Geometric Design of Road Infrastructure of a Small Town

By

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(Dr. Anwaar Ahmad, Ph.D)

Dedicated

To

Our Department

ACKNOWLEDGEMENT

We, first of all, would like to thank Allah (SWT) who assisted us to stand where we are today. We would like to show our gratitude to our supervisor, Dr. Anwaar Ahmad who was a massive source of support and guidance throughout the year, to the academic members of NUST Institute of Civil Engineering who provided a lot of knowledge during undergraduate program and we pay our earnest gratitude with sincere sense of respect to our parents for their encouragement, sincere prayers and good wishes. Last but not the least we would like to thank Gohar Matiullah for his time and support to help us with the project.

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ABSTRACT

Road design is based on the principles of linking transportation and land-use policies, where the designers' practice of such concerning situations are widened to incorporate, the needs of people on foot and on bicycles, mass transit, motor vehicles, the street's relationships to bordering and subsequent land uses and where numerous factors must be compared, considered and chose with a specific end goal to add to the last plan arrangements.

Rapid increase in the population and also, the developing interest of people to live in extravagant and tranquil social orders, has become the basic reasons for the development of new towns and so our project is concerned with the road infrastructure of one of these societies. This report contains and explains the framework in which the project runs and formulates the overall objectives of the project. It includes a specific guidance on the geometric design of streets and roadways, presentation of the design parameters underlying the guidelines by the community design standards, the town planning, and finally the modelling of streets and roadways of this new phase using AutoCAD Civil 3D software and with the conventionally used Eagle Point software in order to further develop insight and scrutinize the strength and weaknesses with a baseline. On the other hand, the basic objectives in our project of geometric design are to optimize efficiency, provide safe, efficient, rapid, convenient and comfortable transportation system for users while minimizing cost and environmental damage.

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Chapter 1

INTRODUCTION

This archive is a review of work processes utilizing AutoCAD Civil 3D and Eagle Point for fundamental street plan. These work processes are clear in the making of dynamic models and are based on industry-perceived or client characterized measures (standards).

An ongoing project namely Defence Housing Authority Phase-IV, Islamabad was selected in order to familiarize ourselves with the key core competencies of the software and provide a practical outlook in association with the execution on ground. The overview starts with fundamentals and the general workflow for building road models. Then the behaviors and functionality of the overall road model and its individual components are described, additionally the results and learning outcomes were compared with the conventionally used Eagle Point software in order to further develop insight and scrutinize the strength and weaknesses with a baseline.

1.1 Background

1.1.1 Road Construction

Street development requires the production of a consistent right-of-way, overcoming geographic snags and giving low levels (grades) to allow vehicle or passengers on foot, to meet client characterized principles or authority rules.

The procedure is started with the eviction of earth by digging or impacting, development of dikes and chopping off of vegetation. After the configuration, legitimate and ecological contemplations and arrangement, the alignment set forward by a surveyor. The radii and inclination are outlined and staked out to befit the characteristics at ground levels to minimize the measure of cut and fill. Disintegration and sediment controls are developed to anticipate adverse impacts, consequently the seepage frameworks must be sufficiently proficient to convey a definitive design discharge for the outfall given by the appropriate authority. The road way is then completed by paving or left with a gravel or other characteristic surface. The sort of street surface is subject to monetary components and expected use. Safety enhancements like Traffic Signs, Crash Barriers, Raised Pavement Markers, and other different types of street surface marking are used. Last recovery after street development is

finished incorporates; seeding, planting, watering and different exercises to reestablish the territory to be reliable with the untouched encompassing zones.

1.1.2 AutoCAD® Civil 3D® Software

AutoCAD Civil 3D, civil engineering design and documentation software to bolster Building Information Modeling (BIM) work processes, that provides Civil Engineering Professionals with intended solutions for diverse base tasks, including land development, transportation, and water ventures for application in a real life workplace. With an emphasis on optimizing a variety of civil infrastructure project workflows, such as roads and highways, land development, rail, airports and water, AutoCAD Civil 3D aides' civil infrastructure task groups to enhance delivery, maintain more reliable information and processes, and respond faster to venture changes.

1.1.3 Eagle Point Software

Eagle Point (RoadCalc™) is a design & analysis software which is internationally utilized as a part of Road Projects. In Pakistan, the majority of Consultants and Road Constructions Companies are likewise having advantage of this product. It is Windows based, easy to understand and runs in coalition with AutoCAD. This product can create plan & profile drawings, curve geometry information, co-ordinates, elevations, mass haul diagrams and cross sections according to characterized interims and global standards. It can likewise be utilized for the execution of site work like cutting or filling and for progressing street ventures. It can also compute all obliged information like finished road levels (FRL), subgrade levels, superelevations and so on.

1.1.4 Project Site

The Project Site provided us with great learning opportunities as it featured a variety of Physical Features, undulating terrain with natural drainage, steep slopes, ditches and ravines. The efficient designing was crucial to minimize earthwork that translated into cost, keeping in mind the provisions of high speed design elements for the main Road thus balancing both aspects for an Optimum Design.

Defence Housing Authority, Islamabad-Rawalpindi is a lodging society situated in the twin urban communities of Rawalpindi-Islamabad. Because of the site of the lodging society, the name was viewed as questionable and befuddling. Then again, Defence Housing Authority

revised its name on 19 March 2013. It has now been set up that Phase I and Phase I Extension are situated in the city of Rawalpindi, while whatever remains of the area (Phase II and Phase II Extension) are in Zone V of the capital city Islamabad. It was principally settled for Defense administration staff in 1992 by Armed Forces of Pakistan welfare office. It is spread on a territory of more than 97 903 Kanals (50 sq. Km).

Since its initiation in 2005, Defence Housing Authority, Rawalpindi-Islamabad is plotting the idea of premier community way of life. Defence Housing Authority, itself has turned into a brand and its legacy has shed a gigantic obligation in outlining course of development and extension. It has turn into a model of creating and making residencies and communities for the assorted crowd, growing dynamically yet with economical pace, concentrated more towards dependability in the improvement of communities.

The project's master plan was designed by the Californian Company, 'OJMR Architects'.

'Habib Rafiq (PVT) Ltd.' is responsible for the transportation infrastructure.

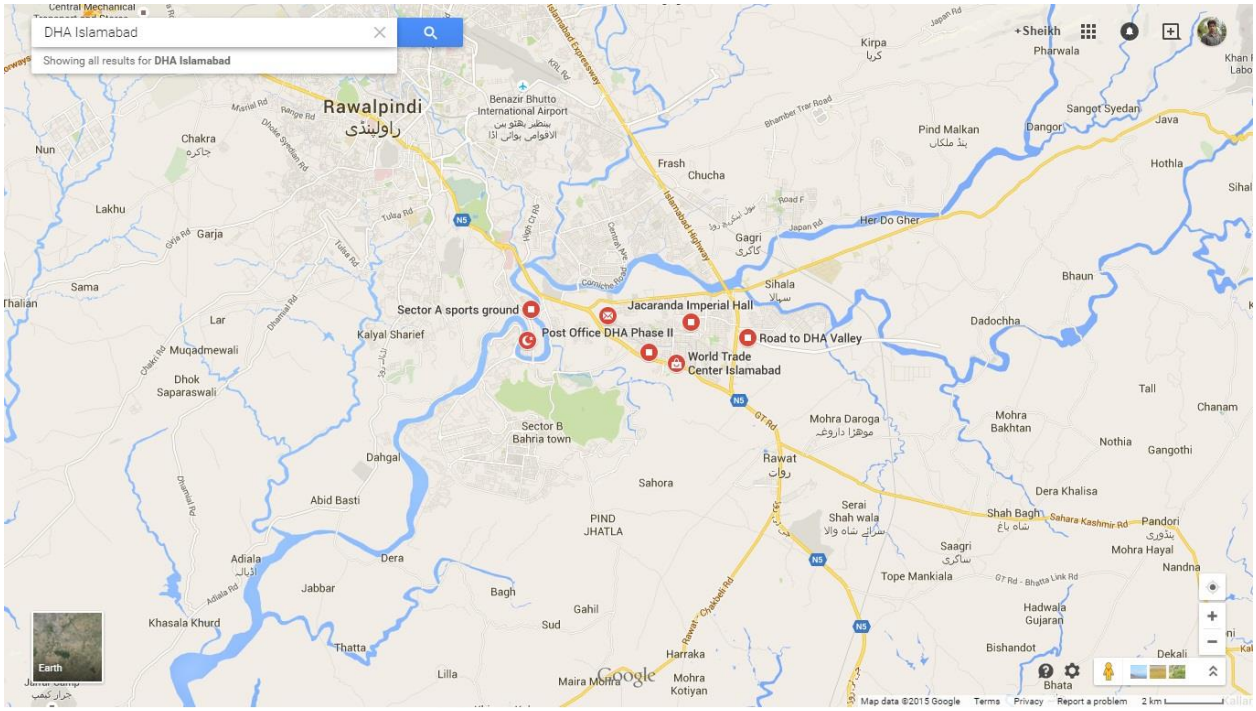


Figure 1: DHA Rawalpindi/Islamabad Location (Google Maps)

Phase IV, a considerably more prominent territory gained by Defence Housing Authority situated at the south end of Rawalpindi City close to Askari-XIV Housing Society, south west of Phase-I covering 16 750 Kanals (8.47 sq. km) with its border extending out to Dhagal village on Adyala Road of Rawalpindi District and Rawalpindi Central Jail.

The three main parties in this project include:

- The Client: DHA
- The Consultant: ACES
- The Primary Contractor: NLC

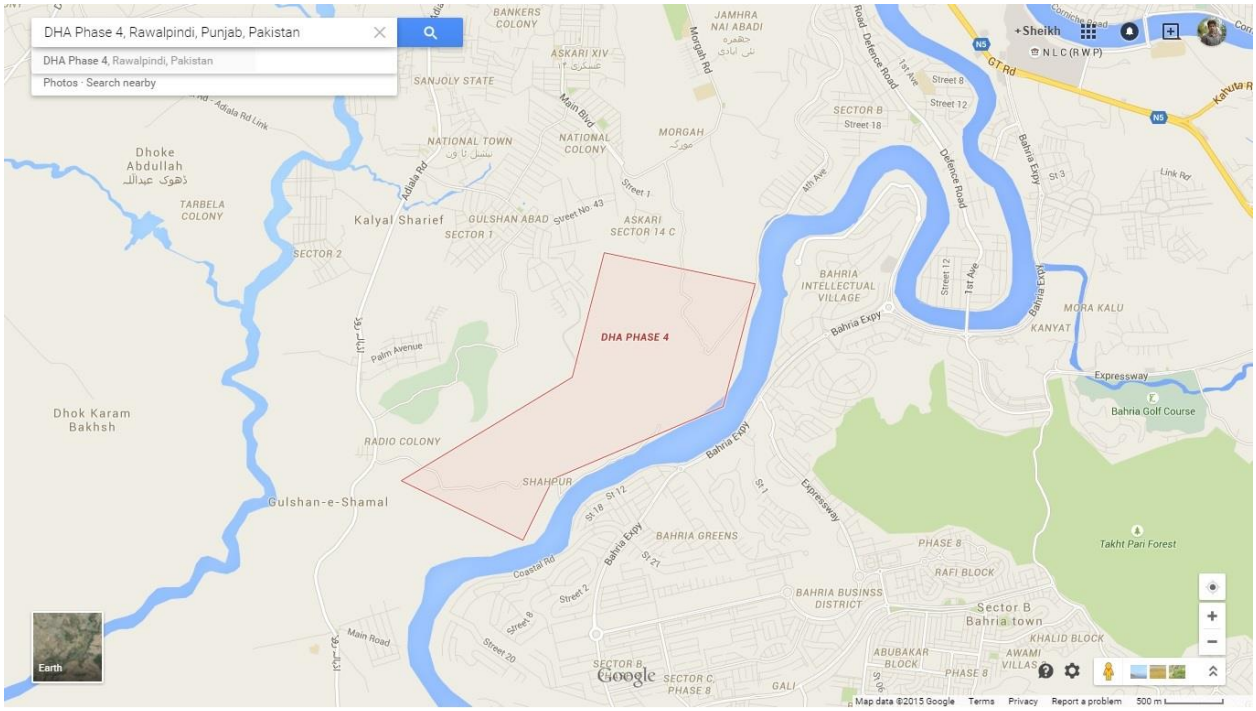


Figure 2: DHA Phase-IV, Islamabad Location (Google Maps)

1.2 Objectives

- Design Standards adopted by state and national authorities - American Association of State Highway and Transportation Officials (AASHTO). Design guidelines take into account speed, vehicle type, road grade (slope), view obstructions, stopping distance, and etc.
- The fundamentals and the general workflow for building road models.
- Overview of workflows using AutoCAD Civil 3D for basic road design.
- To provide a practical outlook in association with the execution on ground.
- Compute Quantity Take Offs, using AutoCAD Civil 3D, and compare the results with the traditional Eagle Point software.
- The functionality of the overall road model and its individual components are described.

Chapter 2

LITERATURE REVIEW

2.1 Geometric Design

Geometric design, also known as geometric modelling, is a branch of computational geometry. It deals with the construction and representation of free-form curves, surfaces, or volumes. The road geometric design is affected by the stationing of the physical components of the roadway as indicated by the standards and constraints. Additionally, geometric design influences the designing of roads to gain extensive community objectives which includes, access to employment, schools, organizations and abodes, accommodate variety of travel modes e.g. strolling, bicycling, mass transit, and autos, and minimizing fuel consumption, emanations and environmental harm. The configuration is additionally affected by driver characteristics, vehicular characteristics and traffic characteristics, the volume and velocity.

