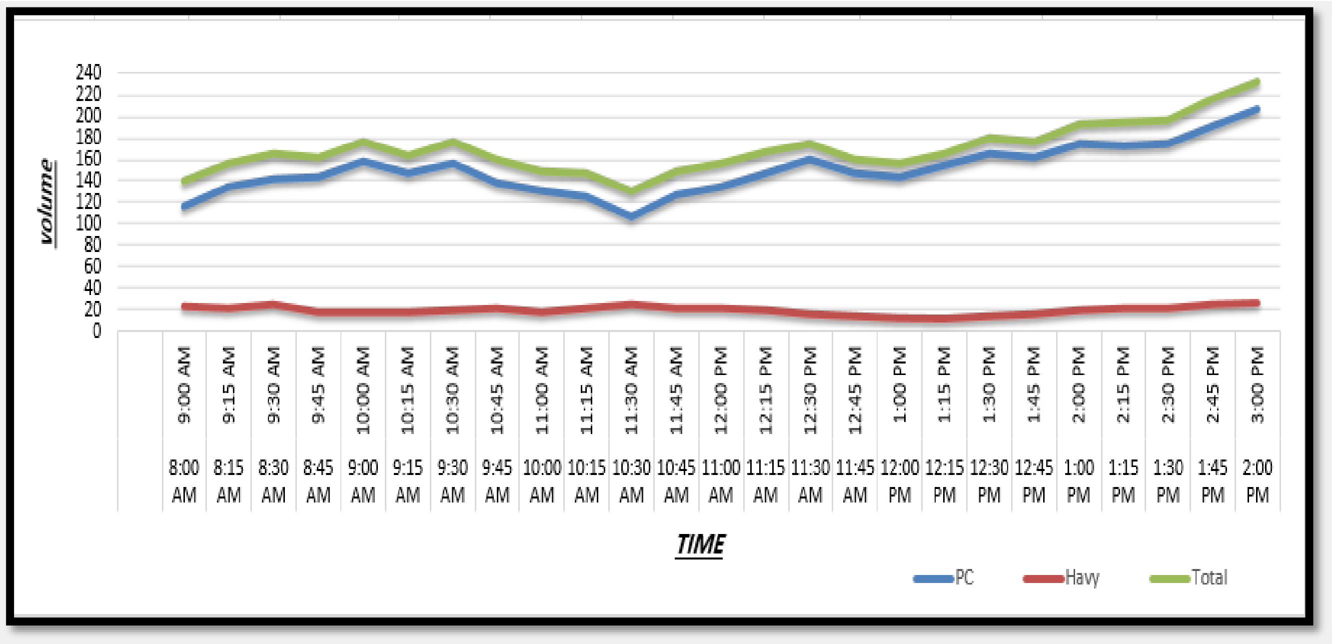

Figure 3-6 The relationship between the number of vehicles (volume) and the time for the second day.

And from the figure we can see that the hour between 2:00 and 3:00 give the highest flow of vehicles and it's the peak hour.

Table 3-3 The volume of traffic and flow rate for 15 min in peak hour

IN										
Day	Time		Vehicle Tybe							
	From	To	Motor Cycles	passenger Cars	Van	Buses	Single Unit 2,3,4 Axle	Single Trailer 3,4,5,6 Axle	Multi Trailer 5,6,7 Axle
Sun 11/3	14:00	14:15	1	49	0	1	5	0	0
	14:15	14:30	0	50	1	1	3	1	0
	14:30	14:45	1	47	1	1	3	0	0
	14:45	15:00	1	61	1	1	4	0	0
Percent %			0.01	0.89	0.01	0.02	0.064378	0.004292	0

$$\text{PHF} = \frac{v}{4 * Vm15}$$

$$\text{PHF} = \frac{233}{4*67} = 0.87$$ Equation (3.5)

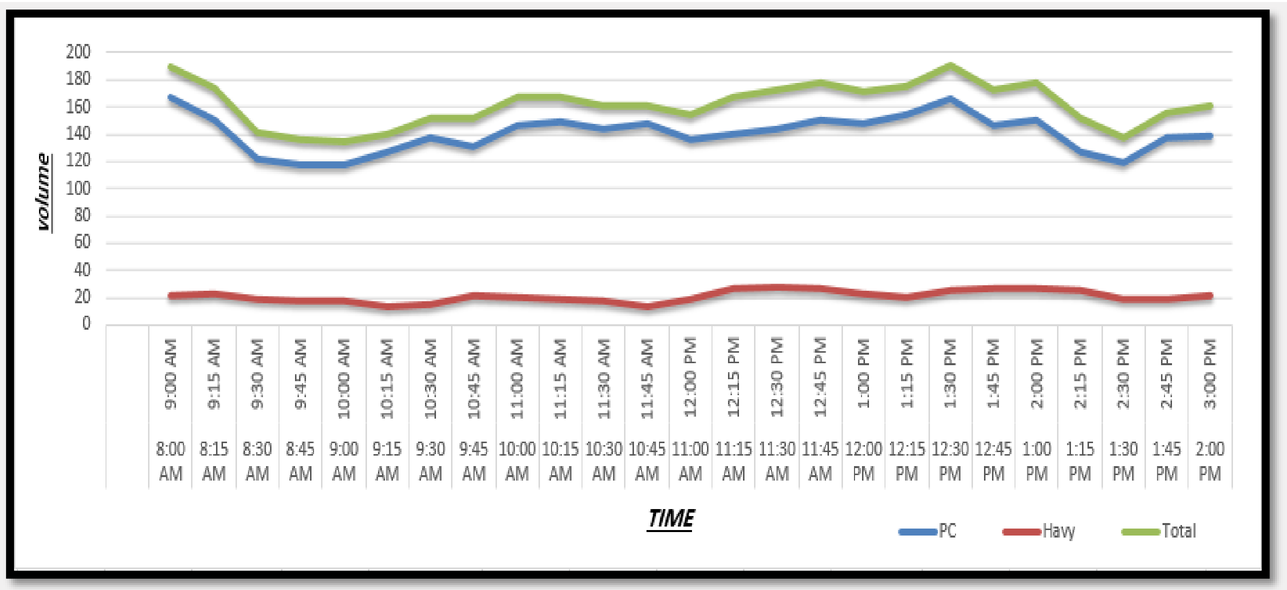

Figure 3-7 The relationship between the number of vehicles (volume) and the time for the second day

And from the figure we can see that the hour between 11:30 and 12:30 give the highest flow of vehicles and it's the peak hour.

Table 3-4 The volume of traffic and flow rate for 15 min in peak hour

OUT									
Day	Time		Vehicle Tybe						
	From	To	Motor Cycles	passenger Cars	Van	Buses	Single Unit 2,3,4 Axle	Single Trailer 3,4,5,6 Axle	Multi Trailer 5,6,7 Axle
Sun 11/3	11:30	11:45	0	37	0	1	3	0	1
	11:45	12:00	0	35	1	1	2	0	0
	12:00	12:15	0	40	1	1	3	0	1
	12:15	12:30	1	49	0	1	1	1	0
Percent %			0.006	0.89	0.01	0.02	0.05	0.006	0.01

$$\text{PHF} = \frac{v}{4*Vm15}$$

$$\text{PHF} = \frac{180}{4*52} = 0.8$$ Equation (3.6)

3.5 Calculation of (AADT) per category

The state highway agency will use its counting program to generate basic trend data throughout the state. It will also generate, for contiguous portions of each state highway classification, a set of daily and monthly variation factors that can be applied to any coverage count within the influence area of the subject control grouping. An example of the type of data that would be made available is shown in Table 9.11. Using these tables, any coverage count for a period of 24 hours or more can be converted to an estimate of the AADT using the following relationship.

AADT using the following relationship:

AADT = V1Mj*DFi*MFj Equation (3.7)

Where AADT average annual daily traffic, vehs/day

V24ij= 24-hour volume for day / in monthvehs

DFj = daily adjustment factor for day i

MFj= monthly adjustment factor for month j

Calculate the AADT for the first day (Saturday)

From Table 9.11 the daily factor (DF) for Saturday is 0.899, and the month factor (MF) for March is 1.1. Then:

Table 3-5 The volume of traffic

The Days / Catogary	Motor Cycles	passenger Cars	Van	Buses	Single Unit 2,3,4 Axle	Single Trailer 3,4,5,6 Axle	Multi Trailer 5,6,7 Axle
Saturday (in & out)	5	2121	65	43	153	14	12

AADT = V1Mj*DFi*MFj

AADTmotor cycles = 5 ×3.43×0.899×1.1= 17 vehs/day

AADTpassenger cars = 2121 ×3.43×0.899×1.1= 7195 vehs/day

AADTvan = 65 ×3.43×0.899×1.1= 221 vehs/day

AADTbuses = 43 ×3.43×0.899×1.1= 146 vehs/day

AADTsingle unit = 153 ×3.43×0.899×1.1= 519 vehs/day

AADTsingle trailer = 14 ×3.43×0.899×1.1= 48 vehs/day

AADTmulti trailer = 12 ×3.43×0.899×1.1= 41 vehs/day

Calculate the AADT for the first day (Sunday)

From Table 9.11 the daily factor (DF) for sunday is 0.789, and the month factor (MF) for march is 1.1. Then

Table 3-6 The volume of traffic

The Days / Catogary	Motor Cycles	passenger Cars	Van	Buses	Single Unit 2,3,4 Axle	Single Trailer 3,4,5,6 Axle	Multi Trailer 5,6,7 Axle
Sunday (in & out)	12	2012	50	53	147	18	9

$AADT = V1Mj*DFi*MFj$

$AADT_{motor\ cycles} = 12 \times 3.43 \times 0.789 \times 1.1 = 36$ vehs/day

$AADT_{passenger\ cars} = 2012 \times 3.43 \times 0.789 \times 1.1 = 5990$ vehs/day

$AADT_{van} = 50 \times 3.43 \times 0.789 \times 1.1 = 149$ vehs/day

$AADT_{buses} = 53 \times 3.43 \times 0.789 \times 1.1 = 158$ vehs/day

$AADT_{single\ unit} = 147 \times 3.43 \times 0.789 \times 1.1 = 438$ vehs/day

$AADT_{single\ trailer} = 18 \times 3.43 \times 0.789 \times 1.1 = 54$ vehs/day

$AADT_{multi\ trailer} = 9 \times 3.43 \times 0.789 \times 1.1 = 27$ vehs/day

3.6 Traffic Signs [6]

It must be acknowledged that whenever an engineer designs a road, he/she must put signs whether these signs are on land (road itself) or on the sides of the road in order to reach the main targets of designing the road, and to get high levels of safety for all road users. This reduces the rate of accidents and it raises the level of easiness and comfort for road users, Lights must also be done to create safety at night especially in winters when mist screens the vision, consequently, these topics will be discussed according to its importance.

There are many types of traffic signs. Each one has special shape and color in order to make it easy for the passengers to use, In general traffic signs fall into one of three major categories:

1) **Regulatory signs:** Regulatory signs. Regulatory signs convey information concerning specific traffic regulations. Regulations may relate to right-of-way, speed limits, lane usage, parking, or a variety of other functions.

