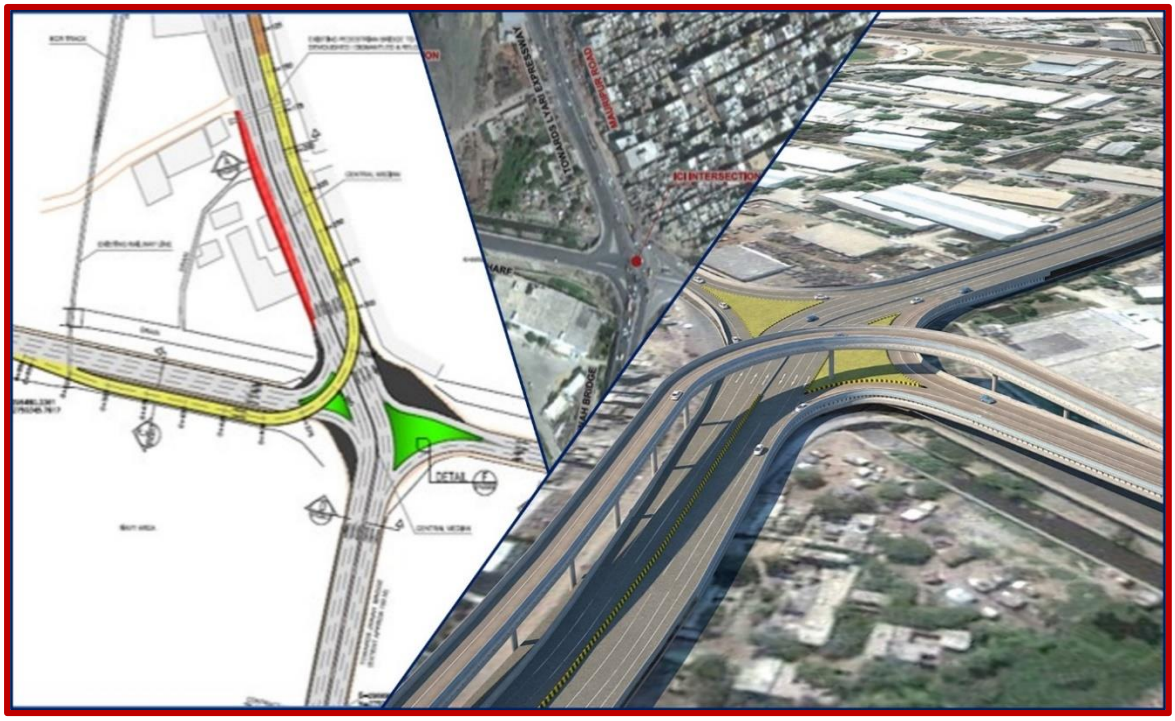
# URBAN ROAD INITIATIVES IN KARACHI

## LOCAL GOVERNMENT & HTP DEPARTMENT

### Technical Feasibility Study

# Sub-project 3 - ICI INTERSECTION




## FINAL REPORT

## April 2021

**National Engineering Services Pakistan (Pvt.) Ltd.**
**13th Floor, N.I.C. Building, Abbasi Shaheed Road, Off. Shahrah-e-Faisal, Karachi**
**Phone: (0092 21) 99207277-84**
**Fax: (0092 21) 35651994**
**E-mail: nespakkh@khi.wol.net.pk**
**Web: http://www.nespak.com.pk**

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# Abbreviations

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ATLAS | Advanced Traffic Lab for Analytics & Simulation, NED |
| CBR | California Bearing Ratio |
| CSR | Composite Schedule of Rates |
| EIA | Environmental Impact Assessment |
| ESALs | Equivalent Standard Axle Loads |
| GoS | Government of Sindh |
| GNSS | Global Navigation Satellite System |
| HCM | Highway Capacity Manual |
| JICA | Japan International Cooperation Agency |
| KCR | Karachi Circular Railway |
| KMC | Karachi Metropolitan Corporation |
| KPT | Karachi Port Trust |
| KTIP | Karachi Transportation Improvement Project |
| KWSB | Karachi Water & Sewerage Board |
| LOS | Level of Service |
| NDT | Non-destructive Testing |
| NHA | National Highway Authority |
| NRL | National Refinery Limited |
| PARCO | Pak-Arab Refinery Company Limited |
| PCU | Passenger Car Unit |
| PN | Pakistan Navy |
| PPP | Public Private Partnership |
| PR | Pakistan Railways |
| PRL | Pakistan Refinery Limited |
| PTCL | Pakistan Telecommunication Corporation Ltd. |
| RFP | Request for Proposal |
| ROW | Right-of-Way |
| SRB | Sindh Revenue Board |
| SSGC | Sui Southern Gas Company Ltd. |
| SST | Sindh Sales Tax |
| URI | Urban Road Initiative |
| UTM | Universal Transverse Mercator |
| WGS | World Geographic System |

# 1.0 INTRODUCTION

Karachi is the largest city, main seaport and the financial center of Pakistan, as well as the capital of the province of Sindh. According to Karachi Metropolitan Corporation (KMC), the metropolitan area of Karachi is spread over 3,530 sq km and, has an estimated population of over 15 million as per Census 2017. It is one of the world's largest cities in terms of population. It is Pakistan's premier center for banking, industry, economic activity and trade and is home to Pakistan's largest corporations, including those involved in textiles, shipping, automotive, entertainment, the arts, fashion, advertising, publishing, software development and medical research.

The commercial activities generate large volume of traffic within the city. Considerable volume of heavy freight traffic is generated to and from the Karachi Port and industrial areas to the rest of the country.

In 1947, Karachi was populated on an area of 83 sq. km. which has presently expanded to 3,530 sq. km (Karachi Metropolitan Corporation website). Due to the growth in population and the size of the city, the developments led to increase in the number of vehicles on the road network.

The increase in population, industrialization and commercial activities in the city has resulted in rapid increase in all kinds of motorized traffic, and it has become imperative to avert further aggravation of the problems of the residents.

As per Japan International Cooperation Agency (JICA) funded Karachi Transportation Improvement Project (KTIP), 2030, Karachi roughly maintains a 10,000 km road network. This road space combined with poor maintenance, delayed repair work, poor quality construction, and absence of essential support functions creates problems in satisfying the traffic demand. There are many places where large numbers of commuters move at the same time from one location to another, however, the access roads and links offer very few choices and hence there is considerable congestion on the roads specially during the peak hours.

The urban transport needs of a city are cyclic in nature and largely depend on the travel behavior of the citizens. Although the trips made by private and para transit vehicles are increasing, the public transport system (buses / minibuses) caters to over 34% of the modal share in 2018 (Green Climate Fund (GCF) Funding Proposal document by the Asian Development Bank (ADB), 2018), down from 53.5% in 2008 (JICA, KTIP, 2030). Due to reduction in public transport services in

Karachi, the modal share of motorcycles has increased significantly from 16% in 2008 (JICA, KTIP, 2030) to 33% (GCF, ADB, 2018).

To mitigate the traffic congestion problems and provide quick and safe access to the commuters of Karachi, the Government of Sindh (GoS) through its Local Government & HTP Department, has initiated three urban road projects under Public Private Partnership (PPP) mode under the Urban Road Initiatives (URI). These three (03) sub-projects are:

1. **Sub-project 1:** Link Road from Korangi (from KPT Interchange to PAF Airmen Academy),
2. **Sub-project 2:** Expressway from Mauripur Road (end of Lyari Expressway) to Y Junction (Kakapir Road / Mauripur Rd Intersection), and
3. **Sub-project 3:** Interchange at ICI Bridge Intersection.

This report discusses the technical feasibility of **Sub-project 3 (at ICI Bridge intersection)**.

## 1.1 Project Description

Mauripur Road is one of the busiest roads with heavy traffic plying (to / from Karachi Port). Cargo traffic from the East and West wharves of Karachi Port use this road for onward journey to up-country via Northern Bypass or Hub Road. ICI intersection is located along Mauripur Road between Jinnah Flyover and Lyari Expressway (Refer **Figure 1-1** for project location map). It is one of the busiest intersections which carries a high number of heavy vehicles from the East and West Wharves of Karachi Port. Cross street traffic from Kharadar constitutes mainly private vehicles (motorcycles, rickshaws, private cars), which serve the needs of residential area of Kharadar.

The intersection of Mauripur Road with Ghulam Ali Allana Road, commonly known as ICI Bridge Intersection (due to its location at the approach to ICI Bridge over Karachi Circular Railway (KCR)), is among the most congested road junctions in the southern part of the city. It serves the heavy traffic moving between Karachi Port, SITE area and other parts of the country through the Motorway, M10 / Northern Bypass and Site Avenue in addition to the city traffic moving along Mauripur Road from Mai Kolachi Bypass and M.T. Khan Road via Jinnah Bridge and from other areas of the city through Lyari Expressway.

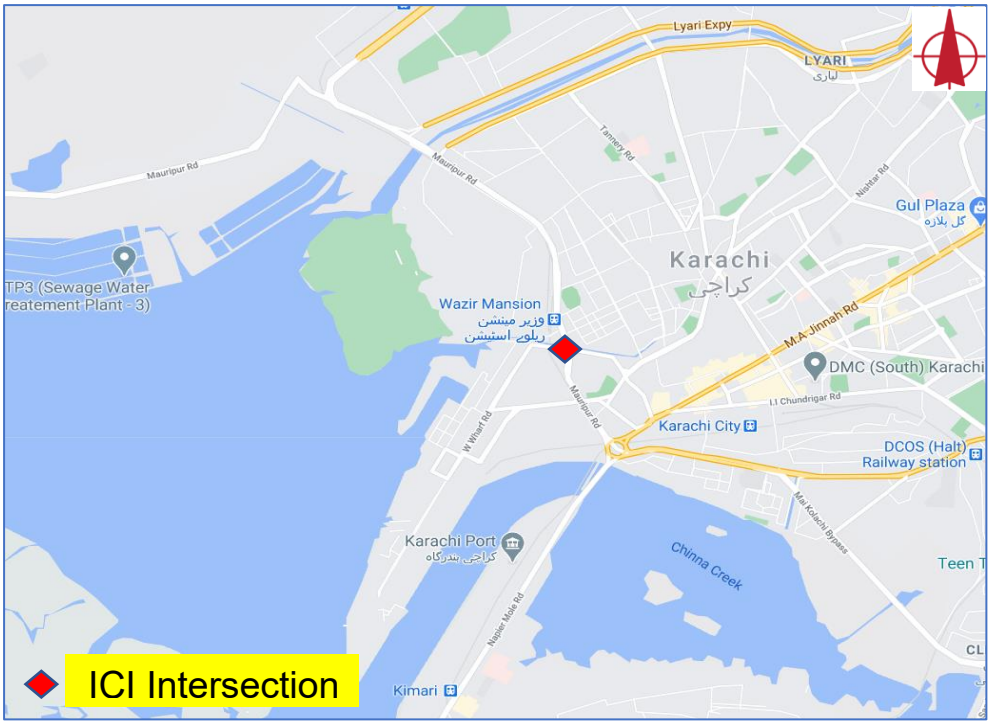



***Figure 1-1: Project Location Map***

This intersection also serves the localized traffic from the densely populated adjoining areas of Lyari and other old city areas and the recreational traffic towards the Hawkesbay, Sandspit and Manora beaches.

Heavy traffic congestion is witnessed during most of the day due to non-working signals, poor road condition and high number of heavy vehicles. The major movements at this intersection are the straight movements along Mauripur Road and right-turning traffic from Mauripur Road towards West Wharf Road.

The proposed solution envisages to reduce the overall delays witnessed at this intersection through construction of a grade-separated structure. Due to non-availability of Right-of-Way (ROW) for construction of a high-level interchange at the present at-grade intersection, it may be necessary to acquire land. Therefore, land acquisition and resettlement of people (including arrangement of alternate residence for the affected people, if required) maybe an integral component of this proposed project.

## 1.2 Project Objectives

The Government of Sindh (GoS) through the Local Government & HTP Department has planned to construct this project to alleviate the congestion issues along this corridor. The project objective is to facilitate the freight traffic that is coming from all over the country and to reduce the traffic congestion at ICI

Intersection. Another objective is to reduce the traffic congestion at Jinnah Bridge that causes large delays for all modes of traffic.

## 1.3 Scope of Work

The scope of works for technical study shall cover, but not be limited to following:

- Reconnaissance Survey,
- Data Collection / Coordination with local agencies and stakeholders,
- Alignment Study and Preparation of Inception report,
- Detailed Topographic Survey,
- Traffic Survey,
- Geotechnical Investigation Survey,
- Preliminary Design of Roads, and allied civil works,
- Preliminary Structural designs,
- Preliminary Electrical designs,
- Preliminary Cost Estimates,
- Technical Feasibility Study Report, and
- Environmental and Social Impact Assessment (separate document).

## 1.4 Project Deliverables

The contract agreement was signed on October 15, 2020, while the letter of award was issued in June 2020. The project deliverables from the contract signing date and as per the Terms of Reference (TOR), comprise of the following:

***Table 1-1: Project Deliverables (from signing of Agreement)***

| Phase | Timeline | Dates |
|---|---|---|
| **Phase-1: Feasibility** | | |
| Inception Report | One week | 22-Oct-20 |
| Technical Feasibility Study | 4 months | 12-Feb-21 |
| Environment and Social Impact Assessment | 5.5 months | 29-Mar-21 |
| Financial Viability Assessment Report | 6 months | 13-Apr-21 |
| PPP Options Analysis Report | 6 months | 13-Apr-21 |
| Legal and Regulatory Assessment Report | 8 months | 12-Jun-21 |
| **Phase-2: Transaction Advisory** | **Timeline** | |
| Marketing & Submission of Procurement Package | 9 months | 12-Jul-21 |
| Submission of Bid Evaluation Report | 11 months | 10-Sep-21 |
| Issuance of Letter of Award/Acceptance | 12 months | 10-Oct-21 |
| **Phase-3: Transaction Negotiation and Financial Closure** | **Timeline** | |
| Transaction negotiation and Signing of Concession Agreement | 13 months | 09-Nov-21 |
| Financial Close | 18 months | 08-Apr-22 |

## 1.5 Report Outline

This report describes the technical feasibility of the proposed project and elaborates on the proposed methodology. It includes information on the several surveys conducted for the project as well as the current site conditions including utility locations.

The report outline is as follows:

- Details of surveys including Reconnaissance Survey, Topographic Survey and Traffic Survey,
- Geotechnical / soil investigations,
- Identification of Existing Utilities and their relocation,
- Stakeholder consultation,
- Project Design including Preliminary Geometric, Pavement & Structural Design for Civil Works including Storm Water Drainage System and Allied Electrical Works,
- Details about Intersection Improvements,
- Land Acquisition Requirement, and
- Cost Summary based on Preliminary Design.

# 2.0 SURVEYS

## 2.1 Reconnaissance Survey

A series of reconnaissance surveys were performed by engineers of various disciplines and planners from NESPAK to obtain information about the existing traffic, road conditions and availability of additional Land- required for geometric improvement plan within the Project Area. During these surveys, photographs of various existing features, facilities and surroundings were captured. Important locations such as intersections, geometric layout & traffic bottlenecks were observed.

During the site visits, information regarding traffic flow, traffic control, traffic mix, and on-street parking was collected. Few minor structures were identified at the northwest corner (near Wazir Mansion Station). Present pavement conditions & geometrical features were observed. The data collected during reconnaissance, was preserved for the purpose of design in form of sketches drawn at site, written notes, and photographs.

**Figures 2-1** thru **2-4** below show some of the reconnaissance survey activities.

***Figure 2-1: Intersection View from ICI Bridge***

***Figure 2-3: Drain along ICI intersection***

***Figure 2-2: Minor Structures near Wazir Mansion***

***Figure 2-4: Existing West Wharf Road***

## 2.2 Topographic Survey

Topographic surveys required for preliminary design were carried out using modern electronic surveying equipment, and data obtained was processed and recorded in digital form. Based on reconnaissance survey data, available maps / information and approved concept plans, detailed topographic survey program was prepared.

The linear measurement units used in survey and mapping work are in metric system of units and the angular measurement are in degrees, minutes and second of arc.

Local control points were established prior to actual commencement of surveying and mapping of the project area. The values obtained in World Geographic System (WGS) were transferred to Universal Transverse Mercator (UTM) Systems.

The coordinates & location of established control points are presented in **Table 2-1** and **Table 2-2** in WGS-84 and UTM coordinate system, respectively, and shown below:

***Table 2-1: List of Control Points Coordinates in World Geographic System (WGS) 84***

| S. No. | Control Point | Latitude (DMS) | Longitude (DMS) | Elevation (m) |
|---|---|---|---|---|
| **1** | P3/CP01 | 24° 51' 26.186" N | 66° 59' 11.681" E | 10.712 |
| **2** | P3/CP02 | 24° 51' 14.751" N | 66° 59' 18.354" E | 6.708 |

***Table 2-2: List of Control Points Coordinates in UTM Zone 42N***

| S. No. | Control Point | Easting (m) | Northing (m) | Elevation (m) |
|---|---|---|---|---|
| **1** | P3/CP01 | 296564.844 | 2750646.992 | 10.712 |
| **2** | P3/CP02 | 296746.976 | 2750292.384 | 6.708 |

Topographic survey was drawn on appropriate scales and contour intervals. Planning and Design of this sub project has been carried out considering the following objectives:

- Development of site plans of right-of-way of the roads and service corridor,
- Observe and plot cross-sections of reaches of the roads at strategic locations,
- To establish ground control for road alignment and vertical profile,
- Preparation of survey plans on appropriate horizontal and vertical scales,
- Establishment of permanent benchmarks and reference points at site.
- Identification of all above ground existing services and utilities, located in the right-of-way, and their marking in survey maps / layout.
- approximate outline of water bodies - including drains, nullahs, rivers/ streams/ ponds etc. along with direction of flow, angle of skew and locations,
- Collect field measurement and digital representation of ground levels at appropriate distances / grids, and
- Mark location, orientation and levels of all existing features and structures.

The topographic survey report is attached as **Annexure-1** to this report.

## 2.3 Geotechnical Investigations

The geotechnical investigations are aimed to examine the surface and subsurface soils at the proposed site for designing of pavements and structures. The objective of the investigation is to identify the core properties of the soil and a realistic basis for recommendation for an appropriate and realistic foundation design which has subsequently been used till construction of works. The study specified an efficient and cost-effective system of foundation for structures and pavement design. Relevant ASTM/AASHTO standards were used for field and laboratory studies.

These initial Geotechnical Investigations were carried out to get the idea of the sub-soil conditions. However, confirmatory geotechnical

Investigations are recommended to be carried out by the successful bidder / contractor at detailed design stage.

**Figure 2-7** below shows the locations of bore holes and test pits.

Detailed Geotechnical Investigation Report is attached as **Annexure-3** to this report**.**

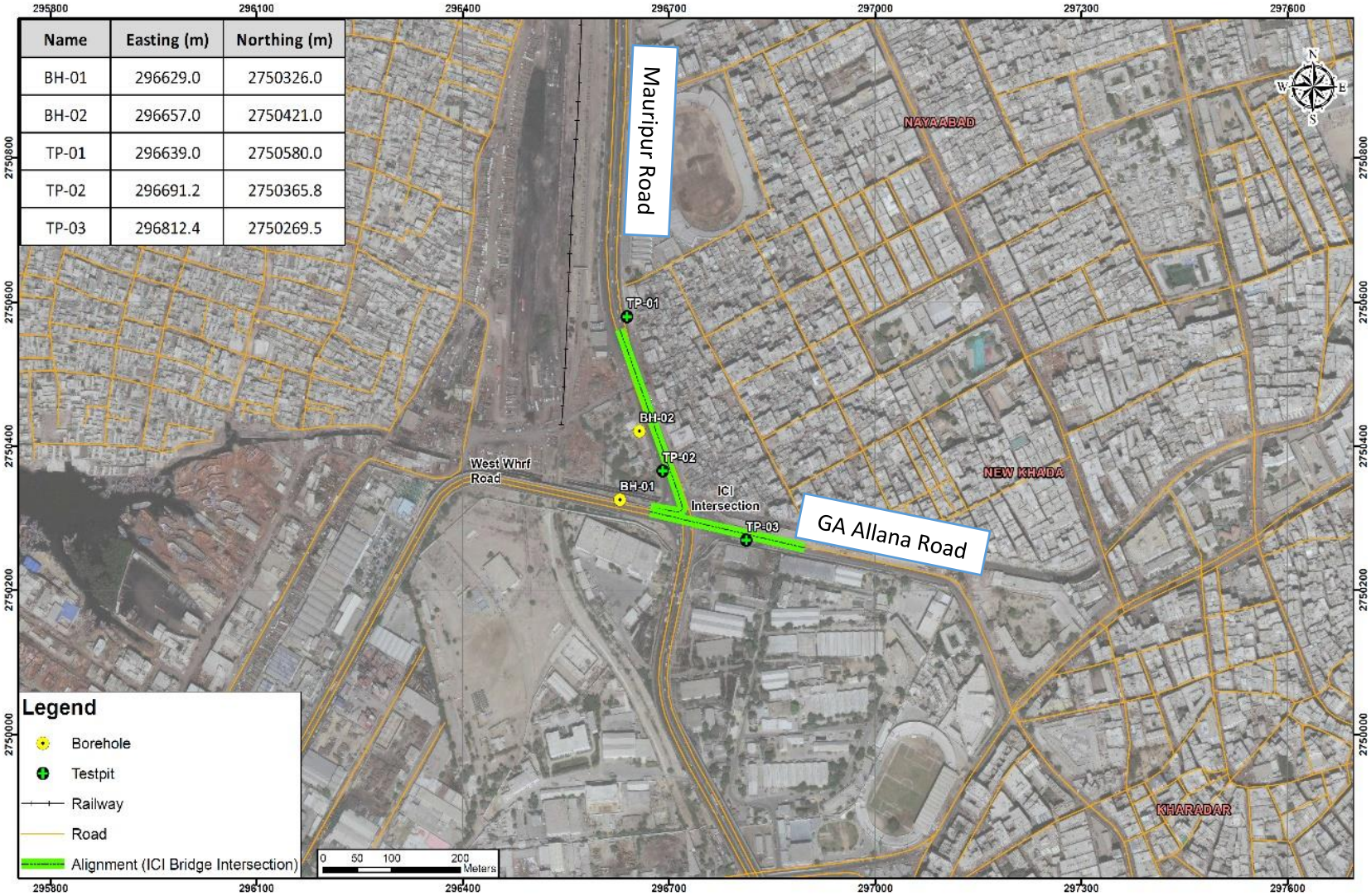



***Figure 2-5: Locations of Boreholes and Tests-Pits***

# 3.0 PROJECT ALIGNMENT

ICI intersection is a critical intersection in the southern part of Karachi and connects the Karachi Port (West Wharf) with Mauripur Road for movement towards Northern Bypass (up-country) and Jinnah Flyover. The LOS results indicate this intersection exhibits severe congestion most of the day. Hence, it was necessary to propose a solution to mitigate the traffic congestion at this intersection.

## 3.1 Alignment Options

Several options were considered for improving the geometry of the intersection to reduce congestion, however, the presence of Naval establishments in the southwest and southeast corners of the intersection presented limitations in proposing a viable solution. In addition, the northeast corner of the intersection consists of dense residential complexes, thus further limiting the number of options available to mitigate traffic congestion at this intersection.

Several proposals were considered to mitigate traffic congestion at this intersection during concept planning phase, which are discussed below:

### *3.1.1 Do-Nothing Option*

ICI intersection is the busiest and most congested intersection located in the vicinity of Karachi Port. This intersection not only serves the high number of port traffic, but also the local traffic from adjoining residential areas. The major movements at this intersection are straight movement on Mauripur Road /Jinnah Flyover and right-turn movement from Mauripur Road to ICI Bridge which mainly constitutes heavy trucks and trailers. Truck / trailer traffic at this intersection is 33% of the total intersection traffic (PCU). This heavy traffic causes operational problems and disruption in the traffic flow, which results in severe traffic congestion and excessive delays.

This intersection is already operating at a LOS ‘F’. Considering the existing condition and upcoming projects / expansion schemes of Karachi Port Trust (KPT) and other stakeholders, if no solution is provided, then traffic congestion and delays will increase significantly, there will be high travel demand and the intersection will not cater to the future traffic growth.

### *3.1.2 Option-I - Elevated Expressway parallel to Jinnah Flyover*

In order to mitigate traffic congestion at the intersection, an elevated expressway parallel to Jinnah Flyover was proposed to connect Karachi Port traffic of East and West Wharves to Mauripur Road for onwards journey to up-country. The

expressway was proposed as a four (4) lane two-way structure starting near gates to KPT wharves and would pass through Pakistan Navy (PN) area and ramp down at Mauripur Road after crossing the ICI intersection.

The construction of elevated expressway required land acquisition currently under the use of Pakistan Navy. Moreover, Mauripur Road would also be realigned to accommodate ramps of elevated expressway and construction of slip roads for which land towards Wazir Mansion would need to be acquired.

The major benefit of this proposal is that the straight traffic on Mauripur Road would bypass the ICI intersection, thus creating relief for commuters. The major constraint with this option is extensive land acquisition through the highly secure area.

**Figure 4-1** below shows the proposed layout plan for Option-1.

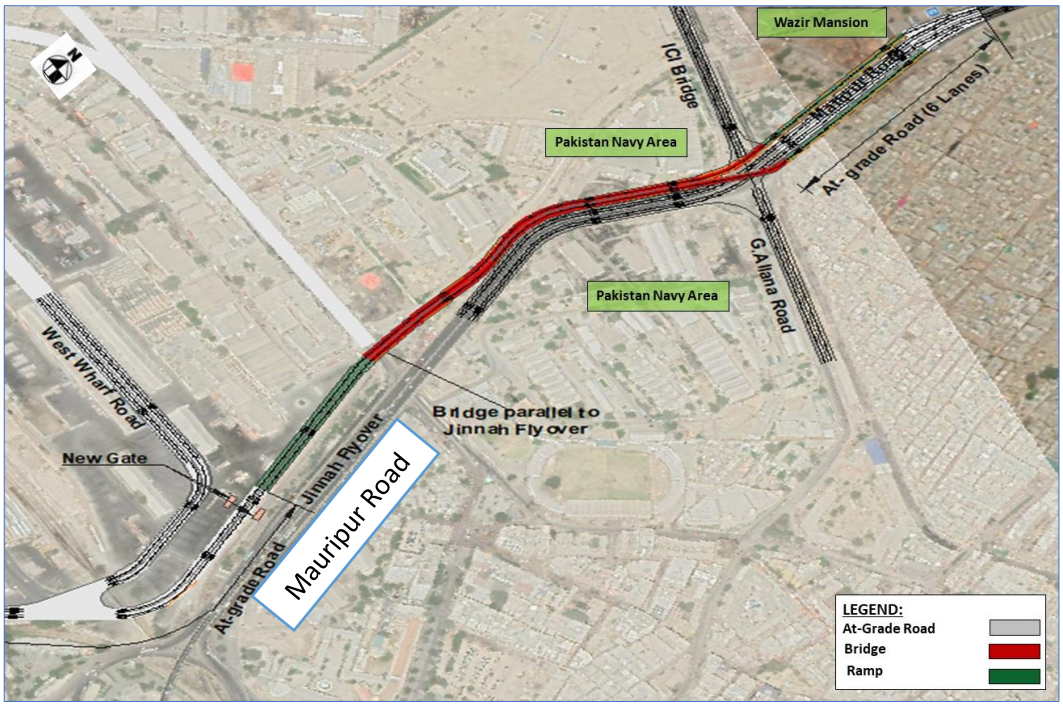



***Figure 3-1: Option-I – Proposed Elevated Expressway along Mauripur Road***

### *3.1.3 Option II – Flyovers on Mauripur Road & Kharadar & at grade U-turn under ICI Bridge*

Another option was to provide right-turn flyover from Mauripur Road and merge with existing ICI bridge. Free-flow traffic movement was proposed on Mauripur Road / Jinnah Flyover, which restricted the cross movements at ICI intersection. To cater to some of the restricted movements, a flyover on Ghulam Ali Allana Road and at-grade U-turn under ICI bridge was proposed to accommodate straight and right-turn movements from Kharadar. The proposed flyover would ramp up from

Kharadar and merge with existing ICI bridge, while the other ramp of the flyover would go down and join at at-grade U-turn under ICI bridge.

In order to construct the above scheme, existing ICI bridge would be demolished up to the height of 6m (before KCR crossing). The new segment of the bridge would be widened, and six (6) lanes (two (2) lanes in one direction and four (4) lanes in other direction) will be introduced to accommodate traffic coming/to ICI bridge.

A major constraint in this option was the steep grade for traffic coming from Kharadar (<7%) since the right-turning traffic from Kharadar would require U-turn under the existing ICI bridge before KCR tracks. This steep grade would cause safety issues for the motorists, which is undesirable.

Following were the major issues with this option:

- Land Acquisition towards Wazir Mansion,
- Demolition of part of ICI bridge, and
- Unsafe movement for traffic from Kharadar.

**Figure 4-2** below shows the proposed layout plan for Option-2.

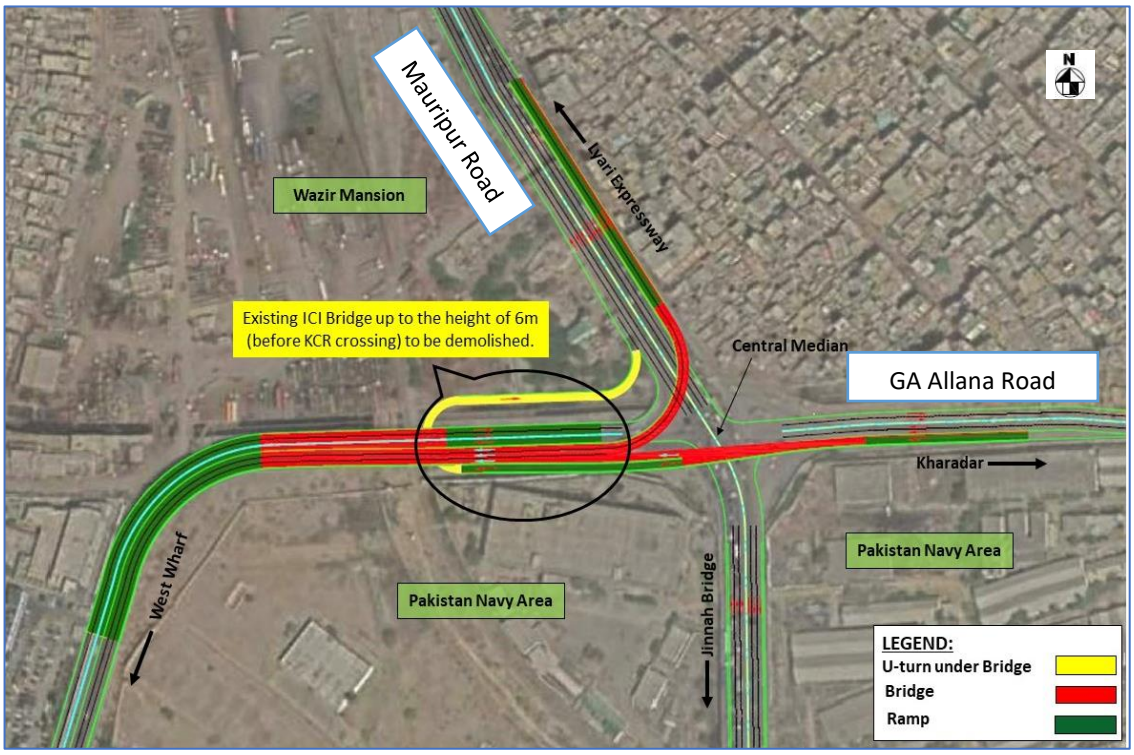



*Figure 3-2: Option II – Right-turn Flyover and Right-turn under ICI Bridge*

## 3.2 Finalized Alignment Option

After careful deliberation among the project team and subsequent consultations with the Client, it was planned to provide a right-turn flyover from Mauripur Road onto existing ICI bridge (approx. 6% of the total intersection traffic). The length of proposed flyover is 556m and it will be used by all types of vehicles. Construction of this flyover will eliminate one of the major at-grade turn movements (consisting of truck / trailer traffic). It has also been proposed that cross-movements across Mauripur Road will be banned to facilitate the thru movements (approx. 59% of the total traffic at this intersection). The banned movements would be made to use existing West Wharf Road / Akbar Siddiq Road just south of the ICI intersection, for which rehabilitation of the road would be carried out as part of this project. This road is under Karachi Metropolitan Corporation (KMC) jurisdiction.

The ICI intersection will be rehabilitated as part of the project. A central median will be introduced to restrict the cross movements. Extra space at the intersection will be paved and may be used as parking area for the residents, subject to approval by the local authorities. Islands will be provided for traffic channelization. These islands will be green areas as use of the same for park / open space purposes is not recommended due to uninterrupted heavy traffic movement.

The proposed scheme would allow for free-flow movements for the thru traffic on Mauripur Road, which would result in the intersection operating within capacity.

**Figure 4-3** below shows the proposed / finalized option, while **Figure 4-4** shows the diverted movements on West Wharf Road

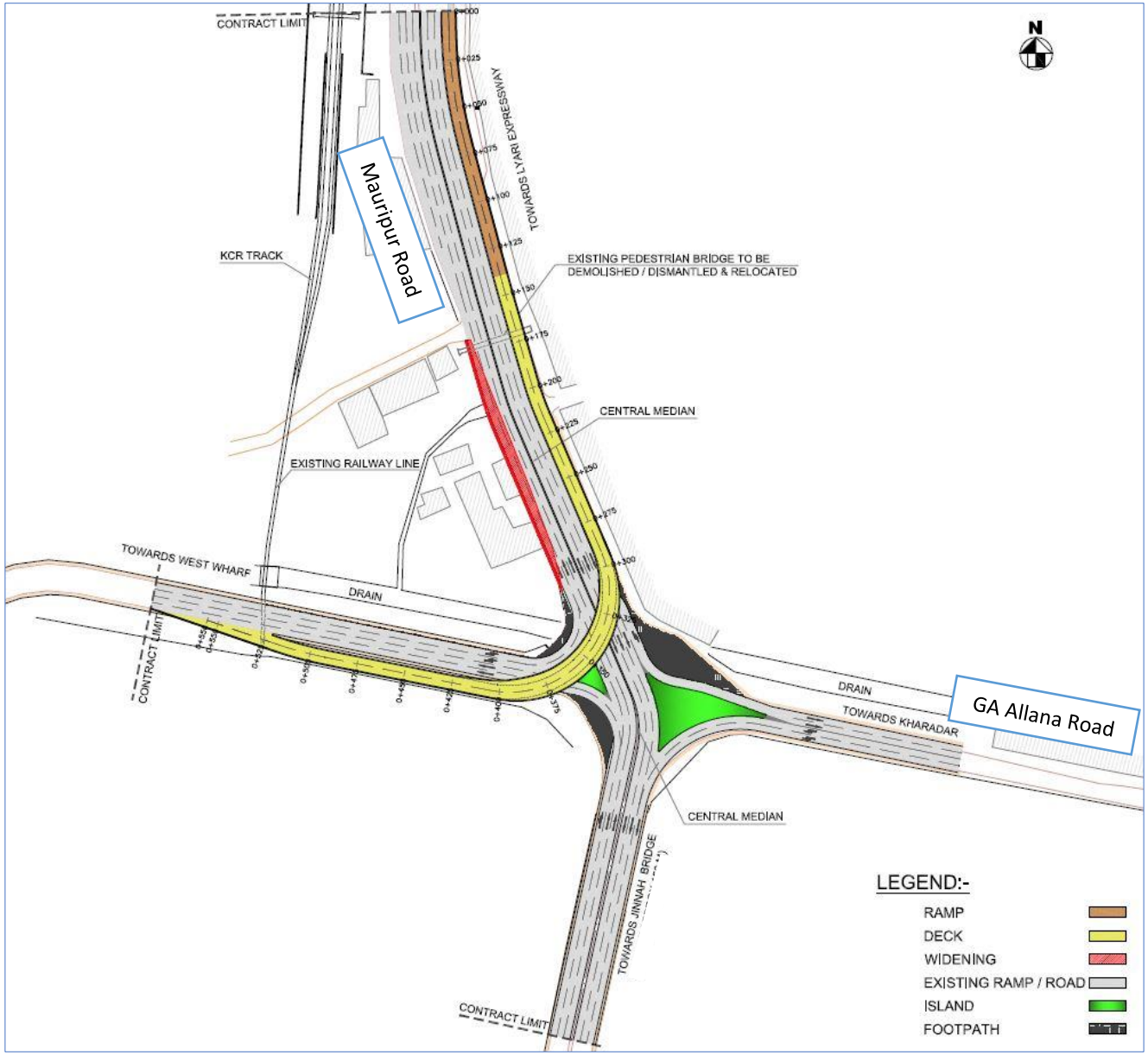



***Figure 3-3: Finalized Project Alignment***


***Figure 3-4: Proposed Diversion of Traffic***

The above scheme was shared with various project stakeholders. In a meeting with Karachi Port Trust (KPT), it was revealed that KPT also has plans to ease the traffic congestion at this intersection by building a road corridor along the KCR track for which land would be required from Pakistan Navy and Pakistan Railways.

