# RURAL ROAD DEVELOPMENT FROM JAYPEE UNIVERSITY GATE TO 1.2 Km STRETCH TOWARDS WAKNAGHAT .

Project Report submitted in fulfilment of the
requirement for the degree of

Bachelor of Technology

in

**Civil Engineering**

Under the Supervision of

***Mr. LAV SINGH***

By

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# ABSTRACT

This Project is an attempt to do road survey from Jaypee University Gate to 1.2km road stretch towards Waknaghat Circle. We have take 6 points at every cross section like extra Left Hand side ,Left hand side ,Centre Line ,Right hand side ,Extra Right hand side and Drainage with the help of Total station . We started our work from point which was very near to **Jaypee University Gate**, so we took that point as our benchmark. We try to find width of the pavement and shoulder width at every cross section with the help of total station .After this , we choose 10 curves from **JaypeeUniversity Gate** to 1.2km and for that curves we have calculated Radius of curve ,Stopping sight Distance (SSD),Overtaking Sight Distance(OSD) and others various Horizontal alignment components of road like Super elevation ,Extra widening of the curves and Minimum length of transition Curve by empirical formula for each curves . To find this, we first calculated Radius of curve through Versine curve method and after obtaining the radius of curves for 10 curves. We calculated other design parameters. After completing this objective, we learnt to operate MX road software. In MX Road software, we learnt how to convert Auto cad File in to MX file.

# CERTIFICATE

This is to certify that the work entitled **“RURAL ROAD DEVELOPMENT FROM JAYPEE UNIVERSITY GATE TO 1.2 Km STRETCH TOWARDS WAKNAGHAT”** submitted by **Ankush Rajta (111631) and Ayush Sharma (111674)** in partial fulfilment for the award of degree of Bachelor of Technology in Civil Engineering of Jaypee University of Information Technology has been carried out under my supervision. This work has not been submitted partially or wholly to any other University or Institute for the award of this or any other degree or diploma as per best of my knowledge.

| | | |
|---|---|---|
| Prof. Dr. Ashok Kumar Gupta | Mr. Lav Singh | .............................. |
| Professor & Head | Assistant Professor | External Examiner |
| Department of Civil Engineering | (Project Supervisor) | |
| JUIT | Department of Civil Engineering | |
| | JUIT | |

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We would like to express our gratitude towards our parents & the Department of Civil Engineering (JUIT) for their kind co-operation and encouragement which helped us in partial completion of this project.
Our thanks and appreciations also goes to our colleagues in developing the project and people who have willingly helped us out with their abilities.

Date: Ayush Sharma (111674)

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# List of Contents

**Page No.**

# LIST OF FIGUERS

# CHAPTER 1

# INTRODUCTION

## 1.1 Pavement

Flexible and Rigid pavement is used between Jaypee gate to Wakhnaghat like Road is made of Rigid pavement from Jaypee gate to Thank you gate and after that road is made of flexible pavement till Wakhnaghat.

To do this project we should have knowledge of the Higway engineering , Surveying, Auto cad software and MX road software

Road between **Jaypee Gate** and **Wakhnaghat** is located 3 kilometers off NH 22 (20 km from Shimla) (from Wakhnaghat ) which runs from Kalka to Shimla (India).

## 1.2 Necessity of the project:

The reason behind to take this project is by seeing the fact that PWD doesnot take so much of interest in rural roads .They are donot follow IRC codes properly when its comes to rural roads. If we talk about rural road in india , Some are the facts about rural road of india :

- India has a Rural Road Network of about 2.70 Million km with Rs.35,000 Crore investment.
- Constitutes over 80% of Total Road Network.
- More than 1,000,000 Km are tracks and roads not meeting Technical Standard.
- Rural Roads Sector suffered from lack of systematic Planning , Quality and Sustained Maintenance.
- It was a Myth that Rural Roads do not require Planning/Design/ Quality Assurance.

  The reason to take this project "**RURAL ROAD DEVELOPMENT FROM JAYPEE GATE TO 1.2 Km ROAD STRETCH TOWARDS WAKNAGHAT"** is that we are very curious to know whether this road follow IRC or not and I also observed that, college have been increasing their admission capacity from the past 3 year but college have only limited Hostel seats available . So local people have started to give Room for Rent for those student who didn't able to get hostel in college. Due to this ,Traffic volume from Jaypee Gate to Wakhnaghat is increasing . So there is need of development of this road.

## 1.3 SCOPE

- To do Road survey from **Jaypee Gate to 1.2 km road stretch towards Waknaghat** with the help of Total station .

- To determine pavement width at every cross section that we took from **Jaypee Gate to 1.2 km road stretch towards Waknaghat .**

- To determine radius of curve of major and sharp curves present between **Jaypee Gate to 1.2 km road stretch towards Waknaghat** by using the concept of versine curve.

- Measurement and analysis of various geometrical design components i.e. SSD(Stopping sight distance), Superelevation and Length of curve at the sharp and major curves.

- To learn MX Road Software.

# CHAPTER 2
# LITERATURE REVIEW

Various research papers/reports were studied as a literature review for this project. A summary of the readings is presented in the following.

**1. Cost and Safety Efficient Design Study of Rural Roads in Developing Countries. By B L Hills, C J Baguley and S J Kirk.**

In this general survey of a highway of Papua New Guinea was carried out. Their focus was how the characteristics of the road were changing with distance. The measurements were of shoulder width, running surface width, curvature, gradient, traffic and pedestrian count was carried out. Mainly they were focusing on geometric design and traffic flow and its affect on accident rates. As in the Papua New Guinea study, Curvature and Gradient proved to be significant explanatory variables, both increasing accident rates the sharper the curve or steeper the gradient. In a study of Tanzania's roads described in it was observed that the number of pedestrian accidents was considerably lower for roads where a 1 metre shoulder had been provided compared to those with a 0.5 metre shoulder .

Similarly we will be calculating shoulder width at various sections of JAYPEE gate to WAKNAGHAT circle and pavement width at various cross sections, we will also be calculating curvature, traffic count.

**2. Traffic Report 2013 Of Agra to Lucknow to access controlled Expressway (Green Field) Project Prepared by Feedbackinfra.**

In this report the traffic surveys were carried out in which they did classified traffic volume count at nine (9) locations. Locations were of upmost importance where one road was diverting into two. For these major roads intersecting the proposed project road were surveyed continuously for seven or three consecutive days for 24 hours on each day. The origin-destination survey was carried out with the primary objective of studying the travel pattern of goods and passenger traffic along the study corridor. Then a proper analysis of survey data was done .The various vehicle types having different sizes and characteristics were converted into a standard unit called passenger car unit.

**3. Traffic volume and accident studies on NH-22 between SOLAN and SHIMLA by Anish Mahajan and Jay Singh**

In this project , They have calculated length of curve, SSD, super elevation of black spots as their main focus was on accident studies. They have checked its value according to IRC code provisions .

# CHAPTER 3
# CLASSIFICATION OF ROADS

## 3.1 Based on weather conditions

**a. All weather roads**: Those which are negotiable during all weather

**b. Fair weather roads**: Traffic may be interrupted during monsoon season at cause way where stream may over flow across the road

## 3.2 Based on the type of the carriage way

**a.Paved roads**: Provided with a hard pavement course which should be atleast WBM.

**b.Unpaved roads**: Not provided with a hard pavement course which should be atleast WBM layer .Thus earth roads and gravel may be called unpaved roads.

## 3.3 Based on type of pavement surfacing

**a.Surface roads**: Provided with a bituminous or cement concrete surfacing.

b.**Unsurfaced roads**: Not provided with a bituminous or cement concrete surfacing, the roads are provided with bituminous surfacing are also called as *black toped roads.*

## 3.4 Classification of Road by Nagpur Road plan

As per the Nagpur Pl, the roads are classified as

a. National highway
b. State highways
c. District highways
d. Major district roads
e. Minor district roads
f. Village roads

a. **National Highways**:- These are the important roads of the country. They connect state capitals, ports and foreign highways. They also include roads of military importance. They are financed by the central government.

b. **State Highways** :- these are the important roads of a state. They connect important cities and district head quarters in the state , national highways & state highways of neighbouring states. They are financed by state government roads and buildings department of the state government constructs & maintain these roads.

c. **District Roads** :- these are the roads within a district . they are financed by zillaparishads with the help of grants given by state government.

d. **The Major District Roads**:- They are roads connecting district head quarters, taluk head quarters and other important town in the district production and market centers with each other and with state & national highways & railways.

e. **Other District Roads** :- They are district roads of less importance

f. **Village Roads**:- They connect villages with each other and to the nearest district road. They are financed by panchayats with the help of zilla parishads and state government

**The road stretch from Jaypee Gate to 1.2 km towards Waknaghat come under in Other District Roads**

# CHAPTER 4
# SURVEYING

## 4.1 Introduction

Surveying is the art of determining the relative position of points on, above or beneath the surface of the earth by means of direct or indirect measurement of distance direction and elevation. It includes the art of establishing points by predetermined angular and linear measurements.

The knowledge of surveying is advantageous in many phases of engineering. The earlier surveys were made in connection with land surveying. Practically every engineering project such as road,water supply and irrigation schemes, railroads and transmission lines, mines, bridges and buildings etc. require surveys. Before plans and estimates are prepared, boundaries should be determined and the topography of the site should be ascertained. After the plans are made, the structure must be staked out in the ground. As the work progresses, lines and grades must be given.

In this project, we have performed one types of survey:-

1. Total Station Survey

## 4.2 Total Station Survey

### 4.2.1 Total Station

A form of an electronic theodolite combined with an electronic distance measuring device (EDM). The primary function is to measure slope distance, vertical angle, and horizontal angle from a setup point to a foresight point. Most total stations use a modulated near-infrared light emitting diode which sends a beam from the instrument to a prism. The prism reflects this beam back to the instrument. The portion of the wavelength that leaves the instrument and returns is assessed and calculated. Distance measurements can be related to this measurement. The accuracy of a total station is dependent on instrument type. Angle Accuracy (Horizontal or Vertical) can range from 2” to 5”. Distance Accuracy can range from: +/- (0.8 + 1 ppm x D) to +/- (3 + 3 ppm x D) mm where D = distance measured . Accuracy is highly dependent on leveling the instrument. Thus two leveling bubbles are provided on the instrument and are referred to the circular level and the plate level. Circular level is located on the tribrack while plate level is on horizontal axis of instrument just below scope of the total station.

- Sensitivity of Circular Level = 10’ / 2mm
- Sensitivity of Plate Level = 30” / 2mm

### 4.2.2 Advantages of Total Station Surveying

1. Relatively quick collection of information .

2. Multiple surveys can be performed at one set-up location.

3. Easy to perform distance and horizontal measurements with simultaneous calculation of project coordinates (Northings, Eastings, and Elevations).

4. Layout of construction site quickly and efficiently.

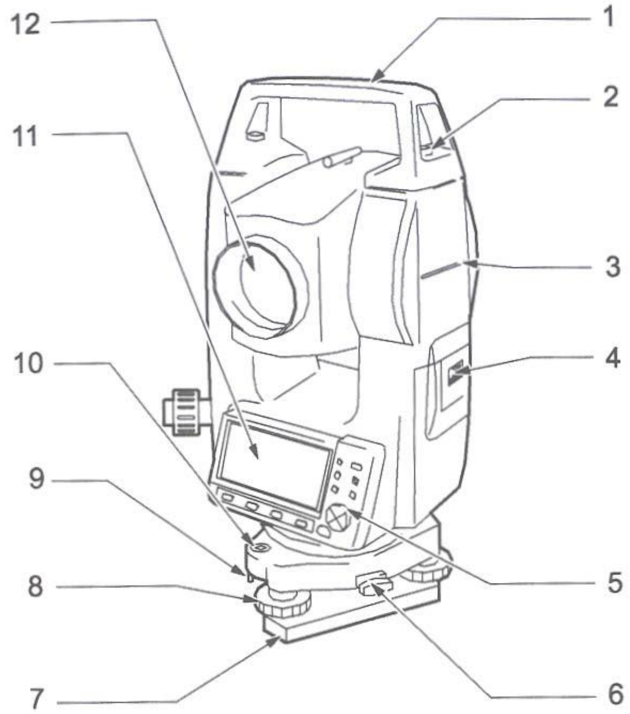
5. Digital design data from CAD programs can be uploaded to data collector.

6. Daily survey information can also be quickly downloaded into CAD which eliminates data manipulation time required using conventional survey techniques.

### 4.2.3 Types of Total Station Surveying

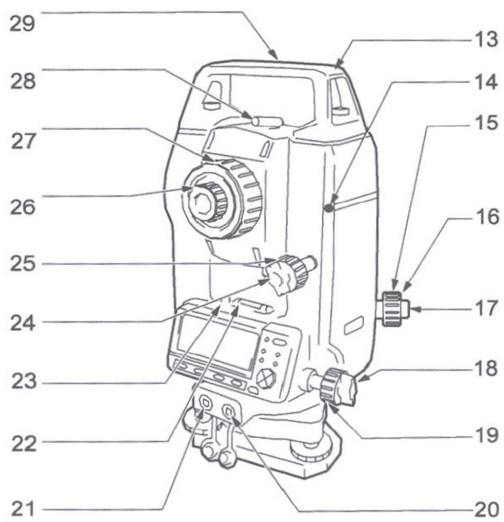
i. Slope Staking
ii. Topographic surveys
iii. Leveling
iv. Areas
v. Road (Highway)
vi. Surveys

# Parts of the SET Total Station




1 Handle
2 Handle securing screw
3 Instrument height mark
4 Battery cover
5 Operation panel
6 Tribrach clamp (SET310S/510S/610S: Shifting clamp)
7 Base plate
8 Levelling foot screw
9 Circular level adjusting screws
10 Circular level
11 Display
12 Objective lens

**Fig 4.1 (Parts of Total Station)**




13 Tubular compass slot
14 Beam detector for wireless keyboard (Not included on SET610/610S)
15 Optical plummet focussing ring
16 Optical plummet reticle cover
17 Optical plummet eyepiece
18 Horizontal clamp
19 Horizontal fine motion screw
20 Data input/output connector (Beside the operation panel on SET610/610S)
21 External power source connector (Not included on SET610/610S)
22 Plate level
23 Plate level adjusting screw
24 Vertical clamp
25 Vertical fine motion screw
26 Telescope eyepiece
27 Telescope focussing ring
28 Peep sight
29 Instrument center mark

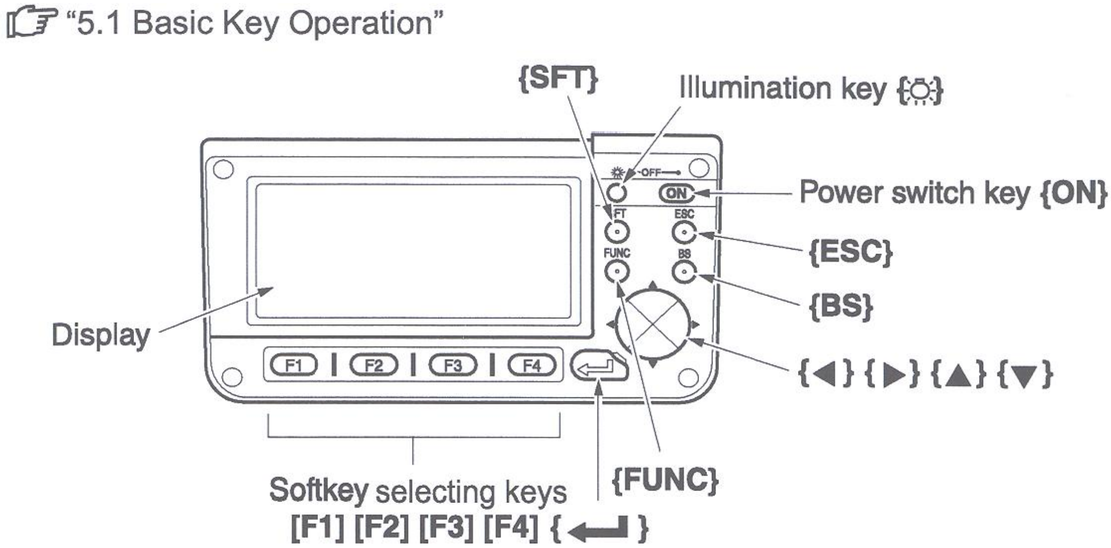



**Fig 4.2 Keys /Screen**

### 4.2.4 Leveling the Total Station

Leveling the Total Station must be accomplished to sufficient accuracy otherwise the instrument will not report result. Leveling the instrument takes 30 to 45 minutes make sure you can see all targets from the nstrument station before going through the process.

**Step 1: Tripod Setup**

a. Tripod legs should be equally spaced.
b. Tripod head should be approximately level.
c. Head should be directly over survey point

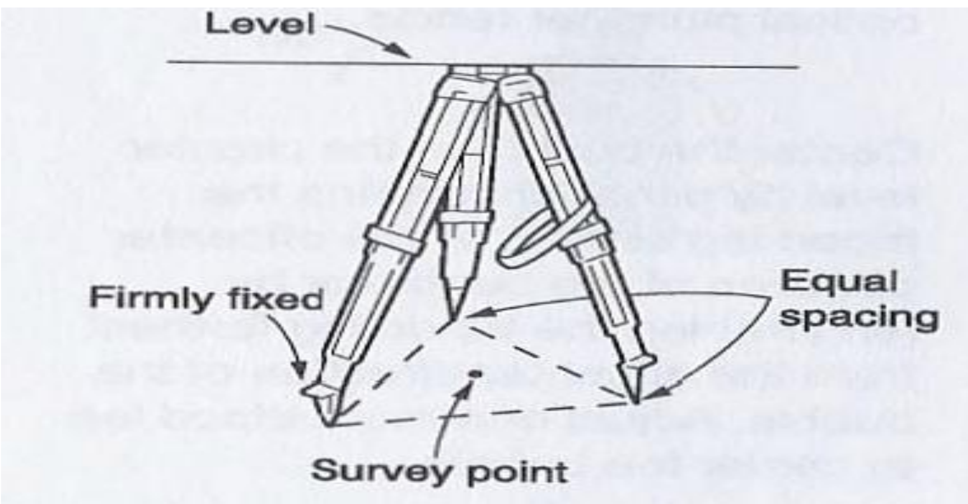



**Fig 4.3Tripod**

**Step 2: Mount Instrument on Tripod**

a. Place Instrument on Tripod.
b. Secure with centering screw while bracing the instrument with the other hand.
c. Insert battery in instrument before leveling

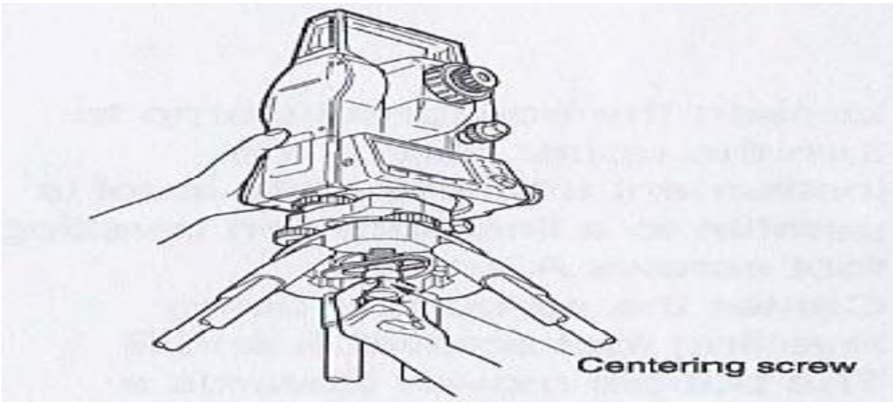



**Fig 4.4 Instrument on Tripod**

**Step 3: Focus on Survey Point**

a. Focus the optical plummet on the survey point

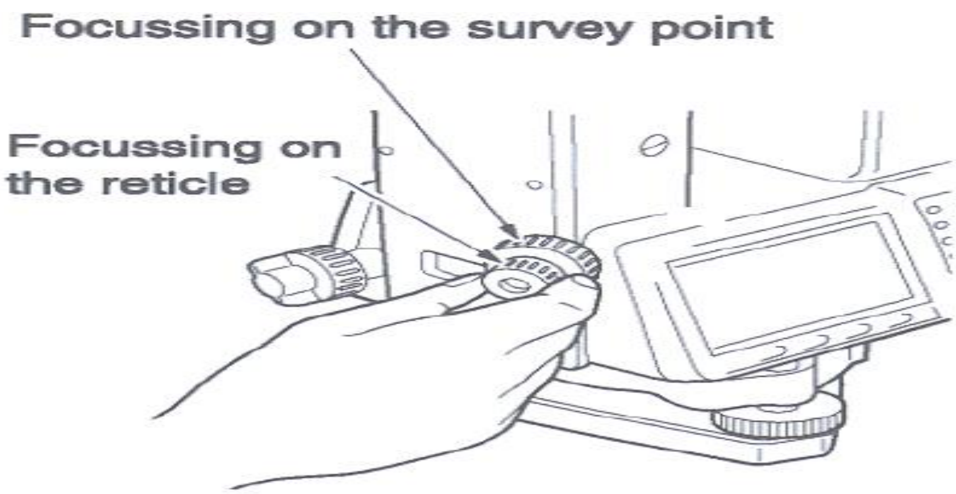



**Fig 4.5 Focus on survey Point**

**Step 4: Leveling the Instrument**

**a.** Adjust the leveling foot screws to center the survey point in the optical plummet reticle.

**b.** Center the bubble in the circular level by adjusting the trip.

c. Loosen the horizontal clamp and turn instrument until plate level is parallel to 2 of the leveling foot screws.frt

d. Center the bubble using the leveling screws- the bubble moves toward the screw that is turned clockwise.

e. Rotate the instrument 90 degrees and level using the 3rd leveling screw.

f. Observe the survey point in the optical plummet and center the point by loosening the centering screw and sliding the entire instrument.

g. After re-tightening the centering screw check to make sure the plate level bubble is level in several directions

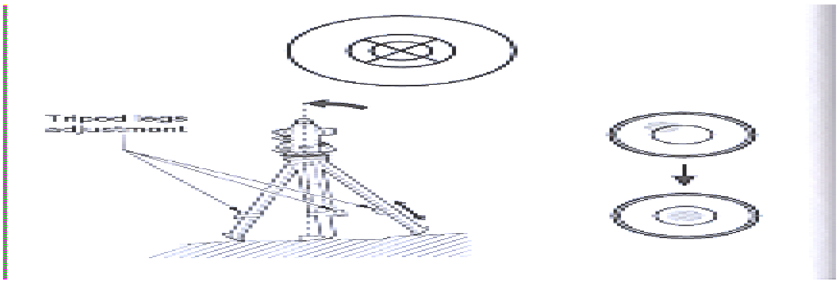



**Fig 4.6 Centering of bubble**

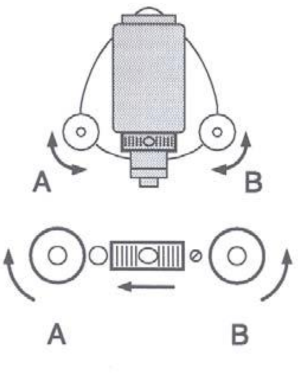



**Fig 4.7 (a) Rotating the A and B screws in Same direction**

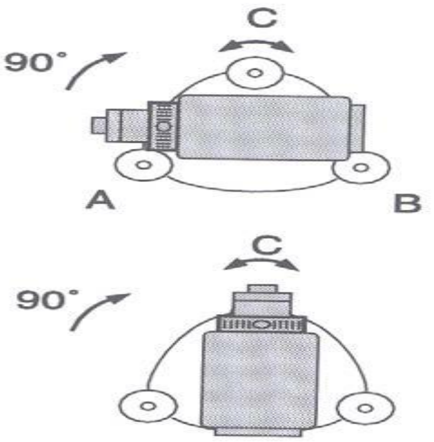



**Fig 4.7(b) Rotate the C screw only**

**Step 4: Electronically Verify Leveling**

a. Turn on the instrument by pressing and holding the "on" button (you should hear an audible Beep)

b. The opening screen will be the "MEAS" screen. Select the [Tilt] function.

c. Adjust the foot level screws to exactly center the electronic "bubble".