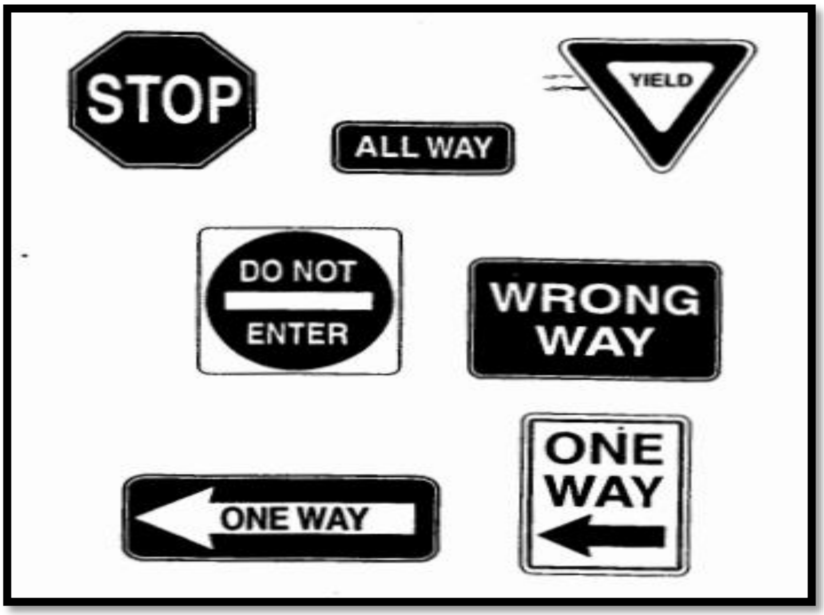

Figure 3-8 Regulatory Signs Affecting Right-of-Way

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

Figure 3-9 Parking-Control Signs

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

Figure 3-10 Guide signs

Descriptions of traffic signs:

1) Size and dimensions: The bigger the sign is, the better the visibility becomes.
2) Shapes: The shape must be proper to the objective according to the accepted standards.
3) Writing on the sign: Using a correct language, right font with good size of letters using enough margins.
4) The proper use of colors (paints): Colors need to be striking and compatible

Conditions of traffic signs:

1) Signs must be easily used day and night.
2) The instructions should be comprehensible.
3) The colors should fit in the situation.
4) The language must be objective and correct.

Functions of Traffic signs:

1) To diverge the street.
2) To stop parking where forbidden.
3) To set priorities.
4) To give instructions.

5) To stop moving when in danger.

Signal Warrants

Traffic signals, when properly installed and operated at appropriate locations, provide a number of significant benefits:

- With appropriate physical designs, control measures, and signal timing, the capacity of critical intersection movements is increased.
- The frequency and severity of accidents is reduced for certain types of crashes, including right-angle, tum, and pedestrian accidents.
- When properly coordinated, signals can provide for nearly continuous movement of through traffic along an arterial at a designated speed under favorable traffic conditions.

They provide for interruptions in heavy traffic streams to permit crossing vehicular and pedestrian traffic to cross safely.

3.7 Planning the road [6]

Using cars in traffic is one of the recurrent cause of dangers. The proper road planning aims at reducing the accidents and regulating the traffic.

Division of tracks property:

1) Pedestrian track.
2) Vehicle track (cars / vans).
3) Public transport track.
4) Tracks for other uses (bikes / baby prams)

3.8 Lightness: [6]

Putting light on the roads reduces the possibilities of accidents, it enables the drivers to monitor the vehicle with proper speed day and night.

Descriptions of lightness

1) Paying attention to the location of the light poles. They are located either on the pavement or on the street refuge.

2) Paying attention to the dimensions (height, lengths, and distances).

3) Paying attention to the types of street lamps, some lamps are affected by wind and rain.

4) Paying attention to the surface of the road and how it can reflex the light.

5) Distributing lights according to a system taking into account the dimensions and the power of the light poles.

It would be impossible to cover the full range of traffic signs and applications in a single chapter. The sections that follow provide a general overview of the various types of traffic signs and their use.

4. CHAPTER FOUR

SOIL TEST

4.1 Introduction

Soil it's the upper layer of earth in which plants grow, a black or dark brown material typically consisting of a mixture of organic remains, clay, and rock particles, soil test is very important , because it give us an index about the soil bearing , so we can know in which layer we can use the soil. [7]

In our project we have two soil tests the first one is Proctor compaction test and the second is CBR (CALIFORNIA BEARING RATIO TEST)

4.2 The first test proctor compaction test [7]

Concept

The Proctor compaction test is a laboratory geotechnical testing method used to determine the soil compaction properties, specifically, to determine the optimal water content at which soil can reach its maximum dry density. The original test is often referred to as Standard Proctor Test, which was later modified and referred to as Modified Proctor Test. The difference between the two tests lies mainly in the compaction energy.

Description and procedure

The Proctor compaction test consists of compacting soil samples at a given water content in a standard mold with standard compaction energy. The standard Proctor test uses a 4-inch-diameter mold with the compaction of five separate layers of soil using 56 blows by a 10 lb hammer falling 18 inches.

In the Proctor test, the soil is first air dried and then separated into 4 to 6 samples. The water content of each sample is adjusted by adding water (3% - 5% increments or more depending on the type of the soil).

The soil is then placed and compacted in the Proctor compaction mold in three different layers where each layer receives 56 blows of the standard hammer. Before placing each new layer, the surface of the previous layers is scratched in order to ensure a uniform distribution of the compaction effects.

At the end of the test, after removing and drying of the sample, the dry density and the water content of the sample is determined for each Proctor compaction test. Based on the whole set of results, a curve is plotted for the dry unit weight (or density) as a function of the water content. From this curve, the optimum water content to reach the maximum dry density can be obtained.

Figure 4-1 While doing the experiment in the lab.

Results:

Compaction is the process of densification of soil by reducing air voids. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at the optimum water content. A curve is drawn between the water content and the dry density to obtain the maximum dry density and the optimum water content.

Calculations:

W.C : water content .

Weight of Empty mold(1) = 5090 gm

Weight of Empty mold(2) = 5088 gm

Volume of mold = 2124 cm3

Wet density (ɣ wet) $=\frac{weight\ of\ wet\ sample}{volume\ of\ mold}$ (kg/cm3)

Dry density (ɣ dry) $=\frac{\gamma wet}{1+w.c}$ (kg/cm3)

Weight of water = (weight of wet sample with mold - weight of dry sample with mold)

Weight of dry sample = weight of dry sample with mold - weight of mold.

4.3 Second test California bearing ratio test (CBR) [7]

Concept

California Bearing Ratio test is conducted in laboratory. This tests provides the load penetration resistance of soil. CBR value is obtained by measuring the relationship between force and penetration when a cylindrical plunger is made to penetrate the soil at a standard rate. The CBR test is used for the evaluation of sub grade strength of roads and pavements.

Description and procedure

1) The soil is compacted into a standard mold with the ideal water ratio to achieve maximum density, then Form 5 layers and hit each layer with a standard hammer 56 blows.

2) Place the sample under the device shown below, then put the compress so that it touches the sample surface, and after that reset the reading devices.

Figure 4-2 (CBR Device)

3) The device is turned on , Read the amount of force in a set of penetration values ,then the force divided at penetration of 2.5 mm and 5 mm on the standard value ,so it produce the CBR value.

Table 4-1 Shows some vales for CBR based on (USC) and (AASHTO)

CBR	Bearing	Use	USC	AASHTO
0-3	Very Poor	Sub-grade	OH,CH,MH,OL	A5,A6,A7
3-7	Poor	Sub-grade	OH,CH,MH,OL	A4,A5,A6,A7
7-20	Accepted	Sub-base	OH,CH,MH,OL	A2,A4,A6,A7
20-50	Good	Sub-base	GC,SW,GM,SM,SP,GP	A1b,A2-5
		Base		A3,A2-6
>50	Excellent	Base	GW,GM	A1a,A2-4,A3

Results:

1) Test for the existing soil sample.

A. modified proctor test.

Values of dry density

Table 4-2 values of wet density

Number of trial	1	2	3	4
weight of added water (gm)	400	100	100	100
weight of mold + compacted wet soil (gm)	9756	9977	10077	10118
weight of Empty mold (gm)	5090	5090	5090	5090
weight of wet soil (gm)	4666	4886	4987	5028
wet density (γwet) (gm/cm³)	2.197	2.3	2.348	2.367

Readings of Proctor compaction test

Table 4-3 readings of proctor test compaction

Number of container	A15	B13	A2	A6
weight of container + wet soil (gm)	288.8	248.4	264.1	253.2
weight of container + dry soil (gm)	280.3	239.1	251.8	237.6
weight of Empty container (gm)	31.8	41.6	32	31.1
weight of water in the sample (gm)	8.5	9.3	12.3	15.6
weight of dry soil (gm)	248.5	197.5	219.8	206.5
moisture content %	3.4	4.71	5.6	7.55
dry density(gm/cm³)	2.121	2.201	2.225	2.205

We draw a relation between moisture content and dry density, the top of the curve represent the maximum dry density and the optimum water content. This figure shows the relation between moisture content and dry density.

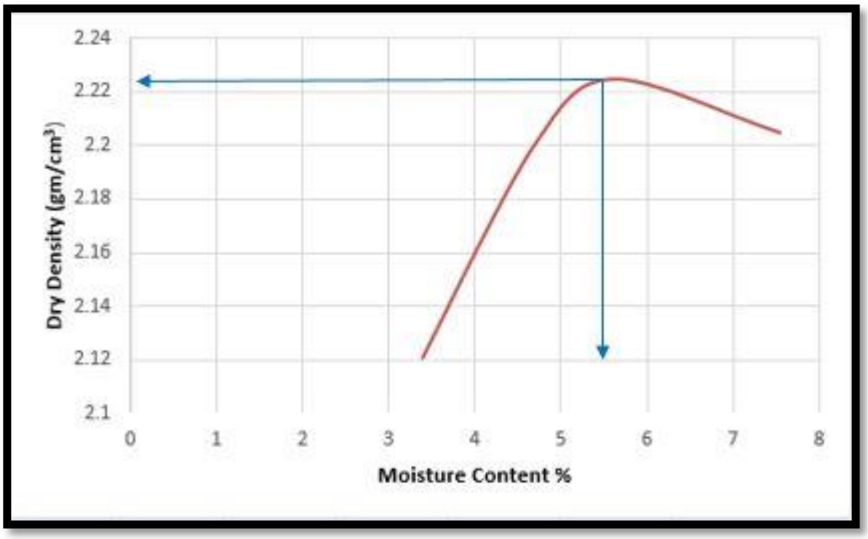

Figure 4-3 the relationship between dry density and moisture content

Maximum dry density = 2.227 gm/cm3

Optimum water content = 5.5%

B. CBR Test

O.W.C = 5.5%

wet $=\frac{4994}{2124}$ = 2.35 ɣ

$= 2.227$ ɣ dry = $\frac{\gamma wet}{1+w.c}$

Area of piston =19.35 cm2

Volume of mold = 2124 cm3

Weight of compacted soil = 4994 gm

1Div = 2.54 kg

1Div = $\frac{1}{100} mm$

Table 4-4 Readings of CBR

penetration depth (div)	penetration depth (mm)	Load in (kg/cm^2)	Load in (div)	pressure in (kg/cm^2)	C.B.R%
0	0		0	0	
50	0.5		50	6.6	
100	1		106	13.6	
150	1.5		176	22.6	
200	2		300	38.62	
250	2.5	70.35	420	54	77
300	3		535	67	
400	4		640	82.56	
500	5	105.35	810	104.5	99
600	6		915	118.1	
700	7		995	128.3	
800	8		1072	138.89	
900	9		1230	158.9	
1000	10		1315	169.5	

We draw a relation between pressure and penetration (mm)

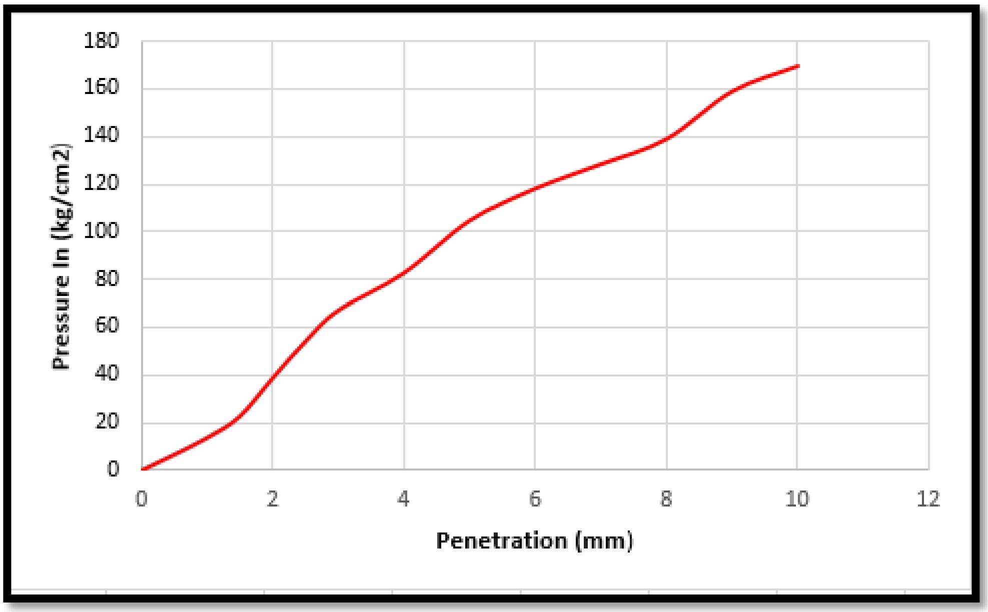

Figure 4-4 the relationship between pressure and penetration

We calculate CBR at two penetration (2.5mm) and (5mm)

$$CBR = \frac{pressure\ (\frac{kg}{cm2})}{standard\ load\ (\frac{kg}{cm2})} * 100\%$$

C.B.R at 2.5 = $\frac{54}{70.35} \times 100\% = 77\%$

C.B.R at 5 = $\frac{104.5}{105.35} \times 100\% = 99\%$

We took the greater CBR value, which is (99%)

2) Test for the base-coarse sample.