KPT recommended to allow right-turning traffic access from ICI bridge as the West Wharf Road would witness heavy congestion due to diversion of this movement. Should the KPT plan for new road corridor along KCR gets approved, most of the port traffic would shift from Mauripur Road, which would relieve the intersection of major traffic congestion (especially on Mauripur Road).

Considering the above, it was decided to provide temporary access to turning traffic at ICI intersection till the time issue of road corridor along KCR is finalized by KPT and PN.

KPT also requested that replacement of Expansion joints at Jinnah Bridge be carried out as part of the project. The same was added in the scope of works along with replacement of expansion joints of existing ICI bridge. **Figure 4-5** shows the extents of Expansion Joints replacement for the project. The temporary intersection improvement plan is provided in **Figure 4-6**.

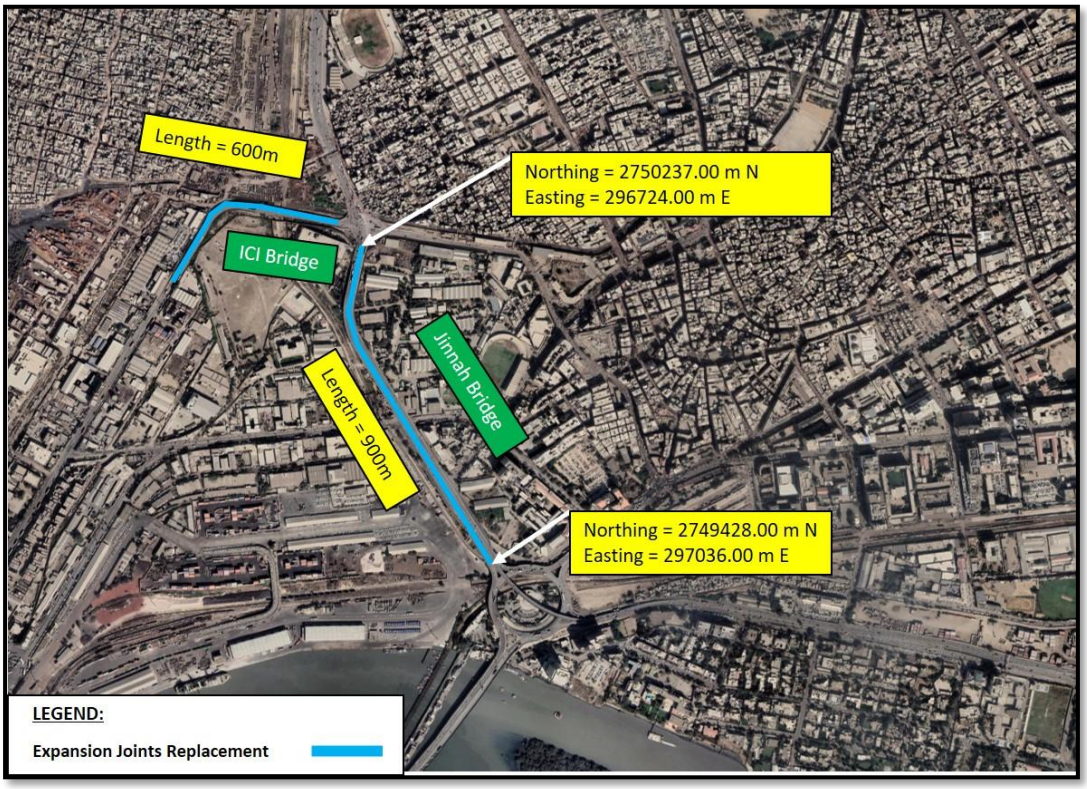



***Figure 3-5: Expansion Joints Replacement***

### 3.2.1 Level of Service (LOS) of Proposed Facility

Construction of this flyover and elimination of cross-movements on Mauripur Road will improve the overall intersection capacity. Since the Mauripur Road straight traffic (in both directions) will be signal-free, the intersection delays will be minimized.

Since this area is built-up, an average growth rate of 3% per annum was applied to the traffic for estimation of LOS for the proposed right-turn flyover. The peak hour traffic was taken as 10.85% based on the traffic data for the right-turn movement (5,489 vehicles in PCU).

Although the right-turn flyover will be a separate structure, the controlling feature of the flyover speed will be the turning radius, which will slow the traffic speeds to 40 km/h. The lane capacity is taken as 1,000 passenger cars per hour per lane (pcphpl) for urban streets, the volume to capacity (v/c) ratio comes out as 0.30 (LOS 'A').

The LOS of proposed expressway is shown in **Table 4-1** below:

***Table 3-1: LOS of Proposed Flyover***

| S. No. | Year | Daily Traffic | Peak Hour Traffic | V/C | LOS |
|---|---|---|---|---|---|
| **1** | 2023 | 5,489 | 595 | 0.372 | A |
| **2** | 2025 | 5,823 | 631 | 0.395 | A |
| **3** | 2030 | 6,751 | 732 | 0.457 | A |
| **4** | 2035 | 7,826 | 848 | 0.530 | A |
| **5** | 2040 | 9,072 | 983 | 0.615 | B |
| **6** | 2045 | 10,517 | 1,140 | 0.713 | C |
| **7** | 2050 | 12,193 | 1,322 | 0.826 | D |

The results shown in table above indicate that the proposed flyover (2-lane) has sufficient capacity to cater to the future demand up to the year 2050.

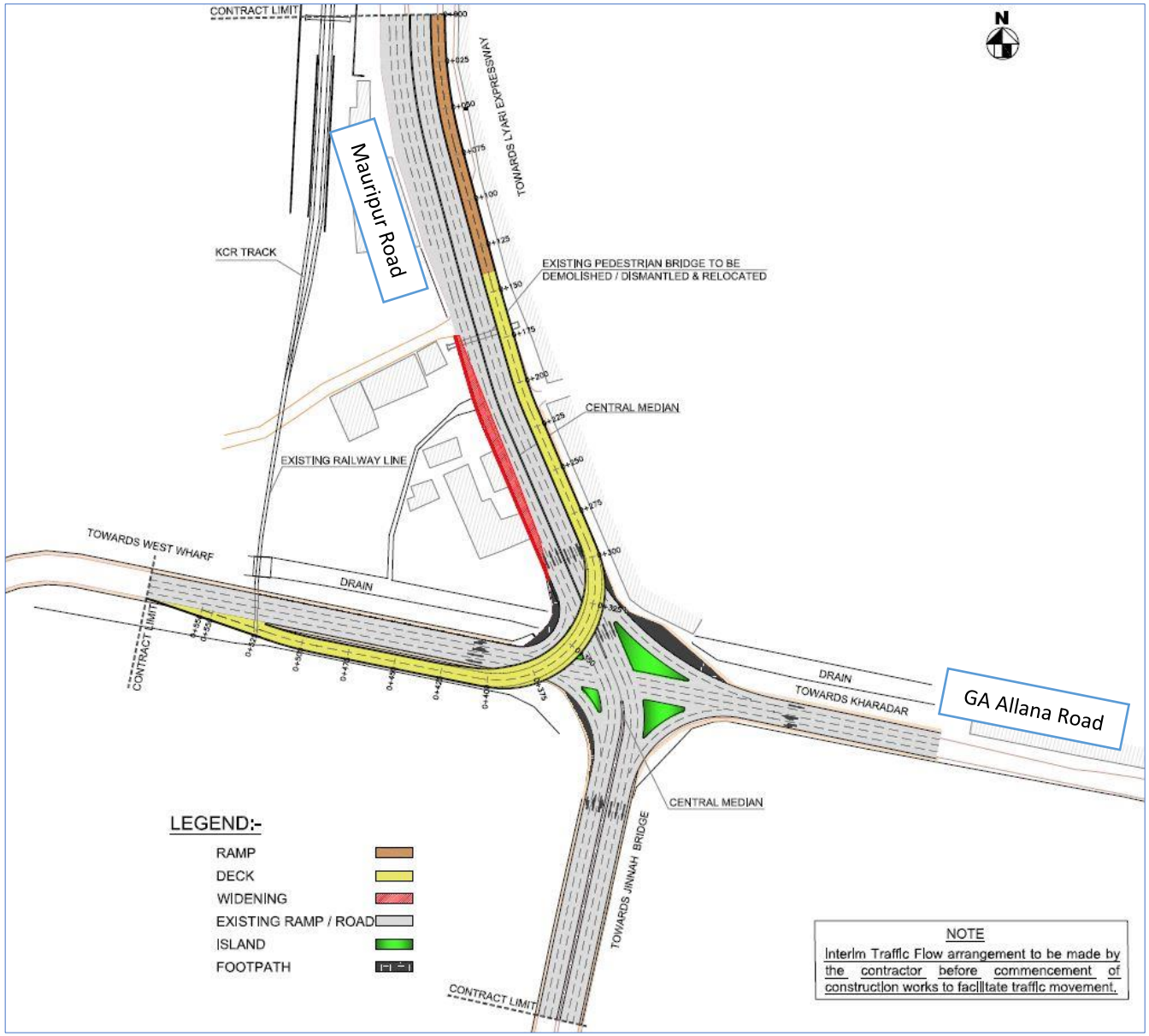



***Figure 3-6: Proposed Intersection Improvement Plan (Short-term)***

# 4.0 PROJECT DESIGN

## 4.1 Design Criteria

A brief Design Criteria Report has been developed for sub-project 3 (ICI intersection). Design Criteria provides information related to design basis, which has been adopted / formulated by different engineering design specialties, to finalize technical data, design assumptions, codes of practice, methods and procedures for Sub-Project 3.

Design Criteria Report is attached as **Annexure – 6** to this report.

## 4.2 Geometric Design

Geometric design involves the elaboration of those roadway features having to do with the road geometry: lane width, shoulder width, horizontal and vertical curvature, fore-slopes and back-slopes, and various ancillary characteristics.

Guided by the applicable geometric standards and as defined in the Request for Proposal (RFP), the project was designed following generally accepted engineering practices. Preliminary alignment and earthwork calculations were made based on initial surveys using latest equipment. Once complete topographic surveys were carried out, the information was processed electronically.

In geometric design, the standards were formulated based on traffic mix, design speed and road classification. The proposed design was based on the concept of easy maneuverability ensuring minimum conflicts and maximum road safety for passengers. Road aesthetics were also part of the criteria.

Pedestrian safety was also considered in the design. Due to the ICI intersection being bounded by Pakistan Navy (PN) boundary wall on two (2) corners and Pakistan Railway (PR) land in the third quadrant, option of pedestrian underpass does not exist as PN boundary wall is located adjacent to the intersection, which will require the boundary walls to be demolished for landing space. Additionally, due to these cordoned-off areas at the intersection, pedestrian movement is nearly non- existent. Therefore, it was proposed that existing pedestrian bridge located on Mauripur Road will be demolished and relocated to the new location.

The pavement composition was kept according to the load of each road category and was designed keeping in view the strength of sub-grade and other geo-technical investigations. The period for construction phase was kept in view to allow for movement of construction vehicles.

The design was prepared showing the following:

- Optimization to determine most economic design,
- Type of pavement and foundation design,
- Width of carriageway, footpaths, services etc.,
- Type of material proposed, and
- Study the location, gradients and other details of the structure including the feasibility from construction point of view, diversion of traffic etc.

Based on the design criteria, the horizontal alignments were fixed to suit the topography, and plans were prepared showing the details of road centerline geometry, the super elevations at curves, setting out data for the centerlines both for its straight and curvilinear segments. The vertical profile was designed to cater for the elevations at structures and the pavement design requirements of various road structural layers. The profile was plotted on 1:1000 scale (Horizontal) and 1:100 scale (Vertical) on the same sheets as for the plans.

Salient features of the geometric design are shown in **Table 5-1** below:

**Table 5-1**: Salient Features of IC Intersection Design

| S. No. | Salient Features | Description |
|---|---|---|
| 1 | Flyover (lanes) | 2 |
| 2 | Mauripur Road (lanes) | 3 + 3 |
| 3 | Lane width (Flyover) | 3.5 m |
| 4 | Lane width (Mauripur Road) | 3.5 m |
| 5 | Design Life (Flyover *as per AASHTO LRFD Bridge Design Guidelines*) | 75 Years |
| 6 | Vehicular Loading | Class A & AA |
| 7 | Vertical Clearance | 5.32 m |
| 8 | Grade (Flyover) | 3.5% |

## 4.3 Pavement Design

The design period for major roads is usually taken as 10 and 20 years, primarily due to the reason that traffic / passenger projections beyond that horizon are very unreliable and un-realistic and it is also economically not feasible to invest a whole sum in a project which may not have effective longer useful life span. In fact, from an economic standpoint, for roads, for which passenger traffic is expected to increase slowly at first, best engineering practice is to propose a geometric feature adequate for the projected 20-year traffic, However, pavement design should be

analyzed for 20 years. Hence by extending the traffic analysis period to 20 years was more to benchmark against international practice as a check.

Pavement design was governed primarily by the following factors:

- Design period in years, for which the pavement should provide acceptable service, with adequate maintenance,
- Number of repetitions of vehicle wheel loads during the design period, measured as Equivalent Standard Axle Loads (ESAL),
- Support value of the material over which the pavement structure will be constructed, commonly defined by California Bearing Ratio (CBR), and
- CBR value of each component layer of the pavement structure.

Testing and surveys conducted and presented in Geotechnical report recommends using on-site material for design of subgrade and road embankment with minimum soaked CBR value as 30% at 95% modified AASHTO maximum dry density. However, if on-site material is not available in required quantity, then suitable borrow areas near the project site needs to be explored prior to start of construction. The borrow areas must contain A-4 or better material as per AASHTO soil classification with minimum soaked CBR value as 7% and 5% for subgrade and road embankment, respectively. Reasonable CBR value of 10% is considered for the pavement analysis.

### *4.3.1 Equivalent Axle Loads*

Equivalent standard axle loads (ESAL) were computed using the equivalence load factors. The pavement design analysis was carried out for 20 years design period.

### *4.3.2 Structural Design*

Sub-project 3 mainly includes a new bridge proposed to be constructed over ICI intersection. The flyover has been planned in a way so as not to disturb the intersection space and that the pier / piles are located in such a manner that the piling works will not create any hindrance to the existing nullah flowing under the interchange. Furthermore, the radius at this location does not allow pre-cast pre-stressed girders to be placed. Hence, a four (4) span continuous box girder of around 57m span each has been designed at this location.

At one end of the flyover the bridge ends at abutment followed by a retaining wall, whereas the other end of the flyover has been designed to match with the existing ICI Bridge while maintaining clearance over the KCR tracks. The piers of the proposed bridge have been planned in a way to maintain the clearance from the

KCR track and its ROW. For rest of the length of bridge, pre-cast I-girders have been planned for fast track construction. Seismic analysis has been carried out as per code requirements (AASHTO). Abutment is provided keeping the height that will allow maintenance work to be carried out underneath.

Typical cross sections are attached as **Annexure – 7** to this report.

# 5.0 STAKEHOLDER CONSULTATION

## 5.1 Coordination with Various Stakeholders

Several meetings were held with various stakeholders including LGD, PPP Unit, KPT, PR, PN, NHA, KMC, and with utility agencies to finalize the project alignment and to determine impacts on existing services. Various alternatives developed for the project were shared with the participants to get their feedback.

The ICI intersection is bounded by Pakistan Navy establishments on the southwest and southeast quadrants, while Pakistan Railways' Wazir Mansion station for the KCR exists at the northwest quadrant. The finalized option was selected after careful deliberation with the various stakeholders, sensitivity of the area (PN installations), and availability of ROW.

For the Environmental Impact Assessment (EIA) and Social Assessment Report, in order to get opinion of different stakeholders and to discuss anticipated social issues of the proposed Project, consultations were held with LGD, PPP Unit, NGOs, Traffic Police Karachi, Road Users and local community as well. Their views and suggestions were recorded and incorporated in the EIA document. Overall, all the stakeholders appreciated the project to reduce traffic congestion at the intersection. Detailed discussion on the same is presented in the EIA report (separate document).

**Figures 6.1** and **6.2** below show coordination with various Stakeholders.

*Figure 5-1: Consultation with KPT*

*Figure 5-2: Consultation with KPT and Pakistan Navy Representatives*

### 5.2 Coordination with Utility Agencies

Requisite surveys were conducted after taking permission from relevant authorities and preliminary design drawings were prepared based on the collected data and project requirements. These preliminary drawings were sent to various government agencies including Sui Southern Gas Company Ltd. (SSGC), K-Electric Company Ltd., Karachi Water & Sewerage Board (KW&SB), Pakistan Telecommunication Corporation Ltd. (PTCL), National Refinery Limited (NRL), Pakistan Refinery Limited (PRL) and Pak-Arab Refinery Company Limited (PARCO).

Information received from various agencies was incorporated in the design drawings. A provisional sum for utility relocation has been separately kept in the cost estimate.

## 6.0 LAND ACQUISITION REQUIREMENTS

The land acquisition plan has been prepared along with the preliminary design. Construction of ramp on Mauripur Road will require the lanes to be shifted to one side, for which land acquisition will be required in order to maintain three (3) lanes in each direction. Approximately 684 sq. meter area is required for the proposed improvements.

The area required for land acquisition is shown in **Figure 7-1** below highlighted in red.


***Figure 6-1: Area Required for Land Acquisition at ICI Intersection***

# 7.0 COST SUMMARY

## 7.1 CAPITAL COST ESTIMATE

Capital cost estimate includes cost estimate of the project, and the provisional sum for utility relocation.

Table 8-1 below shows the summary of cost breakup for the project.

***Table 7-1: Summary of Cost for Improvements at ICI Intersection***

| S. No. | DESCRIPTION | AMOUNT (PKR) |
|---|---|---|
| **A** | **Right-turn Flyover** | |
| | Schedule & Non-schedule Items incl. 5% Premium | 546,575,398 |
| **B** | **Road Rehabilitation** | |
| | Schedule & Non-schedule Items incl. 5% Premium | 147,359,695 |
| **C** | **Electrical Works** | 15,777,432 |
| **D** | **Expansion Joints Replacement** | 59,881,955 |
| **E** | **Confirmatory Geotechnical Investigations** | 1,000,000 |
| **F** | **Environmental Monitoring** | 3,947,600 |
| **G** | **Total Cost of Road Works** *(A + B + C + D + E + F)* | **774,542,081** |
| **H** | **Sindh Sales Tax** *(13% of G)* | **100,690,471** |
| **J** | **Grand Total (Pak Rs.)** | **875,232,551** |

## 7.2 BASIS OF COST DETERMINATION

The cost is determined based on National Highway Authority (NHA) 2014 for scheduled items and market rates for non-scheduled items. A 5% premium was applied on NHA Composite Schedule of Rates (CSR) 2014 rates. Real estate rates for the cost of land required for the project is not included in the capital cost estimate and will be provided by various agencies based on the preliminary design.

## 7.3 SINDH SALES TAX

The Sindh Revenue Board (SRB) issued notification on June 27, 2019 through which exemption of Sindh Sales Tax (SST) for Construction Services (under tariff heading 9824.0000) was withdrawn and 13% SST was applied on such services. The cost estimate, therefore, includes SST@13%.

## 8.0 CONCLUSION / RECOMMENDATIONS

This project is primarily conceived (i) To facilitate Karachi port heavy traffic going / coming from all over country through the junction without stopping, also to facilitate city traffic using Lyari Express way and Mauripur road for their ultimate destination; and (ii) To resolve traffic congestion during evening peak hours on Jinnah Bridge, where currently more than one kilometer queue length of vehicles can be observed due to this signalized junction.

Due to non-availability of adequate ROW for construction of a high-level interchange at the present at-grade intersection, it may be necessary to acquire land and relocate the adjoining residents to a suitable location, if required.

The proposed construction of right-turn flyover for traffic towards ICI Bridge (West Wharf) will facilitate the freight traffic that comes from all over the country to Karachi Port and to reduce the traffic coming from / going to Lyari Expressway and Mauripur Road. The construction of this right-turn flyover will also reduce the traffic congestion at Jinnah Bridge, thereby facilitating smooth flow of traffic in and around the vicinity of the project.

# ANNEXURE – 1

# TOPOGRAPHIC SURVEY REPORT
## Sub – Project 3 - ICI INTERSECTION

## 1. Introduction

The methodology covers details of locations of survey control network, instruments used, measurement details, position fixation and coordinates and layout of the above defined scope of works.

## 2. Location & Extents of The Project Site

The project area for which survey has been carried out includes ICI intersection and connecting roads. The survey data within the project area has also been collected for the study.

The location map of the subject project is shown in Figure-1 and 2 appended in section 1 of this report.

## 3. Scope of Survey Work

Survey is required to obtain basic information regarding topography, terrain, drainage pattern, profile etc. of the project area.

The survey detail is inclusive of, but not limited to the elements listed below;

- Site Reconnaissance visit of the Project area.
- Establishment of survey Bench Marks (BM) in the project area.
- Topographic survey of entire project area.
- Inventory of existing structures.
- Processing of the observed data.
- Preparation of Topographic Survey Map and related report of project area.

The above-mentioned scope of the work has been completed by using the following methodology;

## 4. Work Plan and Site Reconnaissance Visit

A comprehensive work plan has been established and implemented in the field by qualified survey team during execution of survey works.

Site reconnaissance survey of the project area has been carried out to assess the field conditions and general topography to finalize the survey activities/ implementation plan.

## 5. Establishment of Survey Bench Mark (Bm)

Establishment of local control points is an essential activity which is to be carried out prior to actual commencement of surveying and mapping of the project area. New technology Global Navigation Satellite System (GNSS) makes it more efficient and effective to establish a primary control bench mark. Often National Geodetic Survey (NGS) vertical control is not readily available within the project area, thus the new procedures allow for establishing a vertical height easily, efficiently, and economically using GNSS.

Next activity is selection of a project control point and utilization of vertical data derived from GNSS observation processed through Online Positioning User Service (OPUS) as our primary control bench mark.

The values obtained in World Geographic System (WGS) can easily be transferred to local or Universal Transverse Mercator (UTM) Systems.

This Bench Mark has been used as a reference point for further establishment of horizontal and vertical control network, within the project area, to carry out the topographical and cross-sectional survey work.

The coordinates & location of established control points are presented in Table-1 and Table-2 in WGS-84 and UTM coordinate system respectively and shown in Figure-8.

## 6. Selection of Control Points Location

Quality is a characteristic of comparable things that allows us to decide that one thing is better than another. In the context of geographic data, the ultimate standard of quality is the degree to which a data set is fit for its effective use.

Selection of location for control points (Established Bench Marks) were based on three elements i.e. stability for the soil conditions encountered for each point set, safety of the established point and ample clear view to the sky, which are crucial for GNSS observations. In order to mitigate errors and to increase accuracy, the control network was planned and designed to form triangles wherever possible.

## 7. Establishment of Horizontal and Vertical Control Networks

Horizontal and vertical project control survey has been established for the project. Whenever feasible, the horizontal and vertical control is based on high-precision GNSS observations.

In order to achieve maximum possible accuracy and minimal spatial variations in both horizontal and vertical planes, control network was established by using state of the art "GNSS" equipment encompassing the entire project area.

For base line computation, three (3) GNSS instruments have been used simultaneously. To receive the signals from satellite, the receiver should have minimum obstructions like building, trees, power lines etc., around it.

In case of weakening of signals due to unfavorable weather conditions like rainfall, clouds and vehicle noise, the observations have repeatedly been noted till obtaining satisfactory readings/data.
For all time observations, at least four (4) satellites should be available with Geometric Dilution of Precision/Position Dilution of Precision (GDOP/PDOP) value of less than five (5).

The availability of satellites and `GDOP value can be known in advance with the help of computer program for given time, date and point of observations. Each instrument is set to work at least 30 minutes for simultaneous observations.

Out of three (3) receivers, one acted as reference (for which coordinates of the observing point are known) and the other two (2) as rovers (coordinates to be computed). The observed point coordinates served as reference for further observing points to make a triangle or large polygon. CPs has been engraved at the permanent structures.

**Table-1: List of Control Points Coordinates in World Geographic System (WGS) 84**

| Sr. No. | Control Point | Latitude (DMS) | Longitude (DMS) | Elevation (m) |
|---|---|---|---|---|
| **1** | P3/CP01 | 24° 51' 26.186" N | 66° 59' 11.681" E | 10.712 |
| **2** | P3/CP02 | 24° 51' 14.751" N | 66° 59' 18.354" E | 6.708 |

***Table 1 List of Control Points in WGS 84***

**Table-2: List of Control Points Coordinates in Universal Transverse Mercator (UTM) Zone 42N**

| Sr. No. | Control Point | Easting (m) | Northing (m) | Elevation (m) |
|---|---|---|---|---|
| **1** | P3/CP01 | 296564.844 | 2750646.992 | 10.712 |
| **2** | P3/CP02 | 296746.976 | 2750292.384 | 6.708 |

***Table 2 List of Control Points in UTM Zone 42N***

The accuracy of the survey control points in static mode is as follows:

Horizontal …….. ± 3 mm +1 ppm RMS
Vertical…….. ± 5 mm +1 ppm RMS

## 8. Instruments Used

Leica Viva GS 10, GS 15 and Trimble R2, R9 were used to establish the control points. Also, these systems with one base and receivers (rovers) were used to collect the survey data in RTK mode.

The topographic survey has been carried out by using the GNSS in Real Time Kinematic (RTK) mode. The base station was placed on the known control point and the rover has been used for collecting the survey points. The accuracy of the GNSS equipment in RTK mode is as follows:

Horizontal ……. ± 10 mm +1 ppm RMS
Vertical…….. ± 20 mm + 1 ppm RMS

## 9. Measurement Units

The linear measurement units used in survey and mapping work are in metric system of units and the angular measurement are in degrees, minutes and second of arc.

## 10. Field Data Processing

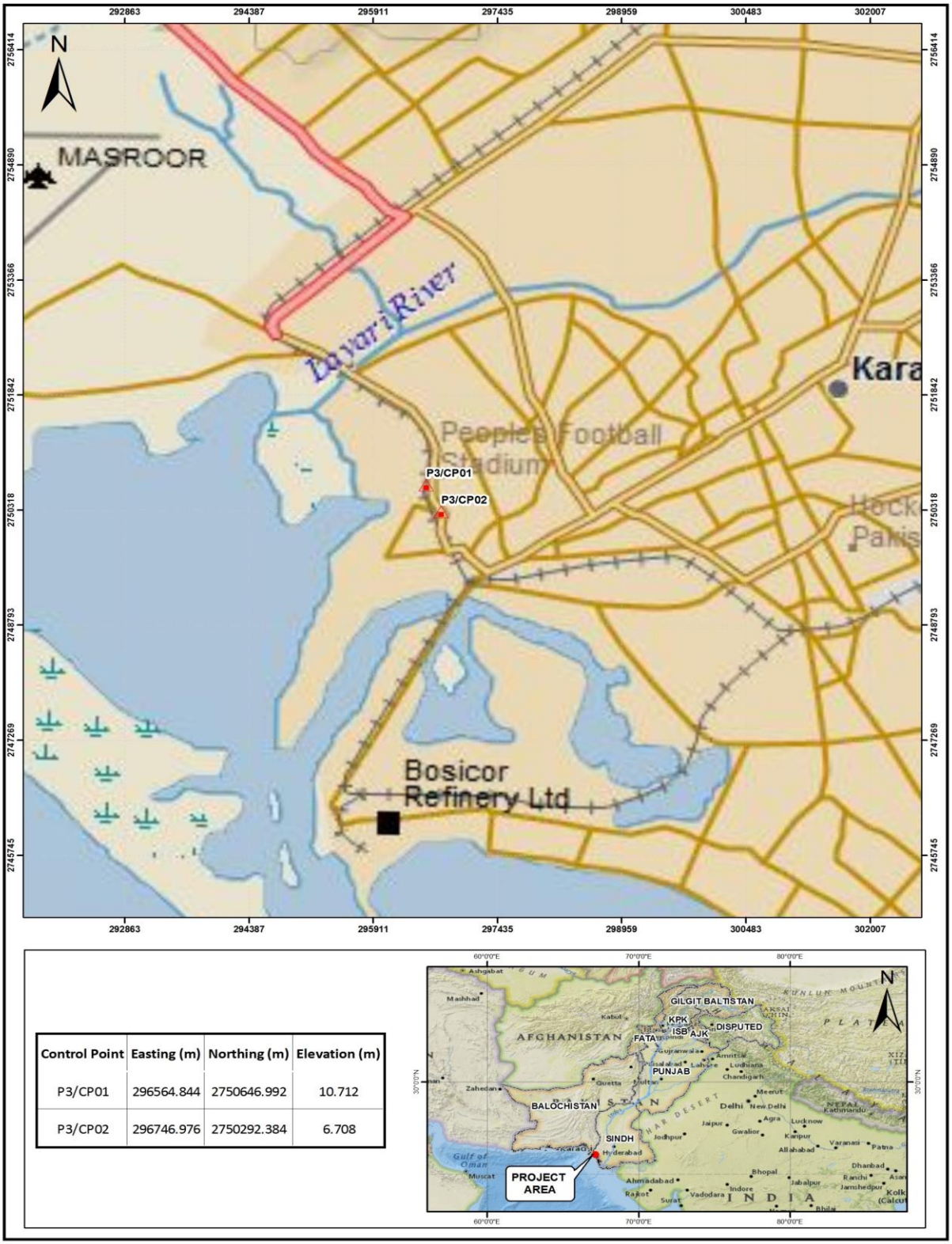
The data observed was downloaded to laptop which always remain available with survey team at the survey site. The data has been processed and checked at the site for quality and gaps, if any. The GPS baselines were processed using Leica Geo Office (LGO) and Trimble Business Centre (TBC) software. The default acceptance criteria for baselines were used in LGO & TBC. Any baseline not fulfilling the acceptance criteria has been repeated. As the GNSS reading is based upon the WGS-84, the data was converted into UTM Zone 42.

## 11. Software Used

All the observed data has been processed using LGO, TBC and ArcGIS software which are widely used for field data processing. AutoCAD and Eagle Point software have been used for preparation of the topographic survey layouts using the field survey data.

## 12. Data Post Processing and Production of Drawings

The observed data was digitized using AutoCAD software in the form of points, lines and polygons. The digitization of features has been done in different AutoCAD layers. The feature layers have unique style and symbols so that these can be well distinguished from other features.




| Control Point | Easting (m) | Northing (m) | Elevation (m) |
|---|---|---|---|
| P3/CP01 | 296564.844 | 2750646.992 | 10.712 |
| P3/CP02 | 296746.976 | 2750292.384 | 6.708 |

***Figure 1 Location Map of Established Survey Bench Marks***

# ANNEXURE – 3

**LOCAL GOVERNMENT & HTP DEPARTMENT**
**GOVERNMENT OF SINDH**

GOS

**Feasibility Study and Transaction Advisory Services, 'Urban Road Initiatives in Karachi'**

**Sub Project 3: Interchange at ICI Bridge**

# Geotechnical Investigation Report

**NOVEMBER 2020**

**National Engineering Services Pakistan (Pvt.) Ltd.**
**13th Floor, N.I.C. Building, Abbasi Shaheed Road, Off. Shahrah-e-Faisal, Karachi**
**Phone: (0092 21) 99207277-84**
**Fax : (0092 21) 35651994**
**E-mail : nespakkh@khi.wol.net.pk**
**Web: http://www.nespak.com.pk**

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|---|---|---|---|---|---|

Consultant

National Engineering Services Pakistan (Pvt.) Ltd.
13th Floor, N.I.C. Building, Abbasi Shaheed Road, Off. Shahrah-e-Faisal, Karachi
Phone: (0092 21) 99207277-84
Fax : (0092 21) 35651994
E-mail : nespakkh@khi.wol.net.pk
Web: http://www.nespak.com.pk

Client

Local Government & HTP Department
Ground Floor, Annexe Tughluque House, Sindh Secretariat
Phone: +92-928-621123
Email: info@lgsindh.gov.pk
http://www.lgdsindh.gov.pk

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| 04 | | | | | | | | |

**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES**
**URBAN ROAD INITIATIVES IN KARACHI**
**(Sub Project – 3: Interchange at ICI Bridge)**

# GEOTECHNICAL INVESTIGATION REPORT

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**APPENDICES**

# LIST OF TABLES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| AASHTO | American Association of State Highway and Transportation Officials |
| ACI | American Concrete Institute |
| ASTM | American Society for Testing and Materials |
| BA | Borrow Area |
| BH | Borehole |
| BS | British Standard |
| CBR | California Bearing Ratio |
| CS | Composite Sample |
| FDT | Field Density Test |
| LL | Liquid Limit |
| MBT | Main Boundary Thrust |
| MDD | Maximum Dry Density |
| m.y. | Million Year |
| NAVFAC | Naval Facilities Engineering Command |
| NESPAK | National Engineering Services Pakistan (Pvt.) Ltd |
| NMC | Natural Moisture Content |
| NSL | Natural Surface Level |
| OMC | Optimum Moisture Content |
| SRC | Sulphate Resistance Cement |
| PI | Plasticity Index |
| PL | Plastic Limit |
| PPRA | Public Procurement Regulatory Authority |
| SPT | Standard Penetration Test |
| TP | Testpit |
| UDS | Undisturbed Soil Sample |
| USCS | Unified Soil Classification System |
| w/c | Water Cement Ratio |
| HTP | Housing Town Planning |
| FHWA | Federal Highway Administration |
| PMA | Pir Mangho Anticline |
| PMF | Pir Mangho Fault |
| LS | Lalji Syncline |

# EXECUTIVE SUMMARY

Local Government & HTP Department, Govt. of Sindh intends to conduct feasibility study and transaction advisory services for three urban road projects that will be initiated under Public Private Partnership (PPP) mode. The project is divided in following sub-projects:

**Sub Project – 1:** Link Road from Korangi (from KPT Interchange to PAF Airmen Academy)
**Sub Project – 2:** Expressway from Mauripur Road (End of Lyari Expressway) to Y Junction (Kakapir Rd / Mauripur Rd Intersection)
**Sub Project – 3:** Interchange at ICI Bridge

National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) has been appointed as a Consultant by the Client for conducting feasibility study and transaction advisory services for the subject project. This report solely deals with geotechnical investigations carried out for Sub Project – 3.

The task of geotechnical investigations was awarded to M/s Soil Testing Services (STS), Karachi through competitive bidding amongst the drilling contractors as per PPRA rules. These investigations were carried out under the full-time supervision of geotechnical engineers of NESPAK from September 01, 2020 to September 19, 2020.

The geotechnical investigations were aimed to delineate the major subsoil / bedrock conditions spread over the site area, to evolve soil / rock parameters for the feasibility level design of foundations for proposed structures, to evolve geotechnical parameters for the feasibility level design of road works & to identify any problematic ground conditions and provide remedy. Geotechnical investigations comprised drilling of boreholes, excavation of test pits, performance of field testing, field density tests, collection of soil / rock / water samples and laboratory testing on selected samples.

The geotechnical investigations indicated that the project area consists of fill material up to 2 m depth underlain by Lean Clay / Silty Clay / Silty Sand / Clayey Gravel up to the depth of 33.5 m below NSL. Bedrock, consists of weak to very weak Sandstone / Claystone, from 33.5 m to maximum investigated depth of 40 m below NSL.

Based on the subsurface ground conditions and the type of loads of the proposed structures, R.C. piles are recommended to be used for proposed interchange and retaining walls. However, square foundations can be considered for light poles. Detailed geotechnical investigations should be carried out prior to finalization of foundations of all the structures.

Chemical test results indicated that groundwater contains severe proportion of harmful salts. Therefore, sulphate resistance cement (SRC) is recommended to be used for concrete works of foundations.

