Wolkite University, College of Engineering and Technology

Civil Engineering Department

CEng5281 BSc Thesis/project

Title: Upgrading cobblestone road to paved road (behind Wolkite university dormitory).

Mara Simion [1], Alazar Haile [2], Abenezer Taye [3], Abeneze Belay [4], Eyob Zewde [5], Nathinael Kebede [6]

[1]Wolkite University, Civil Engineering Department, ID Number ENGR/ 560 /09
[2]Wolkite University, Civil Engineering Department, ID Number ENGR/ 075 /09
[3]Wolkite University, Civil Engineering Department, ID Number ENGR/ 039 /09
[4]Wolkite University, Civil Engineering Department, ID Number ENGR/ 038 /09
[5]Wolkite University, Civil Engineering Department, ID Number ENGR/ 345 /09
[6]Wolkite University, Civil Engineering Department, ID Number ENGR/1265/08

Advisor/s

Mr. Samuel A.

Mr. Desta M.

06; August, 2021

WOLKITE UNIVERSITY

COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING

APPROVAL FOR DEFENSE SHEET

As members of the examining board the final B. Sc. open defiance, we verify that we have read and evaluating the final B. Sc. thesis/project prepared by:

1. Mara Simion
2. Alazar Haile
3. Abenezer Taye
4. Abenezer Belay
5. Eyob Zewde
6. Nathinael Kebede

Entitled: Upgrading cobblestone road to paved road (behind Wolkite university dormitory).

And recommended for acceptance as a fulfilment of the requirement for the degree of

Bachelor of Science in Civil Engineering

Advisors:-

Name of Advisor: ______________________ Signature: _______ Date: _________

Name of Advisor: ______________________ Signature: _______ Date: _________

Chairman:-

Name of Chairman: ______________________ Signature: _______ Date: _________

Internal Examiner:-

Name of Internal Examiner: ______________________ Signature: _______ Date: _________

Preface

This document is a project for BSc Thesis/project Integrated in Civil Engineering on Upgrading cobblestone road to paved road. The following teams members have contributed in writing this report:-

1. Mara Simion
2. Alazar Haile
3. Abenezer Taye
4. Abenezer Belay
5. Eyob Zewde
6. Nathinael Kebede

Abstract/Summary

Highway transportation system is one of the most commonly used modes of transportation system in Ethiopia. The road project we are going to design, as a partial fulfillment of B.Sc. Degree in Civil Engineering, and the project is about upgrading cobble-stone road to paved road. The design includes; geometric design, pavement design (flexible pavement) and drainage design of a selected road.

We intensively depend on the AACRA design manual for the design of all Highways are of major importance in the development of a country as they play a vital role in facilitating the movement of people and goods from place to place in the most comfortable, safe and desirable way. And we have also roughly referred ERA design manual & other related scriptures on highway for some data that are vague on AACRA.

The document includes three design: the first is geometric design; to design geometry of a given road we intensively depends on AACRA geometric design manual, the second part is about pavement design; to design pavement of a given road we intensively depends on AACRA pavement design manual, finally we design highway drainage; to design highway drainage of a given road we intensively depends on AACRA drainage design manual.

So after finishing the project we will submit the report to Civil engineering Department of Wolkite University and the site should be upgraded to flexible pavement according to our design and we recommended that civil 3D software is much better for pavement design so we suggest the software civil 3D.

Acknowledgement

First of all we would like to acknowledge Wolkite University, College of Engineering and Technology, Civil Engineering Department, because they give the great opportunity to design on our need of project area and for their dedication.

And also we would like to give our great thank for our BSc. Thesis /project CEng 5281 coordinator Mr Kibret G. and for our project advisors Mr Samuel A. and Mr Desta M. for their limitless support in addition to that we would like to give great thanks for Mr Mikre, who is chief surveyor, we also thanks for those soil laboratory technicians at Wolkite University.

Finally, we would like to thank our families for their endless support during our stay in Wolkite University.

Table of Contents

List of Tables

Table 5. 9: ESA Value from ERA manual 56

List of figures

Acronyms

AACRA: Addis Ababa City Road Authority

AADT: Average Annual Daily Traffic

AASHTO: American Association of State Highway and Transportation Officials

ADT: Average Daily Traffic

CBR: California Bearing Ratio

CL: Chord length

DV: Design Vehicle

ERA: Ethiopian Roads Authority

ESA: Equivalent Standard Axle

GDP: Gross domestic product

KM: Kilometers

LL: Liquid Limit

MDD: Maximum Dry Density

MM: Millimeters

NF: Night factor

OD: Origin destination

OMC: Optimum Moisture Content

PC: Point of curvature

PC: Point of tangency

PI: Plasticity Index

PL: Plastic Limit

PSD: Passing site distance

SN: Structural Number

SSD: Stopping sight distance

1. INTRODUCTION

1.1. Overview of Transportation System

Transportation deals with the movement of humans and materials from place to place. Transportation plays an enormous role in our everyday lives. Each of us travels somewhere almost every day, whether it is to get to work or school, to go shopping, or for entertainment purposes.

In addition, almost everything we consume or use has been transported at some point. In the world, there are various types of transportations like road, railway, air, water, but in this document we concern on road transportation. A well-developed road transport sector in developing countries is assumed to fuel up the growth process through a variety of activities of the development endeavors of a nation. Today, Ethiopia is expanding its road network to connect its major cities and towns throughout the entire country. Road transport facilities are essential for expanding education, health service provision, trade facilitation both within the country and the export market.

From the above listed transportation types, the trends are towards road transportation. The reason behind is:

- Roads provide a wide geographical coverage, particularly in hilly regions and it provides services for the communities from the start up to end (termination).
- Roads are constructed relatively at low initial cost than others and at the same time stage construction is possible.
- Road transportation gives a flexible service, i.e. free from fixed program.
- It gives door to door services, personalized service, and creates higher employment potential for the community.

For the development of any nation, infrastructure like that of road is very important. It is impossible to think of development without having accessible roads in a given nation. Roads are very important for many reasons, some of them are:

- Connecting nation to nation.
- Reduce wastage of energy during travelling.
- Connecting people to people living in different places.
- Facilitate international and national trades.
- Connecting the gap between producers and consumers.
- Helps in the explorations of natural resources.
- Used in the transportation of materials which are unevenly distributed and
- Also enable the governance of vast areas under control of nation.

Besides the advantages, there are some side effects and these side effects should be reduced by proper design (project handing) and vehicle operation. Some of the disadvantages are:

- Environmental pollution: like noise, vibration, less due to aesthetics point of views.
- Safety: road accidents become a concern in much country.
- Parking: Especially in cities road transportation needs parking land.
- Energy: it contains higher energy per km.

1.2. Objective of the project

1.2.1. Main objective

As a highway engineer the main objective of this project is to design short, easy and economical root connecting entrance 2 to entrance 3(behind Wolkite university dormitory) by upgrading the existing condition of the road (cobblestone road) in to a better standard pavement road.

1.2.2. Sub objectives

Our selected project has the following sub objectives:

- To carry out detailed Engineering design (geometric design, pavement design and drainage design).
- To exercise working manuals of highway (AACRA Manual, ERA Manual and AASHTO Manual) and engineering software's (CIVIL 3D, Excel,…).
- To build up our theoretical concepts.

1.3. General description of the Project

1.3.1. Location

Wolkite University is located in the Southern part of Ethiopia in region of SNNPR (south nation nationalities regional state) in Guraghe zone, 158km southwest capital city, Addis Ababa, on the way to Jimma. The major link road to the university is a direct route to Wolkite - Jimma, Wolkite - Hossana and Wolkite - Butajira.

The project area is located in Wolkite University behind male's dormitory. The project is that connects the paved road of entrance 2 to entrance 3(inside Wolkite University). It covers almost 1.269km. And the road has very important in reducing the high flow of traffic on existing roads. And additionally it has great importance for vehicles and pedestrians because it is located on the way of Wolkite university Biotechnology laboratory.

Figure 1. 1: Location of our project

1.3.2. Climate

The external influence of environmental factors such as rainfall, temperature variation and atmospheric conditions can cause deterioration of pavement. Climate has an influence on the selection of pavement material, surfacing material and construction material. Some of environmental factors that cause deterioration of pavements are:

1. Rain fall
2. Temperature

1. **Rain fall: -** It cause erosion of shoulders, side slopes and ingress of water in pavement structure and sub grade and it affects the performance of drainage structure. The annual rainfall amount for the study area ranged from 309.8 mm to 1738.4 mm, while belg and kiremt rainfall amount varied from 99.55 mm to 481.3 mm and 162.7 mm to 1202 mm respectively.

2. **Temperature: -** Its variation can affect the binder and performance of bituminous surface and cement concrete pavement. The annual maximum temperature varied between 23.35 and 29.02 ^{0}C and mean annual average maximum temperature over the study area was 27.03 ^{0}C.

Table 1. 1: Rainfall and Temperature of Wolkite university compounds

Climate condition	**Range in mm and ^{0}c**
Rainfall	309.8 mm to 1738.4 mm
Temperature	23.35 and 29.02 ^{0}C

1.4. Project Methodology

In designing highway, we are followed the following procedures:

- Traffic study,
- Design control and criteria,
- Geometric design,
- Pavement design, and
- Drainage design.

2. TRAFFIC STUDY

2.1. General

Traffic is the most important factor in pavement design and stress analysis. Traffic constitutes the load imparted on the pavement causing the stresses, strains and deflections in the pavement layers and sub-grades. Hence the pavement design must account for the amount of traffic load expected over its design life. The traffic loads on pavement can be characterized by magnitude of load, axle and wheel configuration, wheel and axle spacing, load repetitions and other considerations include tire pressure, contact area, vehicle speed, and traffic distribution across the pavement.

Road Agencies require traffic data for various purposes. The type of information and the accuracy required differs according to the reason for which it is to be used. The main requirements for the purpose of pavement design and rehabilitation are:

- **Annual Average Daily Traffic (AADT):**
  - The total year volume at a specific location divided by the number of days in the year,
- **Traffic composition:**
  - The proportion of each type of vehicle within the total traffic stream based on a predetermined vehicle classification system,
- **Equivalent Standard Axles (ESA):**
  - The damaging effect of each vehicle or each vehicle classification with respect to a standard axle weight,
- **Traffic Growth:**
  - The growth rate in traffic counts at a specific location.

Traffic studies include both the collection and analysis of useful data relating to traffic and its characteristics. The purposes of traffic studies are as follows:

- Monitoring: Using information about existing traffic conditions to improve flow conditions.
- Forecasting: By using existing traffic data to estimate future traffic demands in changed traffic conditions.
- Calibration: Using traffic data to estimate the values for one or more parameters in a theoretical or simulation model.
- Validation: Verifying a theoretical or simulation model against information independent of that used to calibrate the model.
- Evaluation: Using traffic data to assess whether changes to the traffic system have resulted in the desired improvement in the traffic conditions.

2.2. Types of traffic

Even with stable economic conditions, traffic forecasting is an uncertain process. Although the pavement design engineer may often receive help from specialized professionals at this stage of the traffic evaluation, some general remarks are in order. To forecast traffic growth it is usually necessary to separate traffic into the following three categories:

1. **Normal Traffic:** Traffic volume currently using the roads without any improvements.
2. **Diverted traffic:** Traffic that will be diverted to the project road from adjacent road network either due to shorter travel time or improved facilities.

This traffic amount is estimated by carefully performing an origin destination (OD) survey. This couldn't be done because of data limitation therefore we took the value which is used for most designs which is 3-6%.

- For our road project we took 5% of the total traffic as a generated traffic.

3. **Generated traffic:** Traffic that would be generated due to developments brought about by the improvement of the road.
   Here the development of the area has to be thoroughly studied. The GDP (Gross Domestic Product) growth of the area should also be analyzed.

- For our road we took a generated traffic of 13% of the total traffic.

- From the end of design to the road opening, we have 2 years of construction period.

2.3. Design period

The design period is the length of time expected in years before it is anticipated that rehabilitation of the pavement will be necessary to restore shape, repair other forms of distress, or to provide additional pavement strength. Rehabilitation which may consist of granular or asphalt overlay, major patching or improvements or removal of selected areas of pavement materials, initiates a new design period.

The design period starts when the completed pavement is opened to public traffic over the entire length of a construction project. From AACRA manual for most road projects an economic period of 20 years from the date of opening is appropriate.

- Therefore for our road project a design period of 20 years is selected.

2.4. Growth rate

Based on road traffic survey information, it is reasonable in most circumstances to assume traffic volumes will increase geometrically in the absence of growth figures (mainly GDP) AACRA recommends to select the growth rate based on economic growth zone in which the road project is located and the design period.

The following growth rate matrix provides an appropriate growth rate for road projects in Wolkite University.

Table 2. 1: Growth rate matrix (%pa) (AACRA table6-5)

	Economic growth zone					
Road classification	**1**	**2**	**3**	**4**	**5**	**6**
Arterial	7.0	11.2	7.0	11.1	7.2	9.3
Sub-arterial	6.5	9.3	6.5	9.2	6.6	8.2
Collector	6.0	7.4	6.0	7.4	6.1	6.8
Local	5.5	5.5	5.5	5.5	5.5	5.5

- After carefully analyzing Wolkite University master plan we classified the road project area to be in growth zone of 6. With this growth zone and a local road class the required growth rate can easily be read from the growth matrix to be 5.5%.

2.5. Traffic forecasting

The necessity of traffic survey and computation of its volume have several advantages. Some the advantages are; to assess the traffic carrying capacity of different types of roads, to examine the distribution of traffic between the available traffic lanes, in the preparation of maintenance schedules for in- service roads and in the forecasting of expected traffic on a proposed new road from traffic studies on the surrounding road system.

For our road segment from entrance 2 to entrance 3/ behind Wolkite university dormitory we take a seven day traffic count.

Table 2. 2: Traffic count for motorized

	Shift	**Cars**	**Light**	**Medium**
Thursday	Day	6	4	4
Friday	Day	3	6	3
Saturday	Day	3	8	3
	Night	2	0	0
Sunday	Day	3	4	5
Monday	Day	4	4	4
Tuesday	Day	4	8	7
	Night	2	0	0
Wednesday	Day	4	4	3
NF-1		1.7	1.0	1.0
NF-2		1.5	1.0	1.0

Where, NF=24 hours count/12 hours day count

Sample calculation for NF;

NF-1 for cars = (3+2)/3=1.7

NF-1 for cars = (4+2)/4=1.5

Sample calculation for ADT

ADT for cars = {[(6+3+3+4)*1.5] + (4*1.7) + (3+2+4+2)}/7 =6

ADT for Light = {[(4+6+4+4)*1] + (4*1) + (8+0+8+0)}/7 =6

ADT for Medium = {[(4+3+5+4)*1] + (3*1) + (3+0+7+0)}/7 =5

Then motorized Adjusted Annual Daily Traffic will be:

Table 2. 3: AADT for motorized

	Cars	Light	Medium
ADT	6	6	5
SF	1	1	1
AADT	6	6	5

Non-motorized Adjusted Average Daily Traffic (ADT):

Table 2. 4: Traffic count for non- motorized

	Shift	Pedestrian
Monday	Day	760
Tuesday	Day	980
	Night	1000
Wednesday	Day	1200
NF		1.1

ADT calculation for pedestrian:

= {[1.1(760+1200)] +980+1000}/3=1079

- Fright traffic

  =0.5(1079/3)

  =180
- Average load

  = 180* 50kg

  = 9000kg,

  Where average pedestrian weight 50kg.
- No. S. truck(Light)

  =Average load/truck capacity

  =9000kg/3500kg

  = 3

Then total AADT at the base year will be:

Table 2. 5: Total $AADT_O$

	Cars	Light	Medium
$AADT_o$	6	9	5

Now the traffic volume at the opening year can now be easily determined as:

$AADT_n = AADT_o (1+i)^n$, where

- $AADT_n$: the normal base year (road opening year) traffic volume
- $AADT_n$: initial traffic volume as counted
- i: growth rate
- n: the road construction period

$AADT_n$ calculation

A) $AADT_n$ for Cars

$= AADT_o (1+i)^n$

$=6(1+0.055)^2$

$\underline{=7}$

B) $AADT_n$ for Light

$= AADT_o (1+i)^n$

$=9(1+0.055)^2$

$\underline{=11}$

C) $AADT_n$ for Medium

$= AADT_o (1+i)^n$

$=5(1+0.055)^2$

$\underline{=6}$

The generated and diverted traffic are accounted in percentage to be:

- (13%+5%)*24
  $\underline{=5}$
- Totally the traffic volume at the base year will be:
  24+5= 29 it lies on local street road type.

➡ Then take AADT as 1500 for design.

$AADT_n=1500(1+0.055)^2$

= $\underline{1670}$ …………………………………..for Normal traffic

$AADT_n$=1670*0.13

= $\underline{218}$ …………………………..…..……for Generated traffic

$AADT_n$=1670*0.05

= $\underline{84}$ ………………………………..…for Diverted traffic

The traffic calculation is summarized in table form as follows:

Table 2. 6: Traffic forecast to the base year

Vehicle type	Normal traffic	Generated traffic	Diverted traffic	sum
Cars	1670	218	84	1972
Lights	51	7	3	61
Medium	-	-	-	-
Articulated	-	-	-	-

For the purpose of pavement design the traffic volume can further be extended to the end of design period with the respective growth factor (will be discussed later) and the corresponding load of traffic is calculated.

Tasks performed in under this content:

- Normal, Diverted and Generated traffic estimation,
- Design period selection,
- Growth rate determination and
- Traffic forecasting.

3. DESIGN CONTROLS

3.1. General

For the purpose of taking the design parameters the following design controls has to be determined first. These design controls influence the selection and calculation of the parameters. These controls are listed on AACRA:

- Level of service,
- The functional classification of the road,
- Natural terrain of the road site,
- The design vehicle which the road is expected to serve,
- The expected volume and load of traffic, and
- Economic consideration.

As these factors have a major role in the design process they should be properly analyzed and studied.

3.2. Level of service

Level of Service relates to the operating conditions encountered by traffic. It is a qualitative measure of such factors as speed, trip time, interruptions, interference, freedom to overtake, ability to maneuver, safety, comfort, convenience and vehicle operating costs.

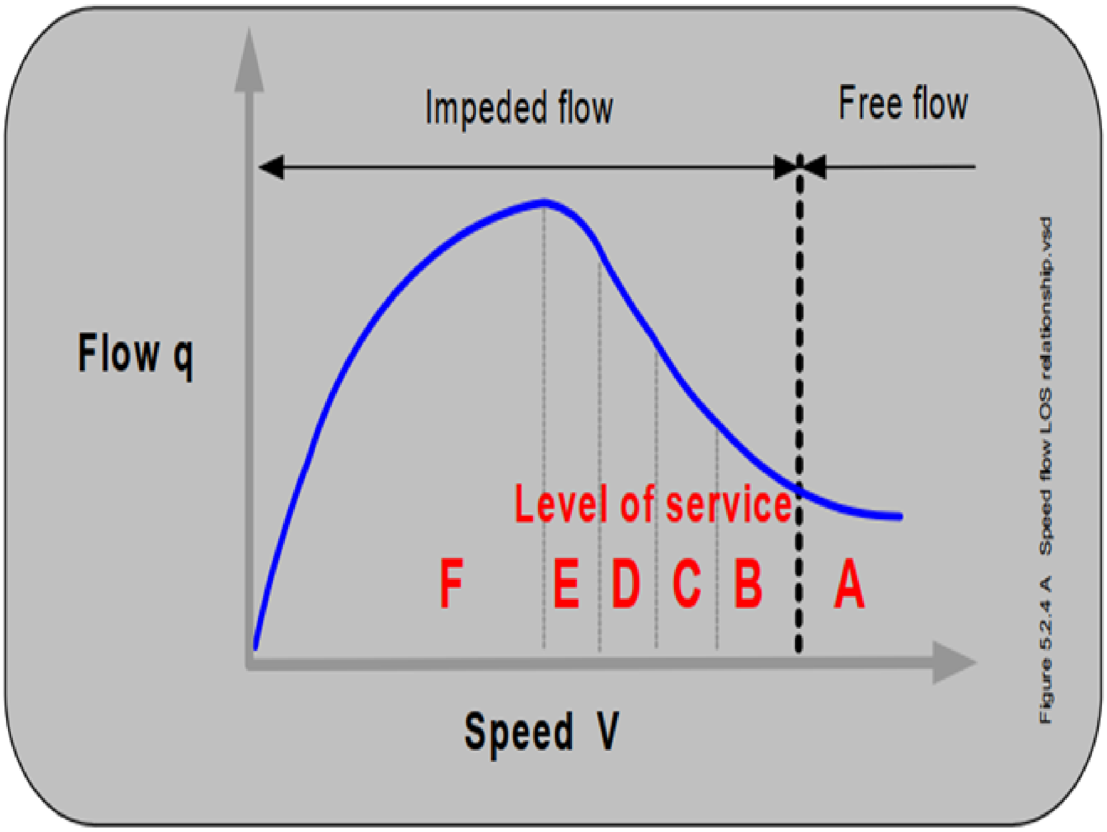


Figure 3. 1: Speed-flow relationship and level of service (AACRA Figure 5.2.4-A)

Table 3. 1: Level of service characteristics (AACRA table 5.2.4-A)

Level of service	Freeways	Other arterial roads
A	Free flow. Average travel speed at or greater than 112km/hr. Service flow rate of 700 passenger cars per hour per lane, or 32% of capacity.	Average travel speed of about 90% of free flow speed. Stopped delay at signalized intersection it is minimum.
B	Reasonable free flow conditions. Average travel speed at or greater than 112km/hr. service flow rate not greater than 1,120 passenger cars per hour per lane, or 51% of capacity.	Average ravel speeds drop due to intersection delay and inter-vehicular conflicts, but remain at 70% of free flow speed. Delay is not unreasonable.
C	Operational stable, but becoming more critical. Average travel speed of 110km/hr. service flow at75%of capacity or not more than flow rate 0f 1,650 passenger cars per hour per lane.	Stable operation. Longer queues at signal result in average travel speed of about 50% of free flow speeds. Motorists will experience appreciable tension.
D	Lower speed range of stable flow operational approaches instability and is susceptible to changing conditions. Average travel speeds approximately 101km/hr. service flow rate 92% of capacity. Flow rate cannot exceed 2,015 passenger cars per hour per lane.	Approaching unstable flow. Average ravel speeds down to 40% of free flow speed. Delay at intersection may become extensive.
E	Unstable flow. Average travel speeds of 96km/hr. flow rate at capacity or 2.200 passengers cars per hour per lane. Traffic stream cannot dissipate even minor disruptions. Any incident may produce a serious break down.	Average travel speeds 33% of free flow speed. Unstable flow. Continuous back up on approach to intersections.
F	Forced flow. Freeway acts as storage for vehicle Backed up from downstream bottleneck. Average travel speed range from near 50 km/hr. to stop-and-go operation.	Average travel speed between 25% and 33% of free flow speed. Vehicular back up and high approach delay at signalized intersection.

Level of service characteristics: It is desirable to aim for Level of Service C for off peak travel, accepting that peak hours will operate closer to capacity conditions. Therefore for our road project we maintain this level of service. The level of service is enhanced by providing:

- Full lane widths,
- Appropriate storage lanes at intersections,
- left turn lanes at intersections and accesses where appropriate,
- Control or absence of crossing or entering traffic at minor intersections,
- Control or absence of parking,
- Control or absence of left turns by banning left turns at difficult intersections,
- Good coordination of traffic signals, and
- Good lighting of the road for night time driving.

3.3. Functional classification of the road

For this purpose AACRA classified the roads into five categories. These are:

1. Freeway,
2. Arterial,
3. Sub arterial,
4. Collector and
5. Local streets.

Based on the given traffic volume and property access issues we can now select our project road class.

Freeways: freeway status is applied only too high speed, high volume arterial roads with full control of access. Freeway is grade separated multi-lane roads with no property access allowed.

Urban arterial and sub-arterial: are the major traffic routes in Addis Ababa. Urban arterials are usually dual function facilities providing service to;

- Through traffic (primary function)
- Local traffic and property access (secondary function)

Feeder and local streets: the road layout should conform to the requirements of the external road network and satisfy the transport provisions of the city master plan. The internal road system should not provide through routes that are more convenient than the external road network. Where a road is needed that provides a convenient through route, then sub arterial road (local crossing route) could be considered with appropriate capacity and abutting land use.

3.4. Natural terrain of the road site (terrain classification)

The geometric design elements of a road depend on the transverse terrain through which the road passes. Transverse terrain properties are categorized into four classes as follows:

A. Flat or gently rolling country, which offers few obstacles to the construction of a road, having continuously unrestricted horizontal and vertical alignment.

B. **Rolling:** Rolling, hilly or foothill country where the slopes generally rise and fall moderately and where occasional steep slopes are encountered, resulting in some restrictions in alignment.

C. **Mountainous:** Rugged, hilly and mountainous country and river gorges. This class of terrain imposes definite restrictions on the standard of alignment obtainable and often involves long steep grades and limited sight distance.

D. **Escarpment:** In addition to the terrain classes given above, a fourth class is added to cater to those situations whereby the standards associated with each of the above terrain types cannot be met. We refer to escarpment situations inclusive of switchback roadway sections, or side hill transverse sections where earthwork quantities are considerable.

Table 3. 2: Terrain classification (ERA's manual)

Terrain character	**Slope (%)**	**Terrain type**
Flat or gently rolling country offers few obstacles unrestricted horizontal and vertical alignment	0-3%	Flat
Rolling, hilly or foothill country Slopes rise and fall Moderately occasional steep slopes some restrictions in alignment	3-25%	Rolling
Rugged, hilly and mountainous country and river gorges definite restrictions of alignment long steep grades and limited sight distance	25-50%	Mountainous
switchback roadway side hill transverse sections where earthwork quantities are considerable	>50%	Escarpment

Based on these criteria the terrain classification of our road project is as follows:

Table 3. 3: Terrain type of our project

Stations	**Left elevation**	**Right elevation**	**Terrain type**
1	1937.02	1937.32	**flat**
2	1936.04	1936.75	**flat**
3	1935.08	1935.82	**flat**
4	1934.12	1934.76	**flat**
5	1933.08	1933.68	**flat**
6	1931.90	1932.68	**flat**
7	1930.78	1931.48	**flat**
8	1929.66	1930.54	**flat**
9	1928.58	1929.50	**flat**
10	1927.62	1928.64	**flat**
11	1926.61	1927.68	**flat**
12	1928.25	1929.80	**flat**
13	1928.16	1929.85	**flat**
14	1928.20	1929.75	**flat**
15	1929.25	1930.82	**flat**
16	1929.18	1930.90	**flat**
17	1929.22	1930.78	**flat**
18	1929.08	1931.02	**flat**
19	1930.02	1931.25	**flat**

20	1930.25	1931.58	**flat**
21	1930.28	1931.62	**flat**
22	1930.50	1931.52	**flat**
23	1931.50	1932.58	**flat**
24	1932.50	1933.50	**flat**
25	1933.50	1934.25	**flat**
26	1934.00	1934.58	**flat**
27	1934.25	1934.75	**flat**
28	1934.50	1935.00	**flat**

From the above, we can clearly see that the road project has a flat surface almost in all of its length, thus the overall terrain class can be considered to be flat.

3.5. Design vehicle

The design vehicle is a hypothetical vehicle whose dimensions and operating characteristics are used to establish certain aspects of road and intersection layout and geometry. The design vehicle is not necessarily the largest of the vehicles but is intended to represent an economical level of design. Larger vehicles will not be precluded from the road but they will need to encroach on adjacent lanes in some circumstances. While this may inconvenience some other road users, the low frequency of the occurrence of these vehicles makes this acceptable. The design vehicle to be used in various circumstances is identified as appropriate throughout the text. In some cases - e.g. intersections, the design is undertaken in accordance with the design vehicle characteristics but is checked with a larger vehicle to ensure that it will be able to navigate the intersection. The larger vehicle will be chosen according to the potential for such vehicles to use the facility and will be at least the next larger vehicle to the design vehicle.

The following design vehicles are used for most purposes:

- Design Car
- Design Single-Unit Truck/Bus
- Design Semi-trailer

In all cases, the layout should be checked with the next larger design vehicle to ensure that occasional use by these vehicles will be possible.

3.5.1. Design Car

The design car is used for access into residential driveways (unless access for a larger vehicle such as a refuse truck is required) and for checking maneuvers on a property that are dependent on the location of the access. In other cases, a car will be able to operate with ease on elements designed for the larger vehicles. The design driver’s eye height is 1.05m.

3.5.2. Design Single-Unit Truck/Bus

This vehicle is often used as the design vehicle for minor road intersections on arterial roads and for intersections between secondary arterials, particularly in urban areas. This unit is also used as the design vehicle for works on feeder roads. On minor residential streets, a design service truck may be adequate.

The single unit truck /bus vehicle should be used as the minimum for all intersections involving two or more arterial roads.

3.5.3. Design Semi-Trailer

The design semi-trailer is the minimum vehicle for the design of intersections between two arterial roads or an arterial road and a freeway ramp.

They are also the check vehicles for those designs where a single-unit truck or bus has been the design vehicle.

Higher order check vehicles may be required to check for occasional use of larger vehicles at intersections. In industrial areas, the check vehicle should be a large low-loader or prime mover and long semi-trailer. For oversize vehicle routes, the design vehicle should be the design low loader.

Accordingly for our road project (a local road with minor intersections) we choose the design vehicle to be single unit truck/bus.

3.6. Design speed

A fundamental aim of geometric road design is to provide road geometry (curvature, sight distance, super elevation etc.) that is suitable for the speeds of the vehicles that operate on the road. The actual operating speeds of vehicles can vary with time due to changes in traffic conditions and from point to point due to changes in the road environment, road characteristics, speed limits, and driver behavior and vehicle types.

Table 3. 4: Minimum design speed for cars and speed limits by road type (AACRA table 6.2-A)

Road Type	**Proposed speed limit Or Speed environment**	**Minimum design speed for cars**
Local residential street	30	30

- Based on the above table the design speed for the road project here after is taken to be 30 km/hr.

Works done under this content includes:

- Level of service selected,
- Road classified,
- Terrain classified,
- Design vehicle selected, and
- Design speed selected.

4. GEOMETRIC DESIGN

4.1. General

Geometric design for transportation facilities includes the design of geometric cross sections, horizontal alignment, vertical alignment, intersections, and various design details. These basic elements are common to all linear facilities, such as roadways, railways, and airport runways and taxiways. Although the details of design standards vary with the mode and the class of facility, most of the issues involved in geometric design are similar for all modes. In all cases, the goals of geometric design are to maximize the comfort, safety, and economy of facilities, while minimizing their environmental impacts.

Geometric design is the process whereby the layout of the road through the terrain is designed to meet the needs of the road users. The principal geometric features are the road cross-section, horizontal and vertical alignment.

In general the aim of a highway selection process is to find a location for the new road that will result in the lowest total construction, level, traffic and environmental costs. Before an attempt can be made at selecting a physical location for a highway design, data must be available regarding traffic desires and the planning intentions with in the area to be transverse.

4.1.1. Steps in Route Location / Selection

1. Know the termini points of the scheme.
2. Conduct preliminary and reconnaissance surveys and collect information on predetermined area
3. Based on the information collected in the previous two steps select a corridor
4. Identify a number of possible center lines within the corridor.
5. Make a preliminary design for the possible alternatives and plot on the areas map.
6. Examine each of the alternative alignment with respect to grades, volume of earth work, drainage, erasing structures, etc. to select best alternative route.
7. Make final design and location of the selected alternative route.

So, for our project having this in our mind and based on the given data and information, we have been used existed route that is previously selected route.to design the geometric parameters of high way we should have surveying data which shows the existing features and after having this data we design the geometric components of highway, so we used Civil 3D software to design geometric elements.

4.1.2. Survey Requirements

Survey data for design purposes consists of mapping of sufficient detail for that specific area for undertaken surface analysis and design being undertaken. We use GOOGLE Earth software for surface analysis.

A) Survey Data Products

While survey data requests will typically originate from the unit responsible for the design, they should also serve the requirements of Construction. The project designer has the Responsibility to ensure that survey data obtained by Design meets Construction needs, eliminating the need for additional pre-construction ground data.

B) Field Surveys

Detailed ground surveys along the length of the proposed project roads should use the most Up-to-date surveying equipment such as total stations or GPS to examine the road alignment And cross sections and any bridge sites and culvert sites that are considered necessary to complete the detailed design and the estimation of quantities. We examine the existing road centerline should be identified and staked every 40 meters and the Coordinates will be recorded automatically using Total Station as shown below. The start and end of horizontal curves, and roadway cross sections will also be taken.

Figure 4. 1*:* Conducting surveying data collection

4.2. Cross section elements of the road

Highway cross sections consist of traveled way (carriage way), median, shoulders (or parking lanes), and drainage channels. Shoulders are intended primarily as a safety feature. They provide for accommodation of stopped vehicles, emergency use, and lateral support of the pavement.

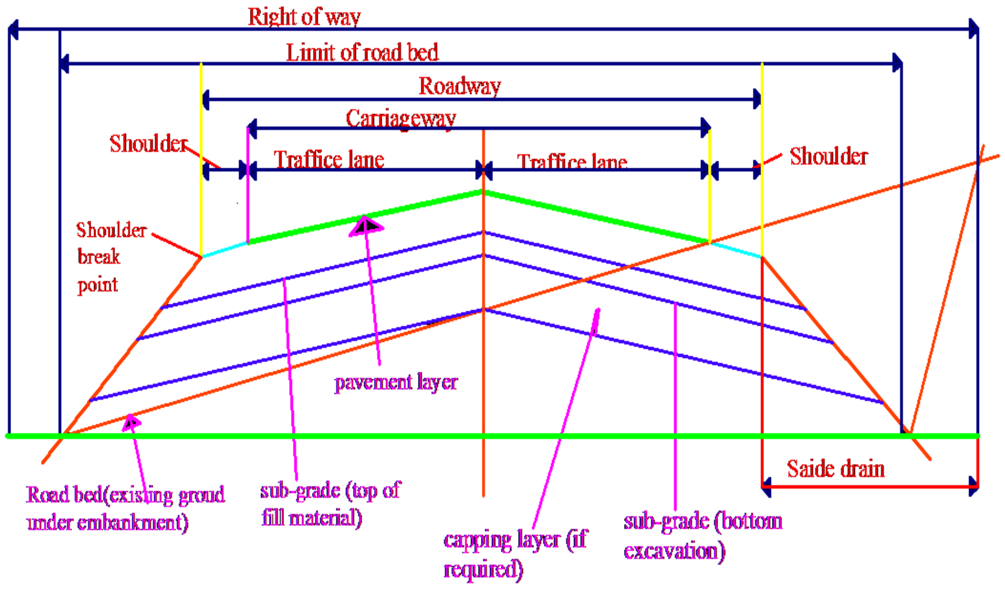


Figure 4. 2: Term of Road Cross Section Elements

4.2.1. Medians

A median is the strip of road that separates opposing travelled ways. On freeways, the median width includes the adjacent shoulders. Residual median is the median excluding any shoulders.

Medians:

- Significantly reduce the risk of collision with opposing traffic (clear zone principle).
- Provides space for median barriers.
- Provide space for street lighting.
- Provide space for traffic signals.
- Provide space for direction and regulatory signs.
- Improve capacity by restricting access to property and minor side streets.
- Provide a safety refuge for pedestrians making it easier and safer to cross busy roads.
- Prevent indiscriminate U-turn movements.
- Direct left turn movements to signalized intersections and/or left turn bays.
- Provide a place to collect run-off from the road and carry the water to the drainage system.
- Accommodate glare screening.
- Provide space for landscape planting.
- Provide space for public transport.
- Provide space for future additional traffic lanes.
- Provide space for underground trunk services.
- Provide space for overpass piers.
- Provide space for skylights to pedestrian underpasses.
- Provide space for visibility offset on horizontal curves.
- Provide space for parking (town center slow speed streets only).

Medians should be provided on all freeways, arterial roads, sub-arterial roads and most commercial area roads.

- In our design there is no media because our road project is local residential street type.

4.2.2. Carriageway

Each carriageway will provide two, three or four through lanes depending on design flows. At intersections, additional lanes for left turns and right turns are usually necessary.

Lane widths are normally 3.5m, but lanes as narrow as 3.0m may be appropriate if the right of way is restricted.

- We selected the carriage width to be 3.0m in both lanes from standard.

4.2.3. Borders on local residential street Roads

It is the area between the carriage and property line. On freeways, it includes the verges. On other urban roads it includes the footpaths and the space for the placement of utility services, landscape planting, and indented bus pays and indented parking.

Functions of Borders

Borders on arterial roads and local streets provide room for:

- Pedestrian movement on footpaths.
- Off road bicycle travel.
- Turning movements between the carriageways and adjacent property entrances.
- Road signs and lighting standards.
- Landscaping.
- Bus bays.
- Providing space for the provision of underground and above ground services.
- Providing space for landscaping to improve the appearance of the street environment.
- Providing a drainage function for overland flows.
- Providing adequate sight distances for traffic on the road (including cyclists and pedestrians on a path) to see vehicles pedestrians or cyclists entering the roadway from blocks.
- Providing a buffer area for reduction in traffic noise level at dwellings.
- Providing for level differences between carriageway and blocks.
- Providing areas for parking off the carriageway if the road pavement is narrow.

