



COMMUNICATION AND WORKS DEPARTMENT (C&W) PUNJAB

TRANSACTION ADVISOR FOR DUALIZATION OF CHINIOT –
SARGODHA ROAD (LENGTH=47.50)
AND O&M OF FAISALABAD - CHINIOT - SARGODHA ROAD
(LENGTH=68.50KM)

TECHNICAL FEASIBILITY STUDY REPORT

NOVEMBER 2020

PUBLIC PRIVATE PARTNERSHIP MODALITY

Feasibility Study Report

- This Report has been prepared by Principal and Senior Engineers in NESPAK, Financial Experts in KPMG and Legal Experts in Axis Law Firm.

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EXECUTIVE SUMMARY:

Roads make a crucial contribution to economic development & growth and bring important social benefits. They are of vital importance in order to make a nation grow and develop. In addition, for providing access to employment, social, health and education services, roads and bridges network play a critical role. Roads networks open up more areas and stimulate economic and social development. In short, for progress and development of any country, Roads/Bridges infrastructure plays an important role by providing efficient mobility of people and goods, especially when major portion of the freight transport is through roads.

The road network in Pakistan carries over 96 percent of inland freight and 92 percent of passenger traffic and is undoubtedly the backbone of the economy. With this large share in carrying the passenger and goods traffic all across the country, roads play a major role in the transportation system and provide connectivity between the centres of production and areas of consumption of agricultural and industrial goods facilitating economic growth, integrating the country, and helping reduce poverty. Due to various economic factors including the declining share of railways in the carriage of passengers and goods and the consequent shift towards their movement by road, the traffic volumes have been on the rise not only in the urban regions of Pakistan but also on the rural roads during the last three decades. The increase in the road traffic, especially the heavy goods vehicles, coupled with a backlog of maintenance due to non-availability of sufficient funds, has resulted in the deterioration of the road infrastructure, economic losses due to travel delays and higher vehicle operating costs, environmental pollution due to traffic congestion and above all severe traffic hazards. All these factors reflect towards an immediate need for the widening and improvement of road infrastructure to meet the rising demand for roadway capacity and pavement strength to sustain the imposed heavy loads in a reliable, safer, economical and environment-friendly manner.

Pakistan was previously facing inadequate transportation system few years ago. Currently, it has developed lot of Motorways as well as improved the network of National/Provincial Highways and many are under progress. Motorways are a network of multiple-lane, high-speed, controlled-access highways in Pakistan, which are owned, maintained, and operated federally by Pakistan's National Highway Authority. As of 18 March 2020, 1973 km of motorways are operational, while an additional 1763 km are under construction or planned. Motorways are an important part of Pakistan's National trade Corridor and plays an important role from regional perspective, which aims to link Pakistan's three Arabian Sea ports (Karachi Port, Port Bin Qasim and Gwadar Port) to the rest of the country through its National Highways and Motorways network and further north with Afghanistan, Central Asia and China and Iran.

One of the most important trade corridor M4 is a north–south motorway in Pakistan. The 309 km motorway connects M2 to M3 & M5. The M4 begins near the M2 Pindi Bhattian Interchange and continues on a southwest course connecting the cities of Faisalabad, Gojra, Toba Tek Singh, Shorkot, Abdul Hakeem, Khanewal and Multan and ends at Sher Shah Interchange giving exit to Multan Cantt over Shujabaad Road & itself continues as M5 Multan-Sukkur Motorway. It is connected to M3 Motorway (Lahore to Abdul Hakeem Motorway) near a village named Darkhana a few kilometers northeast of Abdul Hakeem Interchange. The importance of Faisalabad- Chiniot-Sargodha road improvement is closely related in connection with Motorway M2 ,M3 and M4 in terms of direct linkage, trade route, time saving as well as socio economic activities of the local community and surrounding areas.

The Faisalabad-Sargodha Road is very important Inter District and Inter Provincial Highway Link of almost 90 km in length running between the Punjab cities of Faisalabad, Chiniot and Sargodha. Faisalabad-Sargodha Road connecting two important and major cities of Punjab, as the name implies. It is very busy route. A portion of this road between Faisalabad and Chiniot is in poor condition. The road surface is rough resulting in severe impediment in the smooth flow of traffic.

The alignment from Faisalabad-Chiniot to Sargodha onward passes through plain terrain. At some locations thickly populated small towns and green fields on both sides. In between these two Major cities one major city is Chiniot. Following villages and populated areas are also come into the alignment e.g., Chak 4 JB, Chak 2 JB, Bhutto Colony, Muslim Colony, Chenab Nagar, Dar-ul-Sadr, Ahmad Nagar, Lalian, Qasaeyan Wala and Chak 46 etc. The ground elevation of the Subject road ranges from EL. 187 m at the Faisalabad city to EL. 189m at the Sargodha city. The levels will be confirmed in detail topographic survey. One Major crossing of River Chenab, where the alignment is already dualized. One main Canals (Jhang Branch), one main saim Nullah, along with few distributaries are also crosses the road.

Communication and works Department, Government of Punjab, has hired the National Engineering Services Pakistan (NESPAK) (Pvt.) Ltd as the Project Consultants through open competition for Transaction advisory services for preparing project Feasibility Study report and Detailed Design.

NESPAK conducted Traffic Study, Hydrological Study, EIA, Conceptual and preliminary design, Cost Estimate and Economic Analysis as part of the Feasibility Study. Frequent site visits with experts including road, traffic engineers and material specialist was also carried out. The current traffic pattern of present commuters has been considered as criteria to decide about the Dualization of the existing single road. Accordingly, the most feasible alignment including upgrading of has been finalized keeping in view the topography, existing site conditions and local connectivity. A traffic study is an elaborate investigation and meticulous analysis of the transportation system in a specific area,

which is supported by an expansive collection of data. Usually, traffic studies are used to determine the required level of transportation facility in terms of Level of Service and geometric features.

A cost estimate is necessary to give the stakeholders a reasonably accurate idea of the project cost to help them decide whether the work can be undertaken as proposed or needs to be curtailed or abandoned, depending upon the availability of funds and prospective direct and indirect benefits. The cost estimation is carried out based on MRS 2020 (District Chiniot, Punjab). The project cost is estimated to be Rs. 11,678 Million.

1. INTRODUCTION

1.1 GEOGRAPHY

Faisalabad District, having a total area of 5856 Km is situated between longitude 73° and 74° East, Latitude 30° and 31.5° North and at an elevation of 610 feet above mean sea level. It is bound by Hafizabad, Jhang and Toba Tek Singh districts towards North and North West. Sheikhpura, Okara and Sahiwal lie in its East and South East. The district is not separated by any natural boundaries from the adjoining districts. It comprises of six tehsils namely; Faisalabad City, Faisalabad Saddar, Samundri, Jaranwala, Tandiwala, and Chak Jhumra.

River Chenab flows about 30 Km in the North West while River Ravi meanders about 40 Km off the city in the South East, across which lies Okara. Lower Chenab canal is the key source of water for agriculture purpose and caters about 80% of the total requirements of the cultivated land.

Sargodha is the 11th largest city in Pakistan with a population of 1.5 million. It is also an administrative centre of Sargodha Division located in the Punjab province, Pakistan and one of the fastest growing cities in Pakistan. Sargodha is located 172 kilometres northwest of Lahore, in Sargodha District. It lies about 30 miles from the M-2 motorway, which connects Lahore and Islamabad. It is connected to the M-2 by several interchanges at different locations. Sargodha is roughly 94 km from Faisalabad, due southeast. Directly east connected by the M-2 motorway are Lahore and the route to Rawalpindi and Islamabad. Due east is the city of Jhang; toward the west are the city of Mianwali and the Chashma Barrage. Dera Ismail Khan is located 232 km southwest from the city.

1.2 PROJECT DESCRIPTION

For progress and development of any country, National highways and road infrastructure plays an important role in progress of that country by providing efficient mobility of people and goods. Especially when major portion of the freight transport is through roads. Roads connects the country's various parts and ensure efficient transport communications between different locations. Better transportation leads not only to the development of a country but also helps in boosting countries economy. In short, better the transportation system, the more prosperous would be the country.

Communication and works Department (C&W) Punjab, entrusted National Engineering Services Pakistan (NESPAK) Pvt. Ltd as the project consultants for preparing Feasibility Study and Design for Dualization of existing Faisalabad – Chiniot Sargodha road. As part of the preliminary implementation of this project, NESPAK has carried out a Feasibility Study of the proposed road. This report details, the method and findings of

the feasibility study. Location map of project is attached as figure.1-a.

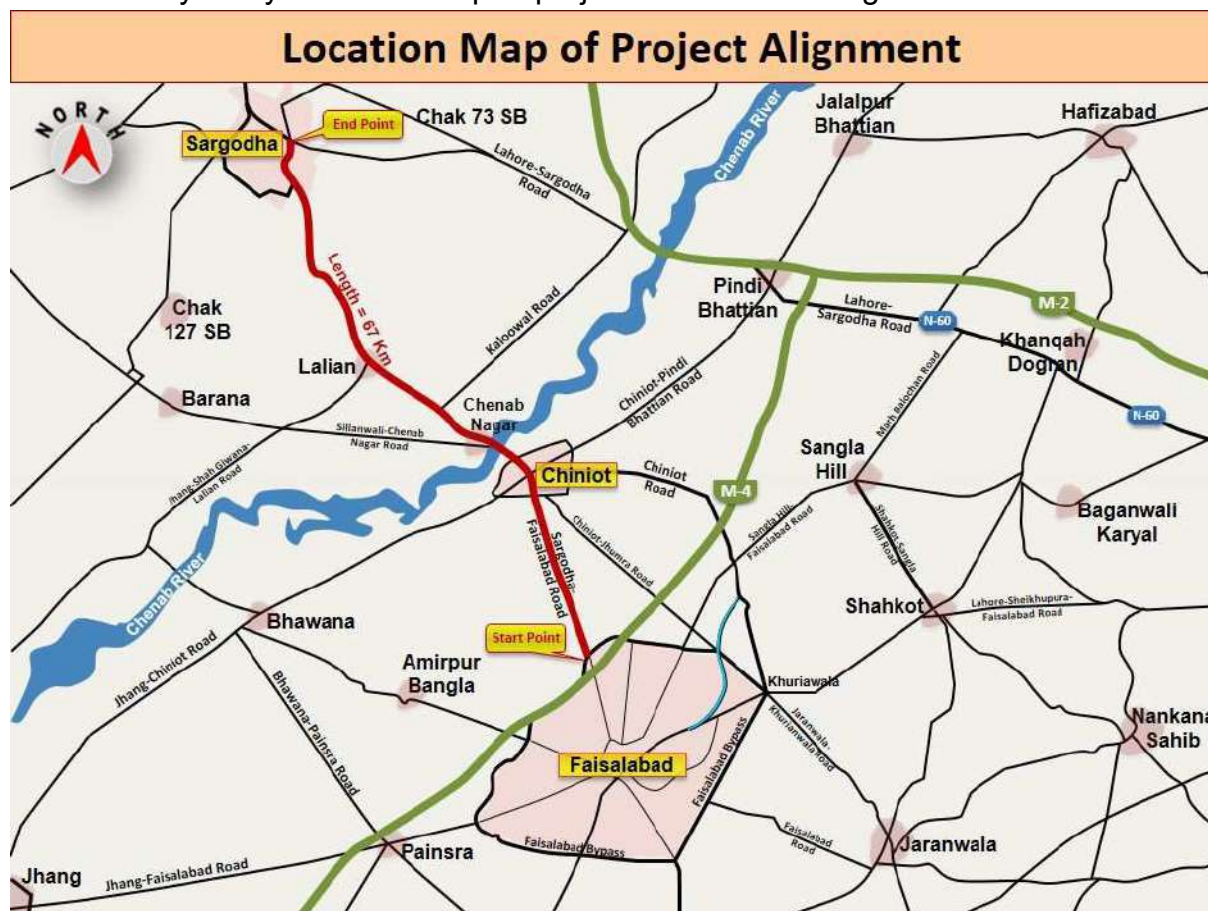


Figure. 1a LOCATION MAP OF PROJECT AREA

1.3 AIMS OF ASSESSMENT

The overall objective of the assessment is to carry out a feasibility study of the proposed dual carriageway in terms of economic and technical evaluation and to come up with feasible recommendations about the project.

The assessment requires following studies for all options:

- i. Traffic Study
- ii. Topographic Survey
- iii. Geometric Design
- iv. Soil Investigation
- v. Hydrologic and Hydraulic Study
- vi. Pavement Design

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

- vii. Structural Design
- viii. Cost Estimation
- ix. Economic Analysis

2. PRELIMINARY CONSIDERATION

2.1. PROJECT BACKGROUND

In Punjab, keeping in view the trade routes flowing in the province, Government of Punjab has formulated a program to upgrade and improve the Highway network in province that forms the part of road network to international standards. As per the vision of the Punjab Government, the Communication and Works Department selected 08 Major Roads for PPP Modality. The government of the Punjab is striving to meet its development objective focusing to engage Private Parties for financing, planning, designing, execution and operation of the projects for sustainable development in the Province.

As far as the importance of this corridor is concerned, Government of Punjab has initiated dualization of Faisalabad - Chiniot - Sargodha Road (66.6 km) on PPP Mode. This project is among one of those 08 major road projects. Due to presence of Industrial zones and stone crushing industry in Sargodha, high traffic flow rate between Faisalabad and Chiniot Industrial zones and Sargodha city derives the concept of extension of Dualized Faisalabad Chiniot Road upto Sargodha.

The Faisalabad - Chiniot - Sargodha Section, after dualization with improved facilities shall provide an efficient / intelligent transport corridor. Main objective of this road is to provide a safe, congestion free and high speed facility to the commuters of project area and heavy traffic travelling from Faisalabad to Sargodha.

Similar benefits associated with the proposed project include:

- Smooth flow of traffic.
- Saving of Vehicle Travel Time and Vehicle Operating Costs of commuters.
- Reduction of traffic accidents and casualties.
- It will also contribute to ensure efficient movement of trade, goods and traffic in relatively shorter time.
- Economic growth leading to provision of additional employment opportunities for the local residents.
- Quicker transports of products including perishable goods to final destination.

Currently this road is incapable to cope with the existing as well as future traffic volume and does not have safe and smooth riding quality. Therefore, after its completion, the availability of better road network from/towards different residential units as well as Faisalabad, Chiniot and Sargodha city, will further facilitate rapid access of goods and services besides improving the commercial activity of the area.

2.2. ALIGNMENT STUDY

NESPAK Team of Technical and Design experts conducted a field visit to Faisalabad - Chiniot - Sargodha Road (Project corridor) in July 2020. After that, meetings were held with C&W Punjab Officials time to time for finalization of selected alignment along with further necessary tasks. Based on ground conditions and series of meetings with Client, road alignment have been finalized for Dualization which was submitted and approved by the Client respectively. Road approved alignment is marked as figure. 2-a.

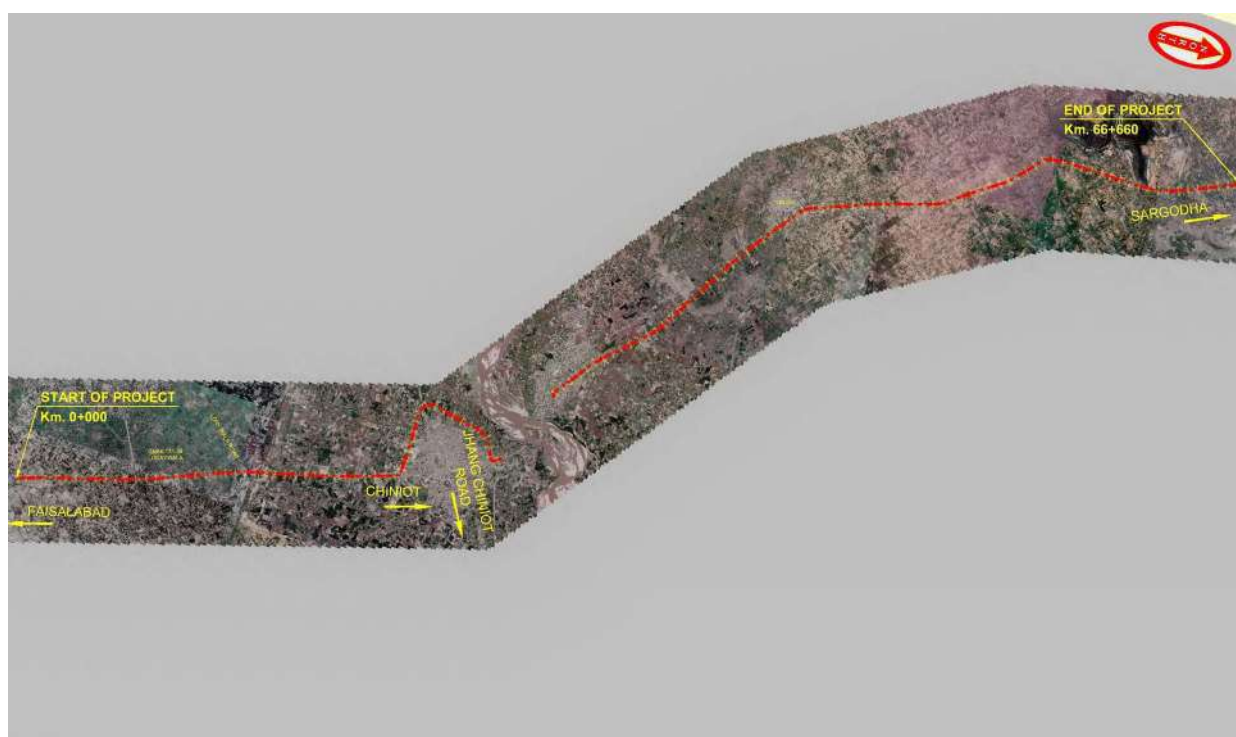


FIGURE. 2a

2.2.1. Dualization of Faisalabad - Chiniot - Sargodha Road Alignment (L=66.6km)

The Faisalabad-Sargodha Road is very important Inter District and Inter Provincial Highway Link of almost 67 km in length running between the Punjab cities of Faisalabad, Chiniot and Sargodha. Faisalabad-Sargodha Road connecting two important and major cities of Punjab, as the name implies. It is very busy route. A portion of this road between Faisalabad and Chiniot is in poor condition. The road surface is rough resulting in severe impediment in the smooth flow of traffic.

The alignment from Faisalabad-Chiniot to Sargodha onward passes through plain terrain. At some locations thickly populated small towns and green fields on both sides. In between these two Major cities one major city is Chiniot. Following villages and populated areas are also come into the alignment e.g., Chak 4 JB, Chak 2 JB, Bhutto

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Colony, Muslim Colony, Chenab Nagar, Dar-ul-Sadr, Ahmad Nagar, Lalian, Qasaeyan Wala and Chak 46 etc. The ground elevation of the Subject road ranges from EL. 188 m at the Faisalabad city to EL. 186.5m at the Sargodha city. One Major crossing of River Chenab, where the alignment is already dualized. One main Canals (Jhang Branch), one main saim Nullah, along with few distributaries are also crosses the road.

The alignment off takes from Faisalabad city at Faisalabad bypass Chowk near Bharia Town and proceeds towards Chiniot City and ends at Sargodha. The first 19.1km is single carriageway road with metalled width of 7.3m. There is a no median for this section. Two-way traffic is operating. At km -19+100 this alignment has three (03) options to pass on Chiniot city. First option is to pass through city. The distance cover for this stretch is 4.8km 4 lane dual carriageway. The other two options available to pass on city are eastern and western bypass having length 16.0km and 9.2km respectively. Both bypasses have two lane single carriageway with poor geometry. Selection of the route in this area is finalized after discussion with Client. The final alignments of this section is passing through western side having length 9.2km. The alignment further proceeds towards River Chenab crossing. This road section is already dualized in a length of 4.8km. The alignment further proceeds passing through populated area of Chenab Nagar, Dar-ul-Sadr and Ahmad Nagar. The next 8.0km road passes through the area where fields on either side. The alignment reaches Lalian town another populated area. Travelling further the alignment take right turn and passes through Qasaeyan Wala and Chak 46. Few distributaries and saim Nullahs are also crossing the road, exact chainage will be mentioned in detailed plan. The alignment terminates at Sargodha Bypass. The end point is finalized after discussion with Client. Alignment plan is shown as figure. 2b to 2f.

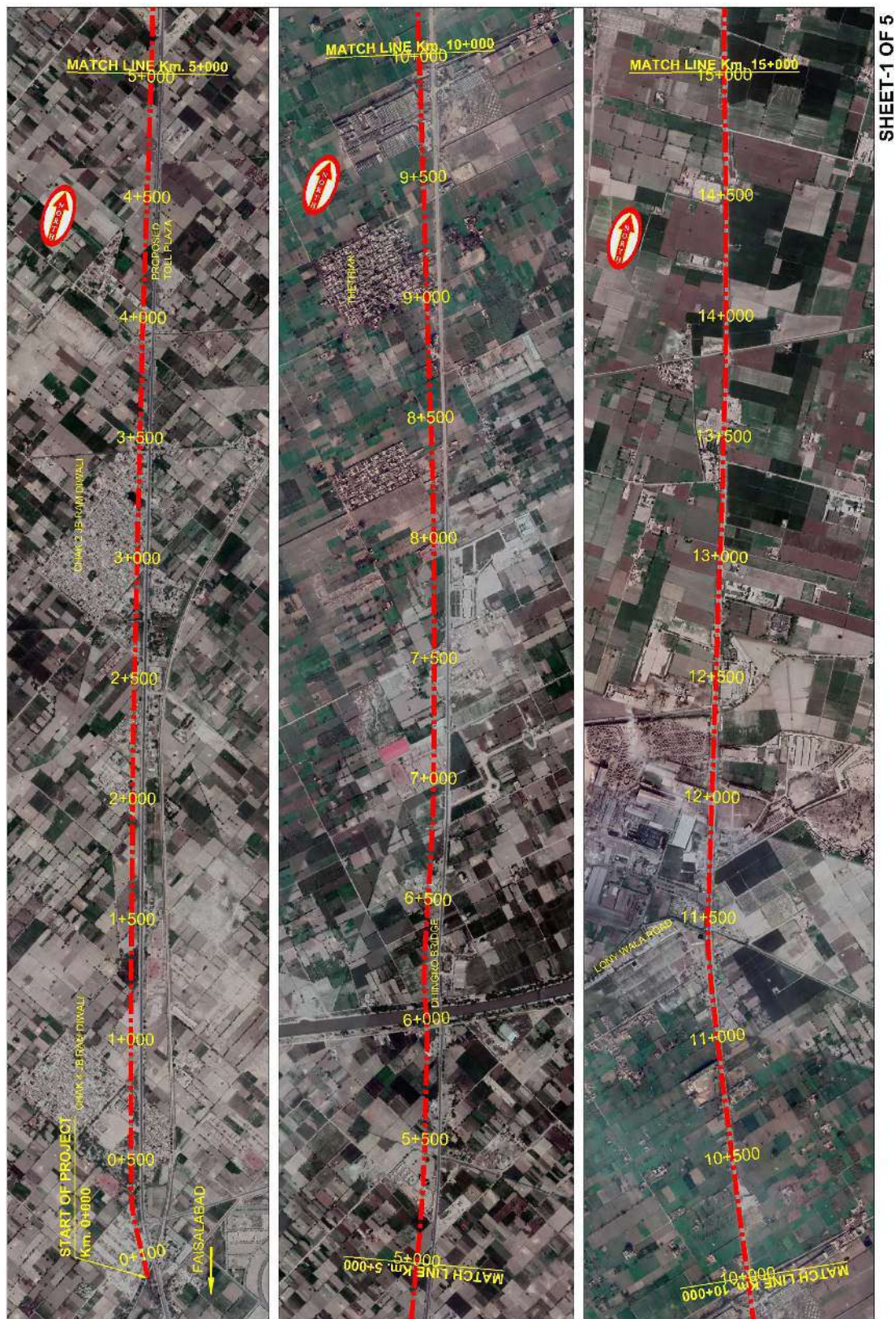
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FIGURE 2-b