Test results for on-site testpits indicated that A-1-a / A-4 soils with soaked CBR as 30 % & 32.5 % at 95 % modified AASHTO maximum dry density are present on existing road

locations. On-site or alternatively, borrow area soils that belongs to A-4 or better AASHTO soil classification group can be used for road works.

# 1. INTRODUCTION

## 1.1 GENERAL

Local Government & HTP Department, Govt. of Sindh intends to conduct feasibility study and transaction advisory services for three urban road projects that will be initiated under Public Private Partnership (PPP) mode. The primary objective of the project is to mitigate the traffic congestion problems and provide quick & safe access to the local commuters. The project consists of following parts:

**Sub Project – 1:** Link Road from Korangi (from KPT Interchange to PAF Airmen Academy)
**Sub Project – 2:** Expressway from Mauripur Road (End of Lyari Expressway) to Y Junction (Kakapir Rd / Mauripur Rd Intersection)
**Sub Project – 3:** Interchange at ICI Bridge

This report solely deals with geotechnical studies and necessary geotechnical recommendations for feasibility level design of foundations for **Interchange at ICI Bridge**.

National Engineering Services Pakistan (Pvt.) Ltd. (NESPAK) has been appointed as a Consultant by the Client for conducting feasibility study and transaction advisory services for the subject project.

In order to evaluate the subsurface conditions at project site and to arrive at a safe and economical design of foundations of the proposed structure, geotechnical investigations were considered necessary.

The task of geotechnical investigations was awarded to M/s Soil Testing Services (STS), Karachi through competitive bidding amongst the drilling contractors as per PPRA rules. These investigations were carried out under the full-time supervision of geotechnical engineers of NESPAK from September 01, 2020 to September 19, 2020.

The selected soil / rock and water samples collected during the field geotechnical investigations were tested at Geotechnical testing Laboratory of SOILCON and University of Engineering & Technology, Lahore as per laboratory testing programs prepared by NESPAK.

This report provides an account of the geotechnical activities carried out at the site, characteristics of subsurface materials, details of field & laboratory tests, selection of geotechnical parameters and geotechnical recommendations for feasibility level design of foundations and road works.

## 1.2 OBJECTIVES OF GEOTECHNICAL INVESTIGATIONS

The geotechnical investigations were undertaken to meet the following objectives:

- To delineate major subsurface material types spread over the site area.
- To evolve geotechnical parameters for feasibility level design of foundations of the proposed structure.
- To evolve geotechnical parameters for feasibility level design of road works.
- To furnish general geotechnical considerations for the construction of foundations and road works.

## 1.3 SCOPE OF WORK

Following scope of work for geotechnical investigations was developed to fulfill the above mentioned objectives:

- Execution of two (02) boreholes up to a maximum depth of 40 m below natural surface level (NSL) at the proposed structure location using straight rotary drilling method.
- Excavation of three (03) test pits up to a maximum depth of 2 m below NSL at road locations.
- Continuous core drilling in bedrock along with collection & preservation of rock cores.
- Performance of Standard Penetration Tests (SPTs) in overburden soils encountered in boreholes, generally at 1 m depth interval.
- Performance of Field Density Tests (FDTs) in test pits, generally at 1 to 3 tests per test pit at designated depths.
- Collection and preservation of disturbed/undisturbed soil samples from the boreholes and test pits.
- Collection and preservation of groundwater samples from the boreholes.
- Laboratory testing of selected soil / rock samples for the evaluation of classification, strength, compressibility, compaction and chemical characteristics.
- Chemical analysis of groundwater samples.
- Analysis of field and laboratory data for determination of foundation design parameters including soil / rock parameters, foundation type, depth and size, allowable bearing pressures, etc.
- Formulation of geotechnical considerations for the construction of foundations and road works.
- Compilation of a Geotechnical Investigation Report on the basis of the above mentioned studies.

## 1.4 DESCRIPTION OF SITE

The proposed project site is located adjacent to the existing ICI Bridge. The site can be accessed through Mauripur Road and Dockyard – Ghulam Ali Allana Road.

The terrain of the site area is flat. Location plan of the project site is appended as Fig. A-1 (Appendix A).

# 2. GEOLOGY AND SEISMICITY OF AREA

## 2.1 GEOLOGY

### 2.1.1 Regional Geology

Regionally, the Project Area is located in the Karachi Arc which is located on the southern margin of the Sulaiman Kirther Fold Belt. Karachi Arc is an eastward arcuate feature bounded by east west oriented sinistral and dextral faults near Mancher Lake in north and near Karachi in south respectively (Sarwar and DeJong, 1979). The east verging structures in the Karachi Arc indicate an eastward tectonic transport in a thin skinned fashion as a result of Indo - Arabian convergence (Sarwar, 1992; Niamatullah, 1998). The Karachi arcuate feature is also bounded by the Chaman Transform Fault System to the west and the Kirthar or Kachhi Foredeep in the east. The fold belt has formed by folding and thrusting of shelf sediments at the northwestern edge of the Indian Plate. The fold belt has originated as a result of Indo-Eurasian convergence to the north and Indo-Arabian to the south (Sarwar, 1992; Niamatullah, 1998). A thin skinned deformation style has been present all along the Karachi Arc as a result eastward tectonic transport. However, some thick skinned deformation has also been reported in the southern part of it (Smewing et al., 2002).

The major structures of the area are the Pir Mangho Anticline (PMA) and the Lalji Syncline (LS). The strike of the pronounced structural trend is NE-SW in the area. In the north of Pir Mangho Anticline, structural trend changes sharply to the NS. A number of sinistral strike slip faults displace the strata. The most important is the Pir Mangho Fault (PMF), which is a NW-SW trending vertical fault with subhorizontal striation and having sinistral displacement. This fault has partitioned the strain in the area.

Laji Syncline is located in the SW of the Pir Mangho Anticline which is a double syncline with a kink geometry and hinges plunging towards SW. The two synclinal hinges are separate in the NE but converge towards SW, where they join together and form a single hinge asymmetric fold facing SE in Orangi area. Where fold is double hinged, its eastern limb is dipping at a low angle towards west, while its northwestern limb is dipping at a higher angle towards SE (Structural Geometry and Tectonics of Southern Part of Karachi Arc - A Case Study of Pirmangho and Lalji Area, April 2012).

### 2.1.2 Site Geology

The project site lie at the foot hills of Sulaiman Kirther Mountains and is comprised of unconsolidated surficial deposits of clay, silt, sand and gravel which forms distinct piedmont plains. These piedmont plains are characterized by gentler slope comprising of softer rocks and commonly contains parallel or concentric, low, scalloped, homoclinal ridges and hogbacks.

## 2.2 SEISMICITY

The Project Area is located in the southern part of Pakistan which is seismically active. The tectonic feature most critical for the Project Area is the Pab Fault which is passing at a

distance of about 18 km north-west from Project Area. Moderate to low level of seismicity is observed to be associated with this fault. Very active Kutch Seismic Zone is present about 200km south-east from Project Area. In Kuch Seismic Zone several damaging earthquakes (with maximum intensity upto XI on Modified Mercellic Intensity Scale) have occurred including 2000 Bhoj Earthquake of magnitude 7.9.

Probabilistic seismic hazard assessment carried out as part of the revision of the Building Code of Pakistan Seismic Provisions (2007) shows that the Project Area falls in Zone-2B.

It is therefore recommended that the project structures should be designed to cater the requirements of Zone-2B of Building Code of Pakistan seismic provisions (2007) after giving due consideration to the soil profile of the site area.

# 3. FIELD GEOTECHNICAL STUDIES

## 3.1 PLANNING

In order to evaluate subsurface ground conditions at the project site, boreholes and test pits of appropriate depth were planned to be executed at the selected locations, in the light of the project requirements. The location of these boreholes and test pits was fixed in such a manner so as to cover the maximum area of the project site. The geotechnical investigation plan showing locations of boreholes and test pits is appended to this report as Fig. A-2 (Appendix-A).

## 3.2 DRILLING OF BOREHOLES

Two (02) boreholes of depth 36.5 m and 40 m below natural surface level (NSL) were drilled by straight rotary drilling method at proposed structure location. A fish tail / tricon roller bit with a diameter of 100 mm was used to drill the boreholes in overburden soils. However, NX sized double tube core barrel was used for drilling in bedrock. Bentonite slurry was used as drilling fluid during execution of boreholes.

Field borehole logs were developed on the basis of material encountered at the site and later confirmed on the basis of laboratory test results. The borehole logs are appended to this report as Appendix-B. The subsurface soil / rock profile developed on the basis of borehole logs is appended with the report as Fig. A-3 (Appendix-A).

## 3.3 EXCAVATION OF TEST PITS

Three (03) test pits of 1.5 – 2.0 m depth below NSL were excavated at road locations. The test pits were excavated using conventional hand digging tools like pick-axe and hand shovel.

The test pits were carefully logged during excavation and field logs were developed, which were later confirmed through laboratory testing. The test pit logs are appended to this report as Appendix-B.

## 3.4 STANDARD PENETRATION TESTS (SPT)

Standard Penetration Tests (SPTs) were performed in both the boreholes according to the latest ASTM D 1586, generally at 1 m depth interval, where possible. A donut type hammer, weighing 63.5 kg, was used for the test. During performance of SPTs in boreholes, the hammer was lifted and dropped mechanically through the flywheel of drilling rig and pulley hanged to a tripod. A split spoon sampler without a liner was used for all the tests. Disturbed soil samples were obtained through the split spoon sampler. The SPT blow counts were recorded for 45 cm total penetration of split spoon sampler. The number of blows required to drive the sampler through the last 30 cm viz. ‘N’ values have been shown on the respective borehole logs (Appendix-B).

Plots of field and corrected SPT-N value with depth have been developed for both the boreholes and appended to this report as Fig. C-1 and Fig. C-2 (Appendix-C), respectively.

### 3.5 IN-SITU DENSITY TESTS

To evaluate the in-situ density of the subsurface soils, density tests were performed in the test pits at selected depths below NSL. Sand replacement method was used to perform the density tests according to the latest ASTM D 1556. Five (05) field density tests were performed in the test pits. The results of these density tests are shown on the individual test pit logs (Appendix-B), also tabulated in Table D-2 (Appendix-D).

### 3.6 UNDISTURBED SAMPLING

Four (04) relatively undisturbed soil samples were recovered from boreholes using Denison / Pitcher samplers as per latest ASTM D 1587. After determining the in-situ density, the soil samples were properly waxed, labeled, preserved and transported to the approved geotechnical testing laboratory.

Twelve (12) representative undisturbed rock samples (rock cores) were carefully recovered from boreholes. These rock samples (rock cores) were properly waxed, labeled and preserved in core boxes before transportation to the geotechnical testing laboratory.

### 3.7 DISTURBED SAMPLING

The SPT samples obtained from overburden soils in the boreholes and composite soil samples collected from on-site test pits were properly labeled and preserved as disturbed samples. All the disturbed samples were transported to the approved geotechnical testing laboratory.

For determination of the in-situ moisture content, small quantity of soil samples were also collected in tin cans from the depths where the density tests were carried out in test pits. These samples were weighted at the site and subsequently sealed & labeled for dispatch to the laboratory for evaluation of moisture content by oven drying method.

### 3.8 GROUNDWATER

Groundwater was encountered at a depth of 1.5 m to 1.7 m below NSL during field geotechnical investigations executed in the month of September 2020.

# 4. LABORATORY TESTING

## 4.1 GENERAL

Selected soil / rock and water samples collected from boreholes and test pits were subjected to the following tests as per laboratory testing program prepared by NESPAK in accordance with latest ASTM / BS or equivalent standard in Geotechnical Testing Laboratories of SOILCON and University of Engineering & Technology, Lahore:

- Grain Size Analysis (ASTM D – 421, 422)
- Atterberg Limits (ASTM D – 4318)
- Natural Moisture Content (ASTM D – 2216)
- Bulk & Dry Density
- Unconfined Compression (ASTM D – 2166)
- Uniaxial Compression Test (ASTM D 7012)
- Modified AASHTO Compaction (AASHTO T-180)
- 3-Point Soaked CBR (AASHTO T-193)
- Sulphate Content (BS 1377 Part 3)
- Chloride Content (BS 1377 Part 3)
- Organic Matter Content (BS 1377 Part 3)

Summary of laboratory test results is appended to this report as Table D-1 (Appendix-D) along with original test result sheets.

## 4.2 DISCUSSION ON RESULTS

### 4.2.1 Classification Test

Grain size analysis was performed on thirteen (13) soil samples collected from boreholes and test pits. Test results showed that the on-site soils generally comprise Lean Clay / Lean Clay with Sand / Sandy Lean Clay (CL), Silty Sand / Silty Sand with Gravel (SM), Clayey Sand (SC), Clayey Gravel (GC) etc. as per Unified Soil Classification System (USCS). As per AASHTO soil classification, on-site soils generally belong to A-2-4, A-4 and A-6 group.

Six (06) on-site soil samples were subjected to Atterberg limits tests. Test results indicated liquid limit (LL) ranging from 29 to 45 % and the plasticity index (PI) ranging from 9 to 20 %.

### 4.2.2 Natural Moisture Content (NMC) and Dry Density Test

Four (04) relatively undisturbed soil samples collected from boreholes were tested for natural moisture content (NMC) and dry density. Test results indicated that NMC value as 12.8 % to 21.7 % and dry density value varies from 15.8 to 18.6 kN/m$^3$.

Six (06) rock core samples collected from boreholes were also tested for natural moisture content (NMC) and density test. Test results indicated NMC value as 1.4 % to 11.0 % and dry density as 19.7 kN/m$^3$ to 24.2 kN/m$^3$.

### 4.2.3 Unconfined Compression Test

Unconfined compressive strength tests were performed on two (02) relatively undisturbed cohesive soil samples extracted from boreholes. Test results indicated the unconfined compressive strength of soil samples as 153 kPa & 184.4 kPa while the failure strain was 7.6 % & 9.9 %.

### 4.2.4 Uniaxial Compression Test

Uniaxial compression tests were performed on six (06) rock core samples collected from boreholes. Test results indicated that the onsite bedrock has uniaxial compressive strength as 0.04 Mpa to 1.42 Mpa with a failure strain as 1.0 % to 6.2 %.

### 4.2.5 Modified AASHTO Compaction Test

Modified AASHTO Compaction tests were performed on two (02) composite soil samples collected from on-site test pits. Test results indicated maximum dry density (MDD) as 20.6 $kN/m^3$ & 21.4 $kN/m^3$ and optimum moisture content (OMC) as 6.5 % & 8.3 %.

### 4.2.6 3-Point Soaked CBR Test

California Bearing Ratio (CBR) tests were performed on two (02) composite soil samples collected from on-site test pits, which revealed CBR value as 30 % & 32.5 % at 95% Modified AASHTO maximum dry density.

### 4.2.7 Chemical Test

Chemical tests were carried out on two (02) soil samples, collected from boreholes from 7.5 to 8.5 m depth below NSL. Test result indicated soluble sulphate content as 0.011 % & 0.026 %, chloride content as 0.006 % & 0.135 % and organic matter as 0.150 & 1.016 %.

Chemical tests were also carried out on two (02) water samples collected from boreholes. Test results indicated sulphate content as 1598 ppm & 2506 ppm, chloride content as 998 ppm & 1486 ppm, total dissolved solids (TDS) as 4813 ppm & 6373 ppm and pH as 5.88 & 6.28.

# 5. SITE GEOTECHNICS

## 5.1 STRATIGRAPHY AND CONSISTENCY

The geotechnical investigations carried out at the site of this project have revealed the presence of the following distinct lithological units:

- Fill Material, mainly consists of Silty Clay with concrete pieces / Gravelly Silt with Sand, was present from top of the ground to maximum depth of 2 m below NSL.
- Overburden soil, mainly consists of Lean Clay / Lean Clay with Sand / Sandy Lean Clay (CL), Silty Clay (CL-ML), Silty Sand / Silty Sand with Gravel (SM), Clayey Sand (SC), Clayey Gravel (GC), was present from 2 m to maximum depth of 33.5 m below NSL.
- Bedrock, mainly consists of weak to very weak Sandstone / Claystone, was present from 33.5 m to maximum drilled depth of 40 m below NSL.
- Groundwater was encountered at a depth of 1.5 m to 1.7 m below NSL.

## 5.2 SHEAR STRENGTH

The field and laboratory investigation data indicated that overburden soils and bedrock, present at the project site, has low to medium shear strength characteristics.

## 5.3 NATURAL MOISTURE CONTENT

Test results for natural moisture content indicated that the overburden soils at the project site are in moist condition while the bedrock is in dry to moist condition.

## 5.4 COMPRESSIBILITY

The standard penetration test results indicated that onsite soil deposits have medium to high compressible characteristics up to 6 – 7 m depth below NSL. However, the overburden soil has low compressibility below 7 m depth.

## 5.5 CHEMICAL CHARACTERISTICS

Chemical test results indicated that the subsurface soil consists of negligible proportion of harmful salts. However, test results for water samples indicated severe proportion of harmful salts as per ACI Building Code Requirements for Structural Concrete.

# 6. CONSIDERATIONS FOR DESIGN AND CONSTRUCTION OF FOUNDATIONS

## 6.1 GENERAL

The considerations for the foundation design have been made keeping in view the type of structure, topography of the area and the subsoil / bedrock characteristics. A safe and an economical design of foundations of the structure have to be ensured. The following sections provide guidelines regarding the geotechnical design criteria, soil / rock parameters, selection of foundation type, depth of placement, foundation size, allowable bearing pressures, foundation settlements and allowable load carrying capacity.

## 6.2 GEOTECHNICAL DESIGN CRITERIA

The foundation of the proposed structures should meet the following minimum design criteria:

- It should be safe against shear failure of the supporting ground. A factor of safety of 2.5 & 3 is adopted for this purpose for both RC pile and square foundation, respectively.
- It should not settle excessively under the service loads. A limit of 25 mm has been put on the total settlement of square foundations. Moreover, a group of piles should not settle in excess of 25 mm to 50 mm, depending upon size of group.

## 6.3 SUBSURFACE SOIL / ROCK PARAMETERS

Engineering analysis for the determination of bearing / load carrying capacity and settlements of foundations for encountered subsurface conditions are based on carefully selected representative subsurface parameters.

The following parameters have been defined for the subsurface on the basis of field investigations, laboratory test results, recent literature, engineering judgment and our experience with the similar ground conditions:

**Table 6-1: Summary of Subsurface Parameters**

| Sr. No. | Material Type | Depth below NSL (m) | Bulk Unit Weight (kN/m$^3$) | Undrained Cohesion (kPa) | Coefficient of Volume Compressibility (cm$^2$/Kg) | Angle of Internal Friction (Degrees) | Uniaxial Compressive Strength (Mpa) |
|---|---|---|---|---|---|---|---|
| 1. | Fill Material | 0.0 – 2.0 | 16 | - | - | - | |
| 2. | Lean Clay / Silty Clay | 2.0 – 6.0 | 16 | 25 | 0.025 | - | |
| 3. | Lean Clay / Silty Clay | 6.0 – 8.0 | 18 | 125 | 0.008 | - | |
| 4. | Silty Sand | 8.0 – 17.0 | 18 | - | - | 34$^o$ | |
| 5. | Silty Clay / Lean Clay | 17.0 – 24.0 | 19 | 150 | 0.003 | - | |
| 6. | Clayey Sand / Clayey Gravel | 24.0 – 33.5 | 19 | - | - | 36$^o$ | |
| 7. | Sandstone / Claystone* | 33.5 – 40.0 | 22 | - | - | - | 0.50 |

**Since, the bedrock at the project site was in very weak to weak condition, therefore, equivalent soil parameters have been used for bedrock during bearing capacity / load carrying capacity evaluation.*

## 6.4 FOUNDATION TYPE

Various foundation types are possible for supporting the loads of the proposed development works. These include pile foundation or square foundation. Considering, the safety of the structure, anticipated structural loads and subsurface ground conditions, cast in-place R.C. piles are recommended to be used for proposed interchange and retaining walls.

Considering the existing pole foundation type adjacent to the project site, square foundations can be considered for proposed light poles as well. However, keeping in view of weak ground conditions at upper depths, design of proposed light pole foundations should be firmed-up after detailed structure specific investigations.

## 6.5 FOUNDATION DEPTH AND ALLOWABLE LOAD CARRYING CAPACITY

The geotechnical recommendations for feasibility level design of foundations for proposed structures are as follows:

*Interchange and Retaining Walls:*

- Foundation Type = R.C. Piles
- Diameter of Piles = 760 mm & 900 mm
- Length of Piles = 20 m – 40 m below NSL
- Load Carrying Capacity under Compression Loading = Refer to Fig. E-1 & E-2**
- Load Carrying Capacity under Tensile Loading = Refer to Fig. E-3 & E-4**
- Soil Spring Stiffness for RC Piles = Refer to Fig. E-5

*Light Poles:*

- Foundation Type = Square
- Minimum Depth of Foundation (DF) = 1 m below NSL
- Width of Foundation (BF) = 1 m – 3 m
- Minimum Thickness of Select Fill = 1 m below foundation base
- Net Allowable Bearing Pressure = Refer to Fig. E-6
- Tolerable Settlement = 25 mm

***No scour depth has been considered during evaluation of pile load carrying capacity. Moreover, the pile capacity curves are only valid if plain water or bentonite mud under controlled conditions as per FHWA requirements will be used as drilling fluid.*

Detailed geotechnical investigations should be carried out prior to the finalization of foundation design for all the proposed development works during detailed design phase.

If loose soil / soft pocket / fill material encountered at the base of the square foundation excavation, it should be completely removed and backfilled with select fill material. Select fill should be A-3 or better material as per AASHTO soil classification. Select fill should be placed and compacted in layers appropriate to the type & size of compaction equipment to at least 95 % of modified AASHTO maximum dry density.

During construction, the excavation of square foundation and casting of in-situ RC piles shall be inspected / supervised by an experienced geotechnical engineer/engineering geologist for firming-up the above recommendations. For any unusual subsurface conditions, geotechnical engineer must be consulted prior to initiation of the foundation construction.

## 6.6 FULL SCALE PILE LOAD TEST

The selected pile length/capacity must be confirmed by performing at least two (02) full scale pile load tests. The full scale pile load test must be carried out before construction of working piles to 3 times the design load (i.e. $P_{design\ load}$ x 3.0/η) to finalize the design.

Further, as per prevailing geotechnical engineering practices, proof load tests should also be carried out on a few selected working piles, to a maximum of 1.5 times the design load. The quantum of proof load tests shall be decided in the light of scope of work and project specifications. The Contractor should submit his Method Statement, for carrying out the proof pile load tests, for approval of the Engineer. Moreover, sonic integrity test (SIT) should also be carried out to ascertain the integrity of all the working piles.

## 6.7 SOIL PROFILE TYPE

The subsoil can be categorized as soil profile type $S_D$, as per criteria of Building Code of Pakistan Seismic Provisions (2007), for structural design of the project structures.

## 6.8 EXCAVATIONS

Temporary excavations (where required) may be carried out at stable slopes as determined by trials at site. In case, excavations have to be made very close to the existing foundation like roads or buildings, suitable temporary excavation support system should be designed to stop any untoward incident. The excavations may preferably not be done during rainy season or otherwise some special precautions may deem necessary to ensure drainage of the excavations. The contractor should submit his Method Statement and design for temporary excavation support system, for Engineer's approval.

## 6.9 COEFFICIENTS OF LATERAL EARTH PRESSURE

It is recommended to use granular material as the backfill, where required. The granular material should be compacted to around 90 % Modified Proctor density.

The static lateral earth pressure coefficients for active ($K_a$), at rest ($K_o$) and passive ($K_p$) conditions, using granular material as backfill having $\Phi = 30^o$ are recommended as follows:

$K_a$ = 0.33
$K_o$ = 0.50
$K_p$ = 3.00

The lateral earth pressures to be used in the design should be increased for the additional residual earth pressures to be induced by the effect of compaction, as per provisions of Naval Facilities Engineering Command (NAVFAC) Design Manual 7.02 (Chapter-3, Section-6).

The dynamic earth pressures for active and passive conditions should be evaluated on the basis of Mononobe-Okabe model.

### 6.10 TYPE OF CEMENT

On the basis of chemical test results for soil and water samples, Sulphate Resistance Cement (SRC) is recommended to be used for concrete works of foundations.

### 6.11 WATER FOR MIXING AND CURING

Water will be required during the construction for mixing and curing of concrete. The water required for this purpose needs to be reasonably clean and free from the detrimental amounts of soluble salts, alkalies, oil, organic matter and other deleterious substances that are injurious to concrete. In addition to these, the suspended solids also affect the water quality.

It is therefore recommended that during the construction stage before mixing and curing, the water should also be tested against the permissible limits of salts and solids of mixing and curing water as specified in BS 3148.

### 6.12 CONCRETE MATERIALS

Detailed material studies have not been carried out for this project. However, fine and coarse aggregates can be obtained from local sources subject to meeting the project specifications / ASTM gradation.

# 7. CONSIDERATIONS FOR DESIGN AND CONSTRUCTION OF ROADWAYS

## 7.1 GENERAL

The project also includes rehabilitation of approach roads for the proposed interchange. The following sections provide guidelines regarding geotechnical design and certain construction considerations for roadways:

## 7.2 PAVEMENT MATERIAL AND DESIGN CBR

### 7.2.1 Embankment and Subgrade Soils

The primary soil parameter required for the pavement design is the California Bearing Ratio (CBR) or alternatively, the resilient modulus. Laboratory facilities for evaluation of the latter parameter do not exist in Pakistan at present. If a pavement design method requires the use of resilient modulus, it can readily be evaluated from CBR value, using the recent literature.

Four (04) representative soil samples were collected from two (02) on-site test pits of 2 m depth below NSL to evaluate the characteristics of in-situ soils. Test results have revealed that the on-site soils generally belong to A-1-a and A-4 soil group as per ASSHTO soil classification with soaked CBR value as 30.0 % and 32.5 % at 95 % modified AASHTO maximum dry density.

It is therefore, recommended to use on-site material for design of subgrade and road embankment with minimum soaked CBR value as 30 % at 95 % modified AASHTO maximum dry density. However, if on-site material is not available in required quantity then suitable borrow areas near the project site must be explored. The borrow areas must contain A-4 or better material as per AASHTO soil classification with minimum soaked CBR value as 7 % and 5 % for subgrade and road embankment, respectively. The CBR values are w.r.t the 95% of modified AASHTO maximum dry density. The suitability of on-site and borrow area material must be confirmed by performing appropriate laboratory testing prior to their use in road works.

### 7.2.2 Sub-Base and Base Course

Material from local sources can be used for the construction of sub-base and base course subject to meeting Project Specifications. The design CBR for these materials shall be governed by the project specifications. However, it would be desirable to use materials with minimum CBR values of 50 and 80, respectively, for these courses.

## 7.3 SITE PREPARATIONS

For a roadway to perform well, it is imperative that the subgrade of the pavement is competent to support the anticipated vehicular loads. It is therefore recommended that the subgrade should be properly prepared to meet the design CBR. In order to meet this

requirement, the area that will support the pavement, should be properly cleared, grubbed by removing any topsoil containing objectionable material.

## 7.4 FILL PLACEMENT AND COMPACTION

Before placement of the borrow fill, in-situ soil should be proof-rolled to eliminate any soft pocket of soil. For the placement and compaction of the embankment and subgrade fill, loose lift thickness should generally not exceed 30 cm. The moisture content of the fill material should be controlled within ± 2% of the optimum moisture content.

For the sub-base and base courses, the placement should be in such a manner that the compacted thickness of 15 cm is not exceeded.

The following layer thickness and compaction levels are recommended for various pavement elements:

**Table 7-1: Fill Placement and Compaction**

| Material Type | Maximum compacted Layer thickness (cm) | Recommended Modified AASHTO Compaction (%) |
|---|---|---|
| Base Course | 15 | 100 |
| Sub-base | 15 | 98 |
| Subgrade & General Fill | | |
| Upper 30cm | 20 | 95 |
| 30cm – 70cm | 25 | 93 |
| Below 70cm | 30 | 90 |

The above compaction levels have to be attained by the Contractor using appropriate machinery. However, prior to construction, the Contractor should submit method statement for fill placement and compaction, for approval of the Engineer.

# 8. CONCLUSION AND RECOMMENDATIONS

1) Fill material, with a thickness of 2 m below NSL, was present at proposed interchange location. Below fill material, overburden soil mainly consists of Lean Clay / Silty Clay / Silty Sand / Clayey Gravel was present up to maximum depth of 33.5 m below NSL. For detail, Refer to Section 5.1 and Appendix B.

2) Bedrock, mainly consists of weak to very weak Sandstone / Claystone, was present from 33.5 m to maximum drilled depth of 40 m below NSL.

3) Groundwater was encountered at a depth of 1.5 m to 1.7 m below NSL.

4) R.C. piles are recommended to be used for proposed interchange and retaining walls. However, square foundations can be used for lightly loaded structures i.e. light poles. For detail, refer to Section 6.4 & 6.5.

5) The selected pile length / capacity must be confirmed by performing at least two (02) full scale pile load tests. Load test arrangement and execution should be as per ASTM requirements.

6) On the basis of chemical test results for soil and water samples, Sulpahet Resistance Cement (SRC) is recommended to be used for concrete works of foundations.

7) Coarse and fine aggregates for concrete can be obtained from local quarries. The fine and coarse aggregates from these quarries must meet Project specifications and requirements of ASTM C 33.

8) On-site A-1-a or A-4 soil can be used for road works with minimum soaked CBR value as 30 % at 95 % modified AASHTO maximum dry density. Alternatively, suitable borrow areas of A-4 or better material with minimum CBR value as 7 % and 5 % for subgrade and road embankment, respectively must be explored. CBR of on-site and borrow area material must be confirmed by performing appropriate laboratory testing prior to their use in subgrade and road embankment. For detail, refer to Section 7.2.

9) Findings of this report can only be used for feasibility level design of structures.

10) Structure specific geotechnical investigations should be carried out prior to the finalization of design of foundations for proposed development works during detailed design phase.

# 9. DISCLAIMER

This report has been prepared by National Engineering Services Pakistan Pvt. Ltd (NESPAK) for interchange at ICI bridge which is the part of the project titled as “Feasibility Study and Transaction Advisory Services for Urban Road Initiative Project. The material contained in this report reflects engineering characteristics of soils / rocks and recommendations on the basis of actual field and laboratory test results at the time of preparation of this report. The recommendations provided in the report can only be used for feasibility level design of foundations. Detailed geotechnical investigations must be carried out prior to the finalization of design of foundations.

This document and the information are solely for the use of the authorized recipient. Any use, which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such party and NESPAK accepts no responsibility for damages, if any, suffered by any third party as a result of such decisions or actions.

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During construction, the construction activity may alter the conditions from those prevailing at the time, this report was written or may reveal somewhat different conditions at places. This may require performance of additional investigations during the construction stage so as to adjust the design to safeguard against the revealed conditions. NESPAK does not accept any responsibility for the changes in the conditions and design recommendations provided in this report due to above circumstances.

# APPENDICES

- **APPENDIX-A:**

  ***LOCATION PLAN, GEOTECHNICAL INVESTIGATION PLAN & SUBSURFACE SOIL PROFILE***

- **APPENDIX-B:**

  ***BOREHOLE AND TESTPIT LOGS***

- ***APPENDIX-C:***

  ***SUBSURFACE CHARACTERISTICS***

- ***APPENDIX-D:***

  ***SUMMARY OF LABORATORY TEST RESULTS & DETAILED RESULT SHEETS***

- ***APPENDIX-E:***

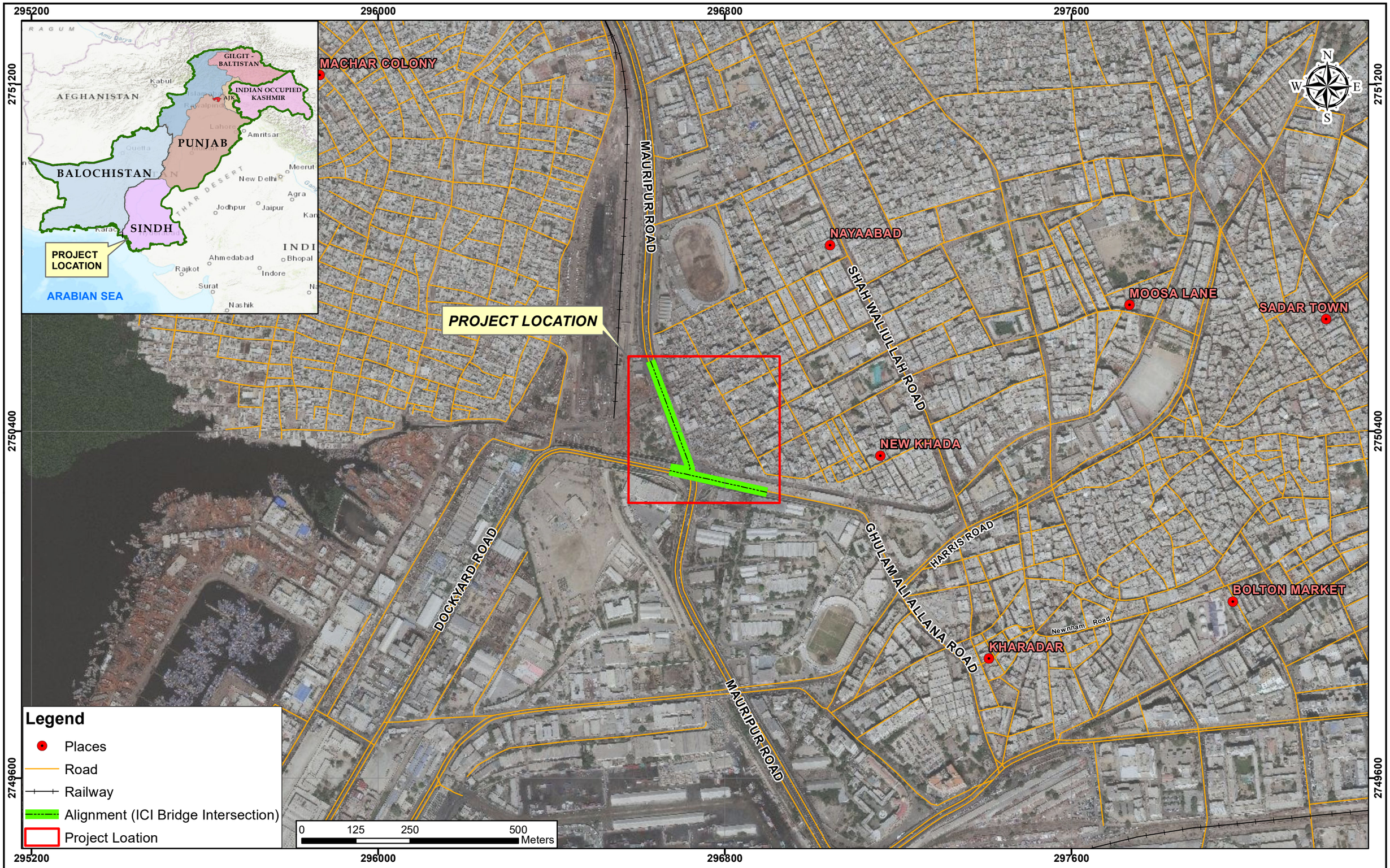
  ***FOUNDATION PROPORTIONING CURVES***

- ***APPENDIX-F:***

  ***SITE PHOTOGRAPHS***

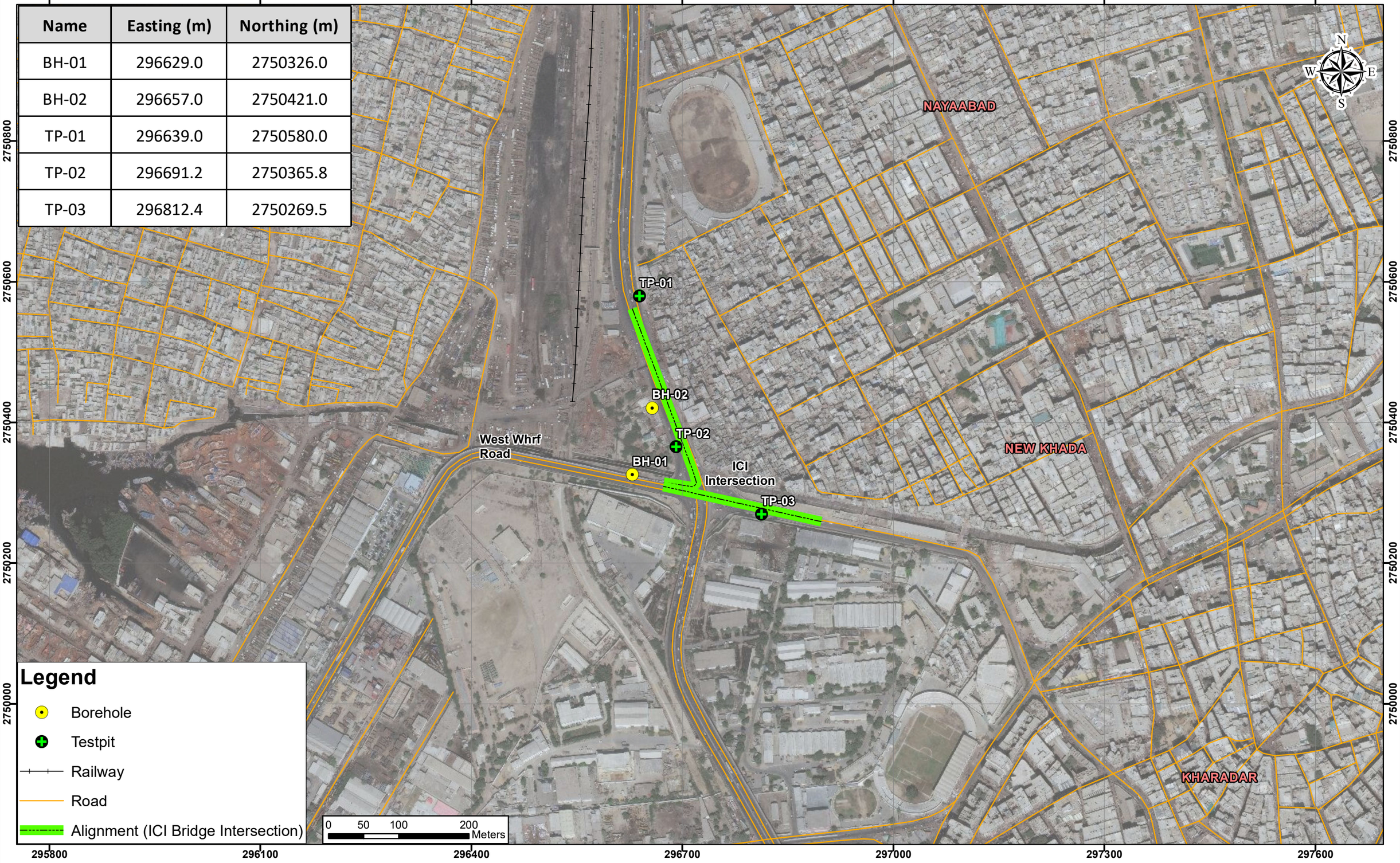
*APPENDIX-A*

# LOCATION PLAN, GEOTECHNICAL INVESTIGATION PLAN & SUBSURFACE SOIL PROFILE




| CLIENT | CONSULTANT | | | | | | | PROJECT | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH | NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD<br>HEAD OFFICE:- NESPAK HOUSE ,1-C, BLOCK-N MODEL TOWN EXTENSION, LAHORE, PAKISTAN | 04 | | | | DRAWN | IMRAN | FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI'<br>SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE INTERSECTION | LOCATION PLAN | | SCALE 1:8,000 |
| | | 03 | | | | SUBMITTED | | | | | |
| | | 02 | | | | RECOMMENDED | | | | | |
| | | 01 | | | | CHD/VER. | S.BADAR | | DATE OCTOBER, 2020 | FIG. A-1 | REV. 0 |
| | | REV. | DATE | DESCRIPTION | APPROVED | APPROVED | M.ALI | | | | |

| Name | Easting (m) | Northing (m) |
|---|---|---|
| BH-01 | 296629.0 | 2750326.0 |
| BH-02 | 296657.0 | 2750421.0 |
| TP-01 | 296639.0 | 2750580.0 |
| TP-02 | 296691.2 | 2750365.8 |
| TP-03 | 296812.4 | 2750269.5 |