**d.** Rotate the instrument 90 degrees and repeat

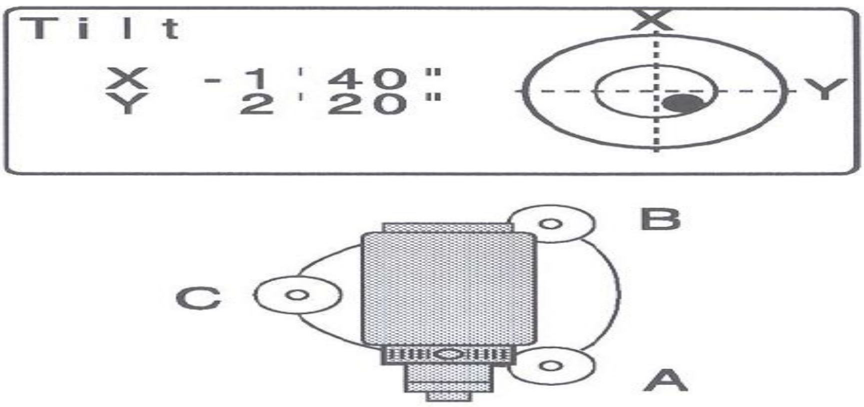



**Fig 4.8Electronically Verify Levelling**

**Step 5: Adjust Image & Reticle Focus**

a)Release the horizontal & vertical clamps and point telescope to a featureless light background

b) Adjust the reticle (i.e. cross-hair) focus adjustment until reticle image is sharply focused.

c) Point telescope to target and adjust the focus ring until target is focused.

d) Move your head from side-to-side to test for image shift (i.e. parallax). Repeat the reticle focus step if parallax is significant.

NOTE: When the instrument operator changes the reticle focus may need to be adjusted.

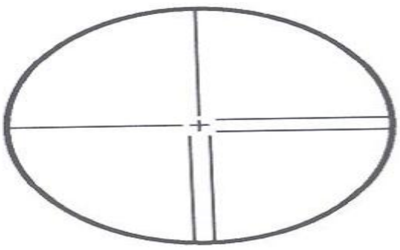


**Fig 4.9 Reticle Focus**

### 4.2.5 Accessories of Total station

Fig 4.10 Total Station

Fig 4.11Tripod

Fig 4.12 Prism and Poles

### 4.2.6 How Survey was done for 1.2 Km from Jaypee Gate to 1.2 km (moving towards Waknaghat)

The following procedure we have followed to do road survey are :

1. To do road survey ,we used total station .
2. We started our work from Jaypee gate.
3. Near to jaypee gate ,we took our first point as a bench mark where we put zero value of northing ,easting and zenith in the station coordinates of the total station.
4. What we have done is ,we divided 1.2 km span of the road into many cross section with varied length .
5. At every cross section , we took 6 points like centre line ,R.H.S, L.H.S ,Extra R.H.S ,Extra L.H.S and Drainage which all having unique value of northing ,easting and zenith.
6. The values that we got with the help of total station at every cross section , we put it in excel . For example **for Chainage from 0 to 30m**

CHAINAGE from 0 to 30m

| | | N | E | S |
|---|---|---|---|---|
| Centre line | a1 | -1.79 | 31.39 | -0.639 |
| left hand side | a2 | 0.022 | 31.56 | -0.546 |
| right hand side | a3 | -3.708 | 31.432 | -0.69 |
| extra left side | a4 | 2.591 | 31.85 | -0.366 |
| extra right side | a5 | -4.107 | 31.146 | -0.679 |
| drainge towards right side | a6 | -4.292 | 31.035 | -0.44 |

7. To make road alignment in auto cad(2-D), we use Northing and Easting as a coordinates like (N,E) For example

| N | E | S | (N,E) | (Point name ,N,E) |
|---|---|---|---|---|
| 1.79 | 31.39 | 0.639 | 1.79,31.39 | a1,1.79,31.39 |

8. We make a list of (point name ,N,E) coordinates for all the cross section that we have .Let say ,we make a list of coordinates for centre line .This list is used to make a Centre line in Auto Cad Software.

Centre Line (RED)

a1,-1.79,31.39

b1,2.468,60.995

c1,-4.436,89.898

d1,-20.78,147.414

e1,-19.604,207.533

9. The same procedure is followed for R.H.S, L.H.S ,Extra R.H.S ,Extra L.H.S and Drainage that was followed for Centre Line.

# CHAPTER 5

# MODELLING

## 5.1 PROCEDURE

Here, in Auto Cad we have to prepare the layout using the total survey data points. So here we imported these data points to get the layout by following steps:-

**Step1**:- Before importing the points and draw the layout we set the units and layers of the lines to be drawn. For this to be done we used ‘UNITS’ and the ‘LAYER’ commands. On entering the units command a pop window comes on the screen where we set the insertion units to ‘Meters’ and angle type to ‘Surveyor’s Units’. After then type the ‘LAYER’ command and then add new layers of different colors.

**Step2**:- Since the drawing conditions are set and the adequate layer is ‘on’ in Auto CAD. It’s time to import. Type the command ‘LINE’ and then move to the EXCEL SHEET where you have prepared the data points in the required (X, Y) format.

In the EXCEL Sheet select the points that are falling in one line, copy them and then paste them in the command line of Auto CAD. The Auto CAD will join all the points by making a line between two consecutive points.

Here, we achieved the whole layout by joining drawings made in the same fashion upto each change of station of Total Station. After then hatching was done with solid colour to show the carriage way.

**Step3**:- After the layout has been made select the different layer to show the cross section lines and then name them using the ‘MTEXT’ command. Here, to represent the Cross sections we have used the letters “C.S.” followed by the corresponding numeral of the cross section.

## 5.2 Road Survey

Actually to make alignment of the road for 1.2 km span in auto cad .We have first made alignment of road for 200m . Then after that , we made alignmet of the road for stretch 200m to 487m and after that 487m to 726m and finally for stretch 726m to 940m in auto cad. After that , we compile all the drawing in one to make whole stretch of 1.2km in Auto Cad.


**Fig 5.1 Alignment of the selected road stretch from Google Earth**

### 5.2.1 Road Survey and Visual Inspection of the road stretch from of 0 to 210 m starting from Jaypee University gate.

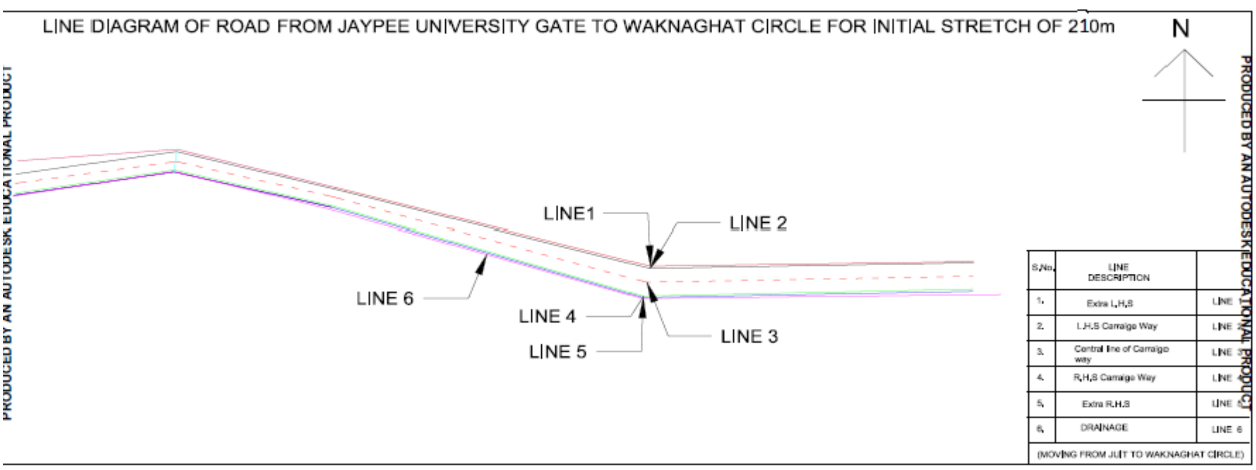



**Fig 5.2 Auto cad drawing for road stretch from Jaypee Gate to 210m stretch**

## Visual Inspection of Road From 0 to 210m starting from Jaypee University gate

- Starting from Jaypee Gate there is taxi stand on the left and Moksh Hotel on the right which sometimes lead to traffic congestion.

- Total Number of curves observed in this section is 3. In which one curve is towards right and the other two curve is towards left.

- Just after the first curve there is cutting of rocks done mainly for construction purposes.

- The type of pavement used is mainly rigid pavement and the condition of rigid pavement is good except a few cracks are observed..

- There are some pictures who are giving information about Road Stretch from Jaypee Gate to 210m.

**Fig 5.3 (a) Starting point of survey**

**Fig 5.3 (b)  View of Moksh Hotel**

**Fig 5.3 (c) Cutting of the Hill Side for Commercial purpose**

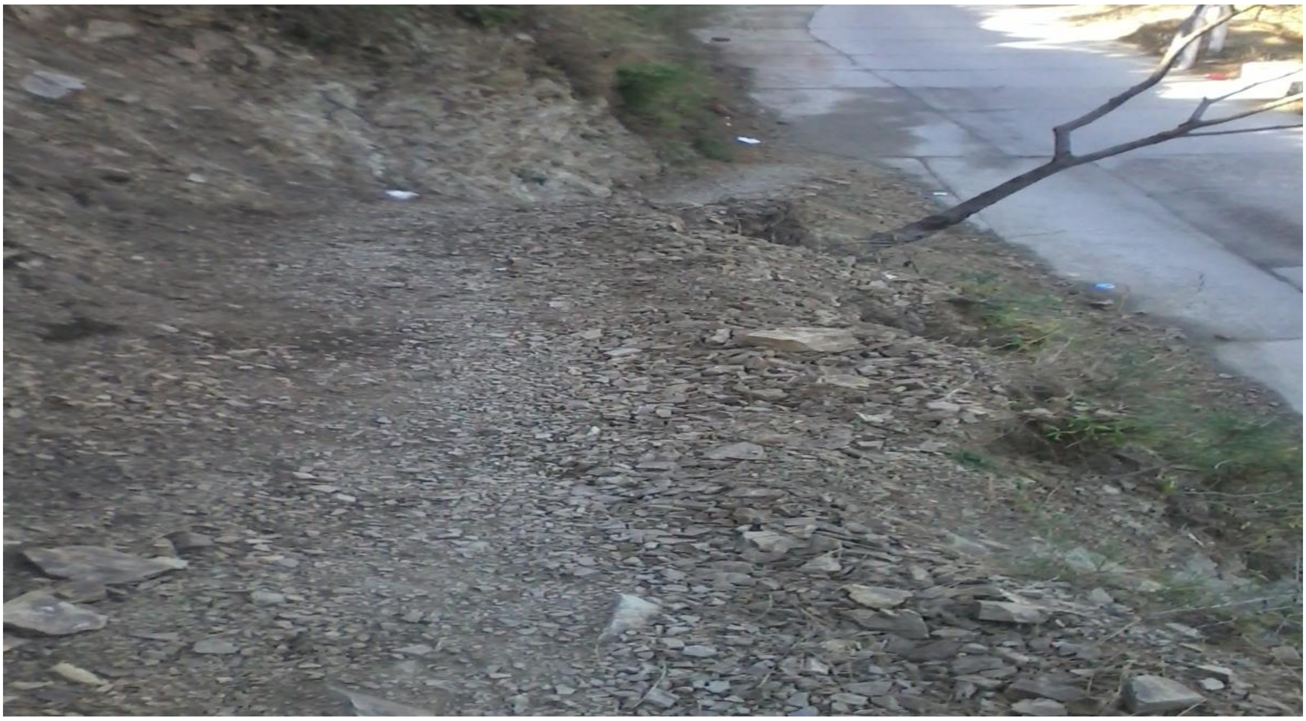


**Fig 5.3(d)  Condition of Tree  is not good**

**Fig 5.3 (e) Condition of the concrete pavement  is not good**

**Fig 5.3(f) Stones lying on the road**

## 5.2.2 Road Survey and Visual Inspection of the road stretch from 210m to 487m.


**Fig 5.4 Auto cad drawing for road stretch from 210m to 487m**

## Visual Inspection of Road stretch from 210m to 487m.

- After the THANKYOU GATE there is use of bituminous pavement and the condition of bituminous pavement is good .

- The parapets thereafter are quite less in number out of which some are not in good condition.

- Drainage is provided but the condition is not good.

- There are some Pictures who are giving some information about Stretch for 210m to 487 m toward Waknaghat Circle like :

**Fig 5.5(a) Intersection of Flexible pavement and Rigid pavement**


**Fig 5.5 (b) View of Hill Point**

## 5.2.3 Road Survey and Visual Inspection of the road stretch from 487m to 726m.

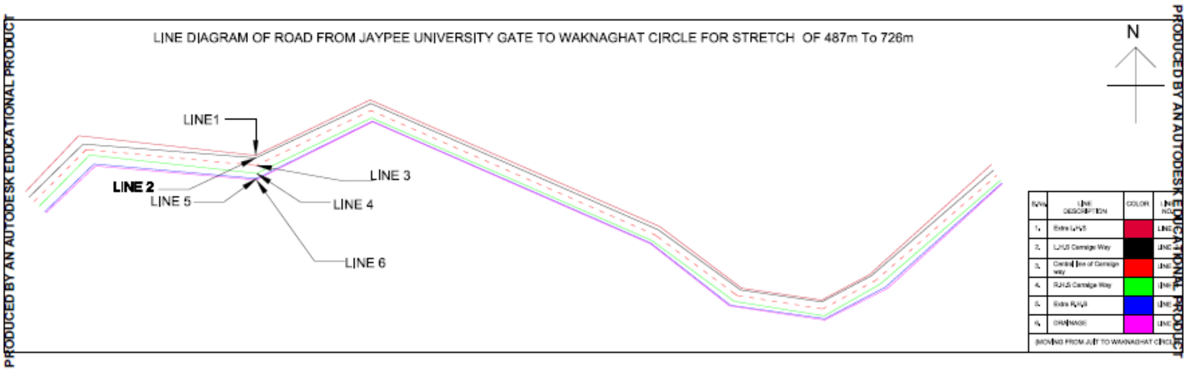



**Fig 5.5 Auto cad drawing for road stretch from 487m to 726m**

### Visual Inspection of Road stretch from 487m to 726 m

.

- Minor holes are visible in the pavement but overall the pavement condition is good.

- Drainage condition is good there.
- We observed hand pump
- Cutting of Hill have been done there

**Fig 5.6 Cutting of Hills**

## 5.2.4 Road Survey for the road stretch from 726m to 940m

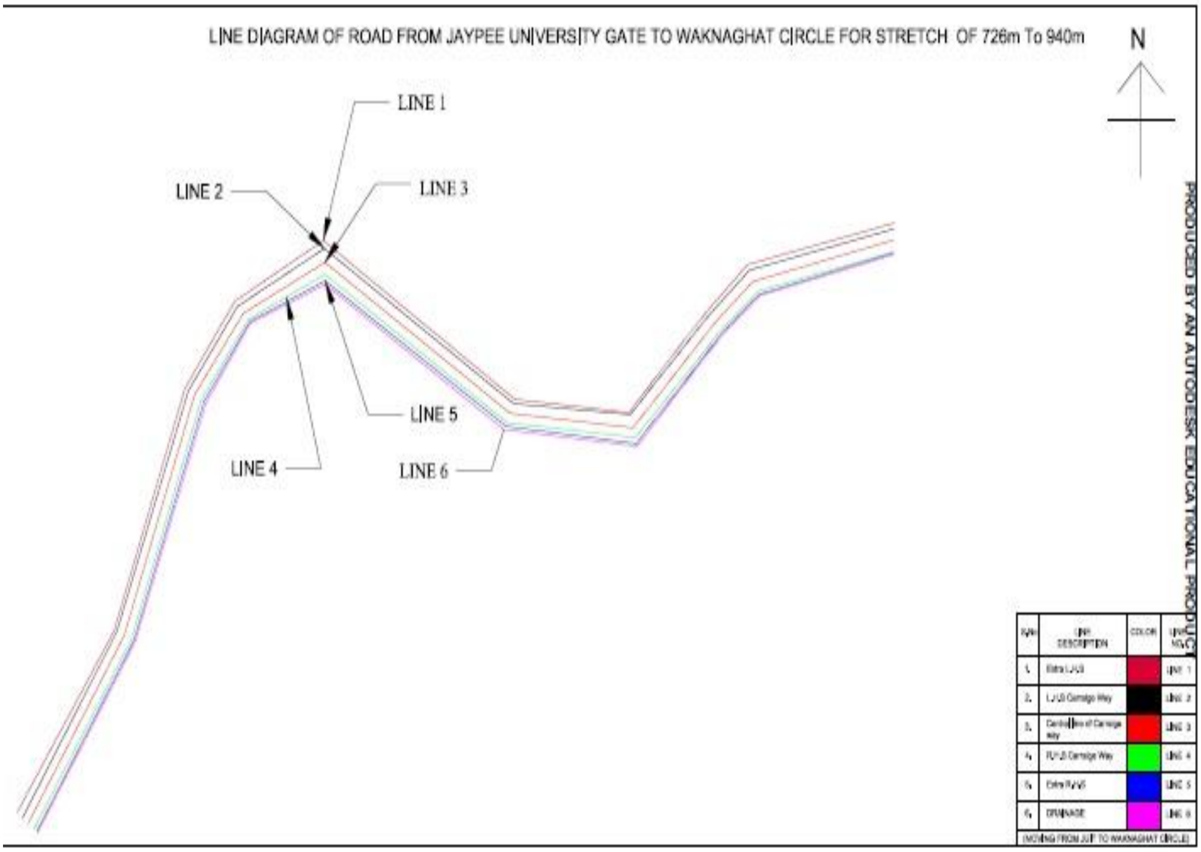



**Fig 5.7 Auto cad drawing for road stretch from 726m to 940m**

## 5.2.5 Road Survey for road stretch from Jaypee University Gate to 1130 m.

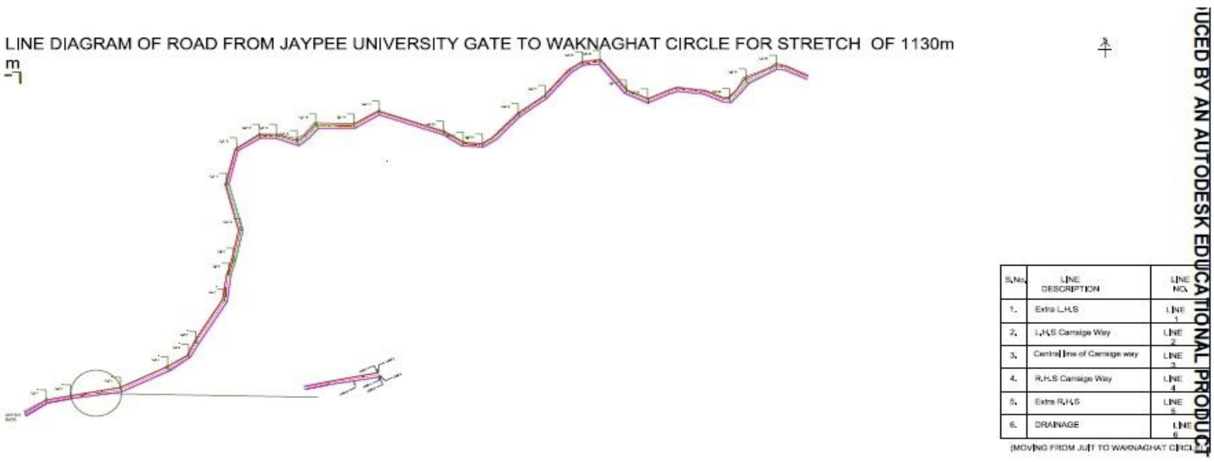



**Fig 5.8 (a) Auto cad drawing for road stretch from Jaypee Gate to 1130m**

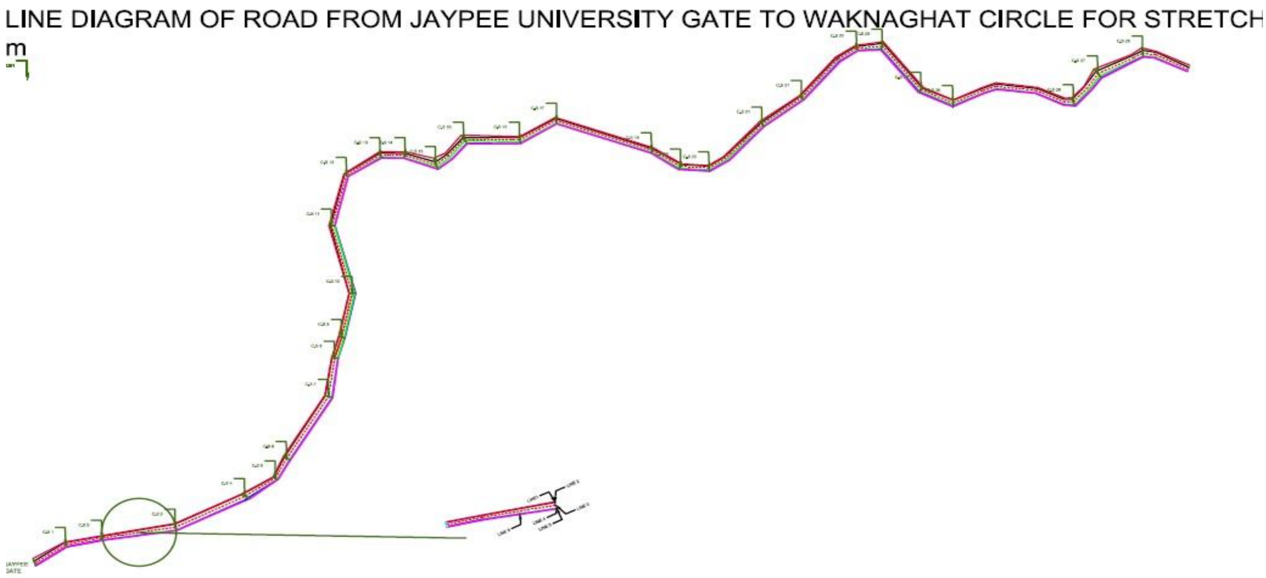



**Fig 5.8 (b) Auto cad drawing for road stretch from Jaypee gate to 1130m (zoom in)**

So Overall observaion that we collected from visual inspection of whole stretch 1130m was that :

- Total no curves were found 22.
- We found Rigid pavement from Jaypee Gate to Thankyou.
  After that we found flexible pavement throughout the road.
- There was no proper drainage at certain cross sections .
- We also observerd crack in rigid pavement .So there is need of repair in rigid pavement.
- We didnot observe Traffic Sign throughout the stretch which is not good sign ,from safety point of view.
- We also observed that there was no proper barrier was provided throught out the stretch .
- Most of the barriers were not good in condition.