A. modified proctor test.

Values of dry density

Table 4-5 values of wet density

Number of trial	1	2	3	4
weight of added water (gm)	380	109	109	109
weight of mold + wet soil (gm)	9346	9525	9698	9689
weight of wet soil (gm)	4258	4427	4610	4061
wet density (γwet) (gm/cm³)	2.01	2.085	2.171	2.166

Readings of Proctor compaction test

Table 4-6 readings of proctor test compaction

Number of container	E7	C5	B13	B8
weight of container + wet soil (gm)	149.3	138.4	137.1	177.7
weight of container + dry soil (gm)	142.9	131.4	128.8	162.5
weight of Empty container (gm)	30.9	42.2	41.6	31.7
weight of water in the sample (gm)	6.4	7	8.3	15.2
weight of dry soil (gm)	112	89.2	87.2	130.8
moisture content %	5.71	7.85	9.51	11.62
dry density(gm/cm³)	1.897	1.933	1.982	1.94

We draw a relation between moisture content and dry density, the top of the curve represent the maximum dry density and the optimum water content. This figure shows the relation between moisture content and dry density.

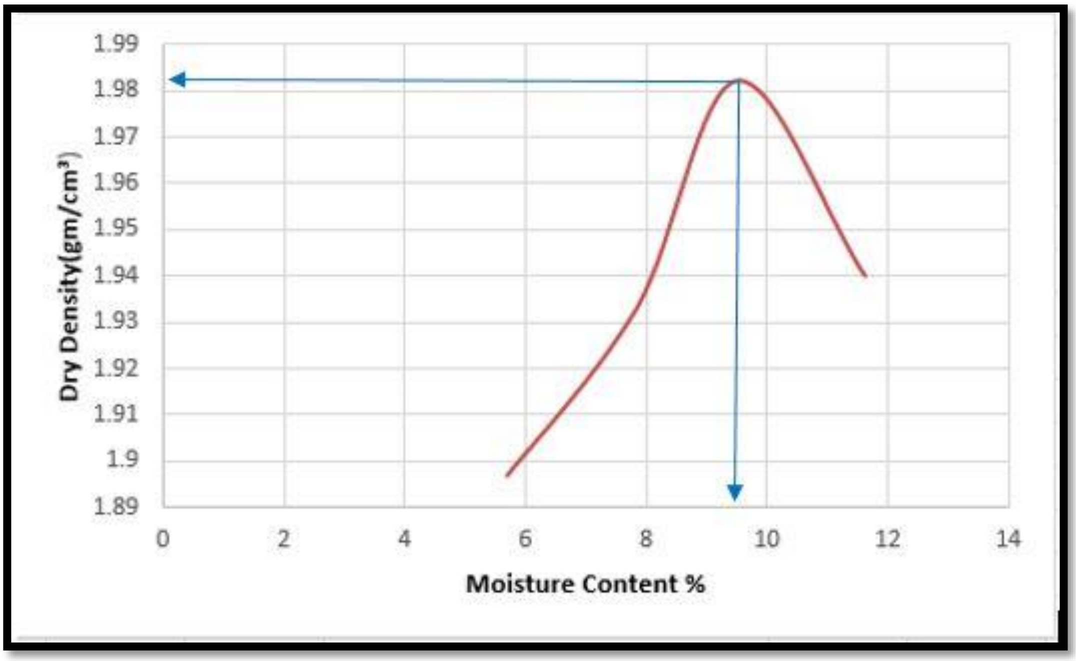

Figure 4-5 the relationship between dry density and moisture content

Maximum dry density = 1.985 gm/cm3

Optimum water content = 9.5%

B. CBR Test

O.W.C = 9.5%

wet $=\frac{4602}{2117.8} = 2.173$ ɣ

$= 1.984$ ɣ dry $= \frac{ɣwet}{1+w.c}$

Area of piston =19.35 cm2

Volume of mold = 2117.8 cm3

Weight of compacted soil = 4602 gm

1Div = 2.54 kg

1Div $= \frac{1}{100} mm$

Table 4-7 Reading of CBR

Penetration Depth (div)	Penetration Depth (div)	Lode in (kg/cm2)	Load in (div)	Pressure in (kg/cm2)	C.B.R %
0	0		0	0	
50	0.5		40	5.2	
100	1		90	11.8	
150	1.5		140	18.38	
200	2		200	24.8	
250	2.5	70.35	250	32.8	46.6
300	3		310	40.7	
400	4		370	48.5	
500	5	105.35	400	52.5	49.8
600	6		450	59	
700	7		490	64.3	
800	8		530	69.6	
900	9		550	72.2	
1000	10		567	74.4	

We draw a relation between pressure and penetration (mm)

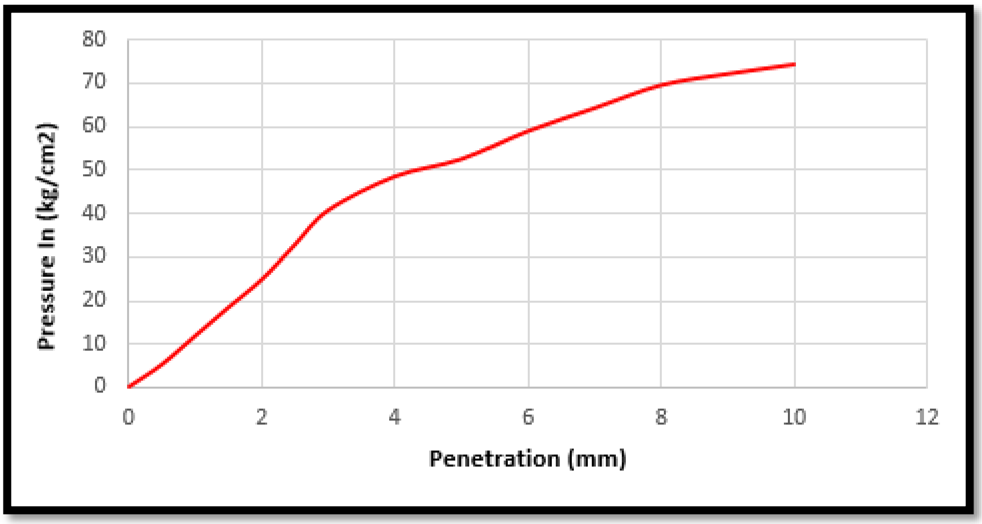

Figure 4-6 the relationship between pressure and penetration

C.B.R at 2.5 = $\frac{32.8}{70.35} \times 100\% = 46.6\%$

C.B.R at 5 =$\frac{52.5}{105.35} \times 100\% = 49.8\%$

We took the greater CBR value, which is (49.8%)

5. CHAPTER FIVE
DESIGN OF FLEXIBLE PAVEMENTS

5.1 Introduction

Pavement is generally being constructed for the purpose of smooth and comfort movement of the traffic, The current condition of the road is very much disturbed with the presence of uneven undulations as The movement of the Cars, Jeeps, Motor Bikes, Bicycles ,buses and heavy loaded, of ahead constructions site makes the incessant movement of the trucks as well. The movement of the Cars, Jeeps, Motor Bikes and Bicycles. [8]

Hence, for the purpose of the fulfillment of all the above factors and for comfort movement, we took this project as for the design of the pavement and it's estimation which will provide much help to the engineers and will also give the idea while the execution of the project realistically.

Highway pavements are divided into two main categories: [9]

1) Rigid pavement; The wearing surface of a rigid pavement is usually constructed of Portland cement concrete such that it acts like a beam over any irregularities in the underlying supporting material.

2) Flexible Pavement; the wearing surface of flexible pavements, on the other hand, is usually constructed of bituminous materials such that they remain in contact with the underlying material even when minor irregularities occur.

Flexible pavements usually consist of a bituminous surface under laid with a layer of granular material and a layer of a suitable mixture of coarse and fine materials. Traffic loads are transferred by the wearing surface to the underlying supporting materials through the interlocking of aggregates, the frictional effect of the granular materials, and the cohesion of the fine materials.

Flexible pavements are further divided into three subgroups:

1) High type; High-type pavements have wearing surfaces that adequately support the expected traffic load without visible distress due to fatigue and are not susceptible to weather conditions.

2) Intermediate type; Intermediate-type pavements have wearing surfaces that range from surface treated to those with qualities just below that of high-type pavements.

3) Low type; Low-type pavements are used mainly for low-cost roads and have wearing surfaces that range from untreated to lose natural materials to surface-treated earth.

5.2 Structural components of a flexible pavement [9]

Figure 5.1 shows the components of a flexible pavement: the subgrade or prepared roadbed, the sub base, the base, and the wearing surface. The performance of the pavement depends on the satisfactory performance of each component, which requires proper evaluation of the properties of each component separately.

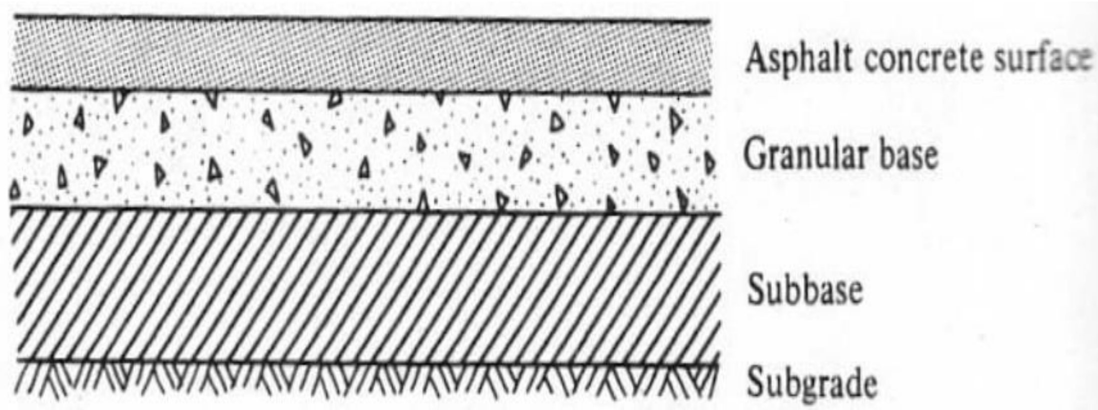

Figure 5-1 Components of a flexible pavement

1) Subgrade (Prepared Road Bed)

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

2) Subbase course

Located immediately above the subgrade, the subbase component consists of material of superior quality to that which generally is used for subgrade construction. The requirements for subbase materials are usually given in terms of the gradation plastics, and strength. When the quality of the subgrade material meets the requirements of the subbase material, the subbase component may be omitted.

