GEOMETRIC DESIGN OF SPIN KAREZ PARK ROAD, QUETTA BALOCHISTAN

By

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Sustainable Development Goals

(Please tick the relevant SDG(s) linked with FYDP)

SDG No	Description of SDG	SDG No	Description of SDG
SDG 1	No Poverty	SDG 9	Industry, Innovation, and Infrastructure
SDG 2	Zero Hunger	SDG 10	Reduced Inequalities
SDG 3	Good Health and Well Being	SDG 11	Sustainable Cities and Communities
SDG 4	Quality Education	SDG 12	Responsible Consumption and Production
SDG 5	Gender Equality	SDG 13	Climate Change
SDG 6	Clean Water and Sanitation	SDG 14	Life Below Water
SDG 7	Affordable and Clean Energy	SDG 15	Life on Land
SDG 8	Decent Work and Economic Growth	SDG 16	Peace, Justice and Strong Institutions
		SDG 17	Partnerships for the Goals

Range of Complex Problem Solving			
	Attribute	**Complex Problem**	
1	Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.	
2	Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.	
3	Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.	
4	Familiarity of issues	Involve infrequently encountered issues	
5	Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.	
6	Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.	
7	Consequences	Have significant consequences in a range of contexts.	
8	Interdependence	Are high level problems including many component parts or sub-problems	

Range of Complex Problem Activities			
	Attribute	**Complex Activities**	
1	Range of resources	Involve the use of diverse resources (and for this purpose, resources include people, money, equipment, materials, information and technologies).	
2	Level of interaction	Require resolution of significant problems arising from interactions between wide ranging and conflicting technical, engineering or other issues.	
3	Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.	
4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.	
5	Familiarity	Can extend beyond previous experiences by applying principles-based approaches.	

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AUTHOR’S DECLARATION

We hereby state that our BS thesis entitled **Geometric Design of Spin Karez Park Road, Quetta Balochistan** is our own original work and has not been submitted previously by us for award of any degree from Balochistan University of Information Technology, Engineering & Management Sciences, Quetta or elsewhere in the country/world.

At any time, even after graduation, if the above statement is found incorrect, the university has the right to withdraw degree.

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We solemnly declare that project/research work presented in the thesis titled **"Geometric Design of Spin Karez Park Road, Quetta Balochistan"** is our own work with no significant contribution from any other person or sources. Small contribution/help wherever taken has been duly acknowledged and that complete thesis has been written by us.

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This is to certify that the project/research work presented in this thesis, entitled **"Geometric Design of Spin Karez Park Road, Quetta Balochistan"** was supervised by **Engr. Prof. Zafar Baloch**. No part of this thesis has been submitted anywhere else for any other degree. This thesis is submitted to the Department of Civil Engineering, FOE&A, BUITEMS, in partial fulfillment of the requirements for the degree of BS Civil Engineering.

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Dated: ____

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Dated: ____

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Signature: ____

Dated: ____

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I, Syed Bilal Ahmed, as the group leader, would like to express my heartfelt gratitude to the individuals who have contributed to the successful completion of our thesis on the "Geometric Design of Spin Karez Park Road, Quetta, Balochistan."

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ABSTRACT

The road leading to Spin Karez park serves as a crucial link connecting tourists from different regions and local residents to this scenic destination. Recognizing the significance of road infrastructure in promoting economic development and regional connectivity, this project undertook a comprehensive study to enhance the geometric design of the road. The aim was to create a safe, efficient, and sustainable roadway that seamlessly integrates with the surrounding environment while meeting the needs of the local community and visitors.

The research methodology encompassed multiple stages, beginning with a meticulous survey using Total Station to collect precise data on angles, distances, and elevations along the road alignment. This data formed the foundation for generating an accurate existing ground profile and design grades. Advanced software tools were employed to develop a dynamic 3D model representing the road corridor, allowing for a comprehensive analysis of the road's cross-sectional components and their interaction with the terrain. The proposed geometric design was a result of extensive analysis, considering factors such as topography, traffic patterns, and community preferences. The design minimized sharp curves and steep gradients to enhance road safety and traffic flow.

The study underscored the importance of community engagement in the road development process. Feedback from local residents and stakeholders was incorporated into the design, ensuring that the road aligns with their aspirations and needs. The study's results have significant implications for the geometric design of low-volume roads in rural areas. While the findings present valuable insights, certain limitations exist, such as the need for further research in different geographic contexts to enhance generalizability.

In conclusion, the project work presents a well-planned and comprehensive road infrastructure design that aligns with the objectives of promoting tourism, recreational opportunities, regional development, economic growth, and environmental stewardship. The study's approach, encompassing surveying, and community engagement, contributes to a road infrastructure that fosters positive socio-economic impact and enriches the overall travel experience for residents and visitors to Spin Karez park.

Keywords: Geometric Design, Horizontal Alignment, Vertical Alignment, Cross Sections.

CHAPTER 1

1.1 Introduction:

The region of Spin Karez has emerged as an attractive tourist spot, particularly due to its Dam and Spin Karez park, drawing people from nearby cities and towns. This increased travel demand has underscored the necessity for improved and safe roads. The location is situated at a distance of 27.3 km, from Quetta city, making it an essential link connecting the city to the picturesque Spin Karez park.

In this rural setting, the road under consideration falls into the Low-Volume Road category. Low-Volume Roads (LVRs) play a crucial role in enhancing rural well-being, economic development, and food security in Spin Karez. However, the traditional standards and design methods for rural road infrastructure can be cost-prohibitive and ill-suited to local road environments. Therefore, there is a need to develop new Geometric Designs tailored to the specific requirements of Spin Karez and consider recent advancements in LVR technology both regionally and globally.

This study focuses on the geometric design of low volume access roads, considering factors that differ significantly from higher volume mobility roads. It addresses fundamental design parameters, such as cross-section elements, horizontal and vertical alignment, and road safety considerations, to establish appropriate design standards for the region.

1.2 Problem statement:

The current undeveloped route leading to Spin Karez park poses significant discomfort and challenges for tourists visiting from various regions and especially for the local residents commuting to work and their homes in Spin Karez. The construction of a geometrically safe and well-maintained road is imperative. Such a road will enhance the overall travel experience, benefiting both the local community and the park's tourism prospects.

1.3 Significance of the Project:

The study holds immense significance as it addresses the pressing need for the development of a geometrically safe and efficient road in Spin Karez. By proposing a well-designed road, the study aims to bring about several significant outcomes:

- Enhanced Tourism: A well-constructed road will improve accessibility to Spin Karez park, attracting more tourists from different regions. This, in turn, can boost local economic growth through increased tourism revenue and job opportunities.
- Improved Local Mobility: The local residents who depend on the road for their daily commute will experience enhanced convenience and comfort, making it easier for them to access work, schools, and other essential services.
- Socio-economic Uplift: The development of a safe and reliable road infrastructure can lead to improved living conditions and socio-economic uplift for the people of Spin Karez. It can contribute to better livelihoods, education, and healthcare facilities.

1.4 Aims and Objectives:

The project aims to achieve the following objectives:

- To design a geometric road infrastructure for the route leading to Spin Karez park.
- To develop a replicable model for rural road development.

CHAPTER 2

LITERATURE REVIEW:

2.1 Geometric design of roads:

The field of highway engineering known as geometric design focuses on arranging the physical components of roadways in accordance with established standards and limitations. The fundamental goals of geometric design encompass maximizing efficiency and safety, while concurrently minimizing expenses and ecological impact. Additionally, geometric design encompasses a growing concept called "livability," which entails designing roads to support broader community aspirations, such as facilitating access to employment, educational institutions, commercial establishments, and housing. This approach also strives to accommodate various modes of transportation, including walking, cycling, public transit, and private vehicles, while reducing fuel consumption, emissions, and environmental harm. (CodeMint, n.d.)

Transportation holds a significant role in our contemporary era. Geometric Design specifically addresses observable aspects of roadways. The paramount consideration in road design is safety, ensuring convenient and efficient movement. Geometric principles encompass the management of horizontal and vertical curves, visibility distance, gradients, as well as intersections – all of which are crucial factors. Mandal Manoj et al, (2019)

2.2 General Design Consideration for Rural Access Road:

The range of factors that impact on the appropriate geometric design of a rural road include

- Design Speed
- Design Vehicle
- Design Traffic Volume
- Sight Distances
- Horizontal Alignment
- Vertical Alignment
- Safety
- Design Life
- Survey Methods

2.2.1 Design Speed:

Rural Road other than freeways, should be designed for speeds of 60 to 120 km/h [40 to 75 mph] depending on terrain, driver expectancy and, in the case of reconstruction projects, the alignment of the existing facility. Transportation Officials. (2011). The idea of design speed came from studying how drivers usually drive at different speeds. Nowadays, it's used as a somewhat random way of planning and aligning road features. When roads are designed for speeds of 90 km/h or slower, driver speeds change along the road and are consistently higher than the planned speed. McLean, J. (1979). For our design project we have selected design speed of 60 to 80 km/h [40 to 50 mph] due to mountainous terrain.

2.2.2 Design Vehicle:

From the AASHTO table 2.1 we are selecting our design vehicle as SU-12 [SU-40] because the road will also be used to transport good, construction materials etc.

AASHTO has defined four main categories of design vehicles such as, passenger cars, buses, trucks, and recreational vehicles. While we focus on the truck class. The truck class covers single-unit trucks, truck tractor-semitrailer combinations, and truck tractors with semitrailers combined with full trailers. Table 2.1 provides the dimensions for design vehicles representing various vehicles within the general classes mentioned.

Table 2.1 Design Vehicle Dimensions (m):

Design Vehicle Type	Symbol	Dimensions (m)					
		Overall			Overhang		WB_1
		Height	Width	Length	Front	Rear	
Passenger Car	P	1.3	2.13	5. 79	0.91	1.52	3. 35
Single-Unit Truck	SU-9	3.35-4.11	2.44	9. 14	1.22	1.83	6.1
Single-Unit Truck (three-axle)	SU-12	3.35-4.11	2.44	12.04	1.22	3.2	7.62

2.2.2.1 Minimum Turning Paths of Design Vehicles:

From the AASHTO Table 2.2, the minimum turning radii for our design vehicles are presented, while Figures 2.1 depict the minimum turning paths. The key dimensions that influence the design include the minimum centerline turning radius (CTR), out-to-out track width, wheelbase, and the path of the inner rear tire. To minimize the impact of driver characteristics and wheel slip angles, it is assumed that the vehicle's speed for the minimum turning radius is below 15 km/h (10 mph). The specific minimum radii for the outside and inside wheel paths, as well as the centerline turning radii (CTR) for each design vehicle, can be found in Table 2.2.