Road geometric design can be broken into three primary components: the alignment - the basic route of the road, characterized by a series of digressions, curves and turns, the profile - the vertical aspect of the road – the vertical alignment, comprising of the crest and sag curves, and the tangent lines connecting them and cross-section of roadway – demonstrating the position and number of travel lanes and sidewalks, alongside the cross slope or banking. Cross sections additionally indicate drainage features, pavement structure and other components outside the classification of geometric design. Joined together, they give a three-dimensional representation of the layout of a roadway.

2.1.1 Objective of Road Geometric Design

The primary objectives in geometric design are to advance proficiency and safety while minimizing expense and environmental harm. However, the road geometric design has the following objectives:

- To design a road that provides, in a cost-effective and safe manner, an adequate level of service to meet the needs of all road users, including pedestrians, cyclists and motorcyclists.
- Establish, within the sanctioned allocation by the design standard and road reserve, the itinerary of the projected road.

- Consolidate within the configuration and standard, different physical components of the road alignment to ensure sufficient sight distance – that the driver have adequate view of the road (and obstacles) ahead of him to alter his speed of travel to maximize and maintain safety (and ride quality).
- Give a premise to the road designer to assess and arrange for the building of a section of the road.

2.1.2 Components of Road Geometric Design

It is possible to design and construct the pavement in stages; but it is very expensive and is rather difficult to improve the geometric elements of a road in later stages. The main components that will be looked upon by us in the geometric design are:

- Factors affecting the geometric design (i.e. Topography, Human, Vehicle etc.);
- Highway alignment, road classification;
- Pavement surface characteristics (i.e. Smooth, Skid-resistant etc.);
- Cross-section elements including cross slope, various widths of roads and features in the road margins;
- Sight distance elements including cross slope, various widths and features in the road margins;
- Horizontal alignment which includes features like super elevation, transition curve, extra widening and set back distance;
- Vertical alignment and its components like gradient, sight distance and design of length of curves; and
- Intersection features like layout, capacity, etc.

2.2 AASHTO – The Green Book

AASHTO publication, "A Policy on the Geometric Design of Highways and Streets" commonly referred as "The Green Book" covers the functional design of roads and highways, for example, the layout of intersections, horizontal curves and vertical curves also it has series of rules and guidelines on geometric design within which the designer has a scope of adaptability. This book was published in late 1930's with the recent edition issued in 2011.

"The plan of this approach is to give direction to the architect by referencing a suggested scope of qualities for basic measurements. Adequate adaptability is allowed to urge autonomous plans custom-made to specific circumstances".

2.3 Functional Classification System

Functional classification of a roadway or road is essential in view of vehicular travel attributes and the level of access given to nearby characteristics. Vehicular travel includes a progression of distinct travel movements, the six conspicuous stages in many treks include:

- Main movement
- Transition
- Distribution
- Collection
- Access, and
- Termination

The street hierarchy is an urban planning technique for laying out road networks that exclude automobile through-traffic from developed areas. It is conceived as a hierarchy of roads that embeds the link importance of each road type in the network topology (the connectivity of the nodes to each other).

2.3.1 Urban Principal Arterials

- Their aim is to provide access to vehicles entering/leaving a highly populated area.
- Urban Principal Arterials have very long alignments thus provide free movement.

2.3.2 Urban Minor Arterials

- Their aim is to interlink with the principal arterials, therefore they have medium sized road segment lengths.
- Urban Minor Arterials also provide entry or exit from urban collectors.

2.3.3 Urban Collectors

- Their aim is to provide a circulation of the vehicles in the locally populated areas.
- Urban Collectors provide entry and exit of vehicles from locals, and may also provide a little direct land access.

2.3.4 Urban Locals

- Their aim is to provide direct access to the lands and residential property.
- Urban Locals are non-connecting links – cal-de-sac streets thus being at the lowest level of hierarchy.

2.4 Design Elements

Roadway alignment is actually a 3-D problem but as its difficult to carry design and construction in 3-D so we treat it individually as two 2-D problems, including, horizontal alignment and vertical alignment.

2.4.1 Design Speed

The Highway Capacity Manual (Transportation Research Board 1994) defines ten different traffic speeds, that includes, spot speed, time mean speed, space mean speed, running speed, etc. These speeds are measured in units, kilometers per hour (kph). In our project, emphasis was principally given to the design and operating speed of vehicles. The design speed is defined as the speed selected to achieve optimum levels of operation (such as horizontal curvature, vertical curvature, sight distance and superelevation) and safety on a road segment under consideration. Thus the design speed is regarded more in the nature of a grouping of various design standards.

The operating speed, on the other hand, is defined the maximum running speed, a driver is comfortable on travelling under favorable weather and prevailing traffic conditions without exceeding the design speed at any time, on a given road segment. Design speed is same as operating speed as both portray the maximum safe speed that can be maintained on a given section of road when traffic conditions are so favorable that the design features of the road govern the driver's selection of speed. Driver's sight ought not to be loss of the way that a level of mediation appends to the idea of greatest safe speed.

The maximum speed at which a driver feels safe not only depends upon the sight distance but also on the driver's aptitude and response time, the quality and state of the vehicle and its tires, the climatic conditions and the time of the day (seeing that this influences perceptibility) as on the design elements of the street. Where it is important to alter the design speed along an area due to topographic or other restricting elements, attention must be given to guarantee that sufficient transitions from higher to lower status quo are given.

On the other hand, situations where need of lowering the operating speeds are regular like the areas where high concentrations of pedestrian traffic prevail. For instance, in the region of schools, old-age homes, modal transfer points, hospitals and clinics. Boulevards, where assorted usage dominates, activity streets may require low operating speeds over a considerable interval. However, it would be extremely imprudent to decrease the design

speed in these vicinities because the decrease in the design speed means a sufficient decrease in sight distance. With the more prominent number of potential risks, that need to be observed and responded to, the driver ought to get enough sight separation, and henceforth response time, as could be expected. In such regions, the design speed should be raised not demoted. An increment in the design speed within 1.2 is not prone to deliver any huge distinction in operating conditions as seen by the driver. Obviously, the higher design speed must not serve as an incitement to increase the operating speed rather the idea of traffic calming must be brought into play.

2.4.2 Horizontal Alignment

The horizontal alignment of a street or road is the blend of turns and digressions exhibited on a plan view. Curves and turns are generally circular, despite the fact that spirals and other higher-order polynomials can be utilized under exceedingly particular circumstances, which are sometimes found in residential environments. The process of establishing the horizontal alignment of an urban road is a planning process instead of thorough and itemized design function, and is very iterative in nature with iteration not just between the three ranges of configuration. For example, where limitations in the vertical measurement may drive a shift in horizontal alignment, additionally it includes nonstop returning to of the intentions initially figured out by concerning settlement making.

Outline of the horizontal alignment should likewise offer impact to the proposed capacity of the street or road. For instance, the horizontal alignment of an expressway is embodied by long digressions and smooth turns, while a residential road is ought to be designed to deter operating velocities higher than 40 to 50 km/h. General standards to be seen in the determination of the horizontal alignment of a street or road are:

- No vehicle can promptly change from crossing a bend in one course to navigating one in the opposite bearing. Short lengths of digression ought to be used between reverse curves.
- Broken-Back Curves (where two bends in the same course are isolated by a short digression) ought not to be used, as they are in opposition to drivers' desires and expectations. In the residential environment, this is hard to evade as cadastral limits are straight lines. Fitting smooth curves within a reserve comprising a series of chords of a circle is not generally conceivable.

- Large and Small-Radius Curves ought not to be mixed. Progressive bends to each side, the left and the right, should generally have comparative radii and the 1:1.5 principle is a helpful guide in their determination.
- In residential zones, the deviation angle of short range bends ought not to surpass 90° as, at higher estimations of deviation, infringement by huge vehicles on restricting lanes gets to be affirmed and, moreover, the spread that must be given to allow sufficient sight distance becomes excessive.
- For small-deflection angles, bends ought to be adequately long to stay away from the impression of a sharp twist or curve that is otherwise straight.
- Alignment ought to be sensitive to the geology, at site, to minimize the requirement for cuts and fills. Boulevards that are perpendicular to the contours can make issues of development, maintenance, drainage, scour (on account of graveled surfaces) furthermore constitute a traffic risk. Amid overwhelming rainstorms, the different utilities, for example, sewerage, power and water reticulation, are commonly situated within the road reserve. The planning of the street system should additionally take insight of the impediments to which these administrations are subjected.

2.4.3 Tangents

As curves are circular, the straights joining them are generally alluded to as tangents. Precisely, a straight line or plane that touches a bend or curved surface at a point, even if extended does not cross it at that point. While the determination of radius of a curve directs the operating speed chosen by the driver, long digressions can bring about velocities to an increment to inadmissible levels, trailed by deceleration as the next bend or turn is experienced. It has been found that restricting the tangent length to around ten times the configuration speed will bring about rates to stay genuinely steady.

2.4.4 Vertical Alignment

Vertical alignment consists of parabolic vertical curves and straight sections going along with them. Straight sections are alluded to as grades, and the estimation of their slope is the gradient, generally represented in percentage. For instance, a 5% grade ascends through 5 meters in addition to a horizontal section of 100 meters. With the entire-life economy of the street at the top of the priority list, vertical alignment ought to be invariably designed to as high a standard as is predictable with the geology of the site.

The standard of horizontal alignment instead of the vertical alignment is rather used to dictate the passenger car speeds, while the speeds of mass transits and other substantial vehicles are compelled by the vertical alignment. The design speed connected to the vertical alignment must accordingly counterpart the speed connected to the horizontal alignment and it could be contended that a higher vertical design speed is best. The vertical alignment should be designed to be aesthetically pleasing, just as in the case of horizontal alignment. Concession must be given to the relation and interdependence of horizontal and vertical curvature.

A vertical curve that corresponds to a horizontal curve should, if conceivable, be contained inside the horizontal curve and, preferably, have more or less the same length. Where a vertical and a horizontal curve meet, the superelevation created by the horizontal bend enhances the accessibility of sight separation past that recommended by the estimation of vertical arch. This empowers the edge profiles to have a shape sharper than the minima recommended in Table 1.

DESIGN SPEED (km/h)	CREST CURVES FOR OBJECT OF HEIGHT		SAG CURVES	
	0,15 m	0,60 m	Without street lighting	With street lighting
40	6	2	8	4
50	11	6	12	6
60	16	10	16	8
70	23	Not applicable	20	Not applicable
80	33		25	
90	46		31	
100	60		36	
110	81		43	
120	110		52	

Table 1: Minimum values of K for vertical curves.

The stipulation, nevertheless, is that the driver's observable pathway is contained inside of the width of the roadway. At the point when the observable pathway goes past the roadway edge, the impact on sight distance of lateral obstructions – dividers, boundary walls or high vegetation must be checked. A smooth grade line with slow changes apportion to the sort of road and the character of the geography is desirable over an alignment with various short lengths of grade and vertical bends. The "roller coaster ride" or "hidden dip" sort of profile must be refrained and prevented, especially this profile. It is deceptive regarding availability of sight distance and, where it can't be prevented. A broken-back alignment is not desirable in droops where a full perspective of the profile is conceivable even under aesthetic reasons. On crests the broken-back curve unfavorably influences passing space.

2.4.5 Curvature

The horizontal curves and turns gives a steady rate of change of bearing. Undifferentiated from this is the vertical parabola which gives a consistent rate of change of inclination. Thus, leaving academic amenities apart, there is little to pick between the utilization of the parabola or the circular curve, the contrasts being practically unplottable.

A few basic types of curves include:

- Horizontal Curves: curves used in horizontal planes to connect two straight tangent sections.
- Simple Curve: circular arc connecting two tangents.
- Compound Curve: a curve which is composed of two or more circular arcs of different radii, with centers on the same side of the alignment Compound curves are used to fit horizontal curves to very specific alignment needs Interchange ramps, intersection curves etc. Radii should not be very different- difficult for drivers to maintain lane position as they transition from one to another curve.

2.5 Concept of Superelevation

Centrifugal force portrays the propensity of an object ensuing a curved path to fly outwards, far from the focal point. It is not by any stretch of the imagination a force; it comes about because of inertia i.e. the leaning of an object to defy any shift in its state of rest or movement. For instance, mud taking off a tire; kids pushed out on a roundabout. From the fundamental laws of physical science…centrifugal force is F=$\frac{MV2}{R}$

Centripetal force is a “real” force that neutralizes the centrifugal force and keeps the object from "flying out", keeping it moving rather with a uniform speed along in a circle. For example, satellite orbiting a planet.

The existence of horizontal bend passes on the centrifugal force, a receptive force acting outward on a vehicle undergoing the drive. Centrifugal force relies on upon velocity and radii of the horizontal bend and is neutralized to a certain degree by transverse rubbing between the tire and asphalt surface. Centrifugal force has a tendency to bring about the vehicle to overwhelm or to slide outward from the focal point of street bend. Subsequently, for legitimate design of the bend, a comprehension of the forces following up on a vehicle taking a horizontal turn is fundamental.