**Fig 5.9 Condition of parapet is not good** .

## 5.3 PAVEMENT WIDTH

After collecting survey data from total station for 1.2Km. Then we find pavement width at every possible cross section .

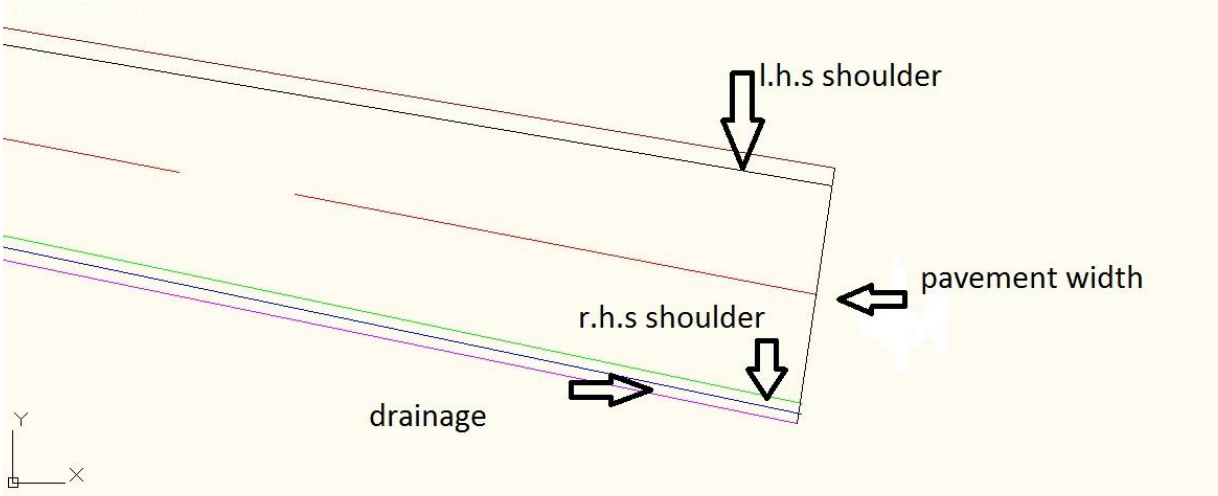



**Fig 5.10 Image showing L.H.S shoulder width ,Pavement width , R.H.S shoulder width and drainage width**

### 5.3.1 ANALYSIS OF THE ROAD SECTION FROM 0 TO 210m.

| DISTANCE | PAVEMENT WIDTH | LEFT HAND SIDE SHOULDER | RIGHT HAND SIDE SHOULDER |
|---|---|---|---|
| 30m(starting from Jaypee Gate) | 3.73m | 2.59m | 0.49m |
| 60m | 3.60m | 0.45m | 0.38m |
| 90m | 3.27m | 0.34m | 0.31m |
| 150m | 5.53m | 0.45m | 0.28m |
| 210m | 5.13m | 0.24m | 0.47m |

According to **IRC :52 -2001** the pavement width of hilly roads in other district roads should be equal to 3.75m and the roadway width (excluding side drains and parapets) should be equal to 4.75m, meaning that the minimum shoulder width should be equal to 0.5m on either side. As the road section in above section is mainly rigid pavement and road width at cross section at 90m is 3.27m which is very less as compared to minimum pavement width laid down by irc and shoulder width is also less there .

## 5.3.2 ANALYSIS OF ROAD SECTION FROM 210m TO 405m.

| DISTANCE | PAVEMENT WIDTH | LEFT HAND SIDE SHOULDER | RIGHT HAND SIDE SHOULDER |
|---|---|---|---|
| 220m | 2.38m | 0.37m | 0.19m |
| 240m | 3.51m | 0.40m | 0.63m |
| 260m | 4.67m | 0.78m | 0.62m |
| 310m | 5.31m | 0.65m | 0.44m |
| 330m | 4.64m | 0.59m | 0.74m |
| 341m | 4.45m | 0.25m | 0.33m |
| 366m | 4.43m | 0.28m | 0.48m |
| 376m | 2.95m | 0.39m | 0.52m |
| 405m | 3.20m | 0.58m | 0.20m |

In this section the pavement width is meeting the required criteria according to irc except at section 220m, 240m, 376m, 405m and left hand shoulder width is within the required criteria except at 220m, 341m,366m,376m and the right hand shoulder is not good at 220m, 405m.

## 5.3.3 ANALYSIS OF ROAD SECTION FROM 435m TO 637m.

| DISTANCE | PAVEMENT WIDTH | LEFT HAND SIDE SHOULDER | RIGHT HAND SIDE SHOULDER |
|---|---|---|---|
| 435m | 3.37m | 1.18m | 1.12m |
| 456m | 3.62m | 1.46m | 0.68m |
| 474m | 4.76m | 0.75m | 0.74m |
| 487m | 3.61m | 0.78m | 0.92m |
| 503m | 3.40m | 0.59m | 0.64m |
| 544m | 4.12m | 0.63m | 1.35m |
| 577m | 3.82m | 0.95m | 0.94m |
| 637m | 3.31m | 0.95m | 0.72m |

The pavement width is within the required criteria and shoulder provides is good in this section .only at a distance of 435m,456m,487m,503m,577m,637m the pavement width is less than the required criteria.

## 5.3.4 ANALYSIS OF ROAD SECTION FROM 652m TO 856 m.

| DISTANCE | PAVEMENT WIDTH | LEFT HAND SIDE SHOULDER | RIGHT HAND SIDE SHOULDER |
|---|---|---|---|
| 652m | 3.45m | 0.51m | 1.43m |
| 671m | 3.78m | 0.44m | 0.75m |
| 688m | 3.21m | 0.59m | 1.60m |
| 726m | 3.25m | 1.57m | 0.81m |
| 765m | 3.58m | 0.62m | 0.65m |
| 805m | 3.32m | 0.87m | 0.75m |
| 822m | 3.35m | 1.10m | 0.49m |
| 844m | 4.56m | 1.17m | 1.12m |
| 856m | 3.64m | 0.82m | 0.64m |

The pavement width is less in this particular section except at 671m and 841m. The shoulder provided is meeting the required criteria.

## 5.3.5 ANALYSIS OF ROAD SECTION FROM 873m TO 1084m.

| DISTANCE | PAVEMENT WIDTH | LEFT HAND SIDE SHOULDER | RIGHT HAND SIDE SHOULDER |
|---|---|---|---|
| 873m | 4.17m | 0.45m | 1.05m |
| 898m | 3.85m | 0.79m | 0.54m |
| 910m | 4.17m | 1.05m | 0.59m |

| | | | |
|---|---|---|---|
| 939m | 3.97m | 1.04m | 0.19m |
| 955m | 4.21m | 1.13m | 0.48m |
| 960m | 5.29m | 1.33m | 1.05m |
| 977m | 4.43m | 0.37m | 1.78m |
| 989m | 5.01m | 2.43m | 1.84m |
| 1024m | 4.57m | 2.27m | 1.02m |
| 1030m | 5.12m | 2.24m | 0.64m |
| 1039m | 4.07m | 0.57m | 1.07m |
| 1058m | 3.47m | 1.98m | 0.24m |
| 1075m | 5.11m | 1.71m | 1.39m |
| 1084m | 4.25m | 1.35m | 0.47m |

The road section is meeting the required condition at all the cross sections except at 1058m. The left hand side shoulder is within the required criteria only at distance of 977m is quite less and the right hand shoulder is within the required criteria except at 939m, 1058m is less .

### 5.3.6 ANALYSIS OF ROAD SECTION FROM 1097m to 1130m.

| DISTANCE | PAVEMENT WIDTH | LEFT HAND SIDE SHOULDER | RIGHT HAND SIDE SHOULDER |
|---|---|---|---|
| 1097m | 4.39m | 1.37m | 0.88m |
| 1130m | 5.21m | 2.26m | 0.94m |

The pavement width is within the required criteria at all the sections . All the shoulder width is meeting the required criteria.

# CHAPTER 6

# Measurement and analysis of various geometrical design components

## 6.1Introduction

### 6.1.1 Circular Curves

Horizontal curves are normally circular. Figure 4.13 illustrates several of their important features. Horizontal curves are described by radius (R), central angle (Δ) (which is equal to the deflection angle between the tangents), length (L),semitangent distance (T),

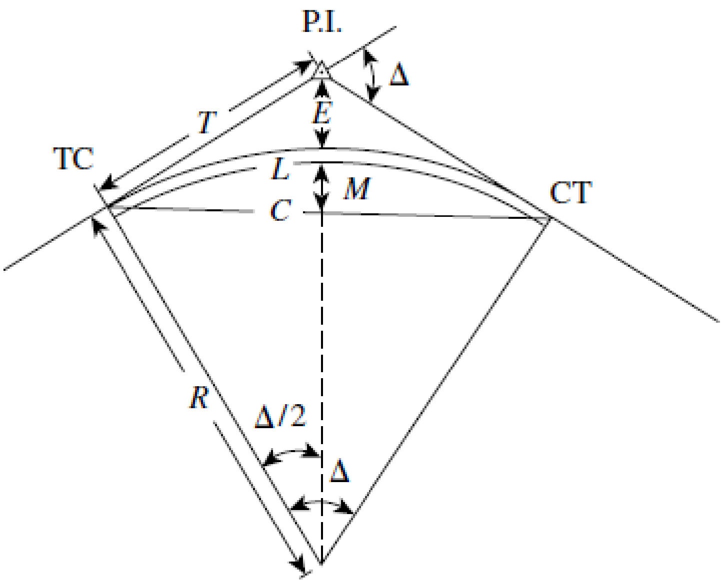



**Fig 6.1 Horizontal curve features**

middle ordinate (M), external distance (E), and chord (C). The curve begins at the tangent-to-curve point (TC) and ends at the curve-to-tangent point (CT). In the past, severity of curvature was sometimes expressed in degree of curvature. Although obsolete in the metric system, degree of curvature may still be encountered in some situations. Degree of curvature may be defined in two ways. The arc definition is **the angle subtended by a 100 ft arc. The chord definition is the angle subtended by a 100 ft chord.** The relationship between radius (in feet) and degree of curvature (arcdefinition) is

$$\mathbf{D=5729.58/R}$$

where *D* =degree of curvature and *R* =radius of curvature, in feet.

**D=1719/R**

where R is Radius of Curve in Metres

### 6.1.2 Relation between Radius of curve and Degree of curve through versine curve method

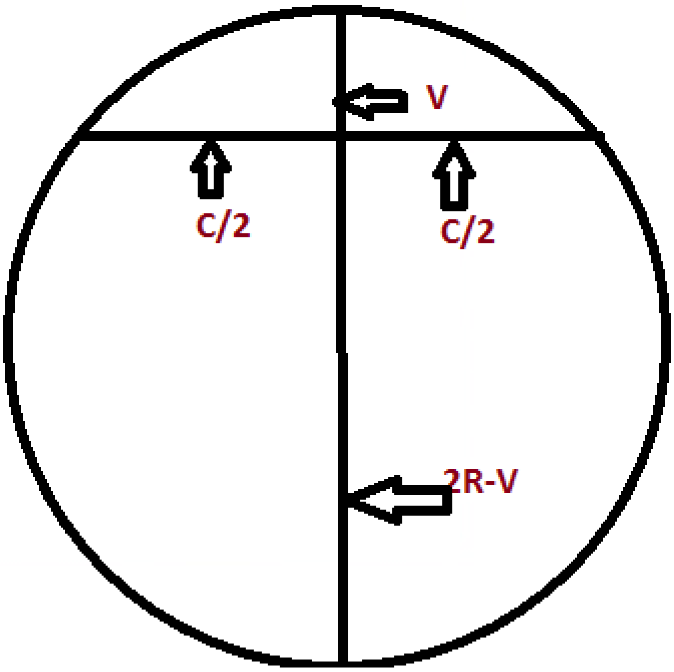



**Fig 6.2 Circular Curve**

Consider a circular curve having Radius of curve is R .Let assume any chord having chord length C and versine V which is shown in fig 6.2

As we know

( C/2 *C/2) = V*(2R-V)

C^2/4 = 2RV –V^2

As V is very small , so we will neglect the value of V^2.

So C^2/4 = 2RV

C^2/8R = V

Where chord length (C) is in metre and Versine (V) is also in metre .

100 C^2/8R = V where Versine (V) is in cm

12.5 C^2/R = V

(12.5/1719) C^2*D =V

(C^2*D)/138 =V

When chord length (C) becomes 11.83 m , then D= V

So if we get know Degree of curve and then we will able to find Radius of any curve.

### 6.1.3 Super-elevation

To counteract the effect of centrifugal force and to reduce the tendency of the vehicle to overturn or skid, the outer edge of the pavement is raised with respect to the inner edge. This transverse inclination to the pavement surface is known as super-elevation or cant.

### Analysis of super-elevation

The force acting on a vehicle while taking a horizontal curve with super-elevation is shown in Figure 2.2. The force acting on horizontal curve of radius R m at a speed of v m/sq.sec is:

1) Centrifugal force (P) acting horizontally outward through the center of gravity,
2) Weight of the vehicle (W) acting downward through the center of gravity, and
3) Frictional force (F) between the wheel and pavement, along the surface inward.

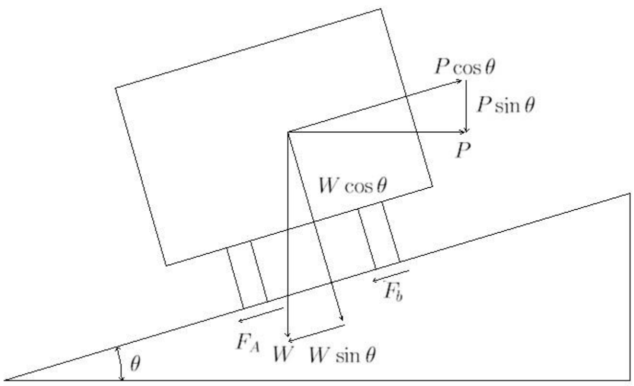



**Fig 6.3 Analysis of super-elevation**

At equilibrium, by resolving the forces parallel to the surface of the pavement we get:

$$P\cos\theta = W \sin\theta + F_a + F_b$$

$$= W \sin\theta + f\,(R_a+R_b)$$

$$= W \sin\theta + f\,(W \cos\theta + P \sin\theta)$$

Where W is the weight of the vehicle, P is the centrifugal force, f is the coefficient of friction, θ is the transverse slope due to super-elevation. Dividing by W cosθ, we get:

$$P\cos\theta/ W \cos\theta = W \sin\theta/ W \cos\theta + \{f\,(W \cos\theta + P \sin\theta)/ W \cos\theta\}$$

$$P/W = \tan\theta + f + f\,P/W \tan\theta$$

$$P/W\,(1-f \tan\theta) = \tan\theta + f$$

$$P/W = (\tan\theta + f)/ (1-f \tan\theta)$$

Since $P/W = v^2/gR$,

$$v^2/gR = (\tan\theta + f)/ (1-f \tan\theta)$$

This is an exact expression for super-elevation. But normally $f = 0.15$ and $\theta < 4^o$ and $1-f \tan\theta$ approximately equal to 1, and for small θ, $\tan\theta = \sin\theta\ E/B = e$, so we have:

$$e+f = v^2/gR = V^2/127R$$

Where e is the rate of super-elevation, f is the coefficient of friction; v is the speed in m/sq.sec, R the radius of curve in m and g the acceleration due to gravity in m/ sq.sce.

Three specific cases that can arise from equation $e+f = v^2/gR$ is as follows:

1. If there is no friction due to some practical reason, then $f = 0$ and equation becomes $e = v^2/gR$. These results in the situation where the pressure on the outer and the inner wheels are same; requiring very high super elevation e.
2. If there is no super-elevation provided due to some practical reason, then $e = 0$ and equation becomes $f = v^2/gR$. This results in very high coefficient of friction.
3. If $e = 0$ and $f = 0.15$ then for safe traveling speed from the equation is give by $v' = \sqrt{fgR}$, where v' is the restricted speed.

## Maximum and minimum super-elevation (IRC)

Maximum allowable super-elevation of

1) 7% for plain and rolling terrain.
2) 10% for mountainous terrain not bounded by snow.

Minimum super-elevation

If the calculated super-elevation is equal or less then camber, then minimum elevation equal to camber should be provided from drainage consideration.

The IRC recommendation giving the radii of horizontal curves beyond which normal cambered section may be maintained and no super-elevation is required for curves, are presented in Table 2.4, for various design speed and cross slope.

Radii beyond which super-elevation is not required

| Design Speed(km\h) | Radii (meters) for camber of | | | | |
|---|---|---|---|---|---|
| | 4% | 3% | 2.5% | 2% | 1.7% |
| 20 | 50 | 60 | 70 | 90 | 100 |
| 25 | 70 | 90 | 110 | 140 | 150 |
| 30 | 100 | 130 | 160 | 200 | 240 |
| 35 | 140 | 180 | 220 | 270 | 320 |
| 40 | 180 | 240 | 280 | 350 | 420 |
| 50 | 280 | 370 | 450 | 550 | 650 |

## Steps for super-elevation design

Various steps in the design of super-elevation in practice may be summarized as given below:

1. Super-elevation for 75% of design speed is calculated neglecting the friction

$$e_{cal} = V^2/225R$$

2. If $e_{cal}$ is less than $e_{max}$ then provide $e_{cal}$. If $e_{cal}$ is greater than $e_{max}$ then provide $e_{max}$ and proceed with step 3 and step 4

3. Check the coefficient of friction developed with e(max) at full value of design speed

$$f = \{(V^2/127R) - 0.07\}$$

if the value of 'f' thus calculated is less than 0.15 then ok, else calculate the restricted speed as given in step 4.

4. Calculate the allowable speed.
5. $e+f = 0.07+0.15 = 0.22 = V^2/127R$

### 6.1.4 Extra Widening

On horizontal curves, especially when they are not of very large radii, it is common to widen the pavement slightly more than the normal width. The objectives of providing extra widening of pavements on horizontal curves are due to the following reasons:

- Off- tracking of vehicle

Automobile with rigid wheel base on horizontal curve, the rear wheel do not follow the same path as that of the front wheel (only the front wheel are turned).

At low speed and up to the design speed with no lateral slipping of rear wheels, rear wheel follow the inner path of the curve as compared with the corresponding front wheel(if inner front wheel on inner edge of the pavement then inner rear wheel on shoulder).

Super-elevation and side friction developed are not adequate to counter act the outward thrust due to centrifugal force for vehicle travelling at higher speed then the design speed, transverse skidding is possible and rear wheels may follow the outer path as compared with corresponding front wheels.

- Psychological reasons

At the beginning of the curve, drivers have tendency to follow the outer side of the lane so as to take a path with larger radius and to have greater visibility.

Crossing or overtaking maneuver on curve, drivers tend to maintain greater clearance between vehicles then on tangents.

The extra width recommended by the Indian Roads Congress for single and two lane pavements are given in Table 2.7.

| Radius of Curves | Up to 20 | 20-40 | 41-60 | 61-100 | 101-300 | Above 300 |
|---|---|---|---|---|---|---|
| Extra Width (m) Two lane | 1.5 | 1.5 | 1.2 | 0.9 | 0.6 | Nil |
| Single-lane | 0.9 | 0.9 | .6 | Nil | Nil | Nil |

**Extra width of the pavement at horizontal curve.**

## 6.1.5 Transition curve

A transition curve has a radius which decreases from infinity at the tangent point to a designed radius of the circular curve. When a transition curve is introduced between a straight and circular curve, the radius of the transition curve decreases becomes minimum at the beginning of the circular curve. The rate of change of radius of the transition curve will depend on the equation of the curve or its shape.

## Objective of providing Transition Curve

The functions of transition curves in the horizontal alignment of highway are as follows:

1) To introduce gradually the centrifugal force between the tangent point and the beginning of the circular curve, avoiding sudden jerk on the vehicle.
2) To enable the driver turn the steering gradually for his own comfort and security.
3) To enable gradual introduction of the design super-elevation and extra widening of the pavement at the start of the circular curve.
4) To improve the aesthetic appearance of the road.

### Calculation of Length of Transition Curve(IRC empirical formula)

1. By empirical formula: According to the IRC standards, the length of horizontal transition curve Ls should not be less than the value given by the following equations for the terrain classifications:

a) For plain and rolling terrain (1 in 150)

$$L_s = 2.67\ V^2/R_c$$

b) For mountainous and steep terrain (1 in 60)

$$L_s = 1.0\ V^2/R_c$$

### 6.1.6 Stopping Sight Distance

The stopping sight distance is calculated from the relation

$$SSD = 0.278Vt + (V^2/254f)$$

Where V= design speed ,kmph

t = reaction time taken as 3 seconds

f = coefficient of friction ,assumed as 0.4

Safe stopping sight distance for various speeds given by IRC are given below :

| | | | | | |
|---|---|---|---|---|---|
| Speed,kmph | 20 | 25 | 30 | 40 | 50 |
| SSD,m | 20 | 30 | 35 | 50 | 70 |

### 6.1.7 Overtaking Sight Distance (OSD)

$$OSD = 0.28V_b t + 0.28 V_b T + 2s + V.T$$

where $V_b$= speed of the overtaking vehicle (V-16) kmph

t = reaction time of driver=2sec

s= spacing of vehicles

= ((0.2*Vb)+6)

T= ((14.4*s)/A)^0.5

## 6.2 Measurement of various Design Components

### A) Measurment of radius of curve and degree of curve through versine curve method

1. **Curve 1**

- Length of chord =11.83m
- Degree of curve(d)=85
- Radius of curve =(1719/d)m =30.7m

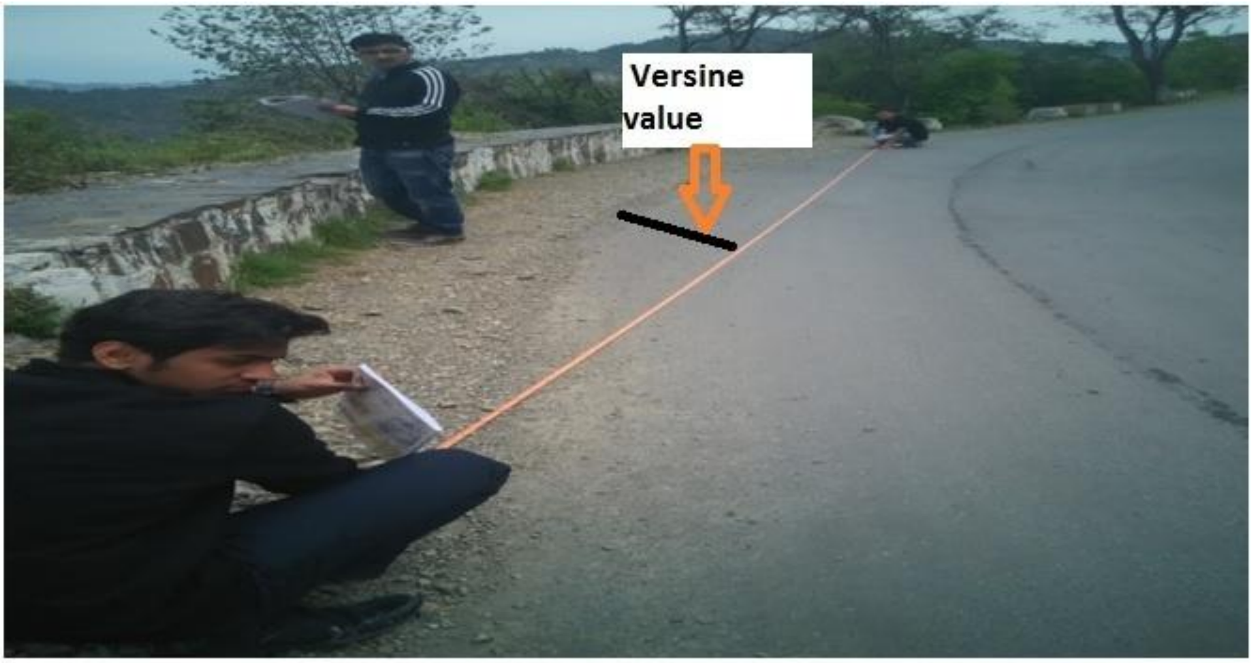



**Fig 6.4 Determining Degree of curve 1 (Versine curve of method)**

| Curve Number | Length of chord (in metre) | Degree of curve(d) | Radius of curve =(1719/d)m |
|---|---|---|---|
| 1 | 11.83 | 56 | 30.7 |
| 2 | 11.83 | 85 | 20.22 |
| 3 | 11.83 | 143 | 12.02 |
| 4 | 11.83 | 110 | 15.63 |
| 5 | 11.83 | 85 | 20.22 |
| 6 | 11.83 | 91 | 18.9 |
| 7 | 11.83 | 193 | 8.906 |
| 8 | 11.83 | 125 | 13.75 |
| 9 | 11.83 | 162 | 10.61 |
| 10 | 11.83 | 173 | 9.936 |

**Calculated value of Degree of curve and Radius of curve**

## B) Super Elevation Design

**1. For curve 1 : R =30.7 m**

a) **e = V^2/225R** where V = design speed (kmph)

= 25 kmph

e= 25^2/225*30.7

= 0.0904 <0.1 ( this value of e may be adopted)

**b) Check For value of friction developed,**

f= (V^2/127R) -0.1 (for Hill roads) =0.060 <0.15 (ok )

**e= 0.0904 is safe for design speed 25 kmph**

**2. For curve 3 : R = 12.02 m**

a) **e = V^2/225R** = 25^2/225*12.02

= 0.231 > 0.1

So e is restricted to 0.1 (for hilly roads )

b) **Check For value of friction developed**,

f= (V^2/127R) -0.1 (for Hill roads)

=0.309 > 0.15 ( speed has to be restricted

c) **Maximum Allowable speed Va(kmph)**

Va = (31.79* R )^0.5

= 19.54 kmph

Hence speed may be restricted to less than 19 or

say 15 kmph at this curve.