Table 2.2 Minimum Turning Radii of Design Vehicles (m):

Design Vehicle Type	**Passenger Car**	**Single Unit Truck**	**Single Unit Truck (Three Axle)**
Symbol	P	SU-9	SU-12
Minimum Design Turning Radius (m)	7.26	12. 73	15.6
Center line[b] Turning Radius (CTR) (m)	6.4	11.58	14.46
Minimum Inside Radius(m)	4.39	8.64	11.09

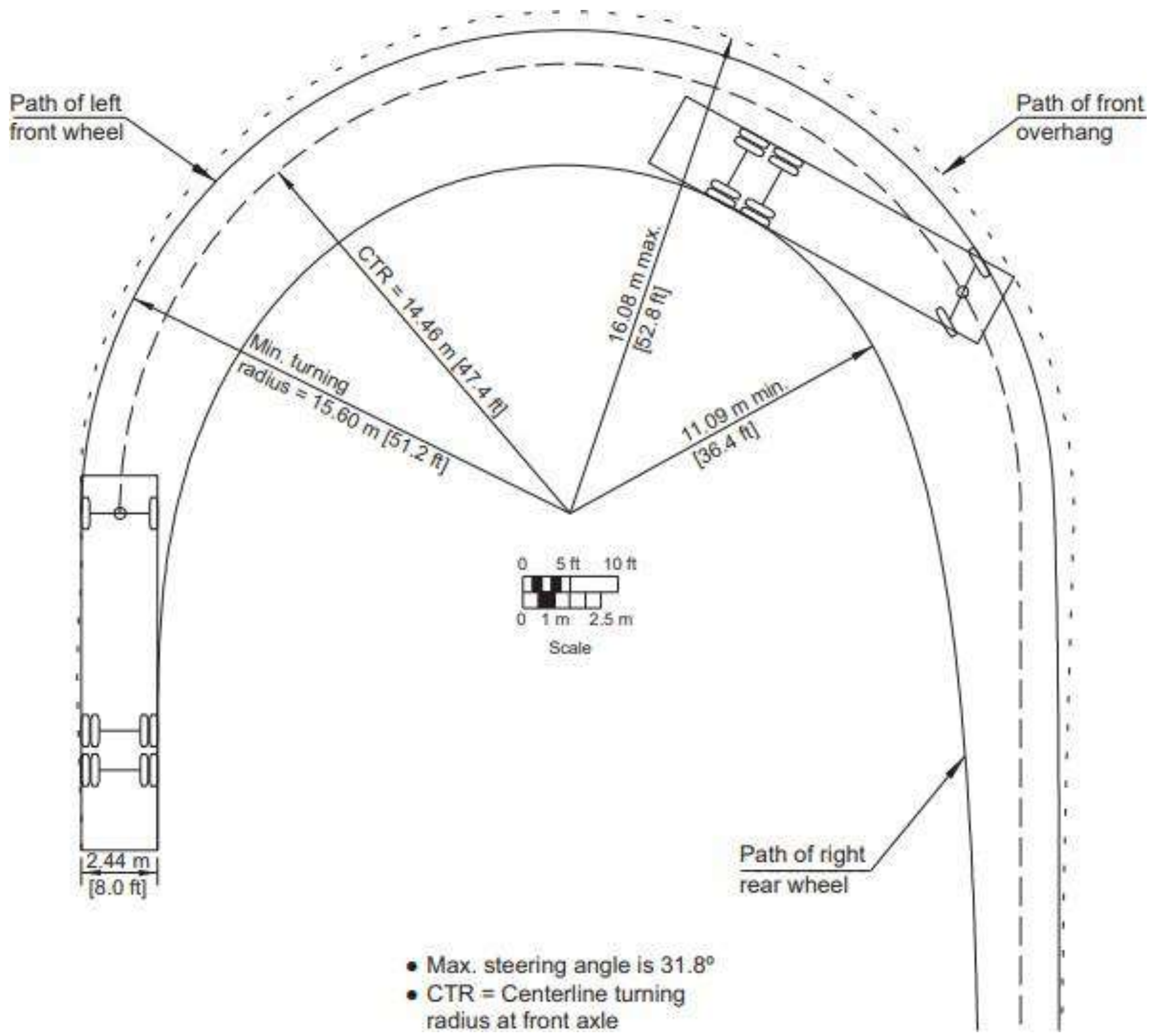


Figure 2.1 Minimum Turning Path for Single-Unit Truck (SU-12[SU-40]) Design Vehicle (AASHTO)

The SU-12 [SU-40] design vehicle represents a larger single-unit truck. The control dimensions indicate the minimum turning path for most single-unit trucks now in operation (see Figures 2.1).

2.2.3 Design Traffic Volume:

Comprising two-thirds of the entire U.S. highway network are low-volume rural roads, which have a daily traffic volume of 400 vehicles or fewer. These roads play a crucial role in achieving the national transportation goal. They not only form the largest category within the highway system but also serve as a fundamental connection for the country's agricultural economy. The 1971 AASHTO publication "Geometric Design Guide for Local Roads and Streets" outlines the national recommendations for designing low-volume rural roads. Glennon, J. C. (1979).

2.2.4 Sight Distances:

2.2.4.1 Stopping Sight Distance:

Sight distance refers to the distance of roadway ahead that is visible to the driver. It is crucial for this visible distance to be long enough to allow a vehicle traveling at or near the design speed to come to a stop before reaching any stationary object obstructing its path. Stopping sight distance is composed of two components: firstly, the distance covered by the vehicle from the moment the driver visually detects an object that necessitates a stop until the brakes are applied (known as brake reaction distance) and secondly, the distance required to bring the vehicle to a complete stop from the moment the brakes are engaged (known as braking distance). The distances combined together make up the total stopping sight distance. Fambro, D., Fitzpatrick, K., & Koppa, R. (2000).

2.2.4.1.1 Brake Reaction Time:

The typical response of a driver in a possible accident scenario is immediate application of brakes. As a result, a crucial determinant of whether the accident can be averted is the driver's response time. Johansson, G., & Rumar, K. (1971). For conditions that are more intricate than the controlled conditions used in laboratory and road tests, a brake reaction time of 2.5 seconds is considered adequate. Transportation Officials. (2011).

2.2.4.1.2 Braking Distance:

According to AASHTO approximately 90 percent of all drivers decelerate at rates greater than 3.4 m/s2 [11.2 ft/s^2]. Such decelerations are within the driver’s capability to stay within his or her lane and maintain steering control during the braking maneuver on wet surfaces. Therefore, 3.4 m/s^2 [11.2 ft/s^2] is recommended as the deceleration threshold for determining stopping sight distance.

Table 2.3 Stopping Sight Distance on Level Roadways:

Metric				
Design Speed (km/h)	**Brake Reaction Distance (m)**	**Braking Distance on Level (m)**	**Stopping Sight Distance**	
			Calculated (m)	**Design (m)**
20	13.9	4.6	18.5	20
30	20.9	10.3	31.2	35
40	27.8	18.4	46.2	50
50	34.8	28.7	63.5	65
60	41.7	41.3	83	85
70	48.7	56.2	104.9	105
80	55.6	73.4	129	130
90	62.6	92.9	155.5	160
100	69.5	114.7	184.2	185
110	76.5	138.8	215.3	220

2.2.4.1.3 Effect of Grade on Stopping:

On inclines, shorter stopping distances are required compared to level roads, while longer distances are needed on declines. The stopping sight distances is provided in Table 2.4. These revised sight distance values are computed for wet-pavement conditions, utilizing the design speeds and brake reaction times identical to those employed for level roadways in Table 2.3. Transportation Officials. (2011).

Table 2.4 Stopping Sight Distance on Grades (m):

Metric						
Design Speed (km/h)	**Stopping Sight Distance (m)**					
	Downgrades			**Upgrades**		
	3%	**6%**	**9%**	**3%**	**6%**	**9%**
20	20	20	20	19	18	18
30	32	35	35	31	30	29
40	50	50	53	45	44	43
50	66	70	74	61	59	58
60	87	92	97	80	77	75
70	110	116	124	100	97	93
80	136	144	154	123	118	114
90	164	174	187	148	141	136
100	194	207	223	174	167	160
110	227	243	262	203	194	186

2.2.4.2 Passing Sight Distance:

The proposed site location length is 1.2 km only and it is hilly road having numerous curves. Hence no passing sight distance is needed.

2.2.5 Horizontal Alignment:

To ensure a harmonious highway design, all geometric elements should be designed, whenever economically feasible, to accommodate the speeds that are typically observed under normal conditions for that particular roadway, catering to the vast majority of motorists. The design of curves on roadways should be based on the appropriate relationship between design speed and curvature, considering their combined influence on super elevation (roadway banking) and side friction. On curves that are not super elevated, it is still possible to travel at different speeds by employing appropriate amounts of side friction to sustain varying lateral acceleration. Transportation Officials. (2011).

2.2.5.1 Super elevation:

The research findings showed that in the case of a basic horizontal curve, the highest permissible degree of superelevation on a downward slope is 12%. In situations where the maximum superelevation rate surpasses 12%, it is advised to employ a spiral curve transition. For inclines of 4% and beyond, the utmost allowable superelevation rate should be restricted to 9% for minimal-radius curves under specific conditions. Torbic, D. J., Donnell, E. T., Brennan, S. N., Brown, A., O’Laughlin, M. K., & Bauer, K. M. (2014).

2.2.5.2 Side Friction Factor:

The side friction factor corresponds to the vehicle's requirement for side friction, also known as the side friction demand. It represents the lateral acceleration (a_f) exerted on the vehicle. This acceleration can be calculated by multiplying the side friction demand factor (*f*) by the gravitational constant (g) (i.e., $a_f = f_g$). It is important to note that the actual lateral acceleration experienced by vehicle occupants tends to be slightly greater than what is predicted by the product of f and g, primarily due to the angle of vehicle body roll.

$$f = \frac{V^2}{127R} - 0.01e \qquad \text{Eq 2.1}$$

This equation is referred to as the simplified curve formula and yields slightly estimates of friction demand than would be obtained using the basic curve formula.

2.2.5.3 Normal Cross Slope:

The minimum rate of cross slope for the traveled way is established based on drainage requirements. Depending on the highway type and the level of precipitation, including rainfall, snow, and ice, the generally accepted minimum values for cross slope vary between 1.5 percent and 2.0 percent.

2.2.5.4 Maximum Super-Elevation Rates for Streets and Highways:

Four factors govern the maximum rates of super elevation applied to highways: climate conditions (such as snow and ice frequency and amount), terrain conditions (flat, rolling, or mountainous), the type of area (rural or urban), and the presence of slow-moving vehicles that could be affected by high super elevation rates. Considering these factors collectively, it can be concluded that no single maximum super elevation rate is universally applicable.

The most commonly used super elevation rate for highways is 10 percent, although 12 percent is employed in specific cases. Super elevation rates exceeding 8 percent are limited to areas unaffected by snow and ice.

2.2.5.5 Design Super-Elevation Tables:

Tables 2.5 display the minimum values of R (radius) for different combinations of super elevation and design speeds, encompassing a wide range of common design conditions. When utilizing one of these tables to determine the appropriate super elevation rate for a given radius, interpolation is not required. Instead, the super elevation rate should be determined from a radius that is equal to or slightly smaller than the radius provided in the table.

Table 2.5 Minimum Radii for Design Super-Elevation Rates, Design Speed, and e_{max} =8%:

Metric						
e **(%)**	V_d **= 20 km/h**	V_d **= 30 km/h**	V_d **= 40 km/h**	V_d **= 50 km/h**	V_d **= 60 km/h**	V_d **= 70 km/h**
	R **(m)**	***R*** **(m)**	***R*** **(m)**	***R*** **(m)**	***R*** **(m)**	***R*** **(m)**
NC	184	443	784	1090	1490	1970
RC	133	322	571	791	1090	1450
3	81	199	354	496	684	916
4	52	134	241	344	479	648
5	30	87	163	246	349	480
6	19	55	106	172	253	360
7	13	37	73	123	185	270
8	7	20	41	73	113	168

2.2.6 Vertical Alignment:

2.2.6.1 Terrain:

The alignment of roads and streets is influenced by the topography of the land they traverse. While topography affects the horizontal alignment, its impact on the vertical alignment is even more significant. Engineers typically categorize topography into three classifications based on terrain: level, rolling, and mountainous.

2.2.6.2 Grades:

The design of highways and streets aims to promote consistent and uniform operation. Design speeds are employed as a tool to achieve this objective by aligning various geometric aspects of the road or street. As discussed before, design speeds are used as a means toward this end by correlation of various geometric features of the road or street.