And also the co-location of public telephones, post boxes, bus stops and drop-off bays to create activity nodes on borders is good practice.

4.2.3.1. Border Cross fall

It is usual to slope the footpath and the rest of the border towards the road so that water does not drain on to adjoining properties. Where it is not possible to do this, drainage onto adjacent properties will have to be arranged with the property owners. The slope of the footpath should be 2% - 2.5% so that it drains but is useable by wheelchairs.

An area of approximately 1.2 meters at 2.5% grade towards the curb is required adjacent to the curb for the following reasons:

- To enable driveway access to blocks without vehicles scraping.
- To provide freeboard for storm water gutter flows.
- For rubbish bin placement if curb side collection is required.
- For pedestrian and cycle refuge.

Table 4. 1: Local residential street boarder, footpath and carriage width (AACRA table 7.6.2-A)

Boarder width	Footpath width	Carriage width
2*4.0	1*1.2	6.0

4.2.4. Shoulders

The shoulder is that portion of freeway carriageway beyond the traffic lanes, adjacent to, and flush with the surface of the pavement. Its purpose is to accommodate stopped vehicles and provide lateral support to the road pavement layers. It also forms part of the clear zone.

The shoulder width is measured from the edge of the traffic lane to the verge. All safety barriers, signs, guide posts, drains and curbs are to be contained outside the shoulder within the verge.

Shoulders are not used on urban roads other than freeways. On these roads, parking lanes perform similar functions.

- We provide 1m shoulder width on both sides**.**

4.2.5. Cross fall

4.2.5.1. Pavement Cross fall

Cross fall is defined as the side slope, normal to the alignment, of the surface of any part of the carriageway. Cross fall is provided primarily to facilitate pavement drainage.

The usual arrangement for straight sections of road is for the pavement cross fall to slope down from either the centerline or the median. However, the designer should not be limited to this arrangement as inwards sloping cross fall, or one way cross fall may be useful for certain grades, drainage or side slope situations.

Cross fall has the important function of shedding water from the roadway to reduce the possibility of a vehicle aquaplaning in wet conditions.

Table 4. 2: Typical pavement cross falls (AACRA table7.8.13-A)

Road surface	Traffic lane (%)	Shoulder (%)
Cement concrete	2.0-3.0	2.0-4.0
Asphalt concrete	2.5-3.0	2.5-4.0
Sprayed seal	3.0-3.5	3.0-4.0

- Since our road has asphaltic road surface we took the pavement cross fall for both traffic lane and shoulder to be 2.5%.

4.3. Sight distance

Sight distance is defined as the length of carriageway that the driver can see in both the horizontal and vertical planes. Sight distance is the distance over which visibility occurs between a driver and an object or between two drivers at specific heights above the carriageway. For safety on the road, sufficient sight distance must be provided to enable drivers to control their vehicles to avoid collisions with other vehicles or objects on the road.

4.3.1. Sight Distance

Truck Sight Distance Check

Roads and junctions must be designed to provide safe operating conditions for both cars and trucks. Both truck and car stopping distance requirements need to be considered. The design speed for cars shall be in urban areas is usually 10km greater than the posted speed limit. The truck sight distance check shall be undertaken using the speed limit (usually 10km/h less than the car design speed) or the estimated truck operating speed, whichever is the lower. Allowance for the different operating speeds of cars and trucks should be made. For example, on an uphill grade truck speeds will be reduced and the truck stopping distance will be reduced by the effect of gravity.

Both of these effects reduce the sight distance required, and cars are usually the most demanding design vehicle. Downhill, truck speeds will be similar to cars and truck stopping distance will increase due to gravity. In this case, the requirements for trucks usually are the most critical.

Truck braking distances increase substantially on steep down grades, and truck sight distance is likely to be the governing factor on horizontal curves on downgrades. Lower speed limits for trucks may be appropriate if an economic design is not possible otherwise. On long steep downgrades, trucks may be required to engage low gear in addition to or instead of the speed limit restriction.

Truck Speeds on Grades

Trucks speeds on upgrades can be estimated from chart below which is based on the observed performance of trucks with 120kg weight for each kW of power.

This chart may be used to estimate truck operating speed and the appropriate truck sight distance checks carried out. On downgrades, the truck should be assumed not to exceed the speed limit.

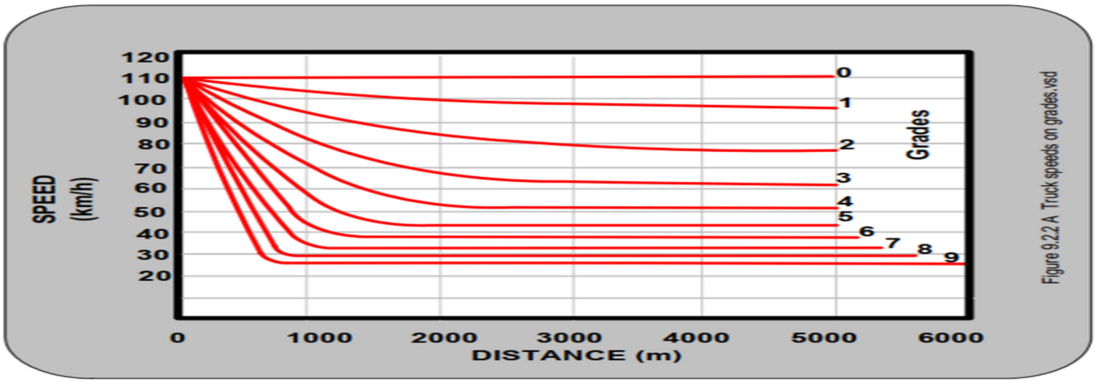


Figure 4. 3: Truck speed on uphill grade (AACRA Figure 9.2.2-A)

Driver Reaction Time

The representative driver reaction time for sight distance calculation purposes is 2.5 seconds. Absolute minimum stopping sight distances based on a 2.0 second reaction time may be used for midblock sections where an economic design cannot be achieved using 2.5 second reaction time. Junction design must be based on 2.5 second reaction time.

- We used reaction time of 2.5 sec to be on the safe side of design.

Driver Eye Height

The representative height for design calculations of the car driver's eye is 1.05m. The representative height of a truck driver's eye for design calculations is 2.40m.

Stopping Sight Distance Derivation

SSD = d1 + d2

Where: d1 = reaction distance (m) = RT*V/3.6 and

d2 = braking distance (m) = $V^2/254(F1+0.01G)$

Where: RT = reaction time (sec)

V = Operating speed (km/h)

F1 = longitudinal friction factor

G =longitudinal grade % (+ for upgrades, - for downgrades)

Longitudinal Friction Factors

The table below provides longitudinal friction factors for cars and trucks used for stopping distance calculations for bituminous and concrete surfaces.

Table 4. 3: Longitudinal Friction Factors (AACRA table 9.3.2-A)

Vehicle	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**110**
Car	0.56	0.52	0.48	0.45	0.43	0.41	0.39	0.37
Trucks	0.29	0.29	0.29	0.29	0.29	0.29	0.28	0.26

- Thus the friction factors for a speed of 40 km/hr. we have friction factors of cars and trucks to be 0.56 and 0.29 respectively.

On level grades where G=0, the SSD for each vehicle type can be calculated as;

SSD for cars

d1= 2.5*40/3.6 =27.78m

$d2 = 40^2 / (254*0.56) =$ 11.25m

SSD=d1+d2=27.78+11.25=39.03m

- SINCE 39.03m ≤ 54m
- take 54 m as SSD

SSD for trucks

d1= 2.5*40/3.6 =27.78m

$d2 = 40^2 / (254*0.29) =$ 21.72m

SSD=d1+d2=27.78+21.72=49.50m

- SINCE 49.50m ≤ 50m take 50 m as SSD

From two the car SSD governs, so take 54 as SSD.

4.3.2. Passing Sight Distance

Passing Sight Distance is the minimum sight distance on two-way single roadway roads that must be available to enable the driver of one vehicle to pass another vehicle safely without interfering with the speed of an oncoming vehicle traveling at the design speed. Within the sight area the terrain should be the same level or a level lower than the roadway. Otherwise, for horizontal curves, it may be necessary to remove obstructions and widen cuttings on the insides of curves to obtain the required sight distance. Care must be exercised in specifying passing/no-passing zones in areas where the sight distance may be obscured in the future due to vegetative growth.

The passing sight distance generally is determined by a formula with for components.

$PSD = D_1+D_2+D_3+D_4$ where, $D_1 = 0.278t_1 (V-m+at_{1/2})$

$D_2 = 0.278Vt_2$

$D_3 =$ given in the next table

$D_4 = 2D_2/3$

Where, D_1 = initial maneuver distance including perception and reaction

D_2 = distance during which passing vehicle is in the opposite lane

D_3 = clearance distance between the vehicles at the end of the maneuver

D_4 = distance traversed by the opposite vehicle

t_1 = time of initial maneuvers, sec

t_2 = time passing vehicle spends at left lane, sec

V = average speed of passing vehicle, km/h

m = difference between passed vehicle and passing vehicle, km/h

a = average acceleration, km/h/s

4.4. Horizontal alignment

The horizontal alignment of a road is usually a series of straights (tangents) and circular curves which may or may not be connected by transition curves. A suitable horizontal alignment is chosen by an iterative process in which trial horizontal alignments are tested for vertical geometry and conformance to controls on the alignment. Compound curves should be avoided, but if used the design speeds of the two curves should be within 5km/h of each other. In urban areas, road alignment is usually controlled by achieving the necessary sight distance on horizontal curves, and not by the side friction limits of vehicles driving around the curves. The presence of intersections on or near horizontal curves will exacerbate sight distance problems. Consideration needs to be given to the requirements for trucks in terms of reduced values of allowable side friction and requirement for lane widening on low radius curves. This includes:

- Tangent or straight line,
- Super elevation section,
- Circular curve,
- Transition (spiral) curve, …

Horizontal alignment for linear transportation facilities such as highways and railways consists of horizontal tangents, circular curves, and possibly transition curves. In the case of highways, transition curves are not always used.

4.4.1. Horizontal Tangents

Horizontal tangents are described in terms of their lengths and their directions. Directions may be either expressed as bearings or as azimuths and are always defined in the direction of increasing station. Azimuths are expressed as angles turned clockwise from due north; bearings are expressed as angles turned either clockwise or counterclockwise from either north or south.

From an aesthetic point of view, tangent sections may often be beneficial in flat country but are less so in rolling or mountainous terrain. From a safety standpoint, they provide better visibility and more passing opportunities. However, long tangent sections increase the danger from headlight glare and usually lead to excessive speeding.

4.4.2. Movement on a Circular Path

As a vehicle traverses a circular curve, it is subject to forces associated with the circular path. According to the principle of inertia, in the absence of forces, a moving body will travel in a straight line. A force must be applied to change direction. For a circular change of direction, the force is called centripetal force and, in road design, this is provided by side friction developed between the tires and the pavement, and by super elevation.

Super elevation is the cross falls that is provided on the pavement on a horizontal curve in order to assist a vehicle to maintain a circular path.

For normal values of super elevation, side friction and radius, the following formula is used:

$$\mathbf{e + f = v^2 / gR = V^2 / 127R}$$

$$\mathbf{R = V^2 / 127 (e + f)} \text{ And } R_{min} = V^2 / 127 (e_{max} + f_{max})$$

Where:

- e = pavement super elevation (m/m or tangent of angle). This is taken as positive if the pavement falls towards the center of the curve.
- f = coefficient of side friction force developed between the vehicle tires and the road pavement -this is taken as positive if the frictional force on the vehicle acts towards the center of the curve.
- g = acceleration due to gravity = 9.8m/s².
- v = speed of vehicle (m/s).
- V = speed of vehicle (km/h).
- R = curve radius (m).

Where f equals zero in the formula, all of the centripetal force is provided by the super elevation.

This condition can occur on large radius curves with positive super elevation or for slow moving vehicles on curves of any radius. At low speeds, f can be negative, and the curve is then over super elevated for that speed. Curves are generally designed, however, so that a positive f is required for the range of vehicle speeds likely to occur.

On short length horizontal curves, the radius of the vehicle path can be considerably larger than the centerline or edge line radius. In these cases, the curve radius R should be made equal to the vehicle path radius in lieu of the horizontal curve radius.

4.4.3. Maximum Side Friction (f_{max})

Research has shown that articulated vehicles may roll over at values of side friction in the range 0.2 (even less for some vehicles carrying livestock) to 0.35. The absolute maximum for trucks turning at low speed is usually taken as 0.25.

Table 4. 4: Maximum design values for side friction (cars on sealed pavement) (AACRA Table 11.3.1-A)

Design speed km/hr.	Coefficient of side friction	
	Absolute maximum	**Desirable maximum**
40	0.35	0.30
50	0.35	0.30
60	0.33	0.24
70	0.31	0.19
80	0.26	0.16
90	0.20	0.13
100	0.16	0.12
110	0.12	0.12

Table 4. 5: Maximum design values for side friction (Trucks on sealed pavement) (AACRA Table 11.3.1-B)

Operating speed km/hr.	**Coefficient of side friction**	
	Absolute maximum	**Desirable maximum**
40	0.25	0.21
50	0.25	0.21
60	0.24	0.17
70	0.23	0.14
80	0.20	0.13
90	0.15	0.13
100	0.12	0.12

For our road:-

Fmax for car=0.30 (desirable maximum)

4.4.4. Curve Super elevation

It is normal practice for horizontal curves to be super elevated. This allows a component of the vehicle weight to provide some of the centripetal force that is needed for the vehicle to move in a circular path.

If a curve is not super elevated, the curve is said to have adverse or negative super elevation. Therefore, ‘e’ is then expressed as a negative value in With adverse super elevation, there is a component of the vehicle weight that acts opposite to the centripetal force that is needed for the vehicle to move in a circular path. This in turn requires greater side friction than for a curve of given radius with positive super elevation if the vehicle is to take the curve at the same speed.

The amount of super elevation is chosen primarily on the basis of safety, but other factors are comfort and appearance. The super elevation that is applied to a horizontal curve should take into account the following:

- Tendency to increase the tracking of the rear wheels of slow moving vehicles towards the center.
- Stability of high laden commercial vehicle.
- Stability of vehicle load.
- Difference between inner and outer formation level, especially in flat country.
- Length available to introduce the necessary super elevation.
- The need to avoid major changes in side friction demand between successive horizontal curves.
- The amount of centripetal force provided by super elevation versus that provided by side.

The amount of super elevation required for a given radius, speed and coefficient of friction can be calculated by rearranging the Equation as follows:

$$\mathbf{e = V^2/127R - f}$$

The absolute maximum and desirable maximum values of the coefficient of side friction ‘f’ can be obtained from AACRA.

4.4.5. Maximum Values of Super elevation and Increases in Side Friction

The maximum values of super elevation in urban area are 5%.

The minimum radius horizontal curve (R_{min}) that is suitable for a given speed requires the use of maximum allowable super elevation and maximum allowable coefficient of side friction. With horizontal curves that are larger than R_{min}, it is normal practice to provide the same proportions of super elevation and side friction that apply to R_{min}. This practice helps (partly but not completely) ensure that any increase in side friction demand between successive horizontal curves is kept within acceptable limits.

Large increases in side friction demand over what drivers have become accustomed to can lead to a change in vehicle response that is not anticipated by some drivers. Furthermore, these situations may create hazards for motorcyclists because they have difficulty in maintaining control when there is a sudden change in side friction demand.

Therefore, the need to limit changes in side friction demand becomes a desirable secondary control for ensuring geometric consistency.

Increases in side friction are considered to be a secondary control because drivers select their speed through their perception of the horizontal curvature. In turn, the selected speed reflects driver experience with a number of factors relating to vehicle control, including side friction demand.

It is not possible to prescribe simple limits on the increase in side friction demand from one horizontal curve to another. However, the following guidelines are provided:

The desirable maximum increase in side friction demand from one horizontal curve to the next is about 25%. (This condition only needs to apply when the side friction factor on the latter curve is greater than about 0.12 as this is a comfortable limit for drivers, even at high operating speeds).

If a curve has a ‘generous’ radius for its design speed (this can still easily occur in a restricted speed environment due to preceding curvature), then a larger increase than the desirable 25% is likely to occur with the next curve. Even when the latter curve has a side friction demand comfortably below the maximum for its design speed, the increase may be greater than 25%. Therefore, an increase of more than 25% is acceptable when a curve follows a ‘generous’ curve. However, it will be necessary to check on any increase in side friction between the latter curve and any curves prior to the 'generous' radius curve. The purpose is to check the side friction demand against the level that drivers have become aware of.

Sections of existing road or sections of road that involve a reduction in desired speed may involve larger increases in side friction. In these cases, the increase will be acceptable when the side friction demand does not exceed the desirable maximum for the curve design speed.

Curves with a side friction demand greater than the desirable maximum for the curve design speed should be preceded by a curve that alerts drivers to the required side friction and May be used to limit an increase in side friction.

4.4.6. Super elevation on Horizontal Curves with Radius > R min

It is normal practice to have super elevation provide a significant amount of the centripetal force that is needed for a vehicle to move in a circular path. This is because super elevation is a positive and permanent feature, whereas side friction is subject to roadway surface and vehicle variations Even so, it is common to have two to three times as much centripetal force provided by side friction as that provided by super elevation.

There are a number of methods to determine the super elevation (and hence resultant side friction) for curves with a radius larger than the minimum radius for a given design speed.

The method that will normally be used for new works, is for the super elevation to be varied linearly from 0 for R = infinity to e_{max} for R_{min}.

This then means that all curves that are designed for a given speed will have approximately the same proportions of super elevation and side friction demand although for construction expediency, super elevation values are normally rounded (upwards) to a multiple of 1% so that there is a corresponding adjustment of side friction.

Other methods have been used in the past so that there are likely to be many cases where the reuse of existing pavement will dictate a different super elevation. This is acceptable if the resultant side friction is suitable for the curve design speed and consistent with that for any adjacent curves.

With the "linear distribution method", the super elevation 'e' for a curve of radius R that is greater than R_{min} is given by:

$e = (v*v)\ e_{max}/127R\ (e_{max}+f_{max})$

Note that f_{max} may be either the absolute maximum value or the desirable maximum value for the design speed V.

The value of 'e' is usually rounded upwards (e.g. 4.0% stays 4.0% but 4.1% becomes 5%) and the corresponding coefficient of side friction is calculated from:

$$\mathbf{f = V^2 / 127R - e\ rounded}$$

With different possibilities for e_{max} and f_{max} (absolute maximum vs. desirable maximum) different values of super elevation may be attributed to a given combination of radius and design speed. However, the subjective basis of the "linear distribution method" (and indeed most other methods) and the practice of rounding the super elevation value, allows a practical rationalization to be made.

For urban areas, rationalization has been achieved by distributing from the combination of 5%maximum super elevation and the desirable maximum value of coefficient of side friction. For design speeds less than or equal to 100 km/h, curves with a radius less than that corresponding to 5% super elevation and the desirable maximum coefficient of side friction, maintain the 5% super elevation with increasing side friction until f_{max}. This practice helps ensure that the relatively low maximum super elevation is applied before vehicles have to make use of increasing side friction.

4.4.7. Minimum Length of Super elevation on Horizontal Curves

In constrained situations such as mountainous terrain or urban roads, curves should be fully super elevated even if only instantaneously. But it is desirable that there be at least 30m of fully super elevated curve.

4.4.8. Super elevation Development Length

Super elevation is developed by rotating the roadway cross-section about some axis; most commonly the horizontal control line.

Super elevation development length is defined as the length required rotating the pavement from the point of normal cross fall on the approach tangent (straight) to the point where the full super elevation for the curve is attained. In turn, this super elevation development length has two components:

- **Super elevation runoff length -** this is the length from the point where the pavement has been rotated to zero cross fall to the point where the full curve super elevation has been attained
- **Tangent run out -** this is the residual length from the point of normal cross fall to the point of zero cross fall (this component lies on the approach tangent)

There are two criteria that are used to determine the length of super elevation development:

- Maximum rate of rotation of cross fall.
- Relative grade between the edge of the carriageway and the control line.

The super elevation development length to be adopted will generally be the longer value calculated for the two criteria above, notwithstanding normal minimum lengths of super elevation runoff. The maximum rate of rotation criterion is a mandatory standard that must be adopted as a minimum. The relative grade criterion is for appearance purposes and should be obtained at all locations unless economic or safety considerations dictate otherwise.

E.g. Between reverse curves on steep grades.

Except for constrained situations such as mountainous areas or urban roads, it is normal practice to recognize minimum lengths for super elevation runoff for both transitioned and not transitioned curves.

This is due to the fact that most vehicles describe some transition path when entering or leaving a curve with the minimum length of the transition path being about 30 to 50 m.

This in turn relates to the practices of:

- Basing transition curve lengths on recommended super elevation runoff lengths and hence, matching the super elevation runoff with the transition
- Not providing transitions when there is sufficient room within a traffic lane for vehicles to make their own transition path

Therefore, the normal minimum lengths for super elevation runoff for a curve are:

- 40 m for transitioned curves, which ties to a 40 m minimum transition length
- 50 m for an un-transitioned curve when the curve design speed is greater than 80 km/h, with this length normally being equidistant about the curve tangent point
- 30 m for an un-transitioned curve when the curve design speed is less than or equal to 80 km/h, with this length normally being equidistant about the curve tangent point

Criteria 1: Maximum Rate of Rotation of Cross fall

The following maximum rates of rotation are applicable:

- 0.025 radians per second for most road types including roads with vehicles that carry livestock
- 0.035 radians per second in low speed areas 70km/h) - this includes roads in steep terrain and geometry consisting of reverses curves with little or no straight between the curves
- 0.04 radians per second in low speed areas (<60km/h) with extremely constricted horizontal alignment i.e. sections of roads in steep terrain and geometry consisting of small radius reverse curves with little or no straight between the curves

The minimum super elevation development length based on the above criteria is given by

Le = 0.278 V (e2-e1)/r

Where **Le** = super elevation development length (m)

V = design speed (km/h)

e1, **e2**= cross fall or super elevation at ends of development length (m/m); positive when sloping upwards from the control line; negative when sloping downwards from the control line

r = rate of rotation of the road cross fall (radians/second)

Note that for the range of cross falls involved, m/m radians.

Le = 0.278 V (e2-e1)/r

Le =0.278*40*0.04/0.04=11.12m

Criteria2: Relative Grade

The relative grade is the percentage difference between the grade of the edges of the carriageway and the grade of the axis of rotation.

The minimum super elevation development length based on the criteria is given by

Le = 100W (e2-e1)/Gr

Where:

- Le = super elevation development length (m)
- W = maximum width from axis of rotation to edge of running lane (m)

- e1, e2= cross fall or super elevation at ends of development length (m/m); positive when sloping upwards from the control line; negative when sloping downwards from the control line.
- W= lateral clearance +lane width= 1+3=4m
- Le=100*4*0.04/0.8=20m.

<u>The cross fall change with chain age is shown below in the figure.</u>

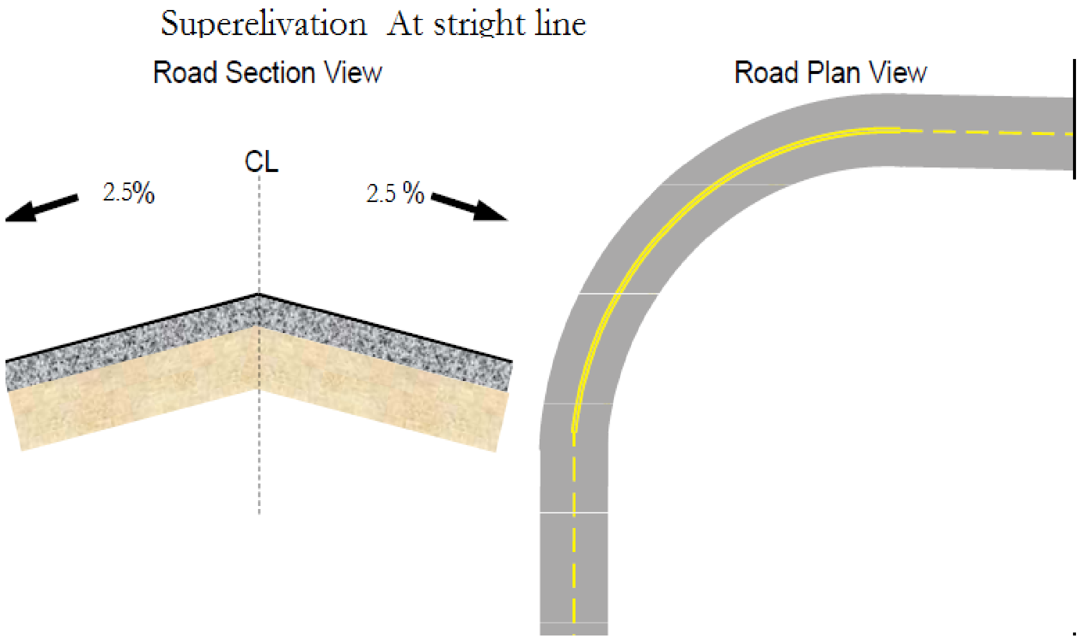


Figure 4. 4: Super elevation at straight line

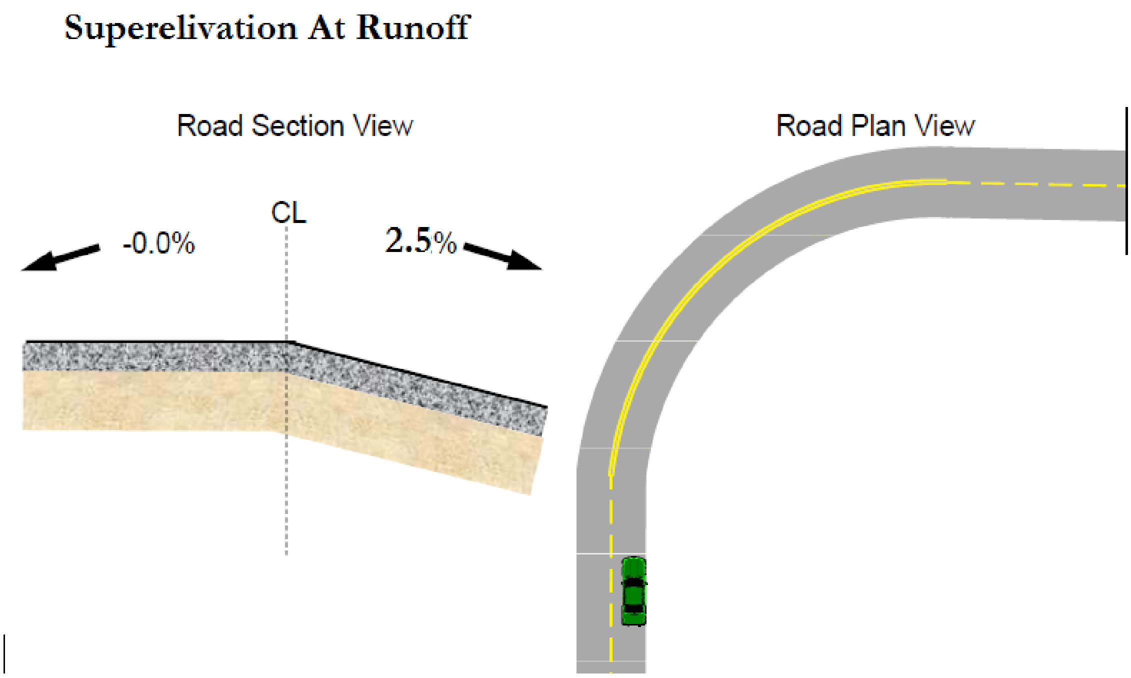


Figure 4. 5: Super elevation at runoff

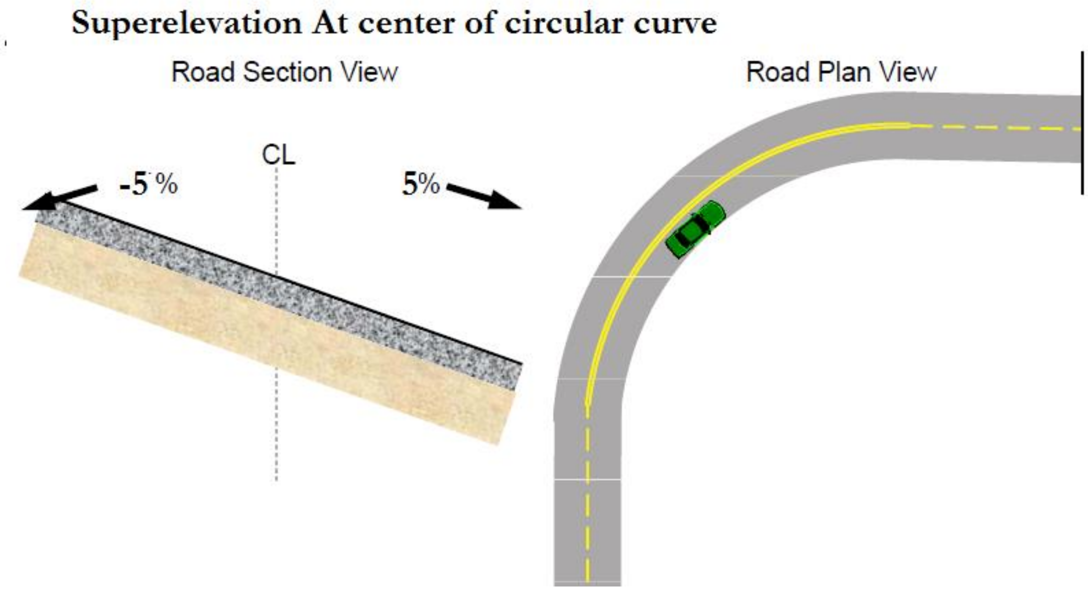


Figure 4. 6: Super elevation at center of circular curve

4.4.9. Horizontal Curves

Depending on the minimum radius, the different restriction, minimum curve length and site constraints we adjusted the radius to meet the requirements. The geometric elements can be calculated each using their formulas or directly taken from Civil 3D.

To design geometry of a given road alignment, we use the geometric summary table:

Table 4. 6: Geometric summary table

Criteria	**Road Class**				
	Freeway	Arterial	Sub-Arterial	Collector	**Local**
Traffic Parameters					
Pedestrian Facilities	Nil	Both sides	Both sides	Both sides	**One side or shared zone**
Parking	Nil	Nil	Limited	Limited	**Full**
Property Access Control	Full	Full	Limited	Limited	**Nil**
Speed Parameters					
Speed Limit (km/h)	80-100	70	60	60	**50**
Car Design Speed (km/h)	90-110	80	70	60	**50**

Truck Design Speed (km/h)	80-100	70	60	52	**43**
Cross Section					
Carriageway	Dual	Dual	Single / Dual	Single	**Single**
Reserve Width (m)	50-75	30-60	25-40	20-30	**15**
Formation Width (min) (m)	50	30	20	20	**15**
Pavement Width (min) (m)	2 x 10	2 x 10	10	9	**8**
Lane Width (m)	3.5 (min)	3.5 (min)	3.5	3.5	**3**
Shoulder Width (m)	1-2	1-2	1-2	1	**1**
Stopping Sight Distance					
SSD Cars (min) (m)	140-205	114	91	71	**54**
SSD Trucks (min) (m)	143-210	116	91	69	**50**
Alignment					
Horizontal Radius (min) (m)	3000	1250	295	200	**130**
Crest K value (min)	46-98	31	20	12	**7**
Sag K value (min)[2]	32-33	29	18	12	**9**
Grade (max) (%)[3]	5	6	7	8	**12**

Data of Horizontal curve:

Table 4. 7: Data of Horizontal curve

Curve	**Radius(m)**	**Delta angle**	**Length(m)**
1	200	67.2422	234.720
2	350	27.0855	165.456
3	300	10.5544	55.263
4	250	27.1953	118.662
5	200	30.0943	105.049

Element of Horizontal Curve

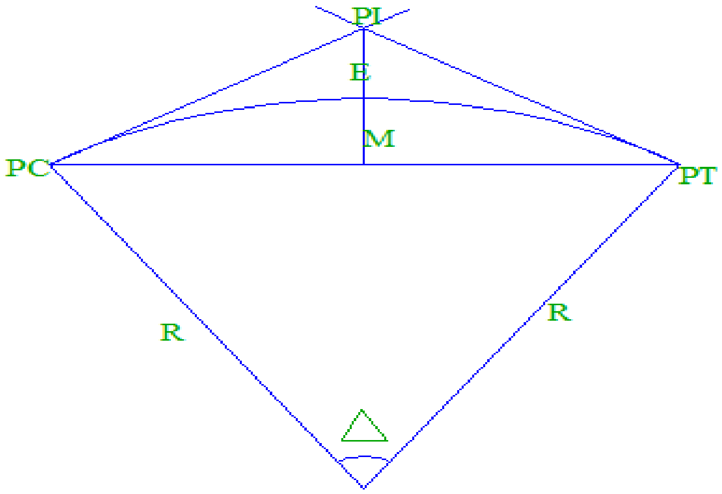


Figure 4. 7: Elements of horizontal curve

Where;

Δ: Deflection angle by arc definition (in degrees)
R: Radius of curve by arc definition ECC
T: Tangent distance T=R tanΔ/2
E: External distance= R (secΔ/2-1)
L: Curve Length L=Δ*2R∏/360
M: Middle Ordinate M=R (1-cosΔ/2)
C: Chord from P.C to P.T = 2RsinΔ/2
Point of Curvature (P.C) = P.I-T
Point of Tangency (P.T) =P.C+LC

Horizontal curve calculation

1st curve:

Tangent Distance, T = R tan (Δ/2) = 200tan (67.242°/2) = 124.2
Length of curve, L = Δ R (2π/360°) =67.2452°x 200 (2π/360°) = 111.3
External Distance E = R [sec (Δ/2) - 1] =200[sec (67.242) -1] = 39.7m
Middle ordinate M = R [1 - Cos (Δ/2)] = 200[1 - Cos (67.242/2)] = 33.93m
Chord Length C = 2R Sin (Δ/2) = 2 x 200Sin (67.242°/2) = 113.30
Intersection Point Chain age PI= 0+178.05
Point of Curvature PC = PI –T== 0+054
Point of Tangency PT = PC + L == 0+288..47

2nd curve:

Tangent Distance, T = R tan (Δ/2) =350tan (27.085/2) = 84.9m
Length of curve, L = Δ R (2π/360o) =27.08°x 350(2π/360°) = 89.25m
External Distance E = R [sec (Δ/2) - 1] =350[sec (27.08°) -1] = 32.46m

Middle ordinate M = R [1 - Cos (Δ/2)] = 350[1 - Cos (27.08°/2)] = 9.44m
Chord Length C = 2R Sin (Δ/2) = 2 x 350Sin (27.08°/2) = 89.27m
Intersection Point Chain age PI= 0+433.9
Point of Curvature PC = PI –T== 0+348.85
Point of Tangency PT = PC + L = 0+513.44

3rd curve:

Tangent Distance, T = R tan (Δ/2) = 300tan (10.35°/2) = 33.54
Length of curve, L = Δ R (2π/360o) =10.35°x 300(2π/360°) = 76.9m
External Distance E = R [sec (Δ/2) - 1] =300[sec (10.35°) -1] = 1.38m
Middle ordinate M = R [1 - Cos (Δ/2)] = 300 [1 - Cos (10.35°/2)] = 1.42m
Chord Length C = 2R Sin (Δ/2) = 2 x 300Sin (10.35°/2) = 66.85
Intersection Point Chain age PI= 0+759.53
Point of Curvature PC = PI –T= 0+725.9
Point of Tangency PT = PC + L = 0+780.97

4th curve:

Tangent Distance, T = R tan (Δ/2) = 250tan (27.33°/2) = 88.16m
Length of curve, L = Δ R (2π/360o) =27.33°x 250 (2π/360°) =173.29m
External Distance E = R [sec (Δ/2) - 1] =250[sec (27.33°) -1] = 9.48m
Middle ordinate M = R [1 - Cos (Δ/2)] = 250 [1 - Cos (27.33°/2)] = 9.369m
Chord Length C = 2R Sin (Δ/2) = 2 x 250Sin (27.33°/2) = 172.76m
Intersection Point Chain age PI= 0+901.72
Point of Curvature PC = PI –T= 0+812.18
Point of Tangency PT = PC + L = 0+931.42

5th curve:

Tangent Distance, T = R tan (Δ/2) = 200tan (30.92°/2) = 118.16m
Length of curve, L = Δ R (2π/360o) =30.92°x 200.3 (2π/360o) = 224.29m
External Distance E = R [sec (Δ/2) - 1] =200[sec (30.92°) -1] = 24.48m
Middle ordinate M = R [1 - Cos (Δ/2)] = 200 [1 - Cos (30.92°/2)] = 22.369m
Chord Length C = 2R Sin (Δ/2) = 2 x 200Sin (30.9°/2) = 216.76m
Intersection Point chain age PI= 1+051
Point of Curvature PC = PI –T= 0+932.81
Point of Tangency PT = PC + L = 1+097

4.5. Other types of curves

4.5.1. Reverse Curves

Reverse Curves are horizontal curves turning in opposite directions that adjoin (have common tangent points) or have a short length of tangent between the curves. Desirably, reverse curves should not be used unless there is sufficient distance between the curves to introduce the full super elevation required for each of the two curves without exceeding the standard rate of change of cross fall for the particular design speed.