CLIENT

LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH

CONSULTANT

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD

HEAD OFFICE:- NESPAK HOUSE ,1-C, BLOCK-N MODEL TOWN EXTENSION, LAHORE, PAKISTAN

| REV. | DATE | DESCRIPTION | APPROVED |
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| 04 | | | |
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| SUBMITTED | |
| RECOMMENDED | |
| CHD/VER. | S.BADAR |
| APPROVED | M.ALI |

PROJECT

FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI'

SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE INTERSECTION

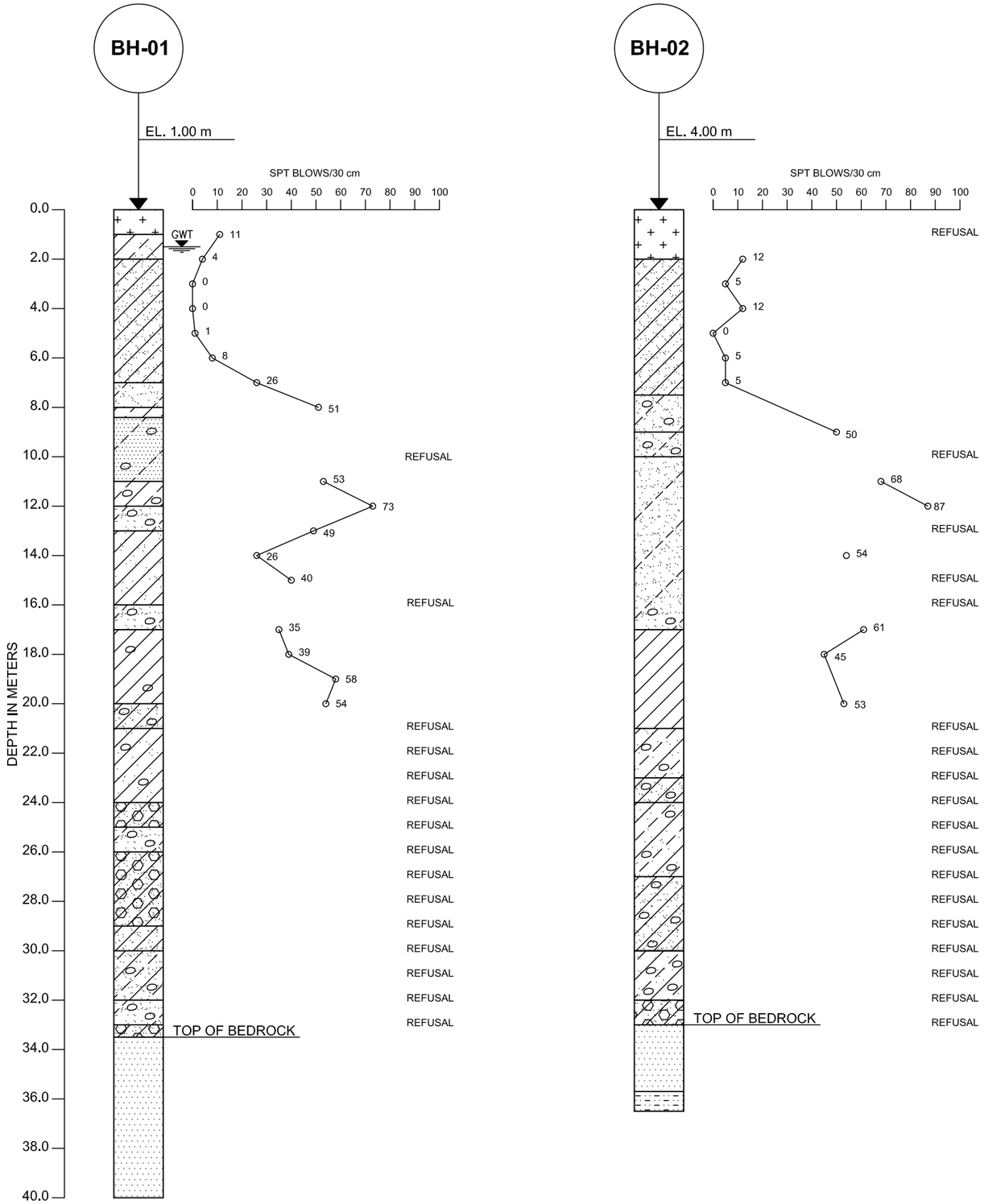
GEOTECHNICAL INVESTIGATION PLAN

SCALE 1:5,000

DATE OCTOBER, 2020

FIG. A-2

REV. 0




## LEGEND

- FILL MATERIAL
- LEAN CLAY
- LEAN CLAY WITH SAND OR SANDY LEAN CLAY
- LEAN CLAY WITH GRAVELS
- CLAYEY SAND
- CLAYEY GRAVELS WITH SAND
- SILTY CLAY
- SANDY SILTY CLAY
- SANDY SILTY CLAY WITH FEW GRAVELS
- GRAVELLY SILTY CLAY
- SILTY CLAYEY SAND WITH GRAVELS
- SILTY SAND
- SILTY SAND WITH GRAVELS OR SAND WITH SILT AND GRAVELS
- SANDSTONE
- CLAYSTONE
- SPT BLOWS/30 cm
- GWT — GROUND WATER TABLE

## NOTES

1. ALL DIMENSIONS ARE IN METERS, UNLESS OTHERWISE NOTED.
2. THE WIDTH OF BORE HOLES IS NOT TO SCALE.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CLIENT: LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH | CONSULTANT: NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LTD. HEAD OFFICE:- NESPAK HOUSE, I-C, BLOCK-N, MODEL TOWN EXTENSION, LAHORE, PAKISTAN. | 04 | | | | DRAWN | RIAZ |
| | | 03 | | | | SUBMITTED | |
| | | 02 | | | | RECOMMENDED | |
| | | 01 | | | | CHD./VER. | M.UMAR |
| | | REV. | DATE | DESCRIPTION | APPROVED | APPROVED | M.ALI |

PROJECT: **FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE**

**SUBSURFACE SOIL / ROCK PROFILE**

DATE: OCTOBER, 2020

**FIG. A-3**

SCALE: HOR. NTS VER. 1:200

REV. 0

*APPENDIX-B*

# BOREHOLE AND TESTPIT LOGS

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 1 OF 5

# BOREHOLE LOG

Job No. P38035 | Project: FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE | Location: INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge: MUDASSAR ZAFAR | Client: LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH | Contractor: M/S STS KARACHI

Type of boring: STRAIGHT ROTARY | Drilling Fluid: BENTONITE SLURRY | Ground Water Depth: 1.50 m

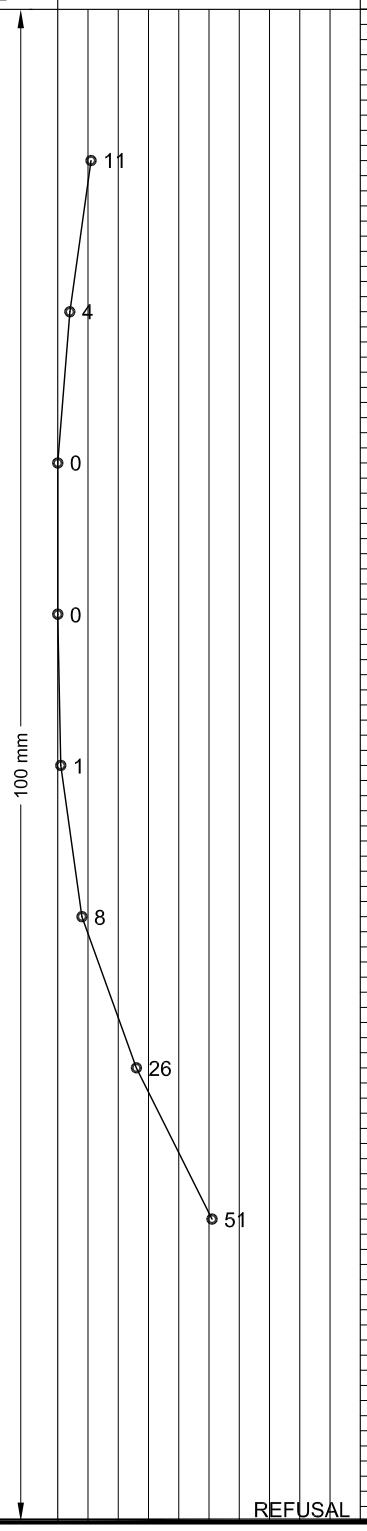
Coordinates: N: 2750326.000 m, E: 296629.000 m | Ground Elevation: 1.0 m | Date: 01-09-2020 To 06-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Remarks |
|---|---|---|---|---|---|
| 0.0 | | | | Top dumped wasted material: Dark grey to brown, SILTY CLAY with concrete pieces, fabrics, polythene bags, plastic piecse, gravels, cobbles and boulders. | |
| 1.0 | CPT-1 | | | | |
| | | | CL-ML | Dark grey, stiff, SANDY SILTY CLAY, low to medium plastic, medium dry strength, trace fabrics, trace gravels, trace cloth pieces. | GWT |
| 2.0 | SPT-1 | | | | |
| | | | CL | Greyish brown, very soft to firm, LEAN CLAY with SAND, low to medium plastic, medium dry strength. | |
| 3.0 | SPT-2 | | | | |
| 4.0 | SPT-3 | | | | |
| 5.0 | SPT-4 | | | | |
| 6.0 | SPT-5 | | | | |
| 7.0 | SPT-6 | | | | |
| | | | SM | Brown, medium dense, fine grained, SILTY SAND, little clay, moist. | |
| 8.0 | SPT-7 | | | | |
| | | | CL-ML | Brown, hard, SILTY CLAY, medium plastic, high dry strength, trace sand. | |
| | UDS-1 | | | | (Pitcher) UDS-1 8.50-9.30m depth. |
| 9.0 | | | SW-SM | Brownish grey, very dense, well graded SAND with SILT and GRAVEL, trace mica, moist. | |
| 10.0 | SPT-8 | | | | |

Dia of Casing/Hole: 100 mm

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 2 OF 5

# BOREHOLE LOG

Job No. P38035 Project FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE Location INTERCHANGE AT ICI BRIDGE INTERSECTION

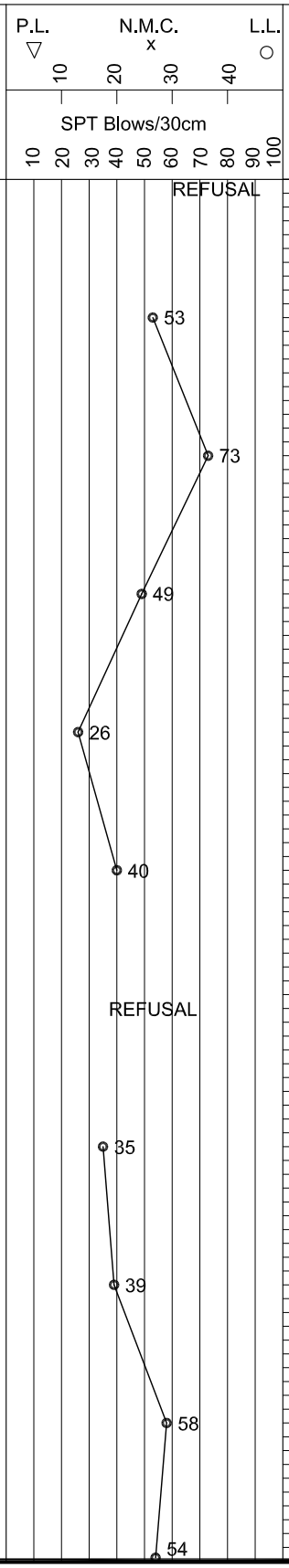
Site Incharge MUDASSAR ZAFAR Client LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH Contractor M/S STS KARACHI

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth 1.50 m

Coordinates N: 2750326.000 m E: 296629.000 m Ground Elevation 1.0 m Date 01-09-2020 To 06-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Remarks |
|---|---|---|---|---|---|
| 10.0 | SPT-8 | | | | |
| | | | SW-SM | Brownish grey, very dense, well graded SAND with SILT and GRAVEL, trace mica, moist. | |
| 11.0 | CPT-2 | | | | |
| | | | CL-ML | Brown, hard, SILTY CLAY, low to medium plastic, high dry strength, trace to little sand, trace gravels. | |
| 12.0 | SPT-9 | | | | |
| | | | SM | Yellowish brown, very dense, fine to coarse grained, SILTY SAND, trace gravels. | |
| 13.0 | SPT-10 | | | | |
| | UDS-2 | | CL | Greyish brown, very stiff to hard, LEAN CLAY, medium plastic, high dry strength, trace to little sand. | (Denison) UDS-2 13.50-14.00m depth. |
| 14.0 | SPT-11 | | | | |
| 15.0 | SPT-12 | | | | |
| 16.0 | SPT-13 | | | | |
| | | | SM | Yellowish brown, very dense, fine to coarse grained, SILTY SAND, little to some fine gravels, trace clay. | |
| 17.0 | SPT-14 | | | | |
| | | | CL | Grey to reddish brown, hard, LEAN CLAY, medium plastic, high dry strength, trace gravels. | |
| 18.0 | SPT-15 | | | | |
| 19.0 | SPT-16 | | | | |
| 20.0 | SPT-17 | | | | |

Dia of Casing/Hole: 100 mm



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 3 OF 5

# BOREHOLE LOG

Job No. P38035 Project FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE Location INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge MUDASSAR ZAFAR Client LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH Contractor M/S STS KARACHI

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth 1.50 m

Coordinates N: 2750326.000 m E: 296629.000 m Ground Elevation 1.0 m Date 01-09-2020 To 06-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Dia of Casing/ Hole | P.L. ▽ / N.M.C. x / L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100) | Remarks |
|---|---|---|---|---|---|---|---|
| 20.0 | SPT-17 | | SC | Brownish grey, very dense, CLAYEY SAND, trace gravels. | 100 mm | 54 | |
| 21.0 | SPT-18 | | CL | Brown, hard, SANDY LEAN CLAY, low to medium plastic, high dry strength, trace gravels. | | REFUSAL | |
| 22.0 | SPT-19 | | | | | REFUSAL | |
| 23.0 | SPT-20 | | | | | REFUSAL | |
| 24.0 | CPT-3 | | GC | Yellowish brown, very dense, CLAYEY GRAVELS with SAND. | | REFUSAL | |
| 25.0 | CPT-4 | | SM | Brown, very dense, fine to medium grained, SILTY SAND, little to some clay, trace gravels. | | REFUSAL | |
| 26.0 | CPT-5 | | GC | Yellowish brown, very dense, CLAYEY GRAVELS with SAND, gravels are sub rounded to rounded of size (6-55mm). | | REFUSAL | |
| 27.0 | CPT-6 | | | | | REFUSAL | |
| 28.0 | CPT-7 | | | | | REFUSAL | |
| 29.0 | CPT-8 | | SC | Brown, very dense, fine to medium grained, CLAYEY SAND. | | REFUSAL | |
| 30.0 | CPT-9 | | | | | REFUSAL | |

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-01

SHEET 4 OF 5

# BOREHOLE LOG

Job No. P38035 Project FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE Location INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge MUDASSAR ZAFAR Client LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH Contractor M/S STS KARACHI

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth 1.50 m

Coordinates N: 2750326.000 m E: 296629.000 m Ground Elevation 1.0 m Date 01-09-2020 To 06-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Dia of Casing/ Hole | P.L. ▽ / N.M.C. x / L.L. ○ (SPT Blows/30cm) | Remarks |
|---|---|---|---|---|---|---|---|
| 30.0 | CPT-9 | | | | | | |
| | | | CL-ML | Brown, hard, SANDY SILTY CLAY, trace to little gravels, low to medium plastic, wet. | 100 mm | REFUSAL | |
| 31.0 | CPT-10 | | | | | REFUSAL | |
| 32.0 | CPT-11 | | SM | Yellowish brown, very dense, fine to medium grained, SILTY SAND, trace to little clay, little gravels. | | REFUSAL | |
| 33.0 | CPT-12 | | GC | Brown, very dense, SILTY CLAYEY GRAVELS, trace to little sand, gravels are sub rounded to rounded size (6-50mm). TOP OF BEDROCK | | REFUSAL | |
| 33.5 | | | | | | | |

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI'
SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE

PROJECT: SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE
SITE: INTERCHANGE AT ICI BRIDGE INTERSECTION
COORDINATES: N: 2750326.000 m, E: 296629.000 m
ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 1.0 m
ROCK ELEVATION: 33.5 m
GROUND WATER ELEVATION: 1.50 m
BACK FILLING MATERIAL: -
PEIZOMETER: -

DATE START: 01-09-2020 COMPLETE: 06-09-2020
DRILLING AGENCY: M/S STS KARACHI
DRILLING RIG: STRAIGHT ROTARY
LOGGED BY: MUDASSAR ZAFAR
CHECKED BY: -

**BOREHOLE No.** BH-01

**SHEET 05 OF 05**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run No. | Core Recovery % | R.Q.D. % | Fragmented Core | Drilling Fluid Loss % | Core Barrel / Bit | Hole Stabilization | Elevation (m) | LITHOLOGY: Legend, Classification symbol, General Description (Soil: Type, Colour, Consistency, Structure, Origin; Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones.) | SAMPLE | DISCONTINUTY DATA: Joint Set, Graphics, Type, Attitude Angle °, Aperture, Roughness, Infilling, Strength Grade, Frequency (Total Joints, Frequency per meter) | WPT: Pressure psi, LU Value | Point Load (Failure Pressure on Dial) | REMARKS |

| Depth (m) | Run No. | Core Recovery % | R.Q.D. % | Drilling Fluid Loss % | Classification symbol | General Description |
|---|---|---|---|---|---|---|
| 30.0 | | | | | | TOP OF BEDROCK |
| 33.5 | 1 | 82 | NIL | 7 | S.St. | SANDSTONE: Greenish grey, fine grained, fresh, extremely weak to very weak. |
| 34.0 | CPT-13 | | | | | |
| | 2 | 64 | NIL | 10 | | |
| 35.0 | CPT-14 | | | | | |
| | 3 | 90.59 | 32.94 | 12 | | |
| 36.0 | 4 | 83 | 10 | 8 | | |
| 37.0 | 5 | 93 | 24 | 5 | | |
| 38.0 | 6 | 98 | 25 | 15 | | |
| 39.0 | 7 | 68 | 14 | 7 | | |
| 40.0 | | | | | | BOTTOM OF BOREHOLE |

Core Barrel / Bit: DOUBLE TUBE CORE BARREL/NX SIZE BIT

Hole Stabilization: BENTONITE SLURRY

**WAX SAMPLES:**
WS-1:35.74-35.84m
WS-2:37.14-37.24m
WS-3:37.83-37.97m
WS-4:38.41-38.54m
WS-5:38.55-38.67m
WS-6:39.72-39.86m

**Key for Description of Discontinuities**

| Type | |
|---|---|
| J | Joint |
| M | Major Joint |
| F | Fault |
| B | Bedding |
| R | Fracture |
| S | Shistocity |
| O | Foliation |

| Aperture | | |
|---|---|---|
| 1 | Very Tight | < 0.10 mm |
| 2 | Tight | 0.10-0.25 mm |
| 3 | Partly Open | |
| 4 | Open | |

**Roughness**

| | STATE | CODE |
|---|---|---|
| STEPPED | Rough | SR |
| | Smooth | SSm |
| | Slickensided | SSI |
| UNDULATING | Rough | UR |
| | Smooth | USm |
| | Slickensided | USI |
| PLANAR | Rough | PR |
| | Smooth | PSm |
| | Slickensided | PSI |

| Infilling | | | |
|---|---|---|---|
| 1 | Clean | 6 | Hydro-Thermals |
| 2 | Surface Staining | 7 | Oxides |
| 3 | Loam | 8 | Breccia |
| 4 | Calcite | 9 | Sheared |
| 5 | Silty Gravel/ Gravely Silt | 10 | Aragonite |

NOTES:- 1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

| Grade | Term |
|---|---|
| I | Fresh |
| II | Slightly Weathered |
| III | Moderately Weathered |
| IV | Highly Weathered |
| V | Verly Highy Weathered |
| VI | Residual Soil |

Strength Grade of Discontinuity Wall

| Grade | Description / MPa | Manual Index Test |
|---|---|---|
| R0 | Extremely Weak / 0.25 - 1.0 | Indented by thumbnail |
| R1 | Very Weak / 1.0 - 5.0 | Peeled easily by knife, crumbled under hammer blow |
| R2 | Weak / 5.0 - 25 | Peeled difficulty by knife, Indentation by firm hammer blows |
| R3 | Medium Strong / 25 - 50 | Cannot peel by knife, fractured with single hammer blow |
| R4 | Strong / 50 - 100 | Requires more than one hammer blow to fracture |
| R5 | Very Strong / 100 - 250 | Requires many hammer blows to fracture |
| R6 | Extremely Strong / > 250 | Specimen can only be chipped with hammer |

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02

SHEET 1 OF 5

# BOREHOLE LOG

Job No. P38035 | Project: FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE | Location: INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge: FAISAL /JUNAID | Client: LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH | Contractor: M/S STS KARACHI

Type of boring: STRAIGHT ROTARY | Drilling Fluid: BENTONITE SLURRY | Ground Water Depth: -

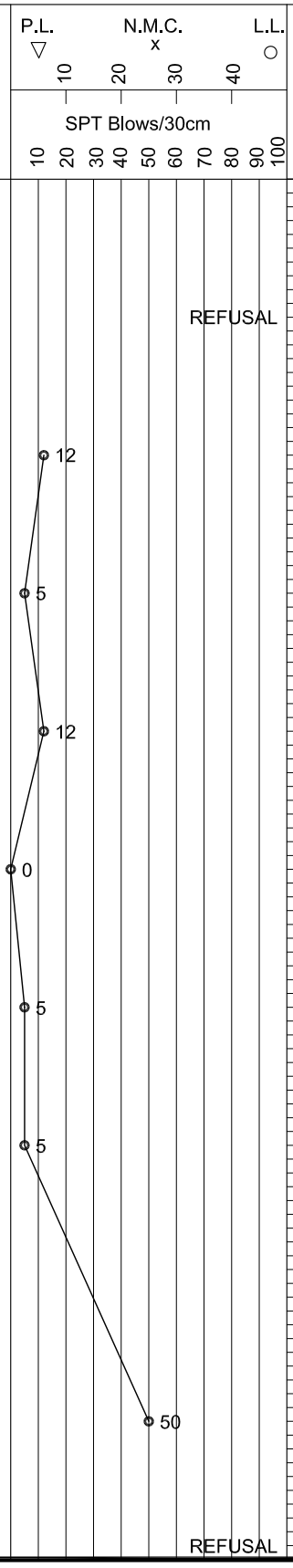
Coordinates: N: 2750421.000 m, E: 296657.000 m | Ground Elevation: 4.0 m | Date: 05-09-2020 To 12-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Remarks |
|---|---|---|---|---|---|
| 0.0 | | | | Fill material: Brownish yellow, GRAVELLY SILT with SAND. | |
| 1.0 | SPT-1 | | | Greyish brown, very dense, GRAVELLY SILT, trace to little sand, moist. | REFUSAL |
| 2.0 | SPT-2 | | | Brownish grey, very loose to medium dense, CLAYEY SAND, moist. | |
| 3.0 | SPT-3 | | | | |
| 4.0 | SPT-4 | | | | |
| 5.0 | SPT-5 | | SC | | |
| 6.0 | SPT-6 | | | | |
| 7.0 | SPT-7 | | | | |
| | UDS-1 | | | Yellowish brown, medium to coarse grained, SILTY SAND with GRAVELS, moist. | (Pitcher) UDS-1 7.50-8.40m depth. |
| 8.0 | | | SM | | |
| 9.0 | SPT-8 | | | Yellowish brown, very dense, fine SILTY SAND with GRAVELS, trace clay, moist. | |
| 10.0 | SPT-9 | | SM | | REFUSAL |

Dia of Casing/Hole: 100 mm

P.L. ▽ N.M.C. x L.L. ○

SPT Blows/30cm



NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02

SHEET 2 OF 5

# BOREHOLE LOG

Job No. P38035 | Project: FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE | Location: INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge: FAISAL /JUNAID | Client: LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH | Contractor: M/S STS KARACHI

Type of boring: STRAIGHT ROTARY | Drilling Fluid: BENTONITE SLURRY | Ground Water Depth: -

Coordinates: N: 2750421.000 m, E: 296657.000 m | Ground Elevation: 4.0 m | Date: 05-09-2020 To 12-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Dia of Casing/ Hole | SPT Blows/30cm (P.L. ▽, N.M.C. x, L.L. ○) | Remarks |
|---|---|---|---|---|---|---|---|
| 10.0 | SPT-9 | | | Brownish yellow, very dense, SILTY SAND, fine grained, trace to little clay, moist, trace to little gravels. | 100 mm | REFUSAL | |
| 11.0 | SPT-10 | | SM | | | 68 | |
| 12.0 | SPT-11 | | | | | 87 | |
| 13.0 | SPT-12 | | | | | REFUSAL | |
| 14.0 | SPT-13 | | | | | 54 | |
| 15.0 | SPT-14 | | | | | REFUSAL | |
| 16.0 | SPT-15 | | | | | REFUSAL | |
| 17.0 | SPT-16 | | | Greyish brown, hard, LEAN CLAY, medium plastic, high dry strength, trace sand, moist. | | 61 | |
| 18.0 | SPT-17 | | CL | | | 45 | |
| 19.0 | UDS-2 | | | | | | (Denison) UDS-2 19.00-19.55m depth. |
| 20.0 | SPT-18 | | | | | 53 | |

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02

SHEET 3 OF 5

# BOREHOLE LOG

Job No. P38035 | Project: FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE | Location: INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge: FAISAL /JUNAID | Client: LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH | Contractor: M/S STS KARACHI

Type of boring: STRAIGHT ROTARY | Drilling Fluid: BENTONITE SLURRY | Ground Water Depth: -

Coordinates: N: 2750421.000 m, E: 296657.000 m | Ground Elevation: 4.0 m | Date: 05-09-2020 To 12-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Dia of Casing/ Hole | P.L. ▽ / N.M.C. x / L.L. ○ SPT Blows/30cm (10 20 30 40 50 60 70 80 90 100) | Remarks |
|---|---|---|---|---|---|---|---|
| 20.0 | SPT-18 | | CL | Brown, hard, LEAN CLAY, medium plastic, high dry strength, moist. | 100 mm | 53 | |
| 21.0 | SPT-19 | | CL-ML | Greyish brown, hard, GRAVELLY SILTY CLAY, low plastic, trace sand, moist. | | REFUSAL | |
| 22.0 | SPT-20 | | | | | REFUSAL | |
| 23.0 | SPT-21 | | SC | Yellowish brown, very dense, CLAYEY SAND, trace to little gravels, moist. | | REFUSAL | |
| 24.0 | SPT-22 | | CL-ML | Greyish brown, hard, GRAVELLY SILTY CLAY, low plastic, trace sand, moist. | | REFUSAL | |
| 25.0 | SPT-23(C) | | | | | REFUSAL | |
| 26.0 | SPT-24(C) | | | | | REFUSAL | |
| 27.0 | SPT-25(C) | | SC-SM | Yellowish brown, very dense, fine to medium grained, SILTY CLAYEY SAND with gravels (11-27mm), moist. | | REFUSAL | |
| 28.0 | SPT-26(C) | | | | | REFUSAL | |
| 29.0 | SPT-27(C) | | | | | REFUSAL | |
| 30.0 | SPT-28(C) | | | | | REFUSAL | |

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

BOREHOLE NO. BH-02

SHEET 4 OF 5

# BOREHOLE LOG

Job No. P38035 Project FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE Location INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge FAISAL /JUNAID Client LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH Contractor M/S STS KARACHI

Type of boring STRAIGHT ROTARY Drilling Fluid BENTONITE SLURRY Ground Water Depth -

Coordinates N: 2750421.000 m E: 296657.000 m Ground Elevation 4.0 m Date 05-09-2020 To 12-09-2020

| Depth (m) | Sample No. | Legend | USCS Symbol | Description of Material | Dia of Casing/ Hole | P.L. ▽ / N.M.C. x / L.L. ○ (SPT Blows/30cm) | Remarks |
|---|---|---|---|---|---|---|---|
| 30.0 | SPT-28(C) | | | | | | |
| | | | CL-ML | Brown, hard, GRAVELLY SILTY CLAY with SAND, moist | 100 mm | REFUSAL | |
| 31.0 | SPT-29(C) | | | | | REFUSAL | |
| 32.0 | SPT-30(C) | | | | | REFUSAL | |
| | | | GC | Variegated, very dense, fine to coarse, sub rounded to rounded CLAYEY GRAVELS with SAND, limestone origin, size (9-67mm), trace silty clay, moist | | | |
| 33.0 | SPT-31(C) | | | TOP OF BEDROCK | | REFUSAL | |

NATIONAL ENGINEERING SERVICES PAKISTAN (Pvt.) LIMITED, LAHORE

FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI'

PROJECT: SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE

SITE: INTERCHANGE AT ICI BRIDGE INTERSECTION

COORDINATES: N: 2750421.000 m, E: 296657.000 m

ANGLE (with vertical): 0 BEARING: _

GROUND ELEVATION: 4.0 m

ROCK ELEVATION: 33.0 m

GROUND WATER ELEVATION: -

BACK FILLING MATERIAL: -

PEIZOMETER: -

DATE START: 05-09-2020 COMPLETE: 12-09-2020

DRILLING AGENCY: M/S STS KARACHI

DRILLING RIG: STRAIGHT ROTARY

LOGGED BY: FAISAL

CHECKED BY: -

**BOREHOLE No.** **BH-02**

**SHEET 05 OF 05**

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | | | 11 | 12 | | | | | | | | | | 13 | | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (m) | Run No. | Core Recovery % | R.Q.D. % | Fragmented Core | Drilling Fluid Loss % | Core Barrel / Bit | Hole Stabilization | Elevation (m) | LITHOLOGY | | | SAMPLE | DISCONTINUTY DATA | | | | | | | | | | WPT | | Point Load (Failure Pressure on Dial) | REMARKS |
| | | | | | | | | | Legend | Classification symbol | General Description<br>Soil: Type, Colour, Consistency, Structure, Origin<br>Rock: Colour, Grain Size, Texture and Fabric. State of Weathering, State of Alteration Name, Strength, Shear Zones. | | Joint Set | Graphics | Type | Attitude Angle ° | Aperture | Roughness | Infilling | Strength Grade | Frequency: Total Joints | Frequency: Frequency per meter | Pressure psi | LU Value | | |
| 30.0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 31.0 | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 32.0 | | | | | | | | | | | TOP OF BEDROCK | | | | | | | | | | | | | | | |
| 33.0 | | | | | | | | | | | | | | | | | | | | | | | | | | WAX SAMPLES:- |
| | 1 | 60 | 12 | | 3% | DOUBLE TUBE CORE BARREL/NX SIZE BIT | STABLE | | | S.St. | SANDSTONE:<br>Greenish grey, fine grained, fresh, extremely weak to very weak. | | | | | | | | | | | | | | | WS-1:33.24-33.36m |
| 34.0 | 2 | 89 | 22 | | | | | | | | | | | | | | | | | | | | | | | WS-2:34.22-34.34m<br>WS-3:34.60-34.70m |
| 35.0 | 3 | 42 | 12 | | | | | | | | | | | | | | | | | | | | | | | WS-4:35.75-35.87m |
| 36.0 | 4 | 100 | 56 | | | | | | | C.St. | CLAYSTONE:<br>Brown, very weak, fragmented, fine grained. | | | | | | | | | | | | | | | WS-5:36.00-36.10m<br>WS-6:36.10-36.28m |
| 36.5 | | | | | | | | | | | BOTTOM OF BOREHOLE | | | | | | | | | | | | | | | |

**Key for Description of Discontinuities**

| Type | |
|---|---|
| J | Joint |
| M | Major Joint |
| F | Fault |
| B | Bedding |
| R | Fracture |
| S | Shistocity |
| O | Foliation |

| Aperture | | |
|---|---|---|
| 1 | Very Tight | < 0.10 mm |
| 2 | Tight | 0.10-0.25 mm |
| 3 | Partly Open | |
| 4 | Open | |