The impact of grades on truck speeds is more significant compared to the speeds of passenger cars. On flat sections of the highway, the average speed of trucks is similar to that of passenger cars. However, when trucks encounter downhill slopes, they typically increase their speed by up to 5 percent.

2.2.6.2.1 Control Grades for Design:

- **Maximum grades**—A design speed of 110 km/h [70 mph] is typically associated with maximum grades of around 5 percent, which are considered appropriate. When the design speed is 50 km/h [30 mph], the maximum grades generally range from 7 to 12 percent, depending on the terrain.

- **Minimum grades**—Typically, a minimum grade of 0.5 percent is considered appropriate, although grades as low as 0.30 percent can be used if the paved surface is accurately sloped and supported by a stable subgrade.

2.2.6.3 Vertical Curves:

2.2.6.3.1 Crest Vertical Curves:

The minimum lengths of crest vertical curves, determined by sight distance criteria, typically meet the requirements for safety, comfort, and aesthetic appeal. However, there is an exception in decision areas like ramp exit gores, where longer sight distances and, consequently, longer vertical curves should be incorporated.

Figure 2.3 depicts the parameters used to calculate the length of a parabolic crest vertical curve required to achieve a specific sight distance. The fundamental equations for determining the length of a crest vertical curve in relation to the algebraic grade difference and sight distance are as follows:

When S is less than L,

$$L = \frac{AS^2}{100(\sqrt{2h_1} + \sqrt{2h_2})^2} \qquad \text{... } Eq\ 2.2$$

When S is greater than L,

$$L = 2S - \frac{2000(\sqrt{h_1} + \sqrt{h_2})^2}{A} \qquad \text{... } Eq\ 2.3$$

Where in Eq 2.2	Where in Eq 2.3
L = length of vertical curve, m	L = length of vertical curve, ft
A = algebraic difference in grades, percent	A = algebraic difference in grades, percent
S = sight distance, m	S = sight distance, ft
h_1 = height of eye above roadway surface, m	h_1 = height of eye above roadway surface, ft
h_2 = height of object above roadway surface, m	h_2 = height of object above roadway surface, ft

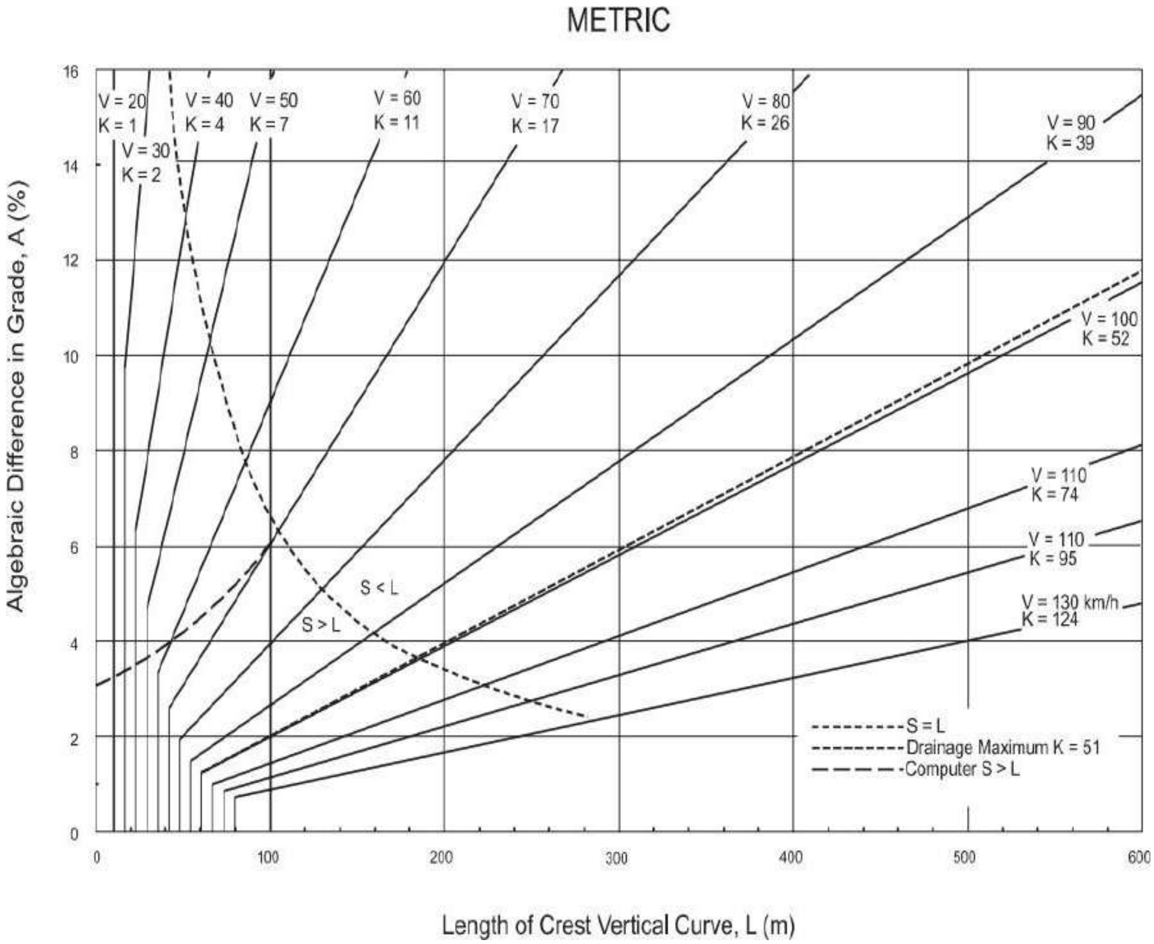


Figure 2.2 Design Controls for Crest Vertical Curve- Open Road Condition (AASHTO)

Table 2.6 Design Controls for Crest Vertical Curve Based on Stopping Sight Distance:

Metric			
Design Speed (km/h)	**Stopping Sight Distance (m)**	**Rate of Vertical Curvature, K^a**	
		Calculated	**Design**
20	20	0.6	1
30	35	1.9	2
40	50	3.8	4
50	65	6.4	7
60	85	11	11
70	105	16.8	17
80	130	25.7	26
90	160	38.9	39
100	185	52	52
110	220	73.6	74

2.2.6.3.2 Sag Vertical Curves:

There are several criteria recognized, to some extent, for establishing the lengths of sag vertical curves. These criteria include headlight sight distance, passenger comfort, drainage control, and general appearance.

Headlight sight distance is commonly used by certain agencies and forms the basis for determining the recommended length of sag vertical curves. During nighttime travel over a sag vertical curve, the illuminated portion of the highway ahead depends on the position of the headlights and the direction of the light beam. It is typically assumed that the headlights are positioned at a height of 0.60 m [2 ft] and that the light beam diverges upward by 1 degree from the longitudinal axis of the vehicle. The resulting lengths of sag vertical curves for the recommended stopping sight distances for each design speed are shown in Figure 2.4 with solid lines using rounded values of K as was done for crest vertical curves.

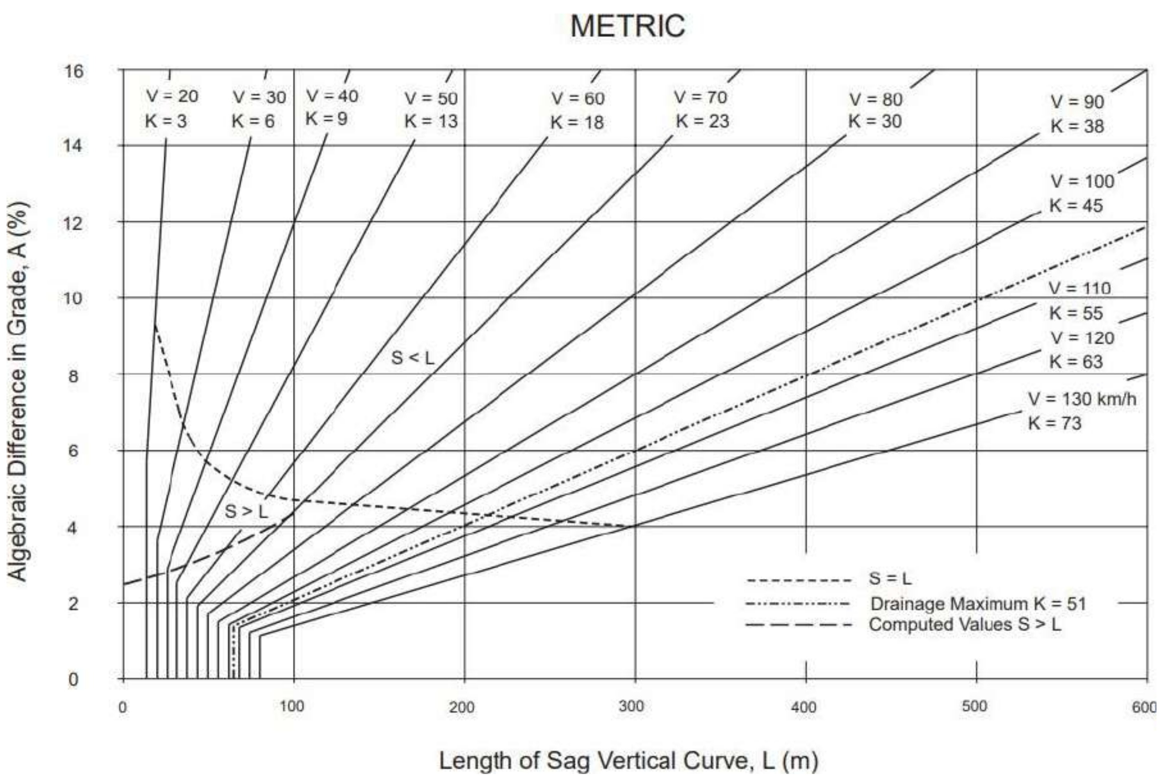


Figure 2.3 Design Controls for Crest Vertical Curve- Open Road Condition (AASHTO)

Table 2.7 Design Controls for Sag Vertical Curves:

Metric			
Design Speed (km/h)	**Stopping Sight Distance (m)**	**Rate of Vertical Curvature, K^a**	
		Calculated	**Design**
20	20	2.1	3
30	35	5.1	6
40	50	8.5	9
50	65	12.2	13
60	85	17.3	18
70	105	22.6	23
80	130	29.4	30
90	160	37.6	38
100	185	44.6	45
110	220	54.4	55

2.2.7 Safety:

Every year more than 1.2 million people are being killed by traffic accidents throughout the world, from which 70 percent happens in developing countries. Eftekharzadeh, S. F., & Khodabakhshi, A. (2014). Roadway design prioritizes safety above all else. Hence, any suggested guidelines must lead to designs that avoid producing hazards or perilous situations. In cases where there are slight decreases in available stopping sight distance, crest curves on rural high-speed highways do not exhibit any discernible safety issues. Fambro, D. B., Fitzpatrick, K., & Koppa, R. J. (2000).

2.2.8 Drainage:

The effects related to roads typically stem from the accumulation of both surface runoff and subsurface discharge that is intercepted. The concentration of drainage from roads can lead to different geomorphic consequences: Firstly, a rise in discharge might not show any distinct geomorphic effect, Secondly, the increased discharge could be adequate to start or expand a channel, or lastly, the focused discharge might add to slope instability beneath the drainage exit. Montgomery, D. R. (1994).

2.2.9 Design Life:

The design life of paved LVRs is usually set at 10 or 15 years. The traffic for which a road is designed should be such that it is not significantly under-designed at the end of its design life or overdesigned at the beginning. Thus, the traffic at mid-life is used for geometric design. However, the most important property for geometric design is usually the capacity of a road, but this is not a major issue for LVRs because the traffic level is generally too low for congestion to be a problem. Roads Authority Malawi (2020).