4.5.2. Broken Back Curves

Broken back curves (also called similar curves) are horizontal curves turning in the same direction joined by a short length of straight or two relatively small unidirectional curves connected by a large radius curve. here the length of straight is less than about 0.6V meters (based on about 2 seconds travel time with V = speed in km/h), the separation of the curves is usually small enough so that there is no visual e the same problems for here the length of straight is greater than about 0.6V and less than 2V to 4V, appearance is compromised there not being sufficient separation of the curves. Within this range of spacing, it is often possible.

4.5.3. Compound curves

Compound curves are horizontal curves of different radii turning in the same direction with a common tangent point. When radii less than about 1000m are involved, compound curves may cause operational though not conclusive, some literature from throughout the world suggests that a smaller radius curve immediately following a larger radius curve (both turning in the same direction) gives drivers inadequate perception of the smaller radius curve which leads to a higher single vehicle accident rate. This is a particular problem where limited visibility of the smaller radius curve exists; for example, where vegetation or a cut-face on the inside of the larger radius curve limits visibility and driver perception of the smaller radius curve. Furthermore, compound curves involve an undesirable change in side friction demand for motorcycles.

Generally, this geometry should be avoided. Where compound curves cannot be avoided, there should be no more than two curves of diminishing radii, and the radius of the smaller curve should be at least 2/3 of the radius of the larger curve. Any change in design speed between the two circular elements should not exceed 5km/h unless the second curve on a one way road is a larger radius than the first.

4.5.4. Transition curve

Any motor vehicle describes a transition path as it changes from a straight to a circular horizontal curve and elements of a compound curve. The way drivers, in general, steer a vehicle at speed results in a path that provides a reasonably uniform attainment of centripetal acceleration. For most here the combination of lane width, vehicle speed and curve radius do not allow sufficient space for a vehicle to describe a suitable transition path, it is necessary to provide a transition curve between the tangent and the circular arc. The need for such transition curves was learned from the early days of railway designed transition curve allows the vehicle's centripetal acceleration to increase or decrease gradually as the vehicle enters or leaves a circular curve. This transition curve minimizes encroachment on adjoining traffic lanes. The transition curve length provides a convenient desirable arrangement for super elevation runoff. The change in the cross fall can be effected along the length of the transition curve in a manner closely fitting the radius-speed relation for the vehicle traversing it.

4.5.4.1. Use of Transitions

Transition curves involve shift of the circular arc in order to accommodate the transition. When this shift is less than 0.25 to 0.3 m, the transition can be omitted because there is sufficient room for a vehicle to describe a transition path. The test for omitting the transition should be based on the length originally calculated for the super elevation runoff (from 0% cross fall to the rounded super elevation value for the curve) before any rounding of the length is applied. Due to the characteristics of vehicle steering geometry, there is a transient state (or distance) where it is possible for the front (steered) wheels of a vehicle travelling at slow speed to follow a circular path while the steering angle is changed from straight ahead to the maximum angle needed to describe the turn. This is a major reason why transitions are not needed for intersection turns and most curves with a design speed below 60 km/h.

4.6. Curve widening

On smaller radius horizontal curves, traffic lanes may need to be widened in order to maintain the lateral clearances that apply to vehicles on straight sections of road. The rear wheels of a vehicle off-track with respect to the front wheels on a curve and this also causes the front overhang of a vehicle to have a lateral component. The off tracking can be either what is commonly called low speed off tracking (or more correctly, off tracking when vehicles have a low side friction demand) or high speed off tracking (or more correctly, off tracking when vehicles have a high side friction demand). With the former form of off tracking, the rear wheels off track towards the Centre of the curve; with the latter form, the rear wheels off track outwards from the Centre of the curve. The swept path widths are based on low speed/low side friction demand off tracking even though normal operation on some curves may involve high speed / high side friction demand off tracking that will be less than the low speed off tracking.

The amount of widening per lane depends on:

- The radius of the curve
- Type (size) of vehicle operating on the road
- An allowance for steering variation by different drivers

4.7. Vertical alignment

Vertical alignment (referred to as grade line or longitudinal section) consists of straight grades joined by vertical curves. The principal vertical alignment design objectives are to obtain the necessary sight distance and to fit to the natural terrain. In designing the vertical alignment consideration also needs to be given to the maximum allowable grades, the volume and balancing of the earthworks, the appearance, property acquisition, environmental impacts, and the co-ordination with the horizontal alignment.

The sight distance requirements include obtaining minimum radius vertical curves for stopping sight distance (SSD) and the sight distance to intersections or ramps.

The design criteria which dominate in deciding on the appropriate vertical alignment vary with the type of road being considered. On minor urban roads, obtaining sight distance to property access points and intersections and minimizing the impacts on adjacent property dominate.

On major roads, sight distance to intersections (or ramps) and appearance will tend to dominate other factors such as earthworks balance, but the need to provide an economically sound design cannot be ignored. It may be possible with good design and appropriate coordination with the horizontal alignment to achieve all of the design objectives.

On undivided roads, the vertical alignment is designed as the surface of the pavement along the construction Centre line. On divided roads, the vertical alignment is usually represented by the line along the lane edge against the median (residual median if there are median shoulders).

On divided roads (typically freeways) with a very wide median and independent grading of the carriageways, the vertical alignment is usually designed as the surface of the pavement along the construction Centre line of each carriageway. In urban areas, it is unlikely that the length of such sections will be a significant proportion of the project, and the control lines may be better located on the edge of the residual median for consistency with the rest of the project.

Sight distance along a road and to intersecting roads is controlled both by the vertical alignment and by obstructions on the side of the carriageway. Lateral obstructions to sight distance may block intersection sight triangles, and may also block sight distance to the pavement if the road has a horizontal curve. Vertical and horizontal sight distance must be considered together when undertaking route location work and in all subsequent design phases.

On two way roads, crest vertical curves are not generally designed for overtaking sight distance. The resulting curve is generally too long for practical purposes.

4.7.1. Grades

Maximum Grades

Generally, grades should be as flat as possible consistent with economy. Flat grades permit all vehicles to operate at similar speeds (away from intersections). Steeper grades produce variation in speeds between lighter vehicles and the heavier vehicles both in the uphill and downhill directions. This speed variation leads to higher relative speeds of vehicles producing the potential for higher accident rates and lower traffic capacity. This speed variation also results in increased queuing and overtaking requirements on single carriageway roads which give rise to further safety problems particularly at higher traffic volumes. In addition, freight costs are increased due to the slow speed of heavy vehicles.

Table 4. 8: Maximum Grades (AACRA table 12.2.1-A)

Road type	Speed limit or speed environment	Minimum design speed	Maximum grade %	
			Flat terrain	Hilly terrain
Suburban freeway through carriageway	100	110	4	6
Suburban freeway to freeway	80	80	5	5
Freeway collector-distribution road	70-80	70-80	6	6
Inner urban freeway through carriage way	80	90	4	7
Inner urban freeway to freeway ramp (excluding loops)	60	60	6	6
Freeway to arterial road exit ramp	60/70	60/70	8up 5down	
Freeway to arterial road entry ramp	60/70	60/70	5 up 7 down	
Freeway loop ramps	Truck advisory sign 35	40	5 up 5 down	

Continuous frontage road	70	80	6	7 desirable 8 max
Arterial road controlled access	70	80	4	6
Discontinuous frontage road	60	60	6	7 desirable 10 max
Arterial and sub-arterial road with frontage access	60	70	4	7 desirable 8 max
Collector road and industrial /commercial access roads(potential bus routes)	60	60	4	7 desirable 8 max
Low volume residential collector roads(<3000vpd) no bus routes	50	50	4	7 desirable 10 max
Local residential street	30	30	5	7 desirable 12 max
Access place	15	15	5	7 desirable 17 max
Temporary roads(e.g. construction sidetracks)	40-60	40-60	4	8

- From the above table depending on terrain type, speed limit and type of road we selected maximum grade of 4%.

Minimum Grades

Very flat grades may make it difficult to provide longitudinal drainage in table drains, curb and channel and medians, where these parallel the road grade. As far as possible, these drainage requirements should not dictate the road grade; rather the drainage facility should be designed to accommodate the road grade. This may require greater recourse to sub-surface drains with closely spaced inlets, or independently graded table drains, or other solutions to suit the circumstances.

Care should be taken in cases where a flat grade is combined with super elevated horizontal curves. The rotation of the pavement may create a situation where the flow path crosses from one side of a lane to the other, resulting in undesirable depths of water on the pavement surface. Worse conditions can occur on steep grades combined with successive curves in opposite directions. The combination of grade and pavement rotation can create a situation where the flow path meanders from one side of the road to the other with the depth of flow becoming excessive.

In both of those cases, pavement contours should be examined to ensure these conditions do not exist. If it found to exist, action to change the parameters (e.g. increasing the rate of rotation) must be taken to control the condition.

A) Cuttings

Generally, the minimum grade in cuttings is 0.5% to allow adequate fall in unlined drains. However, it is permissible to provide flatter grades provided that a minimum grade of 0.5% is retained in the unlined drains. This is done by uniformly widening the drains at their standard slope, thereby deepening them progressively, or alternatively, lining the table drains will permit a flatter grading of table drains to be adopted. In constrained situations, the slope of the drains may be reduced below 0.5% provided that they are lined.

B) Medians

On divided roads the necessity for median drainage may control the minimum roadway grade. However, where very flat roadway grades are the only practical solution, sag gullies at regular intervals with cross drainage may be provided in the median. This will enable median slopes greater than the roadway slope to be used. The grade considerations given for cuttings also apply to medians.

C) Curb and Channel

A curb and channel forms part of the type cross section, for example, a median curb on a divided road, the minimum grade of the channel formed by the pavement edge and curb should not be less than 0.5% except in difficult circumstances, when the absolute minimum shall be 0.2%. This usually influences the grade of the pavement. Where this situation exists on a long flat section of the road, care must be taken to avoid a wavy grade line, by making grade changes either well-spaced or at the start or end of horizontal curve, so as to disguise the changes of grade.

The use of curb and channel on high speed alignments is generally undesirable (except in constrained situations and prior to intersections). In addition to the safety problems caused by the curb, separate drainage facilities are required. In these cases, a shallow concrete lined v-drain with subsoil drainage usually provides a better solution.

D) Bridges

Bridges over roadways should not be provided with scuppers, and pavement drainage will require a minimum grade on the bridge so water can be collected by pits on the lower approach. This will require a minimum grade of 0.3%. Bridges over waterways may be level and fitted with scuppers. However, if roadway runoff is to be channeled to watercourses via pollution control ponds then these bridges also should be located on a grade of 0.3% minimum.

4.7.2. Vertical Curve Geometry

Generally, the type of vertical curve used is a parabolic curve. The parabola is normally used because of its simplicity and because all formulae are exact whereas the same formulae used with the circle would be approximate. The vertical offsets from a tangent are proportional to the square of the distances measured horizontally from the tangent point to the offset point

It is convenient to specify parabolic vertical curves by the length of curve required for a change of grade of 1%, this being a constant for the parabola:

$$\mathbf{K = L/A}$$

K is used in this manual to designate the limiting curvature required for a given design speed. **K** is a single number and is a constant for the curve irrespective of the grades and length of the curve. Large **K** values equate to large radius curves.

The length of curve required for sight distance is given by the following expressions:

L = 2D-C/A when the length of curve is less than the sight distance and

L = D2A/C and K = D2/C when the length of curve is greater than the sight distance**.**

4.7.3. Types of vertical curve

<u>Crest and Sag Curves</u>

The formulae for design of crest and sag vertical curves can be rather complex to apply, and thus the design is best accomplished through the application of a computer program, or by use of design charts.

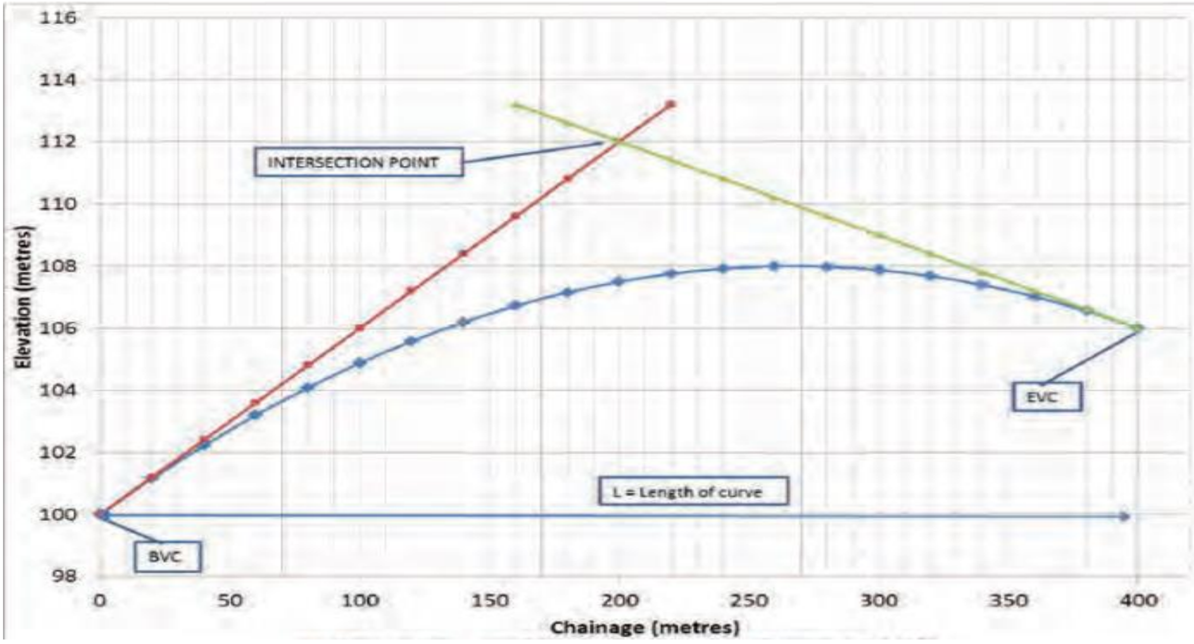


Figure 4. 8: Crest curve

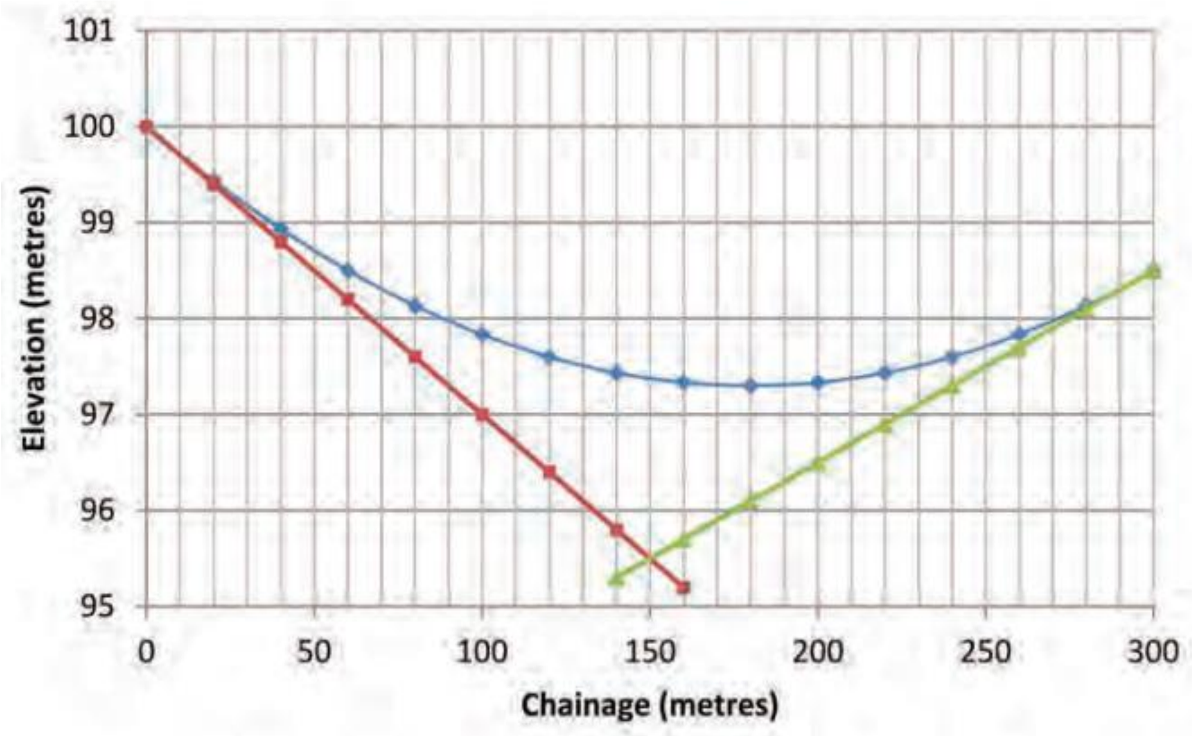


Figure 4. 9: Sag curves

Data of vertical curve:

Table 4. 9: Data of vertical curve

VC	PVC station	PVC elevation	PVI station	PVI elevation	PVT station	PVT elevation	K	LVC
1	0+131.59	1931.59	0+215.00	1928.00	0+298.41	1929.03	30.12	166.82
2	0+447.44	1930.88	0+485.00	1931.34	0+522.56	1931.10	40.00	75.15
3	0+825.00	1929.16	0+850	1929.00	0+875.00	1929.33	25.29	50.00

The minimum lengths of crest and sag curves have been designed to provide sufficient stopping sight distance and it have been recommended based on design speeds and stopping sight distance requirements. They provide for ride comfort, appearance, and most importantly, safety. The design is based on minimum allowable "K" values, as defined by the formula:

$$\mathbf{K=L/A}$$

Where:

K = limiting value, horizontal distance required to achieve a 1% change in grade

L = length of vertical curve (m)

A = Algebraic difference in approach and exit grades (%)

Vertical curves are required to provide smooth transitions between consecutive gradients.

The simple parabola is specified for these. The parabola provides a constant rate of change of curvature, and hence acceleration and visibility, along its length and has the form:

$$r= (g_2-g_1)/L$$

$$Y= (rx^2)/2 +g_1x + \text{Elevation of BVC}$$

Where;

r=rate of change of grade per section (%)
g_1=starting grade (%)
g_2=ending grade (%)
L=length of curve (horizontal distance (m))
Y=Elevation of a point on the curve
X=distance in stations from the BVC (m /100)
BVC =beginning of the vertical curve
EVC=end of the vertical curve

The offset from the tangent to the curve at any point was calculated using the relation

$$\mathbf{Y= (GL/200)\ (X/L)}$$

Where:

Y= vertical offset from the tangent to the curve (m)

X = horizontal distance from the start of the curve (PVC) to the point required

G= algebraic difference of gradient (%)

L= length of the vertical curve (m)

In general the vertical alignment of this project was designed giving due consideration to the following points.

- Compliance to the AACRA
- Provision of adequate slope for draining away water from the road and minimum cover for minor drainage structures
- Provision of adequate stopping sight distance.

Vertical curve calculation

CREST CURVE CALCULATION

For a crest curve in rolling terrain, K=40m

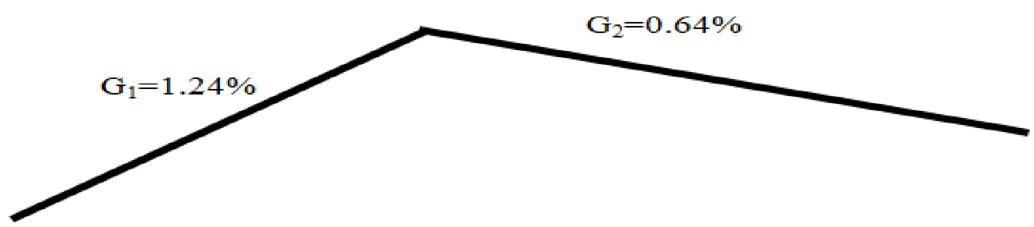


Figure 4. 10: Vertical curve one

$\Delta G = |G_1 - G_2|$

$= |1.24+0.64| = \underline{1.88\%}$

$L = K*\Delta G = 40*1.88 = \underline{75.2m}$

1. **station**

Station PVI_1=485.00

Station PVC_1= PVI_1-L/2=485.00-75.2/2

=447.44

Station PVT_1= PVI_1+L/2=485.00+75.2/2

=522.64

2. **elevation**

Elev. PVI_1=1931.346m

Elev. PVC_1= Elev. PVI_1-G_1*L/2=1931.346-0.0124*75.2/2

=1930.88m

Elev. PVT_1= Elev. PVI_1-G_2*L/2=1931.346+0.0064*75.2/2

=1931.10m

SAG CURVE CALCULATION

For a crest curve in rolling terrain, K=25.29m

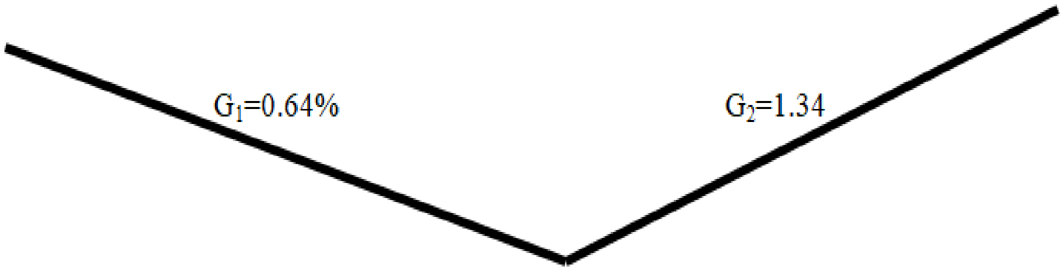


Figure 4. 11: Vertical curve two

$\Delta G=|G_1 - G_2|$

$=|0.64+1.34|=$1.98%

L=K*ΔG=25.29*1.98=50.07m

1. **station**

Station PVI_2=0+850

Station PVC_2= PVI_2-L/2=850-50/2

=825

Station PVT_2= PVI_2+L/2=850+50/2

=875

2. **elevation**

Elev. PVI_2=1929.00m

Elev. PVC_2= Elev. PVI_2+G_1*L/2=1929.49+0.0064*50/2

=1929.16m

Elev. PVT_2= Elev. PVI_2+G_2*L/2=1929.49+0.0134*50/2

=1929.335m

SAG CURVE CALCULATION

For a crest curve in rolling terrain, K=30.12m

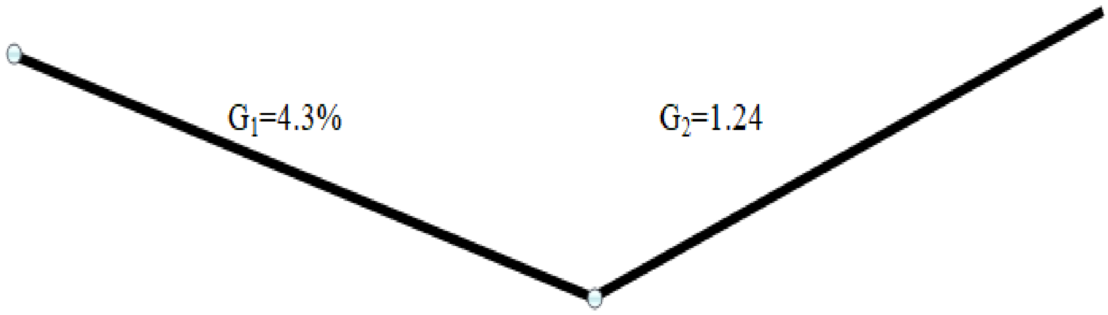


Figure 4. 12: Vertical curve three

$\Delta G = |G_1 - G_2|$

$= |4.3+1.24| = \underline{5.54\%}$

$L = K*\Delta G = 30.12*5.54 = 166.8648m$

1. **station**

Station PVI_3=<u>0+215</u>

Station PVC_3= PVI_2-L/2=215-166.8648/2

=<u>0+131.5676</u>

Station PVT_3= PVI_2+L/2=215+166.8648/2

=<u>0+298.43</u>

2. **elevation**

Elev. PVI_3=<u>1928.00m</u>

Elev. PVC_3= Elev. PVI_2+G_1*L/2=1928+0.043*166.8648/2

=<u>1931.59m</u>

Elev. PVT_3= Elev. PVI_2+G_2*L/2=1929.49+0.0124*166.8648/2

=<u>1929.03m</u>

4.8. Phasing of Horizontal and Vertical Alignment

4.8.1. Alignment Defects Due to Miss-phasing

Phasing of the vertical and horizontal curves of a road implies their coordination so that the line of the road appears to a driver to flow smoothly, avoiding the creation of hazards and visual defects. It is particularly important in the design of high-speed roads on which a driver must be able to anticipate changes in both horizontal and vertical alignment well within the safe stopping distance.

4.8.2. Types of Miss-Phasing and Corresponding Corrective Action

A. Vertical curve overlaps one end of the horizontal curve

B. Insufficient separation between the curves

C. Both ends of the vertical curve lie on the horizontal curve
D. Vertical curve overlaps both ends of the horizontal curve

A. Vertical curve overlaps one end of the horizontal curve

If a vertical curve overlaps either the beginning or the end of a horizontal curve, a driver's perception of the change of direction at the start of the horizontal curve may be delayed because his sight distance is reduced by the vertical curve. The defect may be corrected in both cases by completely separating the curves. If this is uneconomic, the curves must be adjusted so that they are coincident at both ends, if the horizontal curve is of short radius, or they need be coincident at only one end, if the horizontal curve is of longer radius.

B. Insufficient separation between the curves

If there is insufficient separation between the ends of the horizontal and vertical curves, a false reverse curve may appear on the outside edge-line at the beginning of the horizontal curve. Corrective action consists of increasing the separation between the curves, or making the curves concurrent.

C. Both ends of the vertical curve lie on the horizontal curve

If both ends of a crest curve lie on a sharp horizontal curve, the radius of the horizontal curve may appear to the driver to decrease abruptly over the length of the crest curve. If the vertical curve is a sag curve, the radius of the horizontal curve may appear to increase. The corrective action is to make both ends of the curves coincident as in Figure or to separate them.

D. Vertical curve overlaps both ends of the horizontal curve

If a vertical crest curve overlaps both ends of a sharp horizontal curve, a hazard may be created because a vehicle has to undergo a sudden change of direction during the passage of the vertical curve while sight distance is reduced. The corrective action is to make both ends of the curves coincident.

4.9. Earthwork quantities and mass- haul diagram

4.9.1. Introduction

The topic of geometric design would be incomplete without a chapter devoted to the issue of earthwork quantities and a mass haul diagram. The careful attentions to limiting earthwork quantities through the preparation of a mass haul diagram are essential elements in providing the best-combined horizontal, vertical, and cross-sectional design. This is especially true when the design includes consideration of the least cost in relation to earthworks.

Key terms associated with this process, as listed in Definitions, include:

1. **Borrow-** material not obtained from roadway excavation but secured by widening cuts, flattening back slopes, excavating from sources adjacent to the road within the right-of-way, or from selected borrow pits as may be noted on the plans.
2. **Waste-** material excavated from roadway cuts but not required for making the embankment.
3. **Free Haul-** the maximum distance through which excavated material may be transported without the added cost above the unit bid price.
4. **Overhaul-** excavated material transported to a distance beyond the free haul distance.

5. **Economic Limit of Haul-** distance through which it is more economical to haul excavated material than to waste and borrow.

The steps involved in the computation of earthwork quantities and the development of the optimal mass haul diagram are:

- End area calculations,
- Earthwork calculations,
- Preparation of mass haul diagram, and
- Balancing earthworks using the mass haul diagram.

4.9.2. Mass Haul Diagram

The mass haul diagram is a curve in which the abscissas represent the stations of the survey and the ordinates represent the algebraic sum of excavation and embankment quantities from some point of beginning on the profile. The plot can be to any scale, depending on the quantities involved. Project designed by computer will list, tabulate, and plot all of the data shown above including a mass haul diagram and balance points.

The mass haul diagram shows excavation (adjusted) and embankment quantities from some point of beginning on the profile, considering cut volumes positive and fill volumes negative. At the beginning of the curve the ordinate is zero, and ordinates are calculated continuously from the initial station to the end of the project.

The mass haul diagram can be used to determine:

- Proper distribution of excavated material,
- Amount and location of waste,
- Amount and location of borrow,
- Amount of overhaul in kilometer-cubic meters, and
- Direction of hauls.

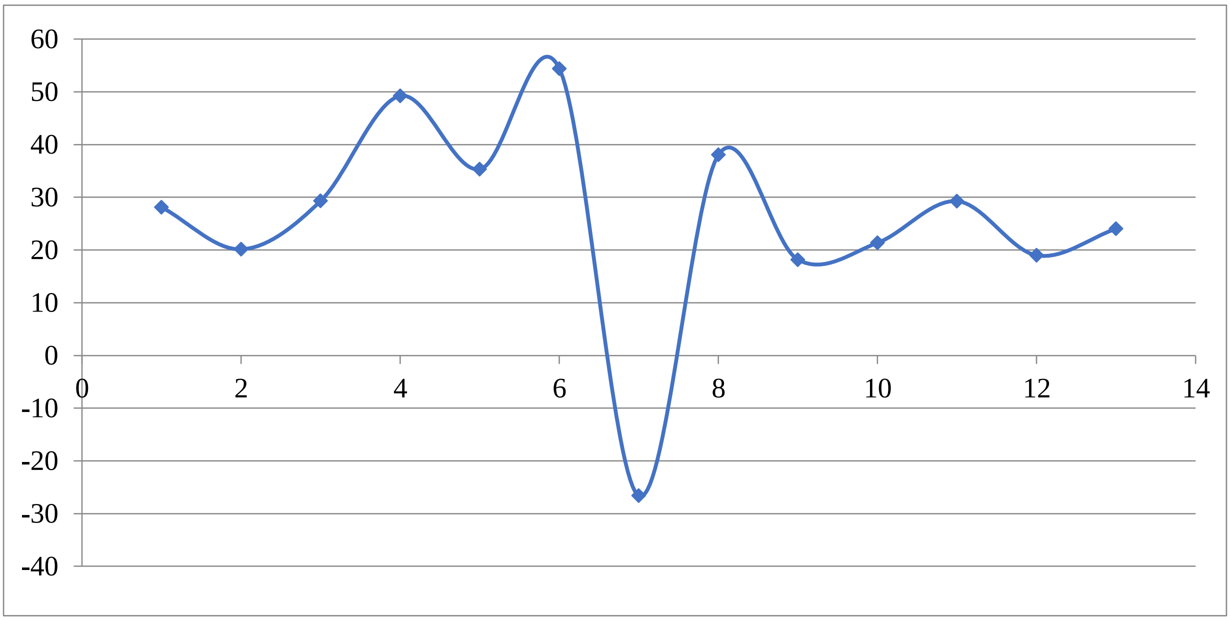


Figure 4. 13: Mass haul diagram

Under this content we performed the following tasks:

- Cross section elements selected,
- Sight distances calculated,
- Horizontal alignment,
- Vertical alignment, and
- Earthwork quantities and mass- haul diagram.

5. PAVEMENT DESIGN

5.1. General

Pavements are designed and constructed to provide durable all weather travelling surfaces for safe and speedy movement of people and goods with an acceptable level of comfort to users. These functional requirements of pavements are achieved through careful consideration in the following aspects during the design and construction phases:-

- **a.** Selection of pavement type.
- **b.** Selection of material to be used for various pavement layers and treatment of sub grade soils.
- **c.** Structural thickness design for pavement layers.
- **d.** Subsurface drainage design for pavement layers.
- **e.** Surface drainage and geometric design.

The two major considerations in structural design of high way pavements are:-

- Material design and
- Thickness design.

5.2. Pavement materials

This Section defines the physical properties for materials to be used in the pavement structure and forms an essential part of the method for design of new roads and rehabilitation design for existing roads. As far as possible all material types commonly used in Addis Ababa are included such as natural gravel/soils, processed or crushed materials, materials stabilized with cement or lime and bituminous materials. The design procedures of this Manual permit the use of a wide range of materials, provided pertinent information on their behavior and likely performance is known. The choice of materials for any particular application should be based on considerations of structural requirements, economics, durability, workability and experience. This section is presented based on the following major material types:

- Unbound Granular materials,
- Cemented materials,
- Bituminous materials,
- Asphalt Concrete,
- Spray Seals, and
- Cement Concrete.

<u>Unbound Granular Materials</u>

This category of material includes natural gravels and crushed granular materials. The natural gravel category includes granular materials without any admixture of stabilizers having the following composition.

- 100% natural gravel, or
- Natural gravel with such small proportions of crushed particles that the material properties are almost identical to the uncrushed portion.

The use of locally available material is encouraged. Except for special construction purposes, natural gravel is used as sub base and also as wearing course for gravel surfaced roads.

For paved roads, the sub base is the lower most layer of a pavement, which separates the sub grade or the capping layer from the base course. It is an important load spreading part of pavement, which reduces the traffic stress on the subgrade to acceptable level and protects the base course from contamination by highly plastic subgrade material.

It also acts as working platform for the construction of the base and wearing course and in some special conditions it serves as drainage layer. The granular sub base material should meet the material property requirements specified in Table below based on AACRA Standard Specification.

Table 5. 1: Sub base material properties (AACRA table 5.1)

Sieve size	**Alternative Grading(% passing)**		
(mm)	**A**	**B**	**C**
50	100	100	-
25	-	75-95	100
9.5	30-65	40-75	50-85
4.75	25-55	30-60	35-65
2.0	15-40	20-45	35-50
0.425	8-20	25-30	15-30
0.075	2-8	5-20	5-30
PI	6	**LA**	50%
LL	-	**CBR**	30%
LS	-	**Compaction**	95%

- The sub base material to be used should fulfill the above requirements.

Table 5. 2: Base material properties (AACRA table 5.2)

Sieve size	**Alternative Grading(% passing)**		
(mm)	**A**	**B**	**C**
50	100		100
37.5	97-100	100	85-100
25		97-100	
19	67-81		60-90
9.5		56-70	
4.75	33-47	39-53	30-65
2.0			20-50
0.425	10-19	12-21	10-30
0.075	4-8	4-8	5-15
PI	6	**LA**	50%
LL	25	**CBR**	80%
LS	5	**Compaction**	98%

The base course material should fulfill the above requirements.

Graded base course layers (GB2&3)

Normal requirements for natural gravels and weathered rocks (GB2, GB3): A wide range of materials including lateritic, calcareous and quartzite gravels, river gravels, boulders and other transported gravels, or granular materials resulting from the weathering of rocks can be used successfully as base course materials. Table 5.3 contains three recommended particle size distributions for suitable materials corresponding to maximum nominal sizes of 37.5 mm, 20 mm and 10 mm. Only the two larger sizes should be considered for traffic in excess of 1.5 million equivalent standard axles. To ensure that the material has maximum mechanical stability, the particle size distribution should be approximately parallel with the grading envelope.

To meet the requirements consistently, screening and crushing of the larger sizes may be required. The fraction coarser than 10 mm should consist of more than 40 per cent of particles with angular, irregular or crushed faces. The mixing of materials from different sources may be warranted in order to achieve the required grading and surface finish. This may involve adding fine or coarse materials or combinations of the two.

Table 5. 3: Recommended Particle Size Distribution for Mechanically Stable Natural Gravels and Weathered Rocks for Use as Base Course Material (GB2, GB3) (ERA manual)

Test sieve(mm)	**Percentage by mass of total aggregate passing test sieve**		
	Nominal maximum particle size		
	37.5mm	**20mm**	**10mm**
50	100	-	-
37.5	80-100	100	-
20	60-80	80-100	100
10	45-65	55-80	80-100
5	30-50	40-60	50-70
2.36	20-40	30-50	35-50
0.425	10-25	12-27	12-30
0.075	5-15	5-15	5-15

Cemented and Stabilized Materials

Cemented materials include all granular materials stabilized by adding sufficient amount of cement, lime or other hydraulically binding agents, to produce a bound layer with good tensile strength.

Cemented materials described in this manual include all natural or crushed materials described where a stabilizer of cement or lime has been admixed. The stabilizer shall be Ordinary Portland Cement or lime meeting the requirements of the AACRA Standard Specifications. Hydrated lime or quicklime may also be used.

Large amounts of stabilizer causes excessive crack developments in the cemented layer. If stabilizer content in excess of 4-5% is required then consideration shall be given to selecting better qualities of materials to stabilize.

Many natural materials can be stabilized to make them suitable for road pavements but this process is only economical when the cost of overcoming a deficiency in one material is less than the cost of importing another material which is satisfactory without stabilization.

Stabilization is feasible if importing quality aggregate is expensive and the hauling distance is far away to transport borrow materials to replace the unsuitable sub-grade materials. Stabilization of materials has some advantages and disadvantages.

The advantages are:

- For stabilized material, substantial proportion of the strength is retained when saturated
- The surface deflection is reduced
- Resistance to erosion is increased
- Materials in the supporting layer could not contaminate the stabilized layer
- The tensile strength increases tremendously and correspondingly the effective elastic modulus of granular layers over the stabilized layer increases

The possible detrimental effects on the pavement layers:

- Cracks can develop due to stresses induced by thermal, shrinkage and traffic
- The cracks can reflect to the surface of the pavement and water can enter the pavement and subgrade.