(For calculation of superelevation design for each curve refer to appendix)

| Curve Number | Elevation Required | Restricted Speed in kmph | Remarks |
|---|---|---|---|
| 1 | 0.0904 | - | Curve is safe for design speed |
| 2 | 0.1 | - | Curve is safe for design speed |
| 3 | 0.1 | 15 kmph | Curve is not safe for design speed |
| 4 | 0.1 | 20kmph | Curve is not safe for design speed |

| | | | |
|---|---|---|---|
| 5 | 0.1 | - | Curve is safe for design speed |
| 6 | 0.1 | 20kmph | Curve is not safe for design speed |
| 7 | 0.1 | 15kmph | Curve is not safe for design speed |
| 8 | 0.1 | 15kmph | Curve is not safe for design speed |
| 9 | 0.1 | 15kmph | Curve is not safe for design speed |
| 10 | 0.1 | 15kmph | Curve is not safe for design speed |

**Super Elevation design For Design speed 25kmph**

## C) Measurment of Extra widening of curve

We =Wm + Wps
= (nl^2/2R)+ (V/9.5*R^.5)m

where We = Extra widening required on curve

Wm = Mechanical Widening

W ps = Widening due to Psychological reason

l = length of wheelbase of longest vehicle,m

V = Design speed,kmph and R = Radius of horizontal curve,m

Here Number of lane = 1

We neglect Wps because this factor is more important when no of lane is more than 1

| Curve No. | Calculated Extra widening(in metres) | Allowable Extra widening according to IRC (in metres) |
|---|---|---|
| 1 | 0.606 | 0.6 |
| 2 | 0.92 | 0.9 |
| 3 | 1.55 | 0.9 |
| 4 | 1.2 | 0.9 |
| 5 | 0.9 | 0.9 |
| 6 | 1 | 0.9 |
| 7 | 2.1 | 0.9 |
| 8 | 1.35 | 0.9 |
| 9 | 1.75m | 0.9 |
| 10 | 1.87 | 0.9 |

**Requirement of Extra widening for each curve**

## D) Measurement of Minimum Transition length required for Design speed of 25kmph on each curve

### 1. For curve 1

**Ls = V^2/R**

= 25^2/30.7

= 20.36m

where V is Design speed in Kmph

and R is Radius of curve in metre.

Same procedure have been followed to find Minimum length of Transition curve for other curves.

| Curve No. | Minimum length of transition curve(in metres) |
|---|---|
| 1 | 20.36 |
| 2 | 31 |
| 3 | 52 |
| 4 | 40 |
| 5 | 31 |
| 6 | 33 |
| 7 | 70.2 |
| 8 | 45.5 |
| 9 | 59 |
| 10 | 63 |

**Calculated value of Minimum Length of Transition Curve**

## E) Sight Distance

**Stopping distance** =0.278Vt+(V^2/254f)

=(0.278*25*3 )+(25^2/254*0.4)

= 20.85 +6.151

= 27 m (Approx)

**SSD = 2*SD** (Two way traffic movement in single lane road)

= 2*27

=54 m

## F) Overtaking sight distance (OSD)

**OSD =0.28Vb t+0.28 Vb T +2s+V.T**

= (0.28*9*2 ) +(0.28 *9*4.74)

+(2*7.8)+(0.28 *25* 4.74 )
=65.764 m

where Vb= speed of the overtaking vehicle (V-16) kmph

t = reaction time of driver=2sec

s= spacing of vehicles

= ((0.2*9)+6) = 7.8m

T= ((14.4*s)/A)^0.5 = 4.74 sec

# Chapter 7

# Bentley MXROAD V8i (SELECT series 2)-Version 08.11.07.427 Software

MXROAD$^{TM}$ is an advanced, string based modeling tool that enables the rapid and accurate design of all road type. With MXROAD$^{TM}$ one can quickly create design alternatives to achieve the ideal road system. Upon selection of the final design alternatives, MXROAD$^{TM}$ automates much of the design detailing process, saving the user time and money.

## 7.1. Working steps

### A) Survey Input

Survey data may come from a number of sources like DWG, DXF, GENIO, NTF and Land XML. GENIO is the MX standard method of data transfer. For our project we have used DWG survey data.

To load the survey data use either *File > Open* or *File > Import* to select required file from CAD Menu.

For example, import CAD file from CD (All Survey Data-Survey 5 data) as shown in Figure 7.1 and after importing the CAD file one should get a screen as shown in Figure 7.2

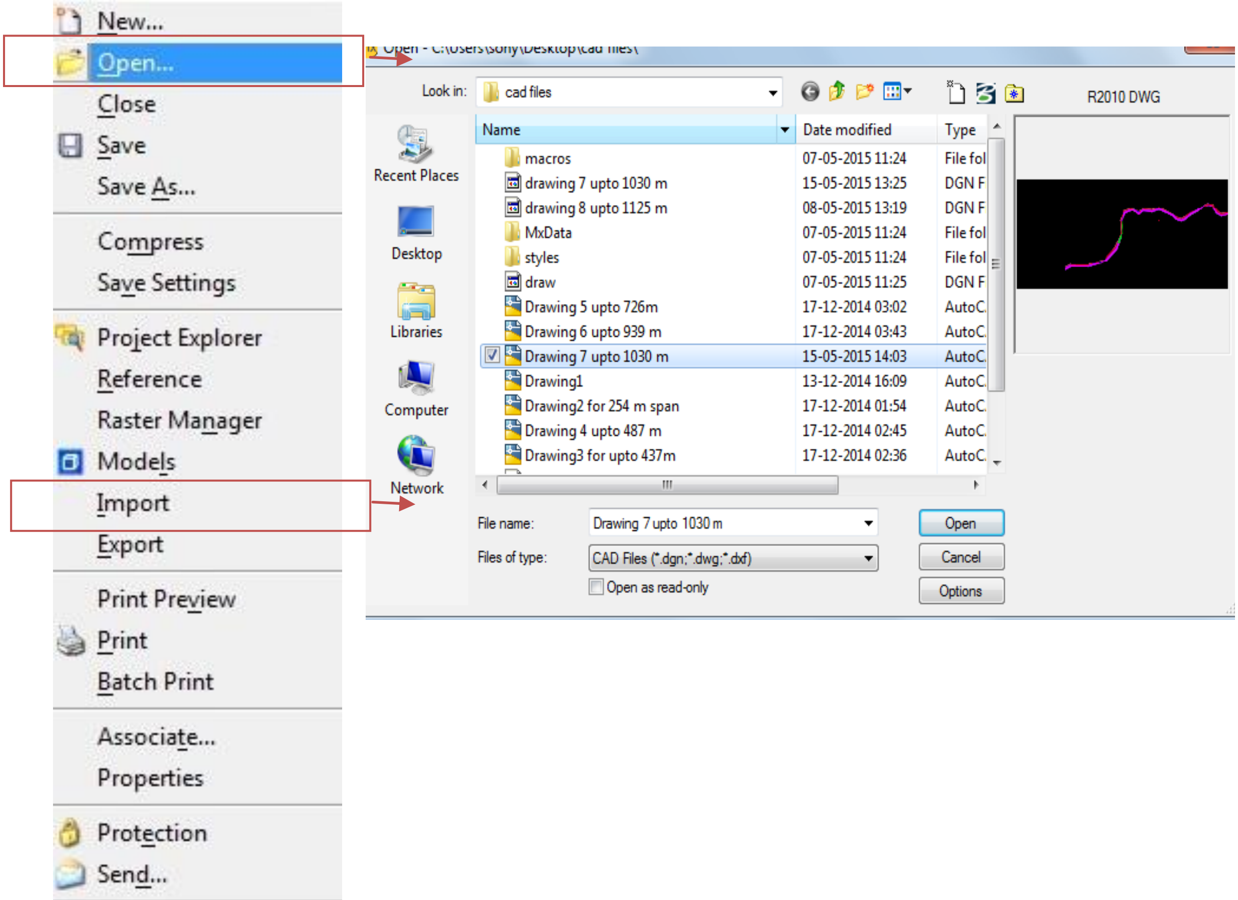



**Figure 7.1 Survey Data Input**

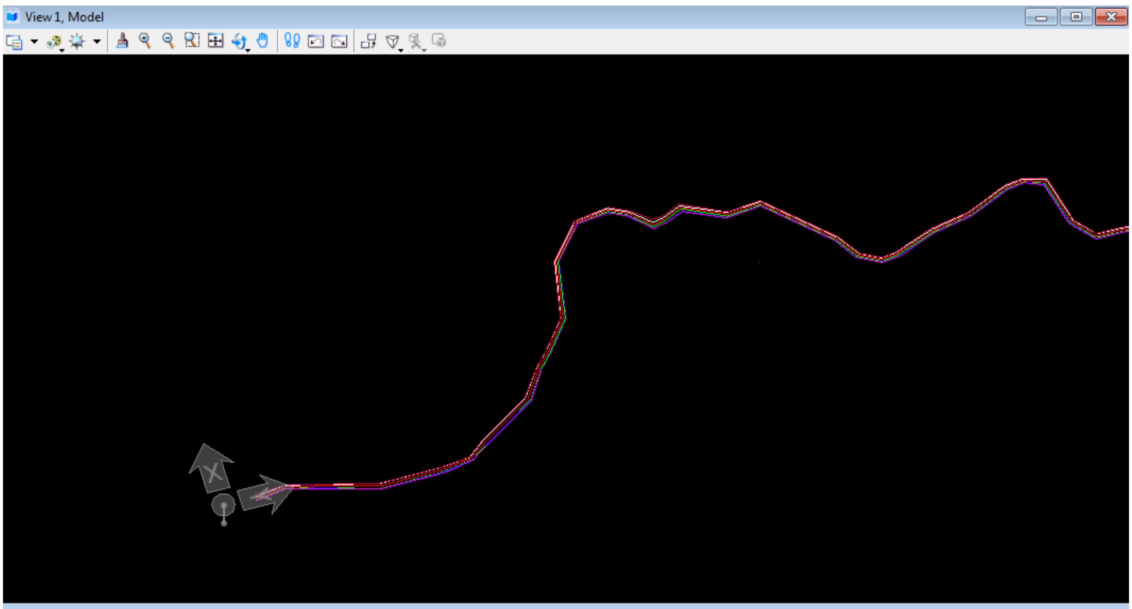



**Fig 7.2 Screen shot of a display window after importing survey data**

## 7.2 Creating model and assigning model defaults:

String names and drawing styles are controlled by assigning model defaults. Model defaults have a two set of features which are Feature Set and Style Set name.

Feature name set offers string name by the type of features used and it controls the use of string type throughout MX.

Style set name defined the drawing style of the various model types and it ensure the consistent style of presentation.

From MX Menu, *select Modify - Edit models – Create models*

Every model created should be related to the style set name and feature set name at the earliest opportunity.

For example, create a model name called GROUND SURVEY and assign the model defaults as shown in figure 7.3

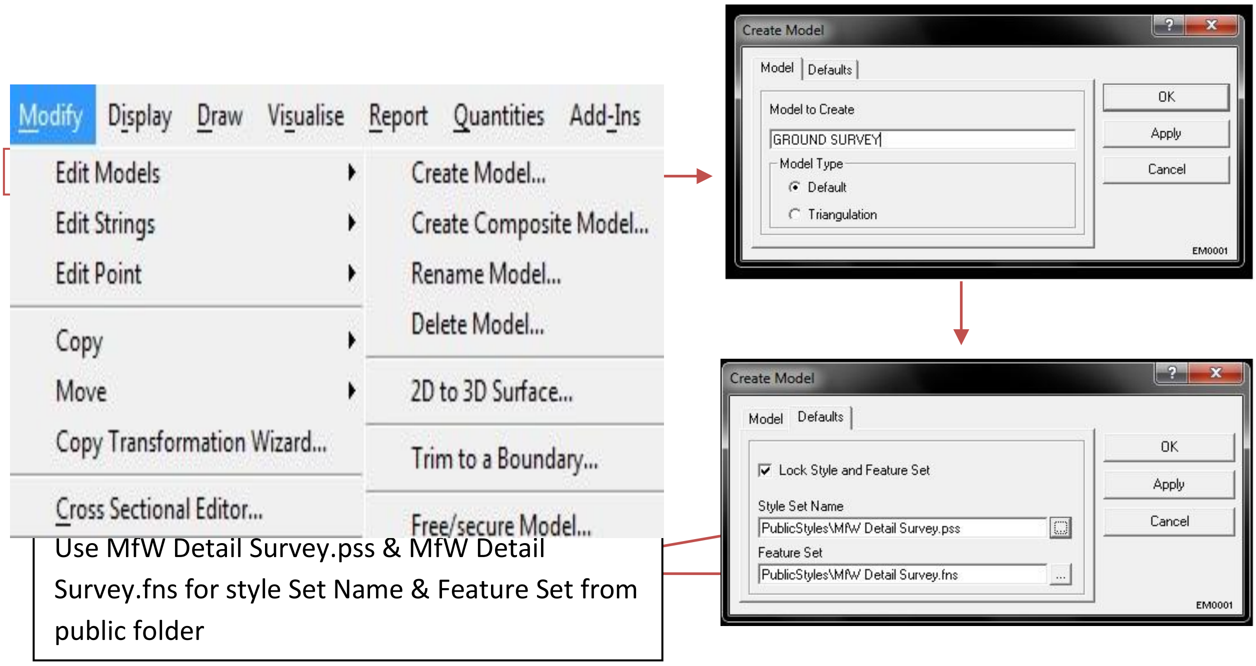



**Figure 7.3 Creating model and assigning model default**

## 7.3 Conversion of CAD file to MX file

All we have done so far is to open a CAD drawing; MX has no information at all in its database (the mode file), and does not know anything about the drawing. We now need to create a link between the MX model and the information in the CAD drawing.

For example, on MX Conversion Toolbar , select the arrow on the feature list to display the entire feature associated with the model. Scroll down the list and select point feature as shown in Figure 7.4. A corresponding level is created with the same name in the level manager as shown in Figure 7.5.

Now select all the point, make Point Features level active (refer Appendix A for active level toolbar) and press convert element icon. After conversion it should look like Figure 7.6.

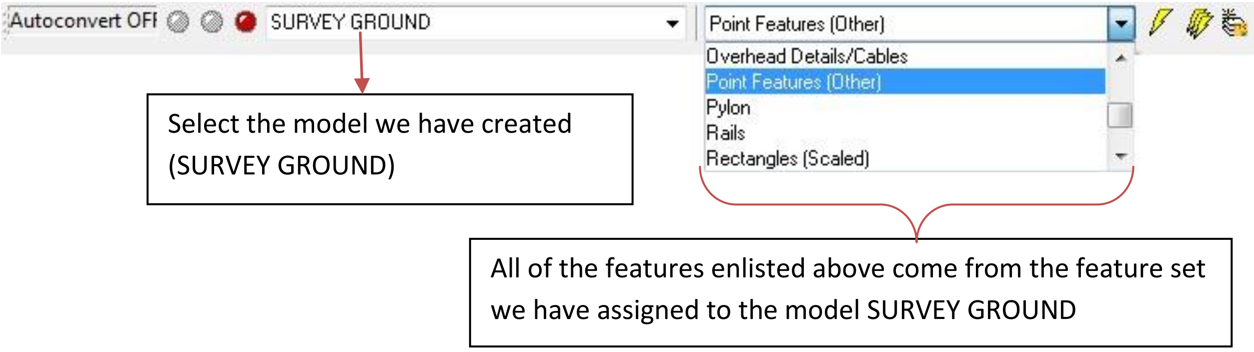



**Figure 7.4 Creating MX level from MX Conversion Toolbar**

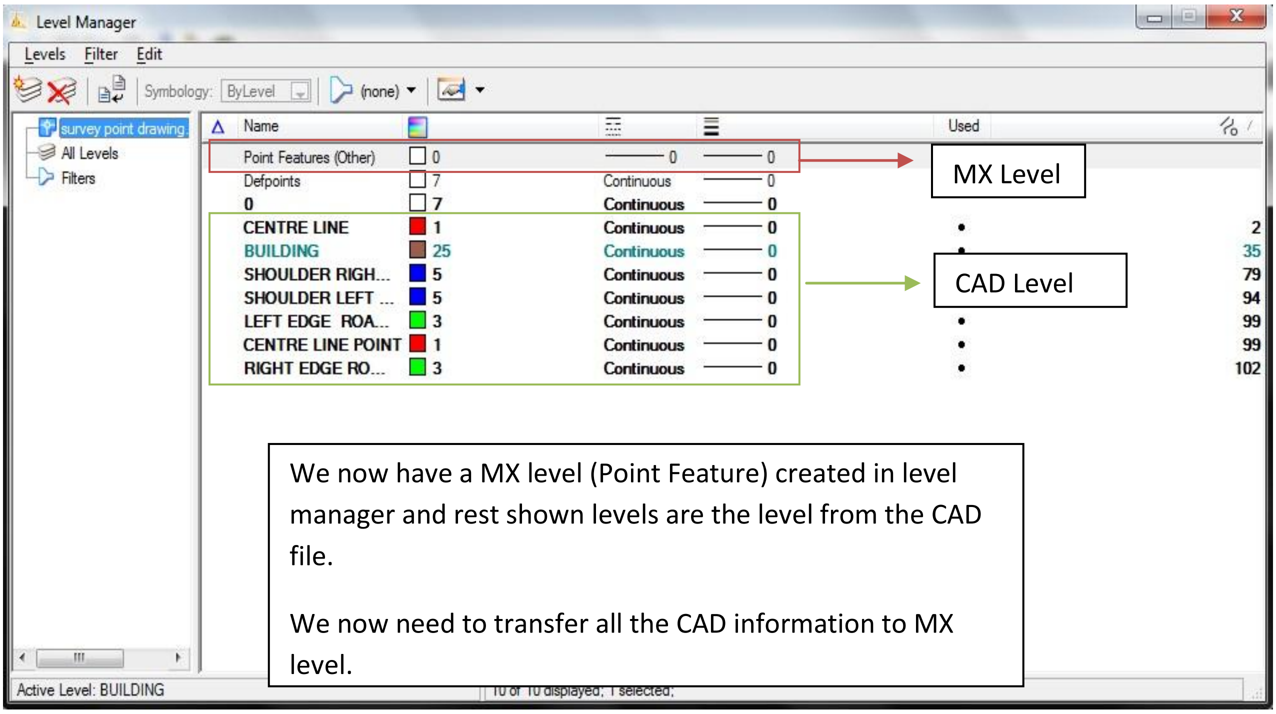



**Figure 7.5 Level Manager**

**Figure 7.6 Screen shot showing MX strings**

# 7.4 Analysis

The survey file is critical to the design and one must check that it contain no serious errors.MX provides two type of analysis; Surface Analysis and Surface Checker. Surface analysis checks level for serious errors and are use to create Triangulations (MX automatically creates a number of triangle connecting every string, triangulation is very much important while designing vertical alignment as it forms a surface connecting every point), Contours, Depth Bands etc. Surface checker search for the standard errors.

It can be accessed from the main menu (*Analysis-Surface Analysis*) or from the application toolbar as shown in the figure 7.7A.

For example, from application toolbar go to Surface Analysis as shown in Figure 7.7A. Select the appropriate model name to be analyzed (GROUND SURVEY) as shown in Figure 7.7 B. Press *Next*, new panel will come as shown in Figure 7.7C. Select Display Triangulation and hit next. Final model should look like Figure 7.8.