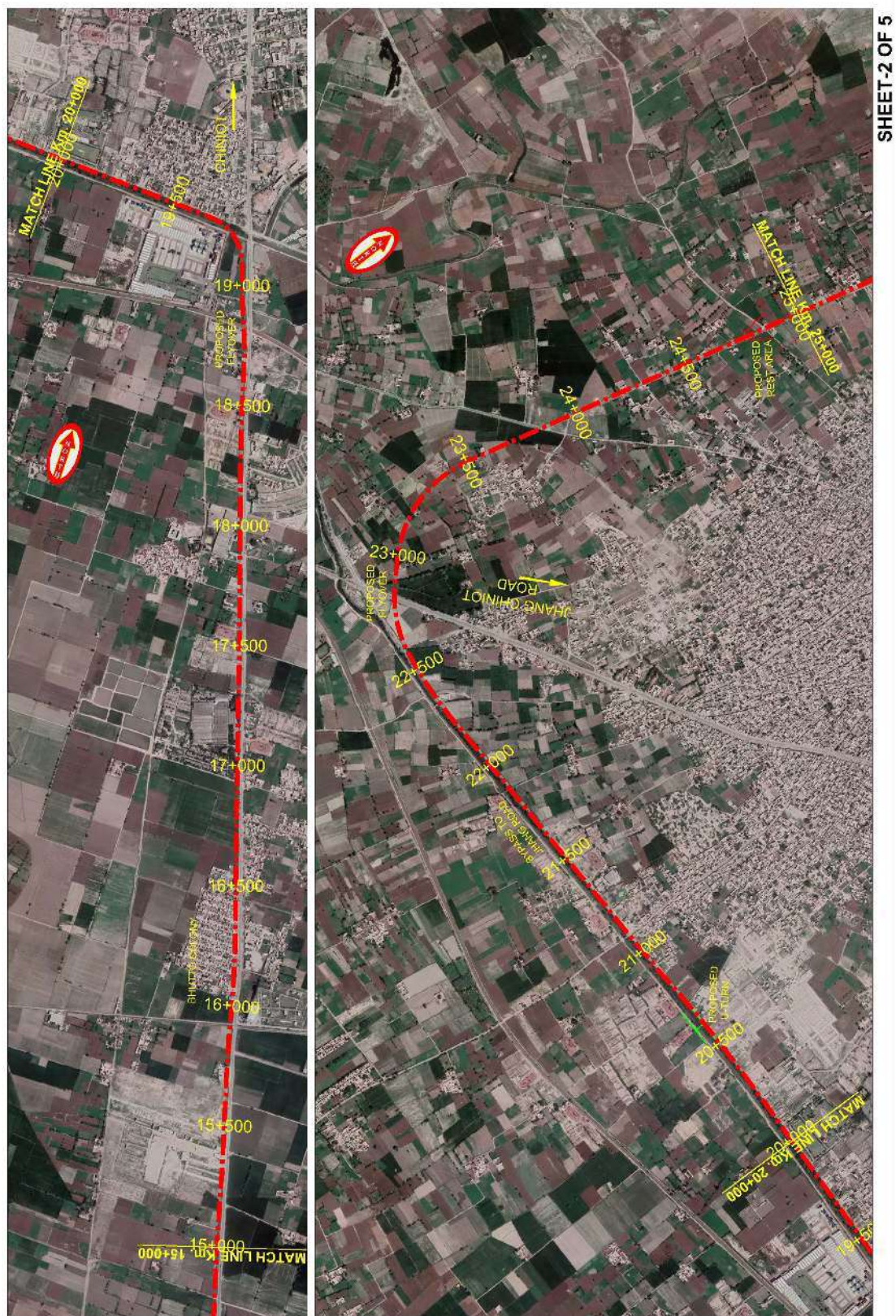
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FIGURE 2-c

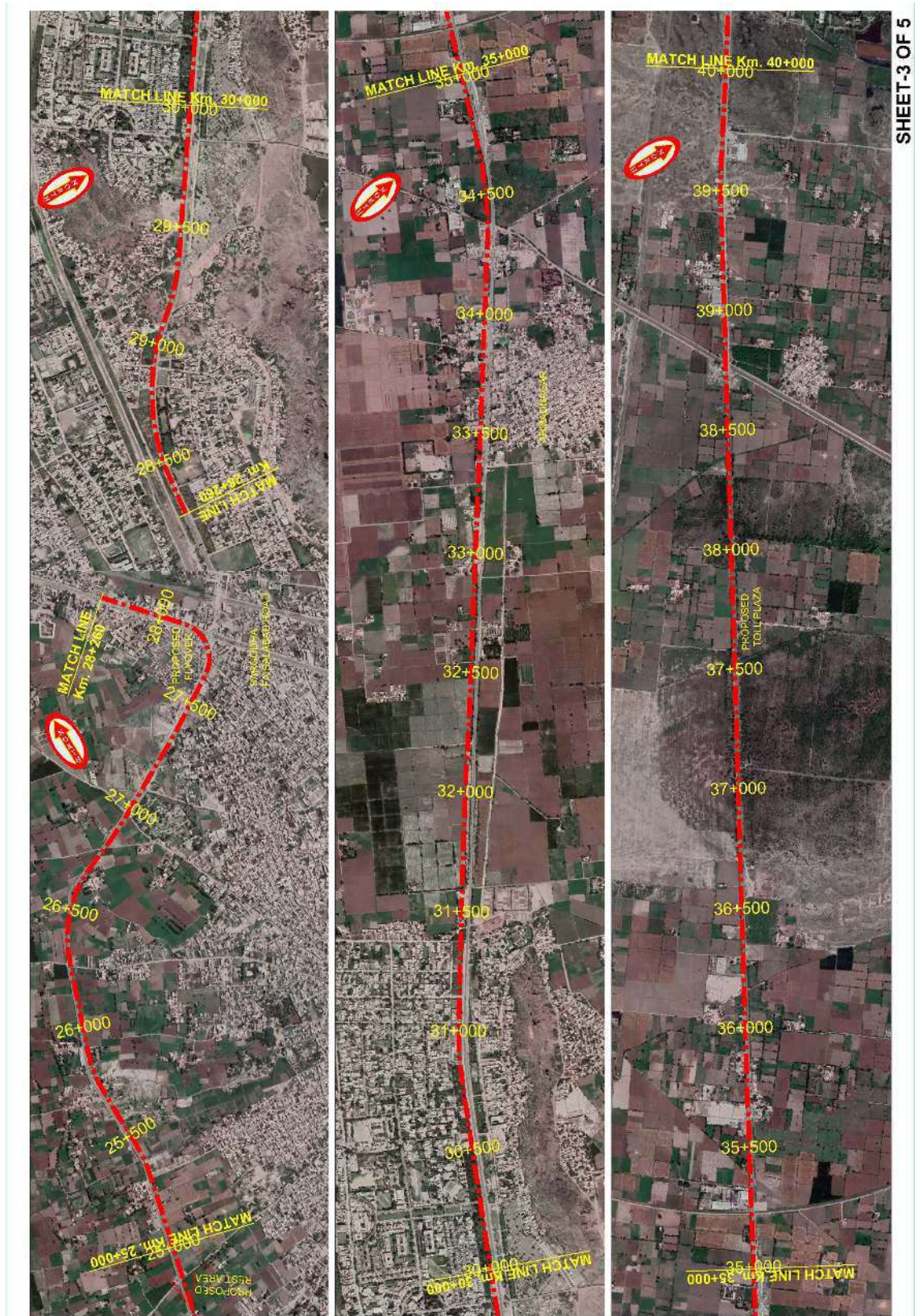
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FIGURE 2-d

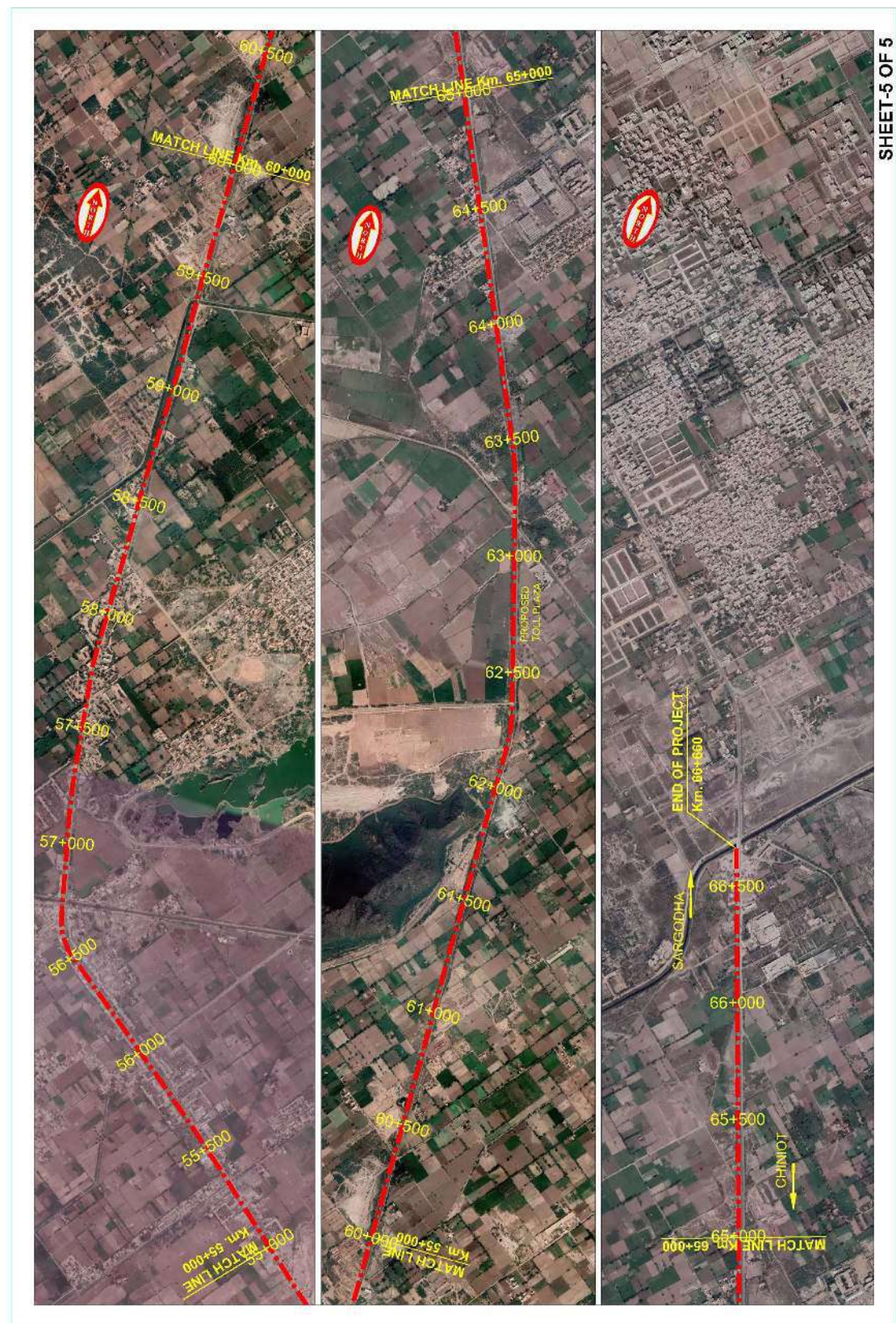
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FIGURE 2-e

The pictorial view of alignment is shown as under.

2.2.2. Pictures showing the terrain and existing road are captioned below:



START POINT OF PROJECT JUST AFTER FAISALABAD BYPASS CHOWK



FAISALABAD – CHINIOT-SARGODHA ROAD NEAR KM 2+500



TYPE OF TRAFFIC LOADING ON ROAD



**EXISTING 2- LANE CANAL CROSSING BRIDGE (JHANG BRANCH)
KM 6+000 (APROX.)**



DRAINAGE CONDITION ON ROAD



ROAD CONDITION AT KM 7+100

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)



START OF CHINIOT WESTERN BYPASS KM 19+100



EXISTING CHINIOT WESTERN BYPASS KM 23+000

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START OF CHENAB NAGAR - SARGODHA SECTION KM 28+300



EXISTING DUALIZED BRIDGE ON RIVER CHENAB



EXISTING ROAD AT KM 38+800



EXISTING ROAD AT KM 44+800 (AFTER LALIAN)

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BUILT-UP AREA AT KM 49+500 (CHAK - 46)



BUILT-UP AREA NEAR PULL 111 AT KM 55+000



EXISTING ROAD NEAR END POINT (SARGODHA)

2.3. SIGNIFICANCE OF THE PROJECT:

The Dualization of the existing road will result in facilitating the local commuters as well as commercial traffic in the vicinity. After its completion, there will be rapid access to the destinations. Resultantly, due to rapid access, their travel time and running cost will be reduced. Conclusively, there would be improvement of economic condition of the region through commercial activity which will also facilitate the traffic of the proximity areas.

The construction of the proposed road will surely save the travel time and vehicle operating costs with increased level of ease and comfort for the commuters.

2.4. PROJECT OBJECTIVES:

The Faisalabad - Chiniot - Sargodha Section of 67km, after Dualization with improved facilities shall provide an efficient / intelligent transport corridor. Main objective of this road is to provide a safe, congestion free and high speed facility to the commuters of project area and heavy traffic travelling from Faisalabad to Sargodha.

The corridor will largely contribute to the economic and social development of the region as well as monetary benefits to Provincial Government through tolling. The Project will bring more population into the stream of benefits, which in turn will improve the social complexion of people around this corridor.

Apart from the usual benefits of saving in time this link will transform the entire pattern of transportation in the surrounding areas resulting in uplift of economic condition of local community.

This link will bring about further revolution in road transport and time saving journey for passengers. It will also contribute to ensure smooth and efficient movement of trade, goods and traffic in relatively shorter time.

1.1

2.5. BENEFITS OF THE PROJECT:

Expected benefits associated with the proposed project include:

- Smooth flow of traffic.
- It will also ease out the traffic of the adjacent villages/areas
- Saving of Vehicle Travel Time and Vehicle Operating Costs of commuters.
- Reduction of traffic accidents and casualties.
- It will also contribute to ensure efficient movement of trade and traffic in relatively shorter time. Quicker transports of perishable goods to final destination.
- Economic growth through providing employment opportunities for the local residents.
- Massive impact of the project on Land use will surely help in the progress of area and local people.
- The availability of dual carriageway and road network will further facilitate rapid access of goods and services through heavy duty vehicles.

2.6. METHODOLOGY

This section provides a description of how the Feasibility study was carried out by the NESPAK Team deployed for the assignment. Site visits, Data collected from site and various departments as well as desk study are the main input for finalization of report.

Following are the studies taken place for this assignment which are detailed below:-

- i. Topographic Survey report
- ii. Geometric Design report
- iii. Traffic Study Report

- iv. Pavement Design report
- v. Soil Investigation report
- vi. Hydrologic and Hydraulic Study
- vii. Structural Design report
- viii. Cost Estimation
- ix. Economic Analysis report

3. TECHNICAL FEASIBILITY REPORTS

This section provides a detailed description of how the Feasibility study was carried out by the NESPAK Team deployed for the assignment. Site visits, data collection from site and various civil departments as well as indoor desk study are the main input for finalization of report.

Following reports have been prepared based on the studies conducted for this assignment.

- I. Topographic Survey report
 - II. Geometric Design report
 - III. Traffic Study Report
 - IV. Pavement Design report
 - V. Hydrologic and Hydraulic Study
 - VI. Structural Design report
 - VII. Cost Estimation
 - VIII. Soil Investigation report has been attached as separate report
- Annexure-1

3.1. TOPOGRAPHIC SURVEY REPORT

3.1.1 METHODOLOGY

3.1.1.1. General

Accurate topographical studies are basic requirement for detailed design and construction of any highway project. NESPAK has in-house capability to complete this task. Accordingly, detailed topographic survey for Dualization of Faisalabad-Chiniot Sargodha Road Project was carried out using state of the art techniques and latest instruments.

Location map of subject project is given as Annexure-2.

3.1.1.2. Scope of work

Scope of survey and mapping tasks was as follows:

- Fixing / Erection of permanent control point
- Observation of Horizontal and Vertical control in the project area using high accuracy Triple Frequency Differential GPS (Trimble R10) in static mode.
- Detailed topographic survey of new proposed alignment including Interchanges by recording field details / features (natural / man-made) with Electronic equipment i.e. Total station, Differential GPS in RTK mode and spot leveling for generation of contours.
- Preparation of topographic survey plans on 1:1000 scales. The mapping is in computer-aided format suitable for computer-aided planning and design of the project structures.

3.1.1.3. Equipment Used for the Project

- Trimble GNSS R-10 (1 base & 1 rover).
 1. Trimble DGPS Model # R-10, Serial # 5611457120
 2. Trimble DGPS Model # R-10, Serial # 5614459092
- Electronic Total Station
 1. Nikon Electronic Total Station (S/No.E-180483)

3.1.1.4. Reference Benchmark

Horizontal and Vertical survey control was established using real time positioning of Differential GPS receiver in static mode zone 43 UTM System.

3.1.1.5. Establishment of Survey Control Network

Location selection of survey control points

The 114 locations of the survey control points was selected on accuracy, stability and safety criteria. The main objective was to locate the survey control points such that those remain safe and will be available for the detailed topographic survey. The Consultant team selected the most suitable locations of survey control points by using the satellite images and field visits.

Fixation of the survey control points

In order to carry out topographic survey and mapping work with maximum possible accuracy and minimal spatial variations in both horizontal and vertical plans, and keeping in view the terrain, it is time saving and very accurate to establish the control network by using GNSS (Global Navigational Satellite System) .

The latest GNSS survey equipment Trimble R-10 (Global Positioning system) (Fig. 3-1a) instrument was used in Static mode to establish the survey control network in the project area. The data was observed and processed by using the Trimble Business Centre (TBC) software to achieve the corresponding results at desired level. The observations made at any point were processed on computer in the field office in order to check the accuracy of results.

For control points, at least 2 DGPS instruments were used simultaneously, making triangulations for 30 minutes were used simultaneously, making triangulations. To receive the signals from satellite, the receiver should have minimum obstructions like building, trees, power lines etc, around it which was ensured. The signals were received at minimum cut of angle of 15° or more.

If the signal is weak due to unfavorable weather conditions like rainfall, clouds and vehicle noise, the observations were repeated till found satisfactory results. It was

ensured that for all time observations, at least 4 satellites should be available with GDOP/PDOP value of less than 2.

One DGPS unit was kept to act as reference or base station and others as rover. The observed point coordinates serve as reference for further observing points to make a triangle or large polygon.



Figure3-1a: Trimble R10 GNSS System (Receiver and data controller)

3.1.1.6. FIELD DATA PROCESSING

The raw data for baselines was post processed to remove the further errors such as time clock error, atmospheric error (ionosphere and hemispheric error) and air noise to ensure the 3D quality of results in the Software Trimble Business Centre (TBC).

In case any baseline failed or did not fulfil the accuracy criteria it was repeated. As the DGPS reading is based upon the WGS 84 in static mode, the coordinates of the survey control points were converted into the UTM zone 43N by using desktop applications as the area to be surveyed falls in the aforementioned UTM Zone-43.

3.1.1.7. ACCURACY OF THE SURVEY CONTROL POINTS

The survey control points were established by using the DGPS in static mode. The designed accuracy in static and rapid static is given as:

Static (phase) with long	Horizontal: 3 mm + 0.1 ppm (rms)
Observations	Vertical: 3.5 mm + 0.4 ppm (rms)
Rapid static (phase)	Horizontal: 5 mm + 0.5 ppm (rms)
Static mode after initialization	vertical: 10 mm + 0.5 ppm (rms)

3.1.1.8. UNITS OF MEASUREMENT

The angular units of the measurement were the degrees, minutes and seconds, and linear units were in meters.

3.1.1.9. TOPOGRAPHIC SURVEY DATA ACQUISITION

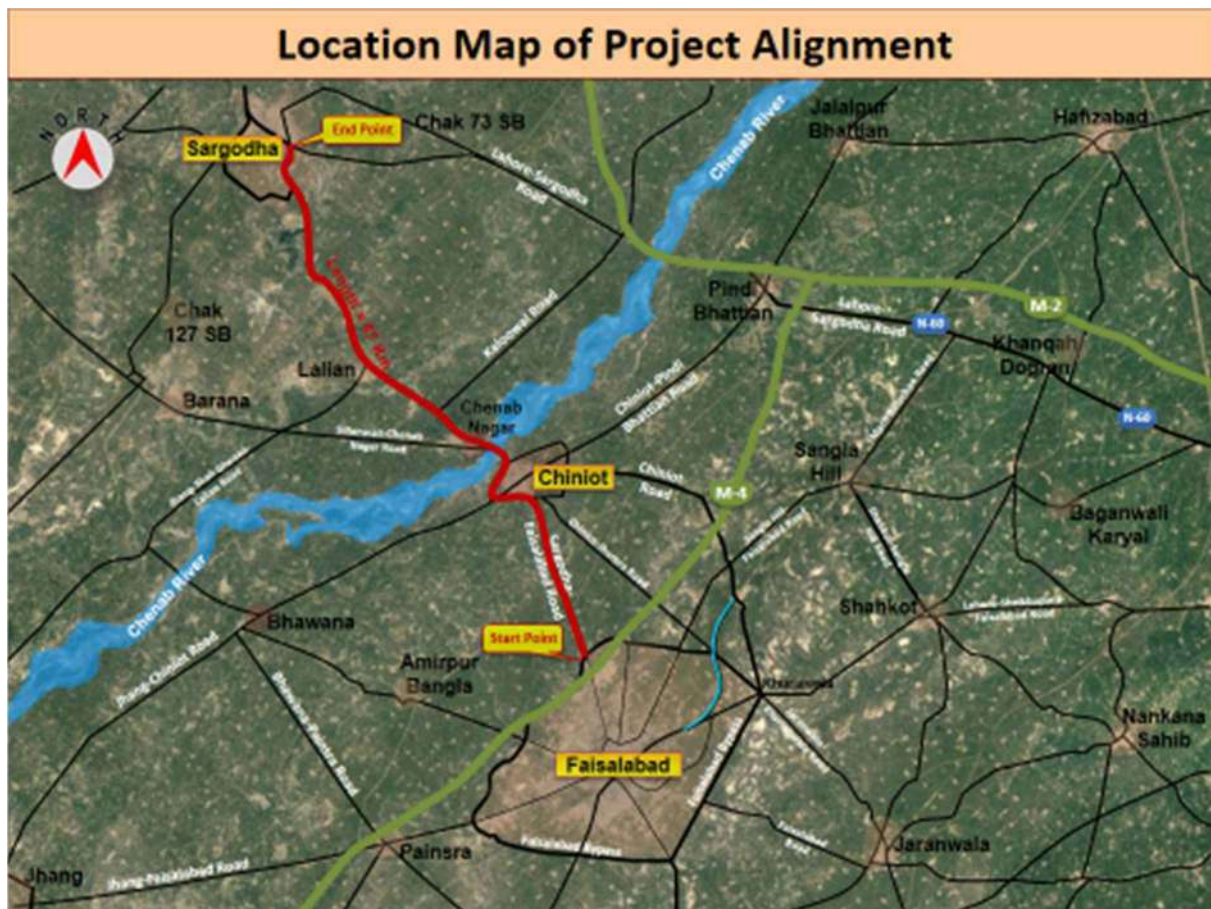
Electronic total station and DGPS in RTK mode was used for detailed topographic survey. All the data was recorded electronically and downloaded in computer for further analysis and processing.

Bulk of the topographic field survey data was acquired using electronic total stations and data recorder on digital format having x, y, z coordinates with reference to the control stations established earlier. All manmade features (Buildings, agriculture lands, roads, tracks, electric poles, telephone poles, channels etc.) and natural features (nullah, rivers etc) were picked during detailed topographic survey. The field topographic survey data acquired in sufficient detail (number of spot levels) to fully depict the manmade and natural physical features plus be able to generate contours at the desired interval. The data was downloaded to the computer at site for further processing.

The data was computer processed to create DTM and computer aided mapping carried out at the desired scale. Contours were generated at 1-meter contour interval from the DTM. The mapping was verified in field and topographic maps were finalized.