CLASS OF ROAD OR STREET	MAXIMUM SUPERELEVATION (%)
Vehicle-only (freeway)	10
Vehicle-only (other)	6 - 8
Mixed-usage (higher-order)	4 - 6
Mixed-usage (middle-order)	2 - 4
Mixed-usage (lower-order)	2 - 4

Table 2: Maximum superelevation for various classes of road.

The rural status where a tight sweep bend can be coordinated by a high estimation of superelevation, in contrast, considerable fluctuations in vehicle speeds experienced in the urban environment cause high estimations of superelevation to be disproportionate. Besides, there is a particular probability that there might not be an adequate length of roadway available to integrate the evolution of superelevation. Property access in the prompt region of the bend presumably would not permit a cross-section where the edge of a street is a meter or more over the other.

Table 3 provides values for minimum radii for horizontal curves against design speed with all values rounded up to the nearest five meters. There is no known use or exertion for a 0% superelevation and it ought to be eschew as, in the absence of a longitudinal inclination, it will result in drainage problems and ponding on the road surface.

DESIGN SPEED (km/h)	SIDE FRICTION FACTOR (f)	MINIMUM RADII FOR MAXIMUM RATES OF SUPERELEVATION (e) OF:					
		-0,02	0	+0,02	0,04	+0,06	+0,08
30	0,19	45	40	35	30	30	30
40	0,18	80	70	65	60	55	50
50	0,17	135	115	105	95	85	80
60	0,16	205	180	160	145	130	120
70	0,15	300	260	230	205	185	170
80	0,14	420	360	315	280	255	230
100	0,13	-	-	525	465	415	375
120	0,11	-	-	875	760	670	600

Table 3: Minimum radii for horizontal curves.

2.6 Perception Reaction Process

Perception Reaction Time (PRT) is important factor:

- Determination of braking distances
- Establishing minimum sight distance on highway
- Establishing length of the yellow phase at a signalized intersection

Typical Perception-Reaction time range - 0.5 to 7 seconds, for stopping sight distance - AASHTO recommends 2.5 sec PRT while for Traffic Signal - Institute of Transportation Engineers (ITE), use 1.0 sec.

2.7 Sight Distances

Sight Distance in simple terms is the ability of the driver to see ahead i.e. the roadway length ahead that is visible to the driver or the distance along a roadway during the course of which a height specific object is continuously visible to the driver. Sight Distance is required for safe and efficient operation of a vehicle on highway.

- Continual changes in speed and path of motor vehicles on highways and streets are subjected to the varied control of drivers – their ability, training, and experiences.
- Designer's aim must be to provide a sight distance of sufficient length, that drivers can regulate the movement of their vehicles, in order to avoid collusion to an unanticipated object in the traveled way.
- Two-lane highways ought to have adequate sight distance to empower drivers to utilize the restricting movement lane for passing different vehicles without meddling with the approaching vehicles.
- Sight distance provision - compatible with the intended function of the highway and desired LOS.

2.7.1 Stopping Sight Distance (SSD)

The Stopping Sight Distance (SSD) is the available sight distance on a roadway that should be sufficient enough for a vehicle to come to standstill before reaching a stationary object in its path while traveling at or near the design speed.

SSD = Perception Reaction Distance (PRD) + Braking Distance (BD)

The stopping sight distances that are recommended by AASHTO are based on passenger car operation and do not explicitly consider truck operation for design though they need marginally longer distances to come to a halt for a given speed as compared to passenger vehicles. The truck driver's ability to see considerably farther beyond the vertical sight obstructions, however, is one factor that mitigates the additional distance for trucks due to higher position of the seat in the vehicle.

Therefore, separate stopping sight distances for trucks and passenger cars are not generally used in highway design.

2.7.2 Decision Sight Distance (DSD)

As per AASHTO recommendations, the decision sight distance must be provided at:

- At locations where unusual or unexpected maneuvers are required, interchanges or intersection;
- At cross-section changes such as lane drops and additions, toll plazas, and intense-demand areas with competing information hence substantial "visual noise" from (e.g., control devices, advertising, and roadway elements).

Avoidance Maneuver A: Stop on rural road—t = 3.0 s Avoidance Maneuver B: Stop on urban road—t = 9.1 s Avoidance Maneuver C: Speed/path/direction change on rural road—t varies between 10.2 and 11.2 s Avoidance Maneuver D: Speed/path/direction change on suburban road—t varies between 12.1 and 12.9 s Avoidance Maneuver E: Speed/path/direction change on urban road—t varies between 14.0 and 14.5 s

Table 4: Time ranges for different avoidance maneuvers.

2.7.3 Passing Sight Distance (PSD)

It is adequate sight distance provided on 2 lane highways, so drivers would have enough distance to perform their passing maneuvers. Below in table 5 values for Passing Sigth Distance are provided for 2 lane highways." Minimum passing sight distances for use in design are formed from the minimum values of PSD given in the manual of MUTCD that serve as warrants for no-passing zones on two-lane highways.

Metric				US Customary			
	Assumed speeds (km/h)				Assumed speeds (mph)		
Design speed (km/h)	Passed vehicle	Passing vehicle	Passing sight distance (m)	Design speed (mph)	Passed vehicle	Passing vehicle	Passing sight distance (ft)
30	11	30	120	20	8	20	400
40	21	40	140	25	13	25	450
50	31	50	160	30	18	30	500
60	41	60	180	35	23	35	550
70	51	70	210	40	28	40	600
80	61	80	245	45	33	45	700
90	71	90	280	50	38	50	800
100	81	100	320	55	43	55	900
110	91	110	355	60	48	60	1,000
120	101	120	395	65	53	65	1,100
130	111	130	440	70	58	70	1,200
				75	63	75	1,300
				80	68	80	1,400

Table 5: Passing sight distance for design of two-lane highways.

2.8 Warrants for Stop Sign

The STOP sign is a causes of considerable hindrance to drivers, especially motorists, thus it ought to be used only where they are justified. It may be warranted at an intersection where one or a greater number of the accompanying conditions exist:

1. At an intersection with a minor street with a fundamental (major) street where utilization of the typical right-of-way rule is excessively perilous.
2. Street coming into a continuing or direct highway or street.
3. At a location where a signalized intersection was preferable but it's actually un-Signalized.
4. Locations where signals are justified and critically required like the ones having several routes, a stop sign is can be introduced rapidly to control activity while game plans are being made for the signal establishment.
5. Other intersections where a combination of high speed, restricted view, and serious accident record indicates a need for control by the STOP sign.

2.9 Warrants for Yield Signs

The YIELD sign may be warranted at locations:

1. Where a minor road is entering an intersection and it is important to assign right-of-way to the major road, a stop sign is not a solution all the times, and where the safe approach speed on the minor road exceeds 10 miles per hour.
2. At the entrance ramp to an expressway where a separate lane for acceleration is not provided.
3. Where there is an intersection on a divided highway, a STOP sign is thus present at the entrance to the first roadway and further control is mandatory to the entrance to the second roadway for smoot and efficient traffic flow, and where the median width exceeds 30 feet.
4. Where a right-turn lane is provided, without sufficient segment of acceleration lane.
5. On an intersection where some unique problem exists where an engineering study indicates the susceptible solution to be the installation of the YIELD sign.

YIELD signs should not ordinarily be placed to control the major flow of traffic at an intersection.

Chapter 3

METHODOLOGY

3.1 AutoCAD® Civil 3D® Software

AASHTO-based design criteria's are incorporated in AutoCAD Civil 3D product. These documents can be utilized as-is, or replicated and adjusted to better suit particular design needs. The use of these design criteria is a discretionary property of the alignment and profile objects.

Design checks, another approach to help track and control the street plan progressively. They can be utilized solely or in conjunction with design criteria documents. These design checks use mathematical expressions to analyze the geometric properties of an alignment or profile with a foreordained value. Design checks are overseen through the Settings tab, in the Toolspace, and can be orchestrated into design check sets.

3.1.1 Surface

Formation of a base map; street outline commonly starts with the creation of existing surface conditions and incorporating a base map of these existing conditions to it; information about the topography, packages , utilities, and other potential effects to the route design. The surface for our undertaking was created using survey points, PNEZD space delimitated file, while represented using contours.

3.1.2 Alignment

Outline alignment; an alignment characterizes the fundamental horizontal route that represents the development pattern – construction baseline of the roadway, for features like, channel ways, utility trenches, streets/roads and bridges. Their geometry is spoken to by straight line tangents, assortment of turns - curves and spiral curves. Alignments can be worked with field-gathered survey data or can be created from existing CAD elements, for example, lines, curves, or polylines. Alternatively, alignments may be created utilizing the wide variety of alignment creation tools.

At the point when singular geometry is joined to create an alignment, rule-based configuration requirements may be connected. We, however, were confined to the current alignments created by NLC.

3.1.3 Roundabout

A roundabout is made from two or more alignments that might possibly meet. Amid its creation process, alignments are consequently created for the offset and curb return geometry. The procedure likewise makes AutoCAD linework and blocks that entitles traffic islands, markings, and signs. The alignments and AutoCAD objects are actively connected to the default alignments. The roundabout was modelled as-is in AASHTO rules under default parameters without any violation to the applied criteria or design checks.

3.1.4 Rule-Based Design

Using AutoCAD Civil 3D, you can come close to the configuration of road elements against perceived industry guidelines or client characterized principles. As designers work to lay out designs, the software provides graphic alerts and/or notification tips to help alert you when standards are not met. This ability helps provide numerous advantages, including appreciable time savings, diminished rework owing to little reviews, more regularity and uniformity, and, above all, sound engineering design. This is made possible using design criteria and design check sets.

Utilization of design criteria - focus the outline aim and the limitations that are to be put on the alignment which incorporates speed and superelevation parameters. Design criteria may be relegated at the onset of the alignment design or whenever amid the configuration process. Warning cautions help in the quick design of a conforming alignment.

Superelevation is the banking of a curve to help counterbalance the centrifugal forces that a vehicle experiences while traveling through a curve. At the point when superelevation parameters are connected to the alignment, the subsequent corridor model will turn and warp the cross-sectional links and shapes to mirror the raising of one edge of the travel way above the other. The corridor relies on the behavior of subassemblies to adjust their final shape and position accordingly. Many out of-the-box AutoCAD Civil 3D subassemblies support superelevation.

3.1.5 Profiles

Profiles define the surface elevation along an alignment. Design grade profiles are defined using tangents and vertical crest and sag curves. Profile geometry may be controlled using design criteria that determine three sorts of minimum K-values – representing the horizontal span along which one percent change in elevation occurs on the vertical bend, tables based on stopping sight distance, passing sight distance, and headlight sight distance. Additional criteria and design checks can include slopes and curves that are designed for safe or comfortable driving at a particular speed, or for sag curve drainage considerations.

Generate existing ground profile and design grades; display existing ground surface data for the design alignment and create the finished grades. Finished grade profiles may be created graphically using profile creation tools, or generated from a best fit analysis of existing entities or from information from an external file. Design criteria is applied to profiles using methods similar to the ones used for alignments; criteria and design checks can be applied at the onset of design or afterwards but in the event that the profile's parent alignment is drawn on design criteria, that design criteria is automatically connected to the profile as a matter of course .

3.1.6 Assemblies and Subassemblies

Assemblies constitutes of the cross-sectional configuration of the street plan. They hold within the collection of individual subassembly components such as medians, lanes, curbs, sidewalks, and shoulders. Assemblies may enclose range of capabilities that are crucial in the building of complex street frameworks, such as intersections, conditional daylighting, and superelevation.

AutoCAD Civil 3D incorporates considerable collection of subassemblies for a vast diversity of street configuration applications. The basic components of subassemblies are points, links, and shapes. Their geometry and behavior are restrained by the input parameters – function of the subassembly. A few of the parameters are static, manually entered quantities, while remaining are derived automatically in addition to an object or element within the drawing. Subassemblies can likewise be fixed to the superelevation criterion of the alignment. While building corridor, any subassemblies that refer superelevation, perceives the data contained in the alignment and responds to it.

Construction of assemblies; assemblies are built by connecting individual subassembly objects, serving to reenact the geometry and material makeup of the road, and helping to define how the assembly merges with neighboring features along the route. The subassemblies are selected

from the prebuilt libraries contained in the AutoCAD Civil 3D Tool Palette. Custom subassemblies can also be created using the Subassembly Composer.

The building block includes:

- **Points** - Not to be confused with Civil 3D COGO points or AutoCAD points, corridor points are at the foundation of a corridor section. They provide the first dimension of the corridor cross section. A corridor point knows whether it is a crown, an edge of travel way, an edge of paved shoulder, or one of more than 50 other standard point codes. These point codes indicate where the point can be found on the subassembly. For example, a point that has the Crown Point code will appear at the crown of a road lane subassembly, and Crown-coded points will be placed in each cross section of the corridor model in the same location.

- **Links** - Links provide the second dimension to the corridor cross section. Think of links as special, intelligent lines that connect the corridor points. Like points, links are coded at the time of subassembly programming to understand that they are a Top, Base, Pave, or one of the more than 15 other standard link codes. Similar to point codes, link codes indicate where the links are used. For example, links that are assigned to the Top link code connect points that are located at the finished grade surface regardless of whether they are paved or unpaved, whereas links assigned to the Pave link code are used to link points representing only the paved elements of the finished grade. A link can be assigned more than one code, if applicable. For example, a road lane would be assigned both Top and Pave, whereas a grassed buffer strip would be assigned only Top.