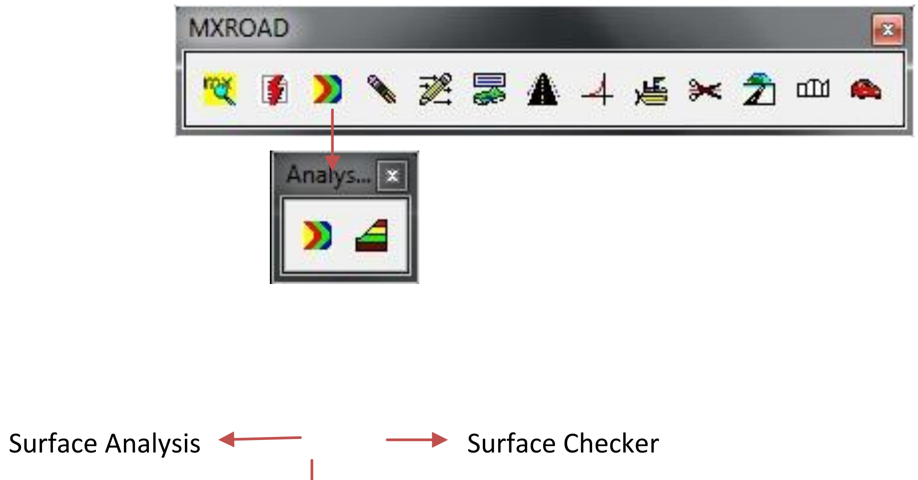
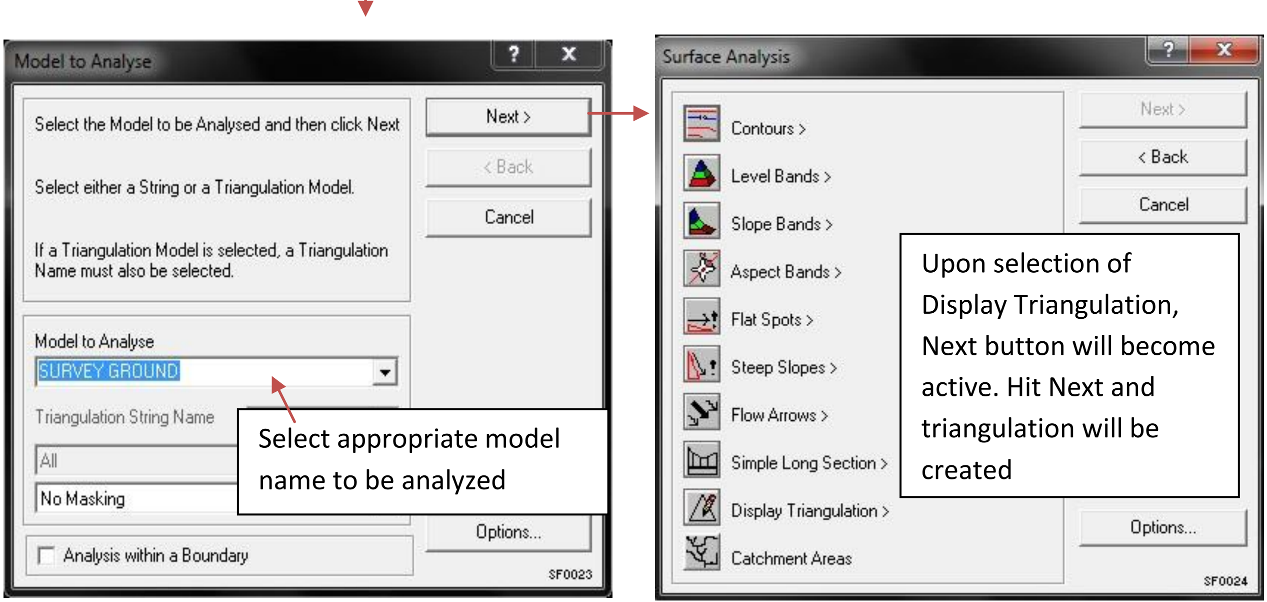



**Figure 7.7(a) Analysis from application**

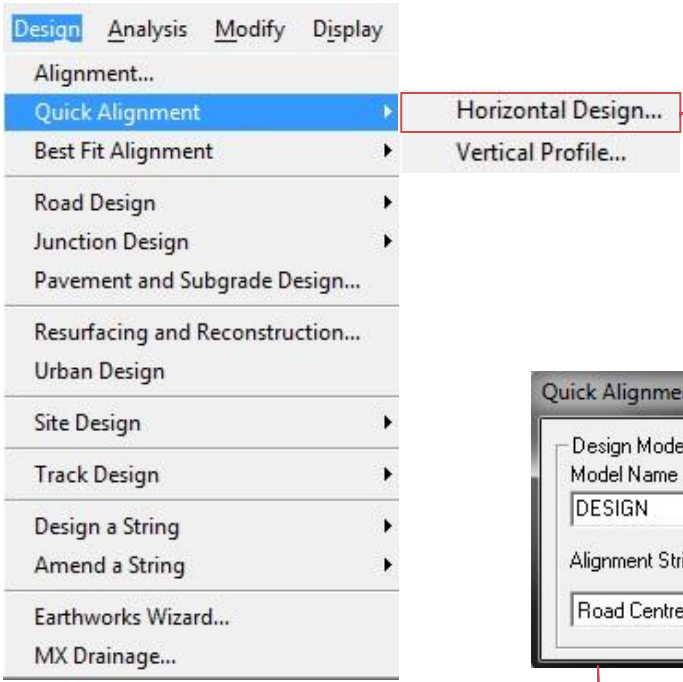


## 7.5 HORIZONTAL ALIGNMENT

For the design of horizontal alignment we have used quick horizontal alignment method and it can be accessed from either the main menu; *Design-Quick Alignment-Horizontal Design*, or if you are using one of the MX applications then Quick Horizontal Design can be accessed from the toolbar.

For example, go to Quick Horizontal Design as shown in Figure 7.8A. Model Selection panel will come up, name a model 'Design' and string name 'MC10' (M stands for master string, C stand for road center line and 10 is road identity) as shown in Figure 7.8B and press Next.

On pressing Next, Quick Horizontal Alignment Toolbar will come  as shown in figure 7.8C.



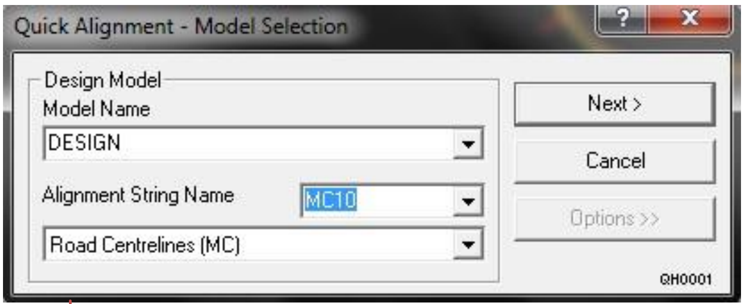




**Figure 7.(8a) Horizontal Design from main menu**

**Figure 7.8(b) Model Selection**

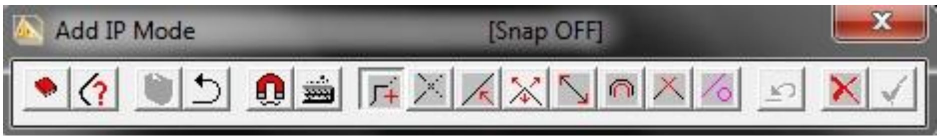



**Figure 7.8(c) Quick Horizontal Alignment Toolbar**

Go to XY Keyboard Entry on Quick Horizontal Alignment Toolbar and enter the value of X=3.280 and Y=871.646 for the construction of 1st IP (intersection point) as shown in the Figure7.9

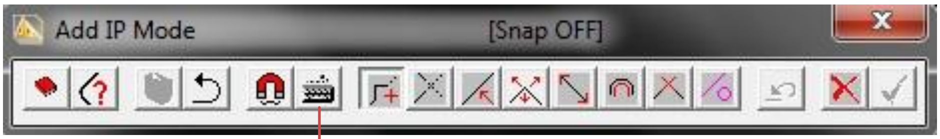



**Figure 7.9(a) QHA Toolbar**

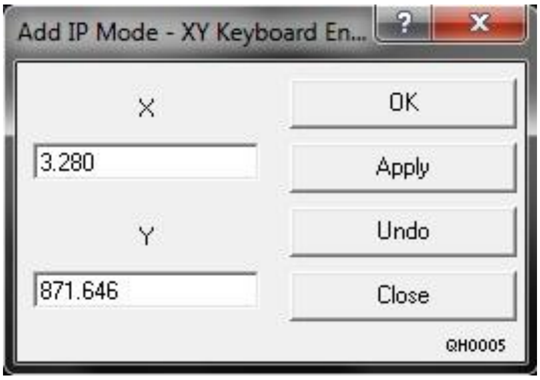



**Figure 7.9(b) XY Keyboard Entry**

1st IP constructed

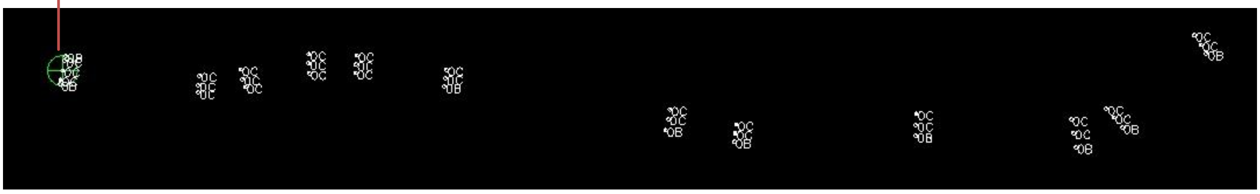


**Figure 7.9(c) Plan**

For 2nd IP, enter X=27.191, Y=867.952 in XY Keyboard Entry and Radius 80m, transition length of 15m in Parameters as shown Figure 7.10

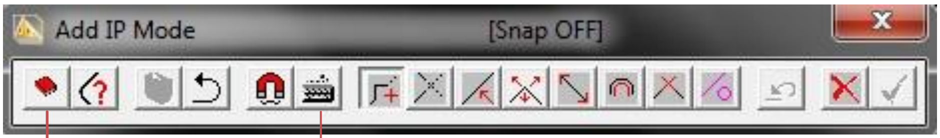



**Figure 7.10(a) QHA Toolbar**

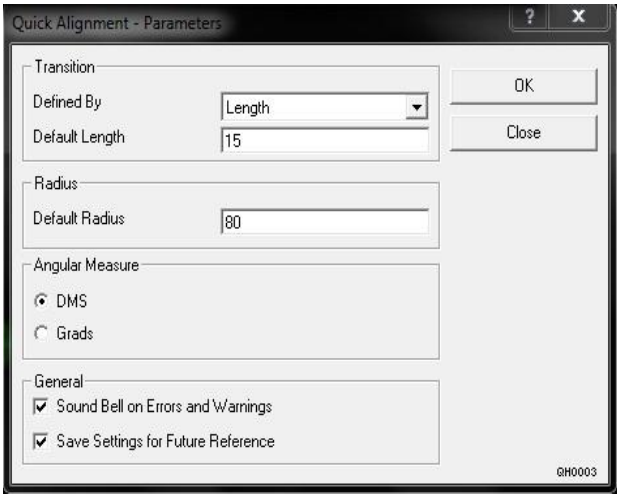



**Figure 7.10(b) Parameters**

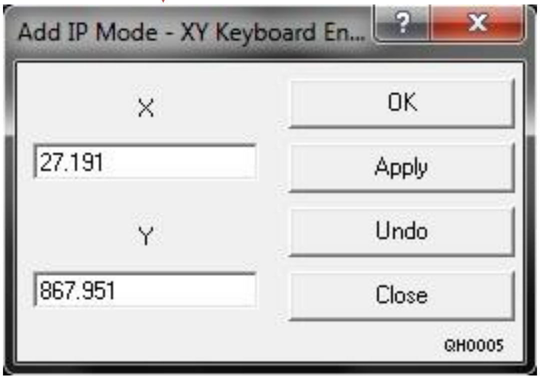



**Figure 7.10(c) XY Keyboard**

2nd IP Constructed

**Figure 7.10 (d) Plan**

**Figure 7.10 Construction of 2nd IP**

Go on constructing IP following the centre dote of survey point till the end and when done press OK button on QHA Toolbar to accept the horizontal design. Figure 7.11 shows the complete horizontal alignment designed by the authors.

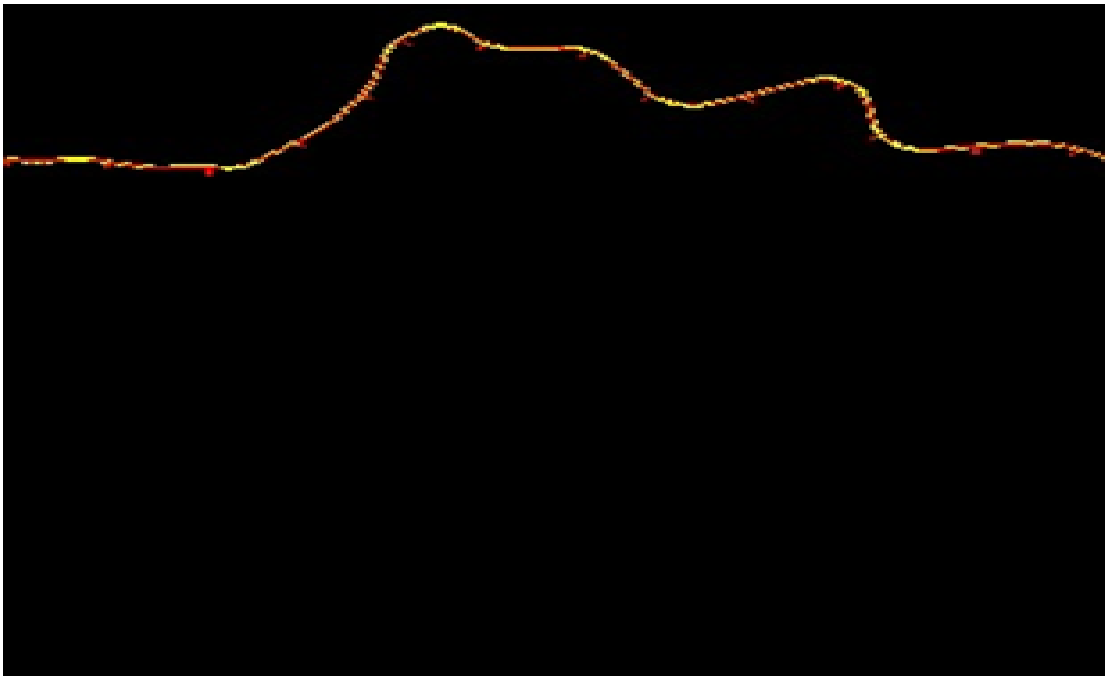


**Figure 7.11Designed Horizontal Alignments for JUIT -1.2 km**

# CONCLUSION AND DISSCUSION

The geometric design of a highway deals with the dimensions and the layout of visible features of the highway such as alignment, sight distances and intersections. The road geometrics of highway should be designed to provide optimum efficiency in traffic operations with maximum safety at reasonable cost.

Therefore it is important to plan and design the geometric features of the road during the initial alignment itself taking into consideration the future growth of the traffic flow and possibility of the road being upgraded to a higher category or to a higher design speed standard at a later speed.

First parameter while considering the design of road is speed, and the road jaypee gate to 1.2 km towards Waknaghat falls under other district roads ,the design speed of which is 25 kmph. All the design parameters of road depends upon design speed, the width of 3.75m for single lane is provided at most of the cross sections and radius of the curve was found out by versine curve method. On horizontal curves, especially when they are not of large radii , it is important to widen the roads. On this road too many sharp curves are there so we checked out the extra widening by the formula and compare it actual site conditions and in most of curve adequate widening was given.

Next thing we did in geometric design of roads is super elevation design . Super elevation is important at curves and its importance become far more important in hilly roads as less roads have crash barriers in case the vehicle skids off the roads . We found out after designing the super elevation that the super elevation is adequate at most of the curves but in some curves it is not adequate, so we have to restrict our design speeds. Proper signs should be there to give information about to restrict the speed before such curves. Proper signs are not provided before such curves to restrict the speed which can leads to skidding of car if it is travelling at design speed or more than that.

## RECOMMENDATIONS

1) Provide traffic signs at desirable places.

2) Provide adequate transition length for the varying horizontal curve as recommended by IRC: 52-2001.

3) Provide retaining walls on the hill side and cut side to protect road from land slide.

4)Provide extra widening wherever needed.

## Problem faced during surveying by total station

1.Surveying was delayed due to unfavorable climatic condition and traffic disturbance.

2..Without transferring the data to PC from total station, data saved in the total station cannot be deleted.

## Shortcomings of the selected road

**1. Absence of Traffic Sign.**

Traffic sign are very much important to warn drivers about the danger ahead.

**2. Drainage System**

We found out that existing drainage system were poorly maintained, drains were solid covered with trash and debris.

**3. Retaining Walls**

We found out that no retaining walls are provided on the hill side and cut side of the mountain for the selected road stretch.

**4 .Pavement Condition was not good**

We detect many cracks in pavement which is  not safe for driving.

## Steps to overcome the shortcoming of the  Selected Road

### 1. Provide proper Traffic Sign

**a) Use Reflecting Mirrors at curves**

**b) Use Speed Limit Traffic Sign**


**c) When Road is Slippery during Rainfall**


### 2. Pavement Type

- Use Bitumen Pavement on Hill road. Cement Concrete pavenments are not considered suitable because of its intial high cost.Since Frequent damages are expected in hilly areas,a flexible pavement can be more easily and cheaply repaired than a concrete pavement
- I.R.C recommends the use of bitumen with penetration grade 175/225 for ground macadam in very cold regions.

### 3. Maintenance of Drainage Structures

- Catch water drains ,side drains ,catch pits and culverts are periodically cleared off of all blockages to prevent overflowing during Drains
- Planting of trees on the upper slopes in order to reduce the scouring action of unstable ground due to rains is often resorted to as a precautionary measure.

# REFERENCES


[1] S.K Khanna and C.E.G Justo ‘Highway Engineering’.

[2] IRC 52 -2001 ‘Recommendations about the alignment, survey and geometric design of hill roads’.

[3] Dr. B.C. Punmia, Ashok Kr. Jain, Arun Kr. Jain ‘Surveying Vol 1’.

[4] N.N. Basak, ‘Surveying and Levelling’.

[5] Hills B Baguley CJ and SJ Kirk ‘Cost and Safety Efficient Design Study of Rural Roads in Developing Countries’2002.

[6] Total station setup and operation ‘http://www.usouthal.edu/geography/allison/GY301/Total%20Station%20Setup%20and%20Operation.pdf’.

[7] Learn autocad ‘http://www.cadtutor.net/’.