ANNEXURE-2

LOCATION PLAN OF TOPOGRAPHIC SURVEY AREA

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)**FIGURE. 3.1b LOCATION PLAN OF SURVEY AREA**

LIST OF CONTROL POINTS

FAISALABAD-CHINIOT SARGODHA ROAD

LIST OF CONTROL POINTS

Sr. #	POINT	EASTING(m)	NORTHING(m)	ELEVATION(m)
1	FS1	315938.117	3490498.266	187.887
2	FS2	315829.993	3490686.404	188.179
3	FS3	315729.354	3490949.039	187.822
4	FS4	315672.357	3491168.092	187.664
5	FS5	315525.752	3491644.185	187.584
6	FS6	315432.378	3491931.974	187.795
7	FS7	315299.279	3492377.797	188.121
8	FS8	315184.927	3492798.713	188.116
9	FS9	315036.504	3493312.721	188.362
10	FS10	314930.053	3493689.697	188.507
11	FS14	314534.697	3495123.128	188.315
12	FS15	314444.871	3495450.189	188.508
13	FS16	314317.969	3495807.952	188.604
14	FS17	314170.240	3496226.408	190.808
15	FS20	313764.441	3497374.174	187.723
16	FS22	313436.490	3498233.019	188.419
17	FS23	313199.333	3498810.105	188.516
18	FS24	313010.264	3499286.168	188.797
19	FS25	312831.340	3499691.326	189.072
20	FS26	312626.896	3500222.087	189.458
21	FS27	312478.655	3500578.812	189.211
22	FS31	312004.524	3502077.595	180.658
23	FS32	311946.635	3502418.179	180.814
24	FS33	311851.993	3502829.313	180.804
25	FS35	311657.708	3503614.336	182.343
26	FS36	311543.488	3504036.636	180.965
27	FS37	311414.277	3504510.043	181.122
28	FS38	311314.409	3504891.506	181.344
29	FS39	311171.647	3505382.674	181.857
30	FS40	311078.210	3505780.446	181.840
31	FS44	310665.939	3507054.426	181.749
32	FS45	310537.232	3507444.152	182.105
33	FS49	310130.553	3508763.837	182.863

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

34	FS50	309841.476	3508788.757	182.580
35	FS53	308696.170	3508824.085	182.243
36	FS54	308295.213	3508806.012	182.470
37	FS58	306821.749	3508790.612	181.330
38	FS59	306358.375	3508821.092	183.317
39	FS62	305453.417	3509155.652	181.420
40	FS65	306356.460	3509848.737	181.780
41	FS66	306444.264	3510270.092	182.227
42	FS67	306551.363	3510702.345	182.675
43	FS70	306872.922	3512180.821	182.777
44	FS73	307778.179	3512785.023	184.214
45	FS74	308007.831	3512928.949	184.221
46	FS75	308118.716	3513039.538	184.539
47	CS1	303868.104	3514980.208	183.656
48	CS2	303593.659	3515100.055	184.524
49	CS6	302687.380	3515824.620	187.101
50	CS8	301913.943	3516379.874	186.636
51	CS7	302316.308	3516084.369	187.376
52	CS9	301524.992	3516772.775	183.284
53	CS10	301149.649	3517172.259	183.151
54	CS11	300834.600	3517483.449	181.157
55	CS12	300498.172	3517832.123	181.013
56	CS13	300108.317	3518231.299	181.225
57	CS17	298794.598	3519305.528	182.595
58	CS19	297948.033	3519807.929	181.342
59	CS20	297547.858	3520057.524	180.925
60	CS21	297209.830	3520259.315	181.099
61	CS23	296373.066	3520760.323	182.031
62	CS24	295754.826	3521122.481	183.055
63	CS27	294274.505	3522089.423	180.595
64	CS28	293993.448	3522284.185	181.796
65	CS30	293119.776	3522893.586	181.476
66	CS31	292724.823	3523211.283	181.514
67	CS36	291434.479	3524288.404	181.740
68	CS39	290939.978	3525516.633	187.583
69	CS38	291055.794	3525222.060	187.133
70	CS37	291251.410	3524718.859	183.079
71	CS40	290801.942	3525889.305	187.739
72	CS41	290629.916	3526308.802	187.874

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

73	CS42	290534.386	3526550.061	187.861
74	CS43	290418.222	3526865.509	187.825
75	CS44	290296.298	3527124.720	187.417
76	CS45	290189.299	3527443.589	186.788
77	CS46	290079.149	3527791.054	188.073
78	CS47	289904.345	3528350.975	187.168
79	CS50	289572.500	3529441.765	187.329
80	CS51	289457.222	3529801.573	187.209
81	CS53	289273.179	3530437.511	187.700
82	CS54	289129.827	3530714.483	187.716
83	CS54	289129.827	3530714.483	187.716
84	CS55	288879.678	3531053.766	187.862
85	CS56	288549.832	3531492.268	188.134
86	CS57	288268.937	3531885.038	188.435
87	CS58	288056.472	3532181.315	188.988
88	CS59	287880.656	3532445.889	189.084
89	CS62	287134.680	3533525.080	190.305
90	CS64	286657.389	3533962.805	189.631
91	CS65	286424.315	3534185.087	189.528
92	CS67	286018.252	3534536.481	189.135
93	CS68	285770.837	3534733.833	190.185
94	CS69	285558.874	3534913.479	190.829
95	CS70	285497.457	3535000.893	191.090
96	CS71	285385.313	3535644.097	189.353
97	CS72	285358.987	3535933.125	188.756
98	CS74	285355.468	3536598.611	189.290
99	CS75	285349.642	3536880.789	189.146
100	CS78	285370.648	3538296.745	188.778
101	CS79	285375.503	3538945.385	189.020
102	CS80	285376.062	3539333.818	189.026
103	CS83	285382.571	3540392.512	188.743
104	CS84	285383.227	3540642.718	189.297
105	CS85	285258.519	3541105.075	188.832
106	CS86	285164.513	3541468.503	189.198
107	CS88	284876.406	3542235.862	188.546
108	CS89	284718.812	3542613.039	188.107
109	CS93	284073.841	3544129.343	186.808
110	CS94	283905.664	3544527.019	186.510

DESCRIPTION SHEETS OF HORIZONTAL AND VERTICAL CONTROL

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

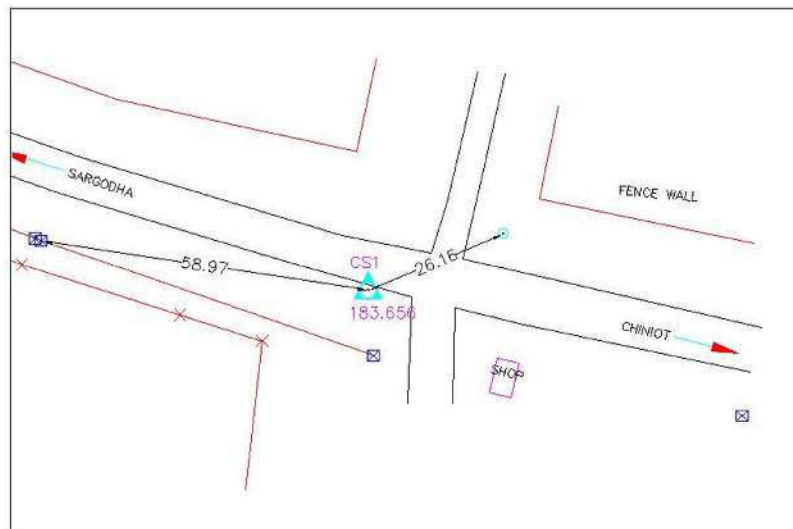
CONTROL POINT DATA SHEET

CONTROL POINT CS1

EASTING 303868.104 m
NORTHING 3514980.208 m
ELEVATION 183.656 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

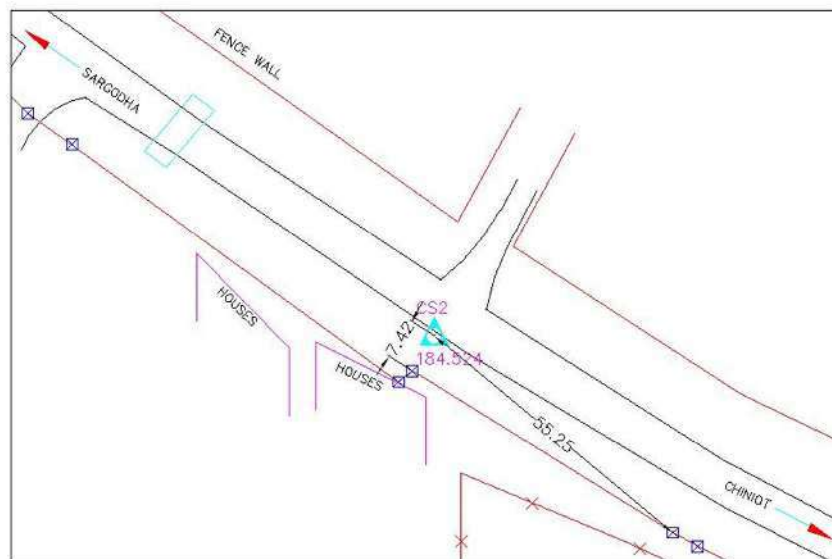
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS2

EASTING 303593.659 m
 NORTHING 3515100.055 m
 ELEVATION 184.524 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ: UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

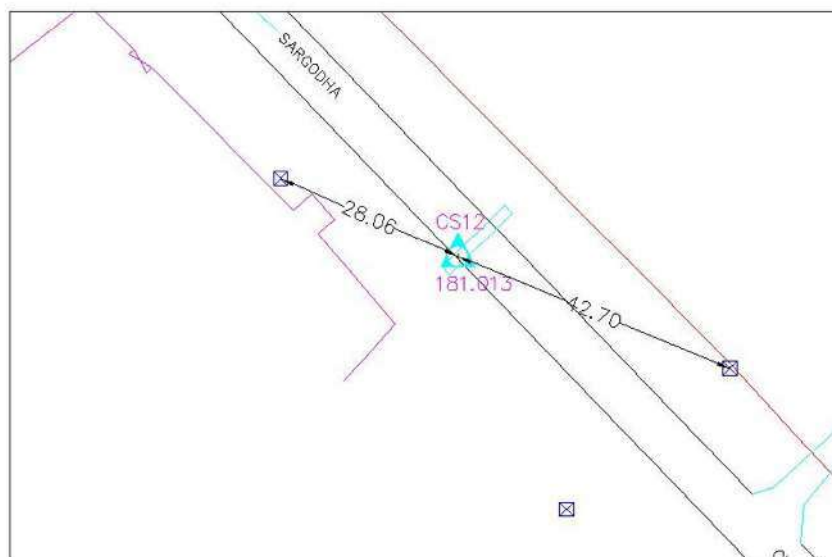
CONTROL POINT CS12

EASTING 300498.172 mDATE: OCTOBER, 2020NORTHING 3517832.123 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 181.013 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS13

EASTING 300108.317 _m
NORTHING 3518231.299 _m
ELEVATION 181.225 _m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

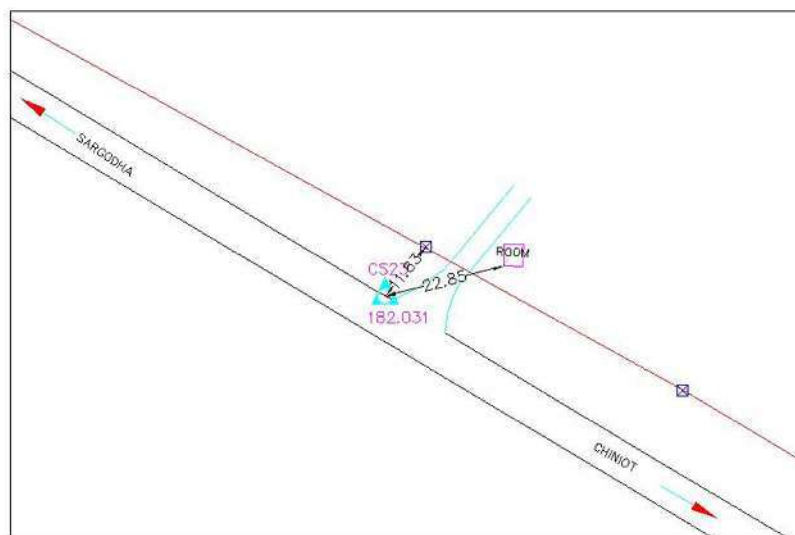
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS23

EASTING 296373.066 m
 NORTHING 3520760.323 m
 ELEVATION 182.031 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ: UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

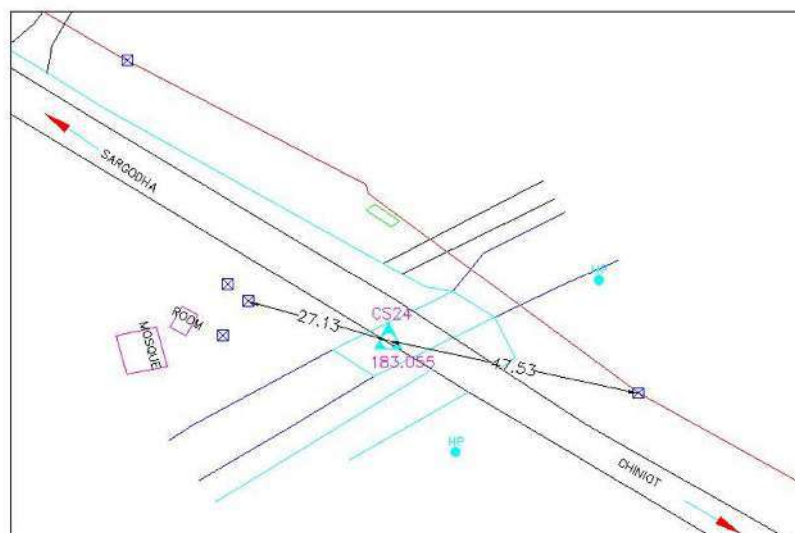
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS24

EASTING 295754.826_m
NORTHING 3521122.481_m
ELEVATION 183.055_m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS36

EASTING 291434.479_m
NORTHING 3524288.404_m
ELEVATION 181.74_m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

CONTROL POINT CS37

EASTING 291251.41 m

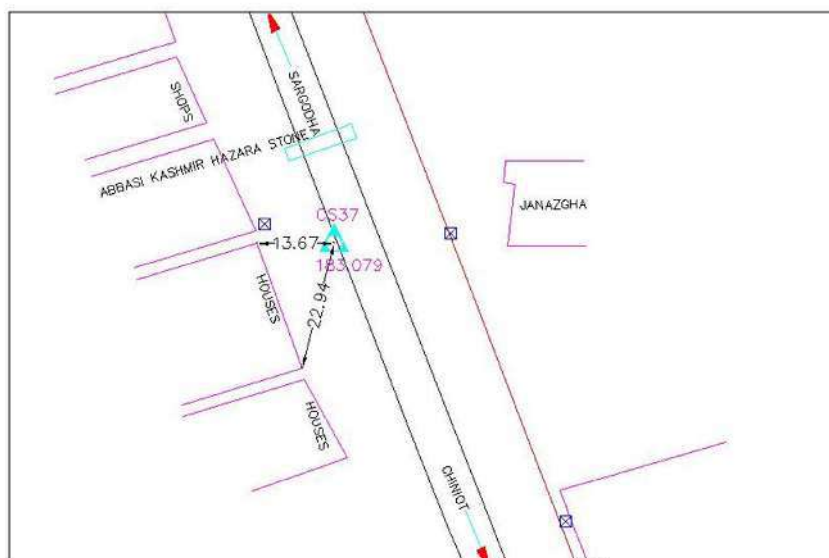
DATE: OCTOBER, 2020

NORTHING 3524718.859 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 183.079 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

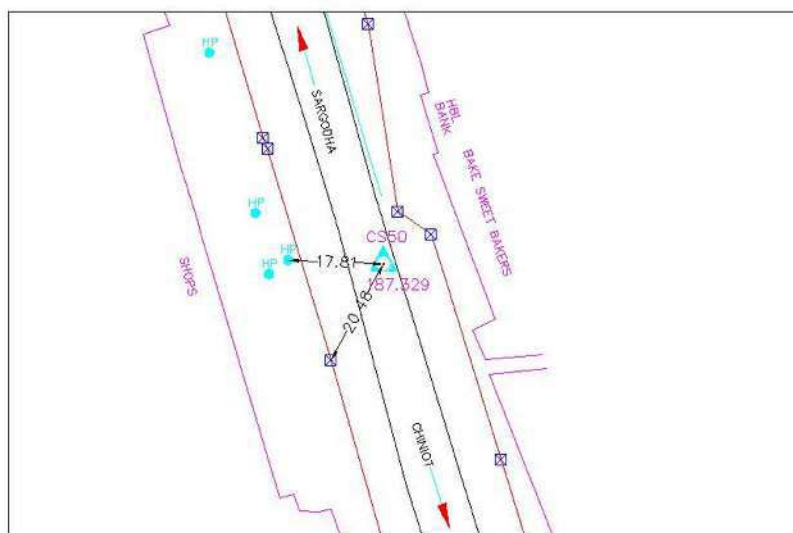
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS50

EASTING 289572.500_m
NORTHING 3529441.765_m
ELEVATION 187.329_m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

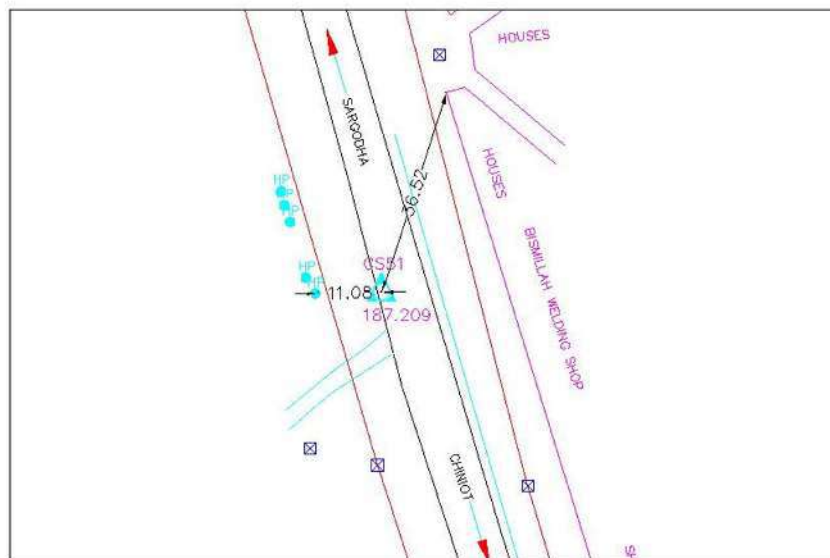
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS51

EASTING 289457.222 m
 NORTHING 3529801.573 m
 ELEVATION 187.209 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

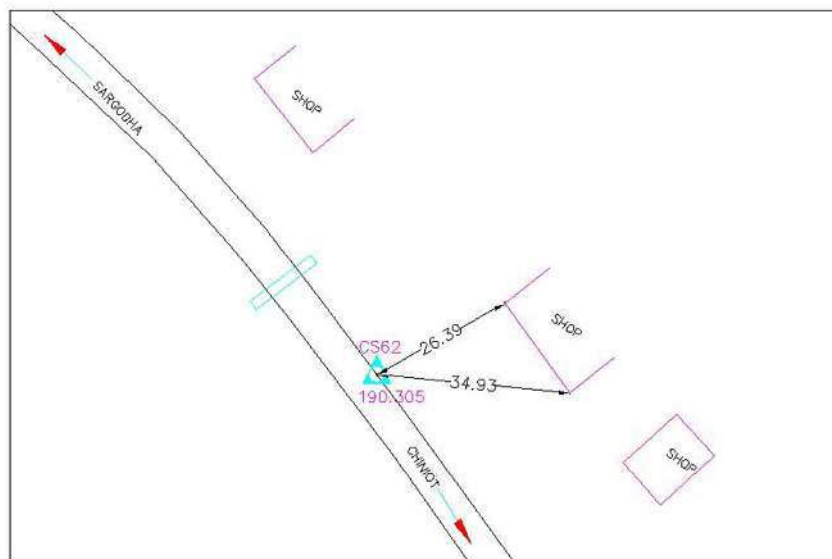
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS62

EASTING 287134.680 m
 NORTHING 3533525.080 m
 ELEVATION 190.305 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ: UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

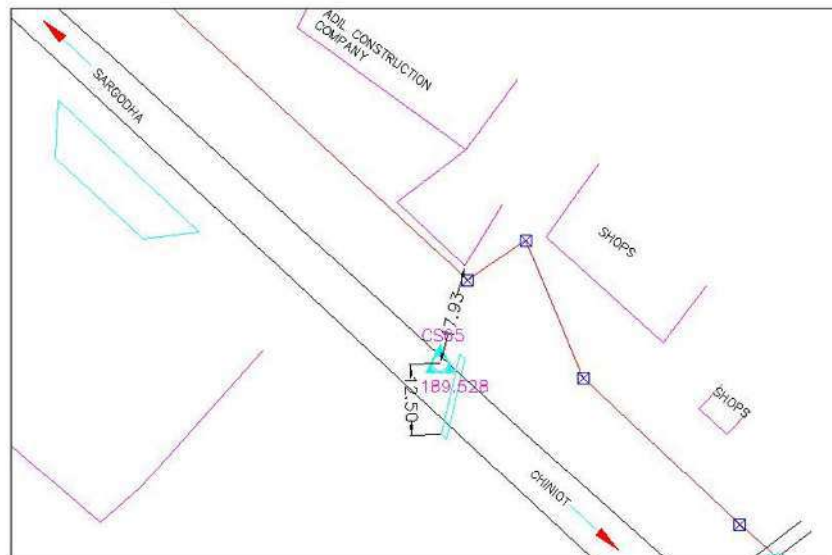
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS65

EASTING 286424.315 m
 NORTHING 3534185.087 m
 ELEVATION 189.528 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ: UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

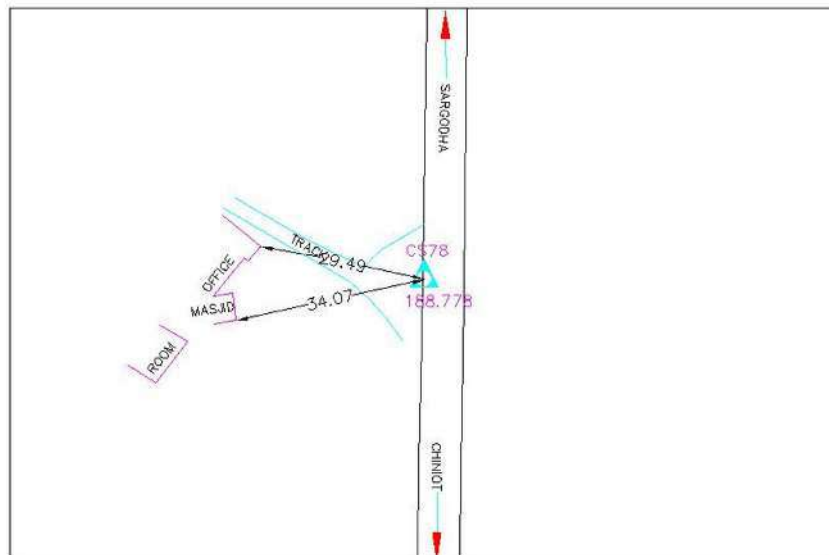
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS78

EASTING 285370.648 m
NORTHING 3538296.745 m
ELEVATION 188.778 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

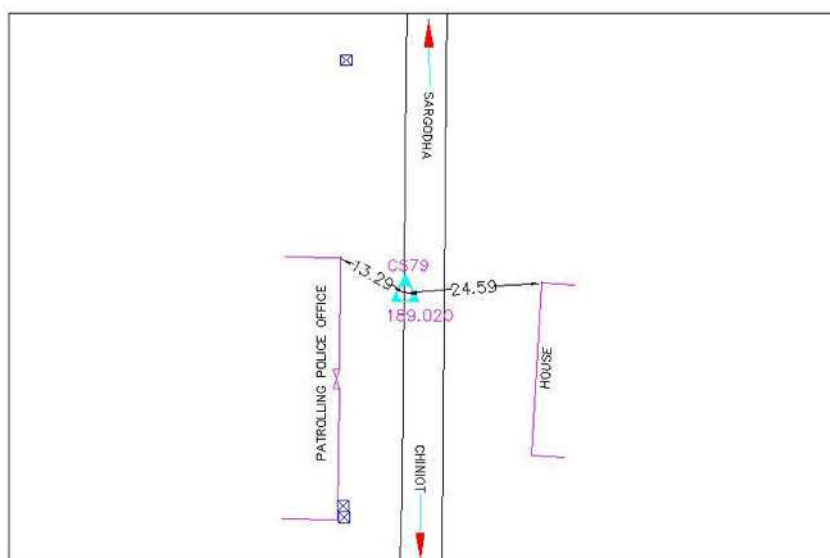
CONTROL POINT CS79

EASTING 285375.503 mDATE: OCTOBER, 2020NORTHING 3538945.385 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 189.020 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD–CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT CS93

EASTING 284073.841 m

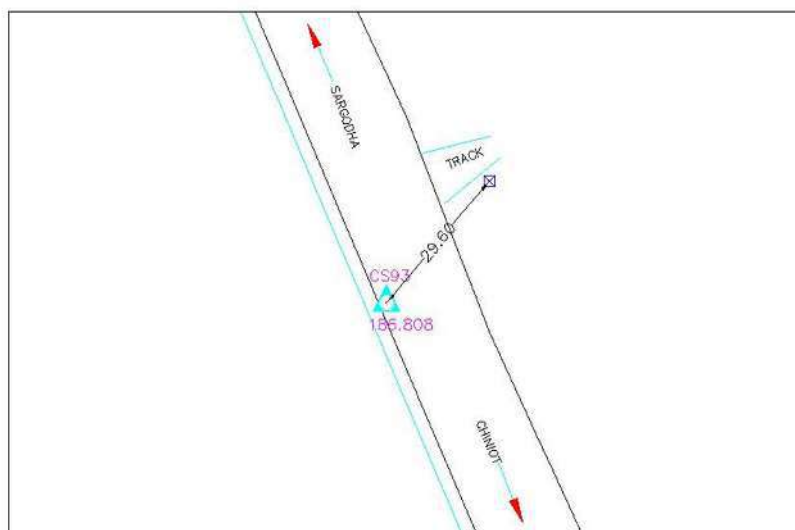
DATE: OCTOBER, 2020

NORTHING 3544129.343 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 186.808 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