**Roughness**

| | STATE | CODE |
|---|---|---|
| STEPPED | Rough | SR |
| | Smooth | SSm |
| | Slickensided | SSI |
| UNDULATING | Rough | UR |
| | Smooth | USm |
| | Slickensided | USI |
| PLANAR | Rough | PR |
| | Smooth | PSm |
| | Slickensided | PSI |

| Infilling | | | |
|---|---|---|---|
| 1 | Clean | 6 | Hydro-Thermals |
| 2 | Surface Staining | 7 | Oxides |
| 3 | Loam | 8 | Breccia |
| 4 | Calcite | 9 | Sheared |
| 5 | Silty Gravel/ Gravely Silt | 10 | Aragonite |

NOTES:-
1. For Detailed Description of Discontinuity Parameters Refer to °ISRM Suggested Method for Quantitative Description of Discontinuities in Roc
2. Masses°. In Case of Clay Filled Discontinuities, the Strength of Clay Seam should be Reported as per ISRM. Depth wise Zones of Similar Discontinuity
3. Characteristics should be Recognized to fill in Column No. 11

Weathering of Rock Mass

| Grade | Term |
|---|---|
| I | Fresh |
| II | Slightly Weathered |
| III | Moderately Weathered |
| IV | Highly Weathered |
| V | Verly Highy Weathered |
| VI | Residual Soil |

Strength Grade of Discontinuity Wall

| Grade | Description / MPa | Manual Index Test |
|---|---|---|
| R0 | Extremely Weak / 0.25 - 1.0 | Indented by thumbnail |
| R1 | Very Weak / 1.0 - 5.0 | Peeled easily by knife, crumbled under hammer blow |
| R2 | Weak / 5.0 - 25 | Peeled difficulty by knife, Indentation by firm hammer blows |
| R3 | Medium Strong / 25 - 50 | Cannot peel by knife, fractured with single hammer blow |
| R4 | Strong / 50 - 100 | Requires more than one hammer blow to fracture |
| R5 | Very Strong / 100 - 250 | Requires many hammer blows to fracture |
| R6 | Extremely Strong / > 250 | Specimen can only be chipped with hammer |

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-01

Sheet 1 OF 1

# TESTPIT LOG

Job No. P38035 Project FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE Location INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge MUDASSAR Client LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH Contractor M/S STS KARACHI

Coordinates N: 2750580.00 m E: 296639.00 m Ground Elevation 4.0 m Date 13-09-2020 TO 15-09-2020

| Depth in meter | Elevation In meter | Legend | USCS Symbol | DESCRIPTION OF MATERIAL | Sample Type/No. | Field Density Test: Dry Density kN/m 3 | Field Density Test: Moisture Content % | Lab. Density Test: Max. Dry Density kN/m 3 | Lab. Density Test: Optimum m.c. % | Inplace % Compaction | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | Asphalt layer. | FDT-1 | 22.4 | 6.79 | | | | |
| 0.5 | | | | Aggregate base course. | | | | | | | |
| 1.0 | | | SC-SM | Blackish grey, fine grained, SILTY CLAYEY SAND with polythene bags, fabrics, trace organic matter. | | | | | | | |
| 1.5 | | | CL-ML | Blackish grey, SILTY CLAY, trace sand, trace organic matter. | | | | | | | |
| 1.55 | | | | BOTTOM OF TESTPIT | | | | | | | Seepage water encountered at 1.55 m depth. |

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-02

Sheet 1 OF 1

# TESTPIT LOG

Job No. P38035 Project FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE Location INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge MUDASSAR Client LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH Contractor M/S STS KARACHI

Coordinates N: 2750365.80 m E: 296691.20 m Ground Elevation 5.24 m Date 13-09-2020 TO 15-09-2020

| Depth in meter | Elevation In meter | Legend | USCS Symbol | DESCRIPTION OF MATERIAL | Sample Type/No. | Field Density Test: Dry Density kN/m 3 | Field Density Test: Moisture Content % | Lab. Density Test: Max. Dry Density kN/m 3 | Lab. Density Test: Optimum m.c. % | Inplace % Compaction | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | Asphalt layer. | FDT-1 | 20.8 | 7.22 | | | | |
| 0.5 | | | GW-GM | Aggregate base course:- Brown, well graded gravel with silt. | CS-1 | | | | | | |
| 1.0 | | | SM | Greyish brown, fine grained, SILTY SAND with gravel, trace to little clay, trace polythene bags. | CS-2 FDT-2 | 17.4 | 8.0 | 20.60 | 8.3 | 84.5 | |
| 1.5 | | | | | FDT-3 | 16.7 | 7.3 | - | - | - | |
| 2.0 | | | | BOTTOM OF TESTPIT | | | | | | | |

NATIONAL ENGINEERING SERVICES
PAKISTAN (Pvt.) LIMITED, LAHORE

Test Pit No. TP-03

Sheet 1 OF 1

# TESTPIT LOG

Job No. P38035 Project FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE Location INTERCHANGE AT ICI BRIDGE INTERSECTION

Site Incharge MUDASSAR Client LOCAL GOVERNMENT & HTP DEPARTMENT GOVERNMENT OF SINDH Contractor M/S STS KARACHI

Coordinates N: 2750269.50 m E: 296812.40 m Ground Elevation 5.99 m Date 14-09-2020 TO 19-09-2020

| Depth in meter | Elevation In meter | Legend | USCS Symbol | DESCRIPTION OF MATERIAL | Sample Type/No. | Field Density Test: Dry Density kN/m 3 | Field Density Test: Moisture Content % | Lab. Density Test: Max. Dry Density kN/m 3 | Lab. Density Test: Optimum m.c. % | Inplace % Compaction | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | Asphalt layer. | FDT-1 | 19.0 | 5.2 | | | | |
| | | | | Water bound macadam (WBM) layer. | | | | | | | |
| 0.5 | | | GP | Yellowish brown, poorly graded GRAVEL, trace COBBLES. | CS-1 | | | | | | |
| | | | SM | Brownish grey, fine to medium grained, SILTY SAND, trace to little clay, trace gravels. | FDT-2 | 20.5 | 5.2 | 21.40 | 6.5 | 95.9 | |
| 1.0 | | | | | CS-2 | | | | | | |
| 1.5 | | | | | | | | | | | |
| 2.0 | | | | BOTTOM OF TESTPIT | | | | | | | |

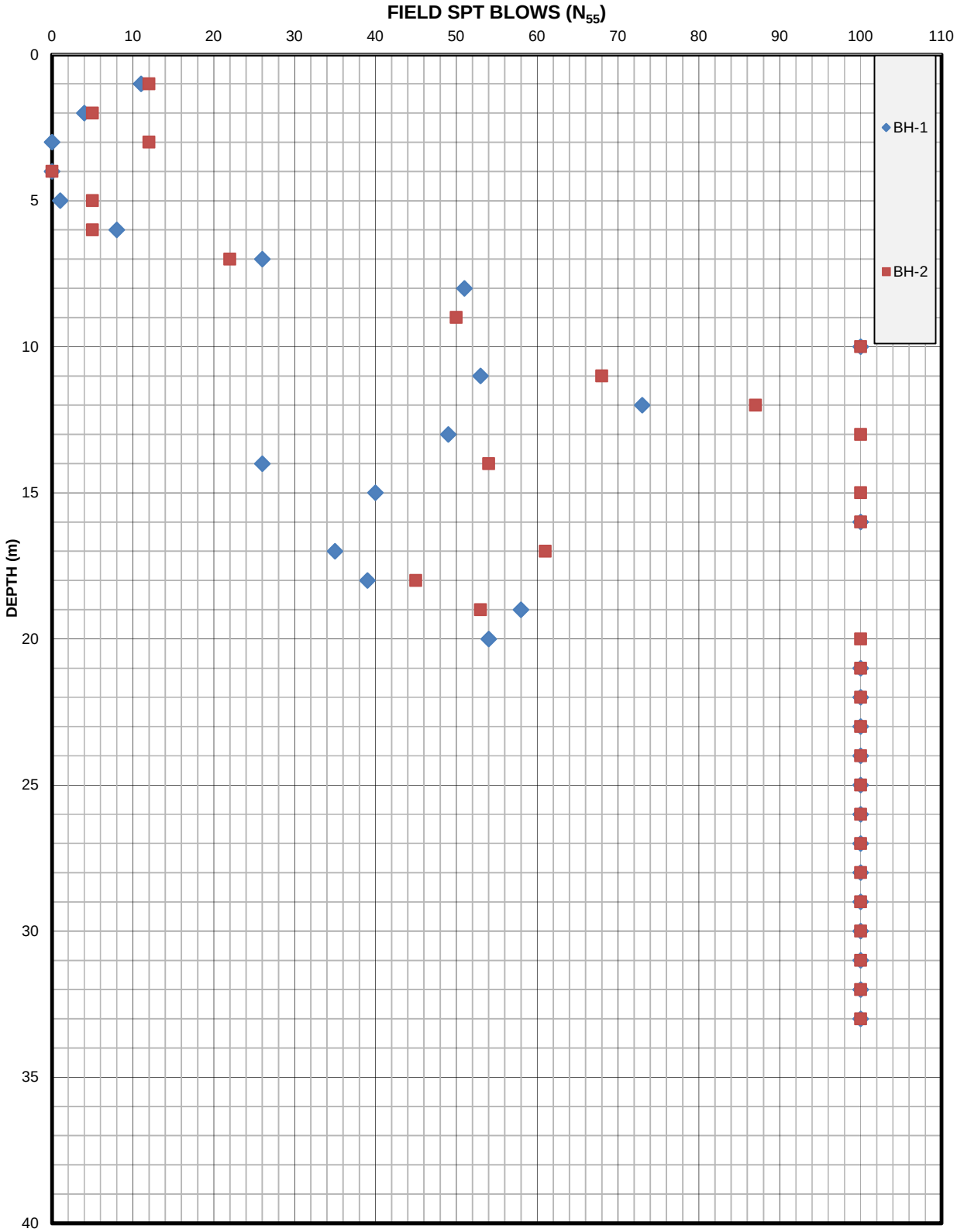
**APPENDIX-C**

# SUBSURFACE CHARACTERISTICS

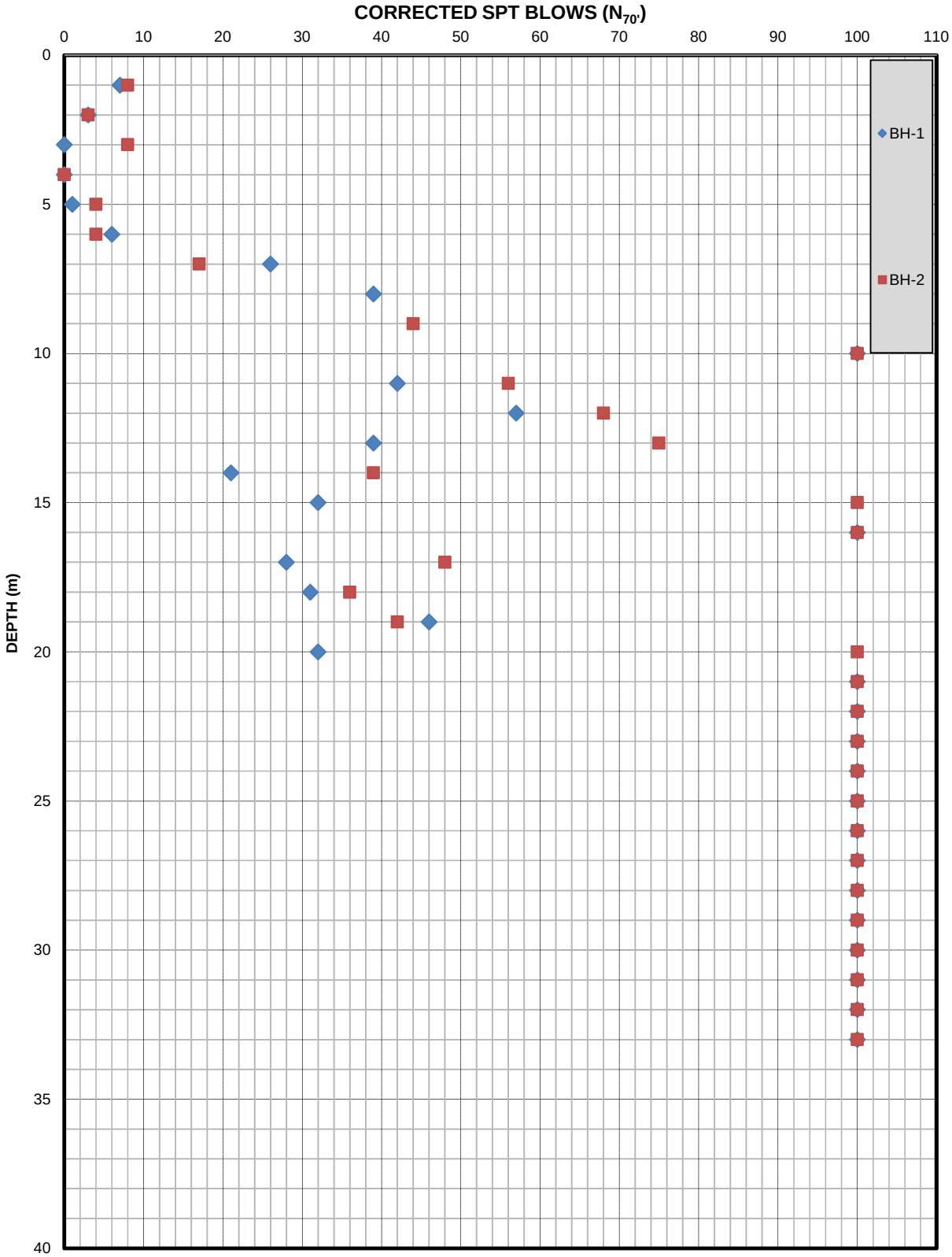
***FIG. C-1 VARIATION OF FIELD SPT BLOWS WITH DEPTH***

***FIG. C-2 VARIATION OF CORRECTED SPT BLOWS WITH DEPTH***

# FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI' (Sub Project 3: Interchange at ICI Bridge) Variation of Field SPT Blows with Depth



# FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI'
## (Sub Project 3 : Interchange at ICI Bridge)
## Variation of Corrected SPT Blows with Depth



*APPENDIX-D*

# LABORATORY TEST RESULTS
## DETAILED TEST RESULT SHEETS

**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI'**
**(SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE)**

# Summary of Laboratory Test Results

| Sr No. | Location | BH/TP No. | Sample No. | Depth | Natural Moisture Content (NMC) | In-situ Bulk Density | In-situ Dry Density | Grain Size Analysis (% Passing) | | | | | | | Atterberg Limits | | | Material Classification | | | Unconfined Compression Test (Soil) | | Uniaxial Compression Test (Rock) | | Direct Shear Test | | Modified AASHTO Compaction Test | | 3 Point Soaked CBR at 95% of MDD | Chemical Analysis of Soil | | | Chemical Analysis of Water | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | LL | PL | PI | Unified Soil Classification System (USCS) Symbol | AASHTO Classification Symbol | Material Description as per USCS | $q_u$ | Failure Strain | $q_u$ | Failure Strain | c | ϕ | OMC | Max. Dry Density (MDD) | | Sulphate Content | Chloride Content | Organic Matter | Sulphate Content | Chloride Content | Total Dissolved Soilds | pH |
| - | - | - | - | (m) | (%) | (kN/m³) | (kN/m³) | #4 | #10 | #40 | #100 | # 200 | 0.02 mm | 0.002 mm | (%) | (%) | (%) | | | | (kPa) | % | (MPa) | % | (kPa) | (deg) | (%) | (kN/m³) | (%) | (%) | (%) | (%) | (ppm) | (ppm) | (ppm) | - |
| 1 | Interchange at ICI Bridge Intersection | BH-01 | SPT-2 | 3.00-3.45 | - | - | - | 100 | 100 | 99 | 89 | 76 | - | - | 32 | 20 | 12 | CL | A-6 | Lean Clay with Sand | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 2 | | | UDS-1 | 8.50-9.30 | 16.0 | 20.8 | 18.0 | 81 | 56 | 22 | 12 | 9 | - | - | - | - | - | SW-SM | A-1-b | Well graded Sand with Silt and Gravel | - | - | - | - | Not performed due to gravelly Strata | | - | - | - | 0.026 | 0.135 | 0.150 | - | - | - | - |
| 3 | | | UDS-2 | 13.50-14.00 | 21.7 | 20.5 | 16.8 | 100 | 100 | 99 | 92 | 86 | - | - | 45 | 25 | 20 | CL | A-7-6 | Lean Clay | 153 | 9.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 4 | | | SPT-18 | 21.00-21.45 | - | - | - | 100 | 95 | 84 | 75 | 56 | - | - | 29 | 20 | 9 | CL | A-4 | Sandy Lean Clay | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 5 | | | WS-1 | 35.74-35.84 | 5.7 | 22.4 | 21.2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.19 | 1.8 | - | - | - | - | - | - | - | - | - | - | - | - |
| 6 | | | WS-5 | 38.55-38.67 | 1.4 | 24.5 | 24.2 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.42 | 1.0 | - | - | - | - | - | - | - | - | - | - | - | - |
| 7 | | | W/S | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2506 | 1486 | 6373 | 5.88 |
| 8 | | BH-02 | SPT-2 | 2.00-2.45 | - | - | - | 100 | 47 | 44 | 42 | 40 | - | - | 37 | 21 | 16 | SC | A-6 | Clayey Sand | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 9 | | | UDS-1 | 7.50-8.40 | 12.8 | 17.9 | 15.8 | 83 | 56 | 33 | 28 | 27 | - | - | - | - | - | SM | A-2-4 | Silty Sand with Gravel | - | - | - | - | Not performed due to gravelly Strata | | - | - | - | 0.011 | 0.006 | 1.016 | - | - | - | - |
| 10 | | | SPT-10 | 11.00-11.45 | - | - | - | 100 | 84 | 79 | 65 | 48 | - | - | - | - | - | SM | A-4 | Silty Sand | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 11 | | | UDS-2 | 19.00-19.55 | 16.6 | 21.6 | 18.6 | 100 | 88 | 87 | 85 | 86 | 53 | 19 | 37 | 21 | 16 | CL | A-6 | Lean Clay | 184.4 | 7.6 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 12 | | | SPT-21 | 23.00-23.45 | - | - | - | 100 | 53 | 44 | 40 | 38 | - | - | 32 | 20 | 12 | SC | A-6 | Clayey Sand | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 13 | | | WS-1 | 33.24-33.36 | 9.9 | 24.1 | 21.9 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.07 | 5.0 | - | - | - | - | - | - | - | - | - | - | - | - |
| 14 | | | WS-2 | 34.22-34.34 | 11.0 | 21.9 | 19.7 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.04 | 5.7 | - | - | - | - | - | - | - | - | - | - | - | - |
| 15 | | | WS-4 | 35.75-35.87 | 9.1 | 24.3 | 22.3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0.42 | 6.2 | - | - | - | - | - | - | - | - | - | - | - | - |
| 16 | | | WS-6 | 36.10-36.28 | 5.0 | 21.4 | 20.4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1.00 | 2.5 | - | - | - | - | - | - | - | - | - | - | - | - |
| 17 | | | W/S | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 1598 | 998 | 4813 | 6.28 |
| 18 | | TP-2 | CS-1 | 0.13-0.79 | - | - | - | 20 | 15 | 11 | 8 | 6 | - | - | - | - | - | GW-GM | A-1-a | Well Graded Gravel with Silt | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 19 | | | CS-2 | 0.79-1.45 | - | - | - | 84 | 75 | 68 | 55 | 42 | - | - | - | - | - | SM | A-4 | Silty Sand with Gravel | - | - | - | - | - | - | 8.3 | 20.6 | 30.0 | - | - | - | - | - | - | - |
| 20 | | TP-3 | CS-1 | 0.13-0.30 | - | - | - | 6 | 5 | 4 | 3 | 3 | - | - | - | - | - | GP | A-1-a | Poorly Graded Gravel | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 21 | | | CS-2 | 0.57-1.20 | - | - | - | 88 | 80 | 65 | 51 | 42 | - | - | - | - | - | SM | A-4 | Silty Sand | - | - | - | - | - | - | 6.5 | 21.4 | 32.5 | - | - | - | - | - | - | - |

**LEGEND:**

| | | | |
|---|---|---|---|
| BH | BOREHOLE | TP | TESTPIT |
| SPT | STANDARD PENETRATION TEST | CS | COMPOSITE SAMPLE |
| UDS | UNDISTURBED SOIL SAMPLE | WS | WAXED SAMPLE |
| W/S | WATER SAMPLE | | |

**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES, 'URBAN ROAD INITIATIVES IN KARACHI'**
**(SUB PROJECT 3: INTERCHANGE AT ICI BRIDGE)**

## Summary of Field Density Tests

| Sr. No. | Location | Testpit No. | FDTs | Depth (m) | Natural Moisture Content (%) | Density | | Modified AASHTO Compaction | | Relative Compaction (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Bulk ($kN/m^3$) | Dry ($kN/m^3$) | Max. Dry Density ($kN/m^3$) | OMC(%) | |
| 1 | (INTERCHANGE AT ICI BRIDGE INTERSECTION) | TP-1 | FDT-1 | 0.20 | 6.79 | 23.9 | 22.4 | - | - | - |
| 2 | | TP-2 | FDT-1 | 0.13 | 7.22 | 22.3 | 20.8 | - | - | - |
| 3 | | | FDT-2 | 1.15 | 8.01 | 18.8 | 17.4 | 20.6 | 8.3 | 84.5 |
| 4 | | | FDT-3 | 1.50 | 7.29 | 17.9 | 16.7 | - | - | - |
| 5 | | TP-3 | FDT-1 | 0.13 | 5.22 | 20.0 | 19.0 | - | - | - |
| 6 | | | FDT-2 | 0.70 | 5.15 | 21.6 | 20.5 | 21.4 | 6.5 | 95.9 |

# SOILCON

GEOTECHNICAL TESTING LABORATORIES

18-Km, Multan Road, Lahore. Ph: 042-37510942-43 Fax:042-37515267


## SUMMARY OF NMC BULK DENSITY TEST RESULTS

**Project:** TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI

**Location:**

**Client:** SOIL TESTING SERVICE

**Lab. Ref:** 61/2020

| BH / TP No. | Sample No. | Depth (m) | Location | MC% | DENSITY (g/cu.cm) | | Specific Gravity | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | | | Bulk | Dry | | |
| BH-2 | UDS-1 | 7.50-8.40 | | 12.75 | 1.821 | | | PACKAGE-1 |
| BH-2 | UDS-2 | 19.00-19.55 | | 16.55 | 2.205 | | | PACKAGE-1 |
| BH-12 | UDS-1 | 6.50-7.40 | | 28.39 | 1.836 | | | PACKAGE-1 |
| BH-12 | UDS-2 | 15.00-15.90 | | 21.53 | 1.767 | | | PACKAGE-1 |
| BH-2 | UDS-1 | 5.50-6.05 | | 15.59 | 2.116 | | | PACKAGE-2 |
| BH-2 | UDS-2 | 10.50-11.05 | | 20.61 | 2.163 | | | PACKAGE-2 |
| BH-5 | UDS-1 | 6.50-7.40 | | 14.73 | 1.818 | | | PACKAGE-2 |
| BH-5 | UDS-2 | 12.60-13.0 | | 17.09 | 2.090 | | | PACKAGE-2 |

**Tested By:** Ikram Ullah

**Checked By:** Mahmood

**Dated:** 29.09.2020

# SOILCON

18-Km, Multan Road, Lahore. Ph: 042-7510942-43 Fax:042-7515267

## SUMMARY OF FIELD DENSITY TEST

**Project:** TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI
**Location:** ICI BRIDGE

**Client:** STA
**Lab. Ref:** 64/2020

| BH / TP No. | Sample No. | Depth (m) | Location | M.C.% | Field Dry Density (g/cu.cm) | Specific Gravity | Remarks |
|---|---|---|---|---|---|---|---|
| TP-1 | FDT-1 | 0.20 | | 6.79 | | | |
| TP-1 | FDT-2 | 0.80 | | 8.21 | | | |
| TP-2 | FDT-1 | 0.13 | | 7.22 | | | |
| TP-2 | FDT-2 | 1.15 | | 8.01 | | | |
| TP-2 | FDT-3 | 1.50 | | 7.29 | | | |
| TP-3 | FDT-1 | 0.13 | | 5.22 | | | |
| TP-3 | FDT-2 | 0.70 | | 5.15 | | | |

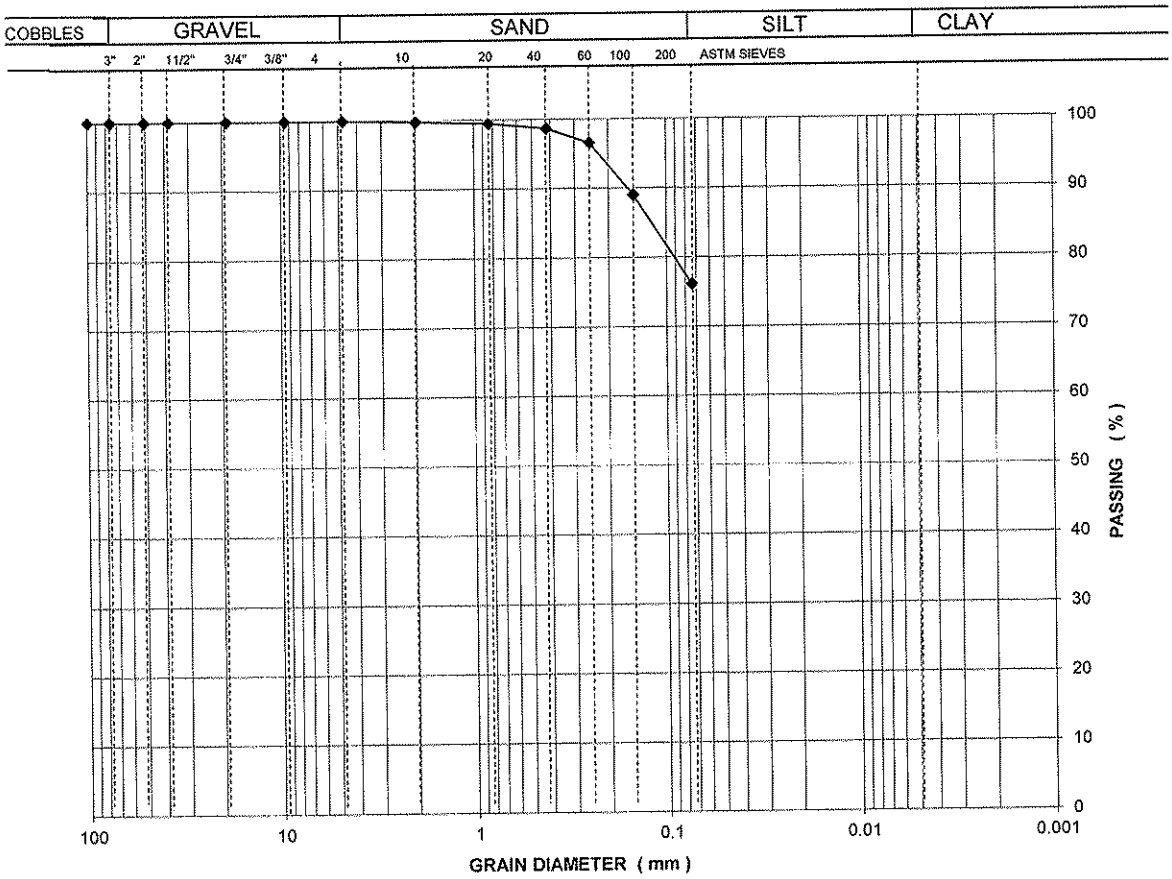
**Tested By:** IKRAM ULLAH
**Checked By:** MAHMOOD
**Dated:** 16.11.2020

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |
| | |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR THREE URBAN ROAD IN KARACHI | | |
| SITE | PACKAGE-1 LINK ROAD FOR KORANGI & INTERCHANGE AT ICI BRIDGE | | |
| BORE HOLE | BH-1 | SAMPLE | SPT-2 |
| TYPE | DISTURBED | DEPTH(m) | 3.00-3.45 |
| SPECIMEN | 1 | DATE | 23.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 89 | 76 |

| LAB. REF. | 57/2020 |
|---|---|

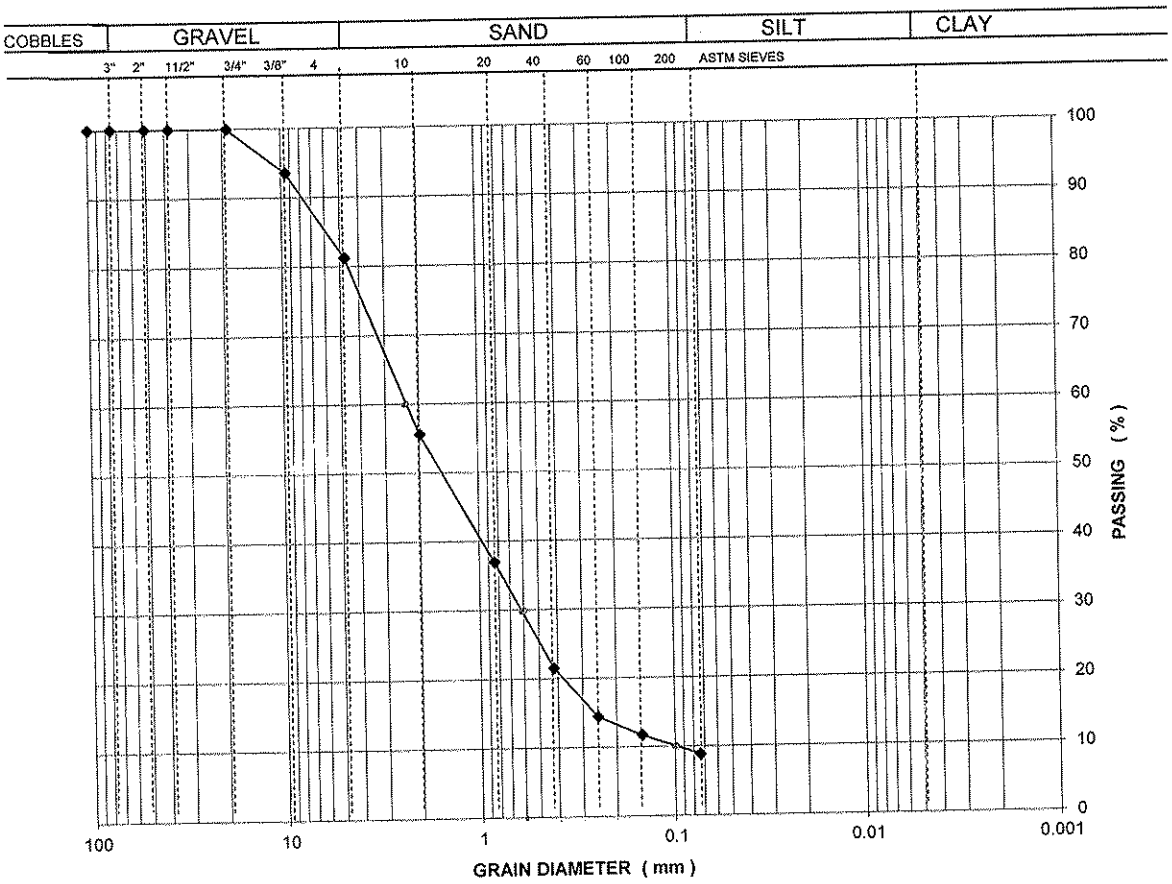
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR THREE URBAN ROAD IN KARACHI | | |
| SITE | PACKAGE-1 LINK ROAD FOR KORANGI & INTERCHANGE AT ICI BRIDGE | | |
| BORE HOLE | BH-1 | SAMPLE | UDS-1 |
| TYPE | UNDISTURBED | DEPTH(m) | 8.50-9.0 |
| SPECIMEN | 1 | DATE | 23.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 94 | 81 | 56 | 22 | 12 | 9 |

| | |
|---|---|
| LAB. REF. | 57/2020 |

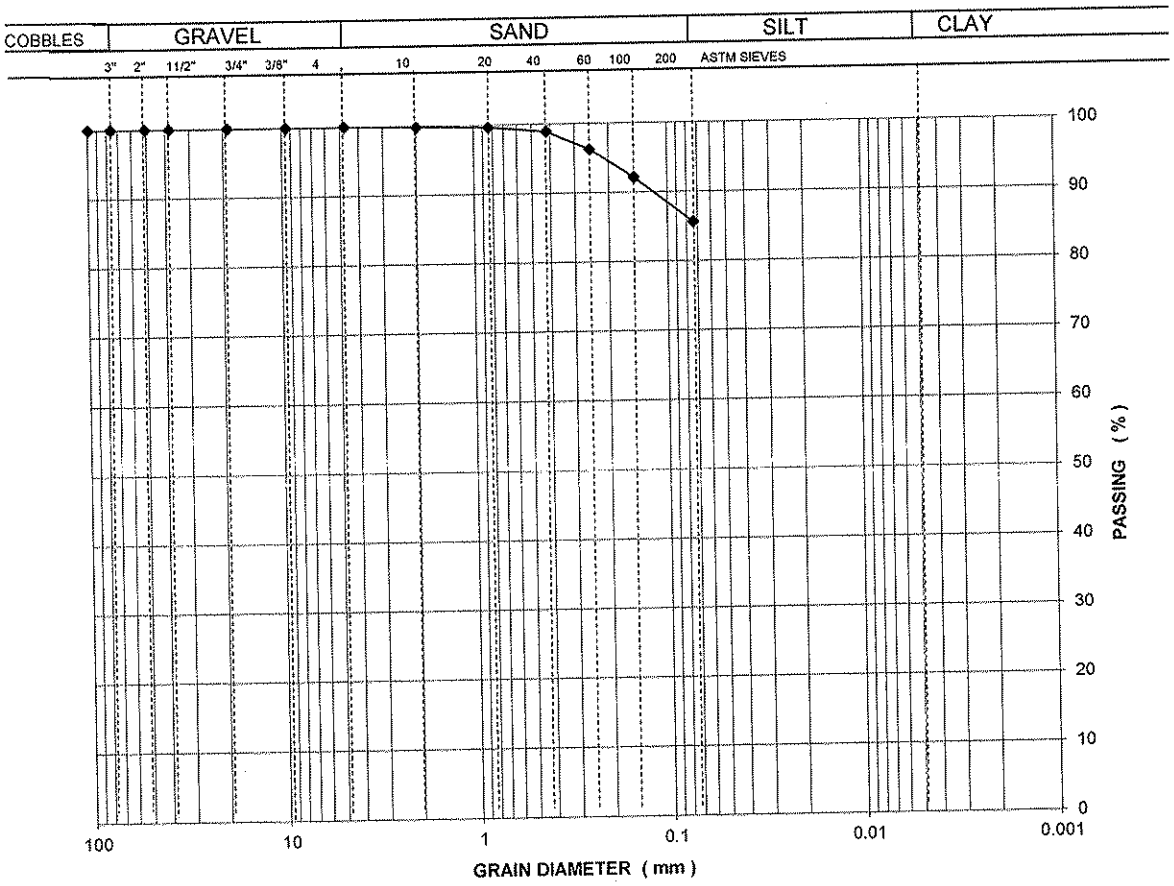
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR THREE URBAN ROAD IN KARACHI | | |
| SITE | PACKAGE-1 LINK ROAD FOR KORANGI & INTERCHANGE AT ICI BRIDGE | | |
| BORE HOLE | BH-1 | SAMPLE | UDS-2 |
| TYPE | UNDISTURBED | DEPTH(m) | 13.50-14.00 |
| SPECIMEN | 1 | DATE | 23.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 99 | 92 | 86 |