# APPENDIX-A

# TOTAL STATION SURVEY DATA FOR 1.130KM

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Chainage from 0m to 30m** | | | | | | | |
| | | **N** | **E** | **Z** | | | |
| Centre line | a1 | -1.79 | 31.39 | -0.639 | | -1.79,31.39 | |
| left hand side | a2 | 0.022 | 31.56 | -0.546 | | 0.022,31.56 | |
| right hand side | a3 | -3.708 | 31.432 | -0.69 | | -3.708,31.432 | |
| extra left side | a4 | 2.591 | 31.85 | -0.366 | | 2.591,31.85 | |
| extra right side | a5 | -4.107 | 31.146 | -0.679 | | -4.107,31.146 | |
| Drainage towards right side | a6 | -4.292 | 31.035 | -0.44 | | -4.292,31.035 | |
| | | | | | | | |
| | | | | | | | |
| **Chainage from 30 to 60 m( Station changed 1)** | | | | | | | |
| | | | | | | | |
| Electric lamp | | 4.96 | 57.523 | -1.675 | | 4.96,57.523 | |
| Centre line | b1 | 2.468 | 60.995 | -1.935 | | 2.468,60.995 | |
| left hand side | b2 | 4.405 | 61.018 | -1.907 | | 4.405,61.018 | |
| right hand side | b3 | 0.831 | 60.615 | -1.99 | | 0.831,60.615 | |
| extra left side | b4 | 4.844 | 61.109 | -1.879 | | 4.844,61.109 | |
| extra right side | b5 | 0.456 | 60.575 | -2.012 | | 0.456,60.575 | |
| drainage towards right side | b6 | 0.544 | 60.556 | -2.117 | | 0.544,60.556 | |
| Electric pole | | 3.409 | 69.164 | -2.138 | | 3.409,69.164 | |
| | | | | | | | |
| **Chainage from 60 to 90m (Station changed 2)** | | | | | | | |
| | | | | | | | |
| Electric pole | | 3.102 | 69.29 | -2.134 | | 3.102,69.29 | |
| Centre line | c1 | -4.436 | 89.898 | -2.875 | | -4.436,89.898 | |
| L.H.S | c2 | -2.891 | 90.095 | -2.866 | | -2.891,90.095 | |
| R.H.S | c3 | -6.099 | 89.483 | -2.892 | | -6.099,89.483 | |
| Extra L.H.S | c4 | -2.575 | 90.207 | -2.856 | | -2.575,90.207 | |
| Extra R.H.S | c5 | -6.403 | 89.424 | -2.898 | | -6.403,89.424 | |
| Drainage | c6 | -6.86 | 89.335 | -2.714 | | -6.86,89.335 | |
| | | | | | | | |
| **Chainage 90m to 150m (Station changed 3)** | | | | | | | |
| | | | | | | | |
| Electric pole | | -12.294 | 109.504 | -3.638 | | -12.294,109.504 | |
| Centre line | d1 | -20.78 | 147.414 | -7.129 | | -20.78,147.414 | |
| L.H.S | d2 | -18.075 | 148.002 | -7.114 | | -18.075,148.002 | |
| R.H.S | d3 | -23.47 | 146.795 | -7.148 | | -23.47,146.795 | |
| Extra L.H.S | d4 | -17.64 | 148.116 | -7.087 | | -17.64,148.116 | |
| Extra R.H.S | d5 | -23.743 | 146.747 | -7.16 | | -23.743,146.747 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Drainage | d6 | -23.949 | 146.626 | -7.109 | | -23.949,146.626 |
| Blue box | | -15.572 | 118.303 | -4.913 | | -15.572,118.303 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Chainage from 150m to 210m (Station changed 4)** | | | | | | |
| Big pole | | -17.736 | 152.47 | -7.271 | | -17.736,152.47 |
| Centre line | e1 | -19.604 | 207.533 | -12.944 | | -19.604,207.533 |
| L.H.S | e2 | -16.965 | 207.67 | -12.929 | | -16.965,207.67 |
| R.H.S | e3 | -22.096 | 207.579 | -12.962 | | -22.096,207.579 |
| Extra L.H.S | e4 | -16.724 | 207.65 | -12.91 | | -16.724,207.65 |
| Extra R.H.S | e5 | -22.566 | 207.553 | -12.952 | | -22.566,207.553 |
| Drainage | e6 | -23.143 | 212.497 | -13.286 | | -23.143,212.497 |
| | | | | | | |
| | | | | | | |
| **Chainage 210m to 220 m(Station changed 5)** | | | | | | |
| | | | | | | |
| Centre line | f1 | -6.64 | 207.539 | -14.028 | | -6.64,207.539 |
| L.H.S | f2 | -6.819 | 207.937 | -14.128 | | -6.819,207.937 |
| R.H.S | f3 | -5.979 | 210.163 | -13.966 | | -5.979,210.163 |
| Extra L.H.S | f4 | -6.858 | 207.567 | -14.114 | | -6.858,207.567 |
| Extra R.H.S | f5 | -7.19 | 214.118 | -13.954 | | -7.19,214.118 |
| Drainage | f6 | -7.097 | 214.186 | -13.967 | | -7.097,214.186 |
| | | | | | | |
| **Chainage 220m to 240m** | | | | | | |
| Centre line | g1 | -15.291 | 238.2 | -16.01 | | -15.291,238.2 |
| L.H.S | g2 | -13.872 | 237.208 | -15.999 | | -13.872,237.208 |
| R.H.S | g3 | -16.741 | 239.228 | -15.985 | | -16.741,239.228 |
| Extra L.H.S | g4 | -13.58 | 236.94 | -16.008 | | -13.58,236.94 |
| Extra R.H.S | g5 | -17.142 | 239.715 | -15.941 | | -17.142,239.715 |
| Drainage | g6 | -17.28 | 239.764 | -15.886 | | -17.28,239.764 |
| | | | | | | |
| **Chainage 240m to 260m** | | | | | | |
| | | | | | | |
| | | | | | | |
| Centre line | h1 | -3.096 | 254.054 | -18.012 | | -3.096,254.054 |
| L.H.S | h2 | -1.14 | 252.93 | -17.86 | | -1.14,252.93 |
| R.H.S | h3 | -5.085 | 255.422 | -18.067 | | -5.085,255.422 |
| Extra L.H.S | h4 | -0.672 | 252.156 | -17.796 | | -0.672,252.156 |
| Extra R.H.S | h5 | -5.615 | 255.747 | -18.071 | | -5.615,255.747 |
| Drainage | h6 | -5.756 | 255.891 | -17.986 | | -5.756,255.891 |
| | | | | | | |
| | | | | | | |
| **Chainage 260m to 310m( Station changed 6)** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| Centre line | i1 | 32.089 | 307.341 | -24.75 | | 32.089,307.341 |
| L.H.S | i2 | 33.796 | 305.402 | -24.822 | | 33.796,305.402 |
| R.H.S | i3 | 30.313 | 309.405 | -24.61 | | 30.313,309.405 |
| Extra L.H.S | i4 | 34.335 | 305.048 | -24.856 | | 34.335,305.048 |
| Extra R.H.S | i5 | 29.962 | 309.673 | -24.638 | | 29.962,309.673 |
| Drainage | i6 | 29.736 | 309.967 | -24.629 | | 29.736,309.967 |
| | | | | | | |
| **Chainage 310m to 330m(Station changed 7)** | | | | | | |
| | | | | | | |
| | | | | | | |
| Centre line | j1 | 61.059 | 326.445 | -26.611 | | 61.059,326.445 |
| L.H.S | j2 | 61.91 | 324.32 | -26.616 | | 61.91,324.32 |
| R.H.S | j3 | 60.188 | 328.625 | -26.566 | | 60.188,328.625 |
| Extra L.H.S | j4 | 62.083 | 324.208 | -26.065 | | 62.083,324.208 |
| Extra R.H.S | j5 | 59.817 | 328.764 | -25.946 | | 59.817,328.764 |
| Drainage | j6 | 59.705 | 328.779 | -25.935 | | 59.705,328.779 |
| | | | | | | |
| | | | | | | |
| **Chainage 330m to 341m (Station changed 8)** | | | | | | |
| | | | | | | |
| | | | | | | |
| Extra L.H.S | k4 | 77.437 | 337.759 | -27.495 | | 77.437,337.759 |
| L.H.S | k2 | 77.226 | 337.886 | -27.464 | | 77.226,337.886 |
| Centre Line | k1 | 75.468 | 339.253 | -27.43 | | 75.468,339.253 |
| R.H.S | k3 | 73.67 | 340.56 | -27.406 | | 73.67,340.56 |
| Extra R.H.S | k5 | 73.386 | 340.729 | -27.358 | | 73.386,340.729 |
| Drainage | k6 | 73.134 | 340.889 | -27.217 | | |
| | | | | | | |
| | | | | | | |
| **Chainage 341m to 366m (Station changed 9)** | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| Extra L.H.S | m4 | 107.8 | 360.812 | -26.683 | | 107.8,360.812 |
| L.H.S | m2 | 107.762 | 361.087 | -26.698 | | 107.762,361.087 |
| Centre Line | m1 | 106.813 | 363.205 | -26.616 | | 106.813,363.205 |
| R.H.S | m3 | 106.072 | 365.071 | -26.576 | | 106.072,365.071 |
| Extra R.H.S | m5 | 105.834 | 365.483 | -26.642 | | 105.834,365.483 |
| Drainage | m6 | 105.693 | 365.732 | -26.638 | | 105.693,365.732 |
| | | | | | | |
| **Chainage 366m to 376m** | | | | | | |
| | | | | | | |
| Extra L.H.S | n4 | 168.841 | 371.559 | -23.359 | | 168.841,371.559 |
| L.H.S | n2 | 168.484 | 372.644 | -23.479 | | 168.484,372.644 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Centre Line | n1 | 168.033 | 373.685 | -23.412 | | 168.033,373.685 |
| R.H.S | n3 | 167.295 | 375.347 | -23.382 | | 167.295,375.347 |
| Extra R.H.S | n5 | 167.055 | 375.811 | -23.415 | | 167.055,375.811 |
| Drainage | n6 | 166.958 | 375.955 | -23.496 | | 166.958,375.955 |
| | | | | | | |
| **Chainage 376m to 405 m(station changed 10 )** | | | | | | |
| | | | | | | |
| | | | | | | |
| Centre line | o1 | 203.378 | 403.348 | -21.24 | | 203.378,403.348 |
| L.H.S | o2 | 204.912 | 402.267 | -21.134 | | 204.912,402.267 |
| R.H.S | o3 | 202.194 | 403.949 | -21.32 | | 202.194,403.949 |
| Extra L.H.S | o4 | 205.359 | 401.895 | -21.086 | | 205.359,401.895 |
| Extra R.H.S | o5 | 202.021 | 404.022 | -21.398 | | 202.021,404.022 |
| Drainage | o6 | 201.92 | 404.055 | -21.475 | | 201.92,404.055 |
| **Chainage 405m to 435m(Station changed 11 )** | | | | | | |
| | | | | | | |
| | | | | | | |
| Centre line | p1 | 208.468 | 435.632 | -19.546 | | 208.468,435.632 |
| L.H.S | p2 | 210.008 | 435.986 | -19.425 | | 210.008,435.986 |
| R.H.S | p3 | 206.735 | 435.228 | -19.638 | | 206.735,435.228 |
| Extra L.H.S | p4 | 211.156 | 436.22 | -19.33 | | 211.156,436.22 |
| Extra R.H.S | p5 | 205.638 | 435.001 | -19.739 | | 205.638,435.001 |
| Drainage | p6 | 205.293 | 434.994 | -19.766 | | 205.293,434.994 |
| | | | | | | |
| **Chainage to 456m (Station changed 12) starting point of curve** | | | | | | |
| | | | | | | |
| Centre line | q1 | 199.445 | 453.227 | -18.34 | | 199.445,453.227 |
| L.H.S | q2 | 200.639 | 454.496 | -18.233 | | 200.639,454.496 |
| R.H.S | q3 | 198.197 | 451.835 | -18.437 | | 198.197,451.835 |
| Extra L.H.S | q4 | 201.513 | 455.668 | -18.221 | | 201.513,455.668 |
| Extra R.H.S | q5 | 197.748 | 451.353 | -18.623 | | 197.748,451.353 |
| Drainage | q6 | 197.6 | 451.19 | -18.572 | | 197.6,451.19 |
| **Chainage to 474m midpoint of the curve** | | | | | | , |
| Centre line | r1 | 181.455 | 472.52 | -16.603 | | 181.455,472.52 |
| L.H.S | r2 | 183.846 | 472.91 | -16.828 | | 183.846,472.91 |
| R.H.S | r3 | 179.149 | 472.27 | -16.362 | | 179.149,472.27 |
| Extra L.H.S | r4 | 187.567 | 473.016 | -17.016 | | 187.567,473.016 |
| Extra R.H.S | r5 | 177.489 | 471.938 | -16.35 | | 177.489,471.938 |
| Drainage | r6 | 177.105 | 471.924 | -16.335 | | 177.105,471.924 |
| **Chainage to 487 m end point of the curve** | | | | | | |
| Centre line | s1 | 184.44 | 484.487 | -15.568 | | 184.44,484.487 |
| L.H.S | s2 | 186.014 | 483.685 | -15.762 | | 186.014,483.685 |
| R.H.S | s3 | 182.829 | 485.357 | -15.491 | | 182.829,485.357 |
| Extra L.H.S | s4 | 187.722 | 483.389 | -15.872 | | 187.722,483.389 |
| Extra R.H.S | s5 | 180.941 | 486.267 | -15.596 | | 180.941,486.267 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Drainage | s6 | 180.575 | 486.462 | -15.625 | | 180.575,486.462 |
| **Chainage to 503 m (Station changed 13)** | 13) | | | | | |
| Centre line | t1 | 192.56 | 502.126 | -14.454 | | 192.56,502.126 |
| L.H.S | t2 | 194.203 | 501.875 | -14.294 | | 194.203,501.875 |
| R.H.S | t3 | 190.869 | 502.471 | -14.586 | | 190.869,502.471 |
| Extra L.H.S | t4 | 196.662 | 501.532 | -14.161 | | 196.662,501.532 |
| Extra R.H.S | t5 | 188.291 | 502.738 | -14.598 | | 188.291,502.738 |
| Drainage | t6 | 187.68 | 502.899 | -14.658 | | 187.68,502.899 |
| **Chainage to 544m (Station changed 14)** | | | | | | |
| Centre line | w1 | 173.159 | 542.696 | -11.84 | | 173.159,542.696 |
| L.H.S | w2 | 175.078 | 543.253 | -12.047 | | 175.078,543.253 |
| R.H.S | w3 | 171.161 | 542.053 | -11.659 | | 171.161,542.053 |
| Extra L.H.S | w4 | 175.679 | 543.439 | -12.057 | | 175.679,543.439 |
| Extra R.H.S | w5 | 169.902 | 541.574 | -11.669 | | 169.902,541.574 |
| Drainage | w6 | 169.593 | 541.386 | -11 | | 169.593,541.386 |
| **Chainage to 577m (Station changed 15)** | | | | | | |
| Centre line | x1 | 176.306 | 575.956 | -9.715 | | 176.306,575.956 |
| L.H.S | x2 | 178.066 | 576.576 | -9.548 | | 178.066,576.576 |
| R.H.S | x3 | 174.436 | 575.457 | -9.903 | | 174.436,575.457 |
| Extra L.H.S | x4 | 178.994 | 576.769 | -9.46 | | 178.994,576.769 |
| Extra R.H.S | x5 | 173.503 | 575.35 | -9.979 | | 173.503,575.35 |
| Drainage | x6 | 173.357 | 575.323 | -9.974 | | 173.357,575.323 |
| **Chainage to 637m (Station changed 16)** | | | | | | |
| Centre line | y1 | 119.725 | 634.809 | -5.1 | | 119.725,634.809 |
| L.H.S | y2 | 120.71 | 636.061 | -4.988 | | 120.71,636.061 |
| R.H.S | y3 | 118.584 | 633.529 | -5.197 | | 118.584,633.529 |
| Extra L.H.S | y4 | 121.411 | 636.699 | -4.879 | | 121.411,636.699 |
| Extra R.H.S | y5 | 118.081 | 633.02 | -5.163 | | 118.081,633.02 |
| Drainage | y6 | 117.917 | 632.881 | -5.124 | | 117.917,632.881 |
| **Chainage to 652m (Station changed 17)** | | | | | | |
| Centre line | z1 | 97.317 | 649.548 | -3.6 | | 97.317,649.548 |
| L.H.S | z2 | 98.355 | 650.929 | -3.713 | | 98.355,650.929 |
| R.H.S | z3 | 96.134 | 648.309 | -3.438 | | 96.134,648.309 |
| Extra L.H.S | z4 | 98.672 | 651.33 | -3.757 | | 98.672,651.33 |
| Extra R.H.S | z5 | 95.449 | 647.051 | -3.424 | | 95.449,647.051 |
| Drainage | z6 | 95.429 | 646.725 | -3.386 | | 95.429,646.725 |
| **Chainage to 671m** | | | | | | |
| Centre line | aa1 | 86.195 | 669.492 | -1.881 | | 86.195,669.492 |
| L.H.S | aa2 | 88.033 | 669.897 | -1.952 | | 88.033,669.897 |
| R.H.S | aa3 | 84.316 | 669.241 | -1.718 | | 84.316,669.241 |
| Extra L.H.S | aa4 | 88.455 | 670.008 | -1.966 | | 88.455,670.008 |
| Extra R.H.S | aa5 | 83.572 | 669.139 | -1.763 | | 83.572,669.139 |
| Drainage | aa6 | 83.282 | 668.944 | -1.577 | | 83.282,668.944 |
| **Chainage to 688m** | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Centre line | bb1 | 88.425 | 685.235 | -0.972 | | 88.425,685.235 |
| L.H.S | bb2 | 89.925 | 684.453 | -1.07 | | 89.925,684.453 |
| R.H.S | bb3 | 87.096 | 685.942 | -0.838 | | 87.096,685.942 |
| Extra L.H.S | bb4 | 90.373 | 684.077 | -1.093 | | 90.373,684.077 |
| Extra R.H.S | bb5 | 85.855 | 686.942 | -0.735 | | 85.855,686.942 |
| Drainage | bb6 | 85.397 | 687.478 | -0.79 | | 85.397,687.478 |
| **Chainage to 726 m** | | | | | | |
| Centre line | cc1 | 103.354 | 724.653 | 0.923 | | 103.354,724.653 |
| L.H.S | cc2 | 104.921 | 724.271 | 0.878 | | 104.921,724.271 |
| R.H.S | cc3 | 101.766 | 725.049 | 0.906 | | 101.766,725.049 |
| Extra L.H.S | cc4 | 106.485 | 724.2 | 0.967 | | 106.485,724.2 |
| Extra R.H.S | cc5 | 100.964 | 725.085 | 0.767 | | 100.964,725.085 |
| Drainage | cc6 | 100.741 | 725.125 | 0.782 | | 100.741,725.125 |
| **Chainage to 765m(Station changed 18)** | | | | | | |
| Centre line | dd1 | 111.259 | 763.117 | 3.35 | | 111.259,763.117 |
| L.H.S | dd2 | 112.914 | 762.395 | 3.305 | | 112.914,762.395 |
| R.H.S | dd3 | 109.667 | 763.9 | 3.376 | | 109.667,763.9 |
| Extra L.H.S | dd4 | 113.447 | 762.078 | 3.295 | | 113.447,762.078 |
| Extra R.H.S | dd5 | 109.078 | 764.122 | 3.232 | | 109.078,764.122 |
| Drainage | dd6 | 108.762 | 764.224 | 3.197 | | 108.762,764.224 |
| **Chainage to 805m (Station changed 19)** | | | | | | |
| Centre line | ee1 | 129.836 | 803.954 | 5.957 | | 129.836,803.954 |
| L.H.S | ee2 | 131.296 | 803.325 | 6.008 | | 131.296,803.325 |
| R.H.S | ee3 | 128.118 | 804.278 | 5.874 | | 128.118,804.278 |
| Extra L.H.S | ee4 | 132.122 | 803.068 | 6.01 | | 132.122,803.068 |
| Extra R.H.S | ee5 | 127.451 | 804.614 | 5.785 | | 127.451,804.614 |
| Drainage | ee6 | 126.946 | 804.683 | 5.817 | | 126.946,804.683 |
| **Chainage to 822 m** | | | | | | |
| Centre line | ff1 | 132.067 | 821.69 | 6.513 | | 132.067,821.69 |
| L.H.S | ff2 | 133.852 | 821.573 | 6.601 | | 133.852,821.573 |
| R.H.S | ff3 | 130.516 | 821.74 | 6.385 | | 130.516,821.74 |
| Extra L.H.S | ff4 | 134.939 | 821.736 | 6.644 | | 134.939,821.736 |
| Extra R.H.S | ff5 | 130.031 | 821.711 | 6.294 | | 130.031,821.711 |
| Drainage | ff6 | 129.743 | 821.628 | 6.255 | | 129.743,821.628 |
| | | | | | | |
| **Chainage to 844m ( Station changed 20)** | | | | | | |
| Centre line | gg1 | 125.32 | 841.194 | 7.057 | | 125.32,841.194 |
| L.H.S | gg2 | 127.144 | 842.786 | 7.341 | | 127.144,842.786 |
| R.H.S | gg3 | 123.841 | 839.688 | 6.836 | | 123.841,839.688 |
| Extra L.H.S | gg4 | 123.277 | 843.563 | 7.462 | | 123.277,843.563 |
| Extra R.H.S | gg5 | 122.994 | 838.958 | 6.743 | | 122.994,838.958 |
| Drainage | gg6 | 122.547 | 838.558 | 6.489 | | 122.547,838.558 |
| | | | | | | |
| **Chainage to 856m (Station changed 21)** | | | | | | |
| Centre line | hh1 | 77.023 | 853.07 | 9.486 | | 77.023,853.07 |

| | | | | | | |
|---|---|---|---|---|---|---|
| L.H.S | hh2 | 77.668 | 854.795 | 9.401 | | 77.668,854.795 |
| R.H.S | hh3 | 76.296 | 851.429 | 9.539 | | 76.296,851.429 |
| Extra L.H.S | hh4 | 77.998 | 855.543 | 9.395 | | 77.998,855.543 |
| Extra R.H.S | hh5 | 76.052 | 850.852 | 9.419 | | 76.052,850.852 |
| Drainage | hh6 | 76.009 | 850.085 | 9.375 | | 76.009,850.085 |
| | | | | | | |
| **Chainage to 873m(Station changed 22)** | | | | | | |
| Centre line | ii1 | 55.565 | 871.356 | 11.47 | | 55.565,871.356 |
| L.H.S | ii2 | 57.659 | 872.489 | 11.256 | | 57.659,872.489 |
| R.H.S | ii3 | 53.972 | 870.559 | 11.583 | | 53.972,870.559 |
| Extra L.H.S | ii4 | 58.108 | 872.553 | 11.232 | | 58.108,872.553 |
| Extra R.H.S | ii5 | 53.08 | 870.004 | 11.544 | | 53.08,870.004 |
| Drainage | ii6 | 52.698 | 869.748 | 11.419 | | 52.698,869.748 |
| | | | | | | |
| **Chainage to 898 m (Station changed 23)** | | | | | | |
| Centre line | jj1 | 55.422 | 897.666 | 13.202 | | 55.422,897.666 |
| L.H.S | jj2 | 57.332 | 897.277 | 13.29 | | 57.332,897.277 |
| R.H.S | jj3 | 53.541 | 897.87 | 13.022 | | 53.541,897.87 |
| Extra L.H.S | jj4 | 58.114 | 897.2 | 13.295 | | 58.114,897.2 |
| Extra R.H.S | jj5 | 53.049 | 897.665 | 12.946 | | 53.049,897.665 |
| Drainage | jj6 | 52.731 | 897.712 | 12.955 | | 52.731,897.712 |
| | | | | | | |
| | | | | | | |
| **Chainage to 910 m(end point of curve 2)** | | | | | | |
| Centre line | kk1 | 54.469 | 908.668 | 13.653 | | 54.469,908.668 |
| L.H.S | kk2 | 56.442 | 909.501 | 13.798 | | 56.442,909.501 |
| R.H.S | kk3 | 52.428 | 908.413 | 13.486 | | 52.428,908.413 |
| Extra L.H.S | kk4 | 57.412 | 909.899 | 13.781 | | 57.412,909.899 |
| Extra R.H.S | kk5 | 51.907 | 908.145 | 13.406 | | 51.907,908.145 |
| Drainage | kk6 | 51.602 | 908.111 | 13.412 | | 51.602,908.111 |
| | | | | | | |
| | | | | | | |
| **Chainage to 939m (Station changed 24)** | | | | | | |
| Centre line | ll1 | 37.143 | 936.617 | 15.03 | | 37.143,936.617 |
| L.H.S | ll2 | 38.471 | 938.003 | 15.066 | | 38.471,938.003 |
| R.H.S | ll3 | 35.695 | 935.173 | 14.953 | | 35.695,935.173 |
| Extra L.H.S | ll4 | 39.124 | 938.814 | 15.106 | | 39.124,938.814 |
| Extra R.H.S | ll5 | 35.523 | 935.112 | 14.899 | | 35.523,935.112 |
| Drainage | ll6 | 35.312 | 934.919 | 14.86 | | 35.312,934.919 |
| | | | | | | |
| | | | | | | |
| **Chainage to 955m (Station changed 25)** | | | | | | |
| Centre line | mm1 | 19.051 | 952.395 | 16.345 | | 19.051,952.395 |
| L.H.S | mm2 | 20.681 | 953.784 | 16.228 | | 20.681,953.784 |
| R.H.S | mm3 | 17.319 | 951.264 | 16.486 | | 17.319,951.264 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Extra L.H.S | mm4 | 21.548 | 954.506 | 16.221 | | 21.548,954.506 |
| Extra R.H.S | mm5 | 17.021 | 950.897 | 16.41 | | 17.021,950.897 |
| Drainage | mm6 | 16.575 | 950.551 | 16.228 | | 16.575,950.551 |
| | | | | | | |
| | | | | | | |
| **Chainage to 960m** | | | | | | |
| Centre line | nn1 | 15.529 | 959.259 | 17.157 | | 15.529,959.259 |
| L.H.S | nn2 | 18.093 | 959.234 | 16.847 | | 18.093,959.234 |
| R.H.S | nn3 | 12.835 | 959.254 | 17.429 | | 12.835,959.254 |
| Extra L.H.S | nn4 | 19.417 | 959.363 | 16.799 | | 19.417,959.363 |
| Extra R.H.S | nn5 | 11.793 | 959.273 | 17.532 | | 11.793,959.273 |
| Drainage | nn6 | 11.325 | 959.284 | 17.715 | | 11.325,959.284 |
| | | | | | | |
| **Chainage to 977m (station changed to 26)** | | | | | | |
| Centre line | oo1 | 22.094 | 974.587 | 18.368 | | 22.094,974.587 |
| L.H.S | oo2 | 24.147 | 972.827 | 18.421 | | 24.147,972.827 |
| R.H.S | oo3 | 20.525 | 975.378 | 18.315 | | 20.525,975.378 |
| Extra L.H.S | oo4 | 24.452 | 972.621 | 18.435 | | 24.452,972.621 |
| Extra R.H.S | oo5 | 19.144 | 976.497 | 18.195 | | 19.144,976.497 |
| Drainage | oo6 | 18.822 | 976.749 | 18.101 | | 18.822,976.749 |
| | | | | | | |
| **Chainage to 989m** | | | | | | |
| Centre line | pp1 | 29.959 | 987.664 | 19.229 | | 29.959,987.664 |
| L.H.S | pp2 | 32.54 | 987.116 | 19.474 | | 32.54,987.116 |
| R.H.S | pp3 | 27.65 | 988.11 | 19.048 | | 27.65,988.11 |
| Extra L.H.S | pp4 | 34.894 | 986.544 | 19.618 | | 34.894,986.544 |
| Extra R.H.S | pp5 | 25.891 | 988.649 | 18.932 | | 25.891,988.649 |
| Drainage | pp6 | 25.107 | 988.824 | 18.756 | | 25.107,988.824 |
| | | | | | | |
| **Chainage to 1024m(Station changed 27)** | | | | | | |
| Centre line | qq1 | 30.58 | 1019.59 | 20.863 | | 30.58,1019.59 |
| L.H.S | qq2 | 32.877 | 1023.863 | 21.17 | | 32.877,1023.863 |
| R.H.S | qq3 | 28.789 | 1019.995 | 20.768 | | 28.789,1019.995 |
| Extra L.H.S | qq4 | 33.934 | 1018.705 | 20.949 | | 33.934,1018.705 |
| Extra R.H.S | qq5 | 27.829 | 1020.309 | 20.638 | | 27.829,1020.309 |
| Drainage | qq6 | 27.428 | 1020.387 | 20.577 | | 27.428,1020.387 |
| | | | | | | |
| **Chainage to 1030m** | | | | | | |
| Centre line | rr1 | 31.093 | 1027.666 | 21.375 | | 31.093,1027.666 |
| L.H.S | rr2 | 33.569 | 1028.682 | 21.653 | | 33.569,1028.682 |
| R.H.S | rr3 | 28.686 | 1027.225 | 21.168 | | 28.686,1027.225 |
| Extra L.H.S | rr4 | 35.754 | 1029.181 | 21.763 | | 35.754,1029.181 |
| Extra R.H.S | rr5 | 28.112 | 1026.961 | 21.066 | | 28.112,1026.961 |
| Drainage | rr6 | 27.873 | 1026.922 | 21.072 | | 27.873,1026.922 |
| | | | | | | |