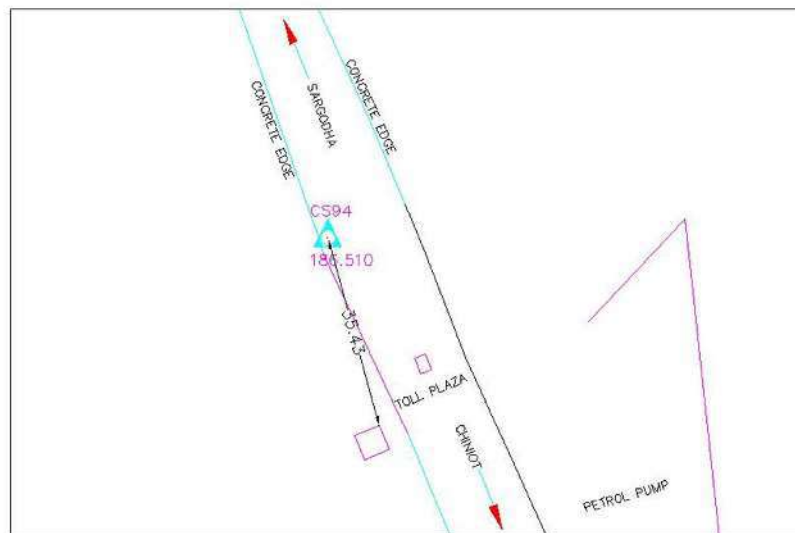
CONTROL POINT DATA SHEET

CONTROL POINT CS94

EASTING 283905.664 m
 NORTHING 3544527.019 m
 ELEVATION 186.510 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ, UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

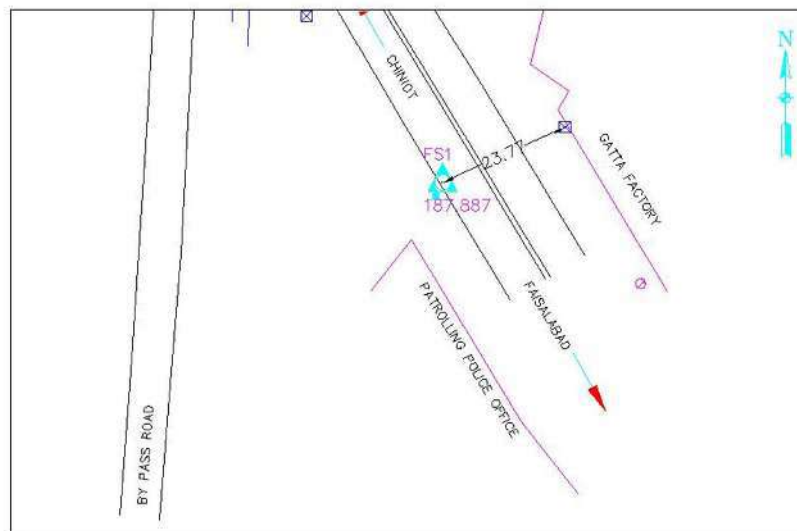
CONTROL POINT DATA SHEET

CONTROL POINT FS1

EASTING 315938.117 m
 NORTHING 3490498.266 m
 ELEVATION 187.887 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

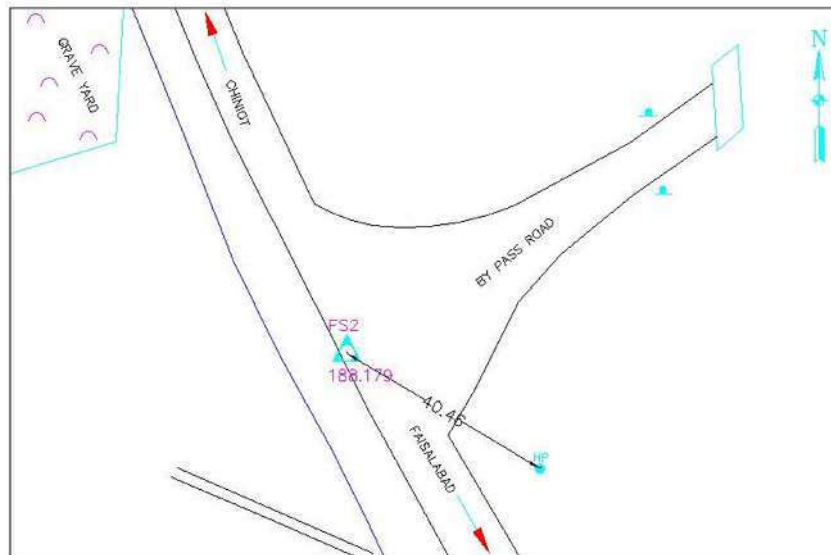
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT FS2

EASTING 315829.993 m
NORTHING 3490686.404 m
ELEVATION 188.179 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM: XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

CONTROL POINT FS15

EASTING 314444.871 m

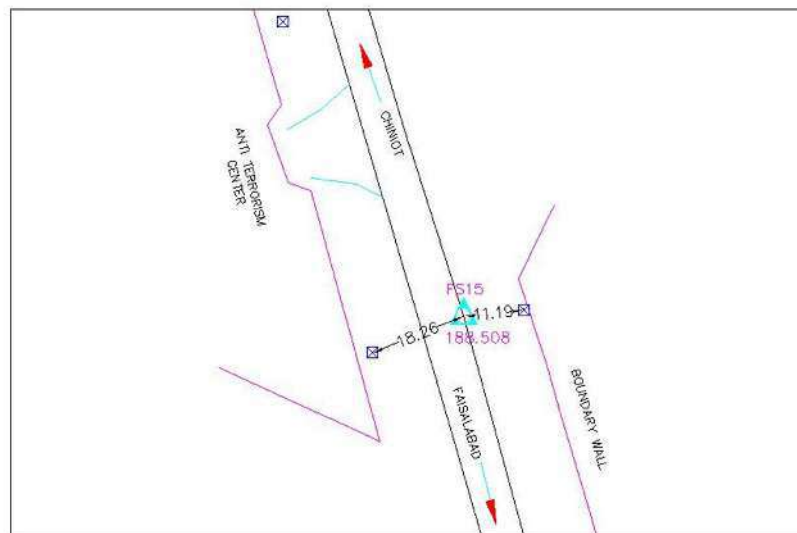
DATE: OCTOBER, 2020

NORTHING 3495450.189 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 188.508 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

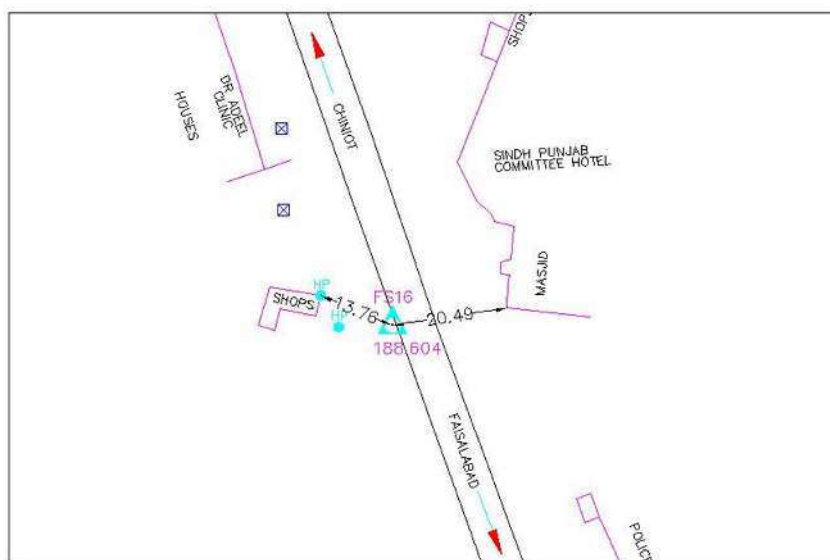
CONTROL POINT FS16

EASTING 314317.969 mDATE: OCTOBER, 2020NORTHING 3495807.952 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 188.604 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

CONTROL POINT FS26

EASTING 312626.896 m

DATE: OCTOBER, 2020

NORTHING 3500222.087 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 189.458 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT FS27

EASTING 312478.655 m
NORTHING 3500578.812 m
ELEVATION 189.211 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

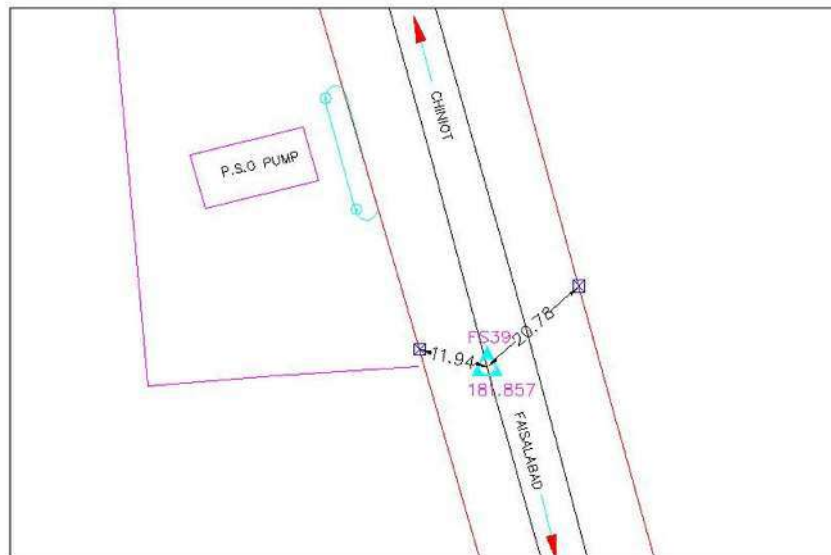
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT FS39

EASTING 311171.647 m
NORTHING 3505382.674 m
ELEVATION 181.857 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

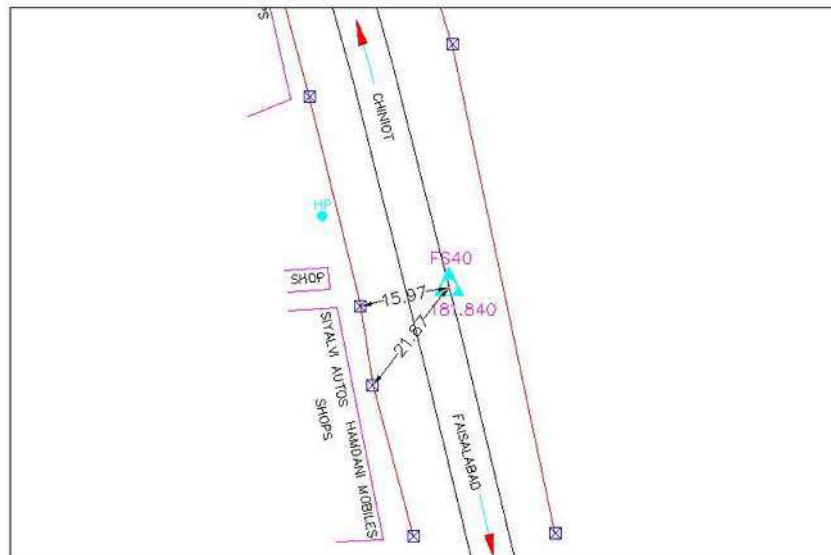
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT FS40

EASTING 311078.210 m
 NORTHING 3505780.446 m
 ELEVATION 181.840 m

DATE: OCTOBER, 2020
 COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
 Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

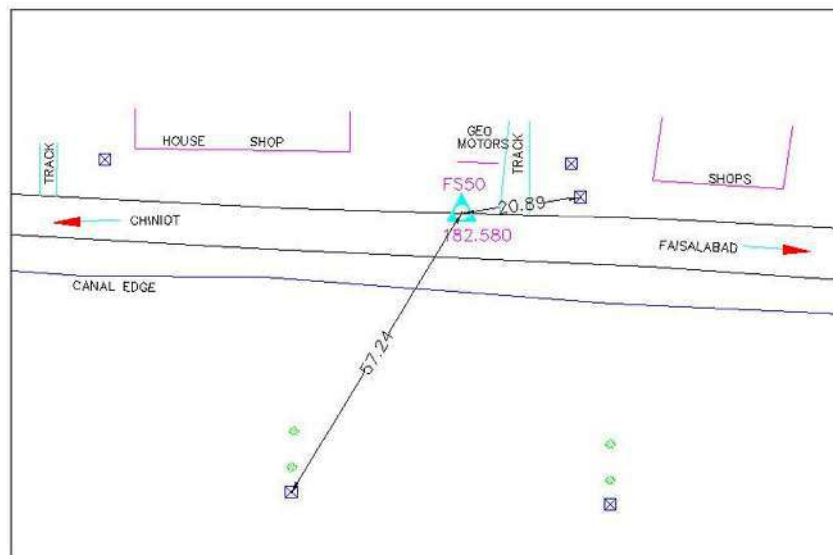
CONTROL POINT FS50

EASTING 309841.476 mDATE: OCTOBER, 2020NORTHING 3508788.757 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 182.580 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

CONTROL POINT FS53

EASTING 308696.17 m

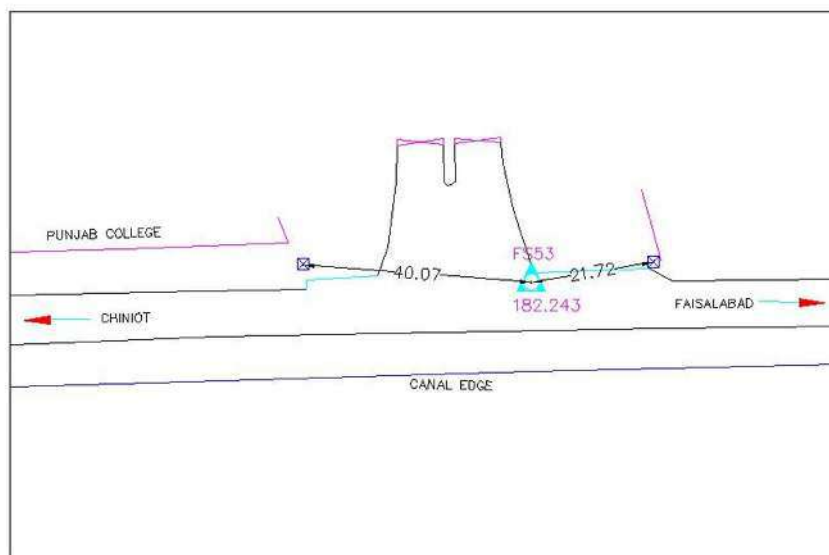
DATE: OCTOBER, 2020

NORTHING 3508824.085 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 182.243 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

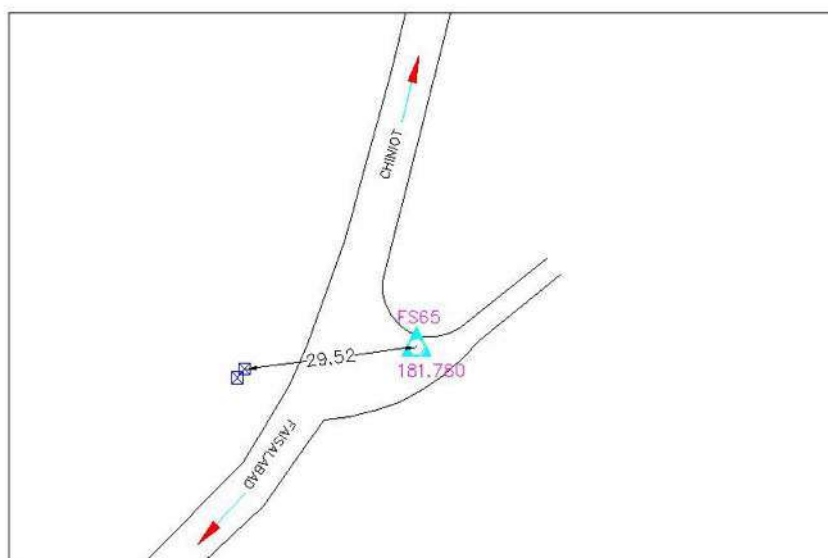
DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT FS65

EASTING 306356.460 m
NORTHING 3509848.737 m
ELEVATION 181.780 m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT CONTROL POINT DATA SHEET

CONTROL POINT FS66

EASTING 306444.264 m

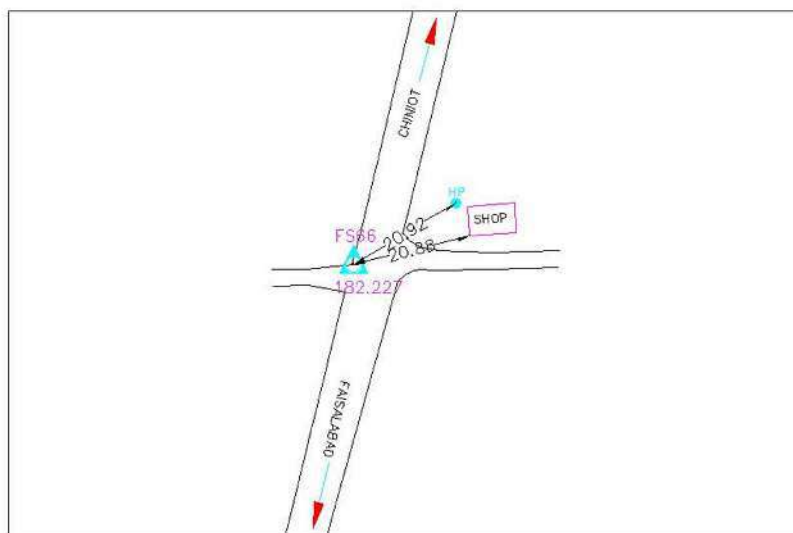
DATE: OCTOBER, 2020

NORTHING 3510270.092 m

COORDINATE SYSTEM XYZ, UTM/WGS84/43N

ELEVATION 182.227 m

LOCATION PLAN



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

CONTROL POINT DATA SHEET

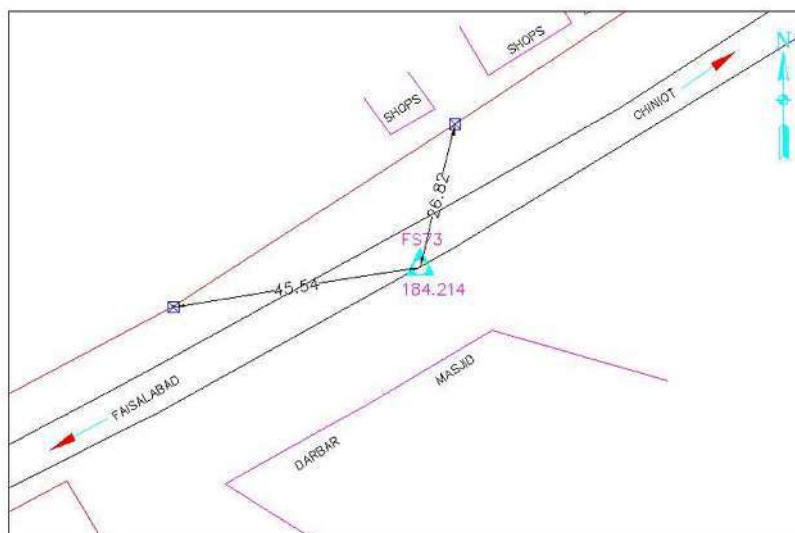
CONTROL POINT FS73

EASTING 307778.179 mDATE: OCTOBER, 2020NORTHING 3512785.023 m

COORDINATE SYSTEM XYZ. UTM/WGS84/43N

ELEVATION 184.214 m

LOCATION PLAN



DESCRIPTION



SURVEY & MAPPING
Lahore PAKISTAN

DUALIZATION OF FAISALABAD-CHINIOT SARGODHA ROAD PROJECT

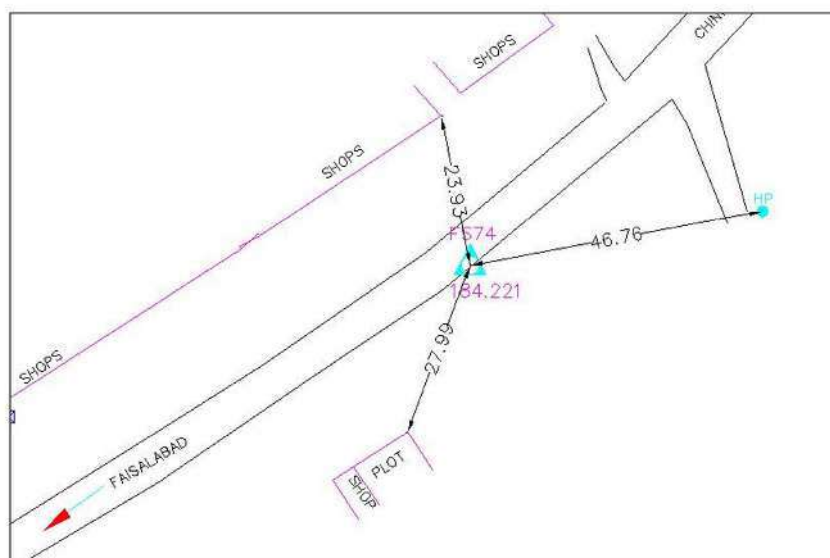
CONTROL POINT DATA SHEET

CONTROL POINT FS74

EASTING 308007.831_m
NORTHING 3512928.949_m
ELEVATION 184.221_m

DATE: OCTOBER, 2020
COORDINATE SYSTEM XYZ. UTM/WGS84/43N

LOCATION PLAN

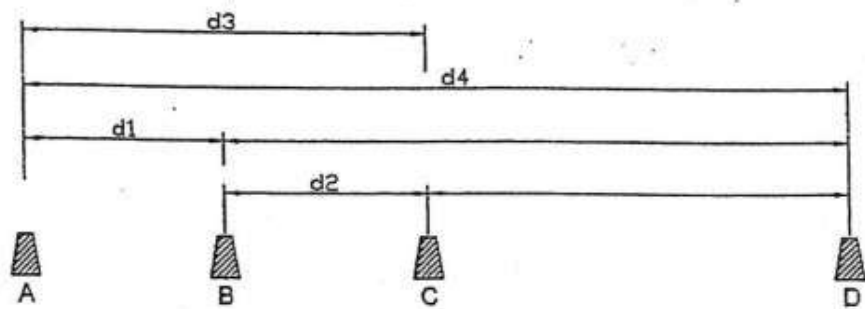


SURVEY & MAPPING
Lahore PAKISTAN

CALIBRATION OF SURVEY INSTRUMENTS

NATIONAL ENGINEERING SERVICES
PAKISTAN (PVT)LIMITED

EDM CALIBRATION BASELINE
UET - LAHORE
SOKKIA SET 630RK#146259



LENGTH A-D.(d4) = 300.053m. (Fixed)

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LTD.**BASE LINE MEASUREMENT****UNIVERSITY OF ENGINEERING AND TECHNOLOGY (UET) ,LAHORE**

Instrument.No: SOKKIA Set 630RK 146259

Date:17-12-2019

A-B	Prism # 1	Prism #2	Prism #3	Remarks
	20.008	20.016	20.007	PPM = 0
	20.006	20.015	20.006	PC = -30
	20.006	20.016	20.006	
	20.007	20.015	20.006	
(d1) Mean.	20.007	20.016	20.006	20.0095
A-C	40.011	40.012	40.011	
	40.013	40.013	40.012	
	40.011	40.014	40.012	
	40.012	40.012	40.013	
(d3) Mean	40.012	40.013	40.012	40.0122
A-D	300.050	300.050	300.050	
	300.050	300.050	300.051	
	300.051	300.050	300.051	
	300.051	300.052	300.052	
(d4) Mean	300.051	300.051	300.051	300.0507
B-C	20.009	20.011	20.005	
	20.008	20.012	20.005	
	20.009	20.013	20.006	
	20.009	20.012	20.005	
(d2) Mean	20.009	20.012	20.005	20.0087

1-Measurements

Form.BLM-01/1

Prism # 1

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = -0.0038
 S = 0.0063
 Sppm = 20.8297

Prism #2

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = -0.014750
 S = -0.01225
 Sppm = -40.8261

Prism #3

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = 0.0005
 S = 0.0025
 Sppm = 8.332