- **Shapes** - Like points and links, shapes are also coded as part of the subassembly. Shapes are defined from links that form a closed polygon, such as a course of pavement, a gravel-base course, or a thickness of sidewalk.

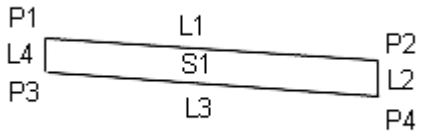


Figure 3: Coding Diagram (AutoCAD Civil 3D User's Guide)

Point, Link, or Shape	Codes	Description
P1	Crown	Crown of road on finish grade
P2	ETW	Edge-of-traveled-way on finish grade
P3	Crown_Subbase	Crown of road on subbase
P4	ETW_Subbase	Edge-of-traveled-way on subbase
L1	Top, Pave	Paved finish grade
L3	Datum, Subbase	Subbase
S1	Pave1	

Table 6: Point, Link, and Shape Codes for the Coding Diagram (AutoCAD Civil 3D User's Guide)

3.1.7 Corridors

Fabrication of corridor; Corridors are the subsequent 3D model representation of route-type components, for example, streets, rail lines, channels, and extensions, fabricated from the mix of even, the principle alignment which is normally the centerline; vertical alignment, the design profile – a serene vertical passage comprising of straight digressions and vertical bends; and cross-sectional design elements, the assemblies which recreate and update the geometry, material makeup of the road, and as to how it should ought to cooperate with existing ground, legal boundaries, and numerous other potential elements. The corridor model plays the part of "backbone" of the design providing numerous forms of data which can then be utilized to examine the resulting corridor model, to calculate earthworks and quantity takeoffs, to perform sight and visual analysis – sight distances, to create surfaces, and to excerpt data for construction purposes. Corridor segments may be inspected and altered individually, to help accommodate particular or circumscribed design conditions.

The corridor components include:

- **Baseline** - A baseline defines the horizontal and vertical route. It is derived from combining the alignment and the design profile.
- **Assembly** - An assembly represents the cross-sectional design of the road. Assemblies are collections of interlocking subassemblies, which may contain dynamic design parameters such as conditional daylighting or lane widening.
- **Regions** - Individual portions of corridors enable application of different design parameters. Transitions from one region to the adjoining region automatically occur. Regions are defined by starting and ending station ranges.
- **Corridor Parameters** - Corridor parameters are required to build a corridor object. These are assigned in the Corridor Properties panorama. The parameters are: region starting and ending stations, assembly name, frequency of assembly attachments along the region station range, and identifying any necessary targets to satisfy subassembly behavior.
- **Corridor Targets** – By utilizing the subassemblies parameters, the corridor can target surfaces, alignments, profiles, feature lines, polylines, and survey figures. Thus the corridors can be intended to consequently attach embankments to a surface, broaden a path (lane width) along an alignment, pair a ditch invert to a profile, and oblige numerous other configuration situations. A corridor may be demonstrated without a surface; nonetheless, daylighting is requisite to perform certain road model analysis, for example, earthwork estimations. As a rule, targets are utilized when the geometry of the corridor needs amendments as the configuration advances along the baseline.

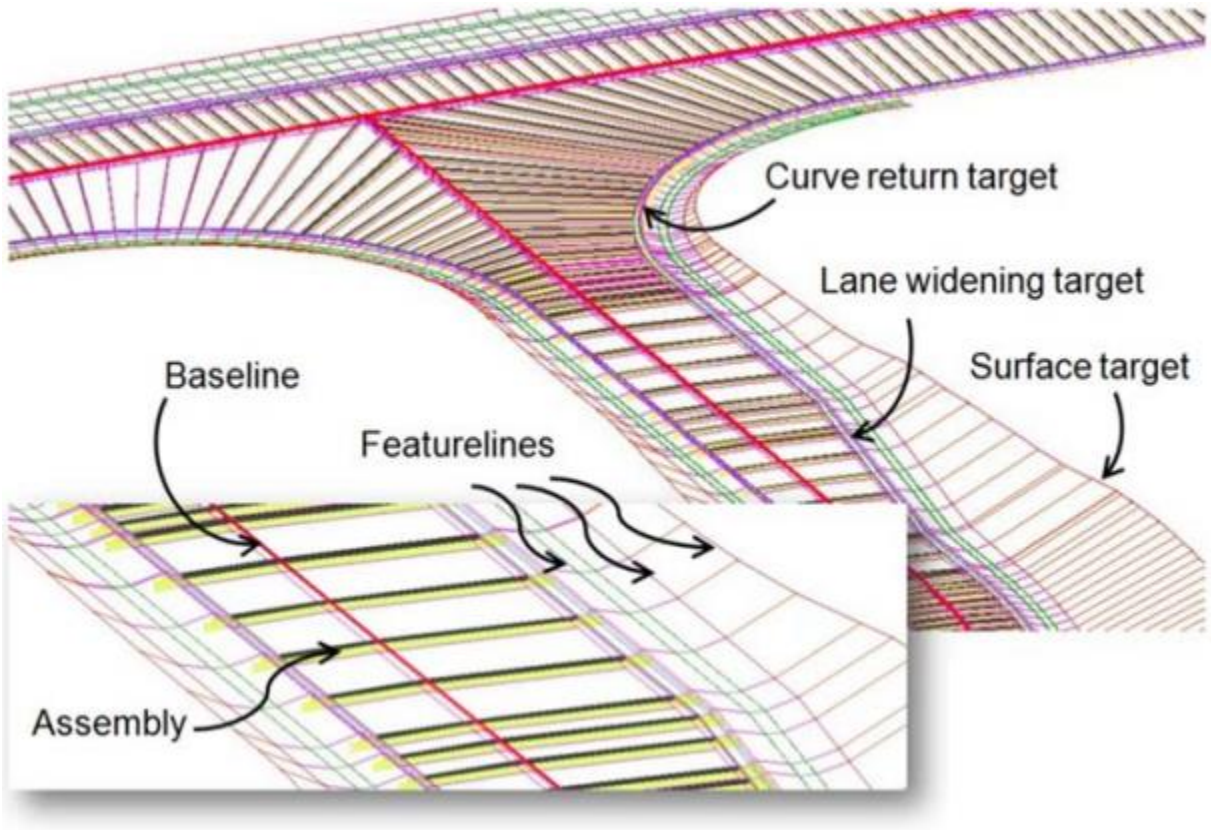


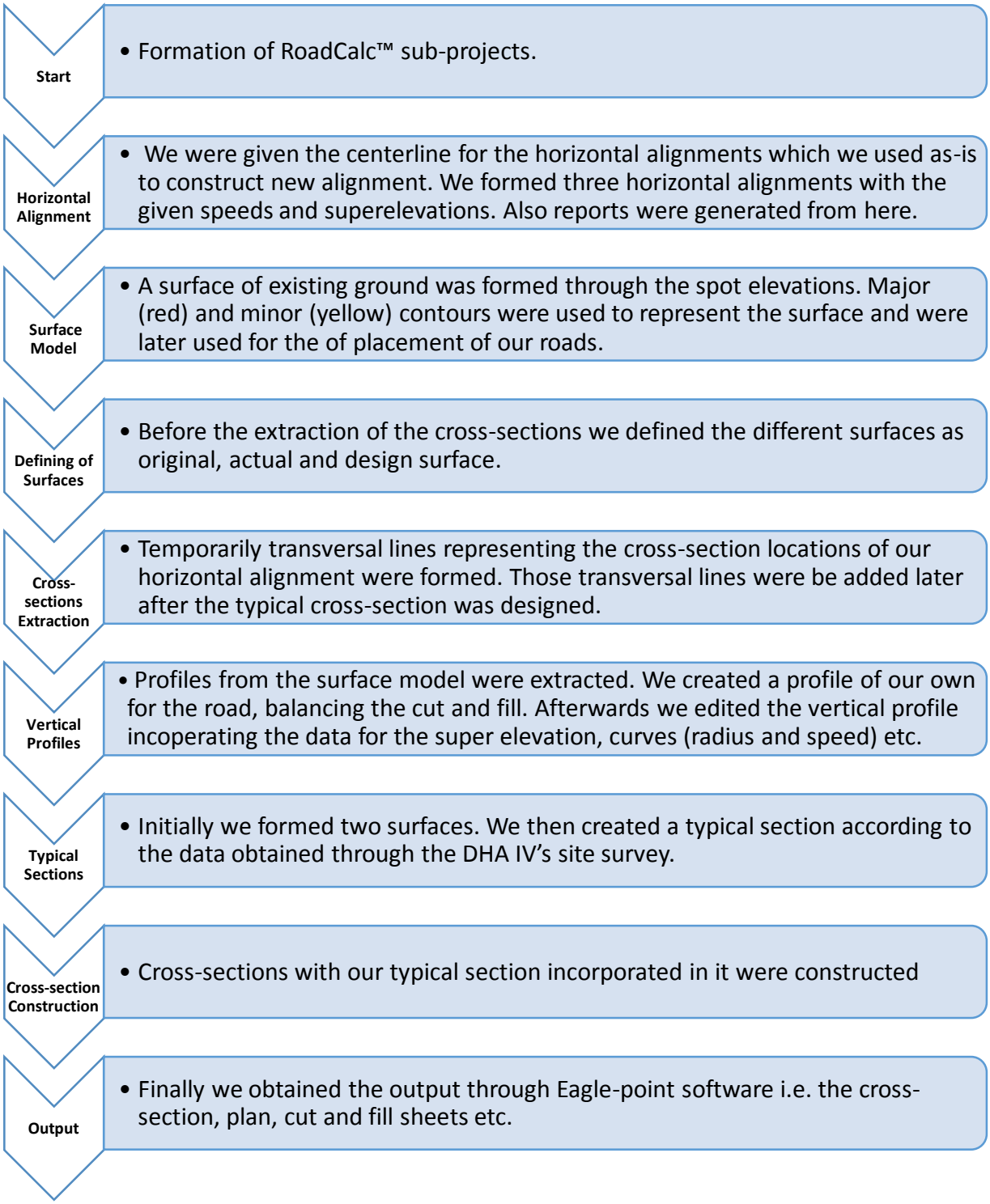
Figure 4: Components of the Corridor Object (James Wedding, P.E. & Scott McEachron)

3.1.8 Optimization

Optimize design; to achieve a better design it may be necessary to adjust one or more of the corridor components. For example, you can adjust the design profile to better balance cut and fill volumes. Edits may be done using a variety of methods, such as grips, via tabular inputs, and with object-specific editing commands. In addition, since the road design is dynamic, changes made to one component affect the entire roadway model.

3.2 Eagle Point Software

General Workflow



Chapter 4

OUTCOMES AND RESULTS

4.1 Data

Description	***Main Access Road***	***Road 3***	***Road 5***	***Road 7***
Total Length	2400ft	2898ft	2450ft	2873ft
Paved Surface	60ft	60ft	60ft	60ft
Cross Slope	2%	2%	2%	2%
Number Of Lanes	3	3	3	3
Lane Width	10ft	10ft	10ft	10ft
Design Speed	40mph	40mph	40mph	40mph
Maximum Superelevation	4%	4%	4%	4%
Minimum Horizontal Radius	varies	varies	varies	Varies
Stopping Sight Distance	varies	varies	varies	Varies
Maximum Allowable Grade	varies	varies	varies	Varies
Median Width	5ft	5ft	5ft	5ft

4.2 Sight Distances

4.2.1 Sight Distance Main Access Road

Eye Path Alignment: Alignment Main Access Road, Eye Path Profile: Layout Main Access Road

Eye Offset: 0, Eye Height: 3.5, Object Offset: 0, Object Height: 0.5

Surfaces: Main Road Corridor Surface

Station1: 1+00.13, Station78: 78+00.13

Station	*ActualSightDistance*	*MinimumSightDistance*	*ObstructionPoint*	*Violated*
1	300.000'	300.000'	-	No
2	300.000'	300.000'	-	No
3	300.000'	300.000'	-	No
4	300.000'	300.000'	-	No
5	300.000'	300.000'	-	No
6	300.000'	300.000'	-	No
7	300.000'	300.000'	-	No
8	300.000'	300.000'	-	No
9	300.000'	300.000'	-	No
10	300.000'	300.000'	-	No
11	300.000'	300.000'	-	No
12	300.000'	300.000'	-	No
13	300.000'	300.000'	-	No
14	300.000'	300.000'	-	No
15	300.000'	300.000'	-	No
16	300.000'	300.000'	-	No
17	300.000'	300.000'	-	No
18	300.000'	300.000'	-	No
19	300.000'	300.000'	-	No
20	300.000'	300.000'	-	No
21	300.000'	300.000'	-	No