Stabilized materials should meet the gradation and other material requirements listed in Table 5.3. After stabilization the material should attain an Unconfined Compressive Strength (UCS) of at least 3 MPa.

Table 5. 4: Stabilized Base Material Properties (AACRA table 5.3)

Sieve size(mm)	(% Passing)
50	100
37.5	85-100
19	60-90
4.75	30-65
2.0	20-50
0.425	10-30
0.075	5-15
PI	6
LL	25
LS	5

Bituminous Materials

This Section includes bitumen penetrated macadam and bituminous mixes used in the base course whether mixed in plant or mixed on the road. The bituminous base material should meet the material property requirements specified based on AACRA Standard Specification.

Table 5. 5: Bitumen macadam mix properties (AACRA table 5.4)

Sieve(mm)	% Passing	Property	Value
50	100	Bitumen content	3.5-5%
37.5	95-100	Marshal stability	>7%
25	70-100	Flow	1.5-4
12.5	48-75	Air voids	4-8%
4.75	30-50	VMA	16-22
0.60	12-30	VFB	65-85
0.075	0-12		

Asphalt Concrete

The asphalt concrete shall provide a water proof surface with good resistance against deformation and ageing, and have acceptable fatigue properties and skid resistance. The following properties are required for AC mixes in surfacing:

- provide sufficient resistance to plastic deformation and cracking to withstand the expected traffic loading
- have sufficient workability to enable efficient laying and compaction of the mix without segregation
- have sufficient air voids of the mix to avoid bleeding or loss of resistance to deformation in cases of post-compaction under traffic
- have sufficient binder of the correct type and a suitable aggregate grading to ensure a durable and near impermeable layer

Table 5. 6: Asphalt concrete mix properties (AACRA table 5.5)

Sieve size	Nominal size of mix			
(mm)	6mm	10mm	14mm	20mm
25	-	-	-	100
19	-	-	100	90-100
13.2	-	100	85-100	70-90
9.5	-	90-100	55-75	-
6.7	100	70-90	-	40-70
4.75	80-100	-	35-52	-
2.36	45-70	40-60	15-30	25-50
0.600	20-43	20-38	3-7	10-27
0.075	4.5-11	4.5-10	4.6-6.1	3-7
Bitumen content	5.1-6.4	4.8-6.2	4.6-6.1	4.0-5.8
Marshal stability	5.5	5.5	6.5	6.5
Air voids	4-6	4-6	4-6	4-6
VMA	16	15	14	13

After AACRA's specifications are set the next step is to calculate the traffic loading and decide on the thickness of each layer.

5.3. Traffic load calculation

According to AACRA's pavement design manual the initial daily traffic loading is calculated using the equation;

$$\mathbf{N=N_CEF_C+N_LEF_L+N_MEF_M+N_HEF_H+N_AEF_A}$$

Where the subscripts: C, L, M, H, and A stand for the traffic categories car, light, medium, heavy and articulated respectively. N and EF are the corresponding number and equivalency factors of the vehicle classes.
Or to brief:

N=initial daily equivalent standard axles.
N_L=the daily number of light vehicles in the current year.
N_M=the daily number of medium vehicles in the current year.
N_H=the daily number of heavy vehicles in the current year.
N_A=the daily number of articulated vehicles in the current year.
EF_L= the equivalent factor for the average light vehicles.
EF_M= the equivalent factor for the average medium vehicles.
EF_H= the equivalent factor for the average heavy vehicles.
EF_A= the equivalent factor for the average articulated vehicles.

5.3.1. Axle Loads and Equivalency Factors

All design of bitumen surfaced road pavements shall be based on axle load surveys. The damaging effect of an axle passing over the pavement is expressed by the equivalency factor related to an equivalent standard axle (ESA) of 8160 kg load:

$$EF=\left(\frac{axle\ load\ in\ kg}{8160}\right)^{4.5}$$

In the absence of exact axle load survey results or studies for the specific project, generic values may be used based results from previous studies completed in Addis Ababa. These are shown in AACRA Table 6.3 but caution should be used and sensitivity of design to the use of default values should be used based on the lower and upper values listed in the table.

Table 5. 7: Typical equivalency factors for Addis Ababa traffic (AACRA table 6.3)

Vehicle Class	Typical	Lower	Upper
Car	0.03	0.00	0.10
Light	0.73	0.39	1.07
Medium	1.31	0.73	1.89
Heavy	1.61	1.03	2.18
Articulated	3.15	2.15	4.14

Since axle load survey is not given to be on the safe side we took the upper equivalency factors put forward by the manual. But first the number of vehicles for each class has to be forecasted to the road opening time (after 2 yrs.);

NC = 1972(including the diverted and generated traffic), similarly
NL = 61,
NA=0,
NH=0 and
NM= 0

Now, N = (1972*0.1) + (61*1.07) + (0*1.89) + (0*4.14)
=197.2+65.27+0
=262.47

For geometric traffic growth throughout the design period, total traffic over the design period is determined by multiplying the total traffic in the first year by the appropriate Cumulative Growth Factor from Table below or calculated exactly using the following equation:

$$GF==\left(\frac{(1+0.01i)+[(1+0.01i)^{y}-1]}{0.01i}\right)$$

Where; i: growth rate in % =5.5% and
y: design period =20 yrs.

While using the table interpolation could be done for intermediate values.

Table 5. 8: Cumulative growth factors (GF) (AACRA table 6.4)

Design period(years)	**Growth rate(%pa)**					
	0	**2**	**4**	**6**	**8**	**10**
5	5	5.2	5.4	5.6	5.9	6.1
10	10	10.9	12.0	13.2	14.5	15.9
15	15	17.3	20.0	23.3	27.2	31.8
20	20	24.3	29.8	36.8	45.8	57.3
25	25	32.0	41.6	54.9	73.1	98.3
30	30	40.6	56.1	79.1	113.3	164.5
35	35	50.0	73.7	11.4	172.3	271.0
40	40	60.4	95.0	154.8	259.1	442.8

- **GF will be 35.05.**

Because asphalt, cemented materials and subgrades each have different performance relationships it is necessary to determine separately for each material the number of standard axles which will cause the same level of accumulated damage as the actual traffic load spectrum.

The design loading is then calculated as the design number of standard axles for:
Asphalt = Nsa x 365 x GF
Subgrade = Nss x 365 x GF
Cemented materials = Nsc x 365 x GF

Where GF is the cumulative growth factor from the Table or equation and a lane distribution factor of 1 (two way two) and direction factor of has to be introduced in the equation.

Nsa =1.1N
Nss =1.1N
Nsc = 10.0N; Where: And N is the initial daily traffic loading.
Thus ESA Asphalt = Nsa x 365 x GF

= (1.1* 262.47)* (365)*(1)*(0.5)*35.05

=**$1.846814 * 10^6$**

From the above calculation of ESA the traffic classes for pavement design is chosen From ERA design manual.

Table 5. 9: ESA Value from ERA manual

TRAFFIC CLASSES	RANGE (10^6 ESA)
T_1	**<0.3**
T_2	**0.3-0.7**
T_3	**0.7-1.5**
T_4	**1.5-3.0**
T_5	**3.0-6.0**
T_6	**6.0-10**
T_7	**10-17**
T_8	**17-30**
T9	**30-50**
T10	**50-80***

Table 5. 10: ESA Value from ERA manual

- According to the above computation the value of ESA which is $=1.846814\times10^6$ falls in **T_4 class**.

5.4. Pavement Structure (For Flexible Pavement)

The major components of a pavement structure are:

- Surface course
- Base course
- Sub base (optional)
- Sub grade

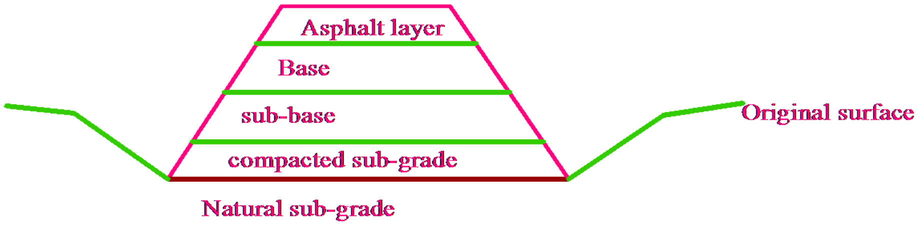


Figure 5. 1: The Components of Pavement Structure

I. **Surface course**: - The surface course is the top course of an asphalt pavement; sometimes called the wearing course.

- It resists distortion under traffic.
- It provides a smooth and skid-resistant riding surface.
- The surface course must be water proof to protect the entire pavement and sub grade from the weakening effect of water.

II. **Base course**: - The base course is the layer of material immediately beneath the surface course. It may be composed of well- graded crushed stone, granular material mixed with binder, or stabilized materials.
It is the main structural part of the pavement and provides a level surface for laying the surface layer.

III. **Sub base Course**; The sub base course is the layer of material beneath the base course constructed using local and cheaper materials for economic reason on top of the sub- grade. It provides additional help to the base and surface courses in distributing the loads and facilitates drainage of free water that might get accumulated below the pavement.

IV. **Sub–grade**: - Sub grade is the foundation on which the vehicle load and the weight of the pavement layers finally rest.
It is a layer of selected material compacted to the desirable density near the optimum moisture content and graded in to a proper shape, properly drained, and compacted to receive the pavement layers.

5.4.1. Sub Grade Soil Strength

The dominate sub grade soil type will be determined by the test result of the sample for CBR value and swell potential.

5.4.2. Material Investigation

The soil and material investigation is an important component of detail engineering design project. Investigation, sampling and identification of construction materials involve complex techniques accomplished by many different procedures and interpretations. These are frequently site specific and are influenced by geological and geographical conditions. Sub grade and Materials investigation was conducted according to the AACRA Manual 2013 and consists of the following major activities.

For the project road, samples were taken by manually digging test pits for tests including, particle size distribution, moisture content, Atterbrgue limit Bering capacity tests etc. For pavement design purposes, soil properties at subgrade level are required. Samples from the designed subgrade level were taken for CBR evaluations. This is considered appropriate for design purpose. The number of CBR tests required will very much depend on the uniformity of the sub grade soil. Since the project road subgrade has uniformity, fewer CBR tests were carried out.

A. Tests conducted on Subgrade Soil

It is recommended that laboratory tests should be carried out to determine the particle size distribution and in-situ moisture content for every sample taken.

Generally, the tests conducted on the subgrade soil sample are;

1. Proctor Compaction test.
2. CBR & Swell test.
3. Particle size distribution (Sieve Analysis).
4. Moisture content determination.
5. Atterbrgue limits.

Sampling is done by hand-dug pits. The detail laboratory test results for all the subgrade tests are attached in Appendix B.

Figure 5. 2: Laboratory test conduction

The required pavement layer is determined based on the strength of the sub grade soil and traffic loading. Sub grade strength being the main design input for determining the pavement layers, its strength has been assessed using laboratory CBR test. Summary of laboratory CBR (modified AASHTO) carried on sub grade soils is presented in table.

ERA 2013 recommends the following if the design value is less than three;

1. **1.** Re-align or shift the route on the direction which has better subgrade strength than the present one.
2. **2.** Construct embankment [capping layer with sufficient thickness].
3. **3.** Construct with equilibrium moisture (close to OMC).
4. **4.** Sealing to prevent surface runoff [drainage].
5. **5.** Use subgrade improvement.

CBR < 3% Replace bed material with better quality material
Swell > 3(5) % Use stabilization techniques to improve the Engineering property of existing soil.

In cases where there are unsuitable subgrade materials, the design CBR value shall be determined based on the CBR values the improved subgrade. Since we have CBR value less than three, which is not suitable soil material to withstand the supper imposed load, we use replacement mechanism (replacement of the existing soil with an improved soil that have CBR value of 5%**)** depending up on the following criteria**.**

1. **1.** Availability of material
2. **2.** Easy of construction (Mechanization requirement)
3. **3.** Requirement of maintenance and rehabilitation
4. **4.** Interest of the designer
5. **5.** Total cost the project (economic viability) and etc.

5.5. Sub-Grade Class

For the purpose of pavement design, the sub grade classes of uniform sections are determined by the different manuals used in pavement design. The sub grade categories specified in ERA manual and summary of the subgrade class is shown in table below.

Table 5. 11: Subgrade Strength Class

Class	**Range (CBR %)**
S_1	2
S_2	**3-4**
S_3	5-7
S_4	8-14
S_5	15-29
S_6	30^+

- Since we use an improved soil with CBR value of 4%; the subgrade is classified under class S2.

5.6. Design of pavement thickness

We design the pavement thickness by two alternatives:

1) Using AACRA:

Using the above data’s as an input we can now look at the available charts in the manual. Chart number 2 is selected depending on traffic loading and CBR value.

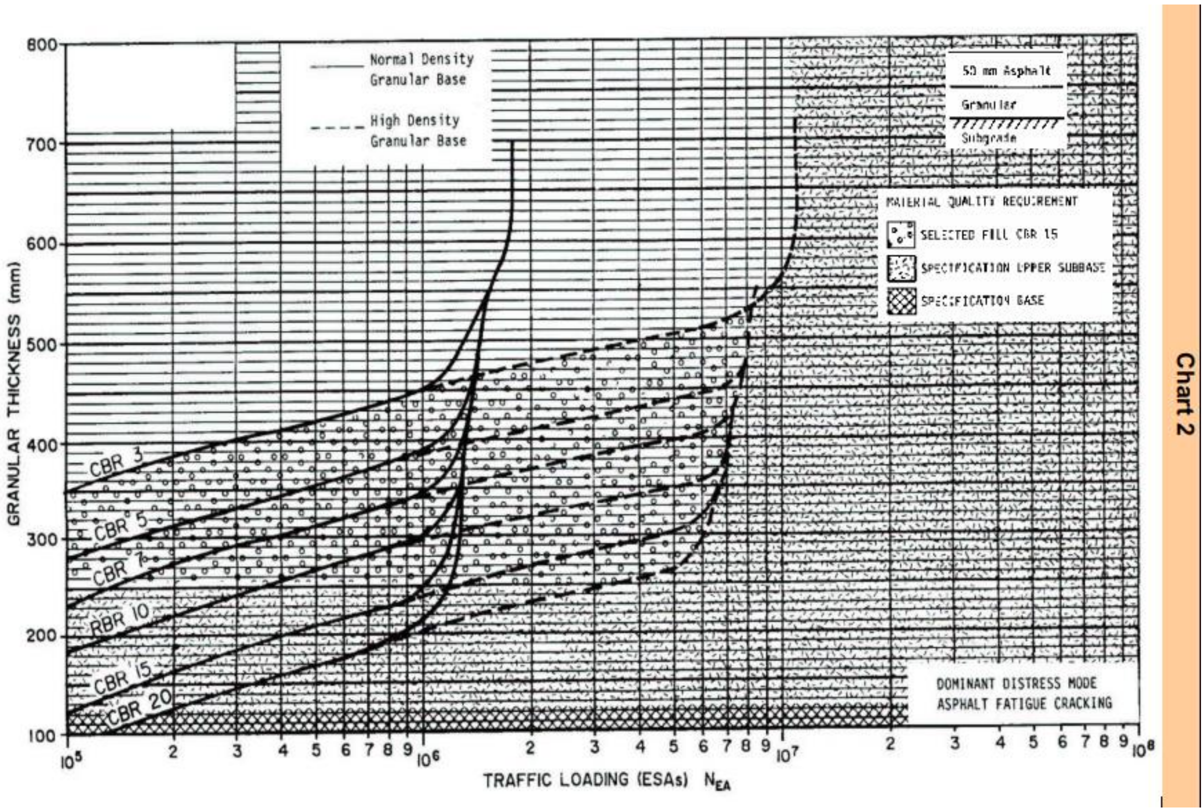


Figure 5. 3:Granular thickness(AACRA Pavement Design Manual, chart 2)

Reading from the chart gives the following thicknesses:
Design subgrade CBR=3
Design traffic=$1.85*10^6$

Available materials: CBR 15 measured at design moisture conditions.

- Assume t=50mm asphalt from chart 2.
- Thickness CBR 15 material=475.250-225=225mm
- Thickness upper sub base material=250-125=125mm
- Thickness of base materials=125mm (minimum)

2) Using ERA:

Based on the given ranges from ERA our road project falls under T4 and S2.

CHART B1: THIN (50mm) FLEXIBLE AC SURFACING, GRANULAR ROADBASE

Subgrade class	T3/LV5[1]	T4	T5	T6
	0.7 – 1.5	1.5 – 3.0	3.0 – 6.0	6.0 – 10.0
S1	175 200 300	175 250 300	175 300 300	200 325 300
S2	175 175 200	175 225 200	175 275 200	200 300 200
S3	175 225	175 275	175 325	200 350
S4	175 150	175 200	175 250	200 275
S5	150 100	175 125	175 150	200 175
S6	150	175	200	225

Figure 5. 4: Pavement thickness (ERA pavement design manual)

- Wearing course (thin flexible AC surfacing) =50mm
- Granular road base GB2 and 3=175mm
- Granular sub base (GS) =250mm
- granular capping layer(GC)=300mm

From the above two options we selected AACRA's layers due to economic consideration.

Under this content we performed the following tasks:

- Traffic load calculation,
- Subgrade evaluation, and
- Pavement thickness selection.

6. HIGHWAY DRAINAGE

6.1 General

Excess surface runoff after entering pits or other surface inlets is conveyed via conduits to the ultimate point of discharge such as a channel or a river. Conduits may comprise pipes or box culverts. Conduits must be designed to have sufficient capacity to convey runoff from the design storm.

Construction of urban highways and arterial roads substantially alter the perviousness of the areas. Large amounts of permeable areas are replaced with hard surfaces. In the older portions of large cities, the pavements may represent over 50% of the total urban impervious area. The diminution of permeable surfaces lessens the depression storage and infiltration. The paved surfaces speed up the conveyance of runoff. Thus, urban highways result in greater quantities of runoff at higher rates than would occur under pre-highway conditions. Storm water management aims at minimizing, or preferably eliminating entirely, these development-caused increases in runoff.

The process of removing and controlling excess surface and sub-surface water with in the right of way of the road is termed as highway drainage. This highway drainage includes interception and diversion of water from the road surface and sub grade. During rains, part of the rain water flows on the surface and part of it reach the ground water.

There are two type of highway drainage:

1) Surface drainage: it is the removal and diversion of surface water from the road way and adjoining land.

2) Sub-surface drainage: it is the diversion or removal of excess soil water from the sub-grade.

6.2 The Importance of Highway Drainage

The strength of stability of soil mass decreases with increasing moisture content also depends on the soil type and mode of stress application.

Highway drainage is important because of the following reasons:

- Excess moisture in sub grade soil causes considerable lowering of pavement strength. So, the pavement is likely to fail due to sub grade failure.
- In some clay soil, there is variation in volume of sub grade. This sometimes contributes for pavement failure.
- Sustained contact of water with bituminous pavement causes failure due to striping of bitumen from aggregate like losing or detachment of the bituminous pavement layers and formation of potholes.
- Excess water in shoulder and pavement edge causes considerable structural impact and discomfort for drivers.
- Erosion of soil from top of subsurface road and slope of embankment cut and fill side also caused due to surface water.

To have adequate and efficient surface drainage system which runs longitudinally at both sides of the road, it is necessary to do hydrological and hydraulic analysis.

In the hydrological analysis for a drainage facility, some of the factors which need to be recognized and considered on an individual site by site basis include:-

- Rainfall amount and storm distribution,
- Drainage area size, shape and orientation,
- Slope of terrain and streams Water shed development potential,
- Types of precipitation (rain, snow, hail or combinations), and
- Geological information (soil condition).

Hence the drainage should enable to drain the surface water efficiently peak flows with an acceptable approach should be known to design the surface drainage systems.

6.3 Design of Urban Road Drainage Runoff

Hydrologic Procedures

Flow measurements for determining a flood frequency relationship at a site are usually unavailable. In this case, it is an accepted practice to estimate peak runoff rates using empirical methods.
There are two methods available for calculating the discharge that best reflects local project conditions. These are:

i) **Rational method: -** Provides peak runoff rates for small urban and rural catchment areas, less than 80 hectares, but is best suited to urban storm drain systems and rural ditches. Here, rainfall is a necessary input.

ii) **SCS method: -** SCS method is based on an analysis of a large number of natural unit hydrographs from a broad cross section of geographic locations and hydrologic regions.

- For a highway in this project, rational method was used.

<u>The Rational Formula</u>

One of the most commonly used equations for the calculation of peak discharges from small areas is the rational formula. The rational formula is given as:

$$Q = \frac{\text{CiA}}{360}$$

Where,

Q = peak flow in m³/s
i = rainfall intensity for the design storm (mm/h)
A = drainage area (hectares)
C = dimensionless runoff coefficient

The quotient, 1/360, is a unit conversion that can be approximated as 0.00278.

- The drainage area should be smaller than 80 hectares.
- The peak discharge occurs when the entire watershed is contributing.
- A storm that has duration equal to tc produces the highest peak discharge for this frequency.

- ❖ The rainfall intensity is uniform over time duration equal to the time of concentration.
- ❖ The frequency of the computed peak flow is equal to the frequency of the
- ❖ Rainfall intensity. In other words, the 10-year rainfall intensity**, i,** is assumed to produce the 10-year peak discharge.

6.3.1. Catchment areas

To design the drainage system for our road, we started from delineating the catchment areas using Google Earth technology. And to delineate the areas, we tried to inspect the topography of each area with Google Earth. We used Elevation as basis to decide the runoff contributing areas.

Figure 6. 1: Catchment area from Google earth

Determining of catchment areas

To design the drainage system for our road, we firstly determine the catchment areas using Google Earth technology. And to delineate the areas, we tried to inspect the topography of each area with Google Earth. We used Elevation as basis to decide the runoff contributing areas.

A=20.7ha from Google Earth

6.3.2. Runoff coefficient(c)

Ground cover determines the runoff coefficient, C. Some tables of C provide for variation due to slope, soil, and the return period of the design discharge. The runoff coefficient is a volumetric coefficient that relates the peak discharge to the "theoretical peak" or 100 percent runoff, occurring when runoff matches the net rain rate. Hence C is also a function of infiltration and other hydrologic abstractions. Some typical values of C for the rational formula are given in the table below.

Table 6. 1: Recommended Runoff Coefficients for Various Selected Land Uses

Type of Area	**Runoff coefficient(C)**
Business down town areas	0.7-0.95
Neighborhood areas	0.5-0.7
Residential – single family areas- Multi units detach	0.3-0.5 0.4-0.6
Multi units attached	0.6-0.75
Sub-urban	0.25-0.4
Residential (0.5 ha or more)	**0.3-0.45**
Apartment dwelling areas	0.5-0.7
Industrial – light areas	0.5-0.7
Heavy areas	0.5-0.8
Unimproved areas	0.1-0.3

- We used C as 0.375, by taking average of Runoff coefficient(C) of Residential (0.5 ha or more) values.

6.3.2. Rainfall Intensity

The rainfall intensity (I) is the average rainfall rate in mm/hr. for duration equal to the time of concentration for a selected return period. Once a particular return period has been selected for design and a time of concentration calculated for the catchment area.

From ERA drainage manual the Wolkite, average rainfall intensity is 41.46mm/min.

6.4 Design of Efficient and Economical Trapezoidal Cross Sectional Channel

6.4.1. Trapezoidal Ditch

The most common channel shape for large flows is the trapezoidal section. Trapezoidal Channels are easily constructed by machinery and are often the most economical to Construct. When a wide trapezoidal section is proposed, both traffic safety and aesthetics can be improved by rounding all angles of the channel cross section with vertical curves. And by applying all these basic consideration during selection of types of cross drainage, we choose trapezoidal cross-section for these specific project.

Manning's Equation: For a given depth of flow in a channel with a steady, uniform flow, the mean velocity, V, can be computed with Manning's equation:

$$V=\left(\frac{1}{n}\right)*R^{\frac{2}{3}}*S^{1/2}$$

Where:

V = velocity, m/s
n = Manning's roughness coefficient
R = hydraulic radius = A/P, m
P = wetted perimeter, m
S = slope of the energy grade line, m/m

Design a trapezoidal ditch

$$Q=\frac{Cf*I*c*A}{360}$$

Where:

Q=peak discharge (m^3/sec)
C= run of coefficient…………………………………… 0.375
C_f=frequency factor……………………………………... 50%
I= average rainfall intensity (mm/min.) ………………… 41.46mm/min.
A= influencing catchments area (ha)…………………… 20.7ha

$$Q=\frac{0.375*41.46*20.7}{360}=0.894m^3/s$$

For safety case and for some inconvenience of runoff determination the calculated discharge is increased by 50%

$$Q_d=0.894m^3*1.5=1.341m^3/s$$

Check the capacity of the ditch

The capacity of the ditch for the largest cut section is given by

$$Q=A*(\frac{1}{n}*R^{2/3}*S^{1/2})$$

$$A = (b + my)*y$$

$$P= b+2y\sqrt{m^2+1})$$

- **R= y/2, y for economical trapezoidal section**

For Grass, some weeds: Values of Roughness Coefficient n =0.025 And side slope S= 1/20=0.05.

Let assume the depth of the ditch is 0.6m and side slope is (1H: 1V) and also slope of the energy grade line S = 0.01 which is the minimum value.

A = (b+1*0.6)*0.6 = 0.6b+0.36------------------------------equation (a)'
P= b+2*0.6$\sqrt{1^2+1}$) = b+1.7 ---------------------------- equation (b)'
R = A/P: R = 0.6/2 =0.3--------------------------------------equation (c)'

By substituting equation (a)’ & equation (b)’ in equation (c)’

$$0.3=\frac{0.6b+0.15}{b+1.34}$$

It can be simplified as and we get width, (b) = 0.5m

By substituting the value of b=0.5m in equation (a)’& equation (b)’ the area and wetted perimeters are 0.66m^2 and 2.2m respectively.

(i.e. A = 0.66m^{2}and P = 2.2m) and R=A/P=0.3

$$\mathbf{Q}=\frac{0.66}{0.025}*0.3^{2/3}*0.05^{1/2}$$

$$\underline{Q = 2.645m^3/S}$$

The capacity of ditch =2.645m^3/s and it is greater than expected run off (Qd),

i.e. Q>Qd (2.645m^3/S > 1.341m^3/S).

Therefore, the provided ditch is adequate and the layout of trapezoidal cross section is drawn as follow;

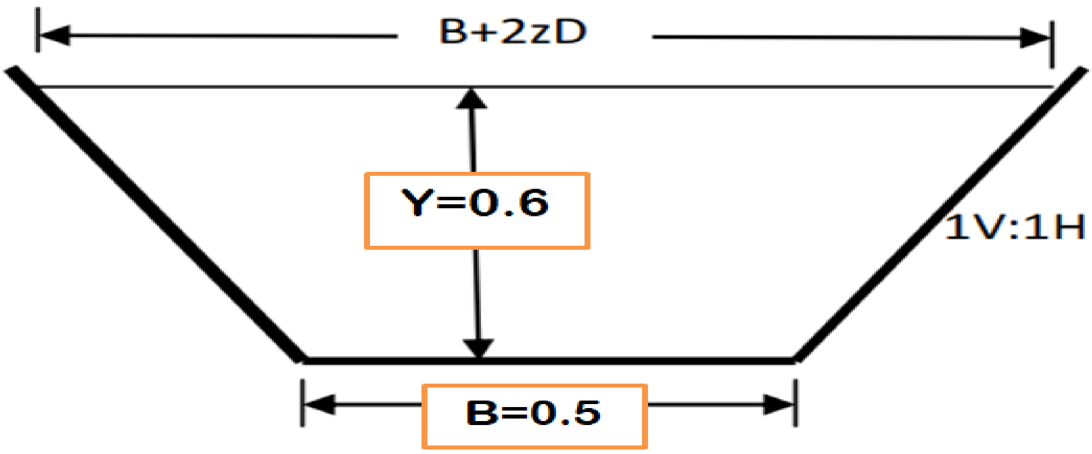


Figure 6. 2: Cross Section of Trapezoidal Ditch

6.5. Culvert Design

A culvert is a covered channel of relatively short length designed to pass water through an embankment (e.g. highway, railroad and dam). It is a hydraulic structure and it may carry flood waters, drainage flows, natural streams below earth fill and rock fill structures. From a hydraulic aspect, a dominant feature of a culvert is whether it runs full or not.

6.5.1. Design Considerations

First the function of the culvert must be chosen and the design flow conditions (e.g. Q_d, flood level) must be selected. The primary design constraints in the design of a culvert are cost should be minimum and scour protection may be considered, particularly if a hydraulic jump might take place near the culvert outlet.

5.4.3. Design Limitations

Allowable Headwater

It is the depth of water that can be ponded at the upstream end of the culvert that will be limited by one or more of the following:

- Will not damage up stream property,
- Not higher than 300 mm below the edge of the shoulder,
- Equal to an HW/D not greater than 1.5,
- No higher than the low point in the road grade, and
- Equal to the elevation where flow can be diverted around the culvert.

Check flow capacity using Manning's Equation

For a given depth of flow in a pipe with a steady, uniform flow, the mean velocity, V, can be computed with Manning's equation with Area of $0.66m^2$

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

Where:

n =0.025

R =0.3m

S =0.05

$V = \left(\frac{1}{n}\right) * R^{\frac{2}{3}} * S^{1/2} = \left(\frac{1}{0.025}\right) * 0.3^{\frac{2}{3}} * 0.05^{1/2}$

V = 4.01m/sec.

$Q = A * V$ = 0.66*4.01 = $0.1645m^3/sec$

Diameter (D) = $\sqrt{4 * A/\pi}$ $=\sqrt{4 * 0.66/\pi}$ = 0.91m (use 1m)

The lay out the designed culvert is as shown below;

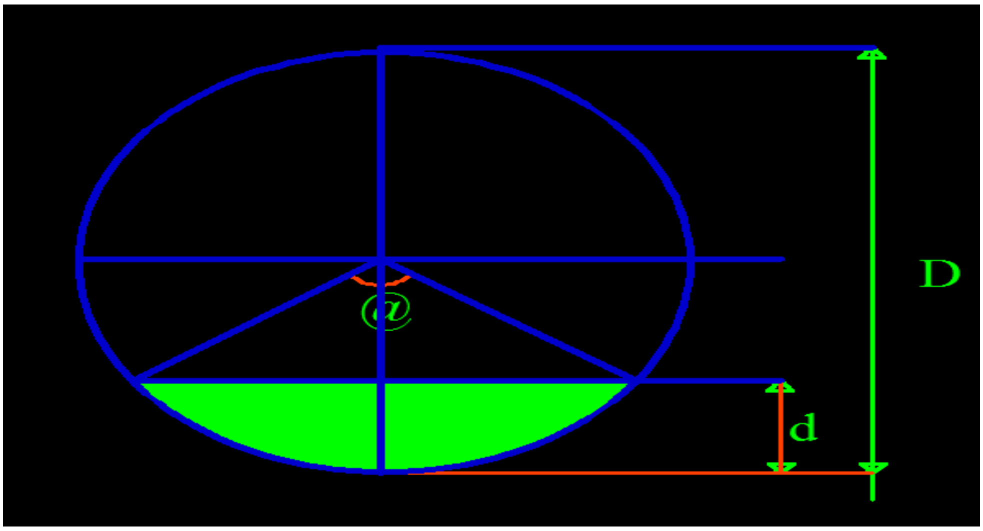


Figure 6. 3: Culvert Design Diagram

Under this content we performed the following tasks:

- Design of Efficient and Economical Trapezoidal Cross Sectional Channel, and
- Culvert Design.

7. RECOMMENDATION, CONCLUSION AND LIMITATION

7.1. Conclusion

Most of the road in urban area becomes deteriorated because of the poor drainage design. This is due to under estimation of the flood & in sufficient drainage galleries providence. Also asphalts pavements wear & tear before their design period .For the reduction of this cause the material used for pavement should full fill the specification requirement. Eventually, for safe driving condition& for longer period of usage, sufficient collection of data, implementation of good design & better construction are the backbone for road construction.

The upgrading road project from behind dormitory is designed geometrically and structurally to serve the inhabitants of the region. Geometric design starts from route selection from the contour map followed by horizontal and vertical alignment by considering the natural topography of the project zone through which the route passes. Geometric design of the road includes careful alignments of the route through the given area as it best fits with the ground profile to reduce the cost of excavation and improves the vehicle comfort by considering all factors affecting vehicle operating characteristics like; terrain condition, horizontal curves, vertical curves, sight distances, and gradients.

To accommodate the effects of the load from traffic and other user's pavement structure is designed to satisfy all requirements throughout the design life of the road way by considering the effects of traffic loading on pavements from traffic loading and design sub grade strength from of characteristics. By doing the project, we enable to search and to learn more than what have been discussed through the class discussion. It also helps us to summarize what have been learnt during their study.

Doing this project enables us to develop self-confidence up on that we learnt theoretically in class and introduces us with the works that are done in the design office. We also grasp the knowledge of Software such as; civil 3D AutoCAD and Microsoft excel.

Finally, for safe driving condition and longer life of the road, sufficient collection of data, good design and implementation of the design and good construction are the corner stone in road construction.

7.2. Recommendation

We would like to recommend that all the data that are necessary for the design purpose should be collected and accessed practically by the students and we visit the project area to visualize what reality available at the site and design takes place. This used to avoid encounter problems emanating from delay of data and insufficient information of the project area.

To keep the efficient and effectiveness of final project work, students try to do the actual work and department should be solve the following problems

- ❖ Limitation of laboratory equipment's
- ❖ So as to do the project which gives benefits for the society, the department should proposed some titles with the collaboration of the town municipality.
- ❖ To make the students rich in information there should be free internet access in the computer room
- ❖ It is better to include software courses such as civil 3D, Excel &others in the curriculum so that they facilitate our design.

Besides of this we recommended that, to upgrade this road project there must be the cooperation of government with the society and also government should give great attention for road construction to solve transportation problem in different parts of the country.