3) Base course

The base course lies immediately above the subbase or subgrade. It is placed immediately on a subgrade if a subbase course is not used. This course usually consists of granular such as crushed stone, crushed or uncrushed slag, crushed or uncrushed gravel. The specifications for base course materials usually include stricter requirement those for subbase materials, particularly with respect to their plasticity, gradation strength. Materials that do not have the required properties can be used as base material if they are properly stabilized with Portland cement, asphalt, or lime.

4) Surface course

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

5.3 General principles of flexible pavement design [9]

In the design of flexible pavements, the pavement structure is usually considered as a multilayered elastic system, with the material in each layer characterized by certain physical properties that may include the modulus of elasticity, the resilient and the Poisson ratio.

It is usually assumed that the subgrade layer is infinite in both the horizontal and vertical directions, whereas the other layers are finite in the vertical direction and infinite the horizontal direction. The application of a wheel load causes a stress distribution which can be represented as shown in Figure 5.2.

The maximum vertical stresses are compressive and occur directly under the wheel load. These decrease depth from the surface. The maximum horizontal stresses also occur under the wheel load but can be either tensile or compressive as shown in Figure 5.2(C) .when load and pavement thickness are within certain ranges, horizontal compressive will occur above the neutral axis, whereas horizontal tensile stresses will occur below the neutral axis. The temperature distribution within the pavement stricter 5.2(d), will also have an effect on the magnitude of the stresses.

The availability of highly sophisticated computerized solutions systems, coupled with recent advances in materials evaluation, has led to of several design methods that are based wholly or partly on theoretical analysis more commonly used design methods are :

1) Asphalt institute method

2) American association of state highway.

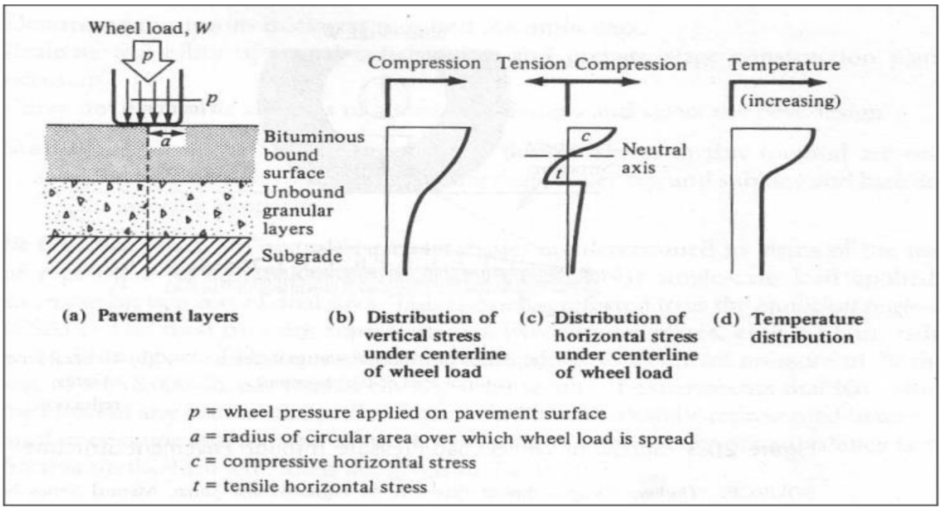

Figure 5-2 Typical Stress and Temperature Distributions in a Flexible Pavement Under a wheel load

5.4 Design Procedure [9]

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

Design charts have been prepared for a range of traffic loads. This range is usually adequate for normal traffic volumes encountered in practice. However, when this range is exceeded, computer version should be used. The procedure consists of five main steps:

1) Select or determine input data.

2) Select surface and base materials

3) Determine minimum thickness required for input data.

4) Evaluate feasibility of staged construction and prepare stage construction plan, if necessary.

5) Carry out economic analyses of alternative designs and select the best design.

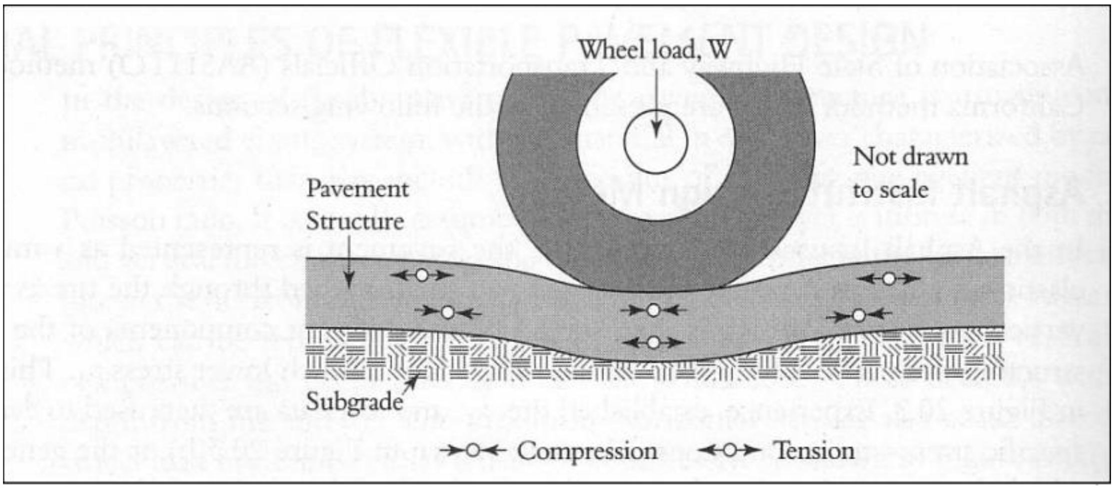

Figure 5-3 Schematic of Tensile and Compressive Stresses in Pavement Structure

5.5 Flexible pavements design [9]

Where the AASHTO method was followed to design Flexible pavements

Determine the equivalent single-axle load (ESAL)

To determine the ESAL, the number of different types of vehicles such as cars, buses, single-unit trucks, and multiple-unit trucks expected to use the facility during lifetime must be known. The distribution of the different types of vehicles expected to the proposed highway can

The total ESAL applied on the highway during its design period can be determined only after the design period and traffic growth factors are known. The design period is the number of years the pavement will effectively continue to carry the traffic load without requiring an overlay.

Flexible highway pavements are usually designed for 20 year period. Since traffic volume does not remain constant over the design period of the pavement, it is essential that the rate of growth be determined and applied when calculating total ESAL. Annual growth rates can be obtained from regional planning agencies or state highway departments. These are usually based on traffic volume counts over several years.

Relevant proportion of trucks on the design lane. A general equation for the accumulated ESAL for each category of axle load is obtained as

$$ESAL_i = F_d \times G_m \times AADT_i \times 365 \times N_i \times FE_i$$

$ESAL_i$ = equivalent accumulated 18,000-lb (80 kN) single-axle load for the axle category I fd =design lane factor

G rn = growth factor for a given growth rate r and design period n

AADTi = first year annual average daily traffic for axle category i

Ni = number of axles on each vehicle in category i

FEi = load equivalency factor for axle category i

When truck factors are used ,the ESAL for each category of truck is given as :

$$ESAL_i = AADT_i \times 365 \times F_i \times F_d \times G_m$$

The value of (Fd) is obtained from the table 5.1.

Table 5-1The percentage of total truck traffic on design lane

Design Lane Factor	
Number of Traffic Lanes	**Percentage Truck in Design Lane %**
2	**50**
4	**45 (35-48)**
6 or more	**40(25-48)**

The road which has to be design have 4 lanes in both directions, (two paths in each direction). The corresponding value fd of 4 is taken from the previous table (5.1) (fd=45%). The value of the growth factors (Gf) is obtained from the table (5.2).

Table 5-2 growth factors

Annual Growth Rate (%)							
Design Period Years(n)	2	4	5	6	7	8	10
1	1	1	1	1	1	1	1
2	2.02	2.04	2.05	2.06	2.07	2.08	2.1
3	3.06	3.12	3.15	3.18	3.21	3.25	3.31
4	4.12	4.25	4.31	4.37	4.44	4.51	4.64
5	5.2	5.42	5.53	5.64	5.75	5.87	6.11
6	6.31	6.63	6.8	6.98	7.15	7.34	7.72
7	7.43	7.9	8.14	8.39	8.65	8.92	9.49
8	8.58	9.21	9.55	9.9	10.26	10.64	11.44
9	9.75	10.58	11.03	11.49	11.98	12.49	13.58
10	10.95	12.01	12.58	13.18	13.82	14.49	15.94
11	12.17	13.49	14.21	14.97	15.78	16.65	18.53
12	13.41	15.03	15.92	16.87	17.89	18.98	21.38
13	14.68	16.63	17.71	18.88	20.14	21.5	24.52
14	15.97	18.29	19.16	21.01	22.55	24.21	27.97
15	17.29	20.02	21.58	23.28	25.13	27.15	31.77
16	18.64	21.82	23.66	25.67	27.89	30.32	35.95
17	20.01	23.7	25.84	28.21	30.84	33.75	40.55
18	21.41	25.65	28.13	30.91	34	37.45	45.6
19	22.84	27.67	30.54	33.76	37.38	41.45	51.16
20	24.3	29.78	33.06	36.79	41	45.76	57.28
25	32.03	41.65	47.73	54.86	63.25	73.11	98.35
30	40.57	56.08	66.44	79.06	94.46	113.28	164.49
35	49.99	73.65	90.32	111.43	138.24	172.32	271.02

Identifies that the projects to be constructed over a 20-year period, and expecting the annual growth will be 4 % so the growth factor will be (GF = 29.78%). Average Annual Daily Traffic is taken from the chapter of the traffic engineering studies.

Table 5-3 Average Annual Daily Traffic per category

The Days / Catogary	Motor Cycles	passenger Cars	Van	Buses	Single Unit 2,3,4 Axle	Single Trailer 3,4,5,6 Axle	Multi Trailer 5,6,7 Axle
Saturday (in & out)	5	2121	65	43	153	14	12
Sunday (in & out)	12	2012	50	53	147	18	9
Average	8.5	2066.5	57.5	48	150	16	10.5
Percentage %	0.005	0.88	0.02	0.02	0.06	0.009	0.006
AADT (veh/day)	***29***	***7088***	***197***	***165***	***515***	***55***	***36***

The value of (Fd) is obtained from the table(5.4)

Table 5-4 Distribution of Truck Factors (TF) for Different Classes of Highways and Vehicles

Track factors												
	Rural Systems						Urban Systems					
Vehicle Type	Interstate	Other Principal	*Minor Arterial*	Collectors		Range	Interstate	Other Freeways	Other Principal	Minor Arterial	collectors	Range
				Major	Minor							
Single-Unit Trucks												
2- axle,4-tire	0.003	0.003	0.003	0.017	0.003	0.003_0.017	0.002	0.015	0.002	0.006		0.006-0.015
2- axle,6-tire	0.21	0.25	0.28	0.41	0.19	0.19_0.41	0.17	0.13	0.24	0.23	0.13	0.13-0.24
3- axle or more	0.61	0.86	1.06	1.26	0.45	0.45_1.26	0.61	0.74	1.02	0.76	0.72	0.61-1.02
All Single Unit	0.06	0.08	*0.08*	0.12	0.03	0.03_0.12	0.05	0.0.6	0.09	0.04	0.16	0.04-0.16
tractor - semitrailers												
4-axle or less	0.62	0.92	0.62	0.37	0.91	0.37-0.91	0.98	0.48	0.71	0.46	0.4	0.40-0.98
5-axle	1.09	1.25	1.05	1.67	1.11	1.05-1.67	1.07	1.17	0.97	0.77	0.63	0.63-1.17
6-axle or more	1.23	1.54	1.04	2.21	1.35	1.04-2.21	1.05	1.19	0.9	0.64		0.64-1.19
All multiple units	1.04	1.21	*0.97*	1.52	1.08	0.97-1.52	1.05	0.96	0.91	0.67	0.53	0.53-1.05
All trucks	0.52	0.38	0.21	0.3	0.12	0.12-0.52	0.39	0.23	0.21	0.07	0.24	0.07-0.39

The value of Fi depends on the number of axial and the type of the road, where the type of the road that we want to design is rural systems where the value of total single unit axial equal 0.08 and the value of multi trailer axial equal 0.97.