22	300.000'	300.000'	-	No
23	300.000'	300.000'	-	No
24	300.000'	300.000'	-	No
25	300.000'	300.000'	-	No
26	300.000'	300.000'	-	No
27	300.000'	300.000'	-	No
28	300.000'	300.000'	-	No
29	300.000'	300.000'	-	No
30	300.000'	300.000'	-	No
31	300.000'	300.000'	-	No
32	300.000'	300.000'	-	No
33	300.000'	300.000'	-	No
34	300.000'	300.000'	-	No
35	300.000'	300.000'	-	No
36	300.000'	300.000'	-	No
37	300.000'	300.000'	-	No
38	300.000'	300.000'	-	No
39	300.000'	300.000'	-	No
40	300.000'	300.000'	-	No
41	300.000'	300.000'	-	No
42	300.000'	300.000'	-	No
43	300.000'	300.000'	-	No
44	300.000'	300.000'	-	No
45	300.000'	300.000'	-	No
46	300.000'	300.000'	-	No
47	300.000'	300.000'	-	No
48	300.000'	300.000'	-	No
49	300.000'	300.000'	-	No
50	300.000'	300.000'	-	No
51	300.000'	300.000'	-	No
52	300.000'	300.000'	-	No

53	300.000'	300.000'	-	No
54	300.000'	300.000'	-	No
55	300.000'	300.000'	-	No
56	300.000'	300.000'	-	No
57	300.000'	300.000'	-	No
58	300.000'	300.000'	-	No
59	300.000'	300.000'	-	No
60	300.000'	300.000'	-	No
61	300.000'	300.000'	-	No
62	300.000'	300.000'	-	No
63	300.000'	300.000'	-	No
64	300.000'	300.000'	-	No
65	300.000'	300.000'	-	No
66	300.000'	300.000'	-	No
67	300.000'	300.000'	-	No
68	300.000'	300.000'	-	No
69	300.000'	300.000'	-	No
70	300.000'	300.000'	-	No
71	300.000'	300.000'	-	No
72	300.000'	300.000'	-	No
73	300.000'	300.000'	-	No
74	300.000'	300.000'	-	No
75	300.000'	300.000'	-	No
76	300.000'	300.000'	-	No
77	300.000'	300.000'	-	No
78	300.000'	300.000'		No

4.2.2 Sight Distance Top Road

Eye Path Alignment: Alignment Top Road, Eye Path Profile: Layout Top Road

Eye Offset: 0, Eye Height: 3.5, Object Offset: 0, Object Height: 0.5

Surfaces: Top Road Corridor Surface

Station1: 1+00.00, Station40: 40+00.00

Station	*ActualSightDistance*	*MinimumSightDistance*	*ObstructionPoint*	*Violated*
1	127.728'	300.000'	10547166.1308',3409666.3154',1339.3608'	Yes
2	300.000'	300.000'	-	No
3	300.000'	300.000'	-	No
4	300.000'	300.000'	-	No
5	300.000'	300.000'	-	No
6	300.000'	300.000'	-	No
7	300.000'	300.000'	-	No
8	300.000'	300.000'	-	No
9	205.409'	300.000'	10546562.0284',3409063.5675',1411.6622'	Yes
10	144.137'	300.000'	10546530.0218',3409042.6161',1417.6258'	Yes
11	166.441'	300.000'	10546413.7104',3409012.9994',1429.5965'	Yes
12	300.000'	300.000'	-	No
13	300.000'	300.000'	-	No
14	300.000'	300.000'	-	No
15	300.000'	300.000'	-	No
16	300.000'	300.000'	-	No
17	300.000'	300.000'	-	No
18	300.000'	300.000'	-	No
19	300.000'	300.000'	-	No
20	300.000'	300.000'	-	No
21	300.000'	300.000'	-	No

22	164.970'	300.000'	10545324.3461',3409410.7390',1475.3891'	Yes
23	205.112'	300.000'	10545290.3001',3409431.9869',1477.2833'	Yes
24	300.000'	300.000'	-	No
25	300.000'	300.000'	-	No
26	300.000'	300.000'	-	No
27	300.000'	300.000'	-	No
28	222.340'	300.000'	10545040.1912',3409932.8188',1536.4474'	Yes
29	167.051'	300.000'	10545039.0430',3409879.7185',1526.0453'	Yes
30	131.554'	300.000'	10545036.2900',3409944.3826',1538.6505'	Yes
31	137.657'	300.000'	10545036.2900',3409944.3826',1538.6505'	Yes
32	300.000'	300.000'	-	No
33	300.000'	300.000'	-	No
34	300.000'	300.000'	-	No
35	300.000'	300.000'	-	No
36	300.000'	300.000'	-	No
37	300.000'	300.000'	-	No
38	300.000'	300.000'	-	No
39	300.000'	300.000'	-	No
40	300.000'	300.000'	-	No

Sight Distances are being violated at some stations. But it is well justified as the turns are really sharp. For smooth transition of traffic we need to provide yield signs or impose speed limits before the start of these curves.

4.2.3 Sight Distance Bottom Road

Eye Path Alignment: Alignment Bottom Road, Eye Path Profile: Layout Bottom Road

Eye Offset: 0, Eye Height: 3.5, Object Offset: 0, Object Height: 0.5

Surfaces: Bottom Road Corridor Surface

Station1: 1+00.00, Station22: 22+00.00

Station	*ActualSightDistance*	*MinimumSightDistance*	*ObstructionPoint*	*Violated*
1	300.000'	300.000'	-	No
2	300.000'	300.000'	-	No
3	300.000'	300.000'	-	No
4	300.000'	300.000'	-	No
5	300.000'	300.000'	-	No
6	300.000'	300.000'	-	No
7	300.000'	300.000'	-	No
8	300.000'	300.000'	-	No
9	300.000'	300.000'	-	No
10	300.000'	300.000'	-	No
11	300.000'	300.000'	-	No
12	300.000'	300.000'	-	No
13	300.000'	300.000'	-	No
14	300.000'	300.000'	-	No
15	300.000'	300.000'	-	No
16	300.000'	300.000'	-	No
17	300.000'	300.000'	-	No
18	300.000'	300.000'	-	No
19	300.000'	300.000'	-	No
20	300.000'	300.000'	-	No
21	300.000'	300.000'	-	No
22	300.000'	300.000'	-	No

4.3 Superelevations

4.3.1 Superelevation Main Access Road

Station	*Description*	*LeftOutsideShoulder*	*LeftOutsideLane*	*LeftInsideShoulder*	*RightOutsideShoulder*	*RightOutsideLane*	*RightInsideShoulder*
1+00.13'	Begin Alignment	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
0+22.74'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
0+84.99'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
1+70.99'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
2+09.49'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
2+39.58'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
2+81.51'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
3+22.95'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
3+64.91'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
4+22.08'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
4+29.76'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
5+96.16'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
7+14.76'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
7+94.21'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
8+37.96'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
9+76.72'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
10+00.92'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
11+30.33'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
11+89.16'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
12+83.60'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
13+07.16'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
14+11.40'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
14+15.27'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
15+64.37'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
15+77.82'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
16+05.87'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%

16+88.87'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
17+51.12'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
18+81.67'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
19+43.92'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
19+85.42'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
20+13.31'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
20+26.92'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
20+54.81'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
20+68.42'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
20+96.31'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
21+37.81'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
22+00.06'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
22+77.34'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
23+39.59'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
23+81.09'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
24+22.59'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
24+62.89'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
24+64.09'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
26+92.58'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
27+26.95'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
28+72.29'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
29+41.51'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
31+04.04'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
31+54.41'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
31+95.91'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%

32+37.41'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
34+10.72'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
34+19.71'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
34+52.22'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
34+61.21'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
35+44.21'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
36+06.46'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
40+25.28'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
40+87.53'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
41+70.53'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
41+71.13'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
42+12.03'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
42+12.63'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
42+95.63'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
43+57.88'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
45+69.17'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
46+31.42'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
46+72.92'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
47+14.42'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
47+54.46'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
47+55.92'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
47+95.96'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
48+37.46'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
48+78.96'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%

49+41.21'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
49+73.98'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
50+36.23'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
50+77.73'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
51+19.23'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
51+60.73'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
51+66.61'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
52+08.11'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
52+49.61'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
52+91.11'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
53+53.36'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
53+62.16'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
54+24.41'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
55+07.41'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
55+08.97'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
55+48.91'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
55+50.47'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
56+33.47'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
57+00.17'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
57+41.67'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
57+83.17'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
57+87.68'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
58+24.67'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
58+29.18'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
58+70.68'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

59+12.18'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
60+27.86'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
61+10.86'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
61+52.36'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
62+04.65'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
62+46.15'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
64+59.77'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
65+01.27'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
66+26.15'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
66+67.65'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
67+50.65'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
68+26.93'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
69+09.93'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
69+13.92'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
69+51.43'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
69+55.42'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
71+30.71'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
71+72.21'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
72+10.94'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
72+52.44'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
72+93.94'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
73+35.44'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
74+04.92'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
74+46.42'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
74+87.92'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
75+29.42'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
75+81.53'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
76+23.03'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%

76+64.53'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
77+06.03'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
78+11.76'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
78+53.26'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
78+94.76'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
79+19.23'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
79+36.26'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
79+60.73'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
80+02.23'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
80+43.73'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
81+05.98'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
82+50.09'	End Alignment	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%

4.3.2 Superelevation Top Road

Station	*Description*	*LeftOutsideShoulder*	*LeftOutsideLane*	*LeftInsideShoulder*	*RightOutsideShoulder*	*RightOutsideLane*	*RightInsideShoulder*
0+00.00'	Begin Alignment	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
-0+57.29'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
0+04.96'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
0+87.96'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
1+03.75'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
1+29.46'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
2+07.15'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
2+50.76'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
2+90.91'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
3+39.10'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
4+35.38'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
4+74.79'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
4+76.88'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
5+18.38'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6+48.93'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6+83.07'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
7+31.93'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
8+69.84'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
9+15.81'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
9+81.92'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
10+29.71'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
10+82.54'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
11+27.38'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
11+99.43'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
12+45.19'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
13+34.33'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
13+83.30'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%

15+37.37'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
15+92.47'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
16+48.42'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
16+93.22'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
17+67.67'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
18+10.95'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
18+50.67'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
19+69.09'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
19+97.90'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
20+52.09'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
21+57.50'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
22+03.48'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
23+61.13'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
23+94.36'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
24+44.13'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
25+70.48'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
26+04.12'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
26+76.12'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
27+11.87'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
28+14.55'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
28+62.07'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
28+97.55'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
30+40.64'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
30+88.39'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
32+09.15'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
32+51.83'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
33+64.36'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
34+02.62'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
35+02.72'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
35+47.13'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
36+24.52'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%

36+68.26'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
37+68.43'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
38+15.83'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
39+33.20'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
39+87.99'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
40+57.70'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
41+19.95'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
43+82.39'	End Alignment	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%

4.3.3 Superelevation Bottom Road

Station	*Description*	*LeftOutsideShoulder*	*LeftOutsideLane*	*LeftInsideShoulder*	*RightOutsideShoulder*	*RightOutsideLane*	*RightInsideShoulder*
0+00.00'	Begin Alignment	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
-0+20.53'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
0+41.72'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
0+83.22'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1+24.72'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
1+34.00'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
1+66.22'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
3+16.93'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
3+67.21'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
5+20.22'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
5+32.48'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
5+61.72'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
5+73.98'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
6+03.22'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
6+44.72'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
7+44.33'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
7+85.83'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8+18.87'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
8+27.33'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
8+60.37'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
8+68.83'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
9+01.87'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9+43.37'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
10+28.71'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
10+70.21'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

11+04.27'	End Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
11+11.71'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
11+45.77'	Reverse Crown	2.00%	2.00%	2.00%	-2.00%	-2.00%	-2.00%
11+53.21'	Begin Full Super	4.00%	4.00%	4.00%	-4.00%	-4.00%	-4.00%
11+87.27'	Level Crown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
12+28.77'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
12+91.02'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
15+33.43'	End Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
15+95.68'	End Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
16+78.68'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
16+80.40'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
17+20.18'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
17+87.69'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
18+22.72'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
19+08.95'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
19+48.91'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
19+50.45'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
21+35.15'	End Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
21+48.58'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
21+76.65'	Reverse Crown	-2.00%	-2.00%	-2.00%	2.00%	2.00%	2.00%
21+90.08'	Begin Full Super	-4.00%	-4.00%	-4.00%	4.00%	4.00%	4.00%
22+59.65'	Begin Normal Crown	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%	-2.00%
23+21.90'	Begin Normal Shoulder	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%
25+17.35'	End Alignment	-5.00%	-2.00%	-5.00%	-5.00%	-2.00%	-5.00%