2.2.10 Survey Methods:

The most common types of surveys for counting and classifying the traffic in each class are:

- Manual and Automatic Traffic Survey
- Moving Observer Methods

Although the methods of traffic counting may vary, the objective of each method remains the same, essentially to obtain an estimate of the Annual Average Daily Traffic (AADT) using the road, disaggregated by vehicle type. Prediction of such traffic is notoriously imprecise, especially where the roads serve a predominantly developmental or social function and when the traffic level is low. Roads Authority Malawi (2020).

2.3 Tools Used for Geometric Design:

2.3.1 Autodesk Civil 3D:

In 2004, the software was initially launched as an independent product, and over time, it has transformed into a collection of tools and functionalities integrated into the broader Autodesk environment. Civil 3D aims to provide engineers with a means to apply design norms throughout the design phase, while also effectively automating the creation of project deliverables and minimizing the time required to adapt to project changes as they unfold. (Autodesk, n.d.).

AutoCAD Civil 3D is a software tool utilized by civil engineers to plan and design construction projects like buildings, roads, and water-related structures. It combines design and drafting, allowing rapid modifications and scenario assessments across the entire project. This application enables efficient creation of 3D models for projects of various sizes, aiding visualization and cost savings. A highway design example demonstrates the software's ability for swift and accurate geometric layouts, highlighting how it outperforms manual methods prone to errors and inefficiencies. Chakole, H., & Wadhai, P. J. (2022).

CHAPTER 3

3.1 Methodology:

A methodology refers to the systematic approach or set of methods and procedures used to conduct the study and gather data to execute a project. It is a critical component of any project as it provides a clear and transparent framework for how the project will be carried out, ensuring the reliability and validity of the findings. Our methodology involved the collection, arrangement, transfer, and analysis of spatial data as well as carrying out the geometric design of road using that spatial data.

3.1.1 Data collection:

3.1.1.1 Location of Site:

As an initial step, a location survey was conducted. The site, where the geometric design of the road was to be implemented, was visited to gather crucial data and insights. The site is situated at a distance of 27.3 km from Quetta city, making it an essential link connecting the city to the picturesque Spin Karez park.

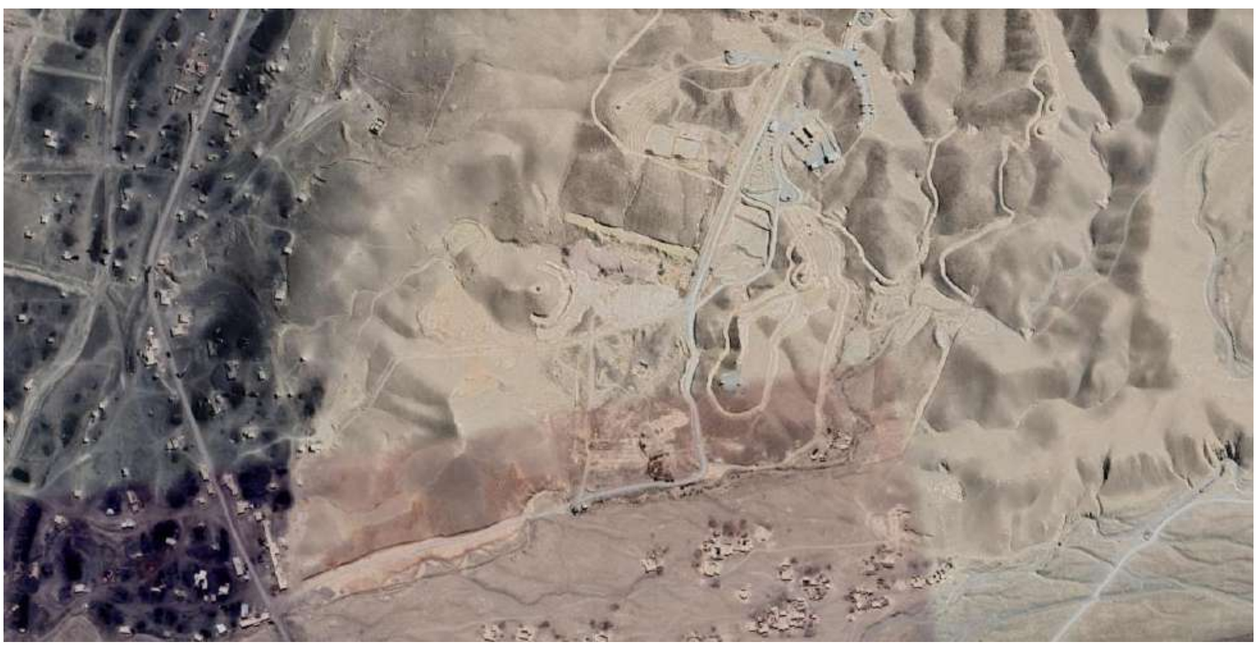


Figure 3.1 Spin Karez Park Location on Google map Northing: 319420.5; Easting: 3345553

3.1.1.2 Reconnaissance Survey:

During the reconnaissance survey, the research team thoroughly assessed the site's geographical features and natural terrain. The primary objective was to gain an in-depth understanding of the landscape, identifying any significant geographical challenges that may impact the road's alignment and construction. The survey took into account factors such as elevations, slopes, water bodies, and geological characteristics.

3.1.1.3 Traffic Survey:

An approximate traffic survey was conducted to gather data on traffic conditions in the area. The approximate traffic survey involved visual observations and manual traffic counts at key locations along the route. Observers were stationed at strategic points to record the number of vehicles passing through during specific time intervals.

3.1.1.4 Construction Survey:

1. **Accessing coordinates:**

The Polaris GPS Navigation system provided real-time access to global positioning satellite (GPS) data. The data collected through Polaris GPS Navigation ensured precise location mapping, contributing to a high level of accuracy in the overall survey results.

2. **Bench mark:**

The first crucial step in the survey process was the establishment of permanent benchmarks at strategic locations. To ensure accuracy and consistency in the subsequent measurements, a benchmark was prominently marked at the starting point of the route. The value of benchmark ‘bm’ elevation is 1948.34m.

3. **Collection of data from various critical points along the route:**

The use of a Total Station, an advanced electronic theodolite integrated with an electronic distance measuring (EDM) instrument, further enhanced the survey's precision. The surveying team meticulously collected data at various key points along the route, including critical intersections, turning areas, and potential development sites. The ‘sh’ in the collected survey data is the name given to a specific point of surface obtained from using Total Station. The gathered data with the use of total station is given in the table below:

Table 3.1 Collected Survey Data:

Points	Northing	Easting	Elevation	Description
1	319420.5	3345553	1948.34	bm
2	319444.3	3345546	1947.924	sh
3	319433	3345544	1947.968	sh
4	319430.4	3345543	1947.89	sh
5	319453.4	3345550	1947.91	sh
6	319458.2	3345552	1948.07	sh
7	319458.2	3345509	1949.04	sh
8	319448.8	3345509	1948.81	sh
9	319446.1	3345509	1948.88	sh
10	319460.5	3345513	1949.02	sh
11	319467	3345515	1950.57	sh
12	319473.2	3345459	1951.29	sh
13	319467.6	3345458	1951.08	sh
14	319464.4	3345457	1951.1	sh
15	319475.8	3345458	1951.42	sh
16	319482	3345459	1953.64	sh
17	319481.2	3345397	1953.98	sh
18	319477	3345396	1954.09	sh
19	319469.5	3345395	1954.01	sh
20	319487.7	3345396	1954.26	sh
21	319494.8	3345397	1956.79	sh
22	319490.1	3345322	1957.43	sh
23	319486.2	3345323	1957.31	sh
24	319479.8	3345322	1956.799	sh
25	319492.4	3345322	1957.47	sh
26	319499.6	3345322	1959.85	sh
27	319495.1	3345254	1958.88	sh
28	319490.3	3345253	1958.75	sh
29	319484	3345253	1958.56	sh
30	319496.8	3345255	1958.85	sh
31	319504.5	3345214	1958.6	sh
32	319500.9	3345256	1960.99	sh
33	319506.1	3345215	1958.63	sh
34	319499.1	3345215	1958.566	sh
35	319496.6	3345214	1958.42	sh
36	319506.1	3345215	1958.65	sh
37	319511.3	3345216	1960.37	sh
38	319502.8	3345185	1959.73	sh
39	319498.9	3345185	1959.9	sh
40	319494.4	3345185	1960.06	sh
41	319510.4	3345187	1959.67	sh
42	319513	3345122	1962.67	sh
43	319516.1	3345122	1962.69	sh
44	319520.3	3345122	1963.14	sh

45	319510.2	3345122	1962.62	sh
46	319507.5	3345121	1963.04	sh
47	319509.1	3345016	1966.92	sh
48	319507.3	3345016	1966.92	sh
49	319506	3345016	1966.93	sh
50	319513.2	3345015	1967.19	sh
51	319519.6	3345015	1965.32	sh
52	319516.9	3344981	1969.877	sh
53	319512.9	3344981	1969.91	sh
54	319509.4	3344980	1969.96	sh
55	319521.3	3344984	1969.75	sh
56	319524	3344989	1968.67	sh
57	319587.3	3344980	1973.77	sh
58	319587.9	3344985	1973.71	sh
59	319588	3344986	1973.55	sh
60	319587.1	3344977	1973.8	sh
61	319587.1	3344977	1974.22	sh
62	319614.7	3344985	1975.54	sh
63	319613.6	3344991	1975.51	sh
64	319615.6	3344983	1975.59	sh
65	319628.6	3344985	1975.28	sh
66	319629.7	3344990	1975.27	sh
67	319617.3	3344980	1978.34	sh
68	319650.7	3344975	1974.76	sh
69	319631.1	3344992	1975.37	sh
70	319651.8	3344978	1974.75	sh
71	319653.5	3344981	1974.77	sh
72	319649.3	3344973	1974.9	sh
73	319648	3344970	1976.09	sh
74	319682.1	3344969	1975.36	sh
75	319682.1	3344973	1975.37	sh
76	319682.6	3344967	1975.44	sh
77	319681.7	3344975	1975.37	sh
78	319682.7	3344965	1977.37	sh
79	319703.5	3344968	1976.92	sh
80	319702.5	3344964	1977.07	sh
81	319703.5	3344973	1976.82	sh
82	319703	3344978	1976.84	sh
83	319701.8	3344962	1979.22	sh
84	319774.2	3344940	1977.4	sh
85	319771	3344935	1977.64	sh
86	319775.6	3344943	1977.41	sh
87	319806.1	3344924	1982.41	sh
88	319808.6	3344926	1982.56	sh
89	319810.1	3344930	1982.72	sh
90	319804.6	3344921	1982.35	sh

91	319802.4	3344917	1982.26	sh
92	319868.1	3344885	1991.8	sh
93	319869.9	3344888	1992	sh
94	319871.9	3344891	1992.75	sh
95	319864.4	3344879	1991.85	sh
96	319862.8	3344877	1991.83	sh
97	319986.8	3344799	2005.08	sh
98	319989.6	3344805	2004.81	sh
99	319991.4	3344808	2005.14	sh
100	319984.5	3344796	2005.028	sh
101	319982.9	3344793	2005.01	sh
102	320008.9	3344766	2007.41	sh
103	320014.9	3344765	2007.92	sh
104	320020.4	3344764	2007.71	sh
105	320002.9	3344768	2007.007	sh
106	320000.2	3344769	2006.855	sh
107	319994.9	3344734	2010.88	sh
108	319998.7	3344732	2010.87	sh
109	320002	3344732	2010.8	sh
110	319987.7	3344734	2010.66	sh
111	319983.8	3344736	2010.63	sh
112	320005.8	3344713	2012.85	sh
113	320007.3	3344717	2012.78	sh
114	320008.6	3344721	2012.23	sh
115	320005.4	3344713	2012.83	sh
116	320005.2	3344710	2013.91	sh
117	320000.9	3344712	2012.81	sh
118	320034.1	3344701	2015.24	sh
119	320034.8	3344703	2015.19	sh
120	320034.8	3344698	2015.4	sh
121	320048.1	3344691	2015.7	sh
122	320045.8	3344691	2015.59	sh
123	320043.9	3344690	2015.68	sh
124	320018.4	3344689	2014.57	sh
125	320021.4	3344688	2014.71	sh
126	320015.8	3344690	2014.55	sh

3.1.1.5 Selected Alignment:

To arrive at the optimal alignment, a comprehensive analysis was undertaken, considering various potential routes. Factors such as terrain conditions, environmental impact, accessibility, and safety were carefully assessed to narrow down the options. The culmination of this thorough evaluation led to the identification of the yellow line, which now marks the chosen alignment.