Sppm Mean = -3.888

Mean Distance

D4 = 300.053 (FIXED /FROZEN VALUE)
 C = -0.0060
 S = -0.0037
 Sppm = -12.220

Accuracy 5mm+ppm*D/1000000

= -3.887

The result is within the limit

Status of Equipment : A

SITE PHOTOGRAPHS



FS 5 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER



FS6 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER



FS 20 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER



FS 17 CONCRETE MONUMENT WITH STEEL NAIL AT CENTER

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)



GPS BASE STATION AT POINT FS 25 COLLECTING DATA



STATIC POINT OBSERVATION FS31

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)



STATIC POINT (FS50) OBSERVATION ALONG THE ROAD



STATIC POINT (FS36) OBSERVATION ALONG THE ROAD

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)



STATIC POINT (FS49) OBSERVATION ALONG THE ROAD AT BRIDGE



STATIC POINT OBSERVATION ALONG THE ROAD

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)



STATIC POINT (FS33) OBSERVATION ALONG THE ROAD



STATIC POINT (FS24) OBSERVATION ALONG THE ROAD

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)



STATIC POINT (FS36) OBSERVATION ALONG THE ROAD



TOPOGRAPHIC SURVEY OF PROJECT AREA WITH TOTAL STATION

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

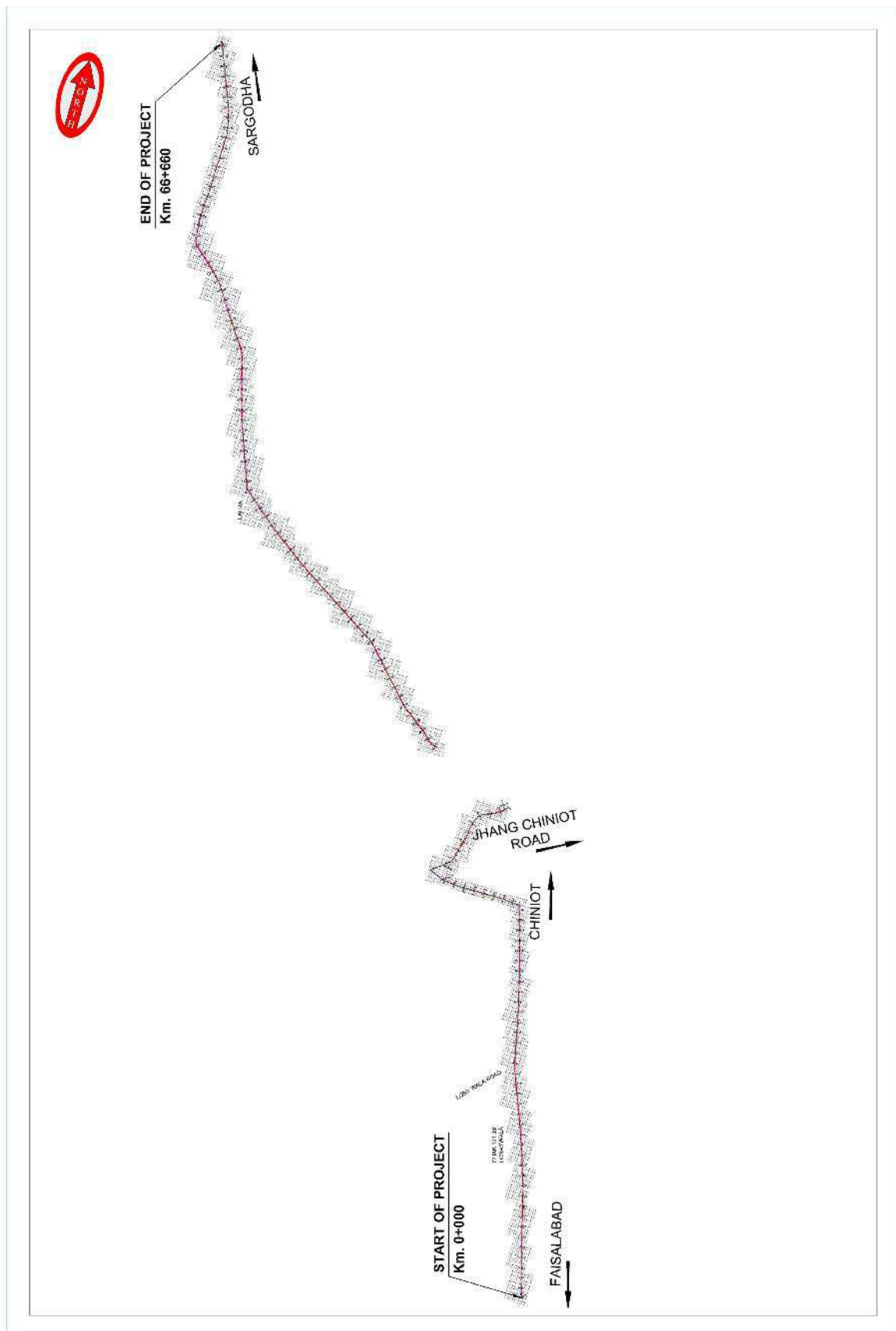


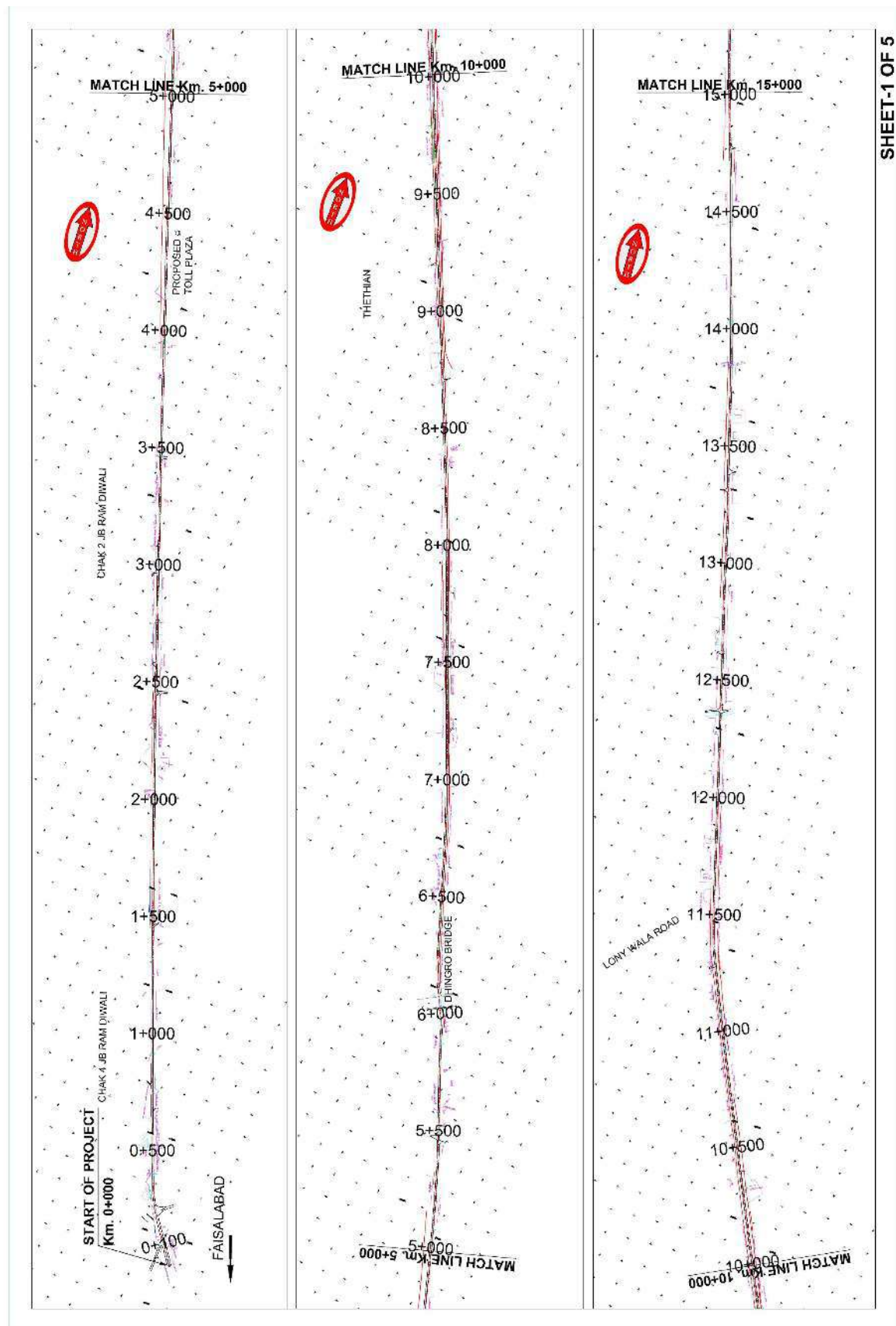
TOPOGRAPHIC SURVEY OF PROJECT AREA WITH TOTAL STATION



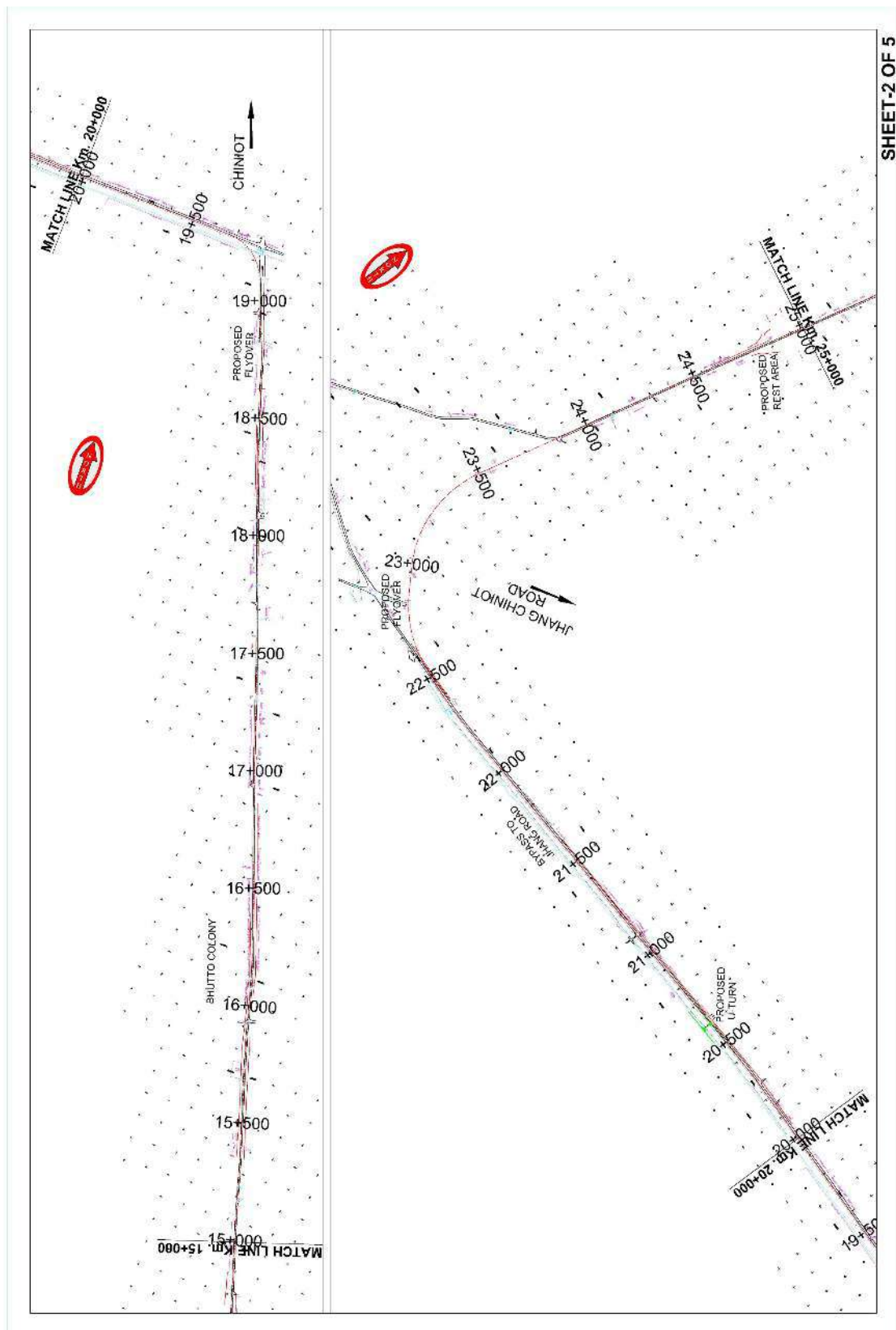
TOPOGRAPHIC SURVEY OF PROJECT AREA WITH TOTAL STATION

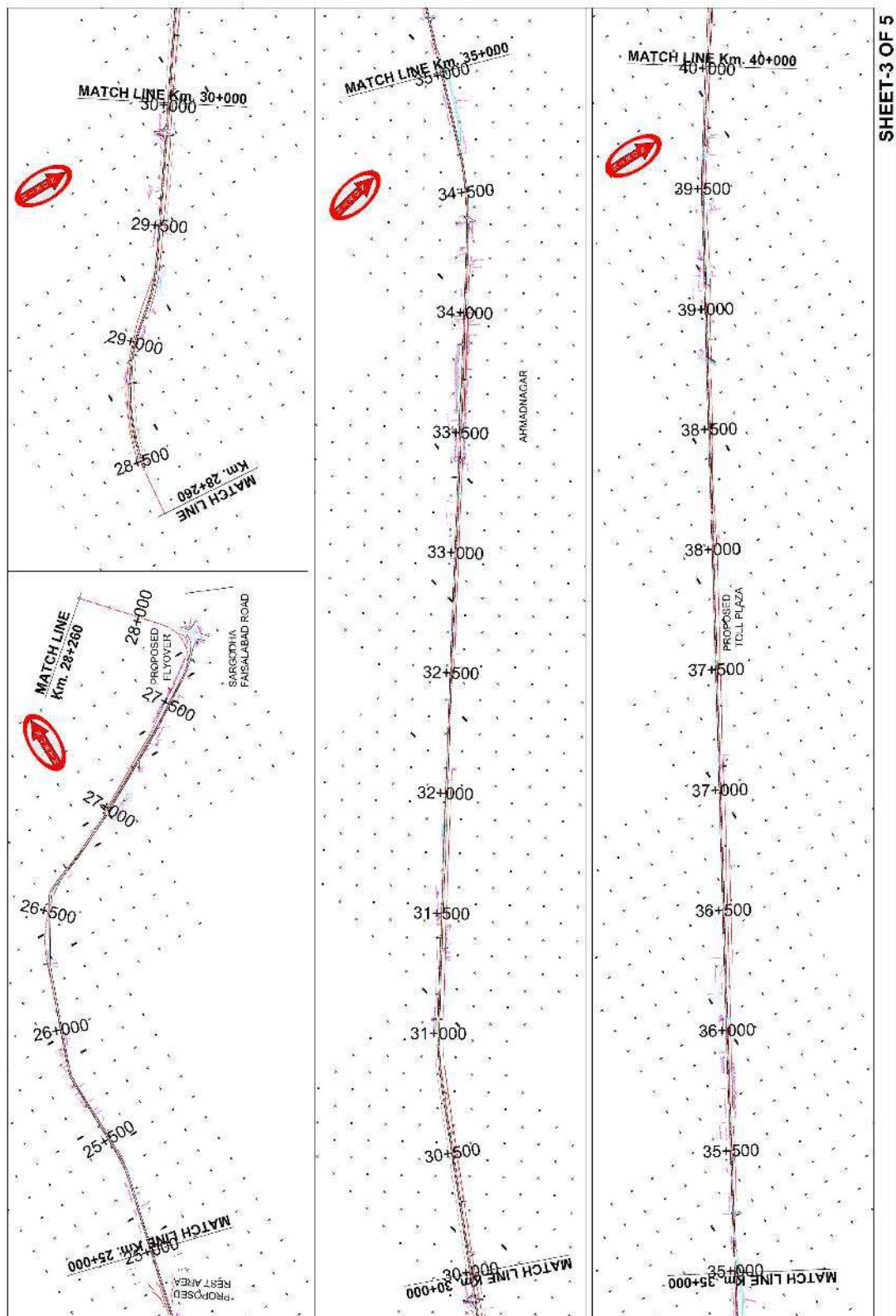
TOPOGRAPHICAL MAP SHEETS

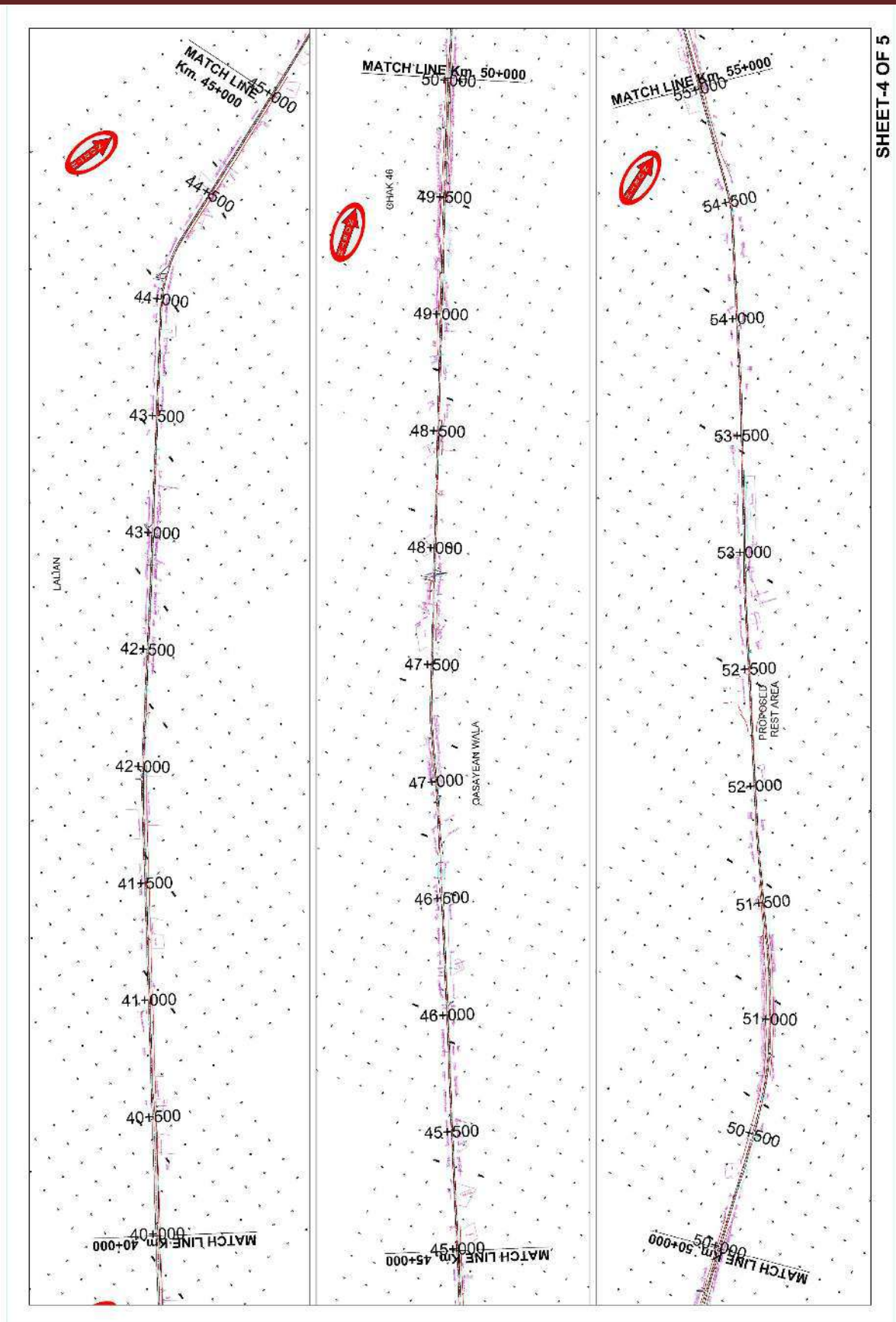
TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

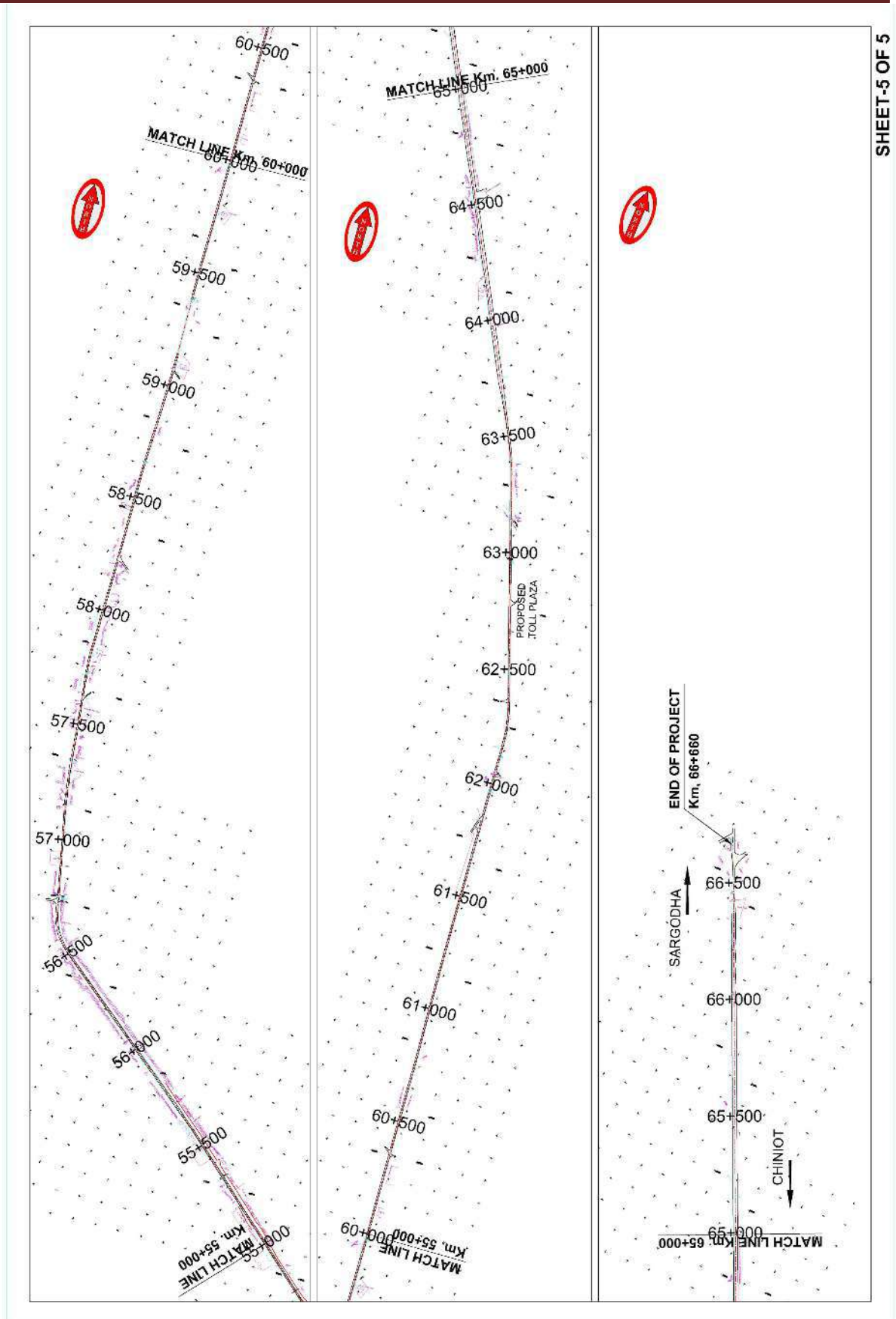
SHEET-1 OF 5

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)



3.2. GEOMETRIC DESIGN REPORT

3.2.1 GENERAL

The detailed design of the road is based on a set of design criteria that represents the best internationally accepted engineering practice for the level of facility being planned. At the same time, the specific local site conditions and constraints are also effectively considered in the interpretation of design criteria. It is to be emphasized that engineering design is an integrated process of information collection, analysis, synthesis and evaluation. The ultimate objective of this process is achievement of the desired performance in the constructed facility. The design criteria should effectively represent the performance objectives while satisfying the economic constraints. The stipulated design criteria (given below) shall be subject to engineering judgment.

3.2.2 INTRODUCTION AND BRIEF DESCRIPTION:

Communication and works Department (C&W) Punjab, entrusted National Engineering Services Pakistan (NESPAK) Pvt. Ltd as the project consultants for preparing Feasibility Study and preliminary design for Dualization of existing single road of Faisalabad – Chiniot-Sargodha section.

- The project road is located in Punjab Province Pakistan
- The project road length is estimated to be 67 km
- An effective and secure road network is essential in order to guarantee the mobility and supply for the whole population.

Location map of project is attached as figure.3.2a.