4.4 Earthworks Volume Reports

4.4.1 Earthwork Main Access Road

Station	*Cut Area (Sq.ft.)*	*Cut Vol. (Cu.yd.)*	*Fill Area (Sq.yd.)*	*Fill Vol. (Cu.yd.)*	*Cum. Cut Vol. (Cu.yd.)*	*Cum. Fill Vol. (Cu.yd.)*	*Cum. Net Vol. (Cu.yd.)*
1+70.988	4.52	0	378.05	0	0	0	0
2+00.000	1.13	3.16	597.59	563.63	3.16	563.63	-560.48
2+09.494	1.32	0.43	586.03	208.1	3.59	771.73	-768.14
2+39.575	0.03	0.75	670.06	699.72	4.34	1471.45	-1467.11
2+81.510	0	0.02	884.2	1465.78	4.35	2937.22	-2932.87
3+00.000	0.44	0.15	886.77	606.4	4.51	3543.62	-3539.11
3+22.950	8.03	3.6	815.36	723.4	8.11	4267.02	-4258.91
3+64.911	18.65	16.75	697.69	1514.36	24.86	5781.38	-5756.52
4+00.000	12.16	20.02	716.71	919.08	44.88	6700.46	-6655.58
4+22.075	8.15	7.69	700.24	640.61	52.57	7341.07	-7288.5
4+29.755	7.18	2.18	678.99	196.16	54.75	7537.22	-7482.47
5+00.000	0	9.77	697.29	1681.89	64.52	9219.12	-9154.6
5+96.156	0	0	1434.94	3674.37	64.52	12893.49	-12828.97
6+00.000	0	0	1491.19	208.3	64.52	13101.79	-13037.27
7+00.000	11.1	22.34	1206.57	4589.68	86.86	17691.48	-17604.61
7+14.764	24.21	10.45	1081.57	597.21	97.32	18288.68	-18191.37
7+94.207	442.76	752.03	738.28	2521.6	849.35	20810.28	-19960.94
8+00.000	427.99	93.41	736.59	158.22	942.76	20968.5	-20025.75
8+37.963	441.9	691.97	732.85	896.2	1634.73	21864.71	-20229.98
9+00.000	374.54	987.06	887.71	1753.83	2621.79	23618.54	-20996.75
9+76.723	735.4	1577.01	1283.43	3084.76	4198.79	26703.29	-22504.5
10+00.000	723.93	703.65	1393.17	1005	4902.44	27708.29	-22805.85
10+00.922	715.39	24.57	1397.52	47.63	4927.01	27755.92	-22828.92
11+00.000	720.87	2635.23	1060.89	4510.64	7562.24	32266.56	-24704.33
11+30.334	1117.05	1153.23	941.2	1003.82	8715.47	33270.39	-24554.92
11+89.156	1474.59	3178.38	663.18	1539.38	11893.85	34809.77	-22915.92
12+00.000	1604.15	696.17	662.97	234.02	12590.02	35043.79	-22453.77
12+83.602	1639.06	5363.63	496.68	1687.22	17953.65	36731.01	-18777.36
13+00.000	1595.55	1106.92	598.74	297.72	19060.58	37028.73	-17968.16
13+07.162	1487.04	408.81	616.35	161.15	19469.39	37189.88	-17720.49
14+00.000	1421.26	5260.14	1465.06	3386.09	24729.54	40575.97	-15846.44
14+11.398	1509.88	676.66	1558.67	564.83	25406.2	41140.8	-15734.61
14+15.267	1551.43	219.3	1587.38	225.37	25625.5	41366.17	-15740.68
15+00.000	2203.08	6070.75	1993.68	5401.01	31696.25	46767.18	-15070.93
15+64.371	2398.36	5603.67	1885.8	4501.4	37299.92	51268.58	-13968.66
15+77.816	2476.86	1337.86	1785.27	804.94	38637.77	52073.52	-13435.75
16+00.000	2524.54	2188.98	1741.53	1336.99	40826.75	53410.5	-12583.76
16+05.871	2532.58	549.81	1754.39	380.07	41376.55	53790.58	-12414.02
16+88.871	2160.29	7213.12	1611.47	5173.44	48589.67	58964.02	-10374.35

17+00.000	2115.25	881.17	1538.5	649.19	49470.84	59613.21	-10142.37
17+51.121	1603.98	3520.93	1271.96	2660.61	52991.77	62273.82	-9282.06
18+00.000	1420.84	2737.97	1634.49	2630.83	55729.74	64904.65	-9174.92
18+81.669	1145.48	3881.25	1333.16	4488.22	59610.99	69392.88	-9781.89
19+00.000	1117.51	768.22	1359.64	914.13	60379.21	70307.01	-9927.8
19+43.919	1422.52	2065.82	1141.34	2034.06	62445.03	72341.07	-9896.04
19+85.419	1328.42	2114.14	912.78	1578.63	64559.17	73919.7	-9360.53
20+00.000	1366.9	727.81	904.52	490.72	65286.98	74410.42	-9123.44
20+13.308	1267.87	649.32	908.78	446.87	65936.3	74857.29	-8921
20+26.919	912.61	549.59	1012.2	484.19	66485.89	75341.48	-8855.59
20+54.808	516.82	738.26	1037.06	1058.37	67224.15	76399.85	-9175.71
20+68.419	543.44	267.24	1111.58	541.57	67491.39	76941.42	-9450.04
20+96.308	876.43	733.31	941.9	1060.56	68224.7	78001.98	-9777.28
21+00.000	945.64	124.58	900.37	125.96	68349.28	78127.94	-9778.66
21+37.808	1113.81	1441.91	818.42	1203.4	69791.19	79331.34	-9540.15
22+00.000	847.15	2258.45	623.79	1661	72049.64	80992.34	-8942.69
22+00.058	846.8	1.81	623.69	1.34	72051.46	80993.67	-8942.21
22+77.341	873.26	2461.7	611.06	1767.15	74513.16	82760.82	-8247.66
23+00.000	872.65	732.59	589.45	503.74	75245.75	83264.56	-8018.81
23+39.591	942.43	1330.77	541.37	829.08	76576.52	84093.64	-7517.13
23+81.091	1262.82	1694.78	686.8	943.87	78271.29	85037.51	-6766.22
24+00.000	1207.92	865.15	560.94	436.91	79136.44	85474.42	-6337.98
24+22.591	1187.79	1002.26	463.58	428.62	80138.71	85903.04	-5764.33
24+62.891	1142.54	1601.33	195.7	537.2	81740.04	86440.25	-4700.21
24+64.091	1142.09	50.79	185.64	8.48	81790.82	86448.72	-4657.9
25+00.000	1134.52	1417.76	2.29	139.43	83208.58	86588.15	-3379.58
26+00.000	986.9	3928.56	0	4.24	87137.14	86592.39	544.74
26+92.577	1421.22	4096.9	0	0	91234.04	86592.39	4641.65
27+00.000	1411.37	389.35	0	0	91623.39	86592.39	5031
27+26.947	1313.01	1313.27	0	0	92936.66	86592.4	6344.27
28+00.000	871.21	2919.68	0.23	0.32	95856.35	86592.72	9263.63
28+72.291	916.46	2341.17	7.4	10.37	98197.52	86603.08	11594.43
29+00.000	804.81	810.69	12.58	10.66	99008.2	86613.74	12394.46
29+41.507	580.05	947.72	161.39	152	99955.92	86765.74	13190.17
30+00.000	420.05	1015.09	93.62	293.64	100971.01	87059.38	13911.62
31+00.000	439.12	1543.83	144.02	453.43	102514.84	87512.81	15002.03
31+04.037	442.5	65.91	178.53	24.11	102580.75	87536.92	15043.83
31+54.406	554.58	797.66	345.21	552.96	103378.41	88089.88	15288.53
31+95.906	614.43	811.04	259.17	500.32	104189.44	88590.2	15599.24
32+00.000	581.09	90.63	282.06	41.03	104280.07	88631.23	15648.84
32+37.406	354.08	647.8	385.95	462.74	104927.88	89093.97	15833.9
33+00.000	190.88	631.68	248.74	735.7	105559.56	89829.67	15729.89
34+00.000	7.42	367.23	346.54	1102.36	105926.79	90932.03	14994.76
34+10.717	19.23	5.29	301.98	128.71	105932.08	91060.74	14871.34

34+19.706	41.86	10.17	249.99	91.88	105942.25	91152.62	14789.63
34+52.217	49.39	56.56	274.34	318.95	105998.81	91471.57	14527.24
34+61.206	52.28	16.92	277.67	91.89	106015.73	91563.46	14452.27
35+00.000	102.04	110.86	268.74	392.54	106126.59	91956	14170.59
35+44.206	138.22	196.69	245.89	421.3	106323.28	92377.3	13945.97
36+00.000	120.59	267.41	300.32	564.35	106590.69	92941.66	13649.03
36+06.456	138.03	30.92	290.82	70.68	106621.61	93012.33	13609.28
37+00.000	114.39	437.28	245.9	929.75	107058.89	93942.09	13116.8
38+00.000	138.08	467.55	339.82	1084.67	107526.44	95026.75	12499.68
39+00.000	231.3	684.04	251.17	1094.42	108210.47	96121.17	12089.3
40+00.000	234.38	862.37	258.82	944.41	109072.84	97065.58	12007.26
40+25.275	320.47	259.71	259.26	242.49	109332.54	97308.07	12024.47
40+87.525	295.64	710.24	232.21	566.55	110042.79	97874.63	12168.16
41+00.000	302.19	138.11	210.33	102.23	110180.89	97976.86	12204.03
41+70.525	302.37	789.58	119.81	431.16	110970.47	98408.02	12562.45
41+71.126	290.87	6.6	111.04	2.57	110977.07	98410.59	12566.48
42+00.000	328.77	347.18	125.64	126.94	111324.25	98537.53	12786.72
42+12.025	377.18	157.21	63.03	42.02	111481.46	98579.54	12901.92
42+12.626	391.09	8.54	69.77	1.48	111490	98581.02	12908.98
42+95.626	482.61	1342.92	54.17	190.5	112832.92	98771.52	14061.4
43+00.000	471.33	77.27	60.1	9.26	112910.19	98780.78	14129.41
43+57.876	477.23	1016.64	54.57	122.89	113926.83	98903.67	15023.16
44+00.000	453.55	726.08	38.8	72.83	114652.91	98976.5	15676.4
45+00.000	494.6	1755.84	25.1	118.33	116408.74	99094.83	17313.91
45+69.173	1355.35	2369.76	19.99	57.76	118778.5	99152.59	19625.91
46+00.000	606.86	1120.17	31.44	29.36	119898.67	99181.95	20716.72
46+31.423	464.4	623.38	24.43	32.51	120522.05	99214.46	21307.59
46+72.923	419.92	679.62	24.8	37.83	121201.67	99252.3	21949.37
47+00.000	460.38	441.4	22.1	23.52	121643.07	99275.81	22367.26
47+14.423	521.82	262.34	20.42	11.36	121905.41	99287.17	22618.24
47+55.923	511.55	27.6	12.86	0.73	122651.1	99311.97	23339.13
47+95.960	751.23	880.39	1.43	10.22	123531.48	99322.19	24209.3
48+00.000	764.61	113.41	1.15	0.19	123644.89	99322.38	24322.51
48+37.460	655.39	985.06	0	0.8	124629.96	99323.18	25306.78
48+78.960	612.72	974.57	0	0	125604.52	99323.18	26281.34
49+00.000	557.49	455.95	0	0	126060.47	99323.18	26737.29
49+41.210	304.04	657.48	5.64	4.3	126717.95	99327.48	27390.47
49+73.979	135.52	266.74	84.07	54.44	126984.69	99381.92	27602.77
50+00.000	150.31	137.73	83.01	80.51	127122.42	99462.44	27659.99
50+36.229	125.98	185.37	220.86	203.87	127307.79	99666.31	27641.48
50+77.729	52.09	136.85	745.37	742.57	127444.64	100408.87	27035.77
51+00.000	77.64	53.51	1011.27	724.49	127498.15	101133.36	26364.79
51+19.229	28.74	37.88	1361.03	844.76	127536.03	101978.12	25557.92
51+60.729	37.95	47.27	1635.59	2336.98	127583.31	104315.09	23268.21

51+66.605	38.58	8.33	1587.02	350.69	127591.64	104665.78	22925.86
52+00.000	21.81	33.92	1090.98	1710.13	127625.55	106375.91	21249.65
52+08.105	16.49	5.75	935.44	304.16	127631.3	106680.07	20951.24
52+49.605	48.46	49.91	281.14	934.96	127681.21	107615.03	20066.19
52+91.105	83.42	101.35	313.25	456.8	127782.57	108071.82	19710.75
53+00.000	84.31	27.63	313.78	103.28	127810.2	108175.1	19635.09
53+53.355	139.48	221.12	298.13	604.6	128031.31	108779.71	19251.6
53+62.157	201.52	55.58	301.68	97.77	128086.89	108877.47	19209.42
54+00.000	137.62	237.66	324.76	439.01	128324.56	109316.48	19008.07
54+24.407	207.95	156.19	336.18	298.73	128480.75	109615.21	18865.54
55+00.000	159.3	514.1	334.9	939.42	128994.84	110554.63	18440.21
55+07.407	159.48	43.72	331.28	91.37	129038.57	110646.01	18392.56
55+08.968	161.02	9.27	332.12	19.18	129047.84	110665.19	18382.65
55+48.907	44.72	146.55	428.06	591.59	129194.39	111256.79	17937.6
55+50.468	40.9	2.48	420.81	24.55	129196.86	111281.33	17915.53
56+00.000	72.8	104.29	441.3	790.77	129301.15	112072.1	17229.05
56+33.468	140.12	131.97	355.04	493.56	129433.12	112565.66	16867.46
57+00.000	242.6	471.54	47.53	496	129904.66	113061.66	16843
57+00.172	242.84	1.55	47.48	0.3	129906.2	113061.96	16844.24
57+41.672	193	334.95	57.64	80.79	130241.15	113142.75	17098.4
57+83.172	207.28	307.62	46	79.65	130548.77	113222.4	17326.37
57+87.680	213.15	35.1	55.93	8.51	130583.87	113230.91	17352.96
58+00.000	228.15	100.68	71.45	29.06	130684.55	113259.97	17424.58
58+24.672	318.22	235.29	97.64	82.39	130919.84	113342.36	17577.47
58+29.180	324.18	53.63	85.32	15.27	130973.47	113357.64	17615.83
58+70.680	421.63	573.16	14.17	76.46	131546.63	113434.09	18112.54
59+00.000	414.85	454.17	16.19	16.48	132000.8	113450.57	18550.23
59+12.180	541.8	215.78	52.42	15.47	132216.59	113466.05	18750.54
60+00.000	751.21	2102.8	90.47	232.37	134319.39	113698.42	20620.97
60+27.858	924.95	864.71	72.54	84.09	135184.1	113782.51	21401.59
61+00.000	1327.05	3008.58	40.84	151.47	138192.68	113933.97	24258.7
61+10.858	1328.66	533.99	46.31	17.52	138726.67	113951.5	24775.17
61+52.358	1656.95	2496.46	45.73	63.68	141223.13	114015.18	27207.95
62+00.000	1787.7	3438.11	14.13	44.69	144661.24	114059.86	30601.37
62+04.653	1747.39	304.58	15.91	2.59	144965.81	114062.45	30903.36
62+46.153	1272.14	2528.36	85.4	71.22	147494.17	114133.67	33360.5
63+00.000	1033.75	2299.38	98.05	182.93	149793.55	114316.61	35476.94
64+00.000	561.07	2953.37	29.85	236.84	152746.92	114553.45	38193.47
64+59.767	1106.36	1845.51	39.51	76.76	154592.43	114630.21	39962.22
65+00.000	1819.36	2348.95	22.91	44.77	156941.38	114674.98	42266.4
65+01.267	1833.14	85.73	22.87	1.07	157027.11	114676.05	42351.06
66+00.000	1484.28	6783.94	100.21	216.45	163811.05	114892.51	48918.54
66+26.151	1426.72	1573.2	141.53	112.96	165384.24	115005.47	50378.78
66+67.651	1855.4	2716.52	199.98	254.81	168100.77	115260.27	52840.49