7.3. Limitation

During the project time there are a lot of limitations (constraints) that we faced. Some of them are: -

- The lack of insufficient data necessary for design purpose.
- Lack of computers and internet room.
- There is no enough time to accomplish all the required components of highway engineering works.
- Unsuitable weather condition.
- No enough reading or reference materials are available in the library, especially in accordance with ACCRA, ERA, AASHTO etc…

References

1. Addis Ababa City Road Authority. 2004. *AACRA Drainage Manual*. Addis Ababa.

2. Addis Ababa City Road Authority. 2004. *AACRA Geometric Manual*. Addis Ababa.

3. Addis Ababa City Road Authority. 2004. *AACRA Pavement Design Manual*. Addis Ababa.

4. Dejene, Yared. 2015. “Senior Project on Highway.” Adama Science and Technology University.

5. Ethiopian Road Authority. 2013. *ERA Drainage Manual*. Addis Ababa.

6. Ethiopian Road Authority. 2013. *ERA Geometric Manual*. Addis Ababa.

7. Ethiopian Road Authority. 2013. *ERA Pavement Design Manual*. Addis Ababa.

8. Garg, Santos kumar. 2005. *Irrigation Engineering and Hydraulic Structures*. Delhi.

Appendix

1. **Sample survey data**

points	Easting(X)	Northing(Y)	elevation(Z)	Remark
1	368598.65	908553.66	1937.02	**L1**
2	368594.96	908549.85	1937.12	**L2**
3	368590.71	908545.89	1937.25	**C**
4	368586.89	908542.05	1937.30	**R1**
5	368583.52	908536.81	1937.32	**R2**
6	368619.95	908541.39	1936.04	**L1**
7	368616.27	908535.91	1936.25	**L2**
8	368612.99	908530.48	1936.40	**C**
9	368609.90	908525.15	1936.55	**R1**
10	368606.03	908520.79	1936.75	**R2**
11	368642.94	908527.39	1935.08	**L1**
12	368638.74	908521.07	1935.22	**L2**
13	368634.63	908515.67	1935.34	**C**
14	368629.97	908509.41	1935.58	**R1**
15	368623.37	908503.48	1935.82	**R2**
16	368662.84	908517.13	1934.12	**L1**
17	368659.88	908507.87	1934.18	**L2**
18	368655.88	908500.71	1934.26	**C**
19	368652.08	908493.59	1934.56	**R1**
20	368646.48	908485.06	1934.76	**R2**
21	368691.12	908503.48	1933.08	**L1**
22	368683.94	908492.23	1933.16	**L2**
23	368680.19	908484.33	1933.26	**C**
24	368675.01	908474.90	1933.42	**R1**
25	368669.23	908468.83	1933.68	**R2**
26	368730.77	908471.03	1931.90	**L1**
27	368719.39	908464.99	1932.10	**L2**
28	368711.33	908462.14	1932.22	**C**
29	368691.71	908451.27	1932.48	**R2**
30	368682.99	908443.72	1932.68	**R3**
31	368739.46	908442.20	1930.78	**L1**
32	368724.92	908436.02	1930.90	**L2**
33	368712.98	908431.96	1931.04	**C**
34	368696.81	908422.83	1931.22	**R1**
35	368683.72	908411.84	1931.48	**R2**
36	368738.14	908386.19	1929.66	**L1**
37	368721.50	908386.69	1929.88	**L2**
38	368709.58	908386.76	1930.02	**C**
39	368693.79	908386.67	1930.24	**R1**
40	368681.94	908388.59	1930.54	**R2**
41	368740.12	908345.83	1928.58	**L1**
42	368723.91	908343.48	1928.84	**L2**
43	368707.10	908340.49	1929.04	**C**
44	368696.23	908338.70	1929.30	**R1**
45	368683.95	908337.37	1929.50	**R2**
46	368738.08	908298.35	1927.62	**L1**
47	368720.16	908296.88	1927.86	**L2**
48	368704.31	908296.55	1928.08	**C**

49	368691.91	908296.32	1928.36	**R1**
50	368678.67	908296.44	1928.64	**R2**
51	368738.34	908261.99	1926.61	**L1**
52	368720.11	908261.47	1926.85	**L2**
53	368702.71	908260.39	1927.04	**C**
54	368689.29	908259.40	1927.34	**R1**
55	368678.77	908258.82	1927.68	**R2**
56	368709.89	908205.82	1928.25	**L1**
57	368693.68	908212.16	1928.50	**L2**
58	368678.62	908217.52	1929.04	**C**
59	368666.45	908221.90	1929.75	**R1**
60	368656.45	908227.28	1929.80	**R2**
61	368670.26	908154.37	1928.16	**L1**
62	368654.49	908162.48	1928.40	**L2**
63	368642.30	908168.05	1929.08	**C**
64	368635.05	908173.13	1929.70	**R1**
65	368621.89	908177.81	1929.85	**R2**
66	368626.18	908107.70	1928.20	**L1**
67	368615.50	908115.07	1928.36	**L2**
68	368605.24	908119.34	1929.50	**C**
69	368597.04	908125.56	1929.60	**R1**
70	368586.80	908131.92	1929.75	**R2**
71	368594.59	908061.98	1929.25	**L1**
72	368582.21	908068.24	1929.50	**L2**
73	368572.60	908073.36	1930.04	**C**
74	368561.49	908079.40	1930.75	**R1**
75	368549.63	908085.59	1930.82	**R2**
76	368556.22	908011.62	1929.18	**L1**
77	368545.69	908019.20	1929.42	**L2**
78	368537.84	908025.32	1930.06	**C**
79	368528.75	908033.43	1930.75	**R1**
80	368518.21	908042.96	1930.90	**R2**
81	368515.41	907966.71	1929.22	**L1**
82	368506.51	907970.85	1929.38	**L2**
83	368500.80	907974.62	1930.52	**C**
84	368494.16	907978.96	1930.62	**R1**
85	368484.91	907984.41	1930.78	**R2**
86	368488.73	907924.90	1929.08	**L1**
87	368479.56	907928.81	1929.96	**L2**
88	368471.26	907934.42	1930.40	**C**
89	368462.65	907939.62	1930.58	**R1**
90	368453.61	907946.89	1931.02	**R2**
91	368455.60	907873.28	1930.02	**L1**
92	368444.49	907880.34	1930.35	**L2**
93	368436.47	907886.95	1930.60	**C**
94	368429.28	907892.40	1931.00	**R1**
95	368419.14	907901.34	1931.25	**R2**
96	368413.36	907828.09	1930.25	**L1**
97	368407.43	907833.26	1930.50	**L2**
98	368401.79	907838.96	1931.00	**C**
99	368394.02	907847.71	1931.25	**R1**
100	368386.52	907856.77	1931.58	**R2**
101	368386.51	907783.35	1930.28	**L1**

102	368376.42	907789.38	1930.56	**L2**
103	368368.92	907794.46	1931.06	**C**
104	368361.26	907798.07	1931.30	**R1**
105	368351.83	907801.77	1931.62	**R2**
106	368348.61	907741.19	1930.50	**L1**
107	368344.46	907751.29	1930.75	**L2**
108	368338.58	907760.29	1931.25	**C**
109	368331.33	907769.53	1931.34	**R1**
110	368324.29	907778.73	1931.52	**R2**
111	368290.66	907720.67	1931.50	**L1**
112	368284.89	907731.15	1931.75	**L2**
113	368282.55	907738.69	1932.00	**C**
114	368279.41	907748.35	1932.25	**R1**
115	368274.29	907760.43	1932.58	**R2**
116	368232.19	907697.61	1932.50	**L1**
117	368229.36	907709.40	1932.75	**L2**
118	368227.56	907717.94	1933.00	**C**
119	368224.39	907731.87	1933.25	**R1**
120	368223.98	907747.67	1933.50	**R2**
121	368164.17	907678.41	1933.50	**L1**
122	368164.94	907685.24	1933.75	**L2**
123	368160.97	907691.47	1934.00	**C**
124	368158.45	907705.32	1934.15	**R1**
125	368155.60	907718.71	1934.25	**R2**
126	368117.90	907674.09	1934.00	**L1**
127	368118.35	907680.53	1934.15	**L2**
128	368118.85	907686.52	1934.25	**C**
129	368119.58	907698.03	1934.35	**R1**
130	368118.66	907706.97	1934.58	**R2**
131	368060.65	907682.21	1934.25	**L1**
132	368061.80	907690.55	1934.40	**L2**
133	368064.28	907700.03	1934.50	**C**
134	368065.31	907707.03	1934.60	**R1**
135	368067.00	907714.98	1934.75	**R2**
136	368022.78	907691.84	1934.50	**L1**
137	368025.80	907701.41	1934.60	**L2**
138	368028.41	907709.30	1934.75	**C**
139	368031.50	907719.44	1934.85	**R1**
140	368034.39	907726.75	1935.00	**R2**

2. Laboratory Test Results

2.1. Moisture –density relationship of subgrade soil (AASHTO T265)

a. Objective

To obtain the moisture content-dry density relationship for a soil and hence to determine

Its maximum dry density (MDD) and optimum moisture content (OMC).

b. Procedure

1. Select a representative sample of about 18 Kg which passes sieve No 4 and divide in to 5-6 equal parts by weight.
2. Prepare a series of 5-6 specimens with different moisture contents. The moisture content selected shall include the optimum moisture content, thus providing specimens which, when compacted will increases in mass to maximum density and then decrease in density.
3. Place the specimens in separate covered containers and allow standing prior to compaction to insure even distribution of moisture throughout the specimens.
4. Weigh the empty mould with base but without collars.
5. Attach the mould and extension collar, compact the first specimen with 25 blows in three layers of approximately height. Each layer should receive 25 evenly distributed blows.
6. Remove the collar. While removing the collar locate it to break the bond between it and the soil before lifting of the mould. This prevents removing some of the compacted soil when the solar is taken off. If the collar is hard to remove do not risk twisting of the last layers of soil. Take a spatula and trim long the sides of the collar until it comes off easily.
7. Remove the base plate. Carefully strike both the top and the base of the compacted cylinder of soil with a steel edge. Fill any holes in the compacted specimens with soil if the smoothing process removes any small pebbles.
8. Weigh the weight of the mould with base and compacted soil.
9. Remove the soil from the cylinder and obtain a representative sample for water content determination.
10. Repeat steps 6-10 for remaining specimens.

➢ This is the test that shall be conducted upon the soil samples obtained from the site.

Water content of soil is defined as:

W= (loss of moisture content/dry mass of soil sample) *100

Trial No.	1	2	3	4	5
Weight of Mold + Wet soil (g)	4675.3	4855.2	4866.3	4859.5	
Weight of Mold (g)	3246.3				
Weight of Wet soil (g)	1429	1608.7	1619.6	1612.4	

Volume of Mold (cc)					
Wet density (g / cm3)					
Moisture Content Determination					
Weight of Wet soil + cont. (g)	63.8	69.1	63.4	59.5	
Weight of Dry soil + cont. (g)	56.1	58.2	53.6	48.9	
Weight of Container (g)	25.3	25.5	25.4	25.4	
Weight of water (moisture) (g)	7.7	10.9	9.8	10.6	
Weight of Dry soil (g)	30.60	32.70	28.2	23.5	
Moisture content (%)	25.16	33.33	34.7	45.1	
Dry Density (g / cm3)	0.54	0.57	0.57	0.53	
	MDD, g/cc	**2.11**	**OMC, %**		**9.2**

Plastic Limit, Liquid Limit & Plasticity Index (AASHTO T89, T90)

ATTERBERG LIMITS TEST

This lab is performed to determine the plastic and liquid limits of a fine grained soil. The liquid limit (LL) is arbitrarily defined as the water content, in percent, at which a part of soil in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove for a distance of 13 mm (1/2in.) when subjected to 25 shocks from the cup being dropped 10 mm in a standard liquid limit apparatus operated at a rate of two shocks per second. The plastic limit (PL) is the water content, in percent, at which a soil can no longer be deformed by rolling into 3.2 mm (1/8 in.) diameter threads without crumbling.

Test Procedure:

Liquid Limit:

(1) Take roughly 3/4 of the soil and place it into the porcelain dish. Assume that the soil was previously passed through a No. 40 sieve, air-dried, and then pulverized. Thoroughly mix the soil with a small amount of distilled water until it appears as a smooth uniform paste. Cover the dish with cellophane to prevent moisture from escaping.

(2) Weigh four of the empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.

(3) Adjust the liquid limit apparatus by checking the height of drop of the cup. The point on the cup that comes in contact with the base should rise to a height of 10 mm. The block on the end of the grooving tool is 10 mm high and should be used as a gage. Practice using the cup and determine the correct rate to rotate the crank so that the cup drops approximately two times per second.

(4) Place a portion of the previously mixed soil into the cup of the liquid limit apparatus at the point where the cup rests on the base. Squeeze the soil down to eliminate air pockets and spread it into the cup to a depth of about 10 mm at its deepest point. The soil pat should form an approximately horizontal surface

(5) Use the grooving tool carefully cut a clean straight groove down the center of the cup. The tool should remain perpendicular to the surface of the cup as groove is being made. Use extreme care to prevent sliding the soil relative to the surface of the cup.

(6) Make sure that the base of the apparatus below the cup and the underside of the cup are clean of soil. Turn the crank of the apparatus at a rate of approximately two drops per second and count the number of drops, N; it takes to make the two halves of the soil pat come into contact at the bottom of the groove along a distance of 13 mm (1/2 in.). If the number of drops exceeds 50, then go directly to step eight and do not record the number of drops, otherwise, record the number of drops on the data sheet.

(7) Take a sample, using the spatula, from edge to edge of the soil pat. The sample should include the soil on both sides of where the groove came into contact. Place the soil into a moisture can cover it. Immediately weigh the moisture can containing the soil, record its mass, remove the lid, and place the can into the oven. Leave the moisture can in the oven for at least 16 hours. Place the soil remaining in the cup into the porcelain dish. Clean and dry the cup on the apparatus and the grooving tool.

(8) Remix the entire soil specimen in the porcelain dish. Add a small amount of distilled water to increase the water content so that the number of drops required closing the groove decrease.

(9) Repeat steps six, seven, and eight for at least two additional trials producing successively lower numbers of drops to close the groove. One of the trials shall be for a closure requiring 25 to 35 drops, one for closure between 20 and 30 drops, and one trial for a closure requiring 15 to 25 drops. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

Plastic Limit:

1. Weigh the remaining empty moisture cans with their lids, and record the respective weights and can numbers on the data sheet.

2. Take the remaining 1/4 of the original soil sample and add distilled water until the soil is at a consistency where it can be rolled without sticking to the hands.

3. Form the soil into an ellipsoidal mass (See Photo F). Roll the mass between the palm or the fingers and the glass plate. Use sufficient pressure to roll the mass into a thread of uniform diameter by using about 90 strokes per minute. (A stroke is one complete motion of the hand forward and back to the starting position.) The thread shall be deformed so that its diameter reaches 3.2 mm (1/8in.), taking no more than two minutes. When the diameter of the thread reaches the correct diameter, break the thread into several pieces. Knead and reform the pieces into ellipsoidal masses and re-roll them. Continue this alternate rolling, gathering together, kneading and re-rolling until the thread crumbles under the pressure required for rolling and can no longer be rolled into a 3.2 mm diameter thread Gather the portions of the crumbled thread together and place the soil into a moisture can, then cover it. If the can does not contain at least grams of soil, add soil to the can from the next trial (See Step 6). Immediately weigh the moisture can containing the soil, record it's mass, remove the lid, and place the can into the oven. Leave the moisture can in the oven for at least 16 hours.

4. Repeat steps three, four, and five at least two more times. Determine the water content from each trial by using the same method used in the first laboratory. Remember to use the same balance for all weighing.

Analysis:

<u>Liquid Limit:</u>

1. Calculate the water content of each of the liquid limit moisture cans after they have been in the oven for at least 16 hours.

2. Plot the number of drops, N, (on the log scale) versus the water content (w). Draw the best-fit straight line through the plotted points and determine the liquid limit (LL) as the water content at 25 drops.

Plastic Limit:

1. Calculate the water content of each of the plastic limit moisture cans after they have been in the oven for at least 16 hours.

2. Compute the average of the water contents to determine the plastic limit, PL. Check to see if the difference between the water contents is greater than the acceptable range of two results (2.6 %).

3. Calculate the plasticity index, PI=LL-PL.

Report the liquid limit, plastic limit, and plasticity index to the nearest whole number, omitting the percent designation.

	Liquid Limit			**Plastic Limit**	
No. of Blows	32	22	18		
Wt. of cont. + wet soil (g) = (w_1)	55.00	46.20	44.30	35.20	25.10
Wt. of cont. + dry soil (g.) = (w_2)	40.20	39.40	38.30	30.40	27.40
Wt. of container (g.) = (w_3)	17.50	23.19	17.70	27.80	25.70
Mass of moisture (g.) (w_1-w_2) = x	14.80	6.80	6.00	4.80	-2.30
Wt. of dry soil (g.) (w_2-w_3) = y	22.70	16.21	20.60	2.60	1.70
Moisture Content (%) = (100x/y)	65.20	41.95	29.13	184.62	-135.29
	45			**25**	
	Plasticity Index			**21**	

3. Volume report data

		Cut Volume (Cu.m.)	Reusable Volume (Cu.m.)	Fill Area (Sq.m.)	Fill Volume (Cu.m.)	Cum. Cut Vol. (Cu.m.)	Cum. Reusable Vol. (Cu.m.)	Cum. Fill Vol. (Cu.m.)
0+020.000	1.78	0	0	0.35	0	0	0	0
0+040.000	1.9	36.87	36.87	0.41	7.51	36.87	36.87	7.51
0+060.000	2.19	40.03	40.03	0.44	8.65	76.9	76.9	16.16
0+080.000	2.27	43.29	43.29	0.91	13.81	120.19	120.2	29.97
0+100.000	2.15	42.91	42.91	0.54	14.8	163.1	163.1	44.77
0+120.000	1.73	37.62	37.62	0.63	11.99	200.72	200.7	56.75
0+140.000	1.58	32.08	32.08	0.52	11.78	232.79	232.8	68.53
0+160.000	2.24	37.02	37.02	0.35	8.88	269.81	269.8	77.41
0+180.000	1.3	34.32	34.32	0.23	5.88	304.13	304.1	83.29
0+200.000	1.2	24.31	24.31	0.18	4.17	328.44	328.4	87.46
0+220.000	1.32	24.54	24.54	0.21	3.96	352.98	353	91.41
0+240.000	1.71	29.45	29.45	0.24	4.56	382.43	382.4	95.97
0+260.000	2.02	36.16	36.16	0.32	5.72	418.59	418.6	101.7
0+280.000	1.9	38	38	0.46	8.03	456.6	456.6	109.7
0+300.000	1.96	38.56	38.56	0.46	9.25	495.16	495.2	119
0+320.000	1.98	39.37	39.37	0.49	9.5	534.53	534.5	128.5
0+340.000	1.66	36.42	36.42	0.45	9.35	570.95	571	137.8
0+360.000	2.48	41	41	0.52	9.72	611.95	612	147.6
0+380.000	3.2	55.78	55.78	0.74	12.74	667.73	667.7	160.3
0+400.000	3.22	63.04	63.04	0.62	13.81	730.77	730.8	174.1
0+420.000	3.13	62.33	62.33	0.59	12.27	793.1	793.1	186.4
0+440.000	3.09	61.1	61.1	0.24	8.33	854.2	854.2	194.7
0+460.000	2.22	52.15	52.15	0.19	4.36	906.35	906.4	199.1
0+480.000	1.82	39.69	39.69	0.19	3.89	946.04	946	202.9
0+500.000	2.14	38.95	38.95	0.17	3.63	984.99	985	206.6
0+520.000	3.05	51.25	51.25	0.18	3.5	1036.2	1036	210.1
0+540.000	3.46	65.15	65.15	0.2	3.73	1101.4	1101	213.8
0+560.000	2.99	64.57	64.57	0.3	4.96	1166	1166	218.8
0+580.000	3.19	61.79	61.79	0.56	8.57	1227.8	1228	227.3
0+600.000	3.65	68.31	68.31	0.83	13.89	1296.1	1296	241.2
0+620.000	3.76	74.07	74.07	1.22	20.5	1370.1	1370	261.7
0+640.000	5.11	88.74	88.74	1.3	25.15	1458.9	1459	286.9
0+660.000	3.27	83.83	83.83	3.77	50.67	1542.7	1543	337.5
0+680.000	1.22	44.94	44.94	4.76	85.27	1587.7	1588	422.8
0+700.000	1.37	25.96	25.96	0.5	52.58	1613.6	1614	475.4
0+720.000	1.51	28.85	28.85	0.35	8.55	1642.5	1642	483.9
0+740.000	1.81	33.51	33.51	0.27	6.21	1676	1676	490.1

0+760.000	2.22	41.1	41.1	0.39	6.47	1717.1	1717	496.6
0+780.000	2.31	46.18	46.18	0.73	11.03	1763.2	1763	507.6
0+800.000	2.59	49.41	49.41	0.41	11.37	1812.7	1813	519
0+820.000	1.89	44.85	44.85	0.36	7.68	1857.5	1858	526.7
0+840.000	1.71	36.02	36.02	1.19	15.47	1893.5	1894	542.2
0+860.000	2.35	39.7	39.7	1.31	25.5	1933.2	1933	567.7
0+880.000	2.35	45.91	45.91	1.22	25.83	1979.1	1979	593.5
0+900.000	1.9	41.46	41.46	1.06	23.29	2020.6	2021	616.8
0+920.000	1.54	33.48	33.48	0.74	18.36	2054.1	2054	635.2
0+940.000	1.27	27.38	27.38	0.19	9.43	2081.5	2081	644.6
0+960.000	1.26	24.68	24.68	0.2	3.99	2106.1	2106	648.6
0+980.000	1.17	24.24	24.24	0.53	7.32	2130.4	2130	655.9
1+000.000	1.98	31.45	31.45	0.48	10.09	2161.8	2162	666
1+020.000	2.12	39.68	39.68	0.35	8.49	2201.5	2202	674.5
1+040.000	2.06	40.51	40.51	0.29	6.61	2242	2242	681.1
1+060.000	1.91	38.5	38.5	0.35	6.62	2280.5	2281	687.7
1+080.000	1.83	36.22	36.22	0.27	6.39	2316.8	2317	694.1
1+100.000	1.71	34.3	34.3	0.22	5.04	2351.1	2351	699.1
1+120.000	1.38	30.9	30.9	0.23	4.45	2382	2382	703.6
1+140.000	1.01	23.86	23.86	0.18	4.03	2405.8	2406	707.6
1+160.000	0.99	19.97	19.97	0.32	4.98	2425.8	2426	712.6
1+180.000	0.98	19.68	19.68	0.37	6.91	2445.5	2445	719.5
1+200.000	1.55	25.3	25.3	0.26	6.31	2470.8	2471	725.8
1+220.000	1.56	31.12	31.12	0.19	4.55	2501.9	2502	730.4
1+240.000	1.38	29.36	29.36	0.18	3.73	2531.2	2531	734.1
1+260.000	1.43	28.13	28.13	0.23	4.1	2559.4	2559	738.2

4. Horizontal Alignment data's

Horizontal Alignment:

Description: project

Station Range: Start: 0+000.00, End: 1+269.27

Tangent Data

Length:	45.069	Course:	S 53° 11' 22.1999" E

Circular Curve Data

Delta:	67° 14' 31.9231"	Type:	RIGHT
Radius:	200		
Length:	234.72	Tangent:	132.986
Mid-Ord:	33.457	External:	40.178
Chord:	221.479	Course:	S 19° 34' 06.2383" E

Tangent Data

Length:	69.161	Course:	S 14° 03' 09.7233" W

Circular Curve Data

Delta:	27° 05' 07.6369"	Type:	RIGHT
Radius:	350		
Length:	165.456	Tangent:	84.304
Mid-Ord:	9.732	External:	10.01
Chord:	163.919	Course:	S 27° 35' 43.5417" W

Tangent Data

Length:	217.612	Course:	S 41° 08' 17.3602" W

Circular Curve Data

Delta:	10° 33' 16.0006"	Type:	LEFT
Radius:	300		
Length:	55.263	Tangent:	27.71
Mid-Ord:	1.272	External:	1.277
Chord:	55.185	Course:	S 35° 51' 39.3599" W

Tangent Data

Length:	53.966	Course:	S 30° 35' 01.3596" W

Circular Curve Data

Delta:	27° 11' 43.0803"	Type:	RIGHT
Radius:	250		
Length:	118.662	Tangent:	60.471
Mid-Ord:	7.007	External:	7.209
Chord:	117.551	Course:	S 44° 10' 52.8998" W

Tangent Data

Length:	37.917	Course:	S 57° 46' 44.4399" W

Circular Curve Data

Delta:	30° 05' 39.5651"	Type:	RIGHT
Radius:	200		
Length:	105.049	Tangent:	53.766
Mid-Ord:	6.858	External:	7.101
Chord:	103.846	Course:	S 72° 49' 34.2224" W

Tangent Data

Length:	166.397	Course:	S 87° 52' 24.0050" W

5. Vertical Alignment data's

Vertical Alignment:

Description: project

Station Range: Start: 0+000.00, End: 1+269.27

Vertical Curve Information:(sag curve)			
PVC Station:	0+131.59	Elevation:	1,931.589m
PVI Station:	0+215.00	Elevation:	1,928.000m
PVT Station:	0+298.41	Elevation:	1,929.032m
Low Point:	0+261.16	Elevation:	1,928.801m
Grade in:	-4.30%	Grade out:	1.24%
Change:	5.54%	K:	30.116m
Curve Length:	166.823m	Curve Radius	3,011.622m
Headlight Distance:	174.506m		

Vertical Curve Information:(crest curve)			
PVC Station:	0+447.44	Elevation:	1,930.875m
PVI Station:	0+485.00	Elevation:	1,931.340m
PVT Station:	0+522.56	Elevation:	1,931.099m
High Point:	0+496.92	Elevation:	1,931.181m
Grade in:	1.24%	Grade out:	-0.64%
Change:	1.88%	K:	40.000m
Curve Length:	75.121m	Curve Radius	4,000.000m
Passing Distance:	860.954m	Stopping Distance:	391.428m

Vertical Curve Information:(sag curve)			
PVC Station:	0+825.00	Elevation:	1,929.160m
PVI Station:	0+850.00	Elevation:	1,929.000m
PVT Station:	0+875.00	Elevation:	1,929.334m
Low Point:	0+841.22	Elevation:	1,929.108m
Grade in:	-0.64%	Grade out:	1.34%
Change:	1.98%	K:	25.295m
Curve Length:	50.000m	Curve Radius	2,529.459m
Headlight Distance:	1,078.793m		

6. Alignment Design Criteria Verification Report

Alignment Name: Alignment
Description: project
Station Range: Start: 0+000.00, End: 1+269.27

1 Tangent

Start Station:	0+000.00	
End Station:	0+045.07	
Length:	45.069m	
Design Speed:	50	
Design Checks:		

2 Circular Curve

Start Station:	0+045.07	
End Station:	0+279.79	
Radius:	200.000m	
Design Speed:	-1	
Design Criteria:		
Minimum Radius:	-1.00	Cleared
Design Checks:		

3 Tangent

Start Station:	0+279.79	
End Station:	0+348.95	
Length:	69.161m	
Design Speed:	50	
Design Checks:		

4 Circular Curve

Start Station:	0+348.95	
End Station:	0+514.41	
Radius:	350.000m	
Design Speed:	-1	
Design Criteria:		
Minimum Radius:	-1.00	Cleared
Design Checks:		

5 Tangent

Start Station:	0+514.41	
End Station:	0+732.02	
Length:	217.612m	
Design Speed:	50	
Design Checks:		

---

6 Circular Curve

Start Station:	0+732.02	
End Station:	0+787.28	
Radius:	300.000m	
Design Speed:	-1	
Design Criteria:		
Minimum Radius:	-1.00	Cleared
Design Checks:		

---

7 Tangent

Start Station:	0+787.28	
End Station:	0+841.25	
Length:	53.966m	
Design Speed:	50	
Design Checks:		

---

8 Circular Curve

Start Station:	0+841.25	
End Station:	0+959.91	
Radius:	250.000m	
Design Speed:	-1	
Design Criteria:		
Minimum Radius:	-1.00	Cleared
Design Checks:		

---

9 Tangent

Start Station:	0+959.91	
End Station:	0+997.82	
Length:	37.917m	
Design Speed:	50	
Design Checks:		

---

10 Circular Curve

Start Station:	0+997.82	
End Station:	1+102.87	

Radius:	200.000m	
Design Speed:	-1	
<u>Design Criteria:</u>		
Minimum Radius:	-1.00	Cleared
<u>Design Checks:</u>		

11 Tangent

Start Station:	1+102.87
End Station:	1+269.27
Length:	166.397m
Design Speed:	50
<u>Design Checks:</u>	

7. General Legal DescriptionG

From the Point of Beginning at a location of N 908545.890 E 368590.710 Thence along a tangent line S 53° 11' 22.2" E a distance of 45.0690 meters (147.8640') to Station 0+45.0690;
Thence along a tangent line S 14° 03' 09.7" W a distance of 69.1609 meters (226.9057') to Station 3+48.9494;
Thence along a tangent line S 41° 08' 17.4" W a distance of 217.6116 meters (713.9488') to Station 7+32.0166;
Thence along a tangent line S 30° 35' 01.4" W a distance of 53.9656 meters (177.0524') to Station 8+41.2451;
Thence along a tangent line S 57° 46' 44.4" W a distance of 37.9172 meters (124.4003') to Station 9+97.8242; Line End

8. Alignment Incremental Station Report

Alignment Name: Alignment
Description: project
Station Range: Start: 0+000.00, End: 1+269.27
Station Increment: 20.00

Station	Northing	Easting	Tangential Direction
0+000.00	908,545.8900m	368,590.7100m	S53° 11' 22"E
0+020.00	908,533.9066m	368,606.7224m	S53° 11' 22"E
0+040.00	908,521.9232m	368,622.7349m	S53° 11' 22"E
0+060.00	908,509.5021m	368,638.4024m	S48° 54' 43"E
0+080.00	908,495.6266m	368,652.7947m	S43° 10' 57"E
0+100.00	908,480.3836m	368,665.7298m	S37° 27' 10"E
0+120.00	908,463.9253m	368,677.0785m	S31° 43' 24"E
0+140.00	908,446.4164m	368,686.7275m	S25° 59' 38"E
0+160.00	908,428.0316m	368,694.5802m	S20° 15' 51"E
0+180.00	908,408.9546m	368,700.5584m	S14° 32' 05"E
0+200.00	908,389.3762m	368,704.6021m	S8° 48' 18"E
0+220.00	908,369.4919m	368,706.6711m	S3° 04' 32"E
0+240.00	908,349.5004m	368,706.7446m	S2° 39' 15"W
0+260.00	908,329.6014m	368,704.8219m	S8° 23' 01"W
0+280.00	908,309.9937m	368,700.9223m	S14° 03' 10"W
0+300.00	908,290.5922m	368,696.0660m	S14° 03' 10"W
0+320.00	908,271.1908m	368,691.2097m	S14° 03' 10"W
0+340.00	908,251.7893m	368,686.3535m	S14° 03' 10"W
0+360.00	908,232.4320m	368,681.3284m	S15° 51' 42"W
0+380.00	908,213.3601m	368,675.3155m	S19° 08' 09"W
0+400.00	908,194.6628m	368,668.2232m	S22° 24' 35"W
0+420.00	908,176.4010m	368,660.0747m	S25° 41' 02"W
0+440.00	908,158.6344m	368,650.8965m	S28° 57' 28"W
0+460.00	908,141.4210m	368,640.7186m	S32° 13' 55"W
0+480.00	908,124.8170m	368,629.5742m	S35° 30' 22"W
0+500.00	908,108.8766m	368,617.4997m	S38° 46' 48"W
0+520.00	908,093.6221m	368,604.5680m	S41° 08' 17"W
0+540.00	908,078.5596m	368,591.4105m	S41° 08' 17"W
0+560.00	908,063.4971m	368,578.2530m	S41° 08' 17"W
0+580.00	908,048.4346m	368,565.0954m	S41° 08' 17"W

0+600.00	908,033.3721m	368,551.9379m	S41° 08' 17"W
0+620.00	908,018.3096m	368,538.7803m	S41° 08' 17"W
0+640.00	908,003.2471m	368,525.6228m	S41° 08' 17"W
0+660.00	907,988.1846m	368,512.4653m	S41° 08' 17"W
0+680.00	907,973.1220m	368,499.3077m	S41° 08' 17"W
0+700.00	907,958.0595m	368,486.1502m	S41° 08' 17"W
0+720.00	907,942.9970m	368,472.9927m	S41° 08' 17"W
0+740.00	907,927.8653m	368,459.9157m	S39° 36' 48"W
0+760.00	907,912.0446m	368,447.6865m	S35° 47' 37"W
0+780.00	907,895.4443m	368,436.5383m	S31° 58' 26"W
0+800.00	907,878.2721m	368,426.2867m	S30° 35' 01"W
0+820.00	907,861.0543m	368,416.1108m	S30° 35' 01"W
0+840.00	907,843.8366m	368,405.9348m	S30° 35' 01"W
0+860.00	907,826.9918m	368,395.1625m	S34° 52' 55"W
0+880.00	907,811.0599m	368,383.0810m	S39° 27' 56"W
0+900.00	907,796.1445m	368,369.7650m	S44° 02' 58"W
0+920.00	907,782.3409m	368,355.2996m	S48° 37' 59"W
0+940.00	907,769.7375m	368,339.7773m	S53° 13' 00"W
0+960.00	907,758.4148m	368,323.2975m	S57° 46' 44"W
0+980.00	907,747.7511m	368,306.3776m	S57° 46' 44"W
1+000.00	907,737.0974m	368,289.4513m	S58° 24' 08"W
1+020.00	907,727.4869m	368,271.9212m	S64° 07' 55"W
1+040.00	907,719.6744m	368,253.5192m	S69° 51' 41"W
1+060.00	907,713.7382m	368,234.4293m	S75° 35' 28"W
1+080.00	907,709.7374m	368,214.8420m	S81° 19' 14"W
1+100.00	907,707.7120m	368,194.9532m	S87° 03' 01"W
1+120.00	907,706.9493m	368,174.9678m	S87° 52' 24"W
1+140.00	907,706.2071m	368,154.9816m	S87° 52' 24"W
1+160.00	907,705.4649m	368,134.9954m	S87° 52' 24"W
1+180.00	907,704.7227m	368,115.0092m	S87° 52' 24"W
1+200.00	907,703.9806m	368,095.0229m	S87° 52' 24"W
1+220.00	907,703.2384m	368,075.0367m	S87° 52' 24"W
1+240.00	907,702.4962m	368,055.0505m	S87° 52' 24"W
1+260.00	907,701.7540m	368,035.0643m	S87° 52' 24"W
1+269.27	907,701.4100m	368,025.8007m	S87° 52' 24"W

9. Alignment PI Station Report

Alignment Name: Alignment
Description: project
Station Range: Start: 0+000.00, End: 1+269.27

PI Station	Northing	Easting	Distance	Direction
0+000.00	908,545.8900m	368,590.7100m		
			178.055m	S53° 11' 22"E
0+178.05	908,439.2048m	368,733.2645m		
			286.450m	S14° 03' 10"W
0+433.25	908,161.3271m	368,663.7103m		
			329.625m	S41° 08' 17"W
0+759.73	907,913.0780m	368,446.8575m		
			142.146m	S30° 35' 01"W
0+901.72	907,790.7065m	368,374.5341m		
			152.154m	S57° 46' 44"W
1+051.59	907,709.5800m	368,245.8121m		
			220.164m	S87° 52' 24"W
1+269.27	907,701.4100m	368,025.8000m		

10. Alignment Station and Curve Report

Alignment: Alignment
Description: project

Tangent Data

Description	PT Station	Northing	Easting
Start:	0+00.000	908545.890	368590.710
End:	0+45.069	908518.886	368626.793

Tangent Data

Parameter	Value	Parameter	Value
Length:	45.069	Course:	S 53° 11' 22.1999" E

Curve Point Data

Description	Station	Northing	Easting
PC:	0+45.069	908518.886	368626.793
RP:		908358.762	368506.959
PT:	2+79.789	908310.199	368700.974

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	67° 14' 31.9231"	Type:	RIGHT
Radius:	200.000		
Length:	234.720	Tangent:	132.986
Mid-Ord:	33.457	External:	40.178
Chord:	221.479	Course:	S 19° 34' 06.2383" E

Tangent Data

Description	PT Station	Northing	Easting
Start:	2+79.789	908310.199	368700.974
End:	3+48.949	908243.108	368684.180

Tangent Data

Parameter	Value	Parameter	Value

Length:	69.161	Course:	S 14° 03' 09.7233" W

Curve Point Data

Description	Station	Northing	Easting
PC:	3+48.949	908243.108	368684.180
RP:		908328.093	368344.655
PT:	5+14.405	908097.836	368608.249

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	27° 05' 07.6369"	Type:	RIGHT
Radius:	350.000		
Length:	165.456	Tangent:	84.304
Mid-Ord:	9.732	External:	10.010
Chord:	163.919	Course:	S 27° 35' 43.5417" W

Tangent Data

Description	PT Station	Northing	Easting
Start:	5+14.405	908097.836	368608.249
End:	7+32.017	907933.947	368465.087

Tangent Data

Parameter	Value	Parameter	Value
Length:	217.612	Course:	S 41° 08' 17.3602" W

Curve Point Data

Description	Station	Northing	Easting
PC:	7+32.017	907933.947	368465.087
RP:		907736.584	368691.025
PT:	7+87.280	907889.223	368432.759

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	10° 33' 16.0006"	Type:	LEFT
Radius:	300.000		
Length:	55.263	Tangent:	27.710
Mid-Ord:	1.272	External:	1.277
Chord:	55.185	Course:	S 35° 51' 39.3599" W

Tangent Data

Description	PT Station	Northing	Easting
Start:	7+87.280	907889.223	368432.759
End:	8+41.245	907842.765	368405.301

Tangent Data

Parameter	Value	Parameter	Value
Length:	53.966	Course:	S 30° 35' 01.3596" W

Curve Point Data

Description	Station	Northing	Easting
PC:	8+41.245	907842.765	368405.301
RP:		907969.964	368190.080
PT:	9+59.907	907758.464	368323.376

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	27° 11' 43.0803"	Type:	RIGHT
Radius:	250.000		
Length:	118.662	Tangent:	60.471
Mid-Ord:	7.007	External:	7.209
Chord:	117.551	Course:	S 44° 10' 52.8998" W

Tangent Data

Description	PT Station	Northing	Easting
Start:	9+59.907	907758.464	368323.376
End:	9+97.824	907738.247	368291.298

Tangent Data

Parameter	Value	Parameter	Value
Length:	37.917	Course:	S 57° 46' 44.4399" W

Curve Point Data

Description	Station	Northing	Easting
PC:	9+97.824	907738.247	368291.298
RP:		907907.447	368184.661
PT:	11+02.873	907707.585	368192.083

Circular Curve Data

Parameter	Value	Parameter	Value
Delta:	30° 05' 39.5651"	Type:	RIGHT
Radius:	200.000		
Length:	105.049	Tangent:	53.766
Mid-Ord:	6.858	External:	7.101
Chord:	103.846	Course:	S 72° 49' 34.2224" W

Tangent Data

Description	PT Station	Northing	Easting

Start:	11+02.873	907707.585	368192.083
End:	12+69.271	907701.410	368025.800

Tangent Data

Parameter	Value	Parameter	Value
Length:	166.397	Course:	S 87° 52' 24.0050" W

11. Daylight Line Report

Corridor Name: Corridor
Description: - thesis
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Station Range: Start: 0+000.00, End: 1+269.27