After that we calculate the value of ESAL for any type of vehicles according equation:

ESALi = AADTi × 365 × Fi × Fd × Gm

ESALall single unit = 735×365×0.08×0.45×29.78 = 287612.3

ESAL all multi trailer = 36×365×0.97×0.45×29.78 =170806.5

ESAL total = 458418.8

5.6 Structural Design [9]

The objective of the design using the AASHTO method is to determine a flexible pavement SN adequate to carry the projected design ESAL. It is left to the designer to select the type of surface used, which can be either asphalt concrete, a single surface treatment, or a double surface treatment. This design procedure is used for ESALs greater than 50,000 for the performance period. The design for ESALs less than this is usually considered under low-volume roads.

The 1993 AASHTO guide gives the expression for SN as

$$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3$$

M_i = drainage coefficient for layer i

a_1, a_2, a_3 = layer coefficients representative of surface , base and subbase courses respectively

D_1, D_2, D_3 = actual thickness in inches of surface base and subbase courses respectively

Design Considerations

The factors considered in the AASHTO procedure for the design of flexible pavement as presented in the 1993 guide are

1) Pavement performance
2) Traffic
3) Roadbed soils (subgrade material)
4) Materials of construction
5) Environment
6) Drainage
7) Reliability

The purpose of this designing method is to find pavement layers which has an enough structure number (SN) to bearing loads that the road is exposed.

Materials of Construction:

The materials used for construction can be classified under three general groups:

1) Subbase construction.
2) Base construction.
3) Surface construction.

Subbase Construction Materials:

The quality of the material used is determined in terms of the layer coefficient, a_3, which is used to convert the actual thickness of the subbase to an equivalent SN, Layer coefficients are usually assigned based on the description of the material used. Note, however, that due to the widely different environmental, traffic, and construction conditions, it is essential that each design agency develop layer coefficients appropriate to the conditions that exist in its own environment.

Charts correlating the layer coefficients with different soil engineering properties have been developed. Figure 5.4 shows one such chart for granular subbase materials.

This figure shows the coefficient of sub-base (a3) layer that required the value of CBR where this value from the experiment in the lab was 48%.

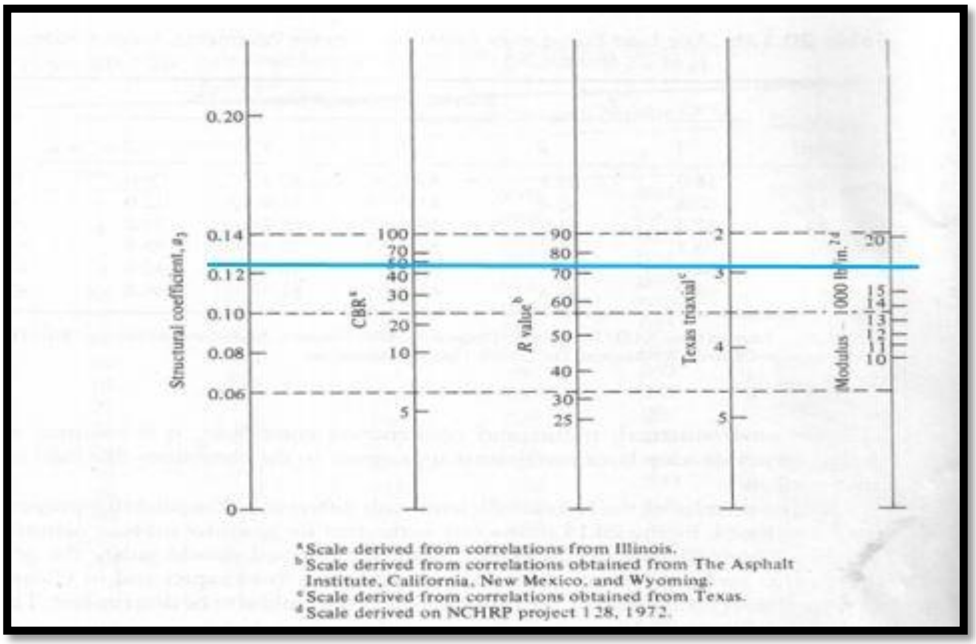

Figure 5-4 Variations in Granular Subbase Layer Coefficient, a3, with Various Subbase Strength Parameters.

When the value of CBR= 48%, the value of modulus of elasticity = 17500, and the value of the factor sub-base (a3) =0.12.

Base Course Construction Materials: Materials selected should satisfy the general requirements for base course materials. A structural layer coefficient, a2, for the material used should also be determined, this can be done using Figure 5.5

This figure shows the coefficient of base (a2) layer that required the value of CBR where this value from the experiment in the lab was 99%.

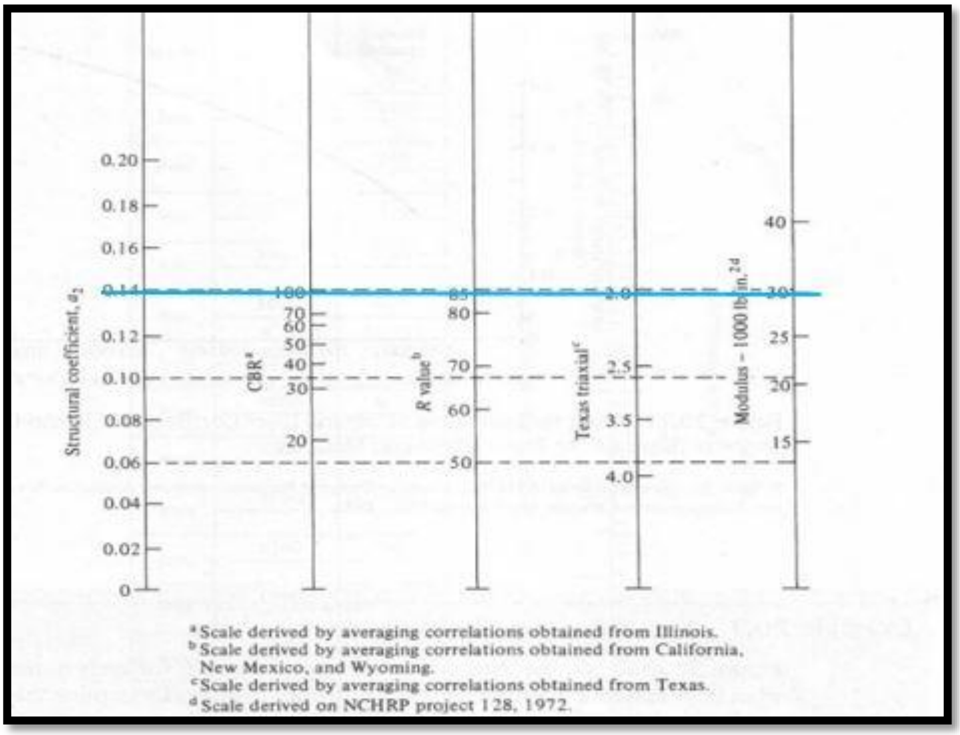

Figure 5-5 Variation in Granular Base Layer Coefficient 02, with Various Subbase Strength Parameters.

When the value of CBR= 99%, the value of modulus of elasticity = 30000, and the value of the factor sub-base (a2) =0.14.

Surface Course Construction Materials: The most commonly used material is a hot plant mix of asphalt cement and dense-graded aggregates with a maximum size of 1 in. The procedure discussed in Chapter 19 for the design of asphalt mix can be used. The structural layer coefficient (a1) for the surface course can be extracted from Figure 5.6.

This figure shows the coefficient of Asphalt (a1) layer that required the value of elastic modulus = 450000.

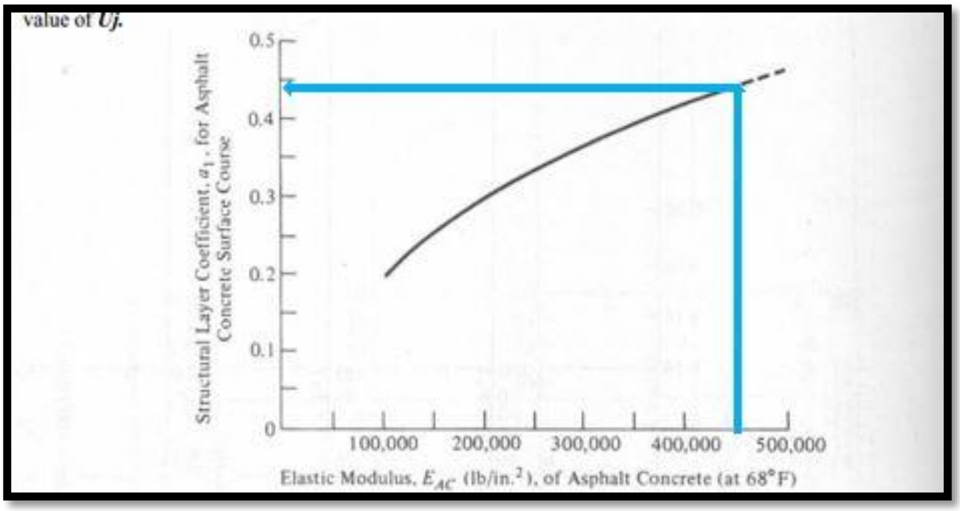

Figure 5-6 Chart for Estimating Structural Layer Coefficient of Dense-Graded/Asphalt Concrete Based on the Elastic (Resilient) Modulus.

When the value elastic modulus = 450000 the value of the factor sub-base(a1) =0.44.

Reliability: It has been noted that the cumulative ESAL is an important input to any pavement design method. However, the determination of this input usually is based on assumed growth rates, which may not be accurate. Most design methods do not consider this uncertainty, but the 1993 AASHTO guide proposes the use of a reliability factor that considers the possible uncertainties in traffic prediction and performance prediction. A detailed discussion of the development of the approach used is beyond the scope of this book; however, a general description of the methodology is presented to allow the incorporation of reliability in the design process, if so desired by a designer. Reliability design.

Table 5-5 Suggested Levels of Reliability for Various Functional Classifications

Recommended Level Of Reliability		
Functional Classification	Urban	Rural
Interstate and other freeways	85-99.9	0.80-99.9
Other principle arterials	80-99	75-95
Collectors	80-95	75-95
Local	50-80	50-80

Considering that road is local the reliability will be = 0.95 to increase the safety.

Table 5-6 standard deviation

Type Rode	Standard Deviation
Flexible pavement	0.40-0.50
Rigid pavement	0.30-0.40

Because we use flexible pavement in our design the standard deviation will be 0.5

The value of drainage coefficient for layer (mi) is found by quality of drainage And water content.