Figure 3.2 Selected Alignment for Spin Karez Park Road Northing: 319420.5; Easting: 3345553

3.1.2 Designing on Civil 3D:

The design and planning of road were done using Civil 3D 2023.

1. **Importing Survey Points:**

The first step in importing survey points to Civil 3D involved ensuring the compatibility of the survey data format with the software. Once the data was in the appropriate format, it was imported into Civil 3D. Next, the imported survey points were processed and organized within Civil 3D.

2. **Create Existing Surface Conditions:**

The road design process commenced with the creation of an existing surface model. This crucial step serves as the foundation for further design and analysis of the new roadway. Existing data pertaining to topography, utilities, and other potential impacts on the route design were diligently collected and integrated into specialized software to generate an accurate representation of the current surface conditions.

3. **Design Alignment**

This crucial stage involves defining the main horizontal route, which serves as the construction baseline for the roadway. The design alignment is instrumental in determining the precise direction of the road, taking into account factors such as terrain, topography, and existing infrastructure.

4. **Generation of Existing Ground Profile and Design Grades:**

The survey data was carefully analyzed and displayed, providing a clear representation of the current ground surface conditions. This data formed the basis for creating the finished grades, which define the desired elevation and slope of the road after construction. Using specialized profile creation tools, the team graphically developed the finished grade profiles. These profiles depicted the elevation changes along the road alignment, showing the transition from the existing ground level to the desired finished road surface.

5. **Construction of Assemblies:**

The construction of assemblies was undertaken to define the cross-sectional components of the road design. The construction of assemblies involved connecting individual subassembly objects to form a comprehensive representation of the road's cross-section. Each subassembly object represents a specific component of the road, such as the pavement, curb, sidewalk, and drainage features. By connecting these subassemblies, the team was able to establish the desired road profile and layout.

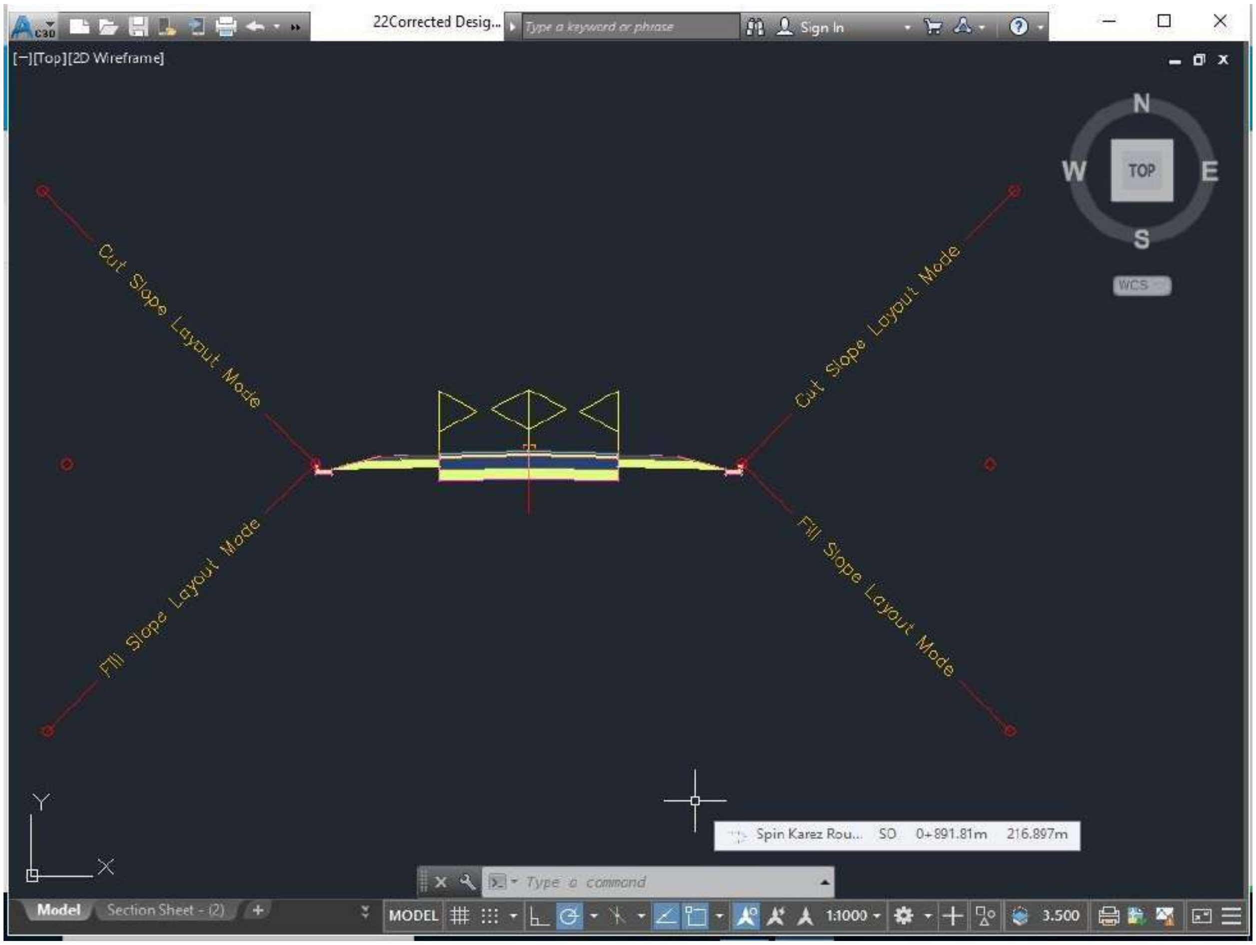


Figure 3.3 Assembly created for Spin Karez Road in Civil 3D

6. Creating the Corridor:

The creation of the corridor was undertaken to develop a dynamic 3D model representation of the road design. Corridors play a central role in visualizing and analyzing the road's alignment and geometry in three dimensions. The corridor serves as a comprehensive and dynamic model that combines horizontal, vertical, and cross-sectional design elements to accurately represent the road's layout and features. It integrates the data from the design alignment, finished grade profiles, and construction assemblies, resulting in a complete depiction of the road's cross-sectional components and their interaction with the surrounding terrain. It facilitates earthwork calculations and quantity takeoffs, helping to estimate the materials required for construction and assess the overall project costs.

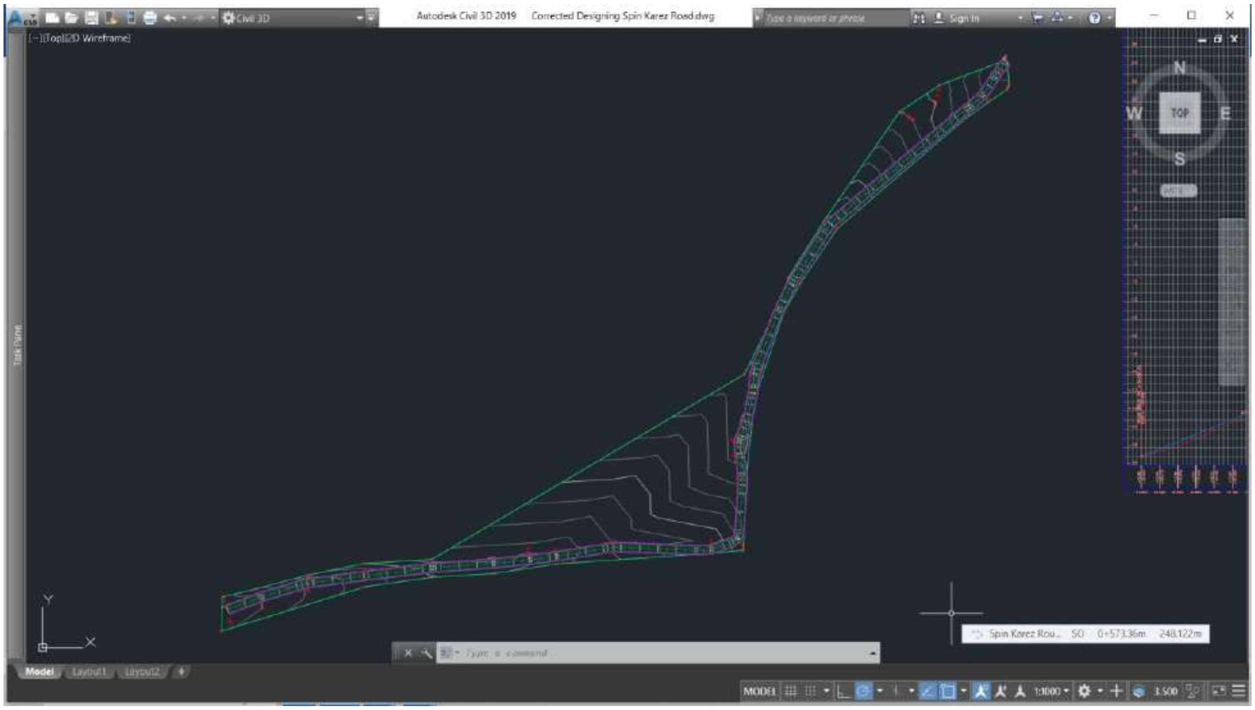


Figure 3.4 Corridor Created using Civil 3D

CHAPTER 4

Results and Discussion:

4.1 Results:

4.1.1 Corridor Generated:

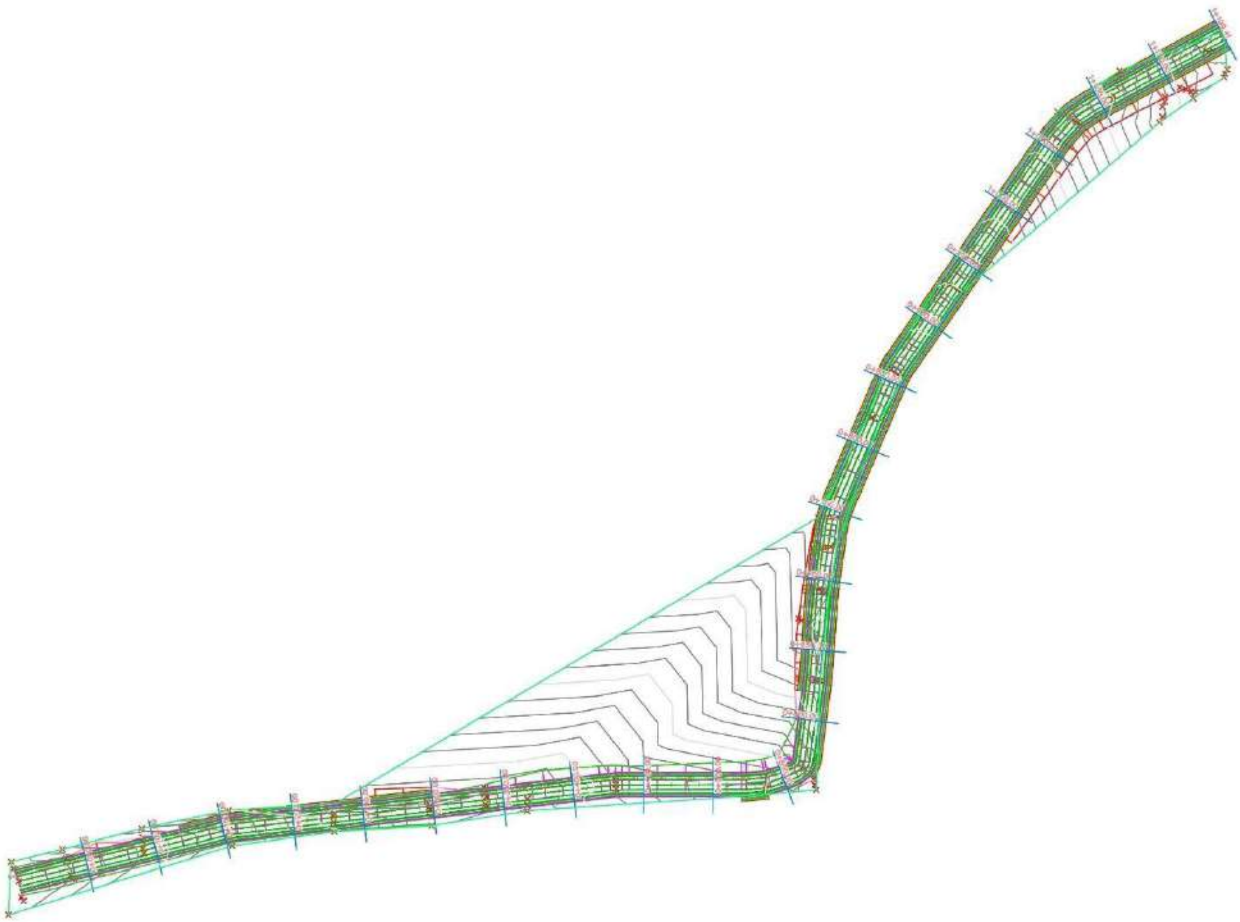


Figure 4.1 Spin Karez Road Corridor generated on Civil 3D

4.1.2 Created Assembly:

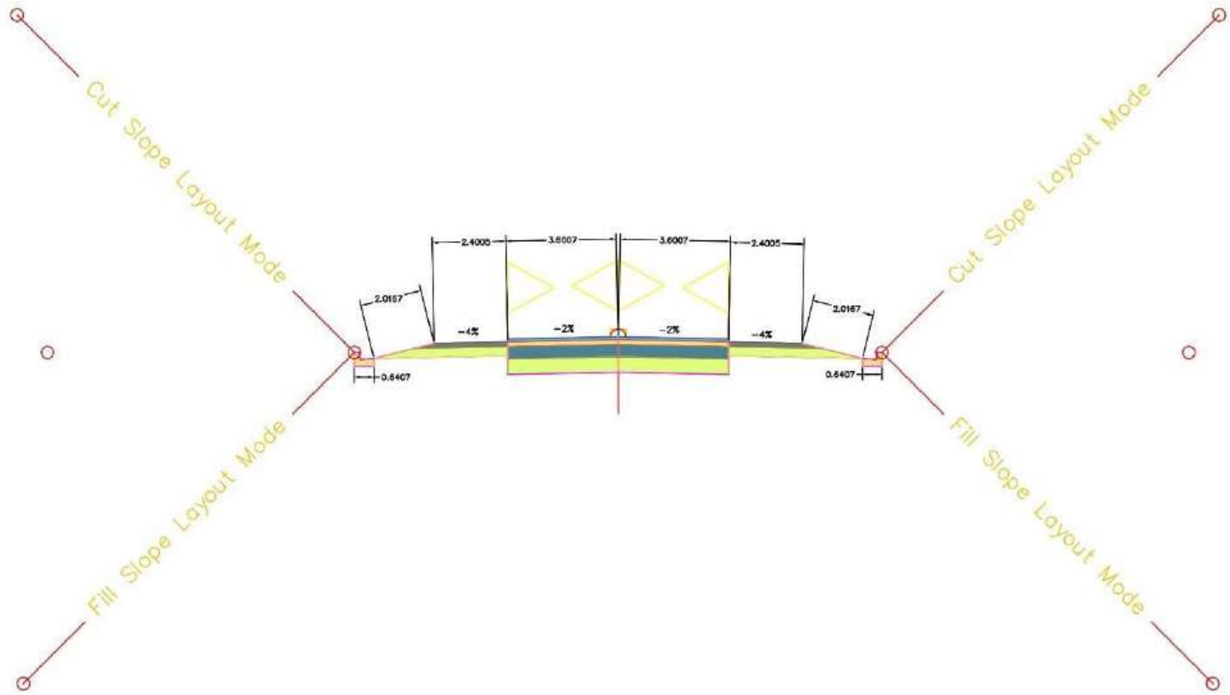


Figure 4.2 Assembly created for Spin Karez Road on Civil 3D

4.1.3 Profile Designed:

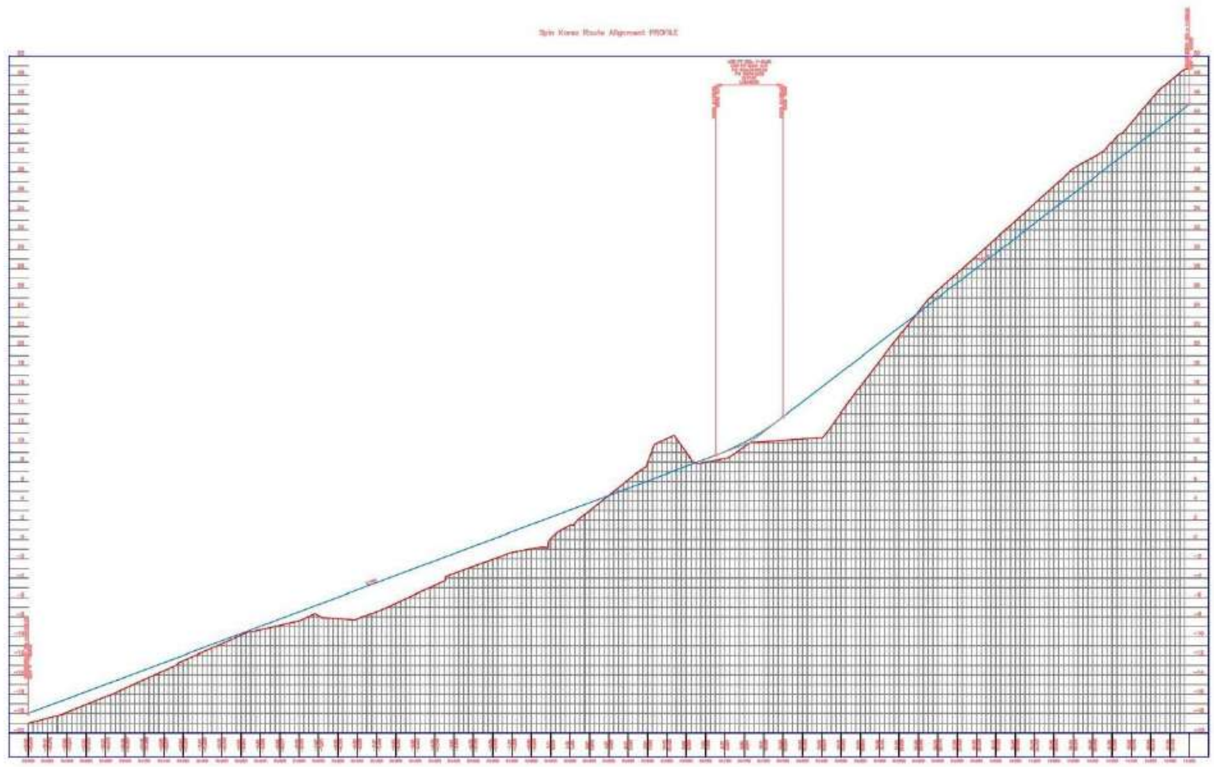
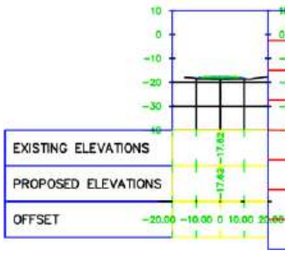


Figure 4.3 Profile Designed for Spin Karez Road on Civil 3D

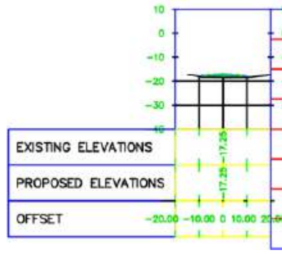
4.1.4 Cross-Sections:

0+010.00



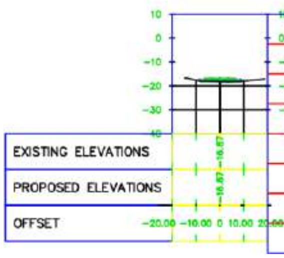
Total Volume at Station 0+010.00	
Cut Area	0.00
Fill Area	13.99
Cut Vol	0.00
Fill Vol	0.00
Cum Cut Vol	0.00
Cum Fill Vol	0.00
Net Vol	0.00

0+020.00



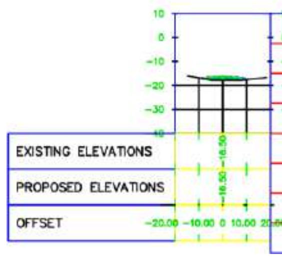
Total Volume at Station 0+020.00	
Cut Area	0.00
Fill Area	15.70
Cut Vol	0.00
Fill Vol	148.49
Cum Cut Vol	0.00
Cum Fill Vol	148.49
Net Vol	-148.49

0+030.00



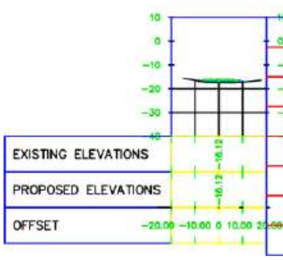
Total Volume at Station 0+030.00	
Cut Area	0.00
Fill Area	17.79
Cut Vol	0.00
Fill Vol	167.49
Cum Cut Vol	0.00
Cum Fill Vol	315.99
Net Vol	-315.99

0+040.00



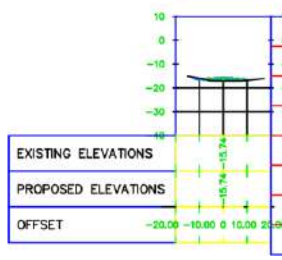
Total Volume at Station 0+040.00	
Cut Area	0.00
Fill Area	17.91
Cut Vol	0.00
Fill Vol	178.51
Cum Cut Vol	0.00
Cum Fill Vol	494.50
Net Vol	-494.50

0+050.00



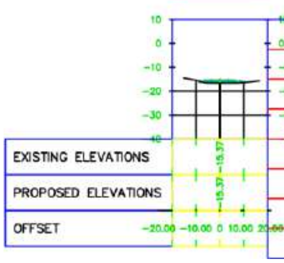
Total Volume at Station 0+050.00	
Cut Area	0.00
Fill Area	17.11
Cut Vol	0.02
Fill Vol	175.10
Cum Cut Vol	0.02
Cum Fill Vol	669.59
Net Vol	-669.57