SL Name	Station	Left Daylight Offset	X Left	Y Left	Z Left	Right Daylight Offset	X Right	Y Right	Z Right
0+020.00	0+020.00	-6.691	368,610.731	908,539.263	1,936.477	9.577	368,600.984	908,526.239	1,936.894
0+040.00	0+040.00	-6.693	368,626.745	908,527.282	1,935.755	9.569	368,617.002	908,514.262	1,936.169
0+060.00	0+060.00	-6.709	368,642.812	908,514.559	1,934.979	9.684	368,632.038	908,502.203	1,935.454
0+080.00	0+080.00	-7.294	368,658.114	908,500.618	1,934.178	9.707	368,645.717	908,488.984	1,934.811
0+100.00	0+100.00	-6.907	368,671.213	908,484.584	1,933.656	9.639	368,658.078	908,474.522	1,934.158
0+120.00	0+120.00	-6.859	368,682.912	908,467.532	1,933.059	9.449	368,669.041	908,458.957	1,933.454
0+140.00	0+140.00	-6.846	368,692.881	908,449.417	1,932.370	9.317	368,678.353	908,442.333	1,932.697
0+160.00	0+160.00	-6.592	368,700.764	908,430.315	1,931.378	9.759	368,685.425	908,424.651	1,931.861
0+180.00	0+180.00	-6.438	368,706.791	908,410.570	1,930.672	9.456	368,691.405	908,406.582	1,930.965
0+200.00	0+200.00	-6.325	368,710.853	908,390.344	1,930.089	9.253	368,695.458	908,387.960	1,930.253
0+220.00	0+220.00	-6.385	368,713.046	908,369.834	1,929.592	9.356	368,697.329	908,368.990	1,929.822
0+240.00	0+240.00	-6.454	368,713.191	908,349.202	1,929.136	9.547	368,697.208	908,349.942	1,929.479
0+260.00	0+260.00	-6.576	368,711.327	908,328.643	1,928.709	9.648	368,695.277	908,331.008	1,929.133
0+280.00	0+280.00	-6.764	368,707.484	908,308.351	1,928.303	9.603	368,691.607	908,312.325	1,928.752
0+300.0	0+300.0	-6.837	368,702.6	908,288.9	1,927.8	9.628	368,686.7	908,292.9	1,928.3

0	0		98	32	90		26	30	70
0+320.00	0+320.00	-6.876	368,697.880	908,269.521	1,927.427	9.702	368,681.798	908,273.546	1,927.952
0+340.00	0+340.00	-6.696	368,692.849	908,250.163	1,927.512	9.614	368,677.028	908,254.124	1,927.949
0+360.00	0+360.00	-6.975	368,688.038	908,230.525	1,928.231	10.040	368,671.671	908,235.176	1,928.950
0+380.00	0+380.00	-7.096	368,682.019	908,211.034	1,928.793	10.191	368,665.688	908,216.701	1,929.619
0+400.00	0+400.00	-7.021	368,674.714	908,191.986	1,928.543	10.173	368,658.818	908,198.541	1,929.341
0+420.00	0+420.00	-6.807	368,666.209	908,173.451	1,928.391	10.136	368,650.940	908,180.794	1,929.117
0+440.00	0+440.00	-6.422	368,656.516	908,155.525	1,928.315	10.120	368,642.041	908,163.534	1,928.937
0+460.00	0+460.00	-6.360	368,646.099	908,138.029	1,928.266	9.886	368,632.356	908,146.694	1,928.755
0+480.00	0+480.00	-6.348	368,634.742	908,121.130	1,928.232	9.911	368,621.506	908,130.573	1,928.731
0+500.00	0+500.00	-6.301	368,622.412	908,104.930	1,928.302	10.179	368,609.565	908,115.252	1,928.923
0+520.00	0+520.00	-6.310	368,609.321	908,089.471	1,928.708	10.529	368,596.638	908,100.549	1,929.506
0+540.00	0+540.00	-6.360	368,596.201	908,074.375	1,929.120	10.227	368,583.708	908,085.288	1,929.780
0+560.00	0+560.00	-6.556	368,583.190	908,059.184	1,929.377	10.101	368,570.646	908,070.142	1,930.022
0+580.00	0+580.00	-6.770	368,570.194	908,043.981	1,929.375	10.237	368,557.386	908,055.169	1,930.142
0+600.00	0+600.00	-7.027	368,557.230	908,028.749	1,929.373	10.345	368,544.147	908,040.178	1,930.258
0+620.00	0+620.00	-7.454	368,544.394	908,013.406	1,929.369	10.379	368,530.963	908,025.138	1,930.378
0+640.00	0+640.00	-7.592	368,531.340	907,998.253	1,929.369	10.601	368,517.639	908,010.222	1,930.524
0+660.00	0+660.00	-9.278	368,519.453	907,982.081	1,929.340	10.016	368,504.922	907,994.774	1,930.624
0+680.00	0+680.00	-10.853	368,507.481	907,965.982	1,929.312	9.326	368,492.284	907,979.257	1,930.644
0+700.00	0+700.00	-7.593	368,491.869	907,953.064	1,930.100	9.374	368,479.090	907,964.227	1,930.642

0+720.00	0+720.00	-6.819	368,478.128	907,938.511	1,930.281	9.463	368,465.866	907,949.223	1,930.673
0+740.00	0+740.00	-6.627	368,465.021	907,923.640	1,930.383	9.610	368,452.513	907,933.993	1,930.801
0+760.00	0+760.00	-6.720	368,453.138	907,908.114	1,930.468	9.634	368,439.872	907,917.679	1,930.921
0+780.00	0+780.00	-7.090	368,442.552	907,891.690	1,930.499	9.669	368,428.336	907,900.564	1,931.062
0+800.00	0+800.00	-6.732	368,432.082	907,874.847	1,930.597	9.845	368,417.811	907,883.281	1,931.158
0+820.00	0+820.00	-6.805	368,421.969	907,857.592	1,930.659	9.699	368,407.761	907,865.989	1,931.165
0+840.00	0+840.00	-7.903	368,412.738	907,839.816	1,930.475	9.532	368,397.729	907,848.687	1,931.173
0+860.00	0+860.00	-7.755	368,401.524	907,822.557	1,930.470	9.678	368,387.224	907,832.526	1,931.204
0+880.00	0+880.00	-7.720	368,389.041	907,806.153	1,930.516	9.692	368,375.599	907,817.220	1,931.248
0+900.00	0+900.00	-7.669	368,375.277	907,790.813	1,930.657	9.615	368,362.854	907,802.830	1,931.337
0+920.00	0+920.00	-7.398	368,360.189	907,776.789	1,930.853	9.462	368,349.046	907,789.442	1,931.389
0+940.00	0+940.00	-6.515	368,343.678	907,764.520	1,931.167	9.341	368,334.184	907,777.219	1,931.423
0+960.00	0+960.00	-6.445	368,326.734	907,752.963	1,931.347	9.326	368,318.325	907,766.305	1,931.578
0+980.00	0+980.00	-6.836	368,310.022	907,741.968	1,931.475	9.392	368,301.370	907,755.697	1,931.836
1+000.00	1+000.00	-6.761	368,292.994	907,731.339	1,931.614	9.623	368,284.409	907,745.294	1,932.072
1+020.00	1+020.00	-6.629	368,274.813	907,721.522	1,931.866	9.659	368,267.707	907,736.178	1,932.309
1+040.00	1+040.00	-6.564	368,255.779	907,713.512	1,932.200	9.641	368,250.200	907,728.726	1,932.617
1+060.00	1+060.00	-6.638	368,236.081	907,707.309	1,932.561	9.570	368,232.048	907,723.007	1,932.961
1+080.00	1+080.00	-6.514	368,215.825	907,703.298	1,932.944	9.518	368,213.406	907,719.146	1,933.287
1+100.00	1+100.00	-6.407	368,195.283	907,701.314	1,933.341	9.446	368,194.467	907,717.145	1,933.622
1+120.0	1+120.0	-6.417	368,175.2	907,700.5	1,933.7	9.289	368,174.6	907,716.2	1,933.9

0	0		06	37	43		23	32	48
1+140.00	1+140.00	-6.308	368,155.216	907,699.903	1,934.121	9.178	368,154.641	907,715.379	1,934.243
1+160.00	1+160.00	-6.558	368,135.239	907,698.911	1,934.250	9.130	368,134.657	907,714.589	1,934.407
1+180.00	1+180.00	-6.677	368,115.257	907,698.050	1,934.361	9.251	368,114.666	907,713.968	1,934.517
1+200.00	1+200.00	-6.456	368,095.263	907,697.529	1,934.404	9.308	368,094.678	907,713.283	1,934.628
1+220.00	1+220.00	-6.338	368,075.272	907,696.905	1,934.445	9.436	368,074.687	907,712.667	1,934.703
1+240.00	1+240.00	-6.323	368,055.285	907,696.178	1,934.491	9.335	368,054.704	907,711.825	1,934.696
1+260.00	1+260.00	-6.411	368,035.302	907,695.347	1,934.512	9.356	368,034.717	907,711.103	1,934.748

12. Lane Slope Report

Corridor Name: Corridor - thesis
Description:
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Station Range: Start: 0+000.00, End: 1+269.27

SL Name	Station	Existing Ground Elevation	Layout Profile Elevation	X	Y	Slope Left	Slope Right
0+020.00	0+020.00	1,936.643	1,936.643	368,606.722	908,533.907	2.5%	2.5%
0+040.00	0+040.00	1,935.922	1,935.922	368,622.735	908,521.923	2.5%	2.5%
0+060.00	0+060.00	1,935.150	1,935.150	368,638.402	908,509.502	2.5%	2.5%
0+080.00	0+080.00	1,934.495	1,934.495	368,652.795	908,495.627	2.5%	2.5%
0+100.00	0+100.00	1,933.876	1,933.876	368,665.730	908,480.384	2.5%	2.5%
0+120.00	0+120.00	1,933.267	1,933.267	368,677.079	908,463.925	2.5%	2.5%
0+140.00	0+140.00	1,932.576	1,932.576	368,686.727	908,446.416	2.5%	2.5%
0+160.00	0+160.00	1,931.519	1,931.519	368,694.580	908,428.032	2.5%	2.5%
0+180.00	0+180.00	1,930.775	1,930.775	368,700.558	908,408.955	2.5%	2.5%
0+200.00	0+200.00	1,930.164	1,930.164	368,704.602	908,389.376	2.5%	2.5%
0+220.00	0+220.00	1,929.682	1,929.682	368,706.671	908,369.492	2.5%	2.5%
0+240.00	0+240.00	1,929.243	1,929.243	368,706.745	908,349.500	2.5%	2.5%
0+260.00	0+260.00	1,928.846	1,928.846	368,704.822	908,329.601	2.5%	2.5%
0+280.00	0+280.00	1,928.488	1,928.488	368,700.922	908,309.994	2.5%	2.5%
0+300.00	0+300.00	1,928.093	1,928.093	368,696.066	908,290.592	2.5%	2.5%
0+320.00	0+320.00	1,927.639	1,927.639	368,691.210	908,271.191	2.5%	2.5%
0+340.00	0+340.00	1,927.679	1,927.679	368,686.353	908,251.789	2.5%	2.5%
0+360.00	0+360.00	1,928.468	1,928.468	368,681.328	908,232.432	2.5%	2.5%
0+380.00	0+380.00	1,929.061	1,929.061	368,675.316	908,213.360	2.5%	2.5%
0+400.00	0+400.00	1,928.792	1,928.792	368,668.223	908,194.663	2.5%	2.5%
0+420.00	0+420.00	1,928.587	1,928.587	368,660.075	908,176.401	2.5%	2.5%
0+440.00	0+440.00	1,928.415	1,928.415	368,650.896	908,158.634	2.5%	2.5%
0+460.00	0+460.00	1,928.350	1,928.350	368,640.719	908,141.421	2.5%	2.5%
0+480.00	0+480.00	1,928.313	1,928.313	368,629.574	908,124.817	2.5%	2.5%
0+500.00	0+500.00	1,928.371	1,928.371	368,617.500	908,108.877	2.5%	2.5%
0+520.00	0+520.00	1,928.779	1,928.779	368,604.568	908,093.622	2.5%	2.5%

0+540.00	0+540.00	1,929.204	1,929.204	368,591.410	908,078.560	2.5%	2.5%
0+560.00	0+560.00	1,929.509	1,929.509	368,578.253	908,063.497	2.5%	2.5%
0+580.00	0+580.00	1,929.561	1,929.561	368,565.095	908,048.435	2.5%	2.5%
0+600.00	0+600.00	1,929.624	1,929.624	368,551.938	908,033.372	2.5%	2.5%
0+620.00	0+620.00	1,929.726	1,929.726	368,538.780	908,018.310	2.5%	2.5%
0+640.00	0+640.00	1,929.761	1,929.761	368,525.623	908,003.247	2.5%	2.5%
0+660.00	0+660.00	1,930.153	1,930.153	368,512.465	907,988.185	2.5%	2.5%
0+680.00	0+680.00	1,930.519	1,930.519	368,499.308	907,973.122	2.5%	2.5%
0+700.00	0+700.00	1,930.493	1,930.493	368,486.150	907,958.060	2.5%	2.5%
0+720.00	0+720.00	1,930.479	1,930.479	368,472.993	907,942.997	2.5%	2.5%
0+740.00	0+740.00	1,930.534	1,930.534	368,459.916	907,927.865	2.5%	2.5%
0+760.00	0+760.00	1,930.641	1,930.641	368,447.686	907,912.045	2.5%	2.5%
0+780.00	0+780.00	1,930.765	1,930.765	368,436.538	907,895.444	2.5%	2.5%
0+800.00	0+800.00	1,930.774	1,930.774	368,426.287	907,878.272	2.5%	2.5%
0+820.00	0+820.00	1,930.854	1,930.854	368,416.111	907,861.054	2.5%	2.5%
0+840.00	0+840.00	1,930.945	1,930.945	368,405.935	907,843.837	2.5%	2.5%
0+860.00	0+860.00	1,930.903	1,930.903	368,395.163	907,826.992	2.5%	2.5%
0+880.00	0+880.00	1,930.940	1,930.940	368,383.081	907,811.060	2.5%	2.5%
0+900.00	0+900.00	1,931.067	1,931.067	368,369.765	907,796.144	2.5%	2.5%
0+920.00	0+920.00	1,931.196	1,931.196	368,355.300	907,782.341	2.5%	2.5%
0+940.00	0+940.00	1,931.290	1,931.290	368,339.777	907,769.737	2.5%	2.5%
0+960.00	0+960.00	1,931.452	1,931.452	368,323.298	907,758.415	2.5%	2.5%
0+980.00	0+980.00	1,931.678	1,931.678	368,306.378	907,747.751	2.5%	2.5%
1+000.00	1+000.00	1,931.798	1,931.798	368,289.451	907,737.097	2.5%	2.5%
1+020.00	1+020.00	1,932.017	1,932.017	368,271.921	907,727.487	2.5%	2.5%
1+040.00	1+040.00	1,932.334	1,932.334	368,253.519	907,719.674	2.5%	2.5%
1+060.00	1+060.00	1,932.714	1,932.714	368,234.429	907,713.738	2.5%	2.5%
1+080.00	1+080.00	1,933.066	1,933.066	368,214.842	907,709.737	2.5%	2.5%
1+100.00	1+100.00	1,933.437	1,933.437	368,194.953	907,707.712	2.5%	2.5%
1+120.00	1+120.00	1,933.841	1,933.841	368,174.968	907,706.949	2.5%	2.5%
1+140.00	1+140.00	1,934.191	1,934.191	368,154.982	907,706.207	2.5%	2.5%
1+160.00	1+160.00	1,934.383	1,934.383	368,134.995	907,705.465	2.5%	2.5%
1+180.00	1+180.00	1,934.524	1,934.524	368,115.009	907,704.723	2.5%	2.5%
1+200.00	1+200.00	1,934.511	1,934.511	368,095.023	907,703.981	2.5%	2.5%
1+220.00	1+220.00	1,934.523	1,934.523	368,075.037	907,703.238	2.5%	2.5%
1+240.00	1+240.00	1,934.566	1,934.566	368,055.050	907,702.496	2.5%	2.5%

1+260.00	1+260.00	1,934.608	1,934.608	368,035.064	907,701.754	2.5%	2.5%

13. Corridor Section Points Report

Corridor Name: Corridor - thesis project
Description:
Base Alignment Name: Alignment - project
Station Range: Start: 0+000.00, End: 1+269.27

CHAINAGE 0+000.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,596.1776	908,553.1959	1,937.2750	-9.125m	Hinge Cut
2	368,595.4586	908,552.2352	1,936.9750	-7.925m	Ditch Out
3	368,594.9793	908,551.5947	1,936.9750	-7.125m	Ditch In
4	368,593.9607	908,550.2336	1,937.2750	-5.425m	Sidewalk Out
5	368,593.2417	908,549.2729	1,937.2750	-4.225m	Back Curb
6	368,593.1069	908,549.0927	1,937.2750	-4.000m	Top Curb
7	368,593.1067	908,549.0925	1,936.9750	-4.000m	ETW_SubBase
8	368,593.1067	908,549.0925	1,937.1500	-4.000m	ETW
9	368,593.1063	908,549.0919	1,936.8500	-3.999m	Bottom Curb
10	368,590.7100	908,545.8900	1,937.0750	0.000m	Crown_SubBase
11	368,590.7100	908,545.8900	1,937.2500	0.000m	Crown
12	368,588.3137	908,542.6881	1,936.8500	3.999m	Bottom_Curb
13	368,588.3133	908,542.6875	1,936.9750	4.000m	ETW_SubBase
14	368,588.3133	908,542.6875	1,937.1500	4.000m	ETW
15	368,588.3131	908,542.6873	1,937.2750	4.000m	Top_Curb
16	368,588.1783	908,542.5071	1,937.2750	4.225m	Sidewalk_In
17	368,587.4593	908,541.5464	1,937.2750	5.425m	Sidewalk_Out
18	368,586.4407	908,540.1853	1,936.9750	7.125m	Ditch_In
19	368,585.9614	908,539.5448	1,936.9750	7.925m	Ditch_Out
20	368,585.2424	908,538.5841	1,937.2750	9.125m	Hinge_Cut
21	368,585.2097	908,538.5404	1,937.3023	9.180m	Daylight

CHAINAGE 0+025.00

CHAINAGE 0+050.00

CHAINAGE 0+075.00

CHAINAGE 0+100.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,671.2131	908,484.5839	1,933.6558	-6.907m	Daylight

2	368,670.4336	908,483.9868	1,933.9013	-5.925m	Hinge
3	368,670.0367	908,483.6827	1,933.9013	-5.425m	Sidewalk_Out
4	368,669.0840	908,482.9530	1,933.9013	-4.225m	Back_Curb
5	368,668.9054	908,482.8162	1,933.9013	-4.000m	Top_Curb
6	368,668.9052	908,482.8160	1,933.7763	-4.000m	ETW
7	368,668.9052	908,482.8160	1,933.6013	-4.000m	ETW_SubBase
8	368,668.9046	908,482.8156	1,933.4763	-3.999m	Bottom_Curb
9	368,665.7298	908,480.3836	1,933.8763	0.000m	Crown
10	368,665.7298	908,480.3836	1,933.7013	0.000m	Crown_SubBase
11	368,662.5549	908,477.9515	1,933.4763	3.999m	Bottom_Curb
12	368,662.5544	908,477.9511	1,933.7763	4.000m	ETW
13	368,662.5544	908,477.9511	1,933.6013	4.000m	ETW_SubBase
14	368,662.5541	908,477.9509	1,933.9013	4.000m	Top_Curb
15	368,662.3755	908,477.8141	1,933.9013	4.225m	Sidewalk_In
16	368,661.4229	908,477.0844	1,933.9013	5.425m	Sidewalk_Out
17	368,660.0733	908,476.0506	1,933.6013	7.125m	Ditch_In
18	368,659.4383	908,475.5641	1,933.6013	7.925m	Ditch_Out
19	368,658.4856	908,474.8344	1,933.9013	9.125m	Hinge_Cut
20	368,658.0780	908,474.5221	1,934.1581	9.639m	Daylight

CHAINAGE 0+125.00

CHAINAGE 0+150.00

CHAINAGE 0+175.00

CHAINAGE 0+200.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,710.8525	908,390.3444	1,930.0892	-6.325m	Daylight
2	368,710.4576	908,390.2832	1,930.1892	-5.925m	Hinge
3	368,709.9635	908,390.2067	1,930.1892	-5.425m	Sidewalk_Out
4	368,708.7776	908,390.0230	1,930.1892	-4.225m	Back_Curb
5	368,708.5553	908,389.9885	1,930.1892	-4.000m	Top_Curb
6	368,708.5550	908,389.9885	1,930.0642	-4.000m	ETW
7	368,708.5550	908,389.9885	1,929.8892	-4.000m	ETW_SubBase
8	368,708.5543	908,389.9884	1,929.7642	-3.999m	Bottom_Curb
9	368,704.6021	908,389.3762	1,930.1642	0.000m	Crown
10	368,704.6021	908,389.3762	1,929.9892	0.000m	Crown_SubBase
11	368,700.6499	908,388.7640	1,929.7642	3.999m	Bottom_Curb
12	368,700.6492	908,388.7639	1,930.0642	4.000m	ETW

13	368,700.6492	908,388.7639	1,929.8892	4.000m	ETW_SubBase
14	368,700.6490	908,388.7639	1,930.1892	4.000m	Top_Curb
15	368,700.4266	908,388.7294	1,930.1892	4.225m	Sidewalk_In
16	368,699.2407	908,388.5457	1,930.1892	5.425m	Sidewalk_Out
17	368,697.5608	908,388.2855	1,929.8892	7.125m	Ditch_In
18	368,696.7702	908,388.1631	1,929.8892	7.925m	Ditch_Out
19	368,695.5844	908,387.9794	1,930.1892	9.125m	Hinge_Cut
20	368,695.4583	908,387.9598	1,930.2530	9.253m	Daylight

CHAINAGE 0+225.00

CHAINAGE 0+250.00

CHAINAGE 0+275.00

CHAINAGE 0+300.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	368,702.6982	908,288.9322	1,927.8904	-6.837m	Daylight
2	368,701.8140	908,289.1535	1,928.1183	-5.925m	Hinge
3	368,701.3290	908,289.2749	1,928.1183	-5.425m	Sidewalk_Out
4	368,700.1649	908,289.5663	1,928.1183	-4.225m	Back_Curb
5	368,699.9466	908,289.6209	1,928.1183	-4.000m	Top_Curb
6	368,699.9463	908,289.6210	1,927.9933	-4.000m	ETW
7	368,699.9463	908,289.6210	1,927.8183	-4.000m	ETW_SubBase
8	368,699.9456	908,289.6212	1,927.6933	-3.999m	Bottom_Curb
9	368,696.0660	908,290.5922	1,928.0933	0.000m	Crown
10	368,696.0660	908,290.5922	1,927.9183	0.000m	Crown_SubBase
11	368,692.1864	908,291.5633	1,927.6933	3.999m	Bottom_Curb
12	368,692.1857	908,291.5635	1,927.9933	4.000m	ETW
13	368,692.1857	908,291.5635	1,927.8183	4.000m	ETW_SubBase
14	368,692.1855	908,291.5636	1,928.1183	4.000m	Top_Curb
15	368,691.9672	908,291.6182	1,928.1183	4.225m	Sidewalk_In
16	368,690.8031	908,291.9096	1,928.1183	5.425m	Sidewalk_Out
17	368,689.1540	908,292.3224	1,927.8183	7.125m	Ditch_In
18	368,688.3779	908,292.5166	1,927.8183	7.925m	Ditch_Out
19	368,687.2138	908,292.8080	1,928.1183	9.125m	Hinge_Cut
20	368,686.7262	908,292.9300	1,928.3696	9.628m	Daylight

CHAINAGE 0+325.00

CHAINAGE 0+350.00

CHAINAGE 0+375.00

CHAINAGE 0+400.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,674.7140	908,191.9862	1,928.5431	-7.021m	Daylight
2	368,673.7011	908,192.4039	1,928.8170	-5.925m	Hinge
3	368,673.2388	908,192.5945	1,928.8170	-5.425m	Sidewalk_Out
4	368,672.1294	908,193.0520	1,928.8170	-4.225m	Back_Curb
5	368,671.9214	908,193.1378	1,928.8170	-4.000m	Top_Curb
6	368,671.9212	908,193.1379	1,928.6920	-4.000m	ETW
7	368,671.9212	908,193.1379	1,928.5170	-4.000m	ETW_SubBase
8	368,671.9205	908,193.1381	1,928.3920	-3.999m	Bottom_Curb
9	368,668.2232	908,194.6628	1,928.7920	0.000m	Crown
10	368,668.2232	908,194.6628	1,928.6170	0.000m	Crown_SubBase
11	368,664.5260	908,196.1874	1,928.3920	3.999m	Bottom_Curb
12	368,664.5253	908,196.1877	1,928.6920	4.000m	ETW
13	368,664.5253	908,196.1877	1,928.5170	4.000m	ETW_SubBase
14	368,664.5250	908,196.1878	1,928.8170	4.000m	Top_Curb
15	368,664.3170	908,196.2736	1,928.8170	4.225m	Sidewalk_In
16	368,663.2077	908,196.7311	1,928.8170	5.425m	Sidewalk_Out
17	368,661.6360	908,197.3792	1,928.5170	7.125m	Ditch_In
18	368,660.8965	908,197.6841	1,928.5170	7.925m	Ditch_Out
19	368,659.7871	908,198.1416	1,928.8170	9.125m	Hinge_Cut
20	368,658.8180	908,198.5412	1,929.3411	10.173m	Daylight

CHAINAGE 0+425.00

CHAINAGE 0+450.00

CHAINAGE 0+475.00

CHAINAGE 0+500.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,622.4116	908,104.9301	1,928.3023	-6.301m	Daylight
2	368,622.1188	908,105.1654	1,928.3962	-5.925m	Hinge
3	368,621.7290	908,105.4785	1,928.3962	-5.425m	Sidewalk_Out
4	368,620.7935	908,106.2301	1,928.3962	-4.225m	Back_Curb

5	368,620.6181	908,106.3710	1,928.3962	-4.000m	Top_Curb
6	368,620.6179	908,106.3712	1,928.2712	-4.000m	ETW
7	368,620.6179	908,106.3712	1,928.0962	-4.000m	ETW_SubBase
8	368,620.6174	908,106.3717	1,927.9712	-3.999m	Bottom_Curb
9	368,617.4997	908,108.8766	1,928.3712	0.000m	Crown
10	368,617.4997	908,108.8766	1,928.1962	0.000m	Crown_SubBase
11	368,614.3820	908,111.3814	1,927.9712	3.999m	Bottom_Curb
12	368,614.3815	908,111.3819	1,928.2712	4.000m	ETW
13	368,614.3815	908,111.3819	1,928.0962	4.000m	ETW_SubBase
14	368,614.3812	908,111.3821	1,928.3962	4.000m	Top_Curb
15	368,614.2058	908,111.5230	1,928.3962	4.225m	Sidewalk_In
16	368,613.2704	908,112.2746	1,928.3962	5.425m	Sidewalk_Out
17	368,611.9451	908,113.3394	1,928.0962	7.125m	Ditch_In
18	368,611.3215	908,113.8404	1,928.0962	7.925m	Ditch_Out
19	368,610.3860	908,114.5920	1,928.3962	9.125m	Hinge_Cut
20	368,609.5647	908,115.2519	1,928.9230	10.179m	Daylight

CHAINAGE 0+525.00

CHAINAGE 0+550.00

CHAINAGE 0+575.00

CHAINAGE 0+600.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	368,557.2304	908,028.7489	1,929.3732	-7.027m	Daylight
2	368,556.4004	908,029.4740	1,929.6488	-5.925m	Hinge
3	368,556.0238	908,029.8029	1,929.6488	-5.425m	Sidewalk_Out
4	368,555.1201	908,030.5924	1,929.6488	-4.225m	Back_Curb
5	368,554.9506	908,030.7404	1,929.6488	-4.000m	Top_Curb
6	368,554.9504	908,030.7406	1,929.5238	-4.000m	ETW
7	368,554.9504	908,030.7406	1,929.3488	-4.000m	ETW_SubBase
8	368,554.9499	908,030.7410	1,929.2238	-3.999m	Bottom_Curb
9	368,551.9379	908,033.3721	1,929.6238	0.000m	Crown
10	368,551.9379	908,033.3721	1,929.4488	0.000m	Crown_SubBase
11	368,548.9259	908,036.0031	1,929.2238	3.999m	Bottom_Curb
12	368,548.9254	908,036.0036	1,929.5238	4.000m	ETW
13	368,548.9254	908,036.0036	1,929.3488	4.000m	ETW_SubBase
14	368,548.9252	908,036.0038	1,929.6488	4.000m	Top_Curb

15	368,548.7557	908,036.1518	1,929.6488	4.225m	Sidewalk_In
16	368,547.8520	908,036.9413	1,929.6488	5.425m	Sidewalk_Out
17	368,546.5716	908,038.0596	1,929.3488	7.125m	Ditch_In
18	368,545.9691	908,038.5859	1,929.3488	7.925m	Ditch_Out
19	368,545.0654	908,039.3754	1,929.6488	9.125m	Hinge_Cut
20	368,544.1471	908,040.1775	1,930.2584	10.345m	Daylight

CHAINAGE 0+625.00

CHAINAGE 0+650.00

CHAINAGE 0+675.00

CHAINAGE 0+700.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	368,491.8690	907,953.0640	1,930.1005	-7.593m	Daylight
2	368,490.6127	907,954.1614	1,930.5175	-5.925m	Hinge
3	368,490.2361	907,954.4904	1,930.5175	-5.425m	Sidewalk_Out
4	368,489.3324	907,955.2798	1,930.5175	-4.225m	Back_Curb
5	368,489.1629	907,955.4278	1,930.5175	-4.000m	Top_Curb
6	368,489.1627	907,955.4280	1,930.3925	-4.000m	ETW
7	368,489.1627	907,955.4280	1,930.2175	-4.000m	ETW_SubBase
8	368,489.1622	907,955.4285	1,930.0925	-3.999m	Bottom_Curb
9	368,486.1502	907,958.0595	1,930.4925	0.000m	Crown
10	368,486.1502	907,958.0595	1,930.3175	0.000m	Crown_SubBase
11	368,483.1382	907,960.6906	1,930.0925	3.999m	Bottom_Curb
12	368,483.1377	907,960.6910	1,930.3925	4.000m	ETW
13	368,483.1377	907,960.6910	1,930.2175	4.000m	ETW_SubBase
14	368,483.1375	907,960.6912	1,930.5175	4.000m	Top_Curb
15	368,482.9680	907,960.8393	1,930.5175	4.225m	Sidewalk_In
16	368,482.0643	907,961.6287	1,930.5175	5.425m	Sidewalk_Out
17	368,480.7839	907,962.7471	1,930.2175	7.125m	Ditch_In
18	368,480.1814	907,963.2734	1,930.2175	7.925m	Ditch_Out
19	368,479.2777	907,964.0629	1,930.5175	9.125m	Hinge_Cut
20	368,479.0901	907,964.2268	1,930.6421	9.374m	Daylight

CHAINAGE 0+725.00

CHAINAGE 0+750.00

CHAINAGE 0+775.00

CHAINAGE 0+800.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,432.0818	907,874.8471	1,930.5970	-6.732m	Daylight
2	368,431.3877	907,875.2573	1,930.7986	-5.925m	Hinge
3	368,430.9573	907,875.5117	1,930.7986	-5.425m	Sidewalk_Out
4	368,429.9242	907,876.1223	1,930.7986	-4.225m	Back_Curb
5	368,429.7305	907,876.2367	1,930.7986	-4.000m	Top_Curb
6	368,429.7303	907,876.2369	1,930.6736	-4.000m	ETW
7	368,429.7303	907,876.2369	1,930.4986	-4.000m	ETW_SubBase
8	368,429.7296	907,876.2372	1,930.3736	-3.999m	Bottom_Curb
9	368,426.2867	907,878.2721	1,930.7736	0.000m	Crown
10	368,426.2867	907,878.2721	1,930.5986	0.000m	Crown_SubBase
11	368,422.8438	907,880.3069	1,930.3736	3.999m	Bottom_Curb
12	368,422.8432	907,880.3073	1,930.6736	4.000m	ETW
13	368,422.8432	907,880.3073	1,930.4986	4.000m	ETW_SubBase
14	368,422.8429	907,880.3074	1,930.7986	4.000m	Top_Curb
15	368,422.6492	907,880.4219	1,930.7986	4.225m	Sidewalk_In
16	368,421.6161	907,881.0324	1,930.7986	5.425m	Sidewalk_Out
17	368,420.1526	907,881.8974	1,930.4986	7.125m	Ditch_In
18	368,419.4639	907,882.3044	1,930.4986	7.925m	Ditch_Out
19	368,418.4309	907,882.9150	1,930.7986	9.125m	Hinge_Cut
20	368,417.8113	907,883.2812	1,931.1584	9.845m	Daylight

CHAINAGE 0+825.00

CHAINAGE 0+850.00

CHAINAGE 0+875.00

CHAINAGE 0+900.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,375.2769	907,790.8125	1,930.6566	-7.669m	Daylight
2	368,374.0237	907,792.0248	1,931.0925	-5.925m	Hinge
3	368,373.6644	907,792.3724	1,931.0925	-5.425m	Sidewalk_Out
4	368,372.8019	907,793.2067	1,931.0925	-4.225m	Back_Curb

5	368,372.6402	907,793.3632	1,931.0925	-4.000m	Top_Curb
6	368,372.6399	907,793.3634	1,930.9675	-4.000m	ETW
7	368,372.6399	907,793.3634	1,930.7925	-4.000m	ETW_SubBase
8	368,372.6394	907,793.3639	1,930.6675	-3.999m	Bottom_Curb
9	368,369.7650	907,796.1445	1,931.0675	0.000m	Crown
10	368,369.7650	907,796.1445	1,930.8925	0.000m	Crown_SubBase
11	368,366.8905	907,798.9251	1,930.6675	3.999m	Bottom_Curb
12	368,366.8900	907,798.9256	1,930.9675	4.000m	ETW
13	368,366.8900	907,798.9256	1,930.7925	4.000m	ETW_SubBase
14	368,366.8898	907,798.9258	1,931.0925	4.000m	Top_Curb
15	368,366.7281	907,799.0822	1,931.0925	4.225m	Sidewalk_In
16	368,365.8656	907,799.9166	1,931.0925	5.425m	Sidewalk_Out
17	368,364.6437	907,801.0985	1,930.7925	7.125m	Ditch_In
18	368,364.0687	907,801.6548	1,930.7925	7.925m	Ditch_Out
19	368,363.2063	907,802.4891	1,931.0925	9.125m	Hinge_Cut
20	368,362.8542	907,802.8297	1,931.3374	9.615m	Daylight

CHAINAGE 0+925.00

CHAINAGE 0+950.00

CHAINAGE 0+975.00

CHAINAGE 1+000.00

POINT	**X**	**Y**	**Z**	**OFFSET**	**STRING CUT**
1	368,292.9938	907,731.3387	1,931.6138	-6.761m	Daylight
2	368,292.5559	907,732.0505	1,931.8228	-5.925m	Hinge
3	368,292.2939	907,732.4764	1,931.8228	-5.425m	Sidewalk_Out
4	368,291.6652	907,733.4985	1,931.8228	-4.225m	Back_Curb
5	368,291.5473	907,733.6902	1,931.8228	-4.000m	Top_Curb
6	368,291.5471	907,733.6904	1,931.6978	-4.000m	ETW
7	368,291.5471	907,733.6904	1,931.5228	-4.000m	ETW_SubBase
8	368,291.5468	907,733.6910	1,931.3978	-3.999m	Bottom_Curb
9	368,289.4513	907,737.0974	1,931.7978	0.000m	Crown
10	368,289.4513	907,737.0974	1,931.6228	0.000m	Crown_SubBase
11	368,287.3559	907,740.5038	1,931.3978	3.999m	Bottom_Curb
12	368,287.3555	907,740.5044	1,931.6978	4.000m	ETW

13	368,287.3555	907,740.5044	1,931.5228	4.000m	ETW_SubBase
14	368,287.3554	907,740.5046	1,931.8228	4.000m	Top_Curb
15	368,287.2375	907,740.6963	1,931.8228	4.225m	Sidewalk_In
16	368,286.6087	907,741.7184	1,931.8228	5.425m	Sidewalk_Out
17	368,285.7180	907,743.1664	1,931.5228	7.125m	Ditch_In
18	368,285.2989	907,743.8478	1,931.5228	7.925m	Ditch_Out
19	368,284.6701	907,744.8699	1,931.8228	9.125m	Hinge_Cut
20	368,284.4094	907,745.2937	1,932.0716	9.623m	Daylight

CHAINAGE 1+025.00

CHAINAGE 1+050.00

CHAINAGE 1+075.00

CHAINAGE 1+100.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,195.2829	907,701.3138	1,933.3414	-6.407m	Daylight
2	368,195.2581	907,701.7946	1,933.4617	-5.925m	Hinge
3	368,195.2324	907,702.2939	1,933.4617	-5.425m	Sidewalk_Out
4	368,195.1706	907,703.4924	1,933.4617	-4.225m	Back_Curb
5	368,195.1591	907,703.7171	1,933.4617	-4.000m	Top_Curb
6	368,195.1590	907,703.7173	1,933.3367	-4.000m	ETW
7	368,195.1590	907,703.7173	1,933.1617	-4.000m	ETW_SubBase
8	368,195.1590	907,703.7181	1,933.0367	-3.999m	Bottom_Curb
9	368,194.9532	907,707.7120	1,933.4367	0.000m	Crown
10	368,194.9532	907,707.7120	1,933.2617	0.000m	Crown_SubBase
11	368,194.7474	907,711.7060	1,933.0367	3.999m	Bottom_Curb
12	368,194.7474	907,711.7067	1,933.3367	4.000m	ETW
13	368,194.7474	907,711.7067	1,933.1617	4.000m	ETW_SubBase
14	368,194.7473	907,711.7070	1,933.4617	4.000m	Top_Curb
15	368,194.7358	907,711.9317	1,933.4617	4.225m	Sidewalk_In
16	368,194.6740	907,713.1302	1,933.4617	5.425m	Sidewalk_Out
17	368,194.5865	907,714.8279	1,933.1617	7.125m	Ditch_In
18	368,194.5454	907,715.6268	1,933.1617	7.925m	Ditch_Out
19	368,194.4836	907,716.8253	1,933.4617	9.125m	Hinge_Cut
20	368,194.4671	907,717.1454	1,933.6220	9.446m	Daylight