Table 5-7 Definition of Drainage Quality

Quality of Drainage	Water Removed Withen
Excellent	2 houer
Good	1 day
Fair	1 week
Poor	1 month
Very poor	water will not drain

Table 5-8 Recommended mi Values

Quality of Drainage	Less Than 1 Precent	1-5 Precent	5-25 Percent	Greater Than 25 Percent
Excellent	1.40-1.35	1.35-1.30	1.30-1.20	1.2
Good	1.35-1.25	1.25-1.15	1.15-1.00	1
Fair	1.25-1.15	1.15-1.05	1.00-0.80	0.8
Poor	1.15-1.05	1.05-0.80	0.80-0.60	0.6
Very poor	1.05-0.95	0.95-0.75	0.75-0.40	0.4

M is representing the drainage coefficient from base layer and layer coefficient for base layer (a2) can be calculated from CBR directly from the figure.

As we get in the CBR experiment that the water content is 9.5% and when the quality of drainage is good we can obtains the mi which is =1.

The SN1 for the asphalt layer can be obtain from Figure 5.7.

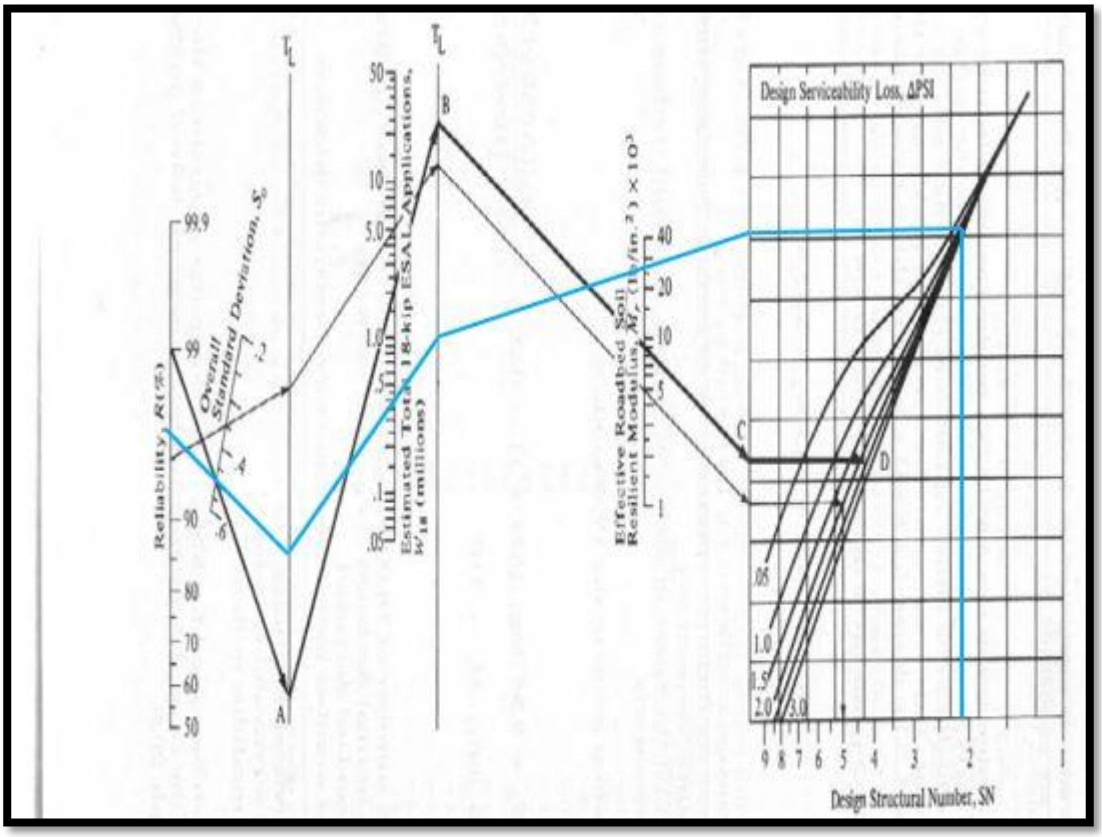

Figure 5-7 The SN1 for the asphalt layer can be obtain from the figure

Design chart for flexible pavement

1) At the first we draw a line between reliability which is equal 95% and standard deviation equal 0.5 until the line cross at point A.

2) Secondly we extent the line from A until B at the calculated ESAL which is equal 458418.8.

3) thirdly we extent the line from B until it cross the design Structure number then it passes from resilient modulus for the base layer which is equal 30000.

4) Then we extent the line until it cross the curve number 2

5) The we go down with the line so we get the SN1 for the asphlt which is equal 2.1.

The SN2 for the base layer can be obtain from the Figure 5.8.

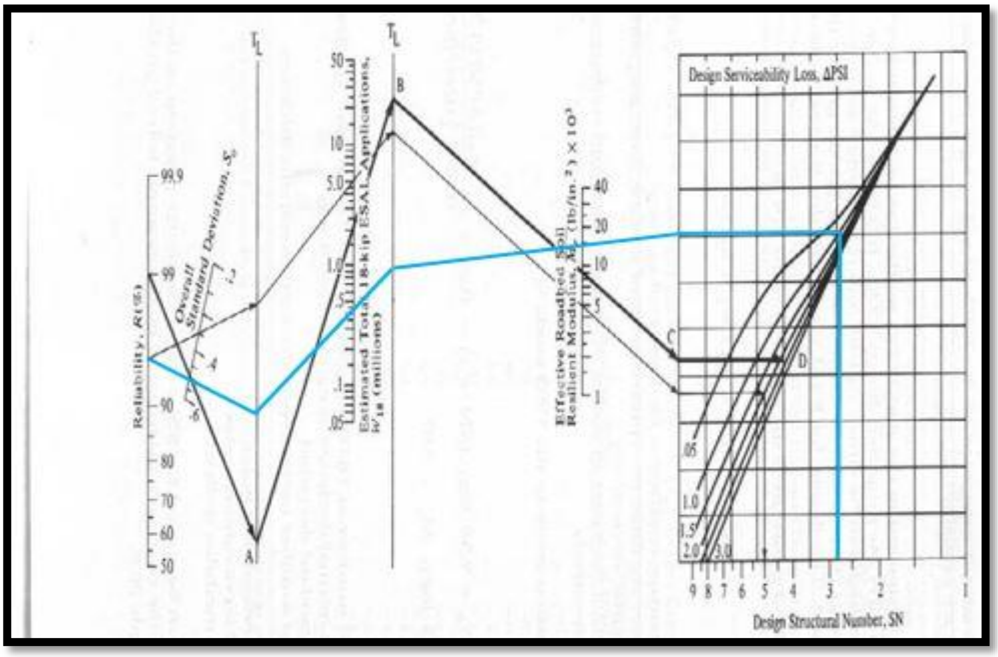

Figure 5-8 The SN2 for the asphalt layer can be obtain from the figure.

Design chart for flexible pavement

1) At the first we draw a line between reliability which is equal 95% and standard deviation equal 0.5 until the line cross at point A.

2) Secondly we extent the line from A until B at the calculated ESAL which is equal 458418.8.

3) thirdly we extent the line from B until it cross the design Structure number then it passes from resilient modulus for the sub base layer which is equal 17500

4) Then we extent the line until it cross the curve number 2

5) The we go down with the line so we get the SN2 for the base which is equal 2.6

5.7 Calculation of pavement layer thicknesses.

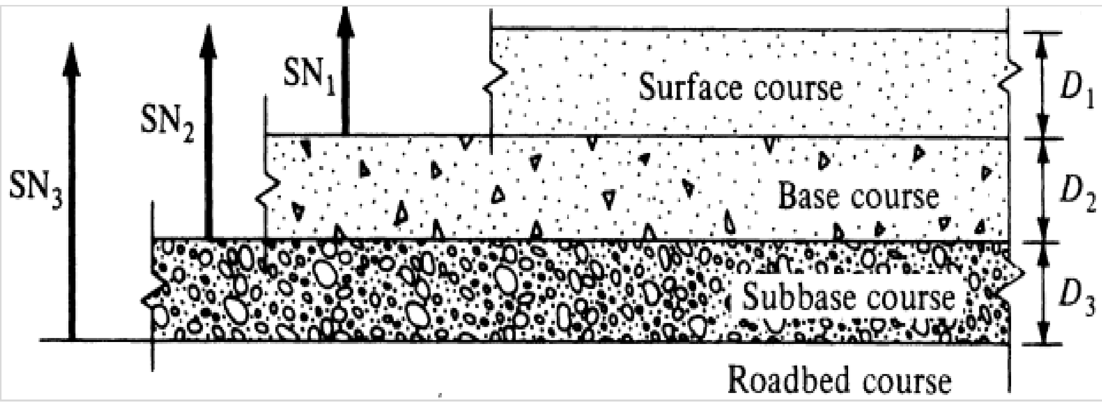

Figure 5-9 Procedure for Determining Thicknesses of Layers Using a Layered Analysis.

Approach

SN= a1D1 + a2D2m2 + a3D3m3

SN1=a1*D1

D1=$\frac{SN1}{a1}$ = $\frac{2}{0.44}$ =4.54 in

D1=4.54*2.54=11.53cm

Take D1= 15cm

SN1=a1*D1

= 0.44* $\frac{11.53}{2.54}$ =1.9 in

SN2 = 2.9

SN2 = SN1 +a2 m D2

D2 =$\frac{SN2-SN1}{a2*m}$

D2=$\frac{2.9-1.9}{0.14*1}$ =7.1 in

D2 = 7.1*2.54 = 18 cm

Take D2=20cm

Table 5-9 this table shows the thicknesses of pavement layers which we got.

Layer	Thicknesses (cm)
Asphalt	15
Bace corse	20

6. CHAPTER SIX
GEOMETRIC DESIGN OF HIGHWAY

Geometric design deals with the dimensioning of the elements of highways, such as vertical and horizontal curves, cross sections, truck climbing lanes, bicycle paths, and parking facilities.

6.1 Factors influencing highway design [8]

Highway design is based on specified design standards and controls which depend on the following roadway system factors:

- Functional classification
- Design hourly traffic volume and vehicle mix
- Design speed
- Design vehicle
- Cross section of the highway, such as lanes, shoulders, and medians
- Topography of the area that the highway traverses
- Level of service
- Available funds
- Safety
- Social and environmental factors

These factors are often interrelated. For example, design speed depends on functional classification which is usually related to expected traffic volume. The design speed may also depend on the topography, particularly in cases where limited funds are available. In most instances, the principal factors used to determine the standards to which a particular highway will be designed are the level of service to be provided, expected traffic volume, design speed, and the design vehicle. These factors, coupled with the basic characteristics of the driver, vehicle, and road, are used to determine standards for the geometric characteristics of the highway, such as cross sections and horizontal and vertical alignments.

6.2 Highway design standards: [8]

Selection of the appropriate set of geometric design standards is the first step in the design of any highway. This is essential because no single set of geometric standards can be used for all highways. For example, geometric standards that may be suitable for a scenic mountain road with low average daily traffic (ADT) are inadequate for a freeway carrying heavy traffic. The characteristics of the highway should therefore be considered in selecting the geometric design standards.

6.3 Traffic volume [9]

Traffic volume is one of the most factors which should be considered when we deign the road, so we have to do some studies to expect the current traffic volume and the future volume, so we calculate the AADT which was as shown in the traffic chapter.