0+060.00



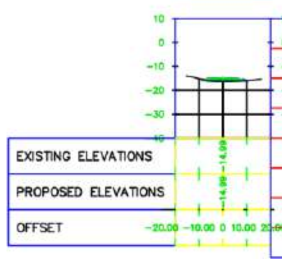
Total Volume at Station 0+060.00	
Cut Area	0.01
Fill Area	16.73
Cut Vol	0.06
Fill Vol	169.23
Cum Cut Vol	0.08
Cum Fill Vol	838.82
Net Vol	-838.74

0+070.00



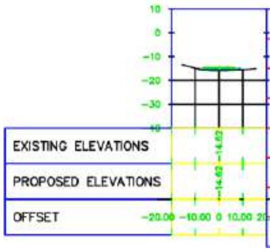
Total Volume at Station 0+070.00	
Cut Area	0.00
Fill Area	16.41
Cut Vol	0.05
Fill Vol	165.70
Cum Cut Vol	0.12
Cum Fill Vol	1004.52
Net Vol	-1004.40

0+080.00



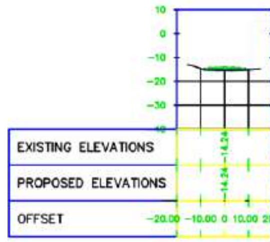
Total Volume at Station 0+080.00	
Cut Area	0.00
Fill Area	16.01
Cut Vol	0.00
Fill Vol	162.06
Cum Cut Vol	0.13
Cum Fill Vol	1166.58
Net Vol	-1166.45

0+090.00



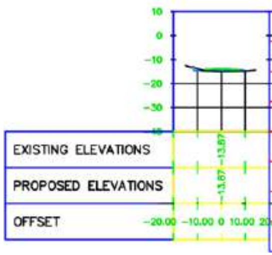
Total Volume at Station 0+090.00	
Cut Area	0.00
Fill Area	15.60
Cut Vol	0.00
Fill Vol	158.04
Cum Cut Vol	0.13
Cum Fill Vol	1324.61
Net Vol	−1324.49

0+100.00



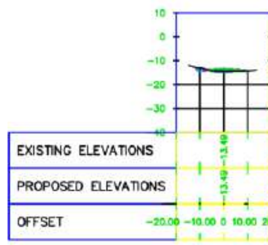
Total Volume at Station 0+100.00	
Cut Area	0.00
Fill Area	14.40
Cut Vol	0.00
Fill Vol	150.01
Cum Cut Vol	0.13
Cum Fill Vol	1474.62
Net Vol	−1474.50

0+110.00



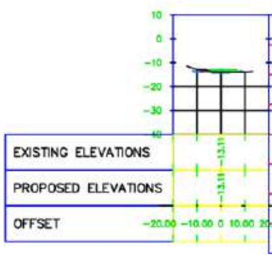
Total Volume at Station 0+110.00	
Cut Area	0.02
Fill Area	13.03
Cut Vol	0.12
Fill Vol	137.18
Cum Cut Vol	0.24
Cum Fill Vol	1611.80
Net Vol	−1611.55

0+120.00



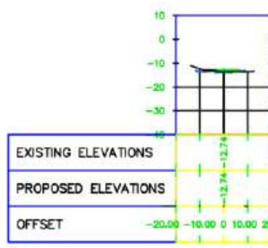
Total Volume at Station 0+120.00	
Cut Area	0.47
Fill Area	11.26
Cut Vol	2.49
Fill Vol	121.50
Cum Cut Vol	2.73
Cum Fill Vol	1733.29
Net Vol	−1730.57

0+130.00



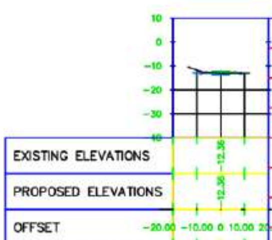
Total Volume at Station 0+130.00	
Cut Area	1.06
Fill Area	9.21
Cut Vol	7.68
Fill Vol	102.38
Cum Cut Vol	10.41
Cum Fill Vol	1835.67
Net Vol	−1825.26

0+140.00



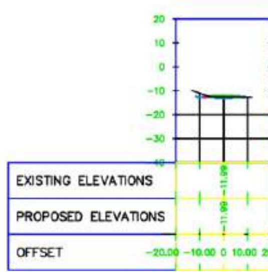
Total Volume at Station 0+140.00	
Cut Area	0.62
Fill Area	7.26
Cut Vol	8.44
Fill Vol	82.36
Cum Cut Vol	18.85
Cum Fill Vol	1918.03
Net Vol	−1899.18

0+150.00



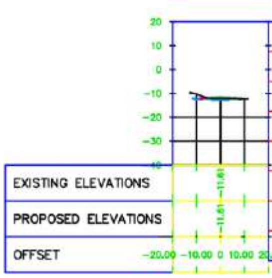
Total Volume at Station 0+150.00	
Cut Area	0.37
Fill Area	6.62
Cut Vol	4.99
Fill Vol	69.38
Cum Cut Vol	23.84
Cum Fill Vol	1987.41
Net Vol	−1963.58

0+160.00



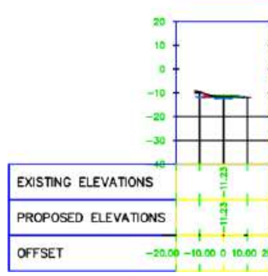
Total Volume at Station 0+160.00	
Cut Area	0.74
Fill Area	5.84
Cut Vol	6.06
Fill Vol	61.68
Cum Cut Vol	29.90
Cum Fill Vol	2049.09
Net Vol	−2019.19

0+170.00



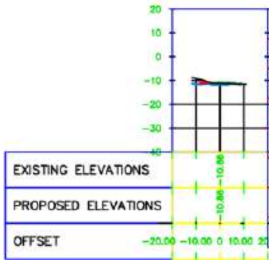
Total Volume at Station 0+170.00	
Cut Area	1.38
Fill Area	4.85
Cut Vol	10.63
Fill Vol	53.45
Cum Cut Vol	40.53
Cum Fill Vol	2102.54
Net Vol	−2062.01

0+180.00



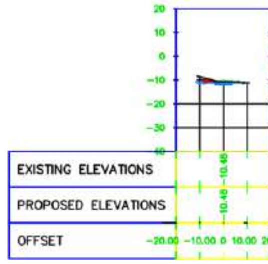
Total Volume at Station 0+180.00	
Cut Area	2.32
Fill Area	3.89
Cut Vol	18.52
Fill Vol	43.69
Cum Cut Vol	59.04
Cum Fill Vol	2146.23
Net Vol	−2087.19

0+190.00



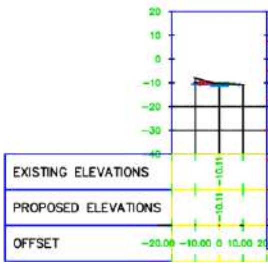
Total Volume at Station 0+190.00	
Cut Area	3.55
Fill Area	3.11
Cut Vol	29.34
Fill Vol	35.00
Cum Cut Vol	88.38
Cum Fill Vol	2181.23
Net Vol	−2092.85

0+200.00



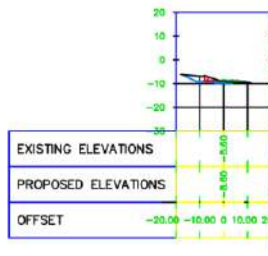
Total Volume at Station 0+200.00	
Cut Area	4.82
Fill Area	2.36
Cut Vol	41.84
Fill Vol	27.32
Cum Cut Vol	130.23
Cum Fill Vol	2208.55
Net Vol	−2078.33

0+210.00



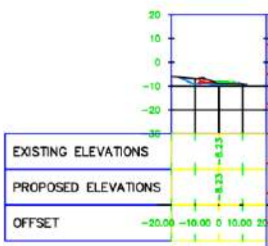
Total Volume at Station 0+210.00	
Cut Area	6.07
Fill Area	1.79
Cut Vol	54.47
Fill Vol	20.71
Cum Cut Vol	184.70
Cum Fill Vol	2229.26
Net Vol	−2044.56

0+250.00



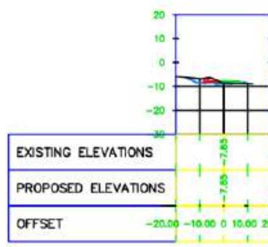
Total Volume at Station 0+250.00	
Cut Area	7.18
Fill Area	4.83
Cut Vol	68.77
Fill Vol	40.81
Cum Cut Vol	455.49
Cum Fill Vol	2329.28
Net Vol	−1873.80

0+260.00



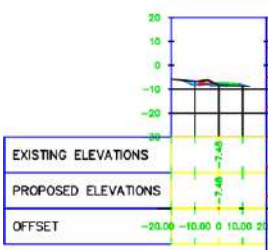
Total Volume at Station 0+260.00	
Cut Area	7.53
Fill Area	6.21
Cut Vol	73.56
Fill Vol	55.19
Cum Cut Vol	529.04
Cum Fill Vol	2384.48
Net Vol	−1855.43

0+270.00



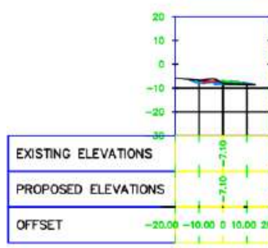
Total Volume at Station 0+270.00	
Cut Area	7.46
Fill Area	7.14
Cut Vol	74.92
Fill Vol	66.72
Cum Cut Vol	603.96
Cum Fill Vol	2451.20
Net Vol	−1847.24

0+280.00



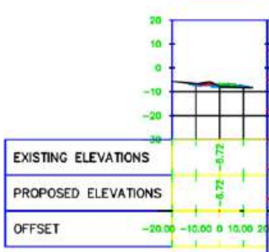
Total Volume at Station 0+280.00	
Cut Area	6.98
Fill Area	7.88
Cut Vol	72.17
Fill Vol	75.08
Cum Cut Vol	676.12
Cum Fill Vol	2526.28
Net Vol	−1850.15

0+290.00



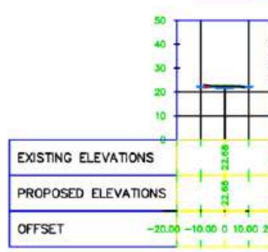
Total Volume at Station 0+290.00	
Cut Area	6.08
Fill Area	8.64
Cut Vol	65.30
Fill Vol	82.58
Cum Cut Vol	741.43
Cum Fill Vol	2608.85
Net Vol	−1867.42

0+300.00



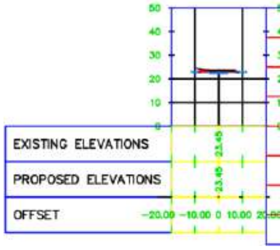
Total Volume at Station 0+300.00	
Cut Area	4.00
Fill Area	10.53
Cut Vol	50.44
Fill Vol	95.82
Cum Cut Vol	791.86
Cum Fill Vol	2704.68
Net Vol	−1912.81

0+910.00



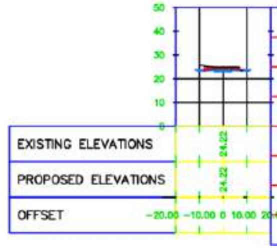
Total Volume at Station 0+910.00	
Cut Area	1.16
Fill Area	2.97
Cut Vol	7.37
Fill Vol	64.32
Cum Cut Vol	2998.50
Cum Fill Vol	17293.25
Net Vol	−14294.74