| LAB. REF. | 57/2020 |
|---|---|

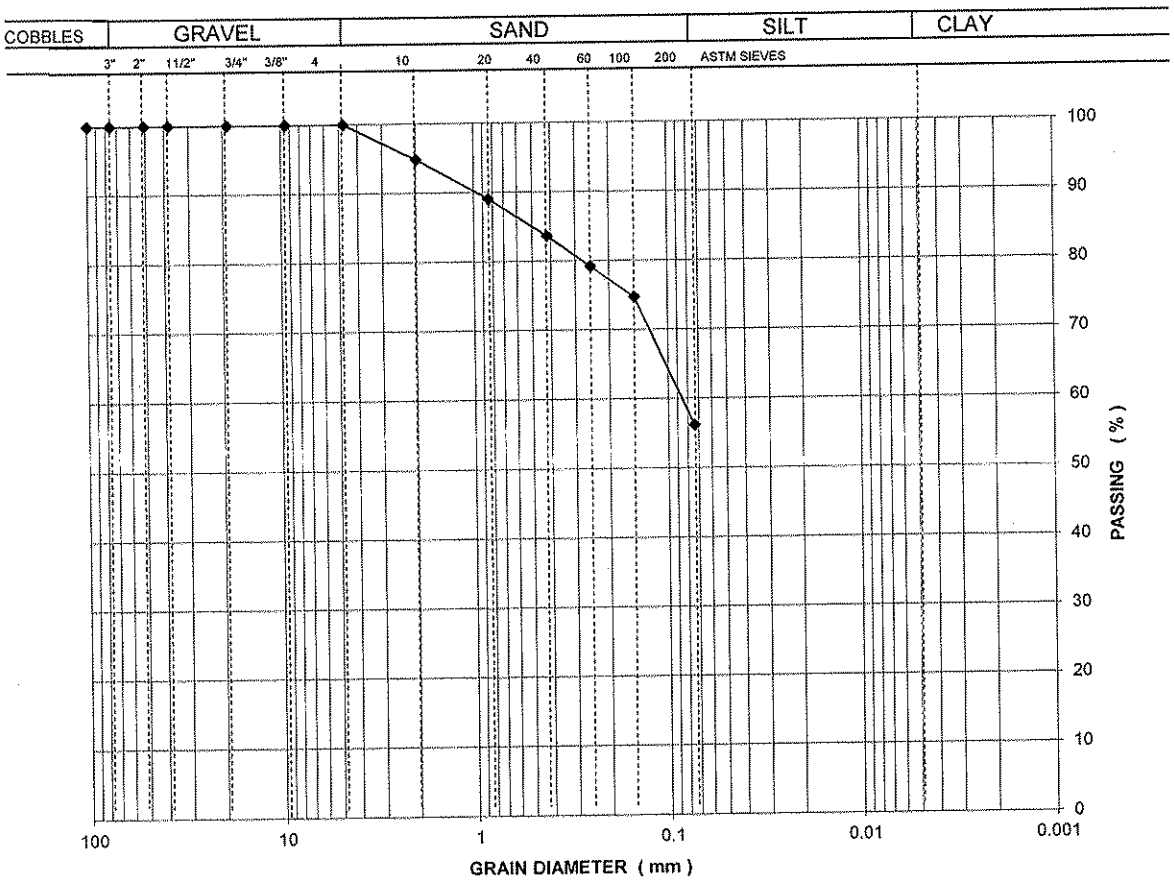
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR THREE URBAN ROAD IN KARACHI | | |
| SITE | PACKAGE-1 LINK ROAD FOR KORANGI & INTERCHANGE AT ICI BRIDGE | | |
| BORE HOLE | BH-1 | SAMPLE | SPT-18 |
| TYPE | DISTURBED | DEPTH(m) | 21.00-21.45 |
| SPECIMEN | 1 | DATE | 23.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 100 | 100 | 95 | 84 | 75 | 56 |

| LAB. REF. | 57/2020 |
|---|---|

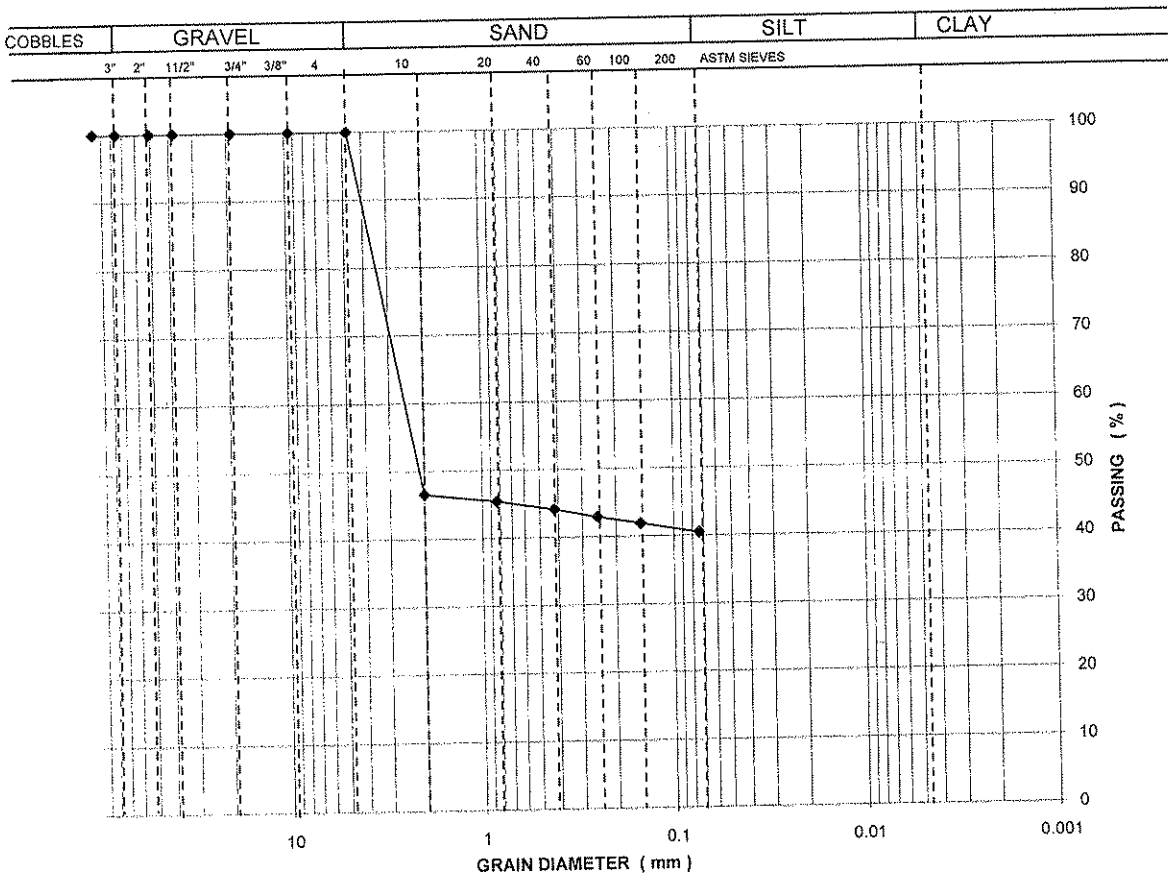
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |
| | |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR 03 URBAN ROADS IN KARACHI | | |
| SITE | PACKAGE-1 | | |
| BORE HOLE | BH-2 | SAMPLE | SPT-2 |
| TYPE | DISTURBED | DEPTH(m) | 2.00-2.45 |
| SPECIMEN | 1 | DATE | 29.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 100 | 100 | 47 | 44 | 42 | 40 |

| LAB. REF. | 61/20 |
|---|---|

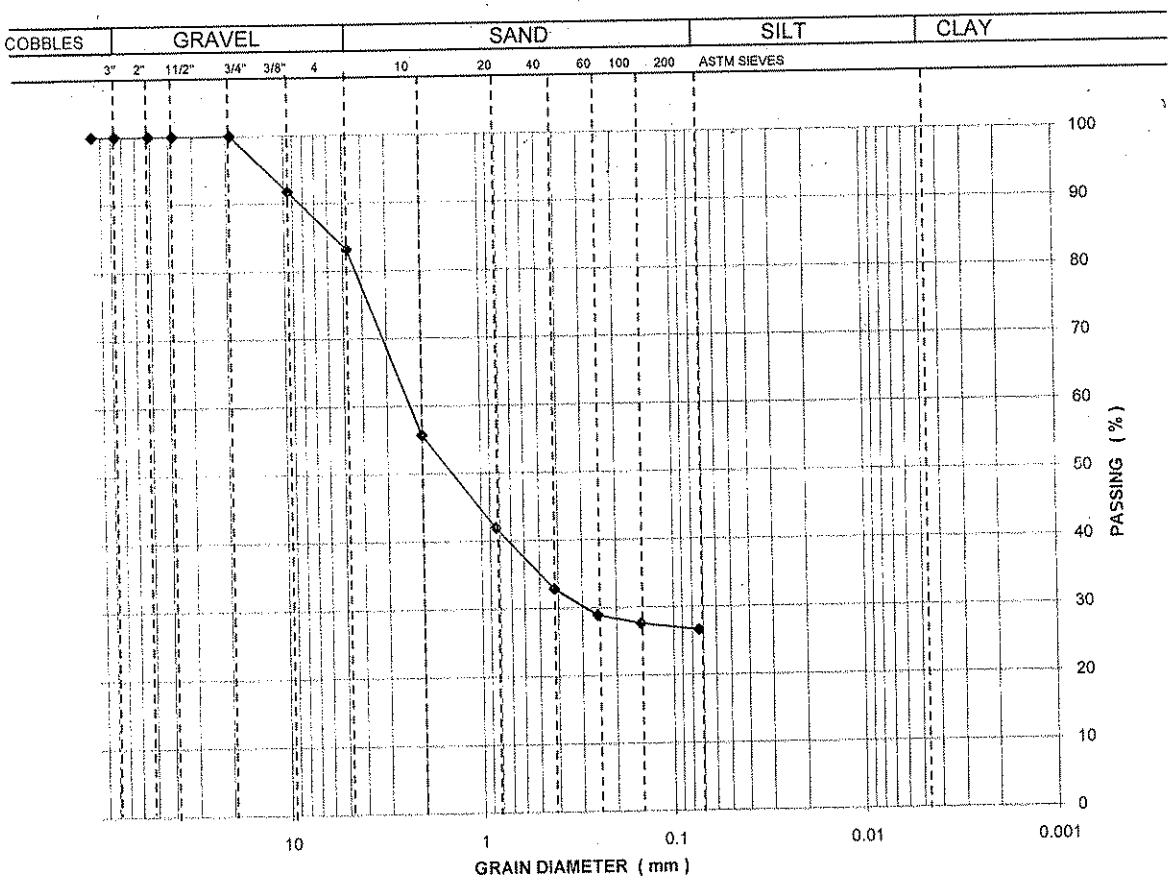
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR 03 URBAN ROADS IN KARACHI | | |
| SITE | PACKAGE-1 | | |
| BORE HOLE | BH-2 | SAMPLE | UDS-1 |
| TYPE | UNDISTURBED | DEPTH(m) | 7.50-8.40 |
| SPECIMEN | 1 | DATE | 29.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/3" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 92 | 83 | 56 | 33 | 28 | 27 |

| LAB. REF. | 61/20 |
|---|---|

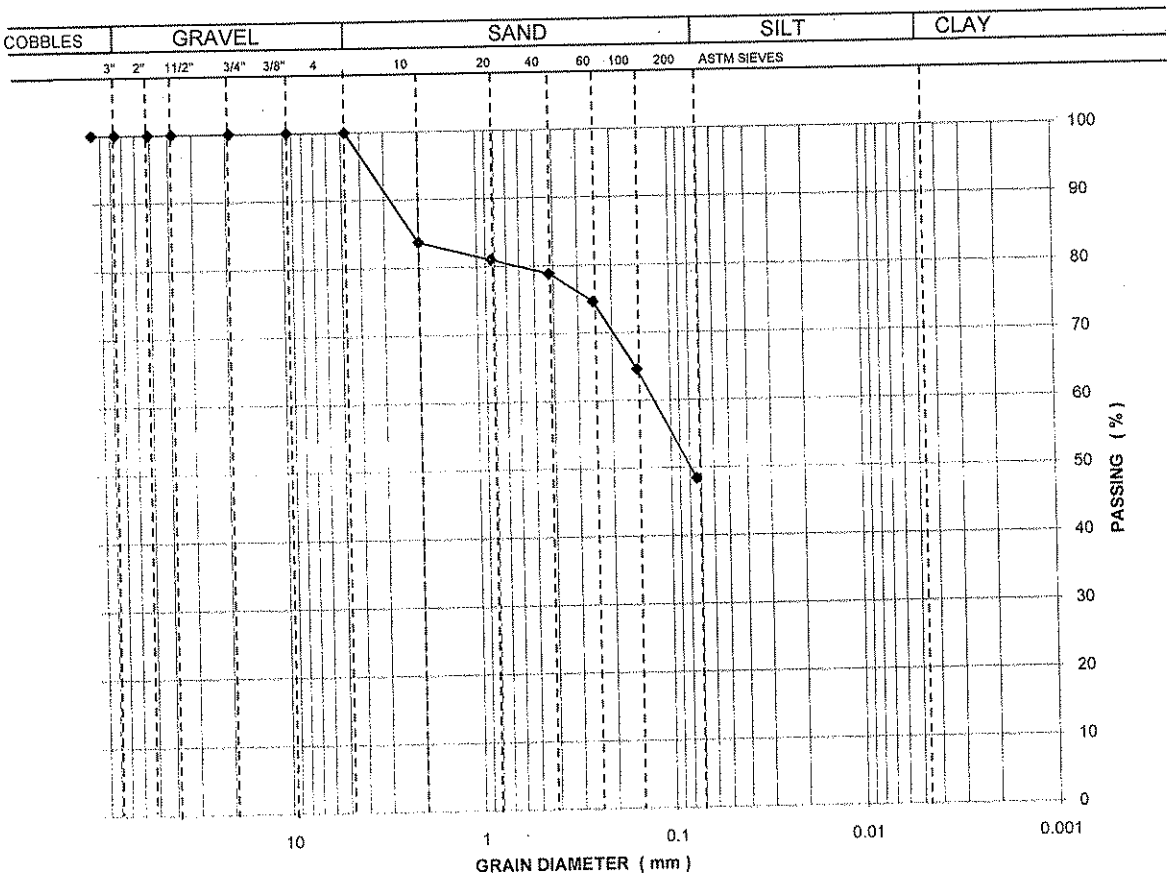
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR 03 URBAN ROADS IN KARACHI | | |
| SITE | PACKAGE-1 | | |
| BORE HOLE | BH-2 | SAMPLE | SPT-10 |
| TYPE | DISTURBED | DEPTH(m) | 11.00-11.45 |
| SPECIMEN | 1 | DATE | 29.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 100 | 100 | 84 | 79 | 65 | 48 |

| LAB. REF. | 61/20 |
|---|---|

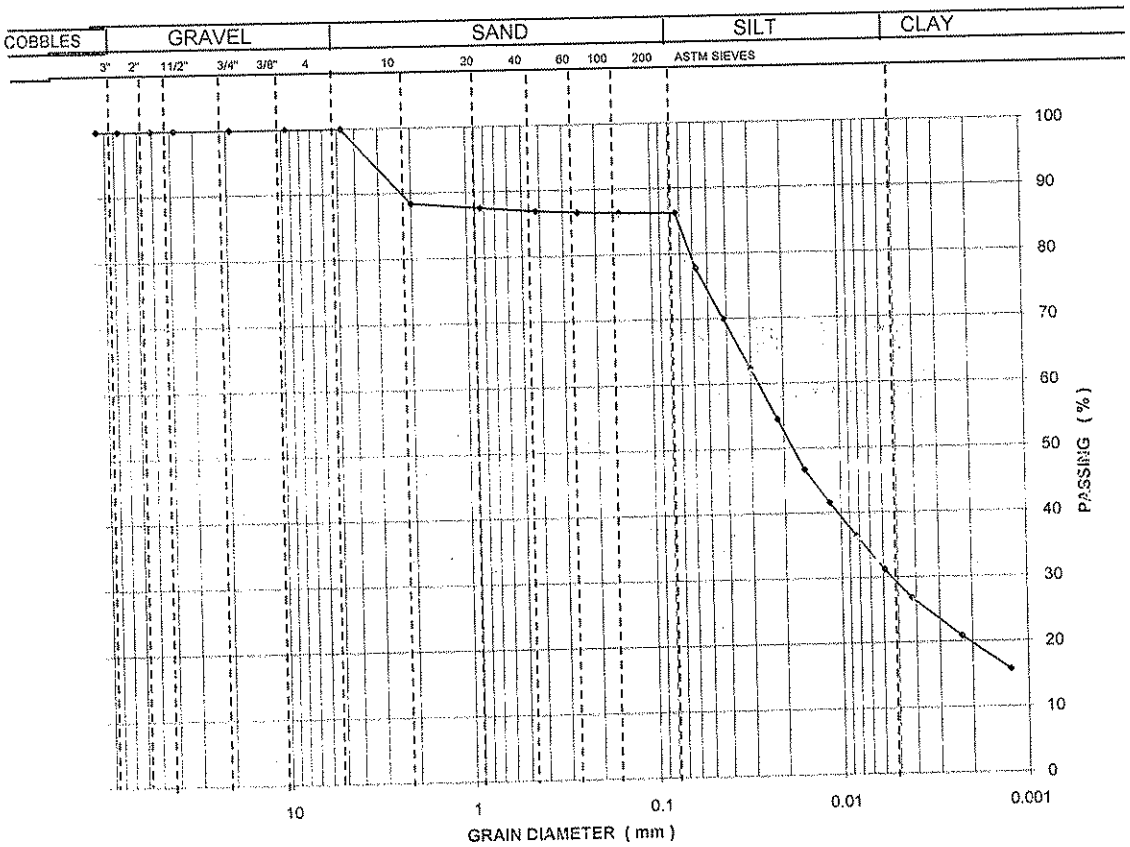
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | APPROVED BY |
|---|---|
| IKRAM | MAHMOOD |
| | |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICE | | |
| PROJECT | TAS FOR 03 URBAN ROAD PROJECT IN KARACHI | | |
| SITE | PACKAGE-1 | | |
| BORE HOLE | BH-2 | SAMPLE | UDS-2 |
| TYPE | UNDISTURBED | DEPTH m | 19.00-19.55 |
| SPECIMEN | 1 | DATE | 29.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 100 | 100 | 88 | 87 | 86 | 86 |

| LAB. REF. | 61/2020 |
|---|---|

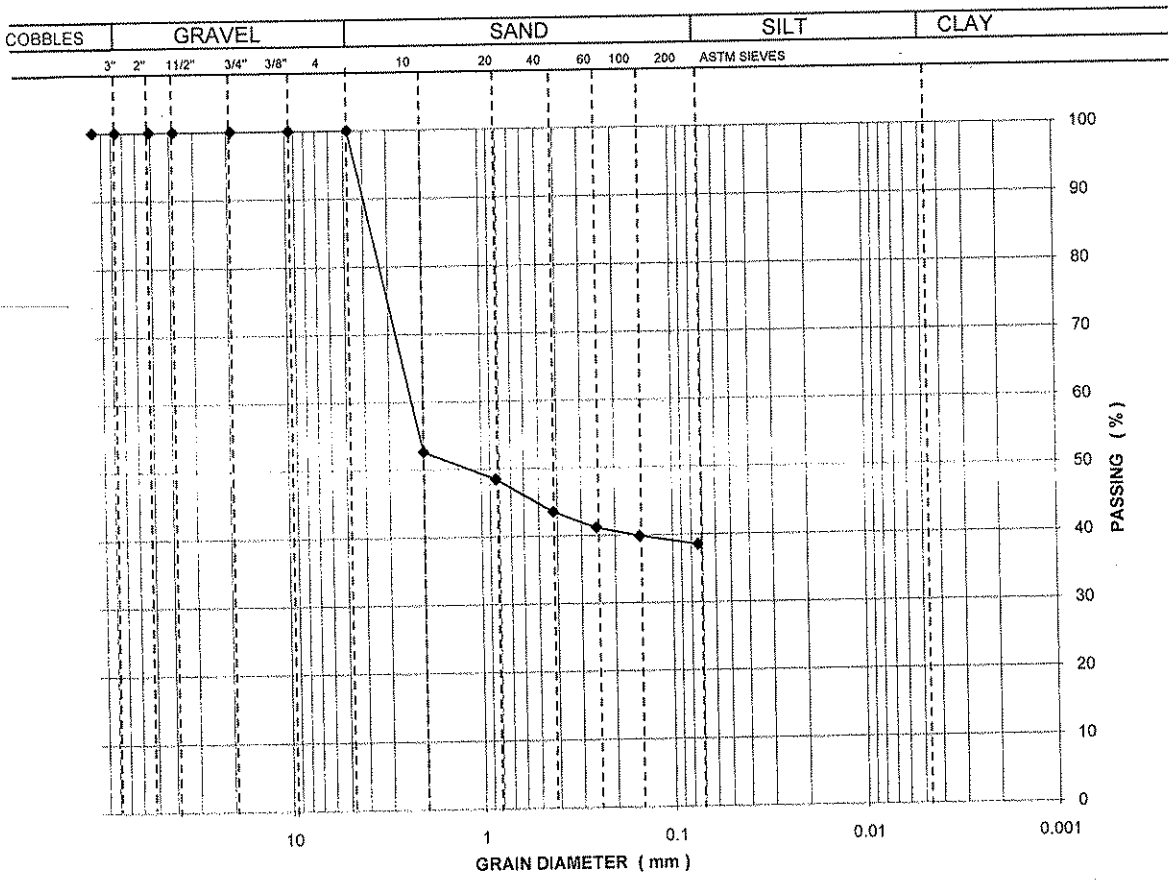
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |
| | |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | TAS FOR 03 URBAN ROADS IN KARACHI | | |
| SITE | PACKAGE-1 | | |
| BORE HOLE | BH-2 | SAMPLE | SPT-21 |
| TYPE | DISTURBED | DEPTH(m) | 23.00-23.45 |
| SPECIMEN | 1 | DATE | 29.09.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 100 | 100 | 100 | 53 | 44 | 40 | 38 |

| LAB. REF. | 61/20 |
|---|---|

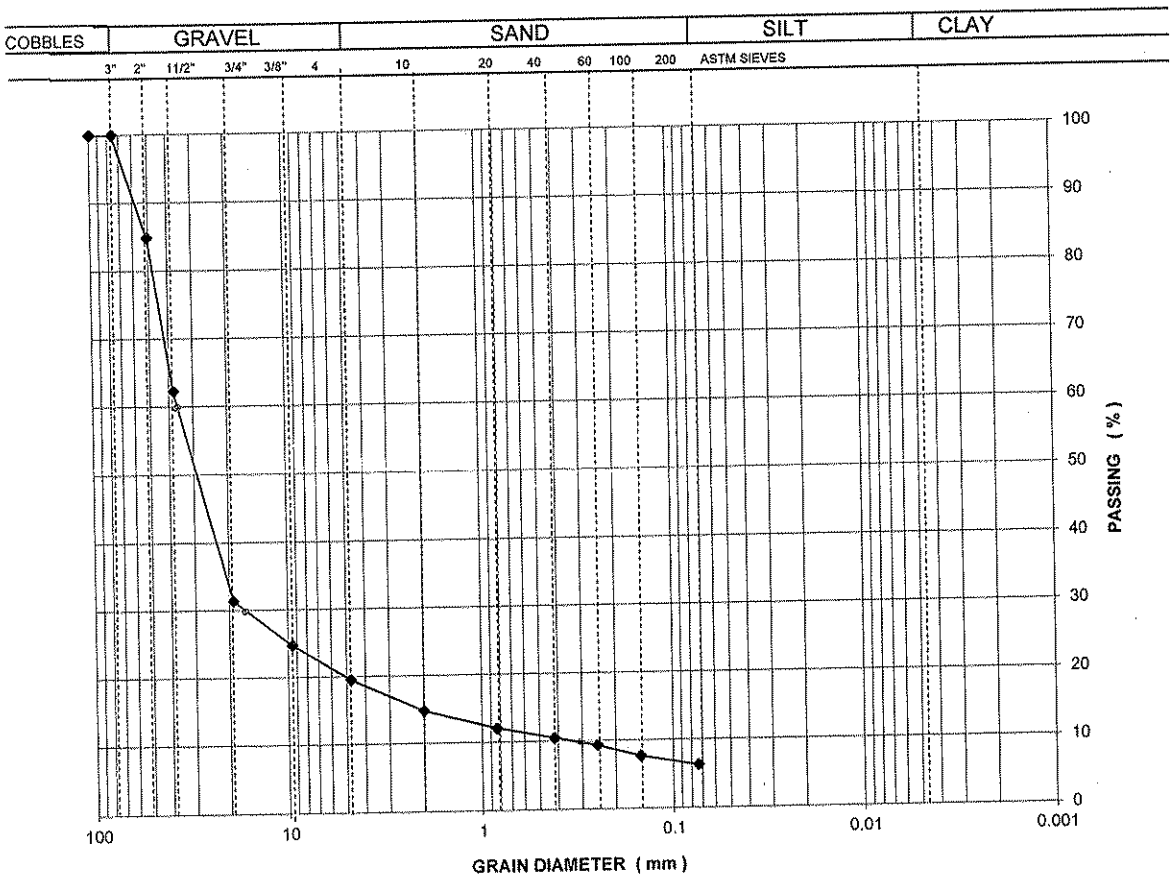
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | FEASIBILITY STUDY & TRANSACTION ADVISORY SERVICES | | |
| SITE | FOR THREE URBAN ROAD PROJECTS IN KARACHI | | |
| BORE HOLE | TP-2 | SAMPLE | CS-1 |
| TYPE | DISTURBED | DEPTH(m) | 0.13-0.79 |
| SPECIMEN | 1 | DATE | 09.10.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 85 | 62 | 31 | 25 | 20 | 15 | 11 | 8 | 6 |

| LAB. REF. | 61/2020 |
|---|---|

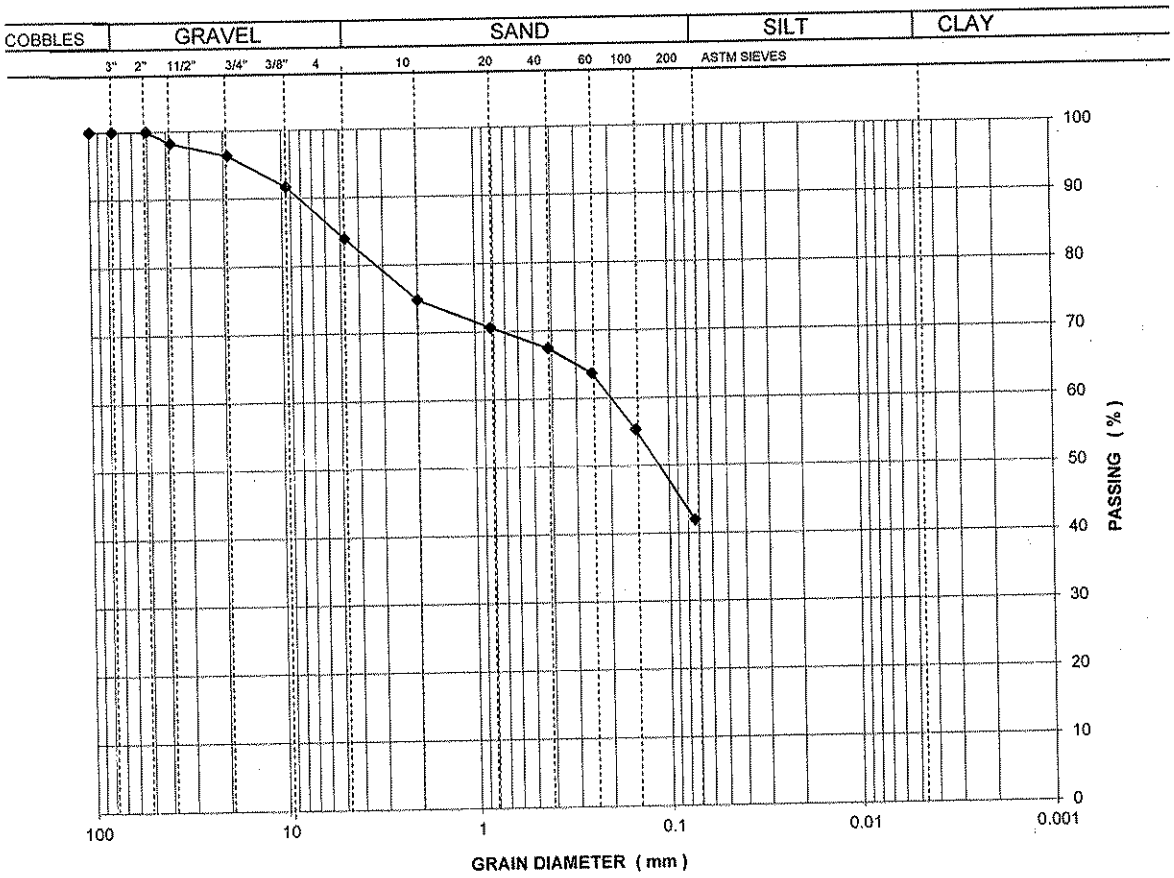
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | FEASIBILITY STUDY & TRANSACTION ADVISORY SERVICES | | |
| SITE | FOR THREE URBAN ROAD PROJECTS IN KARACHI | | |
| BORE HOLE | TP-2 | SAMPLE | CS-2 |
| TYPE | DISTURBED | DEPTH(m) | 0.79-1.45 |
| SPECIMEN | 1 | DATE | 09.10.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 98 | 96 | 92 | 84 | 75 | 68 | 55 | 42 |

| LAB. REF. | 61/2020 |
|---|---|

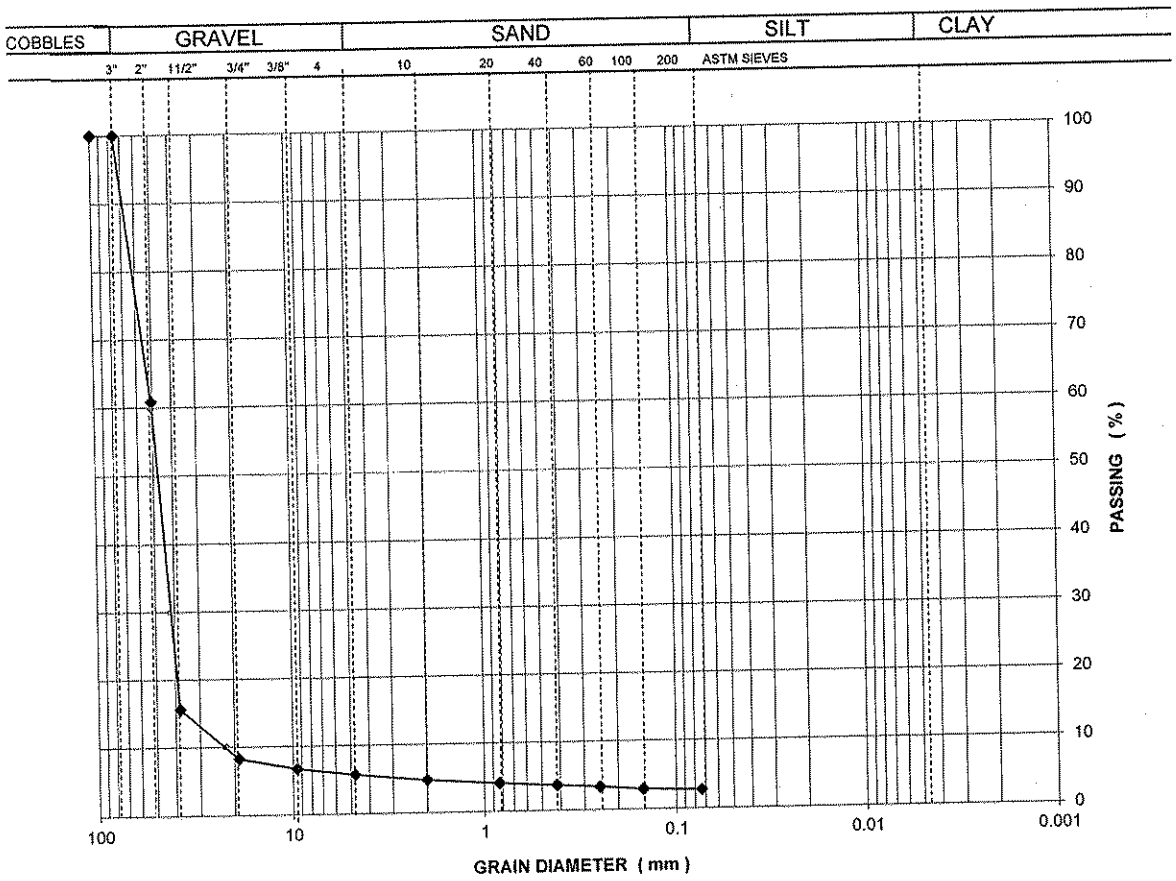
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | FEASIBILITY STUDY & TRANSACTION ADVISORY SERVICES | | |
| SITE | FOR THREE URBAN ROAD PROJECTS IN KARACHI | | |
| BORE HOLE | TP-3 | SAMPLE | CS-1 |
| TYPE | DISTURBED | DEPTH(m) | 0.13-0.30 |
| SPECIMEN | 1 | DATE | 09.10.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 61 | 16 | 8 | 7 | 6 | 5 | 4 | 3 | 3 |

| LAB. REF. | 61/2020 |
|---|---|

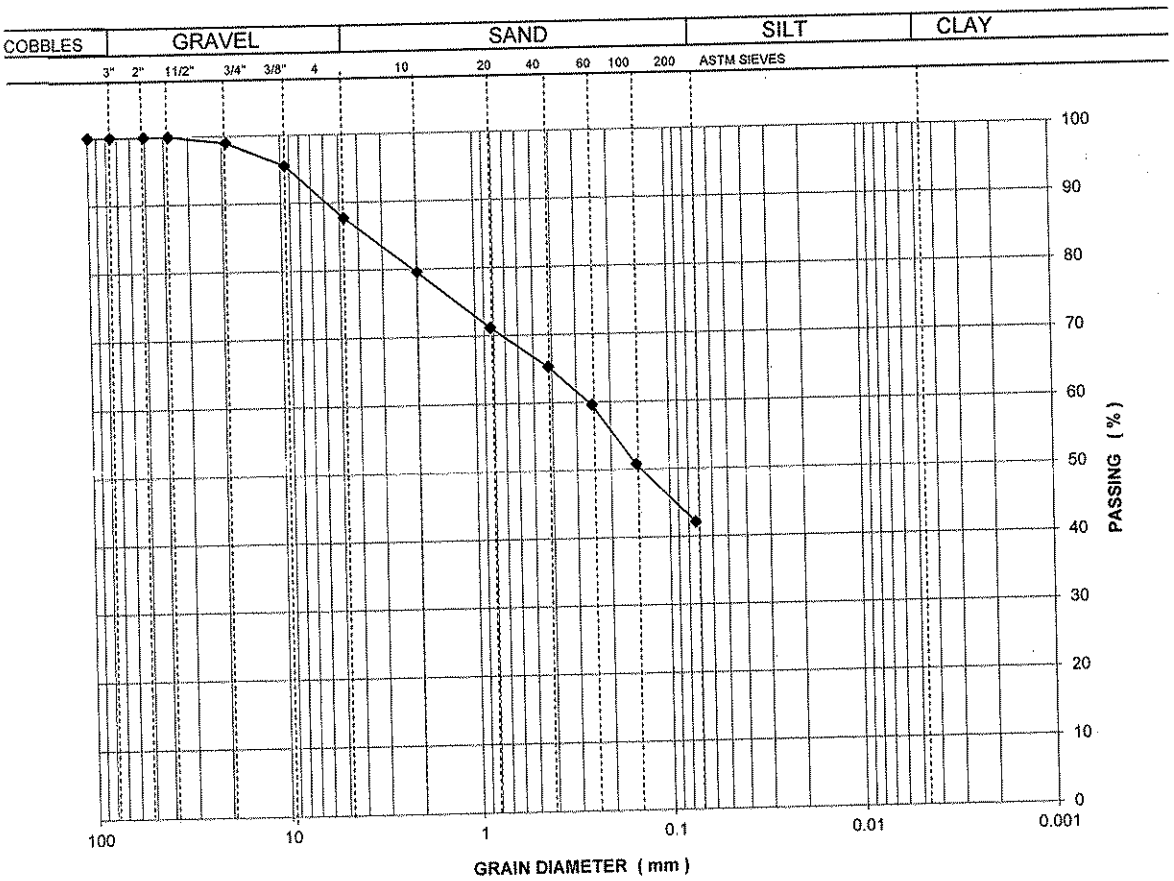
REMARKS :

# SOILCON

## GRAIN SIZE ANALYSIS

| TESTED BY | CHECKED BY |
|---|---|
| IKRAM ULLAH | MAHMOOD |
| | |

| | | | |
|---|---|---|---|
| CLIENT | SOIL TESTING SERVICES | | |
| PROJECT | FEASIBILITY STUDY & TRANSACTION ADVISORY SERVICES | | |
| SITE | FOR THREE URBAN ROAD PROJECTS IN KARACHI | | |
| BORE HOLE | TP-3 | SAMPLE | CS-2 |
| TYPE | DISTURBED | DEPTH(m) | 0.57-1.20 |
| SPECIMEN | 1 | DATE | 09.10.2020 |




| SIEVE NO. | 3" | 2" | 1"1/2 | 3/4" | 3/8" | 4 | 10 | 40 | 100 | 200 |
|---|---|---|---|---|---|---|---|---|---|---|
| PASSING ( % ) | 100 | 100 | 100 | 99 | 96 | 88 | 80 | 65 | 51 | 42 |

| LAB. REF. | 61/2020 |
|---|---|

REMARKS :