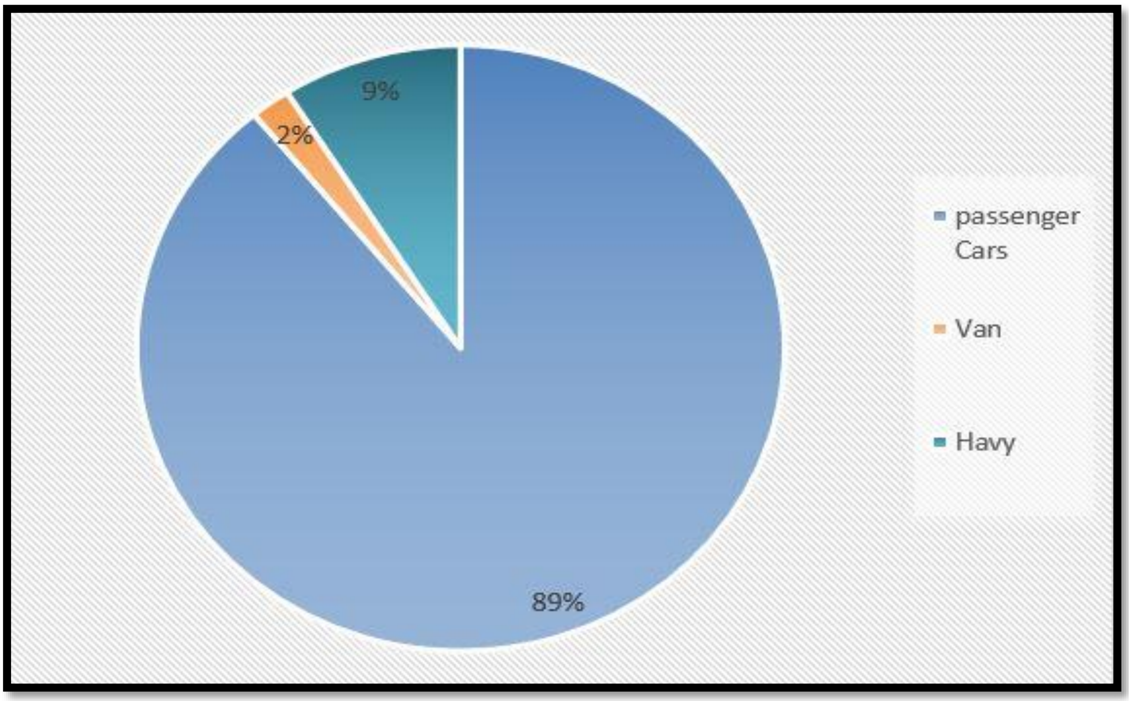

Figure 6-1 The percentage of AADT for vehicle

6.4 Type of traffic [9]

This item depends on the previous one, so as we have to know the traffic of volume we have to know which types of vehicles the road serve, so we found the percent of each type and it was as shown.

6.5 Design Speed [9]

Design speed is defined as a selected speed to determine the various geometric features of the roadway. Design speed depends on the functional classification of the highway, the topography of the area in which the highway is located, and the land use of the adjacent area. A design speed is selected to achieve a desired level of operation and safety on the highway. It is one of the first parameters selected in the design process because of its influence on other design variables.

The Design speed according to AASHTO is defined as a selected speed to determine the various geometric features of road.

The assumed design speed depends on the functional classification of the road which is to reduce the travel time and increasing capacity for (al-majoor) street... so probably the speed will increase to about (60 Km/hr) or more because the road is specified for moving vehicles without parking vehicles & pedestrians that will conflict with vehicles.

6.6 Cross section [8]

For road the cross-sectional shape is typically rectangular , generally The main elements of road cross section consist travel lanes, shoulders, medians and side slopes , as shown in the Figure 6.1.

The dimensions of the shapes employed are dependent on the dimensions of the cross section necessary for traffic. These vary due to:

1) Traffic volumes and the importance of the road.
2) Design speeds, safe stopping distances and sight distances.
3) Space for road equipment such as: signs and traffic.
4) Cost of the facility balanced against the required safety standards.
5) The usual local norms and the financial possibilities.

Internationally the response to the above differences varies greatly. In individual countries the response to the different situations has varied and evolves with time.

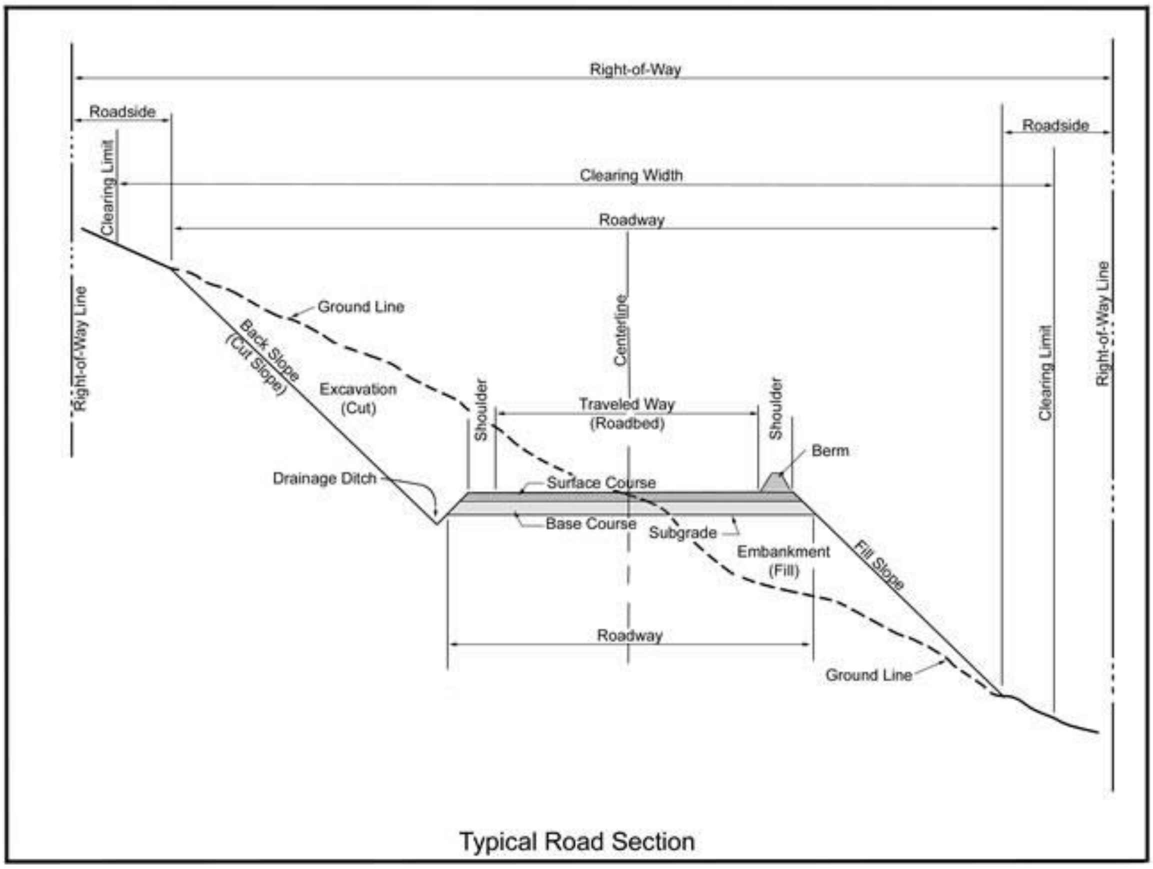

Figure 6-2 typical cross sections and with details for the road

6.7 Lane width

The lane width of a road way greatly influences the safety, comfort of driving. According to AASHTO the Lane widths of 2.7 to 3.6 m [9 to 12 ft.] are generally used, with a 3.6-m [12-ft] lane predominant on most high-speed, high-volume highways, [8], but in our project the right of way on the original Street doesn't enough to make lanes with width of 3.6 m, so we consider it 3.3 m.

6.8 Width of Shoulders

Desirably, a vehicle stopped on the shoulder should clear the edge of the traveled way by at least 0.3 m [1 ft.], and preferably by 0.6 m [2 ft.]. These dimensions have led to the adoption of 3.0 m [12 ft.] as the normal shoulder width that is preferred along higher speed, higher volume facilities. In difficult terrain and on low-volume highways, shoulders of this width may not be practical. A minimum shoulder width of 0.6 m [2 ft.] should be considered for low-volume highways, [8], but in our case we considered it there's no shoulders.

6.9 Medians:

A median is the section of a divided highway that separates the lanes in opposing directions. The width of a median is the distance between the edges of the inside lanes.

Figure 6-3 Sample of medians [9]

6.10 Sidewalks:

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

Figure 6-4 example of sidewalks [9]

6.11 Cross slope

There are two types of cross slopes:

- Rounded cross sections: usually are parabolic, with a slightly rounded surface at the crown line and increasing cross slope toward the edge of the traveled way. Because the rate of cross slope is variable, the parabolic section is described by the crown height (i.e., the vertical drop from the center crown line to the edge of the traveled way). The rounded section is advantageous in that the cross slope steepens toward the edge of the traveled way, thereby facilitating drainage.

Disadvantages are that rounded sections are more difficult to construct, the cross slope of the outer lanes may be excessive, and warping of pavement areas at intersections may be awkward or difficult to construct.

- Plane cross sections: consist of uniform slopes at both sides of the crown.

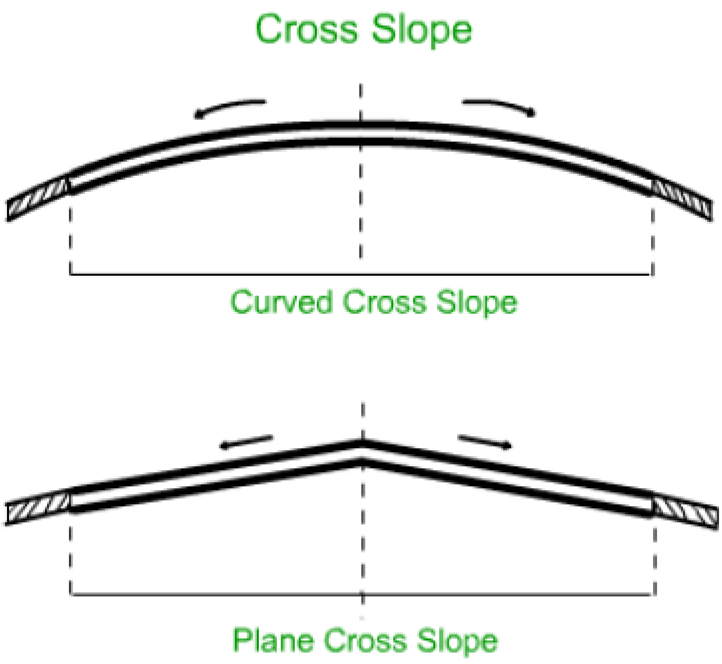

Figure 6-5 Shape of Cross Slope and its value. [8]

In defining the rate of cross slope for design, two conflicting factors should be considered:

• Steep cross slope is required for drainage purposes,

• Steep cross slopes are undesirable since vehicles will tend to drift to the edge of the pavement, particularly under icy conditions, the following tables shows the recommended rates of cross slopes: [8]

Table 6-1 Recommended rates of Cross Slope [8].

Surface Type	Range in Cross Slope Rate for a Single Lane (%)
Paved	1.5–2
Unpaved	2–6

Summary of Standards & Specifications:

The following table shows the Standards & Specification that used in our project:

Table 6-2 Specification Used for Design the road.

Item No.	Item Description	Used
1	Functional Classification	Multilane Highway
2	Design Speed	60 km/h
3	Design Vehicle	Intermediate Semitrailer (WB-50)
4	Cross Section	Rectangular (Cut & Fill Road)
5	Lane Width	3.3 m
8	Cross Slopes	2%
9	LOS	A

6.12 Design alternatives

We may have alternatives to perform the road. But the alternatives alignments differs only from the south side of the road because of the buildings in the northern area also, we must be fair when we take the land, so that no one will be wronged as it possible.

6.13 Design of the alignment [9]

The alignment of a highway is composed of vertical and horizontal elements. The vertical alignment includes straight (tangent) highway grades and the parabolic curves that connect these grades. The horizontal alignment includes the straight (tangent) sections of the roadway and the circular curves that connect their change in direction.