67+00.000	1877.92	2236.46	234.66	260.37	170337.22	115520.64	54816.58
67+50.651	2247.7	3869.77	385.75	581.93	174206.99	116102.58	58104.42
68+00.000	1064.08	3026.53	591.58	893.14	177233.52	116995.72	60237.81
68+26.927	1219.25	1138.57	656.28	622.23	178372.09	117617.95	60754.14
69+00.000	1935.05	4268.43	630.23	1740.92	182640.52	119358.88	63281.64
69+09.927	1958.11	715.67	644.84	234.39	183356.19	119593.27	63762.92
69+13.924	1947.96	289.16	644.34	95.44	183645.35	119688.71	63956.64
69+51.427	2052.18	2935.64	710.76	893.3	186581	120582.01	65998.99
69+55.424	2111.74	308.25	738.04	107.25	186889.25	120689.26	66199.99
70+00.000	2948.87	4177.41	677.46	1168.47	191066.66	121857.73	69208.93
71+00.000	2582.96	10244.12	793.81	2724.58	201310.79	124582.31	76728.47
71+30.713	2864.54	3098.32	859.13	940.12	204409.1	125522.44	78886.67
71+72.213	3593.14	4580.05	824.09	1384.29	208989.15	126906.73	82082.42
72+00.000	3565.86	3251.45	654.8	846.85	212240.6	127753.58	84487.02
72+10.945	3592.83	1277.11	552.07	272.4	213517.71	128025.98	85491.73
72+52.445	3886.57	5286.27	172.01	596.18	218803.98	128622.16	90181.82
72+93.945	3767.7	5882.44	103.33	211.6	224686.42	128833.76	95852.66
73+00.000	3685.98	835.84	102.37	23.07	225522.27	128856.83	96665.44
73+35.445	3263.61	4561.57	71.34	114.02	230083.84	128970.85	101112.99
74+00.000	4906.01	9766.55	114.52	222.19	239850.39	129193.04	110657.35
74+04.916	5234.98	923.26	116.72	21.05	240773.64	129214.09	111559.55
74+46.416	3332.46	6584.23	320.07	335.68	247357.88	129549.78	117808.1
74+87.916	1945.63	4056.31	982.35	1000.93	251414.19	130550.71	120863.48
75+00.000	1691.49	813.89	1130.78	472.86	252228.08	131023.57	121204.51
75+29.416	1709.79	1634.06	1585.86	1596.13	253862.13	132619.7	121242.43
75+81.529	1856.37	2996.74	2082.54	3813.32	256858.88	136433.02	120425.86
76+00.000	2165.92	1198.81	2144.28	1552.47	258057.68	137985.49	120072.19
76+23.029	2428.59	1959.38	2099.87	1809.96	260017.06	139795.45	120221.61
76+64.529	2169.73	3533.89	1730.69	2943.85	263550.95	142739.3	120811.65
77+00.000	2123.63	2820.19	1819.86	2332.26	266371.15	145071.57	121299.58
77+06.029	2287.69	492.5	1818.19	406.17	266863.65	145477.74	121385.91
78+00.000	4838.34	12400.77	1838.74	6363.8	279264.42	151841.54	127422.87
78+11.762	4388.16	2009.72	2011.41	838.64	281274.14	152680.18	128593.96
78+53.262	2862.63	5572.37	2047.11	3119.05	286846.51	155799.23	131047.28
78+94.762	3340.77	4767.43	2024.54	3129.14	291613.94	158928.38	132685.56
79+00.000	3538.54	667.26	2058.38	396.02	292281.19	159324.4	132956.79
79+19.234	3939.09	2512.7	2251.93	1634.16	294793.89	160958.55	133835.34
79+36.262	4011.6	2246.3	2465.34	1659.8	297040.19	162618.35	134421.83
79+60.734	3998.4	3458.6	2576.97	2398.94	300498.78	165017.3	135481.49
80+00.000	5006.34	6547.76	2738.7	3865.27	307046.54	168882.56	138163.97
80+02.234	5041.72	415.72	2759.05	227.46	307462.25	169110.02	138352.23
80+43.734	4729.95	7509.72	2903.85	4352.04	314971.97	173462.06	141509.91
81+00.000	3845.56	8935.35	3441.9	6612.02	323907.32	180074.08	143833.24

4.4.2 Earthwork Top Road

Station	*Cut Area (Sq.ft.)*	*Cut Vol. (Cu.yd.)*	*Fill Area (Sq.yd.)*	*Fill Vol. (Cu.yd.)*	*Cum. Cut Vol. (Cu.yd.)*	*Cum. Fill Vol. (Cu.yd.)*	*Cum. Net Vol. (Cu.yd.)*
0+04.956	8.63	0	73.61	0	0	0	0
0+87.956	58.03	102.47	1904.46	3040.37	102.47	3040.37	-2937.9
1+00.000	22.69	18	856.89	615.87	120.47	3656.24	-3535.77
1+03.746	46.76	8.49	579.9	89.27	128.96	3745.51	-3616.55
1+29.456	1685.97	1510.32	576.68	94.33	1639.29	3839.84	-2200.55
2+00.000	738.96	3230.88	46	782.33	4870.17	4622.17	248
2+07.152	674.63	187.22	108.25	20.43	5057.39	4642.6	414.8
2+50.763	998.87	1673.34	215.78	143.07	6730.74	4785.67	1945.06
2+90.912	586.45	1178.67	520.65	547.52	7909.41	5333.2	2576.21
3+00.000	505.07	183.7	475.56	167.66	8093.11	5500.86	2592.25
3+39.102	612.93	968.14	436.73	520.62	9061.25	6021.48	3039.77
4+00.000	103.31	807.74	891.46	1497.85	9868.99	7519.33	2349.66
4+35.378	74.68	116.61	2278.22	2076.61	9985.59	9595.94	389.65
4+74.793	13.88	33.65	1083.1	3127.75	10019.24	12723.7	-2704.45
4+76.878	10.63	0.95	1052.53	82.45	10020.19	12806.15	-2785.96
5+00.000	23.61	14.66	761.43	776.71	10034.85	13582.85	-3548
5+18.378	65.83	30.44	446.53	411.11	10065.29	13993.97	-3928.68
6+00.000	962.25	1553.95	1403.55	2796.42	11619.25	16790.39	-5171.15
6+48.930	1755.03	2462.17	2253.04	3313.31	14081.42	20103.7	-6022.28
6+83.067	2026.11	2390.24	2992.45	3315.93	16471.66	23419.63	-6947.98
7+00.000	2044.83	1276.58	3266.02	1962.55	17748.23	25382.18	-7633.95
7+31.930	1973.14	1754.58	3045.93	4644.6	19502.82	30026.78	-10523.96
8+00.000	2564.46	5719.86	2391.67	6854.35	25222.67	36881.13	-11658.46
8+69.837	2716.84	6830.15	2865.98	6799.56	32052.82	43680.69	-11627.87
9+00.000	2917.79	1929.22	1930.65	3832.21	33982.04	47512.9	-13530.86
9+15.810	3234.81	1801.37	1990.26	1147.97	35783.41	48660.87	-12877.46
9+81.918	2897.9	7507.78	1831.9	4679.17	43291.19	53340.04	-10048.85
10+00.000	2504.5	1809	1501.49	1116.19	45100.19	54456.23	-9356.04
10+29.709	1934.94	1717.15	898.1	1743.4	46817.34	56199.63	-9382.29
10+82.539	1749.7	3604.8	1218.63	2070.86	50422.14	58270.5	-7848.36
11+00.000	1858.39	1166.72	1228.1	791.18	51588.86	59061.68	-7472.82
11+27.382	2125.97	1130.54	775.27	1447.87	52719.39	60509.54	-7790.15
11+99.427	2478.43	6143.09	656.36	1910.05	58862.48	62419.6	-3557.12
12+00.000	2472.35	52.52	662.41	13.99	58915.01	62433.59	-3518.58
12+45.193	1424.47	2576.66	1084.18	1929.48	61491.66	64363.07	-2871.4
13+00.000	842.13	2300.47	1732.12	2858.39	63792.13	67221.46	-3429.33
13+34.327	590.74	910.86	1211.95	1871.53	64702.99	69092.99	-4390
13+83.300	397.98	735.33	519.48	1760.48	65438.32	70853.47	-5415.14
14+00.000	425.79	254.77	405.01	285.91	65693.09	71139.38	-5446.29
15+00.000	533.96	1777.32	236.58	1188.12	67470.41	72327.5	-4857.09

15+37.372	359.96	618.66	562.31	552.89	68089.07	72880.39	-4791.32
15+92.469	269.86	642.61	888.12	1479.88	68731.68	74360.27	-5628.6
16+00.000	224.17	68.9	739.05	226.93	68800.58	74587.21	-5786.63
16+48.421	267.07	440.48	406.85	1027.51	69241.06	75614.72	-6373.66
16+93.216	154.65	255.41	878.99	1304.57	69496.47	76919.29	-7422.82
17+00.000	150.21	38.3	999.69	236.02	69534.77	77155.31	-7620.54
17+67.669	195.61	433.37	2846.02	4819.2	69968.13	81974.51	-12006.37
18+00.000	254.37	124.43	1018.08	3392.14	70092.56	85366.65	-15274.08
18+10.951	325.04	117.5	618.61	331.92	70210.07	85698.56	-15488.5
18+50.669	573.06	660.57	90.55	521.61	70870.64	86220.17	-15349.53
19+00.000	688.77	1152.72	7.2	89.3	72023.36	86309.47	-14286.12
19+69.092	809.49	1916.99	2.34	12.21	73940.35	86321.68	-12381.34
19+97.900	704.05	807.44	9.83	6.49	74747.78	86328.18	-11580.39
20+00.000	694.76	54.4	10.35	0.78	74802.18	86328.96	-11526.78
20+52.092	311.19	965.05	72.39	81.23	75767.23	86410.19	-10642.96
21+00.000	188.78	443.57	80.2	135.38	76210.8	86545.57	-10334.77
21+57.497	14.11	216.03	133.08	227.09	76426.83	86772.66	-10345.83
22+00.000	7.72	19.37	283.49	349.09	76446.21	87121.75	-10675.55
22+03.481	6.68	0.93	293.83	37.22	76447.13	87158.97	-10711.84
23+00.000	42.25	87.45	267.34	1003.03	76534.59	88162	-11627.41
23+61.133	27.63	79.12	375.9	728.2	76613.71	88890.2	-12276.49
23+94.365	204.76	143.02	126.03	308.89	76756.72	89199.09	-12442.36
24+00.000	241.24	46.55	126.9	26.4	76803.27	89225.48	-12422.21
24+44.133	496.01	519.18	56.77	172.41	77322.45	89397.89	-12075.44
25+00.000	1793.22	2368.4	0	58.74	79690.84	89456.63	-9765.78
25+70.484	2868.08	6084.23	61.08	79.73	85775.07	89536.36	-3761.28
26+00.000	2681.89	909.98	296.12	359.79	86685.05	89896.15	-3211.1
26+04.123	2688.65	410.08	316.01	46.74	87095.13	89942.89	-2847.76
26+76.123	2249.07	6583.56	297.58	818.11	93678.69	90761	2917.69
27+00.000	1995.07	371.81	286.6	366.14	94050.49	91127.13	2923.36
27+11.869	1994.59	527.93	286.46	149.04	94578.42	91276.18	3302.25
28+00.000	1701.51	6032.22	363.67	1061.05	100610.64	92337.23	8273.41
28+14.547	1740.64	927.27	422.28	211.73	101537.91	92548.95	8988.96
28+62.068	1467.55	3219.37	721.44	927.37	104757.28	93476.33	11280.95
28+97.547	1297.44	1816.65	1228.28	1281	106573.93	94757.33	11816.6
29+00.000	1269.74	116.62	1255.6	112.84	106690.55	94870.17	11820.39
30+00.000	40.94	2427.19	2775.31	7464.64	109117.74	102334.81	6782.93
30+40.638	141.75	137.48	480.74	2450.35	109255.22	104785.15	4470.07
30+88.387	561.8	594.93	293.88	713.55	109850.15	105498.7	4351.45
31+00.000	564.29	242.18	237.72	114.33	110092.33	105613.03	4479.3
32+00.000	1232.22	3326.87	44.28	522.22	113419.2	106135.25	7283.95
32+09.152	1291.1	427.67	28.5	12.33	113846.87	106147.59	7699.28
32+51.835	1583.11	2306.41	3.72	31.89	116153.27	106179.47	9973.8
33+00.000	1964.97	3164.7	1.92	5.03	119317.97	106184.5	13133.47