# SOILCON

## LIQUID & PLASTIC LIMIT

( ASTM D - 4318 )

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | TAS FOR THREE URBAN ROADS IN KARACHI | | | | |
| LOCATION | PACKAGE-1, LINK ROAD FOR KORANGI & INTERCHANGE AT ICI BRIDGE | | | | |
| CLIENT | SOIL TESTING SERVICES | | | | |
| BOREHOLE | BH-1 | SAMPLE | SPT-2 | TYPE | Disturbed |
| LAB. REF. | 57/2020 | DEPTH m | 2.00-2.45 | DATE | 23.09.2020 |

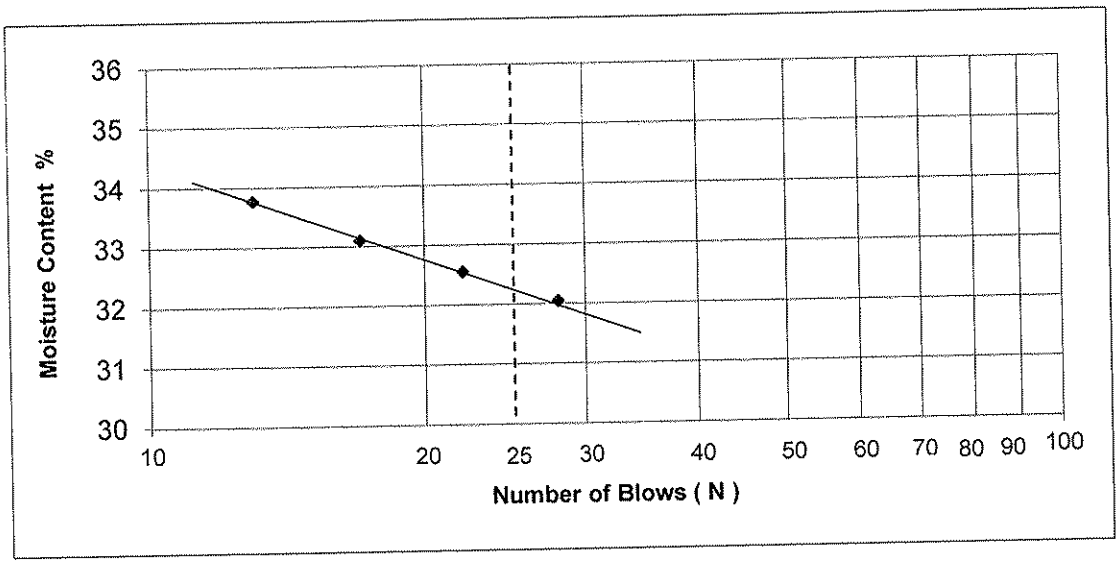
## LIQUID LIMIT

| | | | | | |
|---|---|---|---|---|---|
| Number of Blows N | 13 | 17 | 22 | 28 | |
| Moisture Content % | 33.77 | 33.10 | 32.55 | 32.05 | |

## PLASTIC LIMIT

| | | | |
|---|---|---|---|
| Moisture Content % | 20.14 | 20.18 | 20.22 |

| LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX |
|---|---|---|
| 32 | 20 | 12 |




| TESTED BY | CHECKED BY |
|---|---|
| Azmat | Mahmood |
| | |

# SOILCON

## LIQUID & PLASTIC LIMIT

( ASTM D - 4318 )

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | TAS FOR THREE URBAN ROADS IN KARACHI | | | | |
| LOCATION | PACKAGE-1, LINK ROAD FOR KORANGI & INTERCHANGE AT ICI BRIDGE | | | | |
| CLIENT | SOIL TESTING SERVICES | | | | |
| BOREHOLE | BH-1 | SAMPLE | UDS-2 | TYPE | Undisturbed |
| LAB. REF. | 57/2020 | DEPTH m | 13.50-14.00 | DATE | 23.09.2020 |

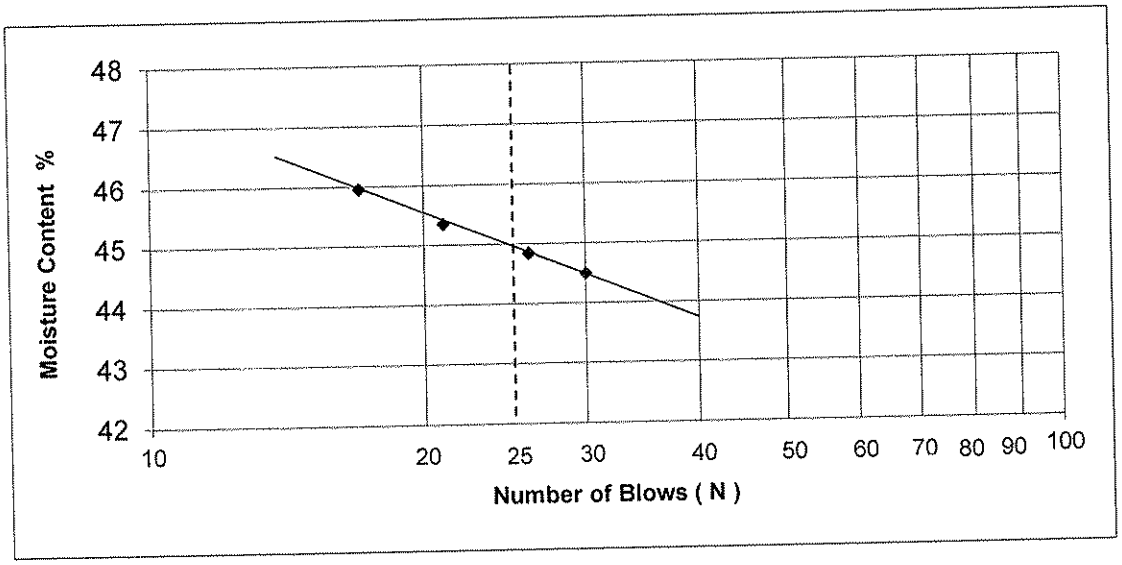
## LIQUID LIMIT

| | | | | | |
|---|---|---|---|---|---|
| Number of Blows N | 17 | 21 | 26 | 30 | |
| Moisture Content % | 45.95 | 45.35 | 44.84 | 44.49 | |

## PLASTIC LIMIT

| | | | |
|---|---|---|---|
| Moisture Content % | 24.98 | 25.02 | 25.05 |

| LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX |
|---|---|---|
| 45 | 25 | 20 |




| TESTED BY | CHECKED BY |
|---|---|
| Azmat | Mahmood |
| | |

# SOILCON

## LIQUID & PLASTIC LIMIT

( ASTM D - 4318 )

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | TAS FOR THREE URBAN ROADS IN KARACHI | | | | |
| LOCATION | PACKAGE-1, LINK ROAD FOR KORANGI & INTERCHANGE AT ICI BRIDGE | | | | |
| CLIENT | SOIL TESTING SERVICES | | | | |
| BOREHOLE | BH-1 | SAMPLE | SPT-18 | TYPE | Disturbed |
| LAB. REF. | 57/2020 | DEPTH m | 21.00-21.45 | DATE | 23.09.2020 |

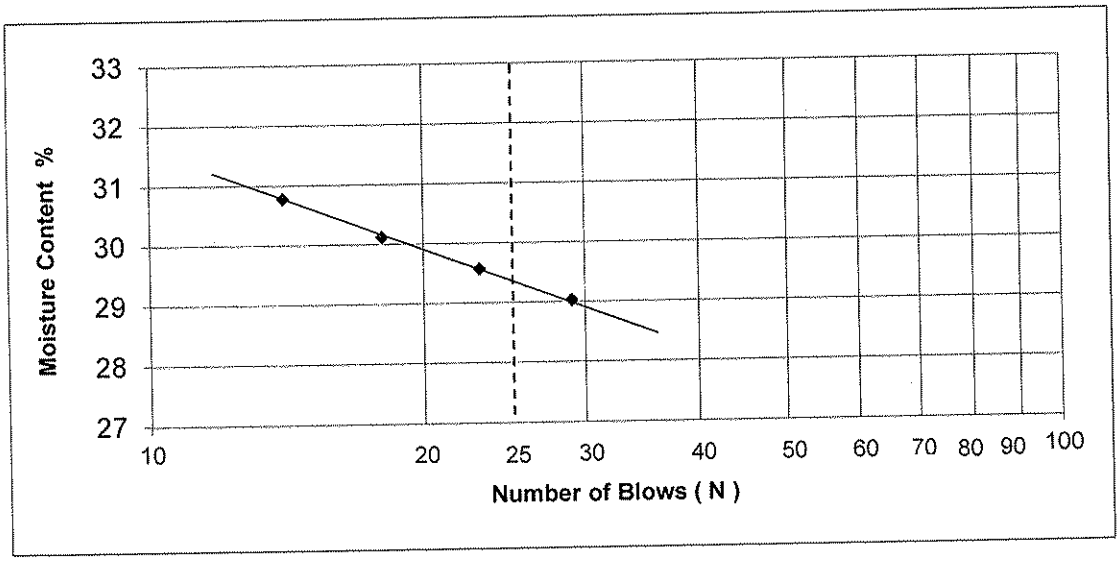
## LIQUID LIMIT

| | | | | | |
|---|---|---|---|---|---|
| Number of Blows N | 14 | 18 | 23 | 29 | |
| Moisture Content % | 30.78 | 30.12 | 29.57 | 29.03 | |

## PLASTIC LIMIT

| | | | |
|---|---|---|---|
| Moisture Content % | 20.21 | 20.24 | 20.27 |

| LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX |
|---|---|---|
| 29 | 20 | 9 |




| TESTED BY | CHECKED BY |
|---|---|
| Azmat | Mahmood |
| | |

# SOILCON

## LIQUID & PLASTIC LIMIT

( ASTM D - 4318 )

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI | | | | |
| LOCATION | PACKAGE-1 | | | | |
| CLIENT | SOIL TESTING SERVICES | | | | |
| BOREHOLE | BH-2 | SAMPLE | SPT-2 | TYPE | DISTURBED |
| LAB. REF. | 61/2020 | DEPTH m | 2.00-2.45 | DATE | 29.09.2020 |

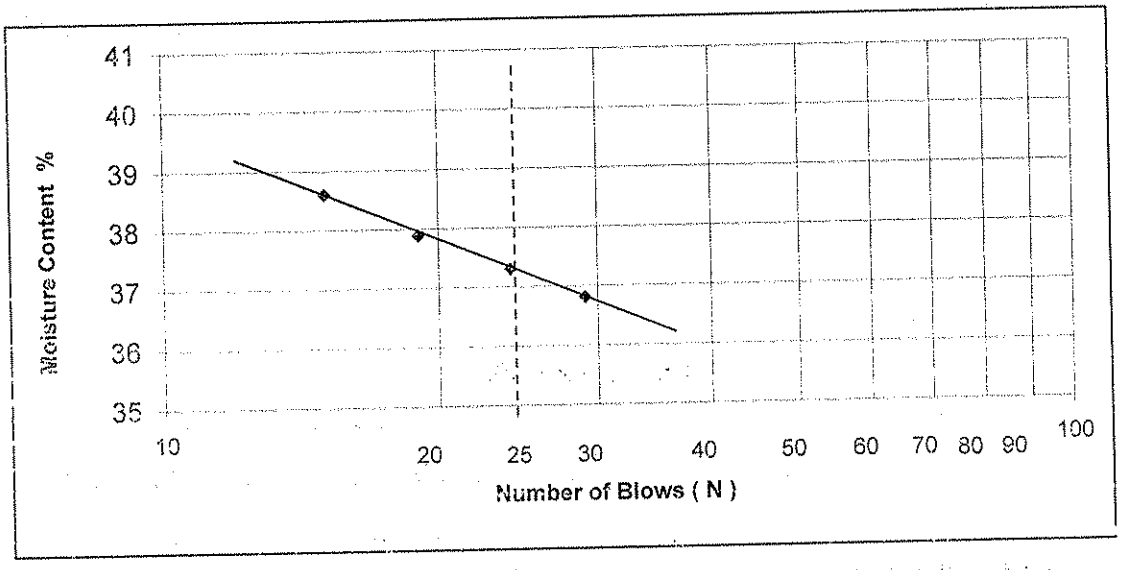
## LIQUID LIMIT

| | | | | | |
|---|---|---|---|---|---|
| Number of Blows N | 15 | 19 | 24 | 29 | |
| Moisture Content % | 38.60 | 37.89 | 37.30 | 36.81 | |

## PLASTIC LIMIT

| | | | |
|---|---|---|---|
| Moisture Content % | 21.08 | 21.12 | 21.16 |

| LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX |
|---|---|---|
| 37 | 21 | 16 |




| TESTED BY | CHECKED BY |
|---|---|
| MAHMOOD | IKRAM |
| | |

# SOILCON

## LIQUID & PLASTIC LIMIT

( ASTM D - 4318 )

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI | | | | |
| LOCATION | PACKAGE-1 | | | | |
| CLIENT | SOIL TESTING SERVICES | | | | |
| BOREHOLE | BH-2 | SAMPLE | UDS-2 | TYPE | UNDISTURBED |
| LAB. REF. | 61/2020 | DEPTH m | 19.00-19.55 | DATE | 29.09.2020 |

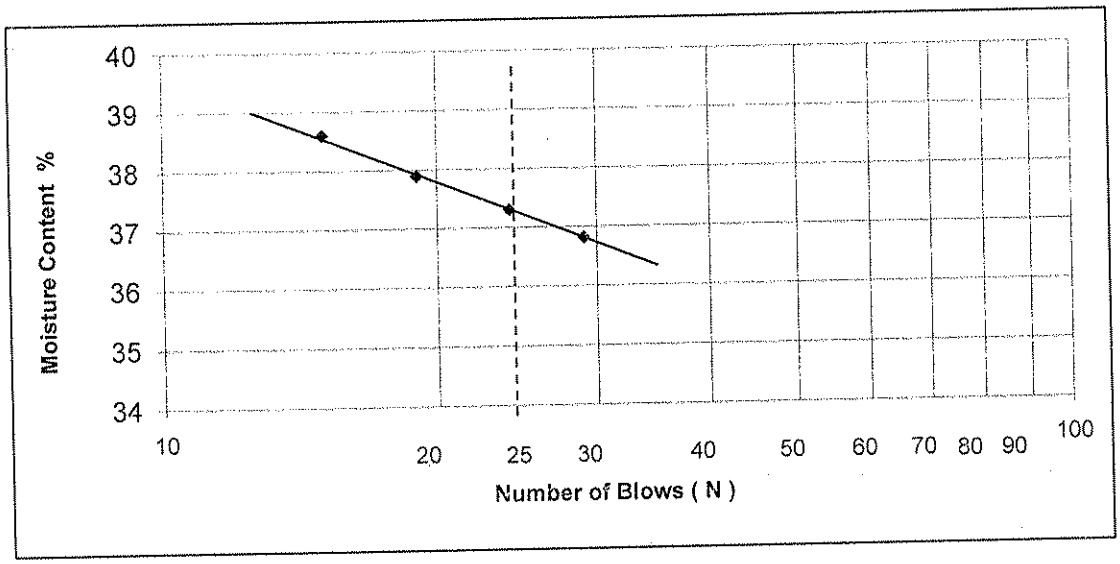
## LIQUID LIMIT

| | | | | | |
|---|---|---|---|---|---|
| Number of Blows N | 15 | 19 | 24 | 29 | |
| Moisture Content % | 38.60 | 37.89 | 37.30 | 36.81 | |

## PLASTIC LIMIT

| | | | |
|---|---|---|---|
| Moisture Content % | 21.08 | 21.12 | 21.16 |

| LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX |
|---|---|---|
| 37 | 21 | 16 |




| TESTED BY | CHECKED BY |
|---|---|
| MAHMOOD | IKRAM |
| | |

# SOILCON

## LIQUID & PLASTIC LIMIT

( ASTM D - 4318 )

| | | | | | |
|---|---|---|---|---|---|
| PROJECT | TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI | | | | |
| LOCATION | PACKAGE-1 | | | | |
| CLIENT | SOIL TESTING SERVICES | | | | |
| BOREHOLE | BH-2 | SAMPLE | SPT-21 | TYPE | DISTURBED |
| LAB. REF. | 61/2020 | DEPTH m | 23.00-23.45 | DATE | 29.09.2020 |

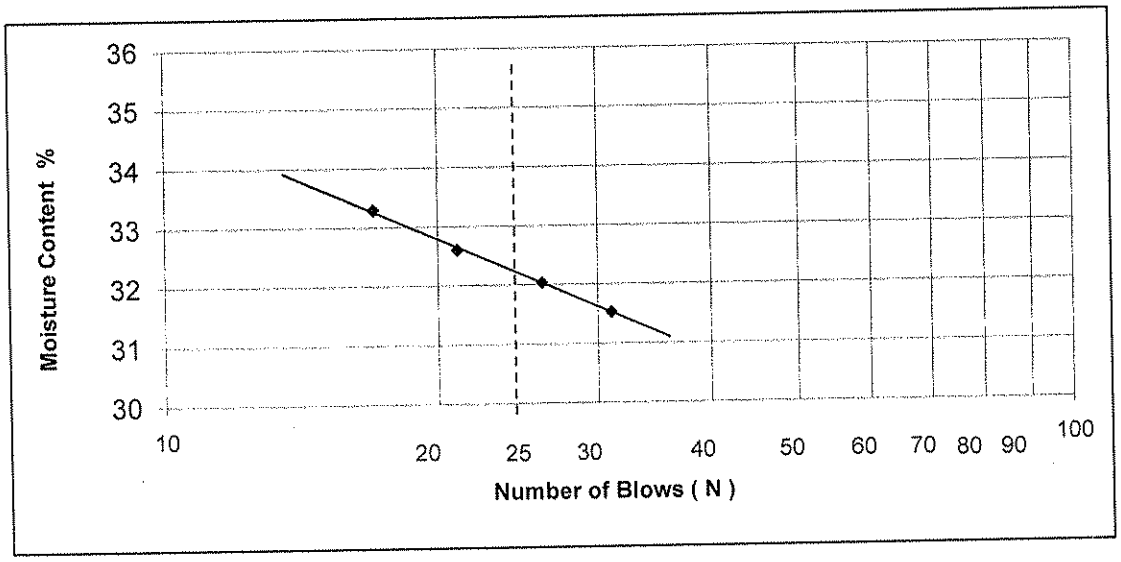
## LIQUID LIMIT

| | | | | | |
|---|---|---|---|---|---|
| Number of Blows N | 17 | 21 | 26 | 31 | |
| Moisture Content % | 33.29 | 32.60 | 32.04 | 31.53 | |

## PLASTIC LIMIT

| | | | |
|---|---|---|---|
| Moisture Content % | 20.09 | 20.13 | 20.16 |

| LIQUID LIMIT | PLASTIC LIMIT | PLASTICITY INDEX |
|---|---|---|
| 32 | 20 | 12 |




| TESTED BY | CHECKED BY |
|---|---|
| MAHMOOD | IKRAM |
| | |

# SOILCON

GEOTECHNICAL TESTING LABORATORIES, 18-Km,

## UNCONFINED COMPRESSION TEST

| | | | |
|---|---|---|---|
| **PROJECT:** | TAS FOR 03 URBAN ROAD IN KARACHI | **BH #** | BH-1 |
| **LOCATION:** | PACKAGE-1 | **SAMPLE NO** | UDS-2 |
| **LAB REF.** | 57/2020 | **DEPTH m** | 13.50-14.00 |
| **DATE:** | 23.09.2020 | **CLIENT** | SOIL TESTING SERVICE |

**SAMPLE DESCRIPTION:**

**Specimen Conditions**

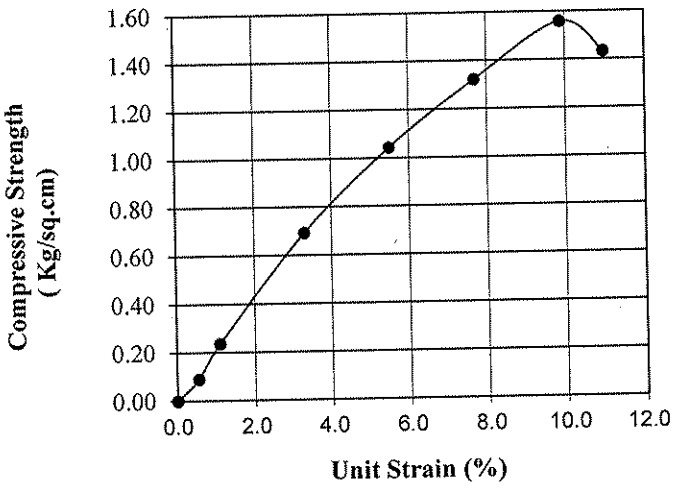
| | | |
|---|---|---|
| Diameter Average | 4.46 | cm |
| Area Average | 15.62 | $cm^2$ |
| Height | 9.12 | cm |
| Volume | 142.50 | $cm^3$ |
| Weight Wet | 297.17 | g |
| Water Content | 21.71 | % |
| Dry Density | 1.713 | $g/cm^3$ |
| P.R Factor | 0.9312 | Kg/div. |
| Compressive Strength | 1.56 | $Kg/cm^2$ |
| Strain | 9.87 | % |

**FAILURE SKETCHES**

Front

Rear

| Deformation Dial Reading | Unit Strain % | Compressive Strength ( Kg/sq.cm) |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 50 | 0.55 | 0.09 |
| 100 | 1.10 | 0.24 |
| 300 | 3.29 | 0.69 |
| 500 | 5.48 | 1.04 |
| 700 | 7.68 | 1.32 |
| 900 | 9.87 | 1.56 |
| 1000 | 10.96 | 1.43 |
| | | |
| | | |
| | | |
| | | |
| | | |




**Remarks:**

**Tested By:** Mahmood

**Checked By:** Ikram Ullah

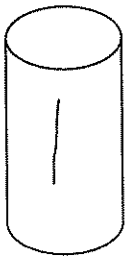
# University of Engineering & Technology, Lahore
## Department of Civil Engineering
## Geotechnical Engineering Laboratory

## UNIAXIAL COMPRESSION TEST

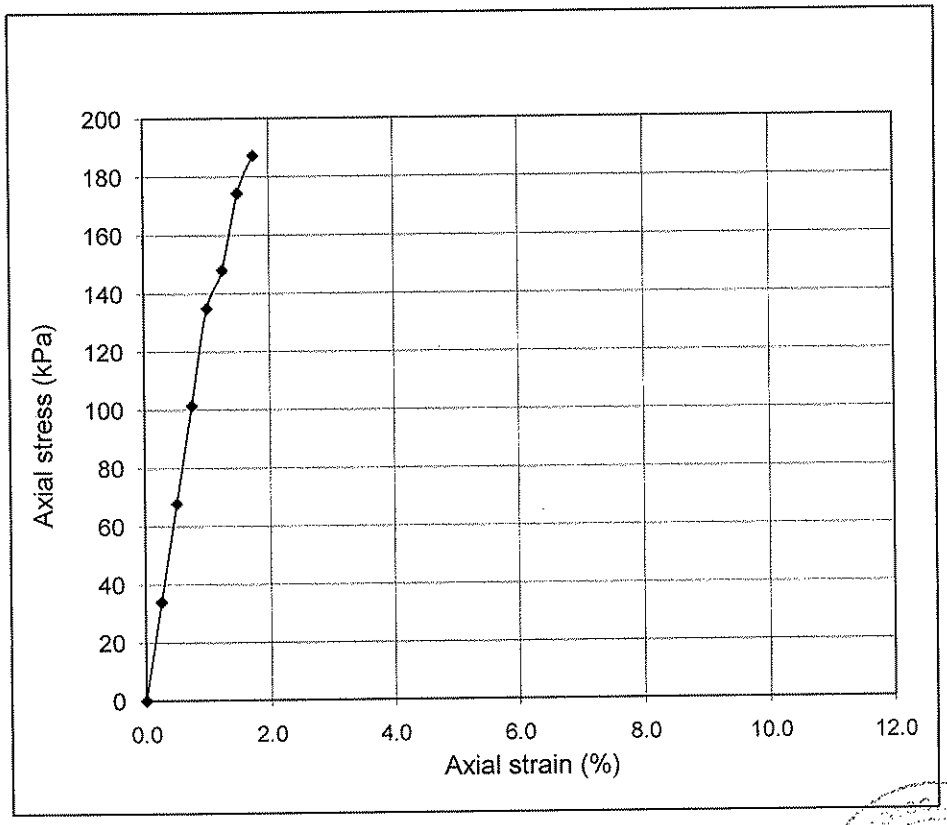
| | | | |
|---|---|---|---|
| **Project:** | Consultancy Services for Feasibility Study and Transaction Advisory Services (TAS) for Three Urban Roads in Karachi Package 1: Link Road at Korangi & Interchange at C1 Bridge | **Job No.** | 3879 |
| | | **Dated:** | 10/9/2020 |
| **Client:** | NESPAK (Pvt) Ltd. | | |

| | | | |
|---|---|---|---|
| **Location:** | Korangi | Height = | 10.16 cm |
| **BH/TP No.** | BH-1 | Diameter = | 5.08 cm |
| **Sample No.** | WS-1 | Bulk Density = | 22.4 kN/m$^3$ |
| **Depth (m)** | 35.74 - 35.84 | Moisture Content = | 5.65 % |

Uniaxial Compression Strength = **188 kPa**



**Test Method: ASTM D7012**




Tested by:

Checked by:

Director

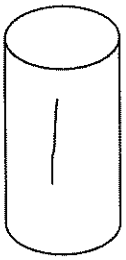
# University of Engineering & Technology, Lahore
## Department of Civil Engineering
## Geotechnical Engineering Laboratory

## UNIAXIAL COMPRESSION TEST

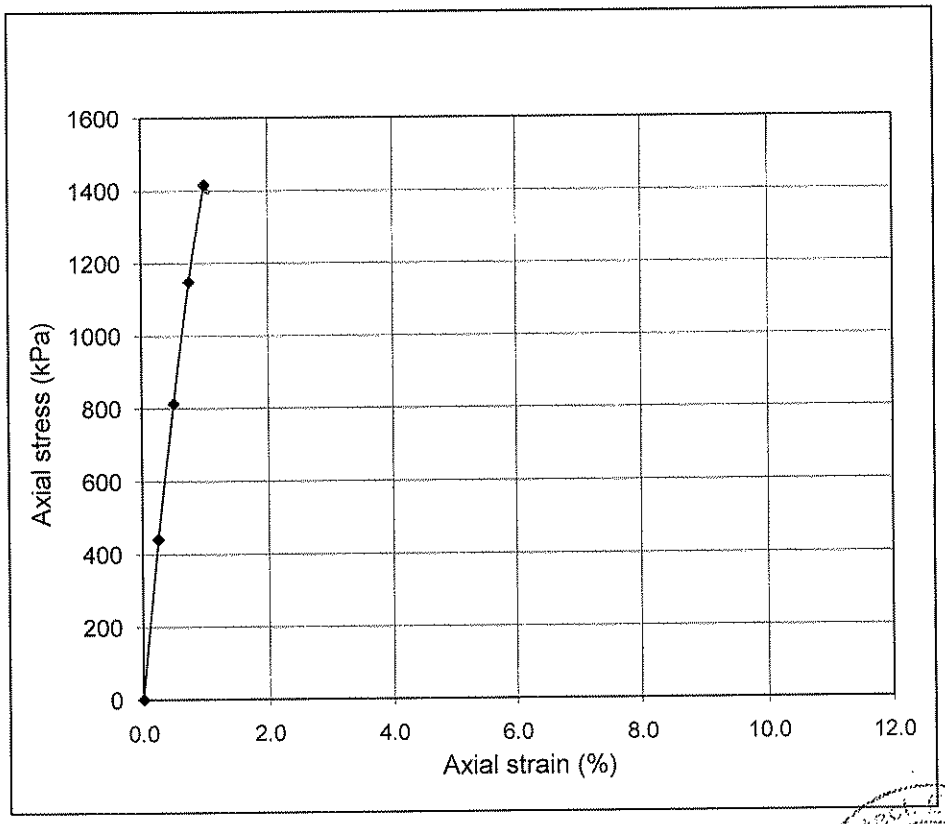
| | | | |
|---|---|---|---|
| **Project:** | Consultancy Services for Feasibility Study and Transaction Advisory Services (TAS) for Three Urban Roads in Karachi Package 1: Link Road at Korangi & Interchange at C1 Bridge | **Job No.** | 3879 |
| | | **Dated:** | 10/9/2020 |
| **Client:** | NESPAK (Pvt) Ltd. | | |

| | | | |
|---|---|---|---|
| **Location:** | Korangi | Height = | 10.16 cm |
| **BH/TP No.** | BH-1 | Diameter = | 5.08 cm |
| **Sample No.** | WS-5 | Bulk Density = | 24.5 kN/m$^3$ |
| **Depth (m)** | 38.55-38.67 | Moisture Content = | 1.38 % |

Uniaxial Compression Strength = **1415 kPa**



**Test Method: ASTM D7012**




Tested by:

Director: Checked by: 21/9/20

# SOILCON

GEOTECHNICAL TESTING LABORATORIES, 18-Km,
MULTAN ROAD, LAHORE

## UNCONFINED COMPRESSION TEST

| | | | |
|---|---|---|---|
| **PROJECT:** | TAS FOR THREE URBAN ROAD IN KARACHI | **BH NO** | BH-2 |
| **LOCATION:** | PACKAGE-1 | **SAMPLE NO** | UDS-2 |
| **LAB REF.** | 61/2020 | **DEPTH m** | 19.00-19.55 |
| **DATE:** | 29.09.2020 | **CLIENT** | SOIL TESTING SERVICES |

**SAMPLE DESCRIPTION:**

**Specimen Conditions**

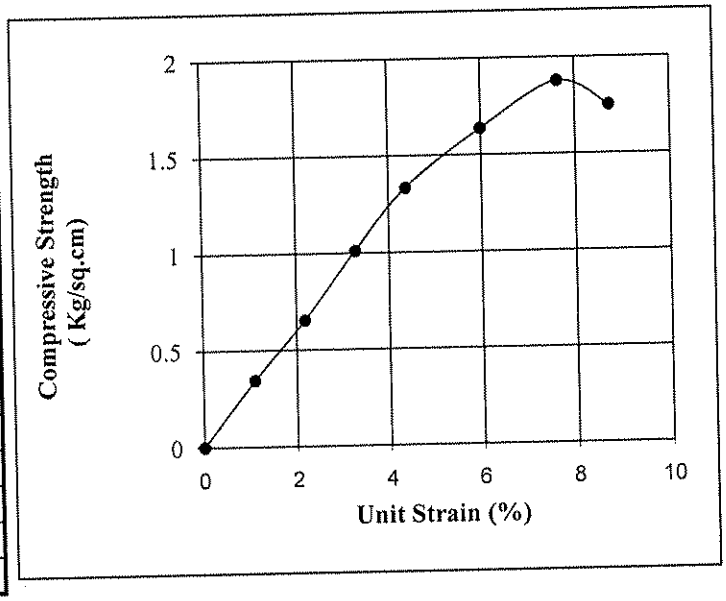
| | | |
|---|---|---|
| Diameter Average | 4.52 | cm |
| Area Average | 16.04 | $cm^2$ |
| Height | 9.17 | cm |
| Volume | 147.16 | $cm^3$ |
| Weight Wet | 314.25 | g |
| Water Content | 16.54 | % |
| Dry Density | 1.832 | $g/cm^3$ |
| P.R Factor | 0.9312 | Kg/div. |
| Compressive Strength | 1.88 | $Kg/cm^2$ |
| Strain | 7.63 | % |

**FAILURE SKETCHES**

Front

Rear

| Deformation Dial Reading | Unit Strain % | Compressive Strength ( Kg/sq.cm) |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 100 | 1.09 | 0.34 |
| 200 | 2.18 | 0.65 |
| 300 | 3.27 | 1.01 |
| 400 | 4.36 | 1.33 |
| 550 | 6.00 | 1.64 |
| 700 | 7.63 | 1.88 |
| 800 | 8.72 | 1.75 |
| | | |
| | | |
| | | |
| | | |
| | | |




**Remarks:**

**Tested By:** Azmat

**Checked By:** Mahmood

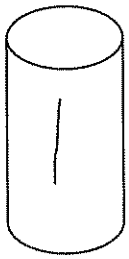
# University of Engineering & Technology, Lahore
## Department of Civil Engineering
## Geotechnical Engineering Laboratory

## UNIAXIAL COMPRESSION TEST

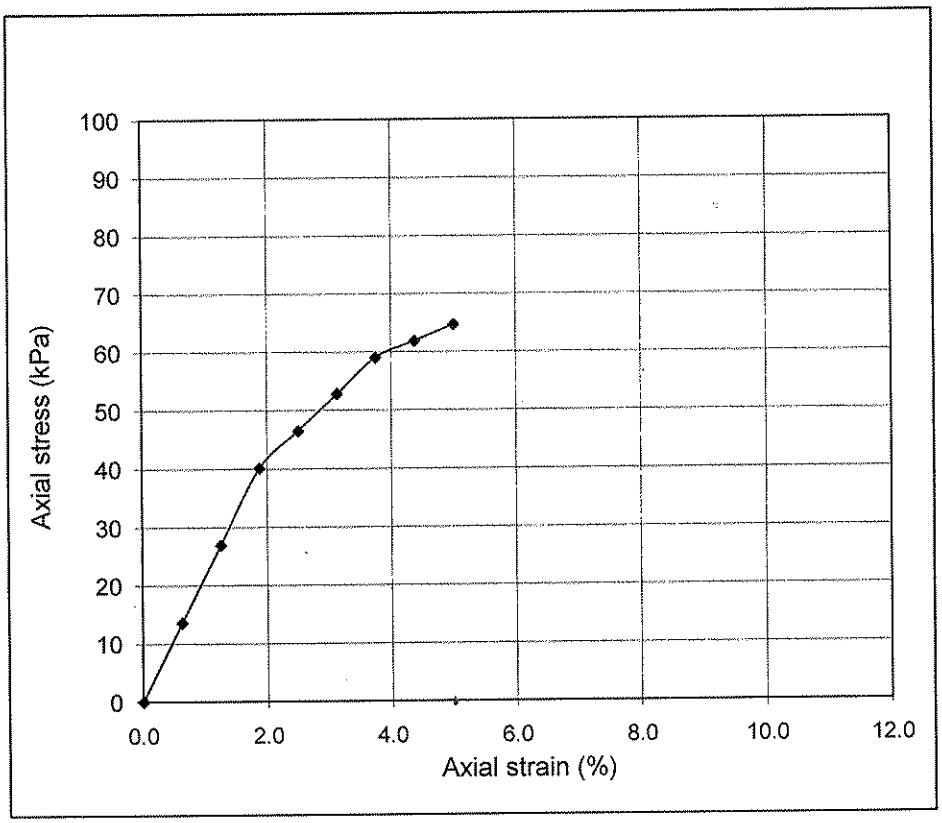
| | | | |
|---|---|---|---|
| **Project:** | Consultancy Services for Feasibility Study and Transaction Advisory Services (TAS) for Three Urban Roads in Karachi Package 1: Link Road at Korangi & Interchange at ICI Bridge (ICI) | **Job No.** | 3879 |
| | | **Dated:** | 15/9/2020 |
| **Client:** | NESPAK (Pvt) Ltd. | | |

| | | | |
|---|---|---|---|
| | | Height = | 10.16 cm |
| **BH/TP No.** | BH-2 | Diameter = | 5.08 cm |
| **Sample No.** | WS-1 | Bulk Density = | 24.1 kN/m$^3$ |
| **Depth (m)** | 33.24-33.36 | Moisture Content = | 9.90 % |

Uniaxial Compression Strength = **65 kPa**



**Test Method: ASTM D7012**




Checked by:

Director

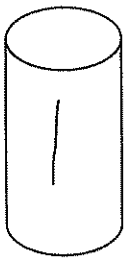
# University of Engineering & Technology, Lahore
## Department of Civil Engineering
## Geotechnical Engineering Laboratory