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|---|---|---|---|---|---|---|
| **Chainage to 1039m(Station changed 28)** | | | | | | |
| Centre line | ss1 | 25.848 | 1036.665 | 21.858 | | 25.848,1036.665 |
| L.H.S | ss2 | 27.244 | 1038.298 | 21.941 | | 27.244,1038.298 |
| R.H.S | ss3 | 24.477 | 1035.319 | 21.762 | | 24.477,1035.319 |
| Extra L.H.S | ss4 | 27.645 | 1038.709 | 21.94 | | 27.645,1038.709 |
| Extra R.H.S | ss5 | 23.678 | 1034.606 | 21.72 | | 23.678,1034.606 |
| Drainage | ss6 | 23.482 | 1034.268 | 21.704 | | 23.482,1034.268 |
| | | | | | | |
| **Chainage to 1058m** | | | | | | |
| Centre line | tt1 | 2.618 | 1055.079 | 23.359 | | 2.618,1055.079 |
| L.H.S | tt2 | 3.855 | 1056.384 | 23.347 | | 3.855,1056.384 |
| R.H.S | tt3 | 1.403 | 1053.935 | 23.446 | | 1.403,1053.935 |
| Extra L.H.S | tt4 | 5.463 | 1057.538 | 23.333 | | 5.463,1057.538 |
| Extra R.H.S | tt5 | 1.277 | 1053.776 | 23.314 | | 1.277,1053.776 |
| Drainage | tt6 | 1.136 | 1053.592 | 23.314 | | 1.136,1053.592 |
| | | | | | | |
| **Chainage to 1075m(Station changed 29)** | | | | | | |
| Centre line | ww1 | -5.774 | 1070.437 | 24.647 | | -5.774,1070.437 |
| L.H.S | ww2 | -3.071 | 1070.068 | 24.345 | | -3.071,1070.068 |
| R.H.S | ww3 | -10.989 | 1074.145 | 25.289 | | -10.989,1074.145 |
| Extra L.H.S | ww4 | 4.231 | 1068.815 | 24.308 | | 4.231,1068.815 |
| Extra R.H.S | ww5 | -9.462 | 1070.572 | 24.981 | | -9.462,1070.572 |
| Drainage | ww6 | -9.893 | 1070.594 | 25.013 | | -9.893,1070.594 |
| | | | | | | |
| **Chainage to 1084m** | | | | | | |
| | | | | | | |
| Centre line | xx1 | 3.85 | 1081.843 | 25.666 | | 3.85,1081.843 |
| L.H.S | xx2 | 4.05 | 1079.352 | 25.497 | | 4.05,1079.352 |
| R.H.S | xx3 | 1.973 | 1083.051 | 25.664 | | 1.973,1083.051 |
| Extra L.H.S | xx4 | 7.818 | 1070.051 | 25.213 | | 7.818,1070.051 |
| Extra R.H.S | xx5 | 1.717 | 1083.436 | 25.577 | | 1.717,1083.436 |
| Drainage | xx6 | 1.55 | 1083.618 | 25.49 | | 1.55,1083.618 |
| | | | | | | |
| **Chainage to 1097m(Station changed 30)** | | | | | | |
| Centre line | yy1 | 20.833 | 1095.461 | 26.846 | | 20.833,1095.461 |
| L.H.S | yy2 | 22.53 | 1094.585 | 26.945 | | 22.53,1094.585 |
| R.H.S | yy3 | 18.658 | 1096.642 | 26.669 | | 18.658,1096.642 |
| Extra L.H.S | yy4 | 23.74 | 1093.964 | 26.793 | | 23.74,1093.964 |
| Extra R.H.S | yy5 | 17.79 | 1096.79 | 26.649 | | 17.79,1096.79 |
| Drainage | yy6 | 17.358 | 1096.877 | 26.539 | | 17.358,1096.877 |
| | | | | | | |
| **Chainage to 1130m(station point changes)** | | | | | | |
| Centre line | zz1 | 21.669 | 1125.854 | 28.541 | | 21.669,1125.854 |
| L.H.S | zz2 | 23.774 | 1128.026 | 28.827 | | 23.774,1128.026 |
| R.H.S | zz3 | 19.555 | 1123.793 | 28.283 | | 19.555,1123.793 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Extra L.H.S | zz4 | 25.158 | 1129.193 | 29.908 | | 25.158,1129.193 |
| Extra R.H.S | zz5 | 18.894 | 1123.119 | 28.246 | | 18.894,1123.119 |
| Drainage | zz6 | 18.926 | 1122.824 | 27.182 | | 18.926,1122.824 |

# APPENDIX B

## Calculation of Pavement Width and Right Hand shoulder width and Left Hand Shoulder Width Till 1.13m

| CROSS SECTION | Distance from previous C.S. | POINT | N | E | Z | D23 (m) | D24 (m) | D35 (m) |
|---|---|---|---|---|---|---|---|---|
| C.S 1 | 30 m | a1 | -1.790 | 31.390 | -0.639 | 3.73 | 2.59 | 0.49 |
| | | a2 | 0.022 | 31.56 | -0.546 | | | |
| | | a3 | -3.708 | 31.432 | -0.69 | | | |
| | | a4 | 2.591 | 31.85 | -0.366 | | | |
| | | a5 | -4.107 | 31.146 | -0.679 | | | |
| | | a6 | -4.292 | 31.035 | -0.44 | | | |
| C.S 2 | 60m | b1 | 2.468 | 60.995 | -1.935 | 3.60 | 0.45 | 0.38 |
| | | b2 | 4.405 | 61.018 | -1.907 | | | |
| | | b3 | 0.831 | 60.615 | -1.99 | | | |
| | | b4 | 4.844 | 61.109 | -1.879 | | | |
| | | b5 | 0.456 | 60.575 | -2.012 | | | |
| | | b6 | 0.544 | 60.556 | -2.117 | | | |
| C.S 3 | 90m | c1 | -4.436 | 89.898 | -2.875 | 3.27 | 0.34 | 0.31 |
| | | c2 | -2.891 | 90.095 | -2.866 | | | |
| | | c3 | -6.099 | 89.483 | -2.892 | | | |
| | | c4 | -2.575 | 90.207 | -2.856 | | | |
| | | c5 | -6.403 | 89.424 | -2.898 | | | |
| | | c6 | -6.86 | 89.335 | -2.714 | | | |
| C.S 4 | 150m | d1 | -20.78 | 147.414 | -7.129 | 5.53 | 0.45 | 0.28 |
| | | d2 | -18.075 | 148.002 | -7.114 | | | |
| | | d3 | -23.47 | 146.795 | -7.148 | | | |
| | | d4 | -17.64 | 148.116 | -7.087 | | | |
| | | d5 | -23.743 | 146.747 | -7.16 | | | |
| | | d6 | -23.949 | 146.626 | -7.109 | | | |
| C.S 5 | 210m | e1 | -19.604 | 207.533 | -12.944 | 5.13 | 0.24 | 0.47 |
| | | e2 | -16.965 | 207.67 | -12.929 | | | |
| | | e3 | -22.096 | 207.579 | -12.962 | | | |
| | | e4 | -16.724 | 207.65 | -12.91 | | | |
| | | e5 | -22.566 | 207.553 | -12.952 | | | |
| | | e6 | -22.586 | 207.899 | -12.989 | | | |
| C.S 6 | 220m | f1 | -6.64 | 207.539 | -14.028 | 2.38 | 0.37 | 0.19 |
| | | f2 | -6.819 | 207.937 | -14.128 | | | |
| | | f3 | -5.979 | 210.163 | -13.966 | | | |
| | | f4 | -6.858 | 207.567 | -14.114 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | f5 | -5.89 | 210.325 | -13.954 | | | |
| | | f6 | -7.097 | 214.186 | -13.967 | | | |
| C.S 7 | 240m | g1 | -15.291 | 238.2 | -16.01 | 3.51 | 0.40 | 0.63 |
| | | g2 | -13.872 | 237.208 | -15.999 | | | |
| | | g3 | -16.741 | 239.228 | -15.985 | | | |
| | | g4 | -13.58 | 236.94 | -16.008 | | | |
| | | g5 | -17.142 | 239.715 | -15.941 | | | |
| | | g6 | -17.28 | 239.764 | -15.886 | | | |
| C.S 8 | 260m | h1 | -3.096 | 254.054 | -18.012 | 4.67 | 0.78 | 0.62 |
| | | h2 | -1.14 | 252.93 | -17.86 | | | |
| | | h3 | -5.085 | 255.422 | -18.067 | | | |
| | | h4 | -1.1 | 252.156 | -17.796 | | | |
| | | h5 | -5.615 | 255.747 | -18.071 | | | |
| | | h6 | -5.756 | 255.891 | -17.986 | | | |
| C.S 9 | 310m | i1 | 32.089 | 307.341 | -24.75 | 5.31 | 0.65 | 0.44 |
| | | i2 | 33.796 | 305.402 | -24.822 | | | |
| | | i3 | 30.313 | 309.405 | -24.61 | | | |
| | | i4 | 34.335 | 305.048 | -24.856 | | | |
| | | i5 | 29.962 | 309.673 | -24.638 | | | |
| | | i6 | 29.736 | 309.967 | -24.629 | | | |
| C.S 10 | 330m | j1 | 61.059 | 326.445 | -26.611 | 4.64 | 0.59 | 0.74 |
| | | j2 | 61.91 | 324.32 | -26.616 | | | |
| | | j3 | 60.188 | 328.625 | -26.566 | | | |
| | | j4 | 62.083 | 324.208 | -26.065 | | | |
| | | j5 | 59.817 | 328.764 | -25.946 | | | |
| | | j6 | 59.705 | 328.779 | -25.935 | | | |
| C.S 11 | 341m | k1 | 75.468 | 339.253 | -27.43 | 4.45 | 0.25 | 0.33 |
| | | k2 | 77.226 | 337.886 | -27.464 | | | |
| | | k3 | 73.67 | 340.56 | -27.406 | | | |
| | | k4 | 77.437 | 337.759 | -27.495 | | | |
| | | k5 | 73.386 | 340.729 | -27.358 | | | |
| | | k6 | 73.134 | 340.889 | -27.217 | | | |
| C.S 12 | 366m | m1 | 106.813 | 363.205 | -26.616 | 4.33 | 0.28 | 0.48 |
| | | m2 | 107.762 | 361.087 | -26.698 | | | |
| | | m3 | 106.072 | 365.071 | -26.576 | | | |
| | | m4 | 107.8 | 360.812 | -26.683 | | | |
| | | m5 | 105.834 | 365.483 | -26.642 | | | |
| | | m6 | 105.693 | 365.732 | -26.638 | | | |
| C.S 13 | 376m | n1 | 168.033 | 373.685 | -23.412 | 2.95 | 0.39 | 0.52 |
| | | n2 | 168.484 | 372.644 | -23.479 | | | |
| | | n3 | 167.295 | 375.347 | -23.382 | | | |
| | | n4 | 168.841 | 372.559 | -23.359 | | | |
| | | n5 | 167.055 | 375.811 | -23.415 | | | |
| | | n6 | 166.958 | 375.955 | -23.496 | | | |
| C.S 14 | 405m | o1 | 203.378 | 403.348 | -21.24 | 3.20 | 0.58 | 0.20 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | o2 | 204.912 | 402.267 | -21.134 | | | |
| | | o3 | 202.194 | 403.949 | -21.32 | | | |
| | | o4 | 205.359 | 401.895 | -21.086 | | | |
| | | o5 | 202.021 | 404.022 | -21.398 | | | |
| | | o6 | 201.92 | 404.055 | -21.475 | | | |
| C.S 15 | 435m | p1 | 208.468 | 435.632 | -19.546 | 3.37 | 1.18 | 1.12 |
| | | p2 | 210.008 | 435.986 | -19.425 | | | |
| | | p3 | 206.735 | 435.228 | -19.638 | | | |
| | | p4 | 211.156 | 436.22 | -19.33 | | | |
| | | p5 | 205.638 | 435.001 | -19.739 | | | |
| | | p6 | 205.293 | 434.994 | -19.766 | | | |
| C.S 16 | 456m | q1 | 199.445 | 453.227 | -18.34 | 3.62 | 1.46 | 0.68 |
| | | q2 | 200.639 | 454.496 | -18.233 | | | |
| | | q3 | 198.197 | 451.835 | -18.437 | | | |
| | | q4 | 201.513 | 455.668 | -18.221 | | | |
| | | q5 | 197.748 | 451.353 | -18.623 | | | |
| | | q6 | 197.6 | 451.19 | -18.572 | | | |
| C.S 17 | 474m | r1 | 181.455 | 472.52 | -16.603 | 4.76 | 0.75 | 0.74 |
| | | r2 | 183.846 | 472.91 | -16.828 | | | |
| | | r3 | 179.149 | 472.27 | -16.362 | | | |
| | | r4 | 184.567 | 473.016 | -17.016 | | | |
| | | r5 | 178.489 | 471.938 | -16.35 | | | |
| | | r6 | 177.105 | 471.924 | -16.335 | | | |
| C.S 18 | 487m | s1 | 184.44 | 484.487 | -15.568 | 3.61 | 0.78 | 0.92 |
| | | s2 | 186.014 | 483.685 | -15.762 | | | |
| | | s3 | 182.829 | 485.357 | -15.491 | | | |
| | | s4 | 186.722 | 483.389 | -15.872 | | | |
| | | s5 | 182.941 | 486.267 | -15.596 | | | |
| | | s6 | 180.575 | 486.462 | -15.625 | | | |
| C.S 19 | 503m | t1 | 192.56 | 502.126 | -14.454 | 3.40 | 0.59 | 0.64 |
| | | t2 | 194.203 | 501.875 | -14.294 | | | |
| | | t3 | 190.869 | 502.471 | -14.586 | | | |
| | | t4 | 194.662 | 501.532 | -14.161 | | | |
| | | t5 | 190.291 | 502.738 | -14.598 | | | |
| | | t6 | 188.005 | 502.899 | -14.658 | | | |
| C.S 20 | 544m | w1 | 173.159 | 542.696 | -11.84 | 4.12 | 0.63 | 1.35 |
| | | w2 | 175.078 | 543.253 | -12.047 | | | |
| | | w3 | 171.161 | 542.053 | -11.659 | | | |
| | | w4 | 175.679 | 543.439 | -12.057 | | | |
| | | w5 | 169.902 | 541.574 | -11.669 | | | |
| | | w6 | 169.593 | 541.386 | -11.56 | | | |
| C.S 21 | 577m | x1 | 176.306 | 575.956 | -9.715 | 3.82 | 0.95 | 0.94 |
| | | x2 | 178.066 | 576.576 | -9.548 | | | |
| | | x3 | 174.436 | 575.457 | -9.903 | | | |
| | | x4 | 178.994 | 576.769 | -9.46 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | x5 | 173.503 | 575.35 | -9.979 | | | |
| | | x6 | 173.357 | 575.323 | -9.974 | | | |
| C.S 22 | 637m | y1 | 119.725 | 634.809 | -5.1 | 3.31 | 0.95 | 0.72 |
| | | y2 | 120.71 | 636.061 | -4.988 | | | |
| | | y3 | 118.584 | 633.529 | -5.197 | | | |
| | | y4 | 121.411 | 636.699 | -4.879 | | | |
| | | y5 | 118.081 | 633.02 | -5.163 | | | |
| | | y6 | 117.917 | 632.881 | -5.124 | | | |
| C.S 23 | 652m | z1 | 97.317 | 649.548 | -3.6 | 3.45 | 0.51 | 1.43 |
| | | z2 | 98.355 | 650.929 | -3.713 | | | |
| | | z3 | 96.134 | 648.309 | -3.438 | | | |
| | | z4 | 98.672 | 651.33 | -3.757 | | | |
| | | z5 | 95.449 | 647.051 | -3.424 | | | |
| | | z6 | 95.429 | 646.725 | -3.386 | | | |
| C.S 24 | 671m | aa1 | 86.195 | 669.492 | -1.881 | 3.78 | 0.44 | 0.75 |
| | | aa2 | 88.033 | 669.897 | -1.952 | | | |
| | | aa3 | 84.316 | 669.241 | -1.718 | | | |
| | | aa4 | 88.455 | 670.008 | -1.966 | | | |
| | | aa5 | 83.572 | 669.139 | -1.763 | | | |
| | | aa6 | 83.282 | 668.944 | -1.577 | | | |
| C.S 25 | 688m | bb1 | 88.425 | 685.235 | -0.972 | 3.21 | 0.59 | 1.60 |
| | | bb2 | 89.925 | 684.453 | -1.07 | | | |
| | | bb3 | 87.096 | 685.942 | -0.838 | | | |
| | | bb4 | 90.373 | 684.077 | -1.093 | | | |
| | | bb5 | 85.855 | 686.942 | -0.735 | | | |
| | | bb6 | 85.397 | 686.895 | -0.745 | | | |
| C.S 26 | 726m | cc1 | 103.354 | 724.653 | 0.923 | 3.25 | 1.57 | 0.81 |
| | | cc2 | 104.921 | 724.271 | 0.878 | | | |
| | | cc3 | 101.766 | 725.049 | 0.906 | | | |
| | | cc4 | 106.485 | 724.2 | 0.967 | | | |
| | | cc5 | 100.964 | 725.085 | 0.767 | | | |
| | | cc6 | 100.741 | 725.125 | 0.782 | | | |
| C.S 27 | 765m | dd1 | 111.259 | 763.117 | 3.35 | 3.58 | 0.62 | 0.65 |
| | | dd2 | 112.914 | 762.395 | 3.305 | | | |
| | | dd3 | 109.667 | 763.9 | 3.376 | | | |
| | | dd4 | 113.447 | 762.078 | 3.295 | | | |
| | | dd5 | 109.078 | 764.122 | 3.232 | | | |
| | | dd6 | 108.762 | 764.224 | 3.197 | | | |
| C.S 28 | 805m | ee1 | 129.836 | 803.954 | 5.957 | 3.32 | 0.87 | 0.75 |
| | | ee2 | 131.296 | 803.325 | 6.008 | | | |
| | | ee3 | 128.118 | 804.278 | 5.874 | | | |
| | | ee4 | 132.122 | 803.068 | 6.01 | | | |
| | | ee5 | 127.451 | 804.614 | 5.785 | | | |
| | | ee6 | 126.946 | 804.683 | 5.817 | | | |
| C.S 29 | 822m | ff1 | 132.067 | 821.69 | 6.513 | 3.35 | 1.10 | 0.49 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ff2 | 133.852 | 821.573 | 6.601 | | | |
| | | ff3 | 130.516 | 821.74 | 6.385 | | | |
| | | ff4 | 134.939 | 821.736 | 6.644 | | | |
| | | ff5 | 130.031 | 821.711 | 6.294 | | | |
| | | ff6 | 129.743 | 821.628 | 6.255 | | | |
| C.S 30 | 844m | gg1 | 125.32 | 841.194 | 7.057 | 4.56 | 1.17 | 1.12 |
| | | gg2 | 127.144 | 842.786 | 7.341 | | | |
| | | gg3 | 123.841 | 839.688 | 6.836 | | | |
| | | gg4 | 126.277 | 843.563 | 7.462 | | | |
| | | gg5 | 122.994 | 838.958 | 6.743 | | | |
| | | gg6 | 122.547 | 838.558 | 6.489 | | | |
| C.S 31 | 856m | hh1 | 77.023 | 853.07 | 9.486 | 3.64 | 0.82 | 0.64 |
| | | hh2 | 77.668 | 854.795 | 9.401 | | | |
| | | hh3 | 76.296 | 851.429 | 9.539 | | | |
| | | hh4 | 77.998 | 855.543 | 9.395 | | | |
| | | hh5 | 76.052 | 850.852 | 9.419 | | | |
| | | hh6 | 76.009 | 850.085 | 9.375 | | | |
| C.S 32 | 873m | ii1 | 55.565 | 871.356 | 11.47 | 4.17 | 0.45 | 1.05 |
| | | ii2 | 57.659 | 872.489 | 11.256 | | | |
| | | ii3 | 53.972 | 870.559 | 11.583 | | | |
| | | ii4 | 58.108 | 872.553 | 11.232 | | | |
| | | ii5 | 53.08 | 870.004 | 11.544 | | | |
| | | ii6 | 52.698 | 869.748 | 11.419 | | | |
| C.S 33 | 898m | jj1 | 55.422 | 897.666 | 13.202 | 3.85 | 0.79 | 0.54 |
| | | jj2 | 57.332 | 897.277 | 13.29 | | | |
| | | jj3 | 53.541 | 897.87 | 13.022 | | | |
| | | jj4 | 58.114 | 897.2 | 13.295 | | | |
| | | jj5 | 53.049 | 897.665 | 12.946 | | | |
| | | jj6 | 52.731 | 897.712 | 12.955 | | | |
| C.S 34 | 910m | kk1 | 54.469 | 908.668 | 13.653 | 4.17 | 1.05 | 0.59 |
| | | kk2 | 56.442 | 909.501 | 13.798 | | | |
| | | kk3 | 52.428 | 908.413 | 13.486 | | | |
| | | kk4 | 57.412 | 909.899 | 13.781 | | | |
| | | kk5 | 51.907 | 908.145 | 13.406 | | | |
| | | kk6 | 51.602 | 908.111 | 13.412 | | | |
| C.S 35 | 939m | ll1 | 37.143 | 936.617 | 15.03 | 3.97 | 1.04 | 0.19 |
| | | ll2 | 38.471 | 938.003 | 15.066 | | | |
| | | ll3 | 35.695 | 935.173 | 14.953 | | | |
| | | ll4 | 39.124 | 938.814 | 15.106 | | | |
| | | ll5 | 35.523 | 935.112 | 14.899 | | | |
| | | ll6 | 35.312 | 934.919 | 14.86 | | | |
| C.S 36 | 955m | mm1 | 19.051 | 952.395 | 16.345 | 4.21 | 1.13 | 0.48 |
| | | mm2 | 20.681 | 953.784 | 16.228 | | | |
| | | mm3 | 17.319 | 951.264 | 16.486 | | | |
| | | mm4 | 21.548 | 954.506 | 16.221 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | mm5 | 17.021 | 950.897 | 16.41 | | | |
| | | mm6 | 16.575 | 950.551 | 16.228 | | | |
| C.S 37 | 960m | nn1 | 15.529 | 959.259 | 17.157 | 5.29 | 1.33 | 1.05 |
| | | nn2 | 18.093 | 959.234 | 16.847 | | | |
| | | nn3 | 12.835 | 959.254 | 17.429 | | | |
| | | nn4 | 19.417 | 959.363 | 16.799 | | | |
| | | nn5 | 11.793 | 959.273 | 17.532 | | | |
| | | nn6 | 11.325 | 959.284 | 17.715 | | | |
| C.S 38 | 977m | oo1 | 22.094 | 974.587 | 18.368 | 4.43 | 0.37 | 1.78 |
| | | oo2 | 24.147 | 972.827 | 18.421 | | | |
| | | oo3 | 20.525 | 975.378 | 18.315 | | | |
| | | oo4 | 24.452 | 972.621 | 18.435 | | | |
| | | oo5 | 19.144 | 976.497 | 18.195 | | | |
| | | oo6 | 18.822 | 976.749 | 18.101 | | | |
| C.S 39 | 989m | pp1 | 29.959 | 987.664 | 19.229 | 5.01 | 2.43 | 1.84 |
| | | pp2 | 32.54 | 987.116 | 19.474 | | | |
| | | pp3 | 27.65 | 988.11 | 19.048 | | | |
| | | pp4 | 34.894 | 986.544 | 19.618 | | | |
| | | pp5 | 25.891 | 988.649 | 18.932 | | | |
| | | pp6 | 25.107 | 988.824 | 18.756 | | | |
| C.S 40 | 1024m | qq1 | 30.58 | 1019.59 | 20.863 | 4.57 | 2.27 | 1.02 |
| | | qq2 | 32.877 | 1022 | 21.17 | | | |
| | | qq3 | 28.789 | 1019.995 | 20.768 | | | |
| | | qq4 | 33.934 | 1020 | 20.949 | | | |
| | | qq5 | 27.829 | 1020.309 | 20.638 | | | |
| | | qq6 | 27.428 | 1020.387 | 20.577 | | | |
| C.S 41 | 1030m | rr1 | 31.093 | 1027.666 | 21.375 | 5.12 | 2.24 | 0.64 |
| | | rr2 | 33.569 | 1028.682 | 21.653 | | | |
| | | rr3 | 28.686 | 1027.225 | 21.168 | | | |
| | | rr4 | 35.754 | 1029.181 | 21.763 | | | |
| | | rr5 | 28.112 | 1026.961 | 21.066 | | | |
| | | rr6 | 27.873 | 1026.922 | 21.072 | | | |
| C.S 42 | 1039m | ss1 | 25.848 | 1036.665 | 21.858 | 4.07 | 0.57 | 1.07 |
| | | ss2 | 27.244 | 1038.298 | 21.941 | | | |
| | | ss3 | 24.477 | 1035.319 | 21.762 | | | |
| | | ss4 | 27.645 | 1038.709 | 21.94 | | | |
| | | ss5 | 23.678 | 1034.606 | 21.72 | | | |
| | | ss6 | 23.482 | 1034.268 | 21.704 | | | |
| C.S 43 | 1058m | tt1 | 2.618 | 1055.079 | 23.359 | 3.47 | 1.98 | 0.24 |
| | | tt2 | 3.855 | 1056.384 | 23.347 | | | |
| | | tt3 | 1.403 | 1053.935 | 23.446 | | | |
| | | tt4 | 5.463 | 1057.538 | 23.333 | | | |
| | | tt5 | 1.277 | 1053.776 | 23.314 | | | |
| | | tt6 | 1.136 | 1053.592 | 23.314 | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | ww1 | -5.774 | 1070.437 | 24.647 | 5.11 | 1.71 | 1.38 |
| | | ww2 | -3.071 | 1070.068 | 24.345 | | | |
| | | ww3 | -6.012 | 1074.145 | 25.289 | | | |
| | | ww4 | -4.23 | 1068.815 | 24.308 | | | |
| | | ww5 | -7.235 | 1073.562 | 25.005 | | | |
| C.S 44 | 1075m | ww6 | -7.453 | 1073.562 | 25.013 | | | |
| | | xx1 | 3.85 | 1081.843 | 25.666 | 4.25 | 1.35 | 0.47 |
| | | xx2 | 4.05 | 1079.352 | 25.497 | | | |
| | | xx3 | 1.973 | 1083.051 | 25.664 | | | |
| | | xx4 | 3.02 | 1078.535 | 25.213 | | | |
| | | xx5 | 1.717 | 1083.436 | 25.577 | | | |
| C.S 45 | 1084m | xx6 | 1.55 | 1083.618 | 25.49 | | | |
| | | yy1 | 20.833 | 1095.461 | 26.846 | 4.39 | 1.37 | 0.88 |
| | | yy2 | 22.53 | 1094.585 | 26.945 | | | |
| | | yy3 | 18.658 | 1096.642 | 26.669 | | | |
| | | yy4 | 23.74 | 1093.964 | 26.793 | | | |
| | | yy5 | 17.79 | 1096.79 | 26.649 | | | |
| C.S 46 | 1097m | yy6 | 17.358 | 1096.877 | 26.539 | | | |
| | | zz1 | 21.669 | 1125.854 | 28.541 | 5.21 | 2.26 | 0.94 |
| | | zz2 | 22.55 | 1128.026 | 28.827 | | | |
| | | zz3 | 19.555 | 1123.793 | 28.283 | | | |
| | | zz4 | 24.155 | 1129.193 | 29.908 | | | |
| | | zz5 | 18.894 | 1123.119 | 28.246 | | | |
| C.S 47 | 1130m | zz6 | 18.926 | 1123.11 | 27.88 | | | |