The design of the alignment depends primarily on the design speed selected for the highway. The least costly alignment is one that takes the form of the natural topography. It is not always possible to select the lowest cost alternative because the designer must adhere to certain standards that may not exist on the natural topography. It is important that the alignment of a given section has consistent standards to avoid sudden changes in the vertical and horizontal layout of the highway. It is also important that both horizontal and vertical alignments be designed to complement each other, since this will result in a safer and more attractive highway. One factor that should be considered to achieve compatibility is the proper balancing of the grades of tangents with curvatures of horizontal curves and the location of horizontal and vertical curves with respect to each other

Vertical Alignment [9]

The vertical alignment of a highway consists of straight sections known as grades, (or tangents) connected by vertical curves. The design of the vertical alignment therefore involves the selection of suitable grades for the tangent sections and the appropriate length of vertical curves. The topography of the area through which the road traverses has a significant impact on the design of the vertical alignment.

Vertical curves are used to provide a gradual change from one tangent grade to another so that vehicles may run smoothly as they traverse the highway. These curves are usually parabolic in shape.

Horizontal alignment [9]

The horizontal alignment consists of straight sections of the road (known as tangents) connected by curves. The curves are usually segments of circles, which have radii that will provide for a smooth flow of traffic. The design of the horizontal alignment entails the determination of the minimum radius, determination of the length of the curve, and the computation of the horizontal offsets from the tangents to the curve to facilitate locating the curve in the field. In some cases, to avoid a sudden change from a tangent with infinite radius to a curve of finite radius, a curve with radii varying from infinite to the radius of the circular curve is placed between the circular curve and the tangent. Such a curve is known as a spiral or transition curve.

6.14 Super elevation [9]

Minimum Radius of a Circular Curve When a vehicle is moving around a circular curve, there is an inward radial force acting on the vehicle, usually referred to as the centrifugal force. There is also an outward radial force acting toward the center of curvature as a result of the centripetal acceleration. In order to balance the effect of the centripetal acceleration, the road is inclined toward the center of the curve. The inclination of the roadway toward the center of the curve is known as superelevation. The centripetal acceleration depends on the component of the vehicle's weight along the inclined surface of the road and the side friction between the tires and the roadway.

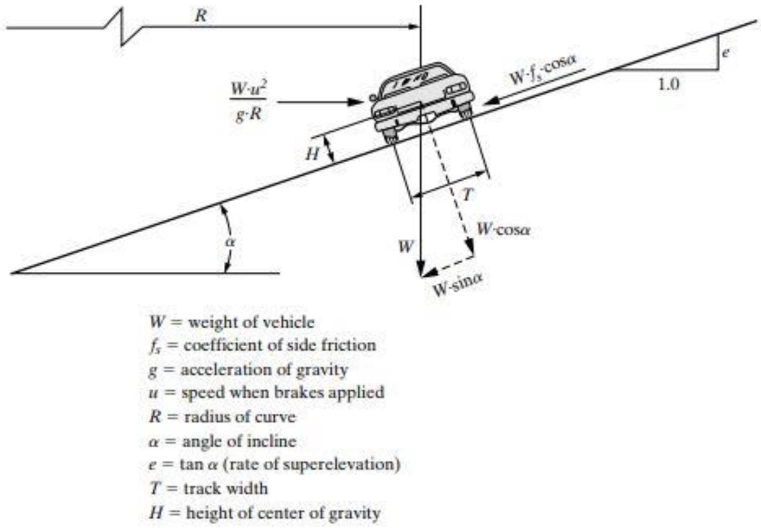

Figure 6-6 vehicle behavior in superelevation

$$e + f = \frac{v^2}{gR} = \frac{(0.75 \times V)^2}{127R}$$

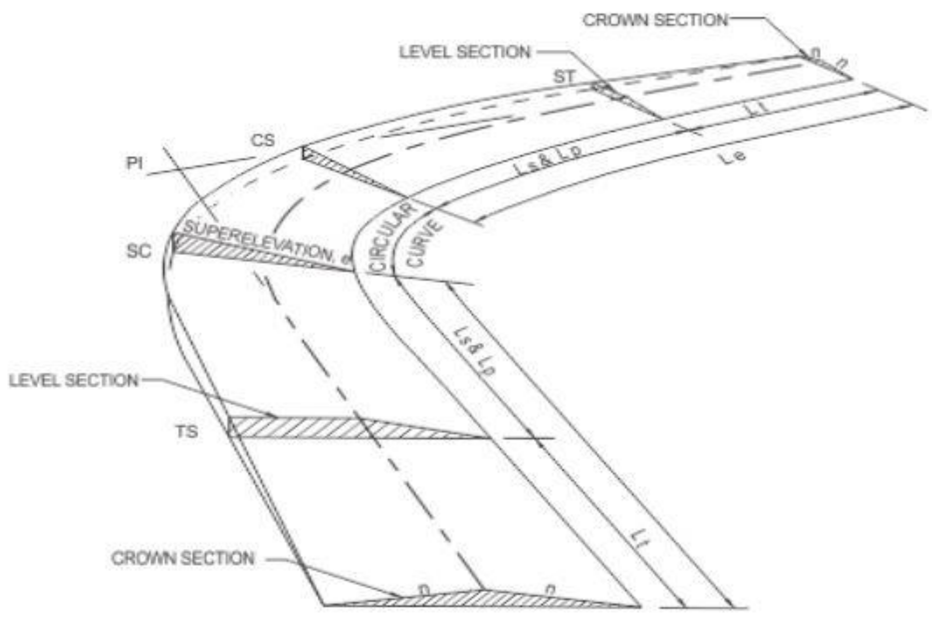

Figure 6-7 Example of applying superelevation

6.15 Curves [9]

Vertical Curve

1) General Vertical Curve Equations the general equation for a parabola is: Where y is the elevation at any point along the parabola located a distance x from the BVC point. The values for a, b, and c are constants.

y =ax2 + bx + c.

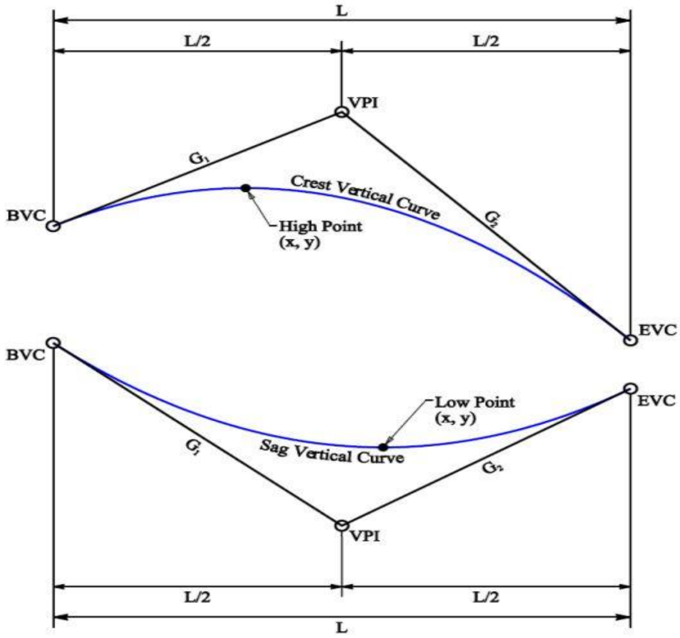

Figure 6-8 typical vertical curves [9]

Horizontal curve

In our project we only use simple curve as shown in the figure

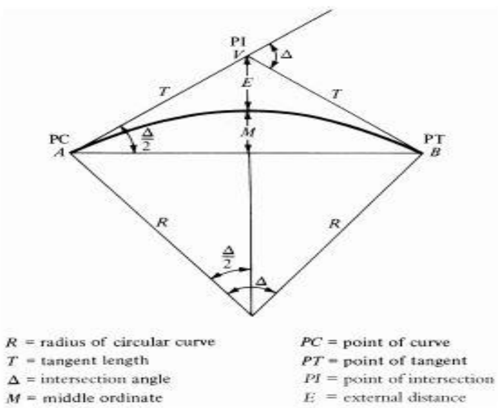

Figure 6-9 typical horizontal curve [9]

Simple curve equations:

1) $T = R\tan\frac{\triangle}{2}$

2) $E = R(\sec(\frac{\triangle}{2})-1)$

3) $M = R(1-\cos(\frac{\triangle}{2}))$

4) $Lc = 2R\sin(\frac{\triangle}{2})$

5) $L = \frac{\pi R\triangle}{180}$

6.16 General design considerations [8]

There are some important considerations to be considered during the work of the project:

- The value of the economic feasibility of this project and reduce the cost as much as possible without being at the expense of quality.
- Roads should be suitable for traffic volume, which depends mainly on vehicle types, weights and its number.
- Curves should be smooth in the alignment.
- Safety and safety standards should be considered for all road users in order to reduce collisions and traffic accidents.
- Reduce the number of intersections in the road.
- Sight distance should be considered, necessarily at the intersections.
- Consider the contour lines of this area and avoid harm to humans and the environment.

7. CHAPTER SEVEN

REUSLTS AND RECOMENDATIONS

7.1 General introduction

When doing any work whether it is engineering work or not, it produces final results that determine what is required to perform this work.

This chapter discuss a set of results that was reached in road designing and it contains a set of recommendations which gives a good impression on the implementation of the project.

7.2 General results

After doing all Monitoring process and road designing, a set of results has been reached:

1) This road is local and the implementation of this road is important in Dura city, because it saves time and effort on the user.

2) The results of the three layers after doing all necessary calculations, as shown in the table:

Table 7-1 pavement results

Layer	Thicknesses (cm)
Asphalt	15
Bace corse	20

3) The road has been designed based on (AASHTO 2006) , and the designing work was done by (civil3D) , the results were :

- Amounts of cutting =13767.21 m3
- Amounts of filling =35121.45 m3
- Asphalt =3594.26 m3
- Base coarse =4792.34 m3
- Side walk = 407.01 m3

4) All horizontal and vertical designs are equipped, and all information needed.

5) The path of the road was chosen based on Dura city planner with some adjustment to be suitable for designing.

6) The estimated cost of the project has been calculated:

Table 7-2 calculated quantities

Work	Amounts (m3)	Cost for 1m3 ($)	Cost ($)
Cut	13767.21	6.5	89486.87
Fill	35121.45	1.6	56194.32
Asphalt	3594.26	12.1	43490.55
Base coarse	4792.34	5.6	26837.1
Side walk	407.01	11	4477.11
Total			220485.95

7.2 Recommendations:

1) Compaction should be done on more than one layer as the amount of filling is not small.

2 We must put a small layer of Bitumen, to make sure that the asphalt is consistent well.

3) We have to prevent the vehicles to pass through this road after at least 24 hours.

4) We have to keep in touch with municipality, to make sure there's no changing in the implementation of this road.

5) Encourage the university to keep in touch with the governmental and non-governmental organizations.

REFERENCES

[1] S. Rohae, البسيط في تصميم وإنشاء الطرق, vol. first one, Aman: DAR EL-THQAFEH, 1982.

[2] M. Dabash, بلادنا فلسطين, QOFER QARE', palestine: DAR El-HUDA, 2013, pp. 195-196.

[3] F. AbuRadi, SURVEY AND CATOGRAPHY, first one ed., Buirt, Lebanon: DAR EL-NAHDA EL-ARABYA, 1992.

[4] H. lichtenegger, E. Wasle and B. Hofmann-wellenhof, GNSS:Global Navgation SatelliteSystem, NewYork: Springer, 2008.

[5] D. Gebre-Egziabher and S. Gleason, GNSS:APPLICATIONS AND METHODS, Norwood: ARTECH HOUSE, 2009.

[6] R. Roess, E. Prassas and w. Mcshane, Traffic Engineering, 4 th ed., Newyork: Pearson, 2011.

[7] A. Verruijt, Soil Mechanics, Delft: Delft uinversity, 2001.

[8] AASHTO Green Book, Washington, DC, Washington, DC: AASHTO, 2011.

[9] N. Garber, Traffic and Highway Engineering, 4 th ed., canda: cangage learning , 2009.