CHAINAGE 1+125.00

CHAINAGE 1+150.00

CHAINAGE 1+175.00

CHAINAGE 1+200.00

POINT	X	Y	Z	OFFSET	STRING CUT
1	368,095.2625	907,697.5292	1,934.4038	-6.456m	Daylight
2	368,095.2428	907,698.0593	1,934.5364	-5.925m	Hinge
3	368,095.2243	907,698.5590	1,934.5364	-5.425m	Sidewalk_Out
4	368,095.1797	907,699.7582	1,934.5364	-4.225m	Back_Curb
5	368,095.1714	907,699.9830	1,934.5364	-4.000m	Top_Curb
6	368,095.1714	907,699.9833	1,934.4114	-4.000m	ETW
7	368,095.1714	907,699.9833	1,934.2364	-4.000m	ETW_SubBase
8	368,095.1714	907,699.9840	1,934.1114	-3.999m	Bottom_Curb
9	368,095.0229	907,703.9806	1,934.5114	0.000m	Crown
10	368,095.0229	907,703.9806	1,934.3364	0.000m	Crown_SubBase
11	368,094.8745	907,707.9771	1,934.1114	3.999m	Bottom_Curb
12	368,094.8745	907,707.9778	1,934.4114	4.000m	ETW
13	368,094.8745	907,707.9778	1,934.2364	4.000m	ETW_SubBase
14	368,094.8745	907,707.9781	1,934.5364	4.000m	Top_Curb
15	368,094.8661	907,708.2029	1,934.5364	4.225m	Sidewalk_In
16	368,094.8216	907,709.4021	1,934.5364	5.425m	Sidewalk_Out
17	368,094.7585	907,711.1009	1,934.2364	7.125m	Ditch_In
18	368,094.7288	907,711.9004	1,934.2364	7.925m	Ditch_Out
19	368,094.6843	907,713.0996	1,934.5364	9.125m	Hinge_Cut
20	368,094.6775	907,713.2826	1,934.6280	9.308m	Daylight

CHAINAGE 1+225.00

CHAINAGE 1+250.00

14. Station Offset to Points Report

Alignment Name: Alignment - project
Description:
Station Range: Start: 0+000.00, End: 1+269.27

Point	Station	Offset	Elevation	Description
9	0+027.79	5.107m	1,936.550m	
65	0+436.97	34.652m	1,929.850m	
1	0+001.70	-10.978m	1,937.020m	
2	0+001.03	-5.717m	1,937.120m	
3	0+000.00	0.000m	1,937.250m	
4	Out of range	Out of range	1,937.300m	
5	Out of range	Out of range	1,937.320m	
6	0+026.11	-13.917m	1,936.040m	
7	0+026.44	-7.325m	1,936.250m	
8	0+027.07	-1.012m	1,936.400m	
10	0+027.30	10.916m	1,936.750m	
11	0+052.30	-16.625m	1,935.080m	
12	0+052.97	-9.070m	1,935.220m	
13	0+053.18	-2.287m	1,935.340m	
14	0+053.53	5.509m	1,935.580m	
15	0+052.06	14.272m	1,935.820m	
16	0+072.07	-22.215m	1,934.120m	
17	0+076.18	-13.584m	1,934.180m	
18	0+078.45	-5.735m	1,934.260m	
19	0+081.01	1.912m	1,934.560m	
20	0+083.60	11.805m	1,934.760m	
21	0+097.53	-34.219m	1,933.080m	
22	0+101.51	-21.666m	1,933.160m	
23	0+105.29	-13.954m	1,933.260m	
24	0+109.79	-4.277m	1,933.420m	
25	0+111.53	3.921m	1,933.680m	
26	0+137.75	-50.391m	1,931.900m	
27	0+138.00	-37.511m	1,932.100m	
28	0+137.07	-29.030m	1,932.220m	
29	0+137.89	-6.617m	1,932.480m	
30	0+140.80	4.540m	1,932.680m	

31	0+161.82	-47.019m	1,930.780m	
32	0+162.61	-31.248m	1,930.900m	
33	0+162.46	-18.638m	1,931.040m	
34	0+165.64	-0.370m	1,931.220m	
35	0+172.39	15.442m	1,931.480m	
36	0+207.12	-32.802m	1,929.660m	
37	0+204.85	-16.351m	1,929.880m	
38	0+203.27	-4.546m	1,930.020m	
39	0+201.08	11.096m	1,930.240m	
40	0+196.97	22.495m	1,930.540m	
41	0+241.82	-33.519m	1,928.580m	
42	0+244.80	-17.488m	1,928.840m	
43	0+248.94	-0.973m	1,929.040m	
44	0+251.86	9.669m	1,929.300m	
45	0+254.79	21.721m	1,929.500m	
46	0+282.27	-38.873m	1,927.620m	
47	0+288.05	-21.846m	1,927.860m	
48	0+292.22	-6.551m	1,928.080m	
49	0+295.45	5.422m	1,928.360m	
50	0+298.55	18.295m	1,928.640m	
51	0+317.48	-47.954m	1,926.610m	
52	0+322.41	-30.396m	1,926.850m	
53	0+327.69	-13.779m	1,927.040m	
54	0+331.90	-1.001m	1,927.340m	
55	0+335.02	9.064m	1,927.680m	
56	0+376.17	-35.159m	1,928.250m	
57	0+375.35	-17.776m	1,928.500m	
58	0+375.01	-1.794m	1,929.040m	
59	0+374.67	11.136m	1,929.750m	
60	0+372.56	22.312m	1,929.800m	
61	0+434.65	-19.050m	1,928.160m	
62	0+434.91	-1.319m	1,928.400m	
63	0+435.78	12.056m	1,929.080m	
64	0+434.67	20.846m	1,929.700m	
66	0+495.58	-7.532m	1,928.200m	
67	0+496.37	5.419m	1,928.360m	

68	0+499.50	16.110m	1,929.500m	
69	0+499.79	26.399m	1,929.600m	
70	0+501.42	38.362m	1,929.750m	
71	0+550.39	-13.302m	1,929.250m	
72	0+553.82	0.140m	1,929.500m	
73	0+556.29	10.746m	1,930.040m	
74	0+559.05	23.087m	1,930.750m	
75	0+562.19	36.091m	1,930.820m	
76	0+613.56	-17.535m	1,929.180m	
77	0+614.78	-4.618m	1,929.420m	
78	0+615.34	5.320m	1,930.060m	
79	0+615.21	17.501m	1,930.750m	
80	0+614.97	31.709m	1,930.900m	
81	0+674.24	-16.345m	1,929.220m	
82	0+676.97	-6.919m	1,929.380m	
83	0+677.89	-0.138m	1,930.520m	
84	0+678.99	7.718m	1,930.620m	
85	0+680.97	18.269m	1,930.780m	
86	0+723.28	-23.758m	1,929.080m	
87	0+726.36	-14.279m	1,929.960m	
88	0+727.60	-4.338m	1,930.400m	
89	0+729.35	5.568m	1,930.580m	
90	0+729.82	17.159m	1,931.020m	
91	0+789.38	-27.775m	1,930.020m	
92	0+788.96	-14.619m	1,930.350m	
93	0+787.35	-4.351m	1,930.600m	
94	0+786.33	4.613m	1,931.000m	
95	0+783.97	17.909m	1,931.250m	
96	0+849.31	-14.542m	1,930.250m	
97	0+848.16	-6.767m	1,930.500m	
98	0+846.33	1.036m	1,931.000m	
99	0+842.80	12.223m	1,931.250m	
100	0+838.74	23.294m	1,931.580m	
101	0+897.74	-20.942m	1,930.280m	
102	0+900.23	-9.487m	1,930.560m	
103	0+901.79	-0.570m	1,931.060m	

104	0+904.67	7.409m	1,931.300m	
105	0+909.03	16.650m	1,931.620m	
106	0+949.00	-28.333m	1,930.500m	
107	0+946.81	-17.678m	1,930.750m	
108	0+946.44	-6.935m	1,931.250m	
109	0+947.03	4.795m	1,931.340m	
110	0+947.51	16.370m	1,931.520m	
111	1+007.06	-14.759m	1,931.500m	
112	1+006.91	-2.797m	1,931.750m	
113	1+005.17	4.907m	1,932.000m	
114	1+002.87	14.826m	1,932.250m	
115	1+000.80	27.816m	1,932.580m	
116	1+065.75	-15.152m	1,932.500m	
117	1+065.90	-3.029m	1,932.750m	
118	1+065.77	5.698m	1,933.000m	
119	1+065.79	19.984m	1,933.250m	
120	1+062.04	35.456m	1,933.500m	
121	1+131.85	-28.119m	1,933.500m	
122	1+130.83	-21.322m	1,933.750m	
123	1+134.56	-14.949m	1,934.000m	
124	1+136.57	-1.015m	1,934.150m	
125	1+138.92	12.471m	1,934.250m	
126	1+178.25	-30.719m	1,934.000m	
127	1+177.56	-24.300m	1,934.150m	
128	1+176.84	-18.333m	1,934.250m	
129	1+175.68	-6.858m	1,934.350m	
130	1+176.27	2.110m	1,934.580m	
131	1+235.16	-20.480m	1,934.250m	
132	1+233.70	-12.188m	1,934.400m	
133	1+230.87	-2.807m	1,934.500m	
134	1+229.58	4.150m	1,934.600m	
135	1+227.60	12.032m	1,934.750m	
136	Out of range	Out of range	1,934.500m	
137	1+269.27	0.000m	1,934.600m	
138	1+266.37	7.788m	1,934.750m	
139	1+262.91	17.806m	1,934.850m	

140	1+259.75	25.004m	1,935.000m	

Out of Range: The Point is not adjacent to alignment.

15. Profile Elevation Differences Report

Vertical Alignment: project
Existing Profile: eg - Surface (1)
Description:
Station Range: Start: 0+000.00, End: 1+269.27

PVI	Station	Easting	Northing	Elevation Existing	Elevation Design	Elevation Difference	Point Type
0	0+000.00	368590.71	908545.89	1,937.250m	1,937.250m	0.000m	Start
1	0+025.00	368610.7255	908530.9107	1,936.491m	1,936.174m	0.317m	Regular
2	0+027.19	368612.479	908529.5985	1,936.425m	1,936.080m	0.345m	Existing
3	0+045.07	368626.7932	908518.886	1,935.723m	1,935.311m	0.412m	Line - Curve
4	0+045.77	368627.3532	908518.4654	1,935.696m	1,935.281m	0.415m	Existing
5	0+049.05	368629.9544	908516.4708	1,935.570m	1,935.140m	0.430m	Existing
6	0+050.00	368630.7043	908515.8831	1,935.534m	1,935.099m	0.435m	Regular
7	0+053.03	368633.0669	908513.9932	1,935.420m	1,934.969m	0.451m	Existing
8	0+053.28	368633.2631	908513.8336	1,935.410m	1,934.958m	0.453m	Existing
9	0+057.00	368636.1295	908511.4542	1,935.265m	1,934.798m	0.467m	Existing
10	0+060.98	368639.1411	908508.8548	1,935.112m	1,934.626m	0.486m	Existing
11	0+064.96	368642.1003	908506.196	1,934.962m	1,934.455m	0.507m	Existing
12	0+066.92	368643.5404	908504.8628	1,934.889m	1,934.371m	0.518m	Existing
13	0+068.94	368645.0061	908503.4788	1,934.825m	1,934.284m	0.541m	Existing
14	0+072.92	368647.8572	908500.7044	1,934.703m	1,934.113m	0.590m	Existing
15	0+075.00	368649.3278	908499.2293	1,934.641m	1,934.023m	0.618m	Regular
16	0+076.90	368650.6526	908497.8738	1,934.585m	1,933.942m	0.643m	Existing
17	0+080.35	368653.0329	908495.3723	1,934.485m	1,933.793m	0.692m	Existing
18	0+080.87	368653.3911	908494.9882	1,934.472m	1,933.771m	0.702m	Existing
19	0+084.41	368655.7796	908492.3748	1,934.389m	1,933.618m	0.771m	Existing
20	0+084.85	368656.0717	908492.0487	1,934.374m	1,933.599m	0.774m	Existing
21	0+088.83	368658.6933	908489.0565	1,934.237m	1,933.428m	0.809m	Existing
22	0+092.40	368660.9925	908486.3302	1,934.117m	1,933.275m	0.842m	Existing
23	0+092.81	368661.2549	908486.0127	1,934.104m	1,933.257m	0.847m	Existing
24	0+096.79	368663.7554	908482.9185	1,933.977m	1,933.086m	0.891m	Existing
25	0+100.00	368665.7298	908480.3836	1,933.876m	1,932.948m	0.929m	Regular
26	0+100.77	368666.1939	908479.7753	1,933.852m	1,932.915m	0.938m	Existing

27	0+104.74	368668.5694	908476.5841	1,933.731m	1,932.744m	0.988m	Existing
28	0+108.72	368670.8809	908473.3464	1,933.613m	1,932.572m	1.040m	Existing
29	0+110.68	368671.997	908471.7329	1,933.556m	1,932.488m	1.068m	Existing
30	0+112.70	368673.1276	908470.0633	1,933.492m	1,932.401m	1.090m	Existing
31	0+116.68	368675.3085	908466.7361	1,933.368m	1,932.230m	1.138m	Existing
32	0+120.66	368677.4229	908463.3663	1,933.247m	1,932.059m	1.188m	Existing
33	0+122.71	368678.4885	908461.6096	1,933.186m	1,931.971m	1.216m	Existing
34	0+124.63	368679.4697	908459.955	1,933.117m	1,931.888m	1.229m	Existing
35	0+125.00	368679.6542	908459.6399	1,933.104m	1,931.872m	1.232m	Regular
36	0+128.61	368681.4484	908456.5037	1,932.976m	1,931.717m	1.260m	Existing
37	0+131.59	368682.8831	908453.8972	1,932.872m	1,931.589m	1.284m	Start Vertical TP
38	0+132.59	368683.3579	908453.0138	1,932.837m	1,931.546m	1.292m	Existing
39	0+136.57	368685.1977	908449.4865	1,932.701m	1,931.378m	1.322m	Existing
40	0+139.58	368686.5429	908446.7938	1,932.599m	1,931.255m	1.343m	Existing
41	0+140.55	368686.967	908445.9234	1,932.546m	1,931.216m	1.329m	Existing
42	0+144.53	368688.6651	908442.3257	1,932.330m	1,931.060m	1.271m	Existing
43	0+148.50	368690.2912	908438.695	1,932.118m	1,930.908m	1.209m	Existing
44	0+150.00	368690.8837	908437.3221	1,932.039m	1,930.853m	1.186m	Regular
45	0+152.48	368691.8448	908435.0327	1,931.908m	1,930.762m	1.146m	Existing
46	0+156.46	368693.3253	908431.3402	1,931.701m	1,930.621m	1.080m	Existing
47	0+160.44	368694.732	908427.619	1,931.497m	1,930.486m	1.011m	Existing
48	0+162.43	368695.4076	908425.7481	1,931.396m	1,930.420m	0.977m	
49	0+164.22	368695.9999	908424.0578	1,931.306m	1,930.362m	0.944m	Existing
50	0+164.42	368696.0645	908423.8706	1,931.296m	1,930.355m	0.940m	Existing
51	0+165.79	368696.5069	908422.5712	1,931.226m	1,930.311m	0.915m	Existing
52	0+166.52	368696.7394	908421.8761	1,931.194m	1,930.288m	0.906m	Existing
53	0+168.40	368697.3221	908420.0963	1,931.135m	1,930.230m	0.906m	Existing
54	0+172.37	368698.5044	908416.2978	1,931.011m	1,930.110m	0.901m	Existing
55	0+175.00	368699.2432	908413.7784	1,930.930m	1,930.034m	0.896m	Regular
56	0+176.35	368699.6109	908412.4766	1,930.888m	1,929.995m	0.892m	Existing
57	0+180.33	368700.6412	908408.6341	1,930.765m	1,929.886m	0.879m	Existing
58	0+184.31	368701.5948	908404.7719	1,930.642m	1,929.782m	0.860m	Existing
59	0+188.29	368702.4715	908400.8914	1,930.520m	1,929.683m	0.837m	Existing
60	0+192.27	368703.2708	908396.9943	1,930.398m	1,929.589m	0.809m	Existing
61	0+196.24	368703.9924	908393.0821	1,930.278m	1,929.501m	0.777m	Existing

62	0+200.00	368704.6021	908389.3762	1,930.164m	1,929.422m	0.742m	Regular
63	0+200.22	368704.636	908389.1562	1,930.157m	1,929.418m	0.740m	Existing
64	0+202.67	368704.9932	908386.7351	1,930.084m	1,929.369m	0.715m	Existing
65	0+204.20	368705.2015	908385.2184	1,930.048m	1,929.340m	0.708m	Existing
66	0+208.18	368705.6885	908381.2701	1,929.954m	1,929.267m	0.687m	Existing
67	0+212.16	368706.0969	908377.3129	1,929.862m	1,929.200m	0.662m	Existing
68	0+215.00	368706.3404	908374.4808	1,929.796m	1,929.155m	0.641m	PVI
69	0+216.14	368706.4265	908373.3483	1,929.770m	1,929.138m	0.632m	Existing
70	0+220.11	368706.6771	908369.378	1,929.680m	1,929.081m	0.598m	Existing
71	0+224.09	368706.8488	908365.4035	1,929.590m	1,929.029m	0.560m	Existing
72	0+225.00	368706.8769	908364.4963	1,929.570m	1,929.018m	0.551m	Regular
73	0+228.07	368706.9414	908361.4263	1,929.501m	1,928.983m	0.518m	Existing
74	0+232.05	368706.9548	908357.4481	1,929.414m	1,928.942m	0.472m	Existing
75	0+236.03	368706.8891	908353.4704	1,929.328m	1,928.906m	0.421m	Existing
76	0+240.01	368706.7443	908349.4948	1,929.243m	1,928.876m	0.367m	Existing
77	0+243.98	368706.5205	908345.5229	1,929.159m	1,928.850m	0.308m	Existing
78	0+246.38	368706.3475	908343.1328	1,929.109m	1,928.838m	0.271m	Existing
79	0+247.96	368706.2177	908341.5562	1,929.083m	1,928.830m	0.253m	Existing
80	0+249.20	368706.1075	908340.3244	1,929.064m	1,928.825m	0.239m	Existing
81	0+250.00	368706.032	908339.5268	1,929.047m	1,928.822m	0.225m	Regular
82	0+251.94	368705.836	908337.5963	1,929.007m	1,928.815m	0.191m	Existing
83	0+255.92	368705.3757	908333.6448	1,928.926m	1,928.806m	0.120m	Existing
84	0+259.90	368704.8369	908329.7032	1,928.848m	1,928.802m	0.047m	Existing
85	0+261.16	368704.6497	908328.4559	1,928.824m	1,928.801m	0.023m	Low Point
86	0+263.88	368704.2197	908325.7732	1,928.773m	1,928.803m	-0.030m	Existing
87	0+267.85	368703.5246	908321.8561	1,928.699m	1,928.809m	-0.109m	Existing
88	0+271.83	368702.7516	908317.9537	1,928.629m	1,928.820m	-0.192m	Existing
89	0+275.00	368702.0807	908314.8575	1,928.575m	1,928.833m	-0.259m	Regular
90	0+275.81	368701.9012	908314.0674	1,928.561m	1,928.837m	-0.276m	Existing
91	0+278.07	368701.3832	908311.8651	1,928.523m	1,928.849m	-0.326m	Existing
92	0+279.79	368700.9737	908310.1988	1,928.492m	1,928.859m	-0.367m	Curve - Line
93	0+279.79	368700.9737	908310.1988	1,928.492m	1,928.859m	-0.367m	Existing
94	0+293.99	368697.5258	908296.4242	1,928.233m	1,928.980m	-0.747m	Existing
95	0+298.41	368696.4517	908292.1332	1,928.130m	1,929.032m	-0.902m	End Vertical TP

96	0+300.00	368696.066	908290.5922	1,928.093m	1,929.051m	-0.958m	Regular
97	0+304.56	368694.9599	908286.1733	1,927.987m	1,929.108m	-1.121m	Existing
98	0+325.00	368689.9957	908266.3404	1,927.527m	1,929.361m	-1.834m	Regular
99	0+326.23	368689.6982	908265.1519	1,927.499m	1,929.376m	-1.877m	Existing
100	0+330.17	368688.7393	908261.3209	1,927.407m	1,929.425m	-2.017m	Existing
101	0+332.21	368688.244	908259.3423	1,927.374m	1,929.450m	-2.076m	Existing
102	0+348.95	368684.1804	908243.1078	1,928.031m	1,929.657m	-1.626m	Line - Curve
103	0+348.95	368684.1804	908243.1078	1,928.031m	1,929.657m	-1.626m	Existing
104	0+350.00	368683.9238	908242.089	1,928.072m	1,929.670m	-1.598m	Regular
105	0+354.12	368682.888	908238.1015	1,928.234m	1,929.721m	-1.487m	Existing
106	0+359.29	368681.5217	908233.1148	1,928.440m	1,929.785m	-1.345m	Existing
107	0+364.46	368680.0819	908228.1489	1,928.647m	1,929.849m	-1.202m	Existing
108	0+369.38	368678.6432	908223.4416	1,928.845m	1,929.910m	-1.065m	Existing
109	0+369.63	368678.5689	908223.2048	1,928.858m	1,929.913m	-1.055m	Existing
110	0+374.80	368676.983	908218.2836	1,929.130m	1,929.977m	-0.847m	Existing
111	0+374.97	368676.9315	908218.1277	1,929.139m	1,929.979m	-0.840m	Existing
112	0+375.00	368676.9208	908218.0954	1,929.138m	1,929.979m	-0.841m	Regular
113	0+379.97	368675.3246	908213.3863	1,929.061m	1,930.041m	-0.979m	Existing
114	0+385.14	368673.594	908208.5141	1,928.986m	1,930.105m	-1.119m	Existing
115	0+390.31	368671.7917	908203.6679	1,928.914m	1,930.169m	-1.254m	Existing
116	0+395.48	368669.918	908198.8489	1,928.847m	1,930.233m	-1.385m	Existing
117	0+400.00	368668.2232	908194.6628	1,928.792m	1,930.288m	-1.496m	Regular
118	0+400.65	368667.9732	908194.0582	1,928.784m	1,930.297m	-1.512m	Existing
119	0+405.82	368665.958	908189.2966	1,928.725m	1,930.360m	-1.635m	Existing
120	0+411.00	368663.8726	908184.5654	1,928.671m	1,930.424m	-1.754m	Existing
121	0+416.17	368661.7175	908179.8655	1,928.621m	1,930.488m	-1.868m	Existing
122	0+421.34	368659.4933	908175.1979	1,928.575m	1,930.552m	-1.978m	Existing
123	0+425.00	368657.8755	908171.9107	1,928.545m	1,930.598m	-2.053m	Regular
124	0+426.51	368657.2003	908170.5637	1,928.533m	1,930.616m	-2.083m	Existing
125	0+430.41	368655.4246	908167.0891	1,928.505m	1,930.665m	-2.160m	Existing
126	0+431.68	368654.8391	908165.9639	1,928.494m	1,930.680m	-2.186m	
127	0+431.68	368654.8391	908165.9639	1,928.494m	1,930.680m	-2.186m	Existing
128	0+435.00	368653.2873	908163.029	1,928.468m	1,930.721m	-2.254m	Existing
129	0+436.85	368652.4103	908161.3995	1,928.447m	1,930.744m	-2.297m	Existing
130	0+441.86	368649.99	908157.0064	1,928.395m	1,930.806m	-2.411m	Existing

131	0+442.02	368649.9143	908156.8714	1,928.395m	1,930.808m	-2.413m	Existing
132	0+447.19	368647.3516	908152.3807	1,928.381m	1,930.872m	-2.491m	Existing
133	0+447.44	368647.2257	908152.164	1,928.380m	1,930.875m	-2.495m	Start Vertical TP
134	0+450.00	368645.9305	908149.955	1,928.374m	1,930.906m	-2.533m	Regular
135	0+452.36	368644.7229	908147.9284	1,928.368m	1,930.933m	-2.566m	Existing
136	0+457.53	368642.0287	908143.5153	1,928.355m	1,930.987m	-2.632m	Existing
137	0+462.70	368639.2697	908139.1426	1,928.344m	1,931.035m	-2.691m	Existing
138	0+467.87	368636.4463	908134.8111	1,928.333m	1,931.076m	-2.742m	Existing
139	0+473.04	368633.5592	908130.5217	1,928.324m	1,931.110m	-2.786m	Existing
140	0+475.00	368632.4489	908128.9079	1,928.321m	1,931.121m	-2.801m	Regular
141	0+478.21	368630.6091	908126.2755	1,928.315m	1,931.138m	-2.822m	Existing
142	0+483.38	368627.5966	908122.0733	1,928.308m	1,931.158m	-2.851m	Existing
143	0+485.00	368626.6413	908120.7676	1,928.306m	1,931.163m	-2.858m	PVI
144	0+488.55	368624.5224	908117.9161	1,928.301m	1,931.173m	-2.871m	Existing
145	0+493.72	368621.387	908113.8048	1,928.295m	1,931.180m	-2.885m	Existing
146	0+496.03	368619.9687	908111.9855	1,928.293m	1,931.181m	-2.888m	Existing
147	0+496.92	368619.4191	908111.2872	1,928.311m	1,931.181m	-2.871m	High Point
148	0+498.89	368618.1913	908109.7402	1,928.349m	1,931.181m	-2.831m	Existing
149	0+500.00	368617.4997	908108.8766	1,928.371m	1,931.180m	-2.809m	Regular
150	0+504.06	368614.9359	908105.7233	1,928.452m	1,931.175m	-2.723m	Existing
151	0+509.23	368611.6215	908101.7549	1,928.555m	1,931.162m	-2.608m	Existing
152	0+513.10	368609.1086	908098.8238	1,928.632m	1,931.149m	-2.516m	Existing
153	0+514.41	368608.2489	908097.8359	1,928.660m	1,931.143m	-2.483m	Curve - Line
154	0+514.41	368608.2489	908097.8359	1,928.660m	1,931.143m	-2.483m	Existing
155	0+522.56	368602.8834	908091.6936	1,928.833m	1,931.099m	-2.266m	End Vertical TP
156	0+525.00	368601.2787	908089.8565	1,928.885m	1,931.083m	-2.198m	Regular
157	0+550.00	368584.8317	908071.0284	1,929.417m	1,930.923m	-1.506m	Regular
158	0+553.79	368582.339	908068.1748	1,929.497m	1,930.899m	-1.401m	Existing
159	0+554.30	368582.004	908067.7912	1,929.497m	1,930.896m	-1.398m	Existing
160	0+555.62	368581.1347	908066.7961	1,929.498m	1,930.887m	-1.389m	Existing
161	0+575.00	368568.3848	908052.2002	1,929.548m	1,930.763m	-1.215m	Regular
162	0+597.20	368553.7785	908035.4792	1,929.606m	1,930.621m	-1.014m	Existing

163	0+600.00	368551.9379	908033.3721	1,929.624m	1,930.603m	-0.979m	Regular
164	0+615.04	368542.0423	908022.0438	1,929.717m	1,930.506m	-0.789m	Existing
165	0+625.00	368535.491	908014.5439	1,929.735m	1,930.442m	-0.708m	Regular
166	0+642.13	368524.2212	908001.6426	1,929.764m	1,930.333m	-0.568m	Existing
167	0+650.00	368519.044	907995.7158	1,929.936m	1,930.282m	-0.346m	Regular
168	0+675.00	368502.5971	907976.8877	1,930.480m	1,930.122m	0.358m	Regular
169	0+676.30	368501.7391	907975.9054	1,930.508m	1,930.113m	0.395m	Existing
170	0+677.91	368500.683	907974.6965	1,930.522m	1,930.103m	0.419m	Existing
171	0+700.00	368486.1502	907958.0595	1,930.493m	1,929.962m	0.531m	Regular
172	0+710.11	368479.4999	907950.4464	1,930.479m	1,929.897m	0.582m	Existing
173	0+725.00	368469.7033	907939.2314	1,930.479m	1,929.801m	0.678m	Regular
174	0+728.36	368467.4895	907936.6972	1,930.479m	1,929.780m	0.699m	Existing
175	0+732.02	368465.0872	907933.947	1,930.497m	1,929.756m	0.740m	Line - Curve
176	0+732.02	368465.0872	907933.947	1,930.497m	1,929.756m	0.740m	Existing
177	0+736.62	368462.0843	907930.4556	1,930.519m	1,929.727m	0.792m	Existing
178	0+741.23	368459.1353	907926.9185	1,930.539m	1,929.697m	0.842m	Existing
179	0+745.83	368456.2409	907923.3365	1,930.559m	1,929.668m	0.891m	Existing
180	0+750.00	368453.6692	907920.0569	1,930.575m	1,929.641m	0.934m	Regular
181	0+750.44	368453.4019	907919.7105	1,930.577m	1,929.638m	0.939m	Existing
182	0+753.55	368451.5156	907917.2364	1,930.589m	1,929.618m	0.970m	Existing
183	0+755.04	368450.6189	907916.0413	1,930.602m	1,929.609m	0.993m	Existing
184	0+759.65	368447.8925	907912.3299	1,930.639m	1,929.579m	1.060m	
185	0+759.65	368447.8925	907912.3299	1,930.639m	1,929.579m	1.060m	Existing
186	0+764.25	368445.2234	907908.5771	1,930.673m	1,929.550m	1.123m	Existing
187	0+768.86	368442.6122	907904.7837	1,930.704m	1,929.520m	1.184m	Existing
188	0+773.46	368440.0596	907900.9507	1,930.732m	1,929.491m	1.241m	Existing
189	0+775.00	368439.2212	907899.6634	1,930.740m	1,929.481m	1.259m	Regular
190	0+778.07	368437.5661	907897.079	1,930.756m	1,929.461m	1.295m	Existing
191	0+782.67	368435.1323	907893.1694	1,930.778m	1,929.432m	1.346m	Existing
192	0+786.85	368432.9794	907889.5955	1,930.794m	1,929.405m	1.389m	Existing
193	0+787.28	368432.7588	907889.223	1,930.794m	1,929.402m	1.391m	Curve - Line
194	0+787.28	368432.7588	907889.223	1,930.794m	1,929.402m	1.391m	Existing
195	0+800.00	368426.2867	907878.2721	1,930.774m	1,929.321m	1.453m	Regular
196	0+801.88	368425.3288	907876.6513	1,930.771m	1,929.308m	1.462m	Existing
197	0+825.00	368413.5668	907856.7499	1,930.876m	1,929.160m	1.716m	Regular

198	0+834.52	368408.7219	907848.5523	1,930.920m	1,929.117m	1.803m	Existing
199	0+841.22	368405.3165	907842.7904	1,930.950m	1,929.108m	1.842m	Low Point
200	0+841.25	368405.3013	907842.7647	1,930.950m	1,929.108m	1.842m	Line - Curve
201	0+841.25	368405.3013	907842.7647	1,930.950m	1,929.108m	1.842m	Existing
202	0+842.37	368404.7247	907841.7941	1,930.955m	1,929.109m	1.847m	Existing
203	0+845.64	368403.0321	907839.0011	1,930.938m	1,929.112m	1.826m	Existing
204	0+846.58	368402.54	907838.2042	1,930.934m	1,929.114m	1.820m	Existing
205	0+850.00	368400.7158	907835.3073	1,930.921m	1,929.124m	1.798m	Regular
206	0+850.03	368400.697	907835.2779	1,930.921m	1,929.124m	1.797m	Existing
207	0+854.43	368398.2969	907831.5963	1,930.910m	1,929.143m	1.767m	Existing
208	0+858.82	368395.8324	907827.9575	1,930.903m	1,929.170m	1.733m	Existing
209	0+863.22	368393.3043	907824.3626	1,930.901m	1,929.204m	1.697m	Existing
210	0+867.61	368390.7135	907820.8127	1,930.904m	1,929.246m	1.658m	Existing
211	0+872.01	368388.0606	907817.3089	1,930.913m	1,929.296m	1.617m	Existing
212	0+875.00	368386.2203	907814.9515	1,930.921m	1,929.334m	1.587m	Regular
213	0+876.40	368385.3465	907813.8522	1,930.925m	1,929.353m	1.573m	Existing
214	0+880.80	368382.5721	907810.4438	1,930.943m	1,929.411m	1.532m	Existing
215	0+885.19	368379.7383	907807.0847	1,930.966m	1,929.470m	1.496m	Existing
216	0+889.59	368376.8458	907803.776	1,930.994m	1,929.529m	1.465m	Existing
217	0+893.98	368373.8955	907800.5186	1,931.026m	1,929.587m	1.439m	Existing
218	0+897.42	368371.5479	907798.0066	1,931.055m	1,929.633m	1.422m	Existing
219	0+898.38	368370.8885	907797.3135	1,931.059m	1,929.646m	1.413m	Existing
220	0+900.00	368369.765	907796.1445	1,931.067m	1,929.668m	1.400m	Regular
221	0+900.58	368369.364	907795.7309	1,931.070m	1,929.676m	1.395m	
222	0+902.00	368368.3722	907794.7161	1,931.077m	1,929.694m	1.383m	Existing
223	0+902.77	368367.8256	907794.1618	1,931.082m	1,929.705m	1.377m	Existing
224	0+907.17	368364.7078	907791.0644	1,931.108m	1,929.764m	1.344m	Existing
225	0+911.56	368361.536	907788.0224	1,931.136m	1,929.822m	1.313m	Existing
226	0+915.96	368358.3112	907785.0365	1,931.166m	1,929.881m	1.285m	Existing
227	0+920.35	368355.0345	907782.1078	1,931.199m	1,929.940m	1.259m	Existing
228	0+924.75	368351.7067	907779.2371	1,931.233m	1,929.998m	1.235m	Existing
229	0+925.00	368351.5143	907779.0743	1,931.235m	1,930.002m	1.233m	Regular
230	0+929.14	368348.329	907776.4254	1,931.270m	1,930.057m	1.213m	Existing
231	0+929.30	368348.2089	907776.3272	1,931.271m	1,930.059m	1.212m	Existing
232	0+933.54	368344.9024	907773.6735	1,931.278m	1,930.116m	1.162m	Existing

233	0+937.93	368341.428	907770.9823	1,931.286m	1,930.174m	1.111m	Existing
234	0+942.33	368337.9068	907768.3525	1,931.294m	1,930.233m	1.061m	Existing
235	0+946.72	368334.3399	907765.7851	1,931.303m	1,930.292m	1.011m	Existing
236	0+946.78	368334.2939	907765.7526	1,931.303m	1,930.293m	1.011m	Existing
237	0+950.00	368331.6507	907763.9113	1,931.339m	1,930.336m	1.003m	Regular
238	0+951.12	368330.7284	907763.2807	1,931.352m	1,930.351m	1.001m	Existing
239	0+955.51	368327.0735	907760.8403	1,931.401m	1,930.409m	0.992m	Existing
240	0+959.91	368323.3762	907758.4644	1,931.451m	1,930.468m	0.983m	Curve - Line
241	0+959.91	368323.3762	907758.4644	1,931.451m	1,930.468m	0.983m	Existing
242	0+975.00	368310.6076	907750.417	1,931.624m	1,930.670m	0.954m	Regular
243	0+979.40	368306.8868	907748.072	1,931.674m	1,930.728m	0.946m	Existing
244	0+997.82	368291.2983	907738.2475	1,931.784m	1,930.974m	0.810m	Line - Curve
245	0+997.82	368291.2983	907738.2475	1,931.784m	1,930.974m	0.810m	Existing
246	1+000.00	368289.4513	907737.0974	1,931.798m	1,931.003m	0.794m	Regular
247	1+001.71	368287.9868	907736.2051	1,931.809m	1,931.026m	0.782m	Existing
248	1+005.61	368284.6362	907734.2276	1,931.836m	1,931.078m	0.757m	Existing
249	1+006.29	368284.0421	907733.8861	1,931.841m	1,931.088m	0.753m	Existing
250	1+009.50	368281.2478	907732.3157	1,931.879m	1,931.130m	0.748m	Existing
251	1+013.39	368277.8228	907730.47	1,931.927m	1,931.182m	0.745m	Existing
252	1+017.15	368274.4796	907728.75	1,931.977m	1,931.233m	0.744m	Existing
253	1+017.28	368274.3626	907728.6912	1,931.979m	1,931.234m	0.745m	Existing
254	1+021.17	368270.8684	907726.9802	1,932.034m	1,931.286m	0.747m	Existing
255	1+025.00	368267.3954	907725.3618	1,932.090m	1,931.337m	0.753m	Regular
256	1+025.06	368267.3416	907725.3374	1,932.091m	1,931.338m	0.753m	Existing
257	1+028.95	368263.7835	907723.7635	1,932.151m	1,931.390m	0.761m	Existing
258	1+032.84	368260.1955	907722.2592	1,932.213m	1,931.442m	0.771m	Existing
259	1+036.73	368256.5788	907720.8249	1,932.278m	1,931.494m	0.784m	Existing
260	1+040.62	368252.935	907719.4612	1,932.345m	1,931.546m	0.799m	Existing
261	1+044.51	368249.2653	907718.1687	1,932.414m	1,931.598m	0.816m	Existing
262	1+048.40	368245.5712	907716.9478	1,932.486m	1,931.650m	0.836m	Existing
263	1+050.00	368244.0485	907716.4676	1,932.517m	1,931.671m	0.845m	Regular
264	1+050.35	368243.7154	907716.3644	1,932.523m	1,931.676m	0.847m	
265	1+052.29	368241.854	907715.799	1,932.560m	1,931.702m	0.858m	Existing
266	1+056.18	368238.1152	907714.7228	1,932.637m	1,931.754m	0.883m	Existing
267	1+060.08	368234.3562	907713.7194	1,932.716m	1,931.806m	0.910m	Existing