0+920.00



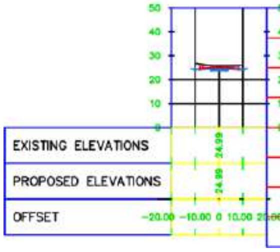
Total Volume at Station 0+920.00	
Cut Area	5.76
Fill Area	0.00
Cut Vol	34.59
Fill Vol	14.86
Cum Cut Vol	3033.10
Cum Fill Vol	17308.11
Net Vol	−14275.01

0+930.00



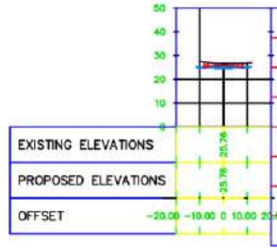
Total Volume at Station 0+930.00	
Cut Area	13.20
Fill Area	0.00
Cut Vol	94.81
Fill Vol	0.00
Cum Cut Vol	3127.91
Cum Fill Vol	17308.11
Net Vol	−14180.20

0+940.00



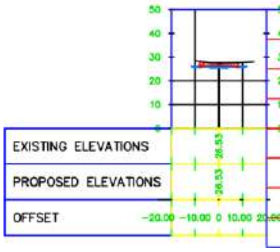
Total Volume at Station 0+940.00	
Cut Area	17.11
Fill Area	0.00
Cut Vol	151.59
Fill Vol	0.00
Cum Cut Vol	3279.49
Cum Fill Vol	17308.11
Net Vol	−14028.61

0+950.00



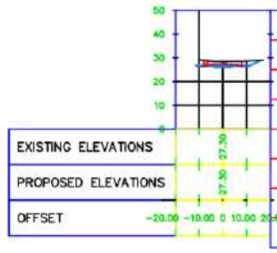
Total Volume at Station 0+950.00	
Cut Area	18.86
Fill Area	0.00
Cut Vol	179.86
Fill Vol	0.00
Cum Cut Vol	3459.35
Cum Fill Vol	17308.11
Net Vol	−13848.75

0+960.00



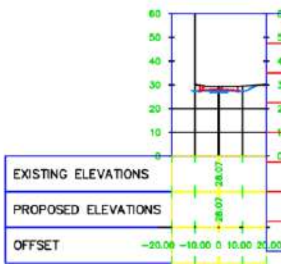
Total Volume at Station 0+960.00	
Cut Area	20.48
Fill Area	0.00
Cut Vol	196.68
Fill Vol	0.00
Cum Cut Vol	3656.03
Cum Fill Vol	17308.11
Net Vol	−13652.07

0+970.00



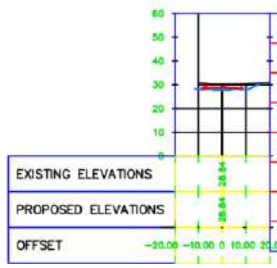
Total Volume at Station 0+970.00	
Cut Area	22.34
Fill Area	0.00
Cut Vol	214.10
Fill Vol	0.00
Cum Cut Vol	3870.13
Cum Fill Vol	17308.11
Net Vol	−13437.97

0+980.00



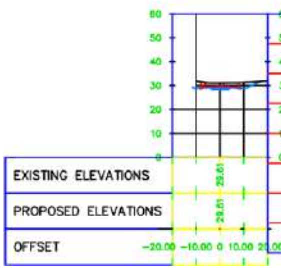
Total Volume at Station 0+980.00	
Cut Area	24.23
Fill Area	0.00
Cut Vol	232.87
Fill Vol	0.00
Cum Cut Vol	4103.00
Cum Fill Vol	17308.11
Net Vol	−13205.11

0+990.00



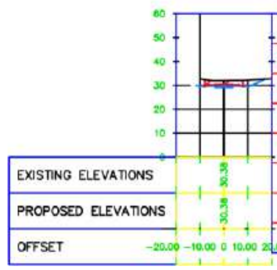
Total Volume at Station 0+990.00	
Cut Area	26.14
Fill Area	0.00
Cut Vol	251.86
Fill Vol	0.00
Cum Cut Vol	4354.86
Cum Fill Vol	17308.11
Net Vol	−12953.25

1+000.00



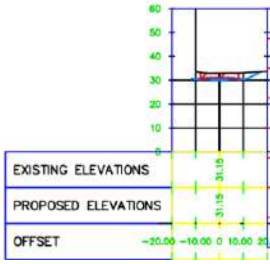
Total Volume at Station 1+000.00	
Cut Area	28.07
Fill Area	0.00
Cut Vol	271.07
Fill Vol	0.00
Cum Cut Vol	4625.93
Cum Fill Vol	17308.11
Net Vol	−12682.17

1+010.00



Total Volume at Station 1+010.00	
Cut Area	30.10
Fill Area	0.00
Cut Vol	290.89
Fill Vol	0.00
Cum Cut Vol	4916.82
Cum Fill Vol	17308.11
Net Vol	−12391.29

1+020.00

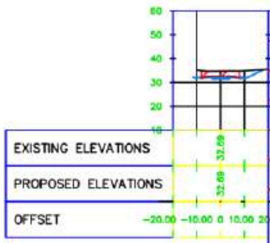


Total Volume at Station 1+020.00	
Cut Area	32.31
Fill Area	0.00
Cut Vol	312.04
Fill Vol	0.00
Cum Cut Vol	5228.86
Cum Fill Vol	17308.11
Net Vol	-12079.24

1+030.00

Total Volume at Station 1+030.00	
Cut Area	34.30
Fill Area	0.00
Cut Vol	333.05
Fill Vol	0.00
Cum Cut Vol	5561.92
Cum Fill Vol	17308.11
Net Vol	-11746.19

1+040.00

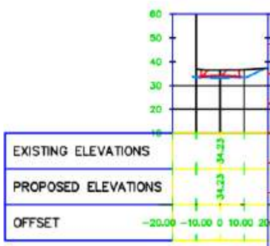


Total Volume at Station 1+040.00	
Cut Area	36.33
Fill Area	0.00
Cut Vol	353.16
Fill Vol	0.00
Cum Cut Vol	5915.07
Cum Fill Vol	17308.11
Net Vol	-11393.03

1+050.00

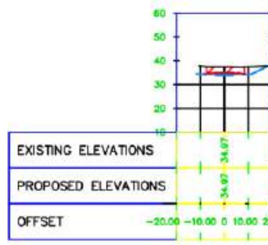
Total Volume at Station 1+050.00	
Cut Area	38.36
Fill Area	0.00
Cut Vol	373.45
Fill Vol	0.00
Cum Cut Vol	6288.53
Cum Fill Vol	17308.11
Net Vol	-11019.58

1+060.00



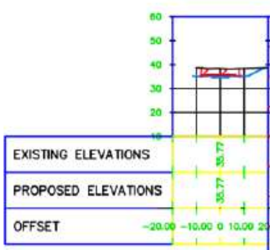
Total Volume at Station 1+060.00	
Cut Area	40.11
Fill Area	0.00
Cut Vol	392.39
Fill Vol	0.00
Cum Cut Vol	6680.92
Cum Fill Vol	17308.11
Net Vol	-10627.19

1+070.00



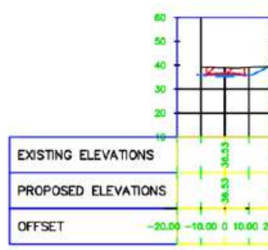
Total Volume at Station 1+070.00	
Cut Area	41.95
Fill Area	0.00
Cut Vol	409.25
Fill Vol	0.00
Cum Cut Vol	7090.17
Cum Fill Vol	17308.11
Net Vol	-10217.94

1+080.00



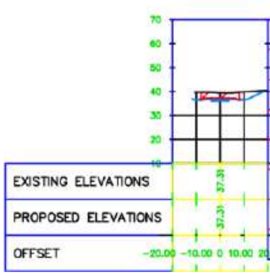
Total Volume at Station 1+080.00	
Cut Area	43.65
Fill Area	0.00
Cut Vol	427.29
Fill Vol	0.00
Cum Cut Vol	7517.45
Cum Fill Vol	17308.11
Net Vol	-9790.66

1+090.00



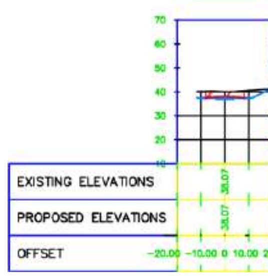
Total Volume at Station 1+090.00	
Cut Area	41.40
Fill Area	0.00
Cut Vol	425.59
Fill Vol	0.00
Cum Cut Vol	7943.04
Cum Fill Vol	17308.11
Net Vol	-9365.06

1+100.00



Total Volume at Station 1+100.00	
Cut Area	39.22
Fill Area	0.00
Cut Vol	403.23
Fill Vol	0.00
Cum Cut Vol	8346.28
Cum Fill Vol	17308.11
Net Vol	-8961.83

1+110.00



Total Volume at Station 1+110.00	
Cut Area	36.52
Fill Area	0.00
Cut Vol	378.74
Fill Vol	0.00
Cum Cut Vol	8725.01
Cum Fill Vol	17308.11
Net Vol	-8583.09

The project has resulted in a well-informed and comprehensive road infrastructure design that aligns with the research objectives and the needs of the local community and tourists. The findings emphasize the importance of effective road planning and design in promoting regional development, economic growth, and environmental stewardship. In addition to the findings of the study, there are a number of other factors that should be considered when designing low-volume roads in rural areas. These factors include:

- **The climate of the area:** The climate of the area will affect the design of the road, such as the type of pavement that is used.
- **The type of vehicles that are likely to use the road:** The design of the road should be able to accommodate the types of vehicles that are likely to use it, such as large trucks or agricultural vehicles.

- **The availability of materials and resources:** The design of the road should be feasible given the availability of materials and resources in the area.
- **The cultural and aesthetic preferences of the local community:** The design of the road should be compatible with the cultural and aesthetic preferences of the local community.

4.2 Discussions:

The findings of this research work hold significant potential in enhancing the geometric design of low-volume roads in rural areas, thereby promoting safer, more efficient, and sustainable transportation networks. By utilizing relevant design standards, engineers and planners can ensure that the road infrastructure is optimally engineered to handle the traffic demands of rural regions.

However, it is crucial to acknowledge certain limitations in the study. One notable limitation is that the research was conducted in a specific location, which may not represent the diverse conditions and challenges faced by other rural areas. Generalizing the findings to broader contexts should be approached with caution, and additional research in different regions may be necessary to account for varying geographic and cultural factors.

Moreover, while the study focuses on the geometric design aspects of low-volume roads, it did not extensively address the environmental impact of road construction and its subsequent effects on the surrounding ecosystem. Incorporating environmental assessments into the road design process is imperative to ensure sustainability and minimize adverse ecological consequences.

To address these limitations, future research efforts could expand the study to encompass multiple rural locations, thereby enhancing the generalizability of the findings. Additionally, conducting comprehensive environmental impact assessments in conjunction with geometric design considerations would facilitate a more holistic and environmentally conscious approach to road development.

CHAPTER 5

5.1 Conclusion:

In conclusion, the research work focused on enhancing the road infrastructure leading to Spin Karez park has yielded comprehensive and valuable insights. The proposed geometric design presents a well-planned and efficient road alignment that prioritizes safety, and functionality. The study's analysis and discussions revealed the successful integration of design criteria. Addressing potential shortcomings and incorporating necessary corrections ensured a refined and optimized road design that aligns with the needs and expectations of the local community and tourists visiting Spin Karez park.

Overall, the project's work provides valuable guidance for decision-makers, planners, and stakeholders involved in the road infrastructure development. By leveraging the research findings and insights, authorities can embark on a road project that not only enhances regional connectivity and economic growth but also prioritizes road user safety and the preservation of the natural environment.

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