# Appendix C

## Images of Curves that we analyzed to find various design parameters

Curve 1


Curve 2

Curve 3

Curve 4

Curve 5

Curve 6

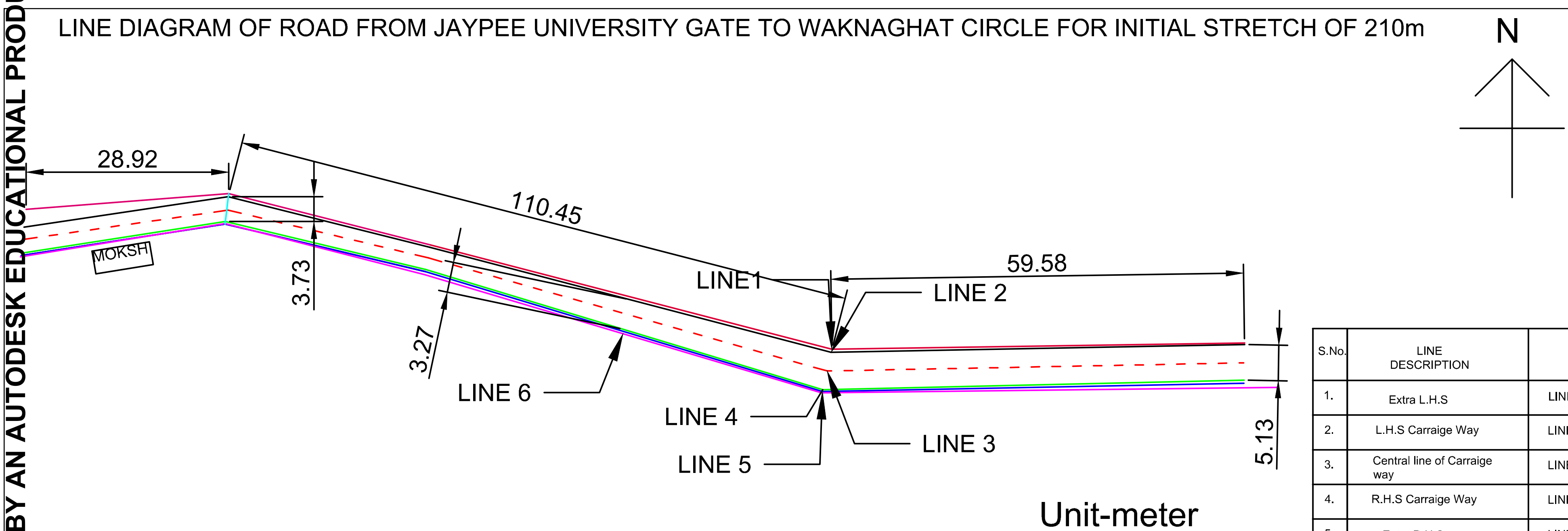
Curve 7

Curve 8

Curve 9

Curve 10

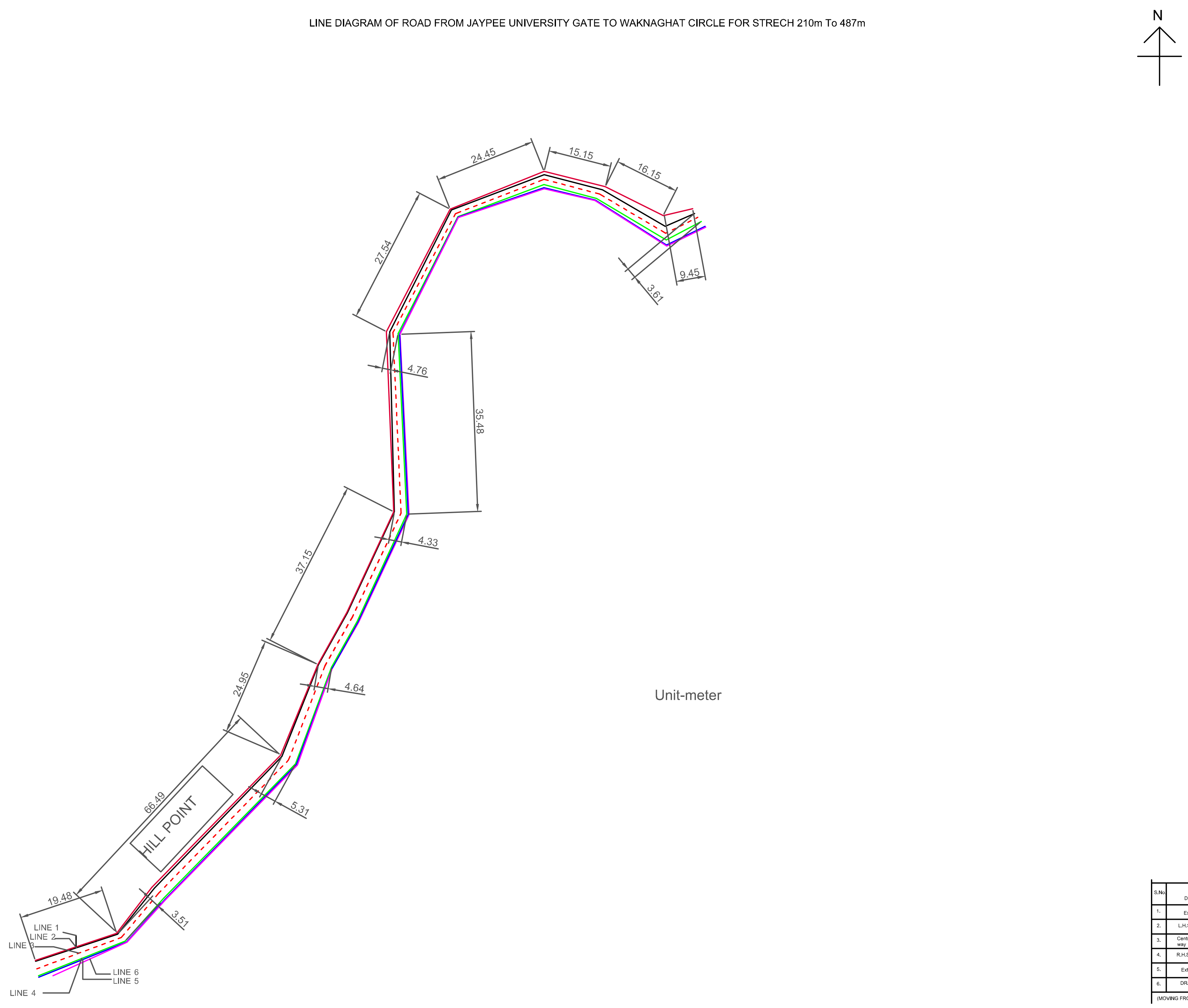
LINE DIAGRAM OF ROAD FROM JAYPEE UNIVERSITY GATE TO WAKNAGHAT CIRCLE FOR INITIAL STRETCH OF 210m




| S.No. | LINE DESCRIPTION | |
|---|---|---|
| 1. | Extra L.H.S | LINE 1 |
| 2. | L.H.S Carraige Way | LINE 2 |
| 3. | Central line of Carraige way | LINE 3 |
| 4. | R.H.S Carraige Way | LINE 4 |
| 5. | Extra R.H.S | LINE 5 |
| 6. | DRAINAGE | LINE 6 |

(MOVING FROM JUIT TO WAKNAGHAT CIRCLE)

LINE DIAGRAM OF ROAD FROM JAYPEE UNIVERSITY GATE TO WAKNAGHAT CIRCLE FOR STRECH 210m To 487m

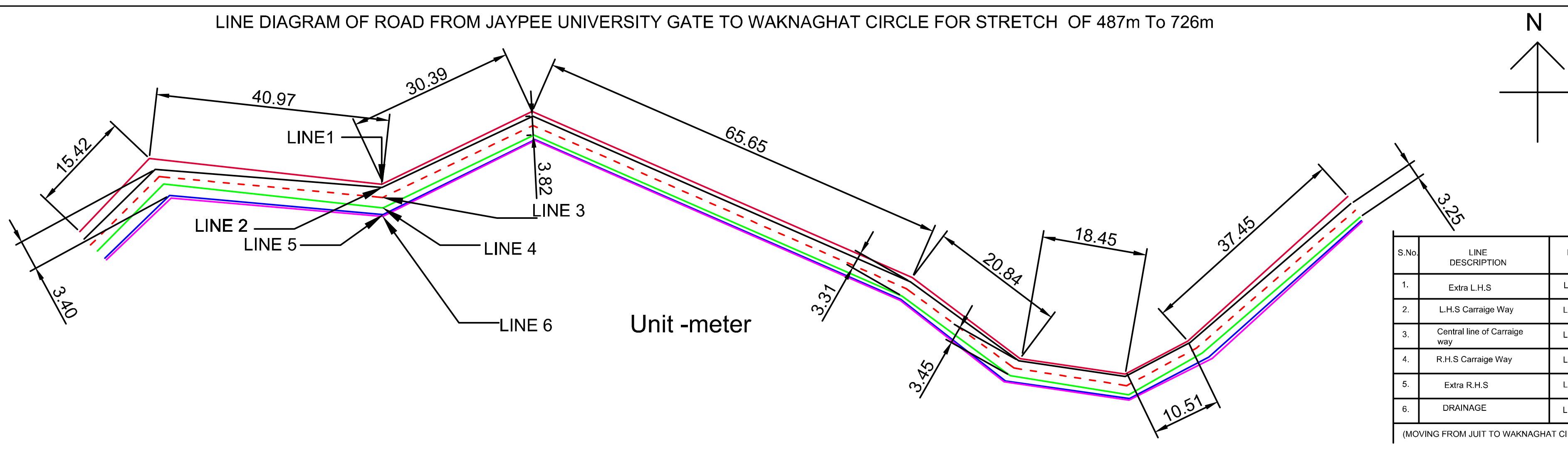



Unit-meter

| S.No. | LINE DESCRIPTION | LINE NO. |
|---|---|---|
| 1. | Extra L.H.S | LINE 1 |
| 2. | L.H.S Carraige Way | LINE 2 |
| 3. | Central line of Carraige way | LINE 3 |
| 4. | R.H.S Carraige Way | LINE 4 |
| 5. | Extra R.H.S | LINE 5 |
| 6. | DRAINAGE | LINE 6 |

(MOVING FROM JUIT TO WAKNAGHAT CIRCLE)

LINE DIAGRAM OF ROAD FROM JAYPEE UNIVERSITY GATE TO WAKNAGHAT CIRCLE FOR STRETCH OF 487m To 726m



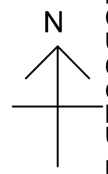

| S.No. | LINE DESCRIPTION | LINE NO. |
|---|---|---|
| 1. | Extra L.H.S | LINE 1 |
| 2. | L.H.S Carraige Way | LINE 2 |
| 3. | Central line of Carraige way | LINE 3 |
| 4. | R.H.S Carraige Way | LINE 4 |
| 5. | Extra R.H.S | LINE 5 |
| 6. | DRAINAGE | LINE 6 |

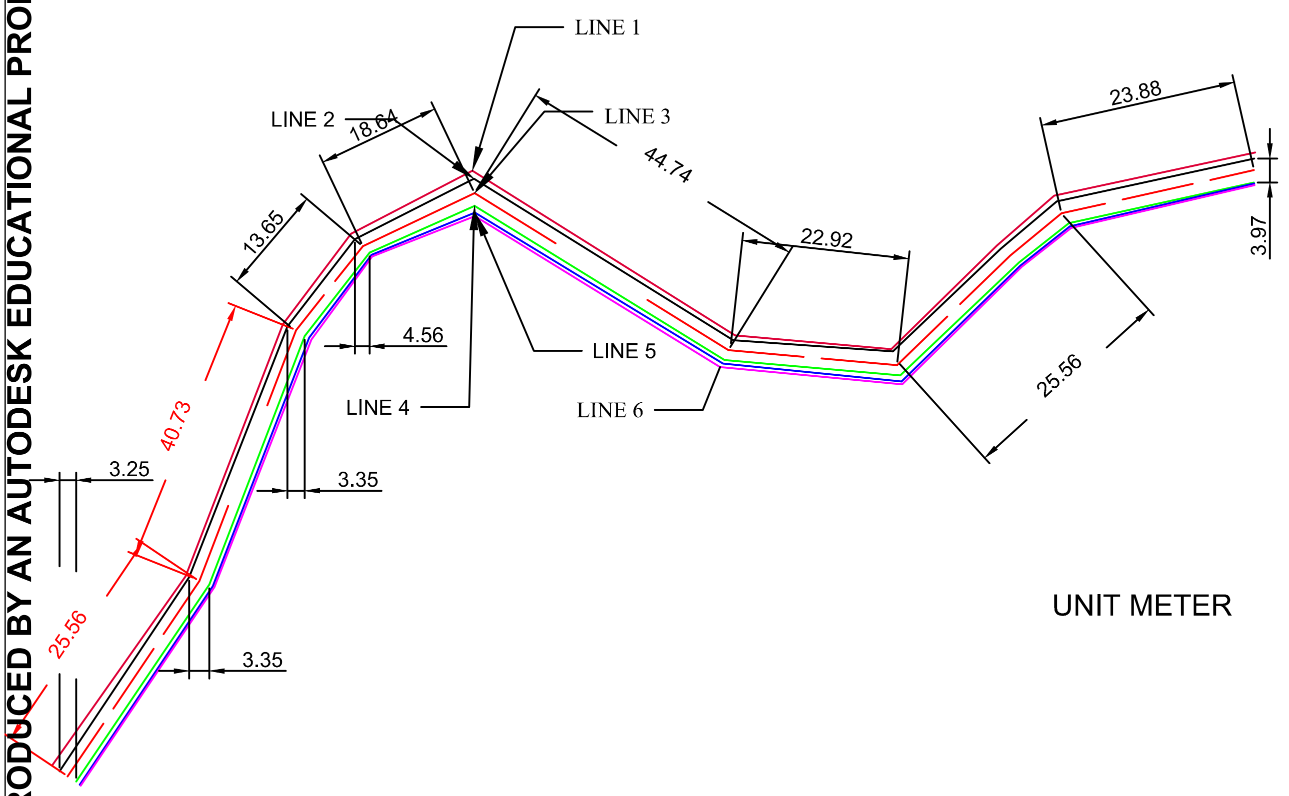
(MOVING FROM JUIT TO WAKNAGHAT CIRCLE)

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

PRODUCED BY AN AUTODESK EDUCATIONAL PRODUCT

LINE DIAGRAM OF ROAD FROM JAYPEE UNIVERSITY GATE TO WAKNAGHAT CIRCLE FOR STRETCH OF 726m To 940m
m




UNIT METER

| S.No. | LINE DESCRIPTION | |
|---|---|---|
| 1. | Extra L.H.S | LINE 1 |
| 2. | L.H.S Carraige Way | LINE 2 |
| 3. | Central line of Carraige way | LINE 3 |
| 4. | R.H.S Carraige Way | LINE 4 |
| 5. | Extra R.H.S | LINE 5 |
| 6. | DRAINAGE | LINE 6 |

(MOVING FROM JUIT TO WAKNAGHAT CIRCLE)

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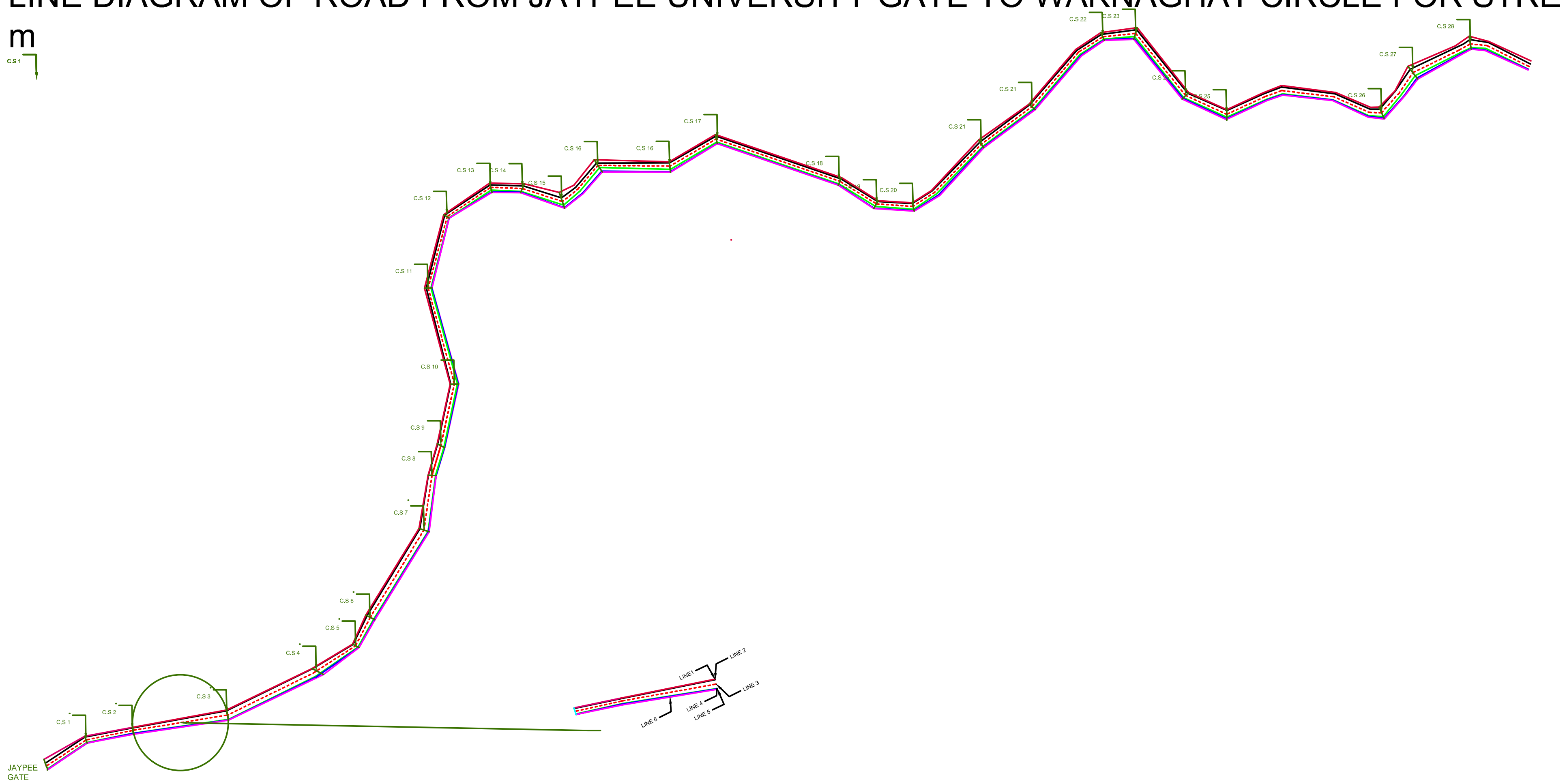
# LINE DIAGRAM OF ROAD FROM JAYPEE UNIVERSITY GATE TO WAKNAGHAT CIRCLE FOR STRETCH OF 1130m m




| S.No. | LINE DESCRIPTION | LINE NO. |
|---|---|---|
| 1. | Extra L.H.S | LINE 1 |
| 2. | L.H.S Carraige Way | LINE 2 |
| 3. | Central line of Carraige way | LINE 3 |
| 4. | R.H.S Carraige Way | LINE 4 |
| 5. | Extra R.H.S | LINE 5 |
| 6. | DRAINAGE | LINE 6 |

(MOVING FROM JUIT TO WAKNAGHAT CIRCLE)

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