## UNIAXIAL COMPRESSION TEST

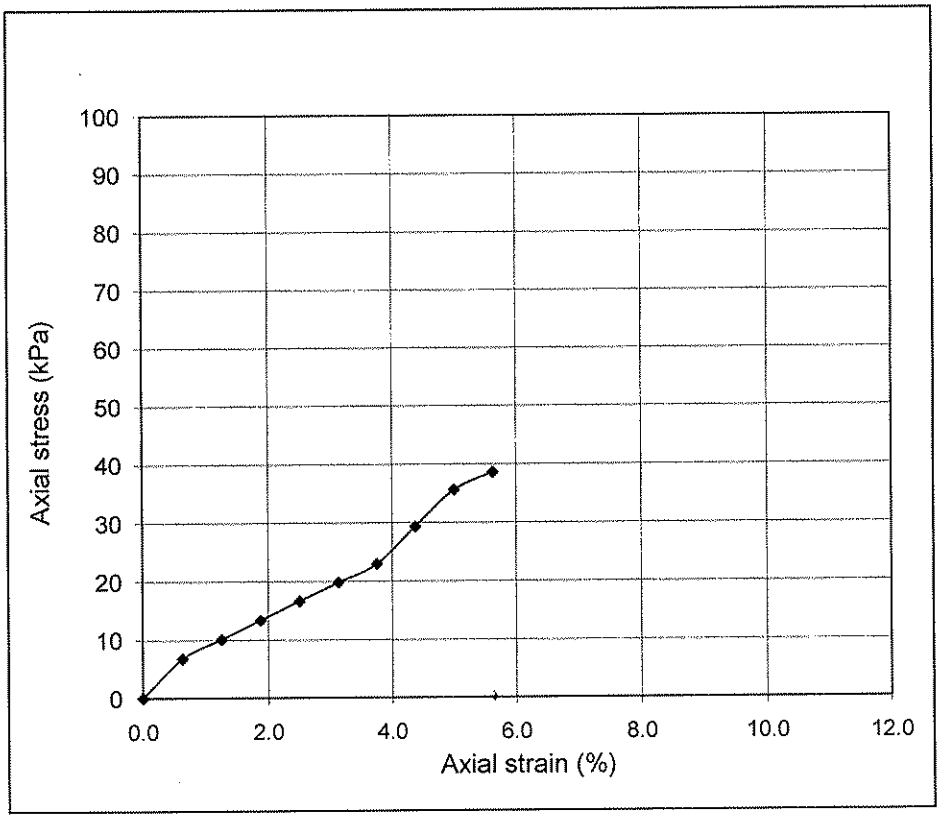
| | | | |
|---|---|---|---|
| **Project:** | Consultancy Services for Feasibility Study and Transaction Advisory Services (TAS) for Three Urban Roads in Karachi Package 1: Link Road at Korangi & Interchange at ICI Bridge (ICI) | **Job No.** | 3879 |
| | | **Dated:** | 15/9/2020 |
| **Client:** | NESPAK (Pvt) Ltd. | | |

| | | | |
|---|---|---|---|
| | | Height = | 10.16 cm |
| **BH/TP No.** | BH-2 | Diameter = | 5.08 cm |
| **Sample No.** | WS-2 | Bulk Density = | 21.9 kN/m$^3$ |
| **Depth (m)** | 34.22-34.34 | Moisture Content = | 11.01 % |

Uniaxial Compression Strength = **38 kPa**



**Test Method: ASTM D7012**




ired by:

Checked by:

Director

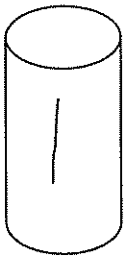
# University of Engineering & Technology, Lahore
## Department of Civil Engineering
## Geotechnical Engineering Laboratory

## UNIAXIAL COMPRESSION TEST

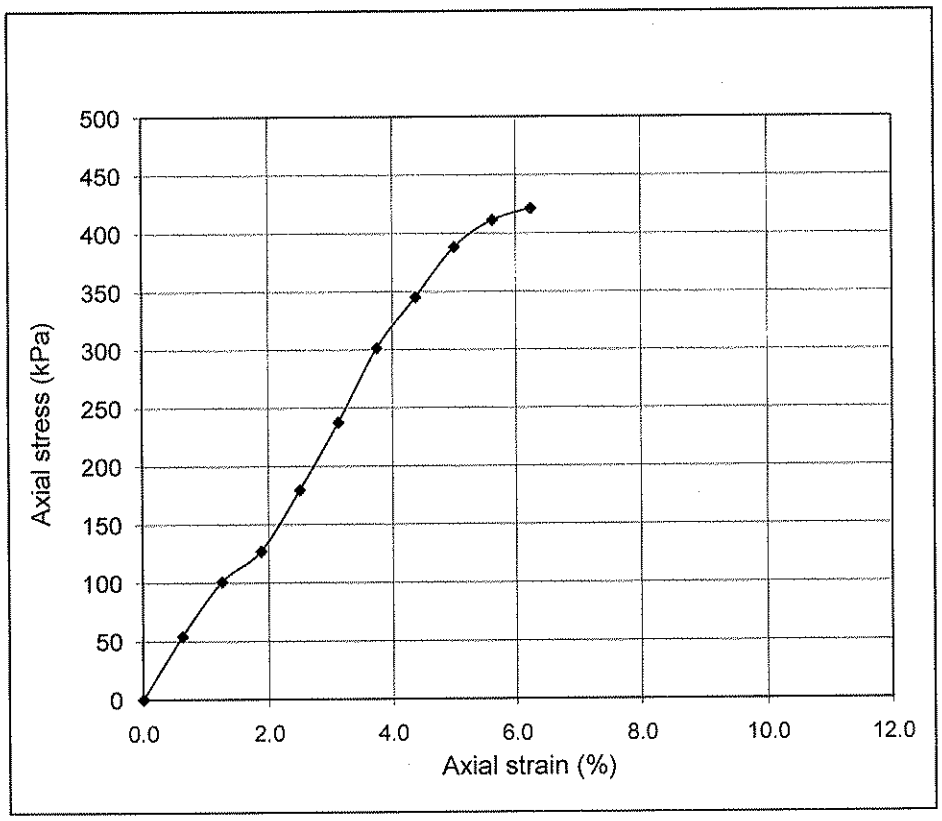
| | | | |
|---|---|---|---|
| **Project:** | Consultancy Services for Feasibility Study and Transaction Advisory Services (TAS) for Three Urban Roads in Karachi Package 1: Link Road at Korangi & Interchange at ICI Bridge (ICI) | **Job No.** | 3879 |
| | | **Dated:** | 15/9/2020 |
| **Client:** | NESPAK (Pvt) Ltd. | | |

| | | | |
|---|---|---|---|
| | | Height = | 10.16 cm |
| **BH/TP No.** | BH-2 | Diameter = | 5.08 cm |
| **Sample No.** | WS-4 | Bulk Density = | 24.3 kN/m$^3$ |
| **Depth (m)** | 35.75 - 35.87 | Moisture Content = | 9.07 % |

Uniaxial Compression Strength = **421 kPa**



**Test Method: ASTM D7012**




red by:

Checked by:

Director

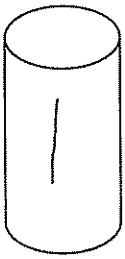
# University of Engineering & Technology, Lahore
## Department of Civil Engineering
## Geotechnical Engineering Laboratory

## UNIAXIAL COMPRESSION TEST

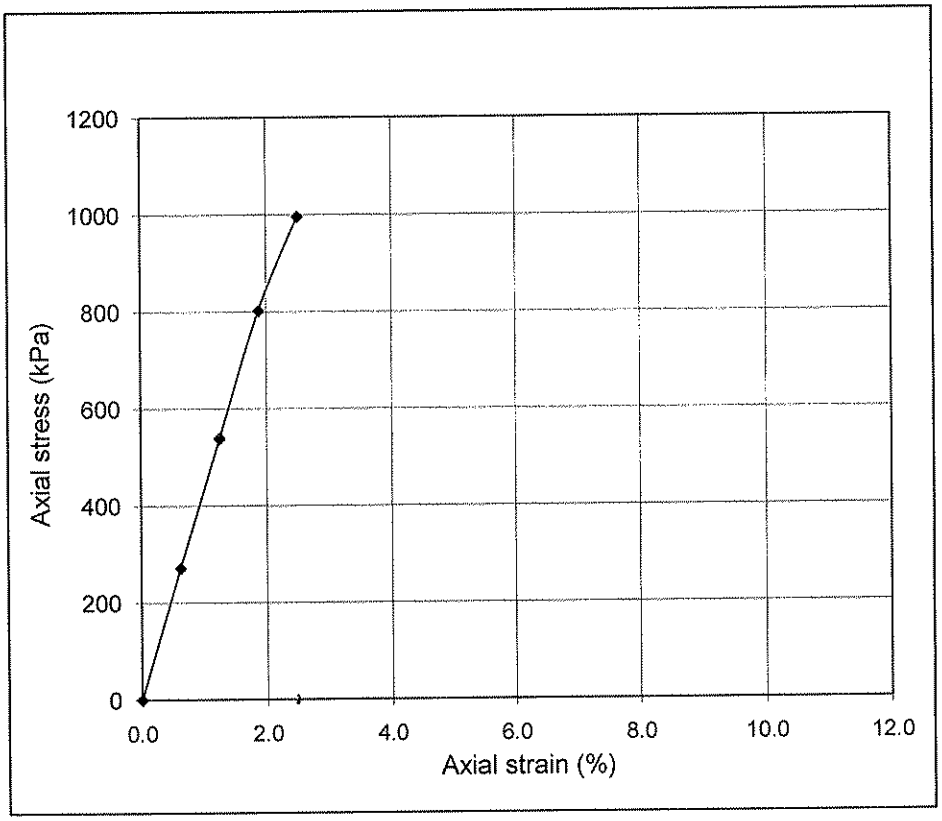
| | | | |
|---|---|---|---|
| **Project:** | Consultancy Services for Feasibility Study and Transaction Advisory Services (TAS) for Three Urban Roads in Karachi Package 1: Link Road at Korangi & Interchange at ICI Bridge (ICI) | **Job No.** | 3879 |
| | | **Dated:** | 15/9/2020 |
| **Client:** | NESPAK (Pvt) Ltd. | | |

| | | | |
|---|---|---|---|
| | | Height = | 10.16 cm |
| **BH/TP No.** | BH-2 | Diameter = | 5.08 cm |
| **Sample No.** | WS-6 | Bulk Density = | 21.4 kN/m$^3$ |
| **Depth (m)** | 36.10-36.28 | Moisture Content = | 5.02 % |

Uniaxial Compression Strength = **1000 kPa**



**Test Method: ASTM D7012**




Checked by:

Director

# SOILCON

GEOTECHNICAL TESTING LABORATORIES, 18-K.M. MULTAN ROAD, LAHORE. Phone No. 37510942-3, Fax No. 37515267


**Dated: 23.09.2020**

**To,**

M/s: Soil Testing Service,
Karachi.

Subject: **NON TESTED SAMPLE(S).**

It is submitted that the following is the detail of non-tested samples of TAS for 03 Urban Road Projects in Karachi (package 1 & 2):

| Sr. No. | BH / TP # | Sample No. | Depth (m) | Test Required | Reason | Remarks |
|---|---|---|---|---|---|---|
| 01 | BH-1 | UDS-1 | 8.50-9.30 | Direct Shear | Due to gravelly strata | Package-1 |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Submitted for kind information please.

**(Ghulam Mahmood Butt)**
Supervisor, SOILCON

**SOILCON**
GEOTECHNICAL TESTING LABORATORIES, 18-K.M. MULTAN ROAD, LAHORE. Phone No. 37510942-3, Fax No. 37515267

**Dated: 30.09.2020**

**To,**

M/s: Soil Testing Service,
Karachi.

Subject: **NON TESTED SAMPLE(S).**

It is submitted that the following is the detail of non-tested samples of TAS for 03 Urban Road Projects in Karachi (package 1 & 2):

| Sr. No. | BH / TP # | Sample No. | Depth (m) | Test Required | Reason | Remarks |
|---|---|---|---|---|---|---|
| 01 | BH-2 | UDS-1 | 7.50-8.40 | Direct Shear | Due to gravelly strata | Package-1 |
| 02 | BH-5 | UDS-1 | 650-7.40 | Direct Shear | Due to clayey and gravelly strata | Package-2 |
| | | | | | | |
| | | | | | | |

Submitted for kind information please.

**(Ghulam Mahmood Butt)**
Supervisor, SOILCON

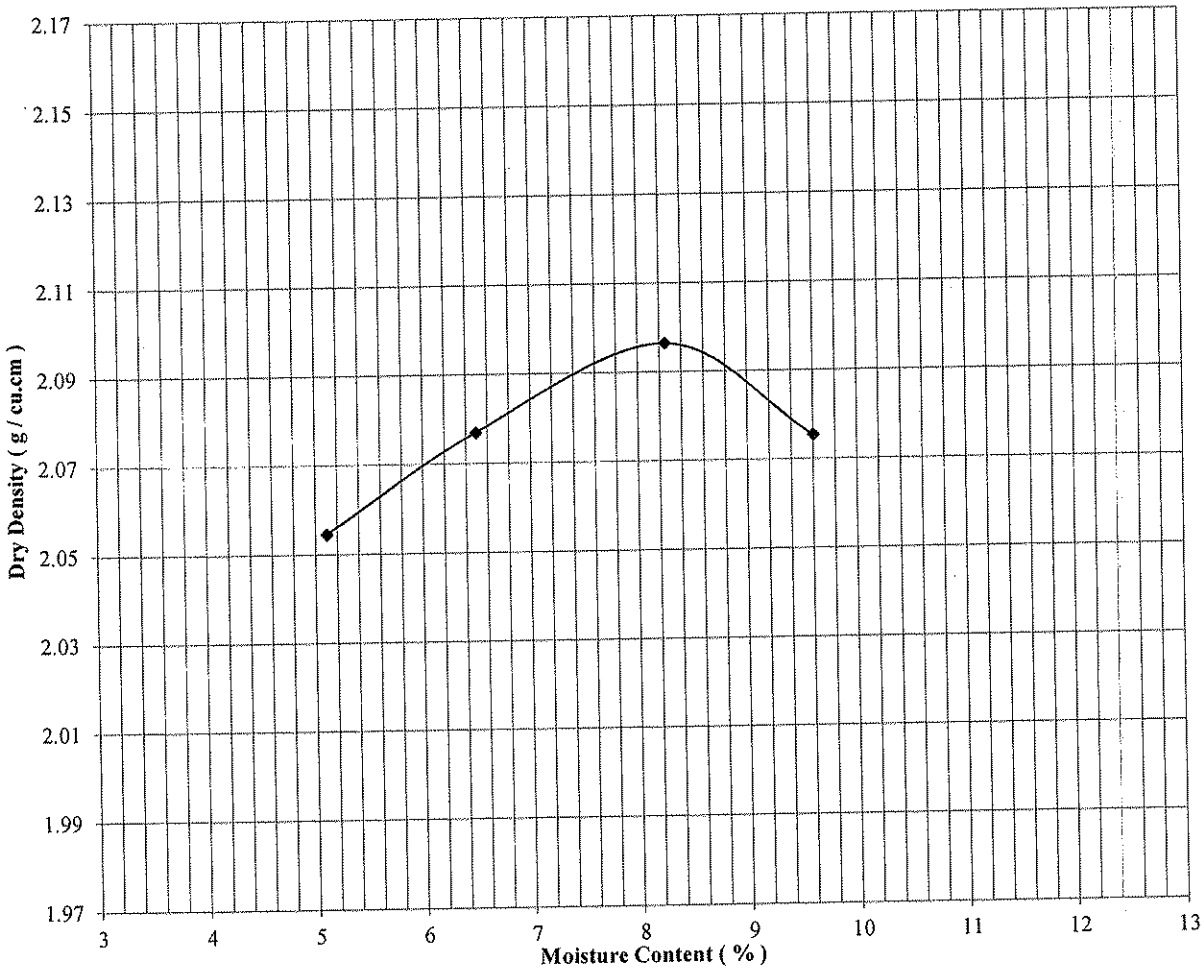
# SOILCON

# COMPACTION TEST

**SOILCON GEOTECHNICAL TESTING LABORATORIES**
18-Km Multan Road Lahore, Ph.No: 042-7510942-3 Fax No: 7510944

**Test Method :** Modified AASHTO T-180 (Method A)
**Dia of Mould :** 4.0 inch
**No of blows :** 25 **No of Layers** 5
**Test Pit No:** TP-2 **Sample No.** CS-2

**Volume of Mould :** 954 $cm^3$
**Drop :** 18 inch
**Wt of Hammer :** 10 lbs
**Depth (m):** 0.79-1.45




| | | | | | |
|---|---|---|---|---|---|
| **Optimum Moisture Content ( % )** | | 8.25 | **Maximum Dry Density** | | 2.096 $g/cm^3$ |
| **Project:** | **TAS FOR THREE URBAN ROAD PROJECTS IN KARACHI** | | | | |
| **Location :** | **KARACHI** | | | **Client: STS** | |
| **Tested By** | | **Checked By** | | **Dated** | **LAB. REF** |
| **Mahmood** | | **Ikram** | | **06.10.2020** | **61/2020** |

**REMARKS:**

# SOILCON

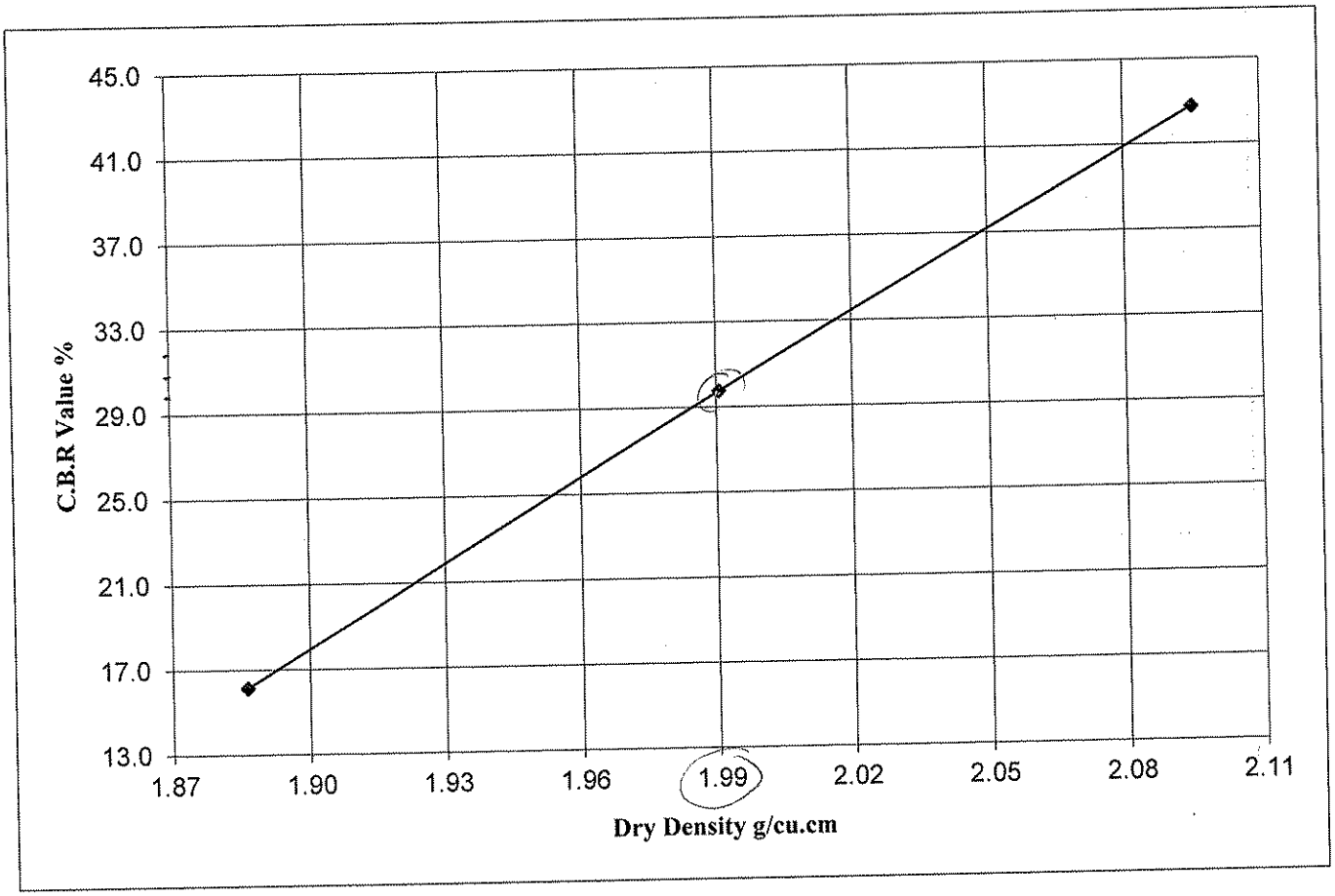
GEOTECHNICAL TESTING LABORATORIES, 18-Km,
MULTAN ROAD, LAHORE

# C.B.R. TEST

( AASHTO T-193 )

| No.of Blows per Layer | 65 | 30 | 10 |
|---|---|---|---|
| CBR Value at 0.1 in % | | | |
| CBR Value at 0.2 in % | 42.8 | 29.8 | 16.1 |
| Dry Density g/ cm $^3$ | 2.095 | 1.991 | 1.886 |
| Moisture Content % | 7.99 | 7.99 | 7.99 |
| Absorption % | 1.37 | 2.32 | 3.21 |
| Swelling % | | - | |

| COMPACTION | MODIFIED |
|---|---|
| M.D.D. g/cu.cm | 2.096 |
| O.M.C % | 8.25 |




| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | TAS FOR THREE URBAN ROAD PROJECTS IN KARACHI | | | | |
| LOCATION: | KARACHI | | | CLIENT | STS |
| TP NO: | TP-2 | SAMPLE NO: | CS-2 | DEPTH (m) | 0.79-1.45 |
| LAB REF. NO : | 61/20 | DATE : | 13.10.2013 | | |
| TESTED BY : Mahmood | | | CHECKED BY : Ikram | | |

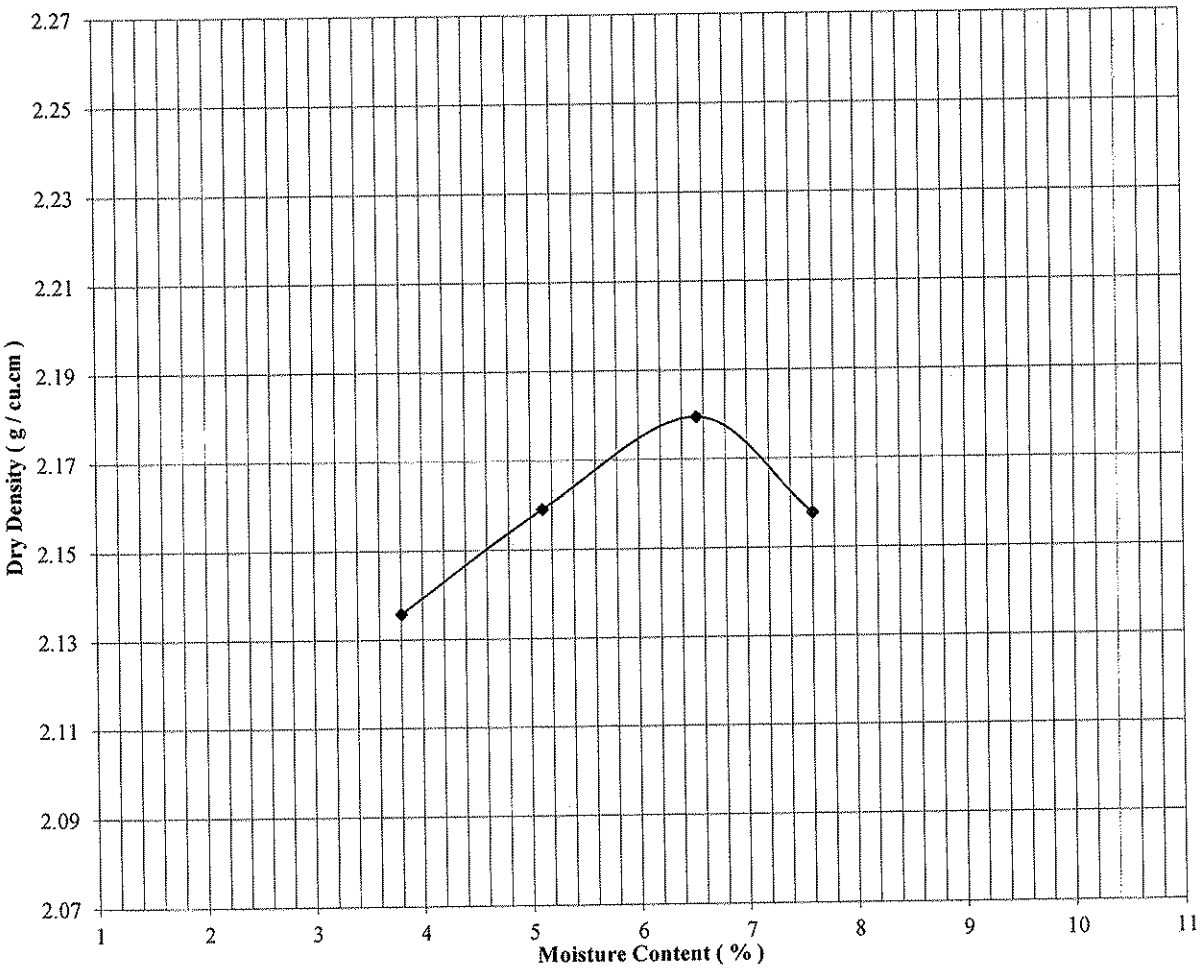
# SOILCON

# COMPACTION TEST

**SOILCON GEOTECHNICAL TESTING LABORATORIES**
18-Km Multan Road Lahore, Ph.No: 042-7510942-3 Fax No: 7510944

**Test Method :** Modified AASHTO T-180 (Method A)
**Dia of Mould :** 4.0 inch
**No of blows :** 25 **No of Layers** 5
**Test Pit No:** TP-3 **Sample No.** CS-2

**Volume of Mould :** 954 $cm^3$
**Drop :** 18 inch
**Wt of Hammer :** 10 lbs
**Depth (m):** 0.57-1.20




| | | | | | |
|---|---|---|---|---|---|
| **Optimum Moisture Content ( % )** | | 6.53 | **Maximum Dry Density** | | 2.179 g/$cm^3$ |
| **Project:** | **TAS FOR THREE URBAN ROAD PROJECTS IN KARACHI** | | | | |
| **Location :** | **KARACHI** | | | **Client: STS** | |
| **Tested By** | | **Checked By** | | **Dated** | **LAB. REF** |
| **Mahmood** | | **Ikram** | | **06.10.2020** | **61/2020** |

**REMARKS:**

# SOILCON

GEOTECHNICAL TESTING LABORATORIES, 18-Km,
MULTAN ROAD, LAHORE

# C.B.R. TEST

( AASHTO T-193 )

| No.of Blows per Layer | 65 | 30 | 10 |
|---|---|---|---|
| CBR Value at 0.1 in % | | | |
| CBR Value at 0.2 in % | 47.8 | 32.6 | 17.2 |
| Dry Density g/ cm $^3$ | 2.178 | 2.070 | 1.960 |
| Moisture Content % | 6.43 | 6.43 | 6.43 |
| Absorption % | 0.92 | 1.75 | 2.83 |
| Swelling % | | - | |

| COMPACTION | MODIFIED |
|---|---|
| M.D.D. g/cu.cm | 2.179 |
| O.M.C % | 6.53 |


| | | | | | |
|---|---|---|---|---|---|
| PROJECT: | TAS FOR THREE URBAN ROAD PROJECTS IN KARACHI | | | | |
| LOCATION: | KARACHI | | | CLIENT | STS |
| TP NO: | TP-3 | SAMPLE NO: | CS-2 | DEPTH (m) | 0.57-1.20 |
| LAB REF. NO : | 61/20 | DATE : | 13.10.2013 | | |
| TESTED BY : Mahmood | | | CHECKED BY : Ikram | | |

# SOILCON

GEOTECHNICAL TESTING LABORATORIES

18-Km, Multan Road, Lahore. Ph: 042-7510942-43 Fax:042-7515267


## SUMMARY OF CHEMICAL TEST RESULTS

**Project:** TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI

**Location:** KARACHI

SOIL TESTING SERVICE

Lab. Ref:57/2020

| BH / TP # | Sample # | Depth (m) | Total Dissolved Solids % | Sulphate Contents % (Water Soluble) | Organic Matter % | Chloride Contents % | REMARKS |
|---|---|---|---|---|---|---|---|
| BH-1 | SPT-9 | 9.00-9.45 | | 0.017 | 0.148 | 0.014 | PACKAGE-2 |
| BH-4 | UDS-1 | 10.00-10.55 | | 0.018 | 0.133 | 0.016 | PACKAGE-2 |
| BH-1 | UDS-1 | 8.50-9.30 | | 0.026 | 0.150 | 0.135 | PACKAGE-1 |

**Tested By:** HAMZA Hamza

**Checked By:** UMAIR Umair

**Dated:** 25.09.2020

# SOILCON

GEOTECHNICAL TESTING LABORATORIES

18-Km, Multan Road, Lahore. Ph: 042-7510942-43 Fax:042-7515267


## SUMMARY OF CHEMICAL TEST RESULTS

Project: TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI

Location: KARACHI

SOIL TESTING SERVICE

Lab. Ref:61/2020

| BH / TP # | Sample # | Depth (m) | Total Dissolved Solids % | Sulphate Contents % (Water Soluble) | Organic Matter % | Chloride Contents % | REMARKS |
|---|---|---|---|---|---|---|---|
| BH-2 | UDS-1 | 7.50-8.40 | | 0.011 | 1.016 | 0.006 | PACKAGE-1 |
| BH-12 | SPT-3 | 3.00-3.45 | | 0.119 | 1.477 | 0.343 | PACKAGE-1 |
| BH-2 | UDS-1 | 5.50-6.05 | | 0.013 | 0.596 | 0.554 | PACKAGE-2 |

Tested By: HAMZA

Checked By: UMAIR

Dated: 29.09.2020

# SOILCON

GEOTECHNICAL TESTING LABORATORIES
18-Km, Multan Road, Lahore. Ph: 042-7510942-43 Fax:042-7515267

## SUMMARY OF CHEMICAL TEST RESULTS

**Project:** TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI
**Location:** KARACHI

SOIL TESTING SERVICE
Lab. Ref:57/2020

| BH / TP # | Sample # | Depth (m) | Total Dissolved Solids (ppm) | Sulphate Contents $SO_3$ (Water Soluble) (g/l) | Chloride Content (g/l) | pH Electrometric Method | REMARKS |
|---|---|---|---|---|---|---|---|
| BH-1 | W-S | | 3374 | 3.265 | 8.31 | 5.88 | PACKAGE-2 |
| BH-4 | W-S | | 3389 | 3.567 | 10.33 | 5.65 | PACKAGE-2 |
| BH-1 | W-S | | 6373 | 2.506 | 1.486 | 5.88 | PACKAGE-1 |

**Tested By:** HAMZA
**Checked By:** UMAIR
**Dated:** 25.09.2020

# SOILCON

GEOTECHNICAL TESTING LABORATORIES
18-Km, Multan Road, Lahore. Ph: 042-7510942-43 Fax:042-7515267

## SUMMARY OF CHEMICAL TEST RESULTS

**Project:** TAS FOR 03 URBAN ROAD PROJECTS IN KARACHI
**Location:** KARACHI

SOIL TESTING SERVICE
Lab. Ref:61/2020

| BH / TP # | Sample # | Depth (m) | Total Dissolved Solids (ppm) | Sulphate Contents $SO_3$ (Water Soluble) (g/l) | Chloride Content (g/l) | pH Electrometric Method | REMARKS |
|---|---|---|---|---|---|---|---|
| BH-2 | W-S | | 4813 | 1.598 | 0.998 | 6.28 | PACKAGE-1 |
| BH-12 | W-S | | 3844 | 1.858 | 11.18 | 5.58 | PACKAGE-1 |
| BH-2 | W-S | | 3426 | 0.995 | 1.029 | 5.95 | PACKAGE-2 |
| BH-5 | W-S | | 3376 | 0.788 | 0.819 | 5.75 | PACKAGE-2 |

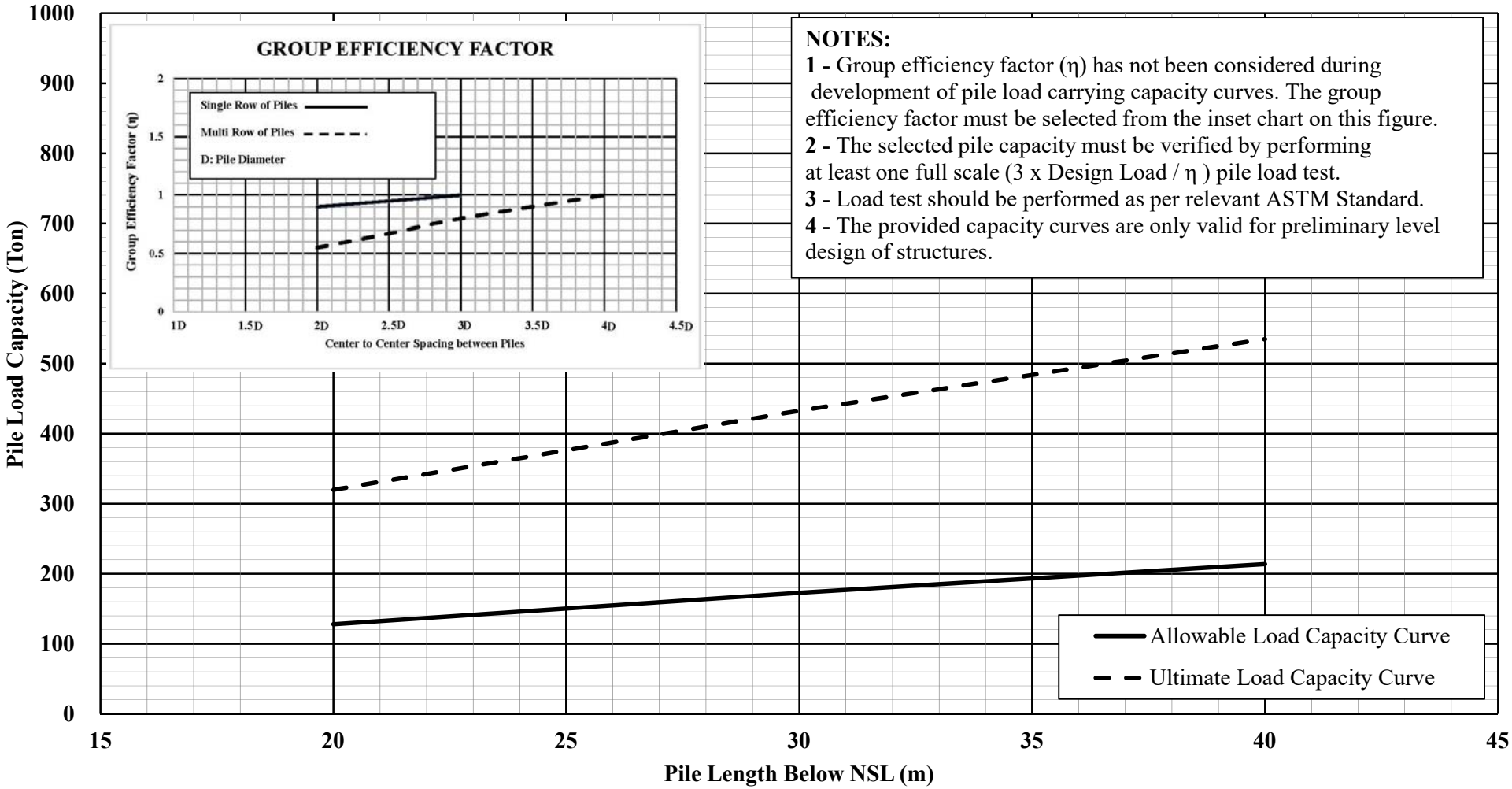
**Tested By:** HAMZA
**Checked By:** UMAIR
**Dated:** 29.09.2020

*APPENDIX-E*

# FOUNDATION PROPORTIONING CURVES