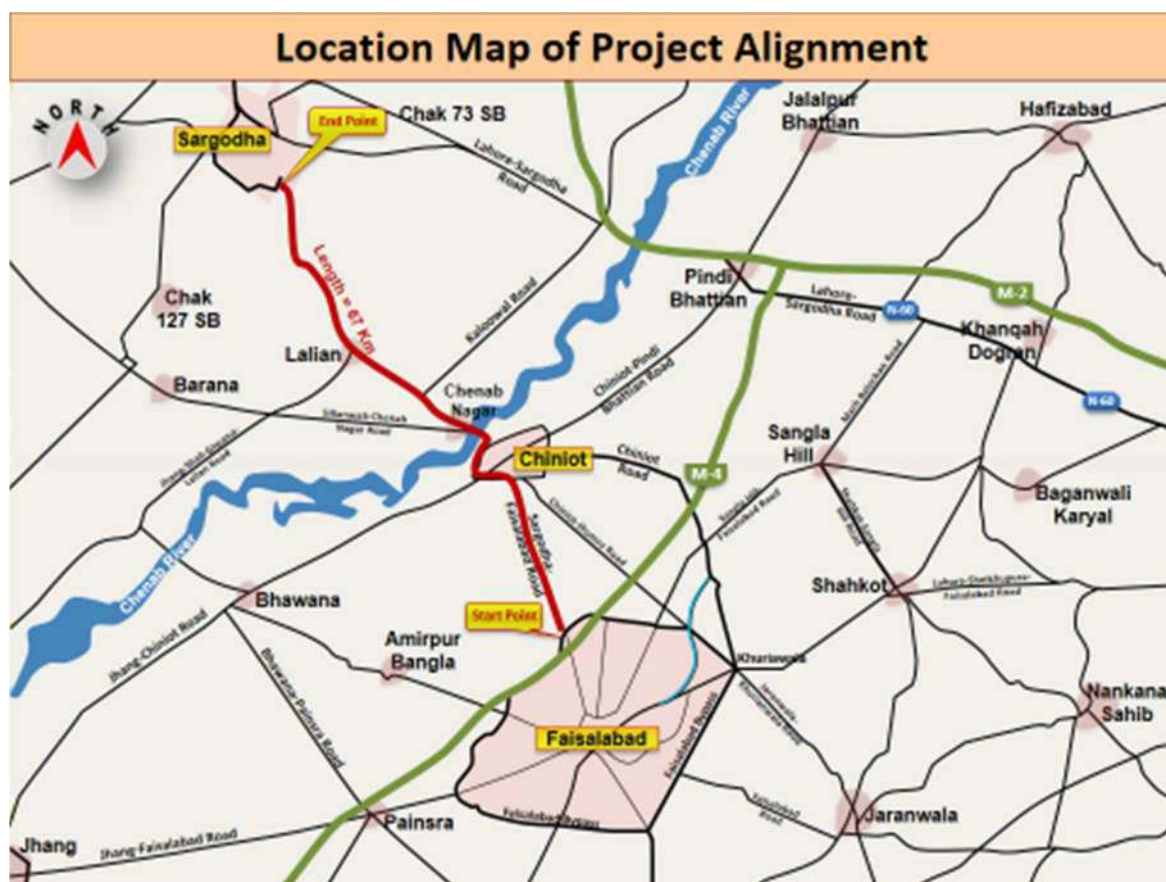


Figure. 3.2a LOCATION MAP OF PROJECT AREA

3.2.3 GEOMETRIC DESIGN:

Geometric design of highway refers to the design of the visible dimension of such features as horizontal and vertical alignments, cross sections, intersections. The main objective of geometric design is to produce a highway with safe efficient and economic traffic operations while maintaining esthetic, environment quality. Geometric design is influenced by the vehicle, driver and traffic characteristics.

Road design is traditionally a manual technique in which the problem is considered separately in three views. i.e.

- a) Plan
- b) Longitudinal profile
- c) Cross section

A. HORIZONTAL ALIGNMENT:

The alignment comprised of a variety of elements joined together to create a facility that serves the traffic in a safe and efficient manner, consistent with the facilities intended function. Each alignment element should harmonize the others to produce a consistent, safe efficient and responsible design. Horizontal alignment must afford at least the minimum stopping sight distance for the design speed at all points on the highway.

I. DESIGN SPEED:

Speed reduces the visual field, restricts peripheral vision, and limits the time available for drivers to receive and process information. Design Speed is a selected speed based on the various geometric features of the roadway. Conversely the geometric design features should correspond with the desired design speed. The selected design speed should be consistent with the speeds that drivers are likely to expect on a given highway facility.

Design Speed for the project on main carriageway was taken 120 Kilometres per Hour (Km/hr). However at few location the design speed is reduced due to site constraints.

II. CURVE RADIUS:

The minimum radius is a limiting value of curvature for a given design speed and is determined from the maximum rate of super elevation and the maximum side friction factor selected for design (limiting value of f).

The Design Consultant has studied the existing Geometry and has made improvements where required.

- Minimum radius at relevant design speed and maximum super elevation is taken as 756m.
- Absolute minimum curve radius at turnings/channelizing islands is taken as 15m.

III. SUPER ELEVATION:

Super elevation is the banking of a roadway around a curve. The purpose of employing super elevation of the roadway cross section is to counter balance the centrifugal force, or outward pull of a vehicle traversing a horizontal curve. Side friction developed between the tires and the road surface also counter balances the outward pull of the vehicle. A combination of these two concepts allows a vehicle to negotiate curves safely at higher speeds.

There are practical upper limits to the rate of super elevations on a horizontal curve.

- Maximum super elevation on the project is taken 6%.

B. VERTICAL ALIGNMENT:

Topography of the land traversed has an influence on the alignment of roads and streets. Topography affects horizontal alignment, but has an even more pronounced effect on vertical alignment. The highways vertical alignment plays a significant role in highway safety, aesthetics and project costs. Vertical curves are normally parabolic. A simple vertical curve may be crest vertical curve or a sag vertical curve. The design of vertical alignments involves, to a large extent, complying with specific limiting criteria. These includes maximum and minimum grades, sight distance at vertical curves and vertical clearances. The project lies in the plan area.

I. GRADIENT:

Road and streets should be designed to encourage uniform operation throughout. Grades are important to facilitate the road users. The desirable maximum grade is taken as 6 %.

II. K VALUE FOR VERTICAL CURVES:

The major control for safe operation on crest & a sag vertical curve is the provision of ample sight distances for the design speed which depends on rate of vertical curvature "K". For this project the "K" value, based on stopping sight distance is taken "52" for Crest vertical curve & "45" for Sag vertical curve.

A. ROAD CROSS SECTION ELEMENTS:

Road Cross Section Elements were as follows:

a) Width of Roadway

Width of Roadway consists of travelled way width and shoulder width. These elements on the Project Road are as follows;

i) Lane Width

Lane width on the Project is 3.65 m and 2 Lanes on Either travelled way of the Project are provided.

ii) Shoulder Width

Paved / TST shoulder on the outer edge (both sides) of travelled way is 1.2m wide for urban areas and 2.45m for rural areas.

b) Cross Slope

On highways cross slope across the entire width of the travelled way is generally provided for surface drainage. For main carriageway design, the cross slope on either side taken as 2.0%.

3.2.4. COMPUTER PROGRAMME:

Computer programs Eagle point/Road Calc. was used for the analysis and design of the road components.

3.2.5. DESIGN CRITERIA

Design criteria are basic to good geometric design and adhering to them will enhance the visual qualities of the roadway. In Pakistan most design parameters and criteria for road design are based on AASHTO guidelines.

The geometric design was carried out as per “A Policy on Geometric Design of Highways and Streets 2011” by AASHTO based on the following main parameters.

ROADS DESIGN CRITERIA:

Sr. no.	Description	Main road	Intersection
1	Length of Project Right of way (Available) Design Vehicle	67 km 110' to 127' Tractor Trailer 6- axle	Tractor Trailer 6- axle
2	Design speed Posted speed	120 Kph 100 Kph	50 Kph
3	Cross section Lane width No of Lanes Travel Lane width Shoulder Inner (Paved) Outer (Rural) Outer (Urban)	3.65m 2 each side 7.3m 0.9m 2.45m + 0.5m rounding 1.2m	3.65m 0.6m 2.45m + 0.5m rounding 1.2m
4	Carriage way cross slope Pavement Outer shoulder TST Inner shoulder	 2% 2% 2%	 2% 2% 2%
5	Horizontal Alignment Minimum Radius Minimum radius with no super elevation Absolute Minimum Curve radius at turnings/Channelizing Islands (m) Maximum super elevation	 756m 4770m 15m 6%	 6%

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

	Minimum stopping sight distance	185m	
	Acceleration length to entrance	360m	n/a
	Deceleration length to 50km/hr.	170	n/a
6	Vertical Alignment Maximum Gradient Minimum Gradient K value for crest vertical curve K value for sag vertical curve	6% - 52 45	6% - - -
7	Design life of pavement Pavement Lane marking White Line Yellow line Studs (white, yellow, green)	10 Years Between two lanes Roadway edge/ Shoulder line Lines, Chevron As required	10 Years Between two lanes Roadway edge/ Shoulder line As required
8	Divider (Highway) Median (Highway) Brick on edge	NJB (Chevron signs at curves) Curb Type At shoulder	- Curb Type

3.3. PAVEMENT DESIGN REPORT



3.4.1 PAVEMENT DESIGN ACTIVITIES:

Pavement design depends upon two basic parameters; traffic and soil strength. The pavement design of the project road has been carried using AASHTO 1993 approach. The AASHTO procedure uses Serviceability Indices, environment, drainage and reliability, Structural Numbers, layer thicknesses.

3.4.2 TRAFFIC STUDIES:

Traffic studies are intended to provide necessary input data for determination of the magnitude and pattern of the traffic load for the project highway through the design period. This entails collection, verification and analysis of the traffic data. From the collected data, the projected traffic for the design life of the subject highway is determined. For details, refer Traffic Study Report.

3.4.3 DESIGN LIFE:

Design life is the number of years reckoned from the completion of pavement construction and application of traffic load until the time when major maintenance is required so that it can continue to carry traffic satisfactorily for further period.

A design period of 10 years has been adopted, which is a normal practice, taking base year as 2023 to calculate the traffic load and eventually carrying out pavement design. However, the ESALs have been calculated for 25 years from base year to work out the thickness requirement of unbound layers, in order to provide a foundation that can sustain 25 years structural life. For asphalt layers, stage construction is opted; the asphalt requirement for 10 years design life is ascertained and shall be placed so that the pavement can perform satisfactorily for 10 years subject to adopting quality control measures during execution of the project.

3.4.4 EQUIVALENT STANDARD AXLE LOAD:

In order to determine the cumulative axle load damage that a pavement will sustain during its design life, it is necessary to express the total number of heavy vehicles that will use the road during the design period, in terms of the cumulative number of Equivalent Single Axle Load (ESALs).

3.4.4.1 Equivalent Axle Load Factors:

The damage caused by vehicles to a road depends on the axle loads and wheel configuration of the vehicles. It is, therefore, important to determine the axle loads of

Heavy commercial vehicles in the projected traffic mix that is likely to use project road in future.

For pavement design purposes the damaging power of axles is related to a standard axle of 8.16 tones (18000 lbs) using equivalence factors which have been derived from empirical studies.

Equivalent Axle Load Factors (EALF) are determined separately, for different types of axle configurations. The EALF obtained by NTRC Survey 1995 have been adopted.

3.4.4.2 Calculation of Cumulative Equivalent Single Axle Loads (ESALs):

In order to determine the cumulative ESALs over the design period the following procedure has been adopted.

- AADT has been determined.
- Direction Factor value has been selected.
- Annual traffic in design lane has been determined.
- Equivalent Axle Load Factors (EALF), for each class of vehicle i.e. Loaded and Empty has been used.
- Equivalent Single Axle Load (ESALs) has been estimated.

3.4.4.3 Total ESALs for the Design Life:

The pavement design procedure is based on the cumulative number of expected Equivalent Single-Axle Loads (ESALs) during the design period. The projected cumulative ESALs for the aforementioned project road has been computed over the design life of the project and mentioned in the Annexure-4.

3.4.5 DESIGN CBR:

The pavement design is based on minimum soaked CBR 10% @ 95 % M.D.D. for Subgrade.

3.4.6 PAVEMENT DESIGN ANALYSIS:

The pavement design process is the technique of developing a combination of top layers of different materials in most economical manner to cater for the total axle load over the



design life of the pavement. In other words, this is an art through which the stresses as induced in the top layers of a highway due to movement of heavy wheel load are disseminated and minimized to safe level through selection of different type and appropriate thickness of pavement layers.

The AASHTO Guide for Design of Pavement Structure 1993 has been used to compute the pavement thicknesses.

3.4.6.1 AASHTO Procedure for Flexible Pavement Design:

The AASHTO Guide for design Pavement Structures 1993 outlines this procedure for determination of flexible pavement thickness by solving AASHTO equations manually, by using different monographs or by using the computer software. For accuracy the computer program is preferred. Basically, the Structure Number (SN) required to be assigned to the proposed pavement structure for a given set of conditions is determined by solving the following numerical equation.

The required variable data to be substituted into this equation is:

$$\log_{10} W_{18} + Z_R S_o + 9.36 \log_{10} (SN + 1) - 0.20 + \frac{\log_{10} [\Delta PSI / 4.2 - 1.5]}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \log_{10} M_R - 8.07$$

- The estimated future traffic in terms of ESAL, for the design period, W_{18}
- The Reliability Level, R
- Standard Normal Deviate Value, Z_R
- The overall Standard Deviation, S_o
- The roadbed soil Resilient Modulus, M_R
- The design serviceability loss, $\Delta PSI = P_o - P_t$.

The above General Design Variables have been discussed in the following paragraphs.

- **Reliability (R)**

Design reliability refers to the degree of certainty that a given design alternative will last for the entire design period. A design reliability level of 90% has been adopted for pavement design of the project road.

- **Standard Normal Deviation (Z_R)**

The standard normal deviation value of -1.282 corresponding to reliability (R) of 90% has been adopted in the design and is based on the recommended values of standard normal deviation (Z_R) by AASHTO Guide 1993.



- **Standard Deviation (S_o)**

The reliability factor is a function of the overall standard deviation that accounts for standard variation in materials and construction, the probable variation in the traffic prediction and the normal variation in pavement performance for a given design traffic application. The recommended value of standard deviation for total variation in material properties and in traffic estimation for flexible pavement is 0.45 and has been adopted for pavement design of the project road.

- **Performance Criteria**

The serviceability of a pavement is defined as its ability to serve the type of traffic that uses the facility. Initial and terminal serviceability indices have been established to compute the total change in serviceability that will be used in the design equations.

- **Initial Serviceability Index (P_o)**

The initial serviceability index is a function of pavement design and construction quality. For flexible pavement design the typical value, as recommended by AASHTO Road Test, is 4.2 which has been adopted.

- **Terminal Serviceability Index (P_t)**

The terminal serviceability index is the lowest index that will be tolerated before rehabilitation, resurfacing or reconstruction, becomes necessary and it generally varies with the importance or functional classification of the pavement. Recommended value of terminal serviceability index is 2.5 for the project road.

- **Resilient Modulus M_R**

The basis for material characterization in the AASHTO Guide 1993 is Elastic or Resilient Modulus (M_R). The following correlation between CBR and M_R has been used to determine resilient modulus of unbound layers. (Refer NCHRP National Cooperative Highway Research Programme and MEPDG (Mechanistic Empirical Pavement Design Guide)).

$$M_R = 2555 (\text{CBR})^{0.64}$$

Where;

CBR =California Bearing Ratio in percentage.

M_R = Resilient modulus in psi

3.4.6.2 Computation of Required Pavement Thickness:

The structure number (SN) requirement as determined through adopting the design parameters as discussed above is balanced by providing adequate pavement structure. Under AASHTO design procedure the following equation provides the means for converting the structural number into actual thicknesses of surfacing, base and sub base materials:

$$SN = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

Where:

- a_1, a_2, a_3 = layer coefficients representative of surface, base and sub base courses respectively
- D_1, D_2, D_3 = actual thicknesses (in inches) of surface, base and sub base courses respectively
- m_2, m_3 = drainage coefficients for base and sub base layers respectively

- **Layer Coefficients:**

In order to transform the structural number of different pavement layers into respected pavement layer thicknesses, following layer coefficients have been adopted (Refer Figure 2.5 ~ 2.7 of AASHTO Guide for Design of Pavement Structure).

Asphaltic Wearing Course, a_1	=	0.42 / inch (0.165/cm)
Asphaltic Base Course, a_1	=	0.42/ inch (0.165/cm)
Water Bound Macadam, a_2	=	0.13 / inch (0.051/cm)
Granular Sub base, a_3	=	0.12 / inch (0.047/cm)



3.4.7 DESIGN THICKNESS:

The minimum pavement thicknesses thus worked out, based on AASHTO approach for pavement design of the subject roads have been mentioned below subject to enforcement of Axle Load restrictions:

Asphalt Concrete Wearing Course	50 mm
Asphalt Concrete Base Course	180 mm
Water Bound Macadam	300 mm
Granular Sub base	200 mm

Subgrade shall have a minimum soaked CBR of 10% @ 95% M.D.D.

3.4. HYDROLOGY STUDY REPORT



3.5.1 GENERAL

Faisalabad and Sargodha districts are thickly populated cities and both are divisional headquarters as well. Large population from Mianwali, Khushab, Jauharabad, Sargodha and Chiniot districts travels to Faisalabad on daily basis due to industrial and business nature of Faisalabad. The existing road is single and also in deteriorated condition. Furthermore, stone crushing plants are located near Chak 46 and 111 which deploys heavy traffic comprises crushing machinery equipment and loader trucks which creates frequent traffic jams and hurdles.

The dual carriage way shall provide transportation ease to a large population. the Government of the Punjab intends to upgrade this important road link to dual carriage way.

3.5.1.1 Scope of Hydrological Studies

The scope of hydrological studies is to locate, check and evaluate catchments of the streams, nullahs and drains along with assessment of discharge against 100 yr and 25 yr. The scope includes assessment of capacity of the existing natural drainage across the route and recommendations for the upgradation, if any.

3.5.1.2 Route Alignment and Water Infrastructure Crossings the Alignment

Total length of the Faisalabad to Sargodha road is about 60 kilometres. The existing alignment passes through industrial and thickly populated area of Faisalabad city, several important settlements i.e. Chiniot district, Chenab Nagar, Ahmad Nagar, Lillian, etc. The road also passes through an important business activity of stone crushing plants near Chak 46 and 111.

The area between Faisalabad and Sargodha is mostly culturable command area and existing route passes through lush green fields and orchards, therefore several irrigation channels from main canal to minor channels cross the road at different locations.

Several drains, constructed under the Salinity Control and Reclamation Project (SCARP) also cross the route alignment. Currently, these drains only carry the sewerage water from the nearby settlements. These drains are usually not designed for storm water.

In addition to the irrigation channels and drains, some natural streams/flood channels also exist at different location for carrying localised sheet flows during rain events. The structures on the road have been provided to cross the flow. As the area is of flat terrain, the rain water can flow to either side depending upon rainfall intensity and standing water accumulation.

The project area map including existing road alignment and road crossings at different RDs is given in the Figure No. 3.5.1.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

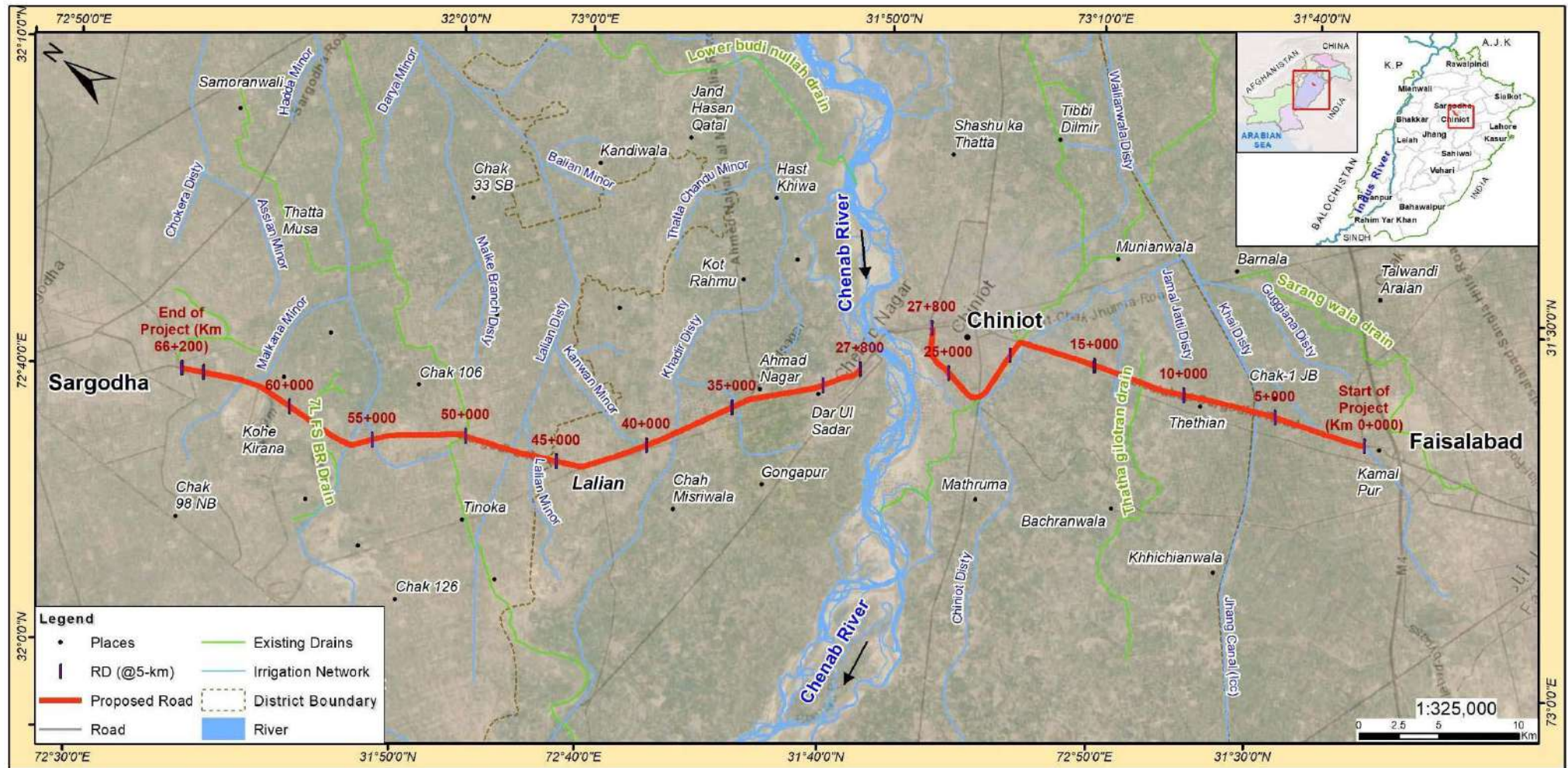


Figure 3.5.1: Project Area Map and Existing Road Alignment

3.5.1.3 Drainage Requirements for the Roads/ Highways

The influence of hydrology and drainage considerations is of key importance in planning, design, rehabilitation and upgradation of the existing roads/highways. Drainage requirements for such developments are established in consideration of:

- The implications associated with the routes i.e. passing in densely populated area, traffic load and etc;
- The number of cross drainage locations encountered and location of major bridges/culverts as potential fixed points along the alignment;
- Anticipated levels of flooding, scour and provision of associated protection structures.

Existing hydrological details of the road crossings were not available to the Consultants therefore, the catchment delineations, stream network generation and assessment of drainage locations have been carried out by the Consultants in current studies.

3.5.2 HYDROLOGICAL AND HYDRAULIC STUDIES

Understanding of regional hydrological phenomenon is an important task for determining the discharge estimations, locations, and dimensions/sizing of cross drainage structures. Climate of the project area.

The climate of the project area is very hot with humid summers and dry cool winters. In summer when conditions are dry, dust storms are common. The monsoon and the western disturbance are the two main factors that change the weather in the area. Main factors that influence the weather of the area are; western disturbances, fog, dust storm, heat waves and monsoon rains. Faisalabad is the nearest climate station which is operated and maintained by Pakistan Meteorological Department (PMD). Climate station of Faisalabad provides a fair representative estimate for the climate parameters of the project site.

Western disturbances generally occur during the winter months and cause moderate rainfall. Monsoon occur in the summer from the month of June till September. Monsoon rains bring much awaited relief from the scorching heat of the summer. These monsoon rains are quite heavy. The maximum recorded temperature in the pre-monsoon season of April to June is 40.2 °C, whereas in winter the minimum temperature recorded is 4.7 °C. The average annual rainfall is 377 mm and maximum amount of rainfall is observed during the monsoon period. Temperature and rainfall trends at Faisalabad station are presented in Figure-3.5.2.

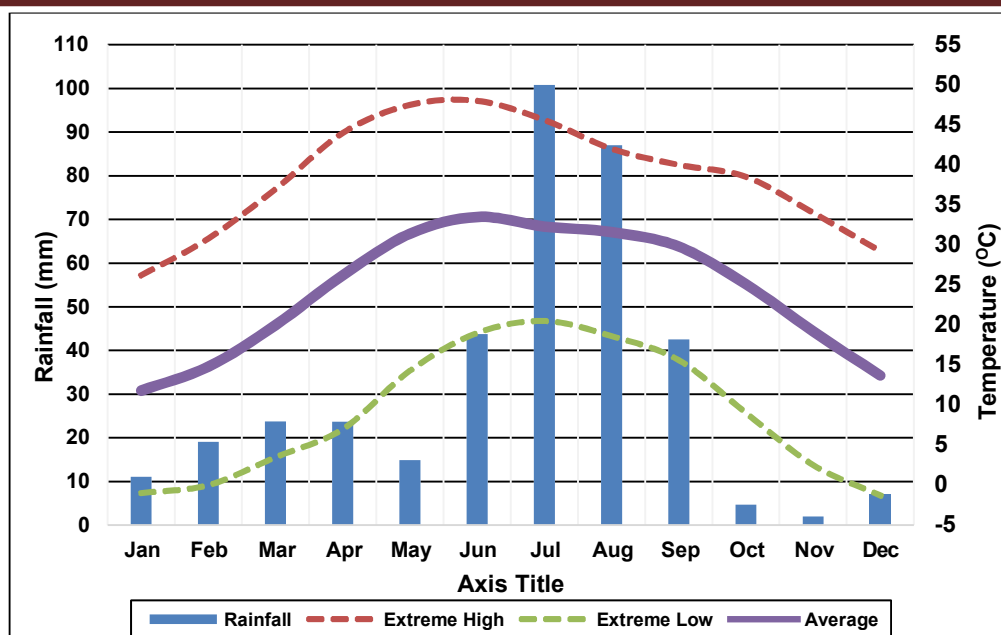


Figure 3.5.2: Temperature and Rainfall Trends at Faisalabad

3.5.2.1 General Topography of the Area

General topography of the area features very flat terrain with no definitive drainage pattern comprising stream and/or nullahs etc. Most of the area remains covered with seasonal agriculture round the year and there are some towns/villages settled along the road. For identification of drainage pattern and slopes around the study area, Digital Elevation Model (DEM) of Shuttle Radar Topography Mission (SRTM) having a resolution of 30 meter has been used. Catchment characteristics like impervious, roughness, hydrologic conditions of area, soil cover, land use & treatments, soil type and extents and other flow controlling parameters have been investigated through satellite and Google Earth imagery. Stream network suggests that the general slopes of the area is from Sargodha to Faisalabad direction. The deskwork observations have also been validated using strip survey details and data. The sample cross verification of the digital data and strip survey is shown in Figure 3.5.3.



Figure 3.5.3: Strip Survey and Data Acquisition

3.5.2.2 Hydro-meteorological Analyses

One-day annual maximum rainfall data of Faisalabad stations has been collected for last 38 years from Pakistan Meteorological Department (PMD) for the estimation of 100-year projections of rainfall magnitudes. Climate of Faisalabad station has already discussed in previous section. Historic data since 1981 suggest an average annual 1-day maximum rainfall value of 63.8 mm, the maximum magnitude of rainfall witnessed till date is 180.3 mm in year 1981. Figure 4 below shows the trends of annual maximum rainfalls observed at Faisalabad station.

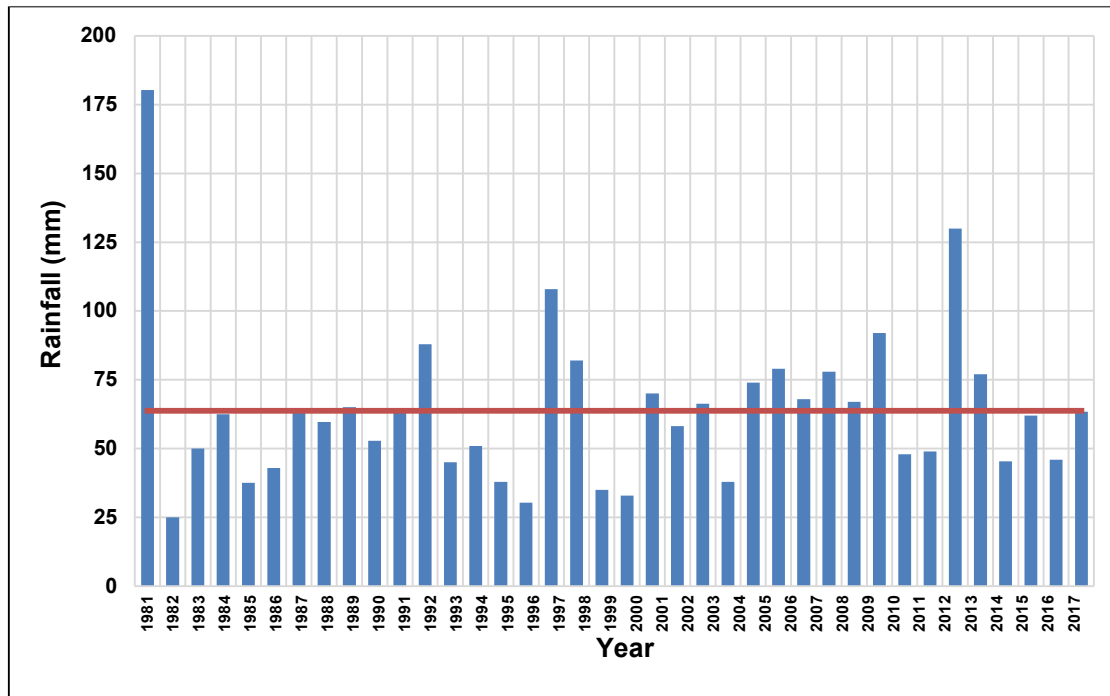


Figure 2: 1-day Annual Maximum Rainfalls at Faisalabad Station

Rainfall frequency analysis for 1-day annual maximum rainfall data of Faisalabad station has been carried out using Gumble's Extreme Value Type-1 Distribution. Gumbel distribution is a member of family of Extreme Value distributions. It is a two-parameter distribution and is

widely used in hydrology. For annual maximum series, Weibull formula has been adopted as the standard plotting position method by the U. S. Water Resources Council (1981). Results of frequency analysis present rainfall magnitudes of 87 mm and 128 mm for 5 and 25-year return periods, respectively as given in Table-1 and provided by graph in Figure-5.

Table 2: Rainfall Depth against Various Return Periods

Return Period (years)	Rainfall Depth (mm)
2.33	65
5	87
10	105
25	128
50	145
100	161

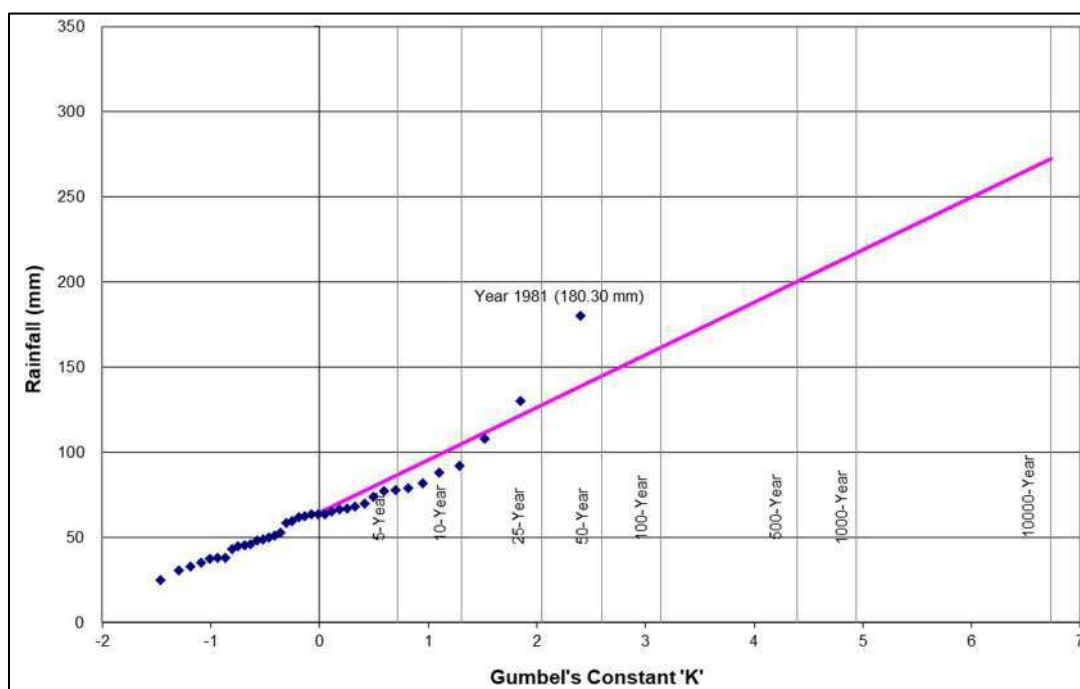


Figure 3: Frequency fitting of 1-day Annual Maxima

3.5.2.3 Water Infrastructure Crossing on Existing Road Network

Deskwork studies and field observation during the strip survey indicates the classification of water crossing across the existing road. There are three (03) type of channels crossing the road alignment:

1. Irrigation channel crossings
2. Drain crossings
3. Natural channels/Sheet flow crossings

The methodology to address the type of crossing is given in the preceding sections.

3.5.2.4 Irrigation Channel Crossings

Irrigation canals ranging from main canals to minor level cross the road alignment at various locations. Design section of irrigation canals based on sanctioned discharge as per culture-able command area and an additional contingent canal capacity is also provided in the form of freeboard to cater for any unforeseen situation.

3.5.2.4.1 Major Irrigation Channel Crossings

The inventory of the irrigation channels is developed from the field data collected from the strip survey and data extracted/verified from the Project Management and Implementation Unit (PMIU) of the Punjab Irrigation Department's website. List of major irrigation channels crossing the road alignment is given in Table-2.

Table 3: List of Major Irrigation Channels Crossings and Design Parameters

Sr. No	RD	Channel Name	Type of Existing Structure	Structure Size (m)	Existing Deck Level (m)
1	00+028	Khai Canal	Box Culvert 02 Spans	3.0X1.50	186.95
2	06+000	Jhang Canal (LCC)	Bridge	47m Width	190.58
3	13+850	Rajoa Canal	Box Culvert	2.0X0.75	182.52
4	18+765	Chiniot Canal	Bridge 03 Spans	3.2X1.50	183.48
5	34+772	Pillowal Canal	Bridge	06m Width	-
6	38+310	Khadir Canal	Box Culvert 03 Spans	2.7X1.50	182.90
7	46+450	Lalian Canal	Bridge	6m Width	-
8	47+415	Lalian Distributary	Bridge 02 Spans	2.5X1.50	187.85
9	54+865	Wasauna Canal	Box Culvert 01 Span	1.0X1.0	189.51
10	56+290	Kirana Canal	Bridge 03 Span	3.0X2.0	190.02
11	62+675	Malkana Canal	Box Culvert	1.0X1.0	189.02

3.5.2.4.2 Smaller/Minor Irrigation Channel Crossings

In addition to major channel crossings, there are numerous smaller irrigation channel crossings i.e. sub minors and watercourse outlets and farm channels. The Consultants captured geometrical details of these crossings during the strip survey of the road corridor. The details of these smaller crossings are given below in Table-3:

Table 4: List of Smaller/Minor Irrigation Channels with Design Details

Sr. No.	Chainage/RD	Structure Type	Structure Size No. of Spans*(WXH) in (m)
1	0+103	Box Culvert	1(2.0X1.5)
2	0+397	Box Culvert	1(1.7X1.0)
3	0+910	Box Culvert	1(1.9X1.0)
4	1+992	Box Culvert	1(1.0X1.0)
5	2+753	Box Culvert	1(1.0X1.0)
6	3+461	Box Culvert	1(2.0X1.0)
7	3+945	Box Culvert	2(2.0X1.0)
8	5+073	Box Culvert	1(1.0X1.0)
9	5+441	Box Culvert	1(2.5X1.0)
10	5+866	Box Culvert	1(0.7X0.9)
11	6+050	Bridge	4 Span of 10.5m

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Sr. No.	Chainage/RD	Structure Type	Structure Size No. of Spans*(WXH) in (m)
12	6+366	Box Culvert	1(2.0X1.0)
13	6+827	Box Culvert	1(1.0X1.0)
14	9+975	Box Culvert	1(2.0X1.0)
15	10+918	Box Culvert	2(1.5X1.0)
16	11+066	Box Culvert	1(1.0X1.0)
17	12+352	Box Culvert	1(3.0X1.5)
18	12+590	Box Culvert	1(1.0X1.0)
19	13+846	Box Culvert	1(2.0X0.75)
20	14+031	Box Culvert	4(4.0X2.0)
21	15+225	Box Culvert	1(2.0X0.75)
22	15+496	Box Culvert	2(2.0X1.5)
23	15+922	Box Culvert	1(2.0X1.0)
24	16+834	Box Culvert	1(1.0X1.0)
25	17+293	Box Culvert	1(1.0X1.0)
26	17+784	Box Culvert	1(1.0X1.0)
27	18+411	Box Culvert	1(1.0X1.0)
28	18+825	Bridge	3(3.2X1.5)
29	19+200	Bridge	2 Span of 9.0m
30	22+340	Bridge	3 Span of 7.5m
31	24+117	Box Culvert	1(0.5X0.5)
32	24+524	Box Culvert	1(0.5X0.5)
33	24+864	Box Culvert	1(1.0X1.0)
34	25+088	Box Culvert	1(0.5X0.5)
35	25+234	Box Culvert	1(0.8X0.8)
36	25+517	Box Culvert	1(0.5X0.5)
37	26+619	Box Culvert	1(0.8X0.8)
38	28+890	Box Culvert	2(2.0X1.5)
39	29+297	Box Culvert	2(1.5X1.0)
40	29+364	Box Culvert	2(1.5X1.0)
41	29+845	Box Culvert	1(1.5X1.0)
42	30+645	Box Culvert	1(0.8X0.8)
43	31+395	Box Culvert	1(1.5X1.0)
44	31+890	Bridge	13 Span of (2.2X2.5)
45	32+168	Box Culvert	3(2.0X1.5)
46	32+977	Box Culvert	1(1.2X1.0)
47	33+246	Box Culvert	1(2.0X1.5)
48	33+378	Box Culvert	1(0.8X0.8)
49	34+145	Box Culvert	1(1.0X1.0)
50	34+900	Box Culvert	1(2.0X1.0)
51	35+240	Box Culvert	1(2.0X1.5)
52	35+460	Box Culvert	2(2.0X1.5)
53	36+045	Box Culvert	1(1.5X1.5)
54	36+668	Box Culvert	3(2.5X2.0)
55	37+535	Box Culvert	1(1.0X1.0)
56	37+926	Box Culvert	1(1.0X1.0)
57	38+401	Box Culvert	1(1.0X1.0)
58	38+785	Box Culvert	3(2.7X1.5)
59	38+942	Box Culvert	1(1.0X1.0)

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Sr. No.	Chainage/RD	Structure Type	Structure Size No. of Spans*(WXH) in (m)
60	39+198	Box Culvert	1(1.0X1.0)
61	39+636	Box Culvert	1(1.0X1.0)
62	40+050	Box Culvert	1(1.0X1.0)
63	40+418	Box Culvert	4(1.7X1.8)
64	40+724	Box Culvert	2(2.0X1.5)
65	41+080	Box Culvert	1(1.0X1.0)
66	41+528	Box Culvert	1(1.0X1.0)
67	41+965	Box Culvert	1(1.0X1.0)
68	42+325	Box Culvert	1(2.0X1.0)
69	43+290	Box Culvert	1(1.0X1.0)
70	43+357	Box Culvert	1(1.0X1.0)
71	43+766	Box Culvert	1(1.0X1.0)
72	44+637	Box Culvert	1(1.5X1.0)
73	44+882	Box Culvert	1(2.0X1.5)
74	46+045	Box Culvert	1(1.0X1.0)
75	46+921	Box Culvert	1(2.5X1.5)
76	46+968	Box Culvert	1(1.0X1.0)
77	47+344	Box Culvert	1(1.0X1.0)
78	47+883	Bridge	2(2.5X1.5)
79	48+354	Box Culvert	1(1.0X1.0)
80	48+826	Box Culvert	1(1.0X1.0)
81	49+144	Box Culvert	1(1.0X1.0)
82	49+557	Box Culvert	1(1.0X1.0)
83	50+264	Box Culvert	1(1.0X1.0)
84	50+486	Bridge	2(8.5X4.0)
85	50+660	Box Culvert	1(1.0X1.0)
86	51+133	Box Culvert	1(1.0X1.0)
87	52+570	Box Culvert	1(1.0X1.0)
88	54+459	Box Culvert	1(1.0X1.0)
89	54+854	Box Culvert	1(1.0X1.0)
90	55+331	Box Culvert	1(2.0X1.5)
91	56+010	Box Culvert	1(1.0X1.0)
92	56+750	Bridge	3(3.0X2.0)
93	57+029	Box Culvert	1(1.0X1.0)
94	57+338	Box Culvert	1(1.0X1.0)
95	57+718	Box Culvert	1(1.0X1.0)
96	58+661	Box Culvert	1(1.0X1.0)
97	59+387	Box Culvert	2(3.0X1.5)
98	59+974	Box Culvert	1(1.0X1.0)
99	61+967	Box Culvert	1(1.0X1.0)
100	62+120	Box Culvert	1(1.0X1.0)
101	62+477	Box Culvert	1(1.0X1.0)
102	62+956	Box Culvert	1(1.0X1.0)
103	63+666	Box Culvert	1(1.0X1.0)

3.5.2.5 Drain Crossings across the Route Alignment

Beside Irrigation network, some drains are also crossing the existing road alignment. These drains carry sewage of the area and can also accommodate drainable surplus water of agricultural fields to some extent. The area topography is flat terrain and sheet flow usually do not become flood flow and rainwater is squeezed within local field bunds which are usually 1ft (0.30m) high. Therefore, chances of rainwater coming into these drains after crossing agricultural field is very less.

The locations and details of these drains are given in Table-4 below.

Table 5: List of Drains Crossings the Road Alignment

Sr. No	RD	Name	Type of Structure	Structure Size (m)	Existing Deck Level (m)
1	12+293	Thatha Gilotran Drain	Box Culvert 01 Spans	3.0X1.50	180.98
2	19+200	Marh Chiniot Drain	Bridge 02 Span	9.0m Bay width	183.01
3	50+020	Hadda Branch Drain	Bridge	15m width	-
4	58+927	7L FS BR Drain	Bridge	08m width	-

3.5.2.6 Irrigation and Drainage Channel Crossings

Channel sections for major as well as minor crossings for irrigation and drainage canals are designed to convey maximum possible discharge sanctioned/authorised for the canal command. However, an additional vertical clearance is provided in all irrigation channels to cater for any unforeseen i.e. freeboard. This freeboard is also provided at the bridge sections to allow for additional water. Thus, the bank level of the channels is the maximum water surface level in the channel and freeboard value. Hence, bank levels can be provided as soffit levels for the bridge or culvert structures for road crossings. Furthermore, it is recommended to get the design discharges of the channels from the concerned Irrigation Departments to review the channel section against the discharge. Box culverts of the same size as channel widths may be provided for small channel crossings however, bridge structures shall be proposed for large channel crossings for which fluming ratio (Structure width/Channel width) of 80-90 (%) can be provided to economize the structure

3.5.2.7 Abandoned Natural Cum Flood Channel Crossings

In addition to irrigation and drainage channel crossings, certain natural channel crossing structures over existing road have been identified in the strip survey. No perennial flow is seen in these crossing structures. While investigating these points with the help of satellite data, it has been revealed that in past, sheet flow was generated at these points as natural channel formation is visible at certain points. However, due to increase in cultural command area and settlements, these natural channels became abandoned. These structures are now serving as crossing of rain water collected at these depressed points and can travel to and from either side of the channel crossings. The Consultants have also considered these existing features and evaluated these structures in view of hydrological analysis and catchment characteristics. The Catchment delineation maps of these smaller crossings is given in Figure-6.

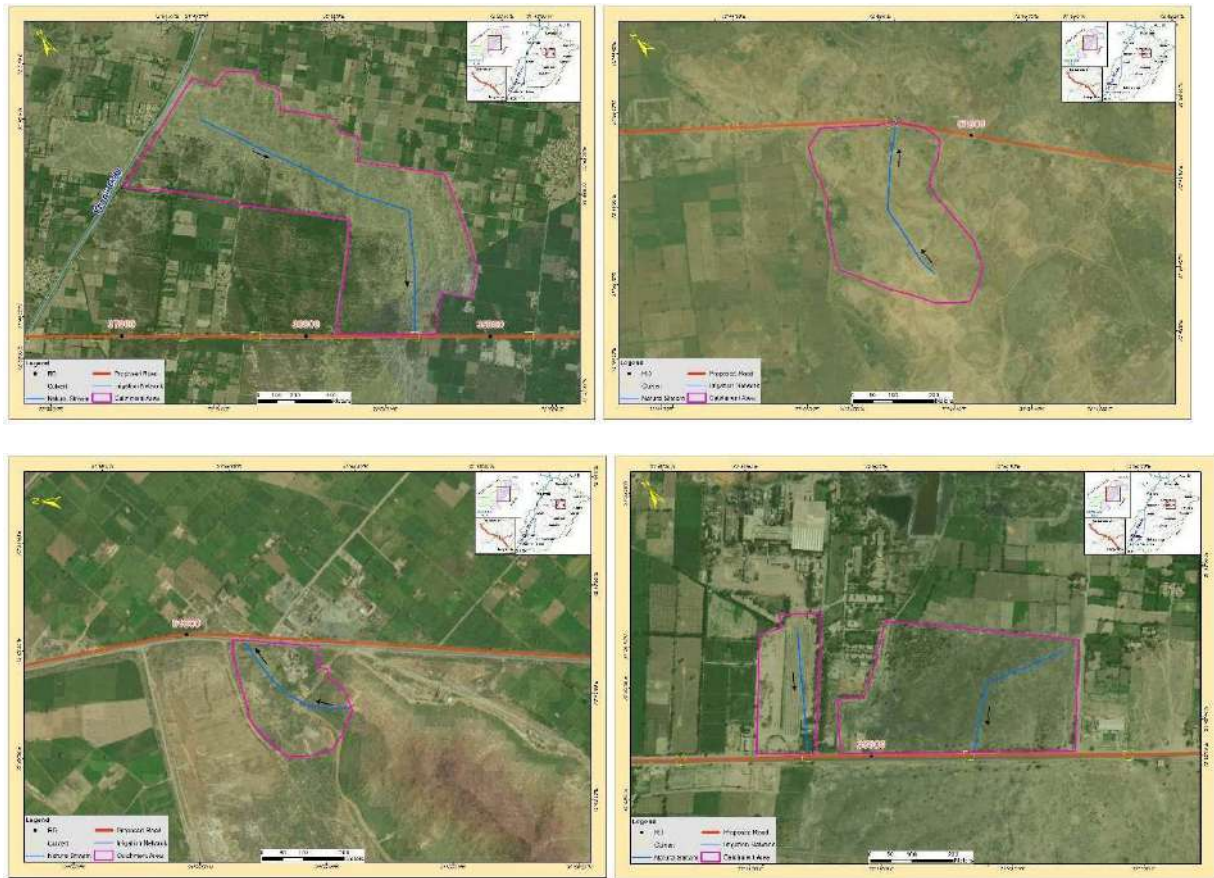
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Figure 4: Delineation of Smaller Catchment for Hydrological Analysis

Catchments area of these channels at crossing points are less than 1km² therefore, rational method is used to compute flood at these locations. Rational method technique is as described under:

$$Q = CiA$$

Where,

Q = Peak Discharge (Cusecs)

C= coefficient of discharge

I = Intensity of Rainfall (Inches/hour)

A = Catchment Area (Acres)

i) Time of Concentration

Time of concentration (T_c) is the time required for runoff to travel from the hydraulically most distant point in the watershed to the outlet. Kirpich formula has been used for computation of time of concentration which is given below:

$$T_c = \frac{(L)^{1.15}}{7700 \times (H)^{0.385}}$$

where

T_c	=	Time of Concentration (hours)
L	=	Length of the longest stream (feet)
H	=	Fall in length L (feet)

ii) Rainfall Intensity

Rainfall intensity is defined as the ratio of the total amount of **rain (rainfall depth)** falling during a given period to the duration of the period. It is expressed in depth units per unit time, usually as mm/hour or inch/hour. Intensity-Duration-Frequency curves have been developed for Faisalabad as shown in Figure-7

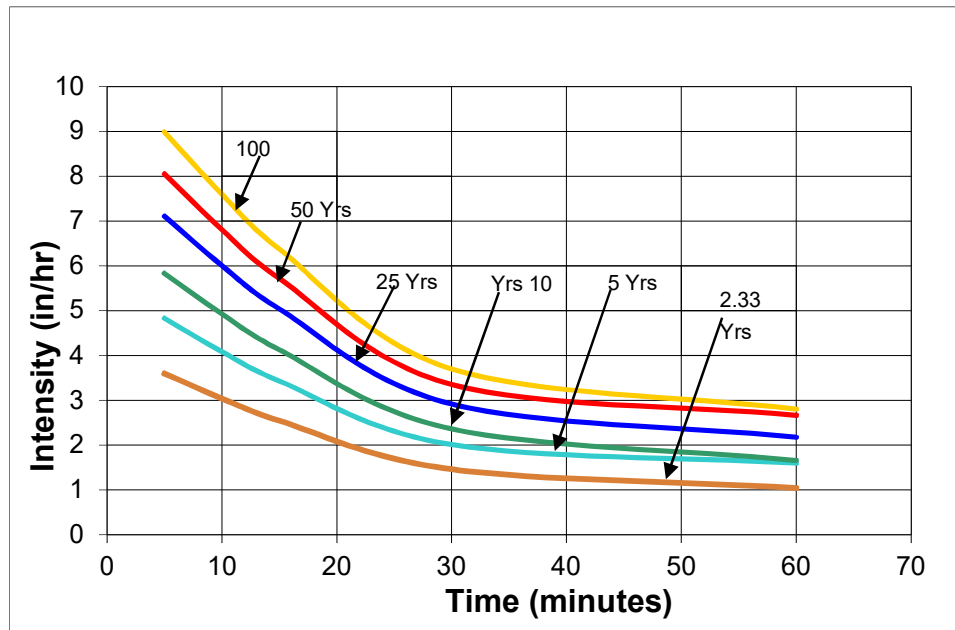


Figure 5: Intensity-Duration- Frequency Curves for Faisalabad

The details of catchment characteristics, results of hydrological analysis in shape of peak flood discharges are given in Table-5:

Table 6: List of Natural Drainage Channels Crossings the Road Alignment

Sr. No.	RD	Catchment Area		Peak Flood Discharges				
		(km ²)	(Acres)	5 yrs	10 yrs	25 yrs	50 yrs	100 yrs
				(cusecs)				
1	36+211	0.64	158.00	41	71	116	155	196
2	39+551	0.09	23.32	25	30	35	45	45
3	39+955	0.05	11.80	15	15	20	25	25
5	61+613	0.04	10.10	25	30	40	45	50

3.5.2.8 Natural Channels Crossing and Evaluation of Existing Capacity

Details of existing parameters collected from strip survey is given below in Table-6.

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)**Table 7: Design Parameters of Existing Natural Crossings**

Sr. No.	RD	Discharge ft ³ /Sec	Discharge m ³ /Sec	Existing Structure Type	No. of Spans	Size of the Structure (m)	Deck Level (m)
1	36+211	116	3.28	Box Culvert	1	2.0X1.0	181.56
2	39+551	35	0.99	Box Culvert	1	1.0X1.0	181.03
3	39+955	20	0.56	Box Culvert	1	1.0X1.0	180.96
5	61+613	40	1.13	Box Culvert	1	1.0X1.0	188.90

Strip survey and satellite data reveals that currently, these natural channels are not fully functional due to increased culturable command area, construction of link road for adjoining areas and populations settlements. However, hydraulic modelling of these channel has been carried out by the Consultants using HY-8 model, as per requirements of the TORs and for hydraulic evaluation of the structures. The results of hydraulic analysis are given in Table-7 below:

Table 8: Design Parameters of Existing Natural Crossings

Sr. No.	Road RD	25 Year flow		Barrel Width (W)	Barrel Height (D)	No. of Barrel	Headwater Level (HWL)	Normal Depth	Outlet Velocity (V)
		ft3/Sec	(m ³ /sec)	(m)	(m)		(m)	(m)	(m/s)
1	36+211	116	3.28	2.00	1.00	1	181.17	0.71	2.33
2	39+551	35	0.99	1.00	1.00	1	180.88	0.43	2.13
3	39+955	20	0.57	1.00	1.00	1	180.40	0.37	1.76
5	61+613	40	1.13	1.00	1.00	1	188.62	0.62	2.23

The results of hydraulic analysis on Hy-8 depicts that existing structures are capable of handling of discharges emerged from the smaller catchments. Therefore, it is recommended to provide same sizes as given in the existing road with extension in length. However, protection arrangements shall also be provided on the upstream and downstream of the new structures.

3.5.2.9 Protection Criteria for Crossing Structures

Existing cross drainage structures shall be extended as per design width of dual carriage way. Extension of bridges and culverts, in case of lined channels, shall not be affected from the scour as the lined sections will be connected bridge abutments or box culverts. However, for four (04) natural channels, bank and scour protection shall be provided on bed and side slopes i.e. upstream and downstream side with appropriate sizes i.e. not less than 10 ft along the road on either side of structure. Furthermore, it is recommended to carry out geotechnical investigation before the start of the construction to confirm the protection extents and sizes.

3.5.3 CONCLUSIONS AND RECOMMENDATIONS

- The existing cross drainage structures provided in the road are adequate and these should be extended in dual carriage way by keeping the same slope. However, design methodology for irrigation channels crossing, provided in this report shall also be

discussed with the concerned irrigation divisions of Faisalabad Irrigation Circle of Punjab Irrigation department for cross verification of L-sections, slope, discharge, and channel section.

- Typical crossing design of the small crossings i.e. less than 1.0 m, shall be duly verified by the concerned irrigation division to avoid any command and irrigation operational problems.
- A pre-construction survey shall be conducted by a team comprising Route Engineer, Hydrologist and Hydraulic Engineer to validate the crossing locations and design.
- Hydraulic modelling for natural streams, having smaller catchments, have been carried out on HY-8 model using input data extracted from the strip survey calibrated with the help of 30 m satellite data. A detailed topographic survey should be conducted and model be re-evaluated.
- Geotechnical investigation should be carried out in the entire reach to assess the true values of mean particle dia (d_{50}) for scour determination.

References

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6. Irrigation and Hydraulic structures by Dr Iqbal Ali
7. Reference Manual HY-8

3.5. STRUCTURE DESIGN REPORT

3.6.1 GENERAL

This feasibility report summarizes the knowledge and skills that our design team has utilized for the design of all the structures that fall on the project alignment. The structural design, suitable design specifications and construction as per specifications are all important parameters to achieve the desired design life of structures.

The concept of influence line is used to analyse the moving track and tank load, which is then combined with other live loads and dead loads to come up with the entire shear force and bending moment envelope along the bridge. However, state of the art software like CSI Bridges, STAAD pro etc. will be used for analysis of relevant structures. Once all the design loads had been determined, detailed computational designs were performed for reinforced concrete girders and concrete decks with respect to bridge design standards.

3.6.2 Design Approach

Design approach followed for preliminary structural design of structures falling on Faisalabad~ Chiniot~ Sargodha road is given in following paragraphs:

3.6.2.1 Inventory of Structures

A site survey of Project road was carried out by the Structural expert for visual inspection of structures falling on the road and all prominent defects in the form of cracks, deteriorated concrete, plaster defects, settlement, movement, or other structural defects have been recorded. The purpose of this survey is to provide a snap-shot of the condition of structures prior to design.

Culverts:

There are total 97 culverts amongst which 96 are Box culverts and 01 Pipe culvert.

Bridges:

There are total 08 bridges.

List of all bridges and culverts are given in list below:

Table 9: List of Culverts

Sr #	CHAINAGE	TYPE	SIZE
1	0+103	BOX CULVERT	1(2.0X1.5)
2	0+397	BOX CULVERT	1(1.7X1.0)
3	0+910	BOX CULVERT	1(1.9X1.0)
4	1+992	BOX CULVERT	1(1.0X1.0)
5	2+753	BOX CULVERT	1(1.0X1.0)
6	3+461	BOX CULVERT	1(2.0X1.0)
7	3+945	BOX CULVERT	2(2.0X1.0)
8	5+073	BOX CULVERT	1(1.0X1.0)
9	5+441	BOX CULVERT	1(2.5X1.0)
10	5+866	BOX CULVERT	1(0.7X0.9)
11	6+366	BOX CULVERT	1(2.0X1.0)
12	6+827	BOX CULVERT	1(1.0X1.0)
13	9+975	BOX CULVERT	1(2.0X1.0)
14	10+918	BOX CULVERT	2(1.5X1.0)
15	11+066	BOX CULVERT	1(1.0X1.0)
16	12+352	BOX CULVERT	1(3.0X1.5)
17	12+590	BOX CULVERT	1(1.0X1.0)

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18	13+846	BOX CULVERT	1(2.0X0.75)
19	14+031	BOX CULVERT	4(4.0X2.0)
20	15+225	BOX CULVERT	1(2.0X0.75)
21	15+496	BOX CULVERT	2(2.0X1.5)
22	15+922	BOX CULVERT	1(2.0X1.0)
23	16+834	BOX CULVERT	1(1.0X1.0)
24	17+293	BOX CULVERT	1(1.0X1.0)
25	17+784	BOX CULVERT	1(1.0X1.0)
26	18+411	BOX CULVERT	1(1.0X1.0)
27	24+117	BOX CULVERT	1(0.5X0.5)
28	24+524	BOX CULVERT	1(0.5X0.5)
29	24+864	BOX CULVERT	1(1.0X1.0)
30	25+088	BOX CULVERT	1(0.5X0.5)
31	25+234	BOX CULVERT	1(0.8X0.8)
32	25+517	BOX CULVERT	1(0.5X0.5)
33	26+619	BOX CULVERT	1(0.8X0.8)
34	28+890	BOX CULVERT	2(2.0X1.5)
35	29+297	BOX CULVERT	2(1.5X1.0)
36	29+364	BOX CULVERT	2(1.5X1.0)

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37	29+845	BOX CULVERT	1(1.5X1.0)
38	30+645	BOX CULVERT	1(0.8X0.8)
39	31+395	BOX CULVERT	1(1.5X1.0)
40	32+168	BOX CULVERT	3(2.0X1.5)
41	32+977	BOX CULVERT	1(1.2X1.0)
42	33+246	BOX CULVERT	1(2.0X1.5)
43	33+378	BOX CULVERT	1(0.8X0.8)
44	34+145	BOX CULVERT	1(1.0X1.0)
45	34+900	BOX CULVERT	1(2.0X1.0)
46	35+240	BOX CULVERT	1(2.0X1.5)
47	35+460	BOX CULVERT	2(2.0X1.5)
48	36+045	BOX CULVERT	1(1.5X1.5)
49	36+668	BOX CULVERT	3(2.5X2.0)
50	37+535	BOX CULVERT	1(1.0X1.0)
51	37+926	BOX CULVERT	1(1.0X1.0)
52	38+401	BOX CULVERT	1(1.0X1.0)
53	38+785	BOX CULVERT	3(2.7X1.5)
54	38+942	BOX CULVERT	1(1.0X1.0)
55	39+198	BOX CULVERT	1(1.0X1.0)

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56	39+636	BOX CULVERT	1(1.0X1.0)
57	40+050	BOX CULVERT	1(1.0X1.0)
58	40+418	BOX CULVERT	4(1.7X1.8)
59	40+724	BOX CULVERT	2(2.0X1.5)
60	41+080	BOX CULVERT	1(1.0X1.0)
61	41+528	BOX CULVERT	1(1.0X1.0)
62	41+965	BOX CULVERT	1(1.0X1.0)
63	42+325	BOX CULVERT	1(2.0X1.0)
64	43+290	BOX CULVERT	1(1.0X1.0)
65	43+357	BOX CULVERT	1(1.0X1.0)
66	43+766	BOX CULVERT	1(1.0X1.0)
67	44+637	BOX CULVERT	1(1.5X1.0)
68	44+882	BOX CULVERT	1(2.0X1.5)
69	46+045	BOX CULVERT	1(1.0X1.0)
70	46+921	BOX CULVERT	1(2.5X1.5)
71	46+968	BOX CULVERT	1(1.0X1.0)
72	47+344	BOX CULVERT	1(1.0X1.0)
73	48+354	BOX CULVERT	1(1.0X1.0)
74	48+826	BOX CULVERT	1(1.0X1.0)

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75	49+144	BOX CULVERT	1(1.0X1.0)
76	49+557	BOX CULVERT	1(1.0X1.0)
77	50+264	BOX CULVERT	1(1.0X1.0)
78	50+660	BOX CULVERT	1(1.0X1.0)
79	51+133	BOX CULVERT	1(1.0X1.0)
80	52+570	BOX CULVERT	1(1.0X1.0)
81	54+459	BOX CULVERT	1(1.0X1.0)
82	54+854	BOX CULVERT	1(1.0X1.0)
83	55+331	BOX CULVERT	1(2.0X1.5)
84	55+399	BOX CULVERT	1(1.0X1.0)
85	56+010	BOX CULVERT	1(1.0X1.0)
86	57+029	BOX CULVERT	1(1.0X1.0)
87	57+338	BOX CULVERT	1(1.0X1.0)
88	57+718	BOX CULVERT	1(1.0X1.0)
89	58+661	BOX CULVERT	1(1.0X1.0)
90	59+387	BOX CULVERT	2(3.0X1.5)
91	59+974	BOX CULVERT	1(1.0X1.0)
92	61+967	BOX CULVERT	1(1.0X1.0)
93	62+120	BOX CULVERT	1(1.0X1.0)

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94	62+477	BOX CULVERT	1(1.0X1.0)
95	62+956	BOX CULVERT	1(1.0X1.0)
96	63+131	BOX CULVERT	1(1.0X1.0)
97	63+666	BOX CULVERT	1(1.0X1.0)

Table 10: List of Bridges

Sr. No.	Chainage	Location	No. of Cell/Spans
1	6+050	Dangro Bridge	4
2	18+825	Culvert/Bridge	3
3	19+200	Canal Bridge	2
4	22+340	Bridge	3
5	31+800	Culvert/Bridge	13
6	47+880	Culvert/Bridge	2
7	50+486	Bridge	2
8	56+750	Culvert/Bridge	3

3.6.2.2 Pictorial Description of Bridges

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18+825	
19+200	

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

31+800	
47+880	

TRANSACTION ADVISOR FOR DUALIZATION OF FAISALABAD - CHINIOT - SARGODHA ROAD (LENGTH=68KM)

50+486	
56+750	

3.6.2.3 Methodology for Extension of Culverts

Based on visual inspection, Culverts have been shortlisted which have capacity to serve and are in reasonable condition. These structures are operating satisfactory and have intact inverts. All of such structures don't need to be replaced and can be extended to the proposed cross section. These structures will be extended and new Inlet and outlet structures will be constructed as per the new extended width of road.

3.6.2.4 Methodology for Extension of Bridges

In case of bridges same concept has been applied to determine that bridges are in reasonable condition and do not need replacement. From the visual inspection, it was assessed that existing bridges should be retained as they are in good shape and serving well. Except one bridge at the entrance of Chiniot City. This bridge appears to constructed in the recent past but it has defected pier. The diameter of this pier is almost 40% reduced (faulty construction) at the joint of pier and transom (see Fig-1).



Fig-1

Nespak recommends to replace of this bridge, but this decision lies with the client.

However, the safety assessment of these bridges structures is not the part of this TOR. If client intends to carryout detailed structural assessment of existing bridge, all

relevant data like as built drawings and other design related documents shall be made available under separate contract.

The cross section of road has been changed and road has been dualized at the location of Bridge No 3 (Km 19+100) over canal towards Chiniot City, therefore, bridge deck has also been dualized. A separate deck has been designed at this location which will have independent super and substructure. Moreover, a Pre-Stressed Girder flyover (09 x 20m Spans) has also been proposed at the same location which will act as an entrance to the bypass of Chiniot City. Furthermore, at KM 22+600, another single deck Pre-Stressed Girder Bridge (03 x 20m Span) over canal towards Jhang~Chiniot Junction along with a Double Deck Flyover of (02 x 20m Span) has been proposed at Km 22+825.

At Km 27+800 a Double Deck Flyover, with independent Super and Substructure arrangements, of 13 ± 03 x 20m Spans has been proposed at Chiniot~Faisalabad-Sargodha Road Junction along with at-grade improvement. All of the above mentioned newly proposed bridges and flyovers shall have a Deck Width Cross Section of 11.4m.

3.6.3 Design Criteria

The main purpose and the objective of the design criteria is to formulate and finalize technical data, design assumptions, codes of practice, methods and procedures to be adopted in the structural design of various structures of the project. The design assumptions and criteria mentioned herein will be used for the structural design of the, bridges, subways, culverts and related works.

3.6.3.1 Units of Measurement

The design has been accomplished using FPS/SI units.

3.6.3.2 Design Codes and Standards

Generally following codes and standards shall be followed:

WPCHB (1967)	-	Government of West Pakistan Highway Bridges Code of Practice Highway Bridges 1967
AASHTO (2017)	-	AASHTO LRFD Bridge Design Specification (For the design of all structural members)

		ASD combination for the calculating length of pile.)
BCP (2007)	-	Building Code of Pakistan
ACI 318-08	-	Building Code Requirements for Reinforced Concrete. American Concrete Institute.
ACI 301-95	-	Specifications for Structural Concrete. American Concrete Institute.
ASTM A-615	-	Specifications for Deformed and Plain Billet Steel Bars for Concrete Reinforcement.
ASTM C-150	-	Specifications for Portland cement
ACI-350 R	-	Environmental Engineering Concrete Structures
ASTM C-33	-	Specifications for Concrete Aggregate
UBC 1997	-	Uniform Building Code of USA.
ASTM C270	-	Standard Specification for Mortar for Unit Masonry.

3.6.3.3 Loads

Structures designed is capable of resisting the following main loads and forces:

- Dead Load
- Live Load
- Impact/ Dynamic Allowance
- Vehicle Collision Force
- Wind Load
- Longitudinal forces due to tractive/braking effort of vehicles
- Earth Pressure
- Earthquake Forces

- Stream flow

Dead loads

Dead Loads will be computed from the unit weights of the materials as given in the Building Code of Pakistan.

Live loads

Vehicle live loads shall be considered in accordance with WPCHB loadings as defined under Class A loading and Class AA loading. The design of structural members shall be made for the severe loadings.

Impact / dynamic allowance

Impact loading on the bridge superstructure shall be in accordance with the WPCHB.

Wind load

Wind loads on the bridges shall be considered in accordance with the provisions of Article 3.15 of AASHTO LRFD Bridges Design Specification; applicable wind Velocity shall be 110 mph for design.

Braking forces

Longitudinal braking /traction forces due to sudden stoppage of vehicles shall be Considered in accordance with WPCHB 1967 Standard Specifications.

Earth pressures

Earth pressure or load on Culverts, Water Courses etc. shall be computed as the weight of earth directly above the slab. When the depth of fill is 600 mm or more, concentrated loads shall be considered as uniformly distributed over a square area, the sides of which are $1\frac{3}{4}$ times the depth of fill. Lateral earth pressure is considered as per requirements of AASHTO LRFD Bridges Design Specification.

Earthquake forces

Seismic design shall be carried out in accordance with the provisions of the Building Code of Pakistan with Zone-2A. The values of peak ground acceleration adopted for analysis and design are 0.08 to 0.16g.

Stream flow forces on Piers and Culverts:

Stream flow forces, where applicable, shall be applied on piers and culverts in accordance with the requirements as per Article 3.18 of AASHTO LRFD Bridges Design Specification.

Loading combination

The design of structures shall be carried out for the load combinations for service and ultimate load conditions in accordance to Article 3.22 of AASHTO LRFD Bridges Design Specification.

3.6.3.4 Materials

Following strengths of construction materials has been used in the design:

Cement:

The limiting value of sulphates in ground water should less than 150 ppm. If it exceeds this value, then OPC cannot be used. Similarly, the limiting value of water soluble chloride ion (Cl-) in concrete is 0.06 & 0.15 (by mass of cement) for Prestressed and reinforced concrete.

Based on published technical paper titled, "Engineering Properties, Mineralogy, Alkali Aggregate Reaction Potential and Provenance of Lawrencepur Sand Pakistan", by Dr. M.Nawaz Chaudhry etc. AI (1997) wherein it has been reported that coarse sand sizes contained in Lawrencepur Sand deposits are reactive in terms of Alkali Silica Reaction (ASR), the detail of recommended cement to be used is as here under:

Ordinary Portland cement containing appropriate pozzolanic materials i.e. Ground Granulated Blast Furnace Slag (GGBFS) in proportion of 40% of the cement content in the concrete.

Concrete:

Four classes of concrete have been used as given below:

- I. Concrete Type A (nominal mix 1:1:2)
- II. Concrete Type B (nominal mix 1:1-1/2:3)
- III. Concrete Type C (nominal mix 1:2:4)
- IV. Lean Concrete (nominal mix 1:4:8)

Concrete strength of Pre-Stressed Girders is Class A. Concrete barriers, sign foundations, chute, catch pit curb stone, duct marker, ROW marker and foundations for posts chain link fabric/wire rope safety fence/ curve delineator/lighting poles is

Class B, whereas for RCC girder, piers, piles, approach slab, curtain wall, wing wall, foundation, transom, abutment seat, diaphragm, deck slab, counterfort and concrete pads it is also Class B.

The concrete strength for median lining, pipe surrounds, service ducts, and duct marker surrounds foundation for steel post of median opening and haunching behind concrete kerb is also Class B.

Reinforcing Steel

High yield strength deformed billet steel bars conforming to Grade 60 AASHTO M31, ASTM A615 shall be used.

3.6.3.5 FOUNDATION PARAMETERS

The geotechnical parameters relating to the bearing capacity, lateral earth pressure and depth of foundations shall be finalized on the geotechnical investigations carried out at site at construction stage.

3.6.3.6 STABILITY CRITERIA

☐ **Overturning**

The following criteria has been followed;

Resultant of applied forces should lie within middle third of the base for normal loading conditions. Resultant of applied forces should lie within middle half of the base for exceptional loading conditions. Minimum factor of safety against overturning shall be 2.0 for footings on soil.

☐ **Sliding**

Minimum factor of safety against sliding shall be equal to 1.5. The factor of safety against sliding and overturning failure under seismic loading may be reduced to 75% of the factor of safety listed above.

ANALYSIS / DESIGN AND DRAWINGS

Design has been carried out with 3D finite element grillage analysis using computer software STAAD Pro/CSI Bridges developed by Computers and Structures Inc. Berkeley, for carrying out Linear, Static and Dynamic Analysis and Design of Three Dimensional Structures. The bridges are analyzed and designed for Class A loading and class AA loading. Design of structural members has been carried out for the adverse load combinations as per recommendations of AASHTO LRFD Specifications, 2017. Dynamic analysis using response spectra has been carried out

for the substructure. The substructures has also been designed for stream flow conditions, where applicable. All drawings have been prepared using computer program AutoCAD.

3.6.4 KEY POINTS IN ACHIEVING DURABLE STRUCTURE

In order to secure the long term durability of a concrete and masonry structure following areas have to be monitored:

For Concrete:

1. Determination of concrete components including water cement ratio, type and content of cement as well as aggregate and use of blast furnace slag, sulphate resistant cement where required.
2. Curing methods.
3. Evaporation control to avoid the damaging effects of drying out which can lead to surface cracking.
4. Protect the reinforcement against corrosion by providing adequate clear cover.
5. Protection against chloride in gross and risk of corrosion.
6. Keeping in view the above mentioned durability factors and proper maintenance schedule, the life service of reinforced concrete structures is expected to be 100 years.

For Brick Masonry Structure:

1. All bricks shall be sound, hard, well burnt and of uniform size, colour and texture. Dimensional variation in sizes shall not exceed 1/8".
2. All brick work shall be erected plumb and true to line and level. The maximum variation in any height or any length of wall shall be 1/8" in 10'-0".
3. Mortar used in masonry construction shall have an ultimate compressive strength of not less than 1800Psi and shall confirm to ASTM C270.
4. The average compressive strength of five bricks shall not be less than 2000Psi and shall not be less than 1500Psi for any individual brick.
5. Bricks should be laid "Frog" upward with mortar joint and in English or Flemish bond.
6. All bricks masonry walls shall be plastered with 1:4 cement sand mortar.

3.6.5 COST ESTIMATE

Cost for Extension/Reconstruction of existing structure has been worked out on Local /MRS rates (**MRS 2nd Bi-Annual 2026**). Cost has been worked out based on preliminary design. However, The Bidder will work out Project cost as per his own Due-Diligence.

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