33+64.355	2506.28	5328.68	0	2.29	124646.65	106186.8	18459.85
34+00.000	2761.93	3663.32	0	0	128309.97	106186.8	22123.17
34+02.620	2772.49	268.54	0	0	128578.51	106186.8	22391.71
35+00.000	3043.65	10488.43	0	0	139066.93	106186.8	32880.14
35+02.722	3043.66	306.79	0	0	139373.72	106186.8	33186.93
35+47.125	2950.72	4775.72	0	0	144149.44	106186.8	37962.64
36+00.000	2882.62	5711.81	0	0	149861.25	106186.8	43674.45
36+24.520	2830.56	2594.16	0	0	152455.41	106186.8	46268.61
36+68.258	2739.72	4122.87	0	0	156578.27	106186.8	50391.48
37+00.000	2727.09	3213.48	0	0	159791.76	106186.8	53604.96
37+68.434	2686.6	6860.8	0	0	166652.56	106186.8	60465.76
38+00.000	2671.48	2815.91	0	0	169468.47	106186.8	63281.67
38+15.830	2695.51	1573.28	0	0	171041.74	106186.8	64854.94
39+00.000	1776.31	6970.27	0	0	178012.01	106186.8	71825.21
39+33.197	1392.4	1947.98	34.77	21.37	179959.99	106208.17	73751.82
39+87.985	1119.85	2548.94	21.84	57.44	182508.94	106265.61	76243.33
40+00.000	1026.14	477.46	51.57	16.33	182986.4	106281.94	76704.46
40+57.697	17.86	1115.47	642.84	741.95	184101.88	107023.89	77077.99
41+00.000	25.19	33.72	854.13	1172.71	184135.6	108196.6	75939
41+19.947	50.46	27.94	810.34	614.83	184163.54	108811.43	75352.11
42+00.000	311.74	536.95	11144.1	17722.06	184700.49	126533.5	58166.99
43+00.000	716.43	1904.02	8184.37	35793.46	186604.51	162326.96	24277.55

4.4.3 Earthwork Bottom Road

Station	*Cut Area (Sq.ft.)*	*Cut Vol. (Cu.yd.)*	*Fill Area (Sq.yd.)*	*Fill Vol. (Cu.yd.)*	*Cum. Cut Vol. (Cu.yd.)*	*Cum. Fill Vol. (Cu.yd.)*	*Cum. Net Vol. (Cu.yd.)*
0+41.725	6.84	0	61.1	0	0	0	0
0+83.225	0.03	5.28	365.09	327.53	5.28	327.53	-322.25
1+00.000	23.29	7.25	521.48	275.42	12.53	602.95	-590.42
1+24.725	39.51	28.76	216.63	337.95	41.28	940.9	-899.62
1+34.002	33.82	12.6	138.5	61.01	53.88	1001.92	-948.04
1+66.225	39.29	1.64	62.81	123.18	55.52	1125.09	-1069.58
2+00.000	62.8	63.86	17.99	50.53	119.37	1175.63	-1056.25
3+00.000	502.18	1046.25	8.25	48.58	1165.62	1224.21	-58.59
3+16.934	638.78	357.8	0.47	2.73	1523.42	1226.94	296.48
3+67.211	659.22	1328.16	3.58	3.41	2851.58	1230.35	1621.23
4+00.000	707.82	830.07	1.05	2.81	3681.64	1233.16	2448.48
5+00.000	257.18	1787.04	97.57	182.64	5468.68	1415.81	4052.87
5+20.218	300.31	208.73	74.79	64.53	5677.41	1480.34	4197.07
5+32.483	335.88	144.5	81.63	35.53	5821.91	1515.87	4306.04
5+61.718	421.53	431.1	64.11	82.98	6253.01	1598.85	4654.16
5+73.983	384.5	183.08	51.97	26.36	6436.09	1625.21	4810.88
6+00.000	383.04	369.8	52.05	50.11	6805.89	1675.33	5130.57
6+03.218	388.75	45.99	53.52	6.29	6851.88	1681.62	5170.26
6+44.718	401.09	607.01	44.78	75.55	7458.89	1757.16	5701.72
7+00.000	325.69	744.04	59.42	106.67	8202.93	1863.83	6339.09
7+44.334	249.42	472.17	82.36	116.4	8675.09	1980.24	6694.86
7+85.834	281.76	408.22	63.21	111.88	9083.32	2092.12	6991.2
8+00.000	255.05	140.82	55.68	31.19	9224.14	2123.31	7100.83
8+18.866	265.57	181.89	51.43	37.42	9406.02	2160.73	7245.3
8+27.334	308.2	89.98	50.39	15.97	9496	2176.69	7319.31
8+60.366	231.93	388.81	15.8	35.53	9884.81	2212.22	7672.59
8+68.834	185.19	65.41	8.32	3.78	9950.22	2216.01	7734.22
9+00.000	179.8	210.65	26.14	19.89	10160.88	2235.9	7924.98
9+01.866	182.71	12.53	27.76	1.86	10173.4	2237.76	7935.65
9+43.366	173.61	273.83	25.36	40.83	10447.24	2278.58	8168.65
10+00.000	112.59	300.16	91.63	122.7	10747.4	2401.29	8346.11
10+28.713	91.72	108.64	150.87	128.94	10856.03	2530.23	8325.81
10+70.213	132.09	172	116.35	205.37	11028.03	2735.59	8292.44
11+00.000	95.3	125.43	65.85	100.51	11153.46	2836.1	8317.36
11+04.271	88.41	14.53	57.87	9.79	11167.99	2845.89	8322.11
11+11.713	93.51	25.07	33.72	12.62	11193.06	2858.51	8334.55
11+45.771	588.78	552.2	3.01	23.25	11745.26	2881.75	8863.51
11+53.213	617.19	166.19	0.42	0.47	11911.45	2882.23	9029.23

11+87.271	635.45	790.06	6.27	4.22	12701.51	2886.45	9815.06
12+00.000	585.77	287.86	9.33	3.68	12989.37	2890.12	10099.25
12+28.771	398.84	524.6	17.64	14.37	13513.98	2904.49	10609.49
12+91.021	129.13	608.63	51.11	79.24	14122.61	2983.74	11138.87
13+00.000	105.26	38.97	60.87	18.62	14161.58	3002.36	11159.22
14+00.000	109.96	398.56	209.57	500.81	14560.13	3503.17	11056.97
15+00.000	77.88	347.86	238.24	829.27	14907.99	4332.44	10575.55
15+33.433	74.3	94.22	259.58	308.21	15002.21	4640.65	10361.56
15+95.683	113.08	216.02	234.88	570.01	15218.23	5210.66	10007.58
16+00.000	108.8	17.74	228.4	37.04	15235.97	5247.69	9988.27
16+78.683	56.39	240.68	470.04	1017.68	15476.65	6265.38	9211.27
16+80.402	61.54	3.75	484.58	30.39	15480.41	6295.77	9184.64
17+00.000	44.66	25.23	500.39	413.29	15505.63	6709.06	8796.58
17+20.183	51.9	23.21	477.94	421.23	15528.85	7130.29	8398.56
17+87.687	143.09	243.76	269.55	934.42	15772.61	8064.71	7707.9
18+00.000	147.11	42.73	261.54	137.7	15815.34	8202.41	7612.93
18+22.717	147.17	49.13	271.38	277.61	15864.47	8480.02	7384.45
19+00.000	131.08	398.22	257.43	756.82	16262.69	9236.84	7025.85
19+08.955	117.08	41.15	258.28	85.52	16303.84	9322.36	6981.48
19+48.907	113.01	100.02	182.16	378.96	16403.86	9701.32	6702.54
19+50.455	106.33	6.28	171.63	10.14	16410.14	9711.45	6698.69
20+00.000	96.29	185.91	200.57	341.49	16596.05	10052.94	6543.11
21+00.000	175.35	503.05	113.49	581.58	17099.1	10634.53	6464.57
21+35.154	258.71	282.58	109.68	145.28	17381.68	10779.81	6601.87
21+48.582	251.63	126.91	124.44	58.22	17508.58	10838.03	6670.56
21+76.654	247.35	259.39	119.75	126.94	17767.98	10964.97	6803.01
21+90.082	276.7	130.32	108.11	56.66	17898.29	11021.63	6876.66
22+00.000	282.15	102.64	113.13	40.63	18000.93	11062.26	6938.67
22+59.654	228.16	563.74	53.77	184.37	18564.67	11246.64	7318.03
23+00.000	202.03	321.41	70.96	93.19	18886.08	11339.83	7546.25
23+21.904	180.73	155.26	82.66	62.31	19041.34	11402.15	7639.19
24+00.000	118.83	433.22	111.13	280.27	19474.56	11682.42	7792.14
25+00.000	78.2	364.86	464.04	1065.13	19839.42	12747.55	7091.87

4.4.4 Earthwork Main Access Road – Eagle Point Software

User Name: Abdul Basit Date: 04-27-15

Project: Geometric Design Of a Small Town Time: 14:08:20

Subproject: Main Access Road, Road 7 Page: 1

ROADCALC DESIGN EARTHWORK - RAW VOLUMES

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STATION	MATERIAL	CUT AREA (FT^2)	CUT VOLUME (yd^3)	FILL AREA (FT^2)	FILL VOLUME (yd^3)
Total	Orig_Surface	342104.68	371252.99		
	Total	342104.68	371252.99	177796.30	1880449.38

4.4.5 Earthwork Top Road – Eagle Point Software

User Name: Abdul Basit Date: 04-27-15

Project: Geometric Design Of a Small Town Time: 13:31:54

Subproject: Top Road, Road 3 Page: 1

ROADCALC DESIGN EARTHWORK - RAW VOLUMES

==========

STATION	MATERIAL	CUT AREA (FT^2)	CUT VOLUME (yd^3)	FILL AREA (FT^2)	FILL VOLUME (yd^3)
Total	Orig_Surface	217104.68	197252.99		
	Total	217104.68	197252.99	172796.30	168940.50

4.4.6 Earthwork Bottom Road – Eagle Point Software

User Name: Abdul Basit Date: 04-27-15

Project: Geometric Design Of a Small Town Time: 13:38:40

Subproject: Bottom Road, Road 5 Page: 1

ROADCALC DESIGN EARTHWORK - RAW VOLUMES

==========

STATION	MATERIAL	CUT AREA (FT^2)	CUT VOLUME (yd^3)	FILL AREA (FT^2)	FILL VOLUME (yd^3)
Total	Orig_Surface	2169.71	2010.35		
	Total	2169.71	2010.35	17713.27	16042.71

Chapter 5

CONCLUSION

Initially when Eagle Point software program was introduced, its aim was to ease the procedure of civil engineering works. For this purpose various different modules were added in the software for the design of different transportation related civil engineering tasks (i.e. RoadCalc™, Intersections, Site Design, Site Analysis, COGO, Water Drainage Design etc.).

AutoCAD Civil 3D also provides a platform through which you can design these same road design related civil engineering tasks. The solutions for road design in AutoCAD Civil 3D software make defining, annotating, and analyzing your road design more efficient and help your design comply with sound engineering standards. Therefore, using criteria-based design, road modeling with real-time analysis and designer feedback helps expedite the design process and minimizes problematic issues.

- In AutoCAD Civil 3D software these tasks are not designed through different modules, instead they are easily accessed through the main menu bar directly. Thus AutoCAD Civil 3D software provides ease of access of different road related design tasks. Whereas in Eagle Point you need to access different modules in which you have to form new sub projects and then perform your design in those sub-projects, this make the design process very long and hectic.
- In AutoCAD Civil 3D software designing would become very easy and quick if we are familiar with different visual and labeling style's used for different aspects of road design tasks. You can also form your own style's in which your design will be presented and labeled as per your demand. Whereas in Eagle Point software you cannot form your own visual and labeling style's for different aspects. Now this aspect make's your work very appealing, as you can form the style in which you want your design to be seen and be easily viewed and understood.
- In AutoCAD Civil 3D software we can also observe our design in 3D without the help of any additional program, whereas in Eagle Point software we cannot observe our design in 3D. Thus we need to export the design, we did, from the Eagle Pont software to another program compatible with Eagle Point software's output for the design's visualization in 3D.

- Through Civil 3D software we can also perform the Quantity Take Off of all the design we have done, whereas we cannot perform any such task through Eagle Point software.

The only disadvantage of AutoCAD civil 3D software is that it requires a very strong and powerful desktop for its use and so is the recommendation.

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APPENDIX