268	1+063.97	368230.5783	907712.7894	1,932.797m	1,931.858m	0.939m	Existing
269	1+065.86	368228.7354	907712.3639	1,932.837m	1,931.883m	0.954m	Existing
270	1+067.86	368226.7831	907711.933	1,932.867m	1,931.910m	0.958m	Existing
271	1+071.75	368222.9719	907711.1506	1,932.929m	1,931.962m	0.967m	Existing
272	1+075.00	368219.7748	907710.5536	1,932.982m	1,932.005m	0.976m	Regular
273	1+075.64	368219.1463	907710.4426	1,932.992m	1,932.014m	0.978m	Existing
274	1+079.53	368215.3076	907709.809	1,933.058m	1,932.066m	0.992m	Existing
275	1+083.42	368211.4572	907709.2503	1,933.125m	1,932.118m	1.008m	Existing
276	1+087.31	368207.5968	907708.7665	1,933.195m	1,932.170m	1.025m	Existing
277	1+091.20	368203.7277	907708.358	1,933.267m	1,932.222m	1.045m	Existing
278	1+095.09	368199.8513	907708.0247	1,933.341m	1,932.274m	1.067m	Existing
279	1+098.98	368195.9692	907707.767	1,933.416m	1,932.326m	1.091m	Existing
280	1+100.00	368194.9532	907707.712	1,933.437m	1,932.339m	1.098m	Regular
281	1+102.87	368192.0828	907707.5848	1,933.494m	1,932.378m	1.117m	Curve - Line
282	1+102.87	368192.0828	907707.5848	1,933.494m	1,932.378m	1.117m	Existing
283	1+125.00	368169.9713	907706.7637	1,933.942m	1,932.673m	1.269m	Regular
284	1+129.54	368165.4332	907706.5952	1,934.034m	1,932.734m	1.300m	Existing
285	1+133.75	368161.2294	907706.4391	1,934.112m	1,932.790m	1.322m	Existing
286	1+136.74	368158.2355	907706.3279	1,934.158m	1,932.830m	1.328m	Existing
287	1+149.46	368145.5257	907705.8559	1,934.290m	1,933.000m	1.290m	Existing
288	1+150.00	368144.9885	907705.836	1,934.294m	1,933.007m	1.287m	Regular
289	1+175.00	368120.0057	907704.9083	1,934.516m	1,933.341m	1.175m	Regular
290	1+176.13	368118.8765	907704.8663	1,934.526m	1,933.356m	1.170m	Existing
291	1+200.00	368095.0229	907703.9806	1,934.511m	1,933.675m	0.837m	Regular
292	1+209.26	368085.7701	907703.637	1,934.506m	1,933.798m	0.707m	Existing
293	1+225.00	368070.0402	907703.0528	1,934.532m	1,934.009m	0.523m	Regular
294	1+230.35	368064.6956	907702.8544	1,934.540m	1,934.080m	0.460m	Existing
295	1+240.27	368054.7765	907702.486	1,934.566m	1,934.213m	0.354m	Existing
296	1+250.00	368045.0574	907702.1251	1,934.601m	1,934.343m	0.258m	Regular
297	1+253.63	368041.4271	907701.9903	1,934.614m	1,934.391m	0.222m	Existing
298	1+269.27	368025.8	907701.41	1,934.600m	1,934.600m	0.000m	End

16. PVI Station Increment Report

Vertical Alignment: project
Description:
Station Range: Start: 0+000.00, End: 1+269.27
Station Increment: 20.00

Station	Elevation	Grade Percent (%)	Location
0+000.00	1,937.250m		PVI
0+020.00	1,936.390m	-4.30%	
0+040.00	1,935.529m	-4.30%	
0+060.00	1,934.669m	-4.30%	
0+080.00	1,933.808m	-4.30%	
0+100.00	1,932.948m	-4.30%	
0+120.00	1,932.087m	-4.30%	
0+131.59	1,931.589m	-4.30%	PVC
0+140.00	1,931.238m	-4.16%	
0+160.00	1,930.500m	-3.69%	
0+180.00	1,929.895m	-3.03%	
0+200.00	1,929.422m	-2.36%	
0+215.00	1,929.155m	-1.78%	Sag
0+220.00	1,929.083m	-1.45%	
0+240.00	1,928.876m	-1.03%	
0+260.00	1,928.802m	-0.37%	
0+280.00	1,928.860m	0.29%	
0+298.41	1,929.032m	0.93%	PVT
0+300.00	1,929.051m	1.24%	
0+320.00	1,929.299m	1.24%	
0+340.00	1,929.546m	1.24%	
0+360.00	1,929.794m	1.24%	
0+380.00	1,930.041m	1.24%	
0+400.00	1,930.288m	1.24%	
0+420.00	1,930.536m	1.24%	
0+440.00	1,930.783m	1.24%	
0+447.44	1,930.875m	1.24%	PVC
0+460.00	1,931.011m	1.08%	
0+480.00	1,931.145m	0.67%	
0+485.00	1,931.163m	0.36%	Crest

0+500.00	1,931.180m	0.11%	
0+520.00	1,931.115m	-0.33%	
0+522.56	1,931.099m	-0.61%	PVT
0+540.00	1,930.987m	-0.64%	
0+560.00	1,930.859m	-0.64%	
0+580.00	1,930.731m	-0.64%	
0+600.00	1,930.603m	-0.64%	
0+620.00	1,930.474m	-0.64%	
0+640.00	1,930.346m	-0.64%	
0+660.00	1,930.218m	-0.64%	
0+680.00	1,930.090m	-0.64%	
0+700.00	1,929.962m	-0.64%	
0+720.00	1,929.833m	-0.64%	
0+740.00	1,929.705m	-0.64%	
0+760.00	1,929.577m	-0.64%	
0+780.00	1,929.449m	-0.64%	
0+800.00	1,929.321m	-0.64%	
0+820.00	1,929.192m	-0.64%	
0+825.00	1,929.160m	-0.64%	PVC
0+840.00	1,929.109m	-0.34%	
0+850.00	1,929.124m	0.15%	Sag
0+860.00	1,929.178m	0.54%	
0+875.00	1,929.334m	1.04%	PVT
0+880.00	1,929.401m	1.34%	
0+900.00	1,929.668m	1.34%	
0+920.00	1,929.935m	1.34%	
0+940.00	1,930.202m	1.34%	
0+960.00	1,930.469m	1.34%	
0+980.00	1,930.736m	1.34%	
1+000.00	1,931.003m	1.34%	
1+020.00	1,931.271m	1.34%	
1+040.00	1,931.538m	1.34%	
1+060.00	1,931.805m	1.34%	
1+080.00	1,932.072m	1.34%	
1+100.00	1,932.339m	1.34%	
1+120.00	1,932.606m	1.34%	

1+140.00	1,932.873m	1.34%	
1+160.00	1,933.141m	1.34%	
1+180.00	1,933.408m	1.34%	
1+200.00	1,933.675m	1.34%	
1+220.00	1,933.942m	1.34%	
1+240.00	1,934.209m	1.34%	
1+260.00	1,934.476m	1.34%	
1+269.27	1,934.600m	1.34%	

Vertical Alignment: project (1)
Description:
Station Range: Start: 0+000.00, End: 0+000.00
Station Increment: 20.00

17. Profile Design Criteria Verification Report

Vertical Alignment: project
Description:
Station Range: Start: 0+000.00, End: 1+269.27

1 Sag Curve: Parabolic

PVC Station:	0+131.59
PVI Station:	0+215.00
PVT Station:	0+298.41
Grade in (%):	-4.30%
Grade out (%):	1.24%
Curve Length:	166.823m
K:	30.12
Design Speed:	50
Design Criteria:	
Minimum K for Headlight Sight Distance:	
Design Checks:	

2 Crest Curve: Parabolic

PVC Station:	0+447.44
PVI Station:	0+485.00
PVT Station:	0+522.56
Grade in(%):	1.24%
Grade out(%):	-0.64%
Curve Length:	75.121m
K:	40.00
Design Speed:	50
Design Criteria:	
Minimum K for Stopping Sight Distance:	
Minimum K for Passing Sight Distance:	
Design Checks:	

3 Sag Curve: Parabolic

PVC Station:	0+825.00
PVI Station:	0+850.00
PVT Station:	0+875.00
Grade in(%):	-0.64%

Grade out(%):	1.34%
Curve Length:	50.000m
K:	25.29
Design Speed:	50

Design Criteria:

Minimum K for Headlight Sight Distance:

Design Checks:

Vertical Alignment: project (1)
Description:
Station Range: Start: 0+000.00, End: 0+000.00

---

18. Profile PVI Station & Curve Report

Vertical		Alignment:			project
Description:					
Station	Range:	Start:	0+000.00,	End:	1+269.27

PVI	Station	Grade Out	Curve Length
0.00	0+000.00	-4.30%	
1.00	0+215.00	1.24%	166.823m

Vertical Curve Information:(sag curve)

PVC Station:	0+131.59	Elevation:	1,931.589m
PVI Station:	0+215.00	Elevation:	1,928.000m
PVT Station:	0+298.41	Elevation:	1,929.032m
Low Point:	0+261.16	Elevation:	1,928.801m
Grade in:	-4.30%	Grade out:	1.24%
Change:	5.54%	K:	30.1162181192184
Curve Length:	166.823m		
Headlight Distance:	174.506m		

PVI	Station	Grade Out	Curve Length
2.00	0+485.00	-0.64%	75.121m

Vertical Curve Information:(crest curve)

PVC Station:	0+447.44	Elevation:	1,930.875m
PVI Station:	0+485.00	Elevation:	1,931.340m
PVT Station:	0+522.56	Elevation:	1,931.099m
High Point:	0+496.92	Elevation:	1,931.181m
Grade in:	1.24%	Grade out:	-0.64%
Change:	1.88%	K:	39.9999999999995
Curve Length:	75.121m		
Passing Distance:	860.954m	Stopping Distance:	391.428m

PVI	Station	Grade Out	Curve Length
3.00	0+850.00	1.34%	50.000m

Vertical Curve Information:(sag curve)

PVC Station:	0+825.00	Elevation:	1,929.160m
PVI Station:	0+850.00	Elevation:	1,929.000m
PVT Station:	0+875.00	Elevation:	1,929.334m
Low Point:	0+841.22	Elevation:	1,929.108m
Grade in:	-0.64%	Grade out:	1.34%
Change:	1.98%	K:	25.2945905831721

	-- Curve Length: 50.000m Headlight Distance: 1,078.793m

19. Profile Vertical Curve Report

Vertical Alignment: project

Description:

Station Range: Start: 0+000.00, End: 1+269.27

Vertical Curve Information:(sag curve)

PVC Station:	0+131.59	Elevation:	1,931.589m
PVI Station:	0+215.00	Elevation:	1,928.000m
PVT Station:	0+298.41	Elevation:	1,929.032m
Low Point:	0+261.16	Elevation:	1,928.801m
Grade in:	-4.30%	Grade out:	1.24%
Change:	5.54%	K:	30.116m
Curve Length:	166.823m	Curve Radius	3,011.622m
Headlight Distance:	174.506m		

Vertical Curve Information:(crest curve)

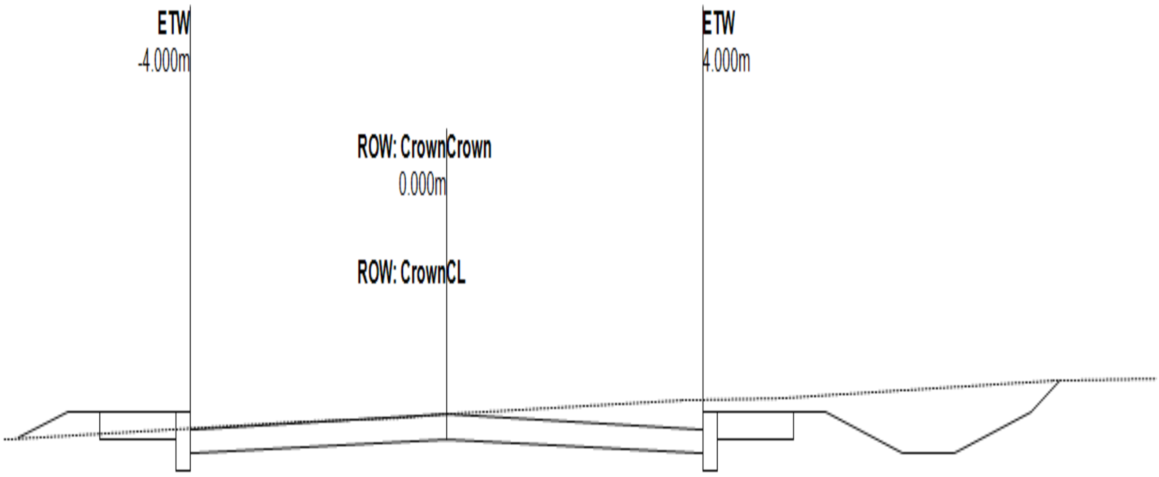
PVC Station:	0+447.44	Elevation:	1,930.875m
PVI Station:	0+485.00	Elevation:	1,931.340m
PVT Station:	0+522.56	Elevation:	1,931.099m
High Point:	0+496.92	Elevation:	1,931.181m
Grade in:	1.24%	Grade out:	-0.64%
Change:	1.88%	K:	40.000m
Curve Length:	75.121m	Curve Radius	4,000.000m
Passing Distance:	860.954m	Stopping Distance:	391.428m

Vertical Curve Information:(sag curve)

PVC Station:	0+825.00	Elevation:	1,929.160m
PVI Station:	0+850.00	Elevation:	1,929.000m
PVT Station:	0+875.00	Elevation:	1,929.334m
Low Point:	0+841.22	Elevation:	1,929.108m
Grade in:	-0.64%	Grade out:	1.34%
Change:	1.98%	K:	25.295m
Curve Length:	50.000m	Curve Radius	2,529.459m
Headlight Distance:	1,078.793m		

20. Corridor Slope Stake Report at station 20

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave



Alignment - project

Station: 0+020.00

Cut Area: 1.78Sq.M.

Fill Area: 0.35Sq.M.

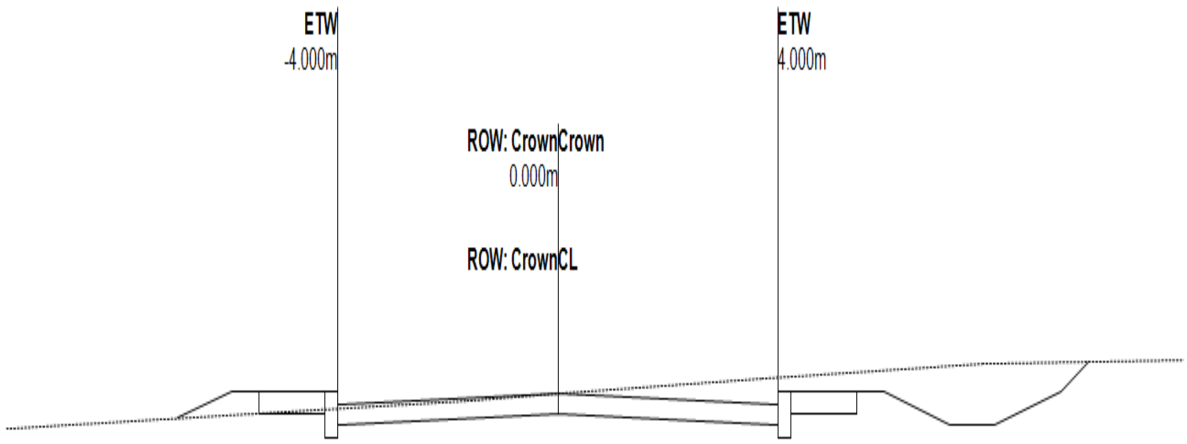
Cumulative Net Volume: 0.00Cu.M.

C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,936.543m	1,936.643m	1,936.643m	1,936.543m	-2.50 %
	2.50 %		-2.50 %		

21. Corridor Slope Stake Report at station 100

Client:	**Prepared by:**
Client	Preparer
Client Company	Your Company Name
Address 1	123 Main Street
Date: 8/5/2021 12:12:52 PM	

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave



Alignment - project

Station: 0+100.00

Cut Area: 2.15Sq.M.

Fill Area: 0.54Sq.M.

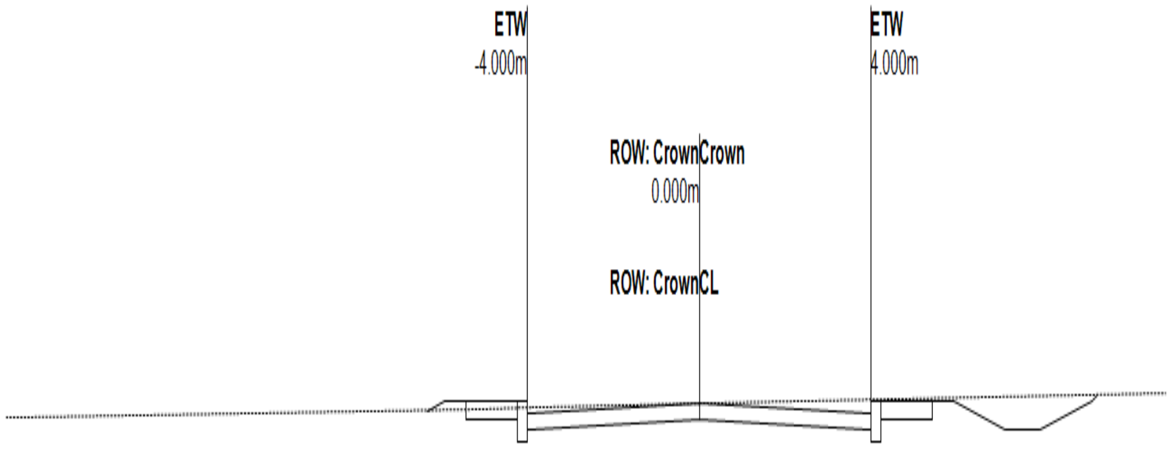
Cumulative Net Volume: 118.33Cu.M.

C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,933.776m	1,933.876m	1,933.876m	1,933.776m	-2.50 %
	2.50 %		-2.50 %		

22. Corridor Slope Stake Report at station 200

Client:	**Prepared by:**
Client	Preparer
Client Company	Your Company Name
Address 1	123 Main Street
Date: 8/5/2021 12:16:44 PM	

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave



Alignment - project

Station: 0+200.00

Cut Area: 1.20Sq.M.

Fill Area: 0.18Sq.M.

Cumulative Net Volume: 240.98Cu.M.

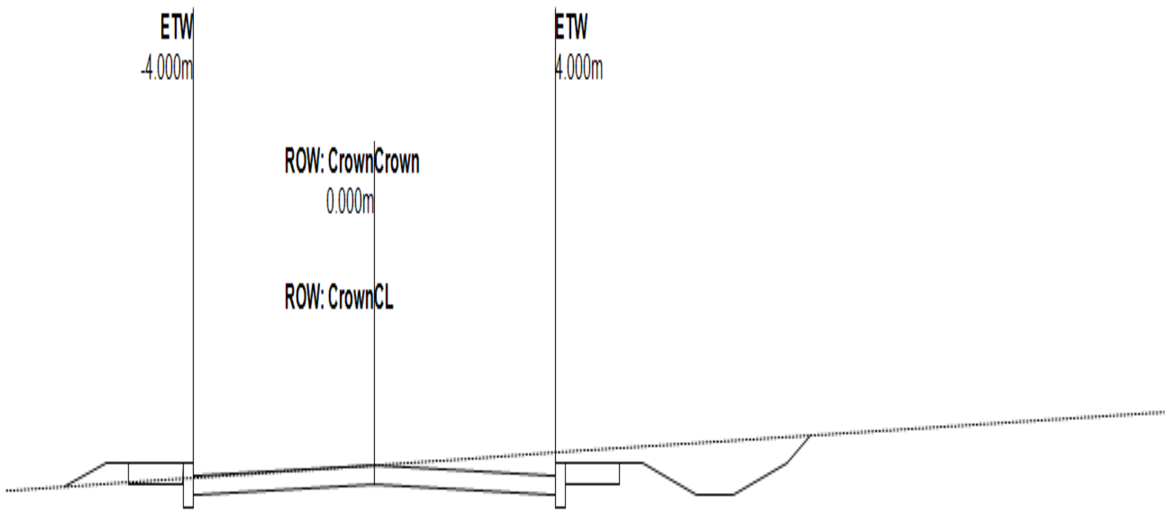
C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,930.064m	1,930.164m	1,930.164m	1,930.064m	-2.50 %
	2.50 %		-2.50 %		

23. Corridor Slope Stake Report at station 300

Client:
Client
Client Company
Address 1
Date: 8/5/2021 12:19:14 PM

Prepared by:
Preparer
Your Company Name
123 Main Street

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave



Alignment - project

Station: 0+300.00

Cut Area: 1.96Sq.M.

Fill Area: 0.46Sq.M.

Cumulative Net Volume: 376.18Cu.M.

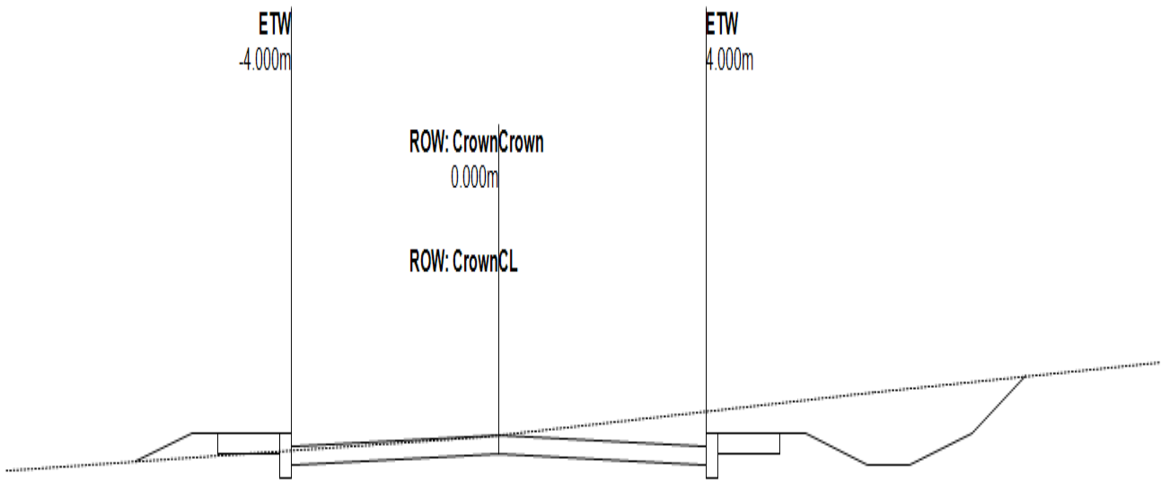
C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,927.993m	1,928.093m	1,928.093m	1,927.993m	-2.50 %
	2.50 %		-2.50 %		

24. Corridor Slope Stake Report at station 400

Client:
Client
Client Company
Address 1
Date: 8/5/2021 12:20:47 PM

Prepared by:
Preparer
Your Company Name
123 Main Street

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave



Alignment - project

Station: 0+400.00

Cut Area: 3.22Sq.M.

Fill Area: 0.62Sq.M.

Cumulative Net Volume: 556.68Cu.M.

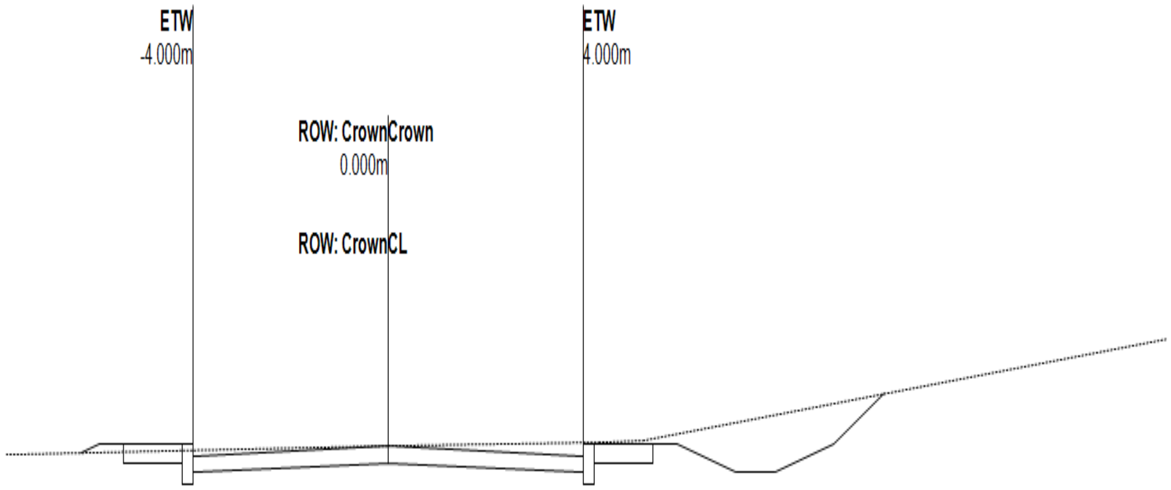
C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,928.692m	1,928.792m	1,928.792m	1,928.692m	-2.50 %
	2.50 %		-2.50 %		

25. Corridor Slope Stake Report at station 500

Client:
Client
Client Company
Address 1
Date: 8/5/2021 12:22:55 PM

Prepared by:
Preparer
Your Company Name
123 Main Street

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave



Alignment - project

Station: 0+500.00

Cut Area: 2.14Sq.M.

Fill Area: 0.17Sq.M.

Cumulative Net Volume: 778.42Cu.M.

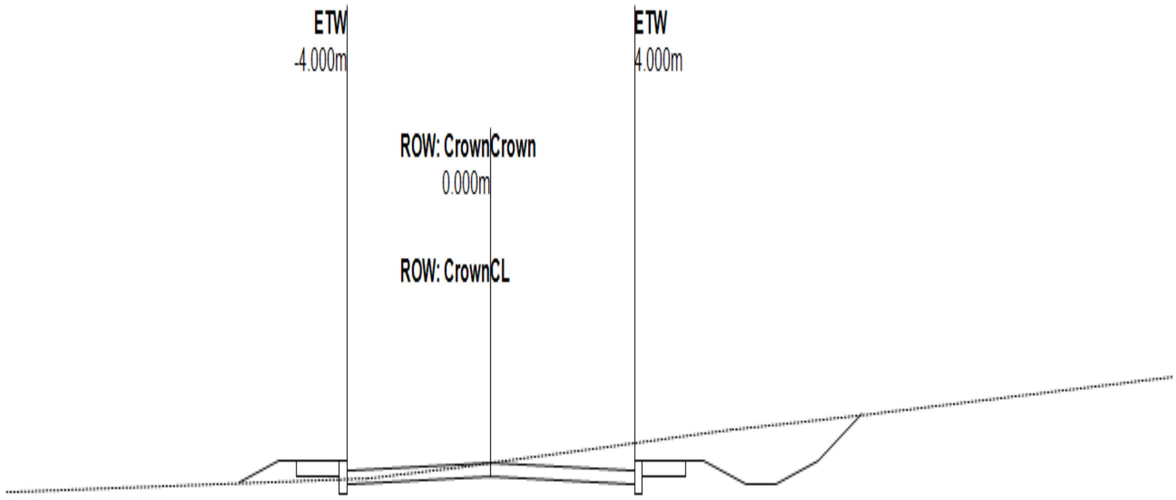
C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,928.271m	1,928.371m	1,928.371m	1,928.271m	-2.50 %
	2.50 %		-2.50 %		

26. Corridor Slope Stake Report at station 600

Client:
Client
Client Company
Address 1
Date: 8/5/2021 12:28:13 PM

Prepared by:
Preparer
Your Company Name
123 Main Street

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave
Station Range: Start: 0+600.00, End: 0+600.00



Alignment - project

Station: 0+600.00

Cut Area: 3.65Sq.M.

Fill Area: 0.83Sq.M.

Cumulative Net Volume: 1,054.84Cu.M.

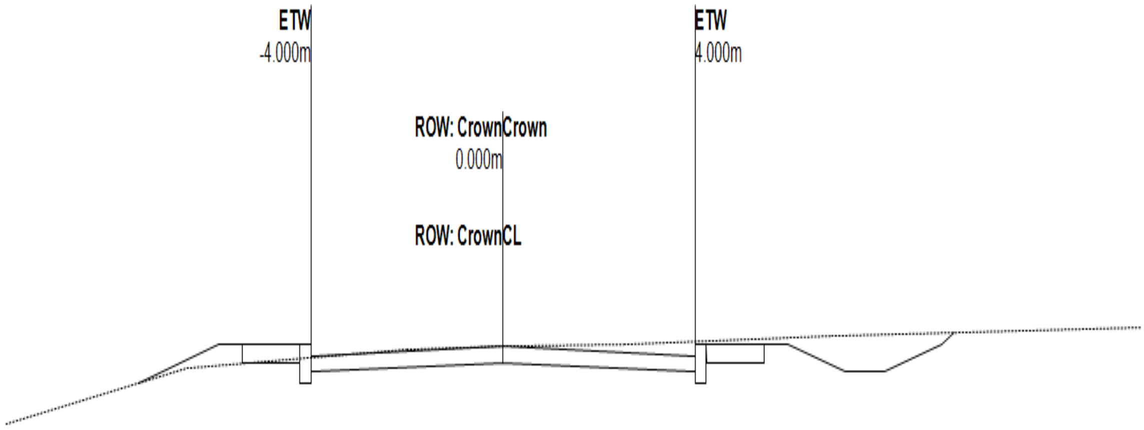
C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,929.524m	1,929.624m	1,929.624m	1,929.524m	-2.50 %
	2.50 %		-2.50 %		

27. Corridor Slope Stake Report at station 700

Client:
Client
Client Company
Address 1
Date: 8/5/2021 12:30:40 PM

Prepared by:
Preparer
Your Company Name
123 Main Street

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave
Station Range: Start: 0+700.00, End: 0+700.00



Alignment - project

Station: 0+700.00

Cut Area: 1.37Sq.M.

Fill Area: 0.50Sq.M.

Cumulative Net Volume: 1,138.23Cu.M.

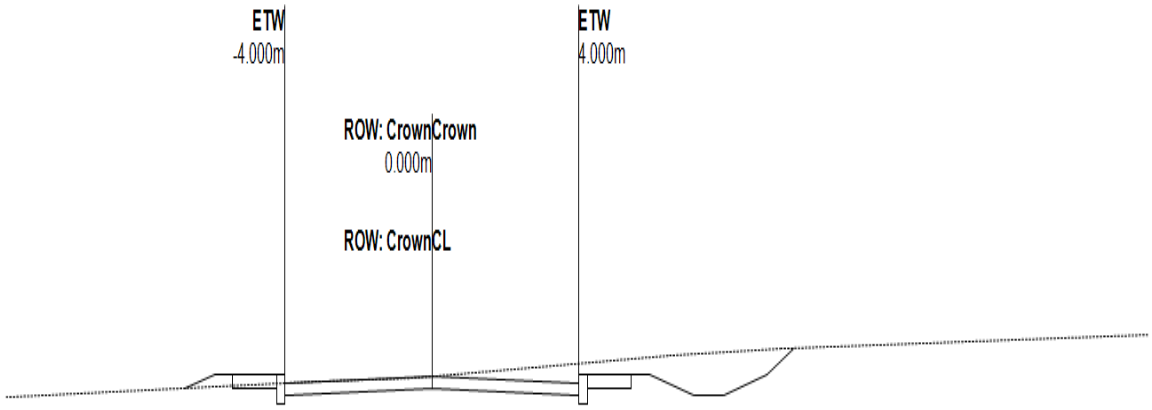
C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,930.393m	1,930.493m	1,930.493m	1,930.393m	-2.50 %
	2.50 %		-2.50 %		

28. Corridor Slope Stake Report at station 800

Client:
Client
Client Company
Address 1
Date: 8/5/2021 12:31:40 PM

Prepared by:
Preparer
Your Company Name
123 Main Street

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave
Station Range: Start: 0+800.00, End: 0+800.00



Alignment - project

Station: 0+800.00

Cut Area: 2.59Sq.M.

Fill Area: 0.41Sq.M.

Cumulative Net Volume: 1,293.64Cu.M.

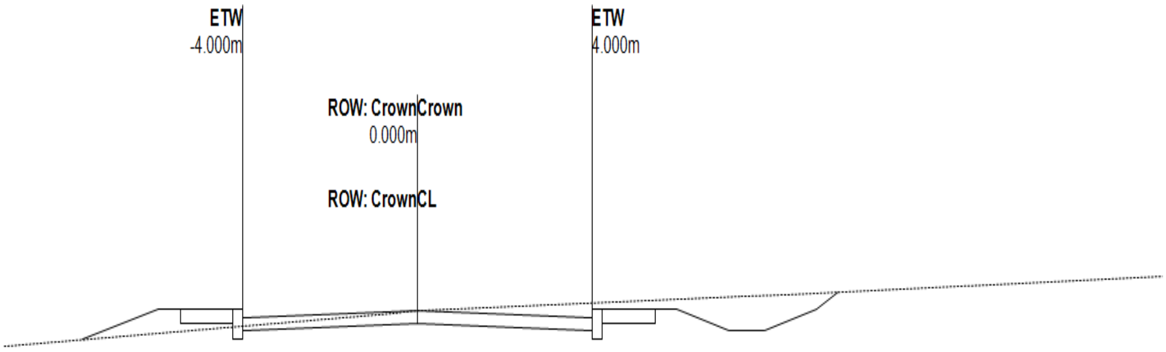
C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,930.674m	1,930.774m	1,930.774m	1,930.674m	-2.50 %
	2.50 %		-2.50 %		

29. Corridor Slope Stake Report at station 900

Client:
Client
Client Company
Address 1
Date: 8/5/2021 12:33:03 PM

Prepared by:
Preparer
Your Company Name
123 Main Street

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave
Station Range: Start: 0+900.00, End: 0+900.00



Alignment - project

Station: 0+900.00

Cut Area: 1.90Sq.M.

Fill Area: 1.06Sq.M.

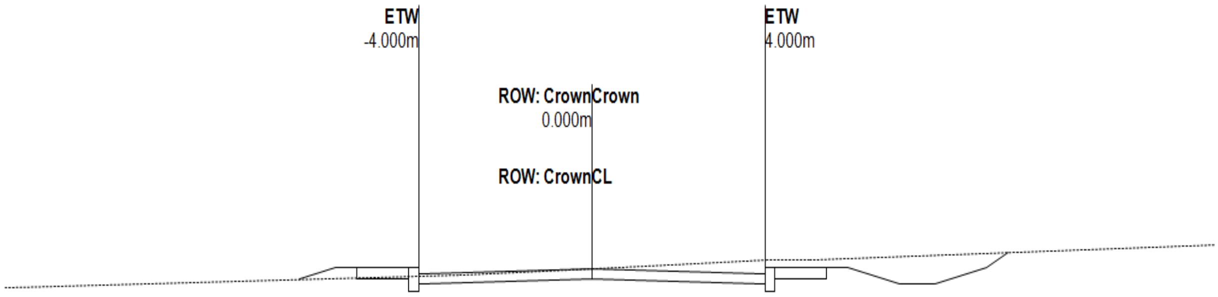
Cumulative Net Volume: 1,403.81Cu.M.

C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,930.967m	1,931.067m	1,931.067m	1,930.967m	-2.50 %
	2.50 %		-2.50 %		

30. Corridor Slope Stake Report at station 1+000

Client:	**Prepared by:**
Client	Preparer
Client Company	Your Company Name
Address 1	123 Main Street
Date: 8/5/2021 12:35:43 PM	

Corridor Name: Corridor - thesis
Description: project
Base Alignment Name: Alignment - project
Sample Line Group Name: SL Collection - thesis
Link Code Name: Pave
Station Range: Start: 1+000.00, End: 1+000.00



Alignment - project

Station: 1+000.00

Cut Area: 1.98Sq.M.

Fill Area: 0.48Sq.M.

Cumulative Net Volume: 1,495.87Cu.M.

C0.10	ETW	CL	Crown	ETW	F0.10
@4.00	-4.000m	0.000m	0.000m	4.000m	@4.00
2.50 %	1,931.698m	1,931.798m	1,931.798m	1,931.698m	-2.50 %
	2.50 %		-2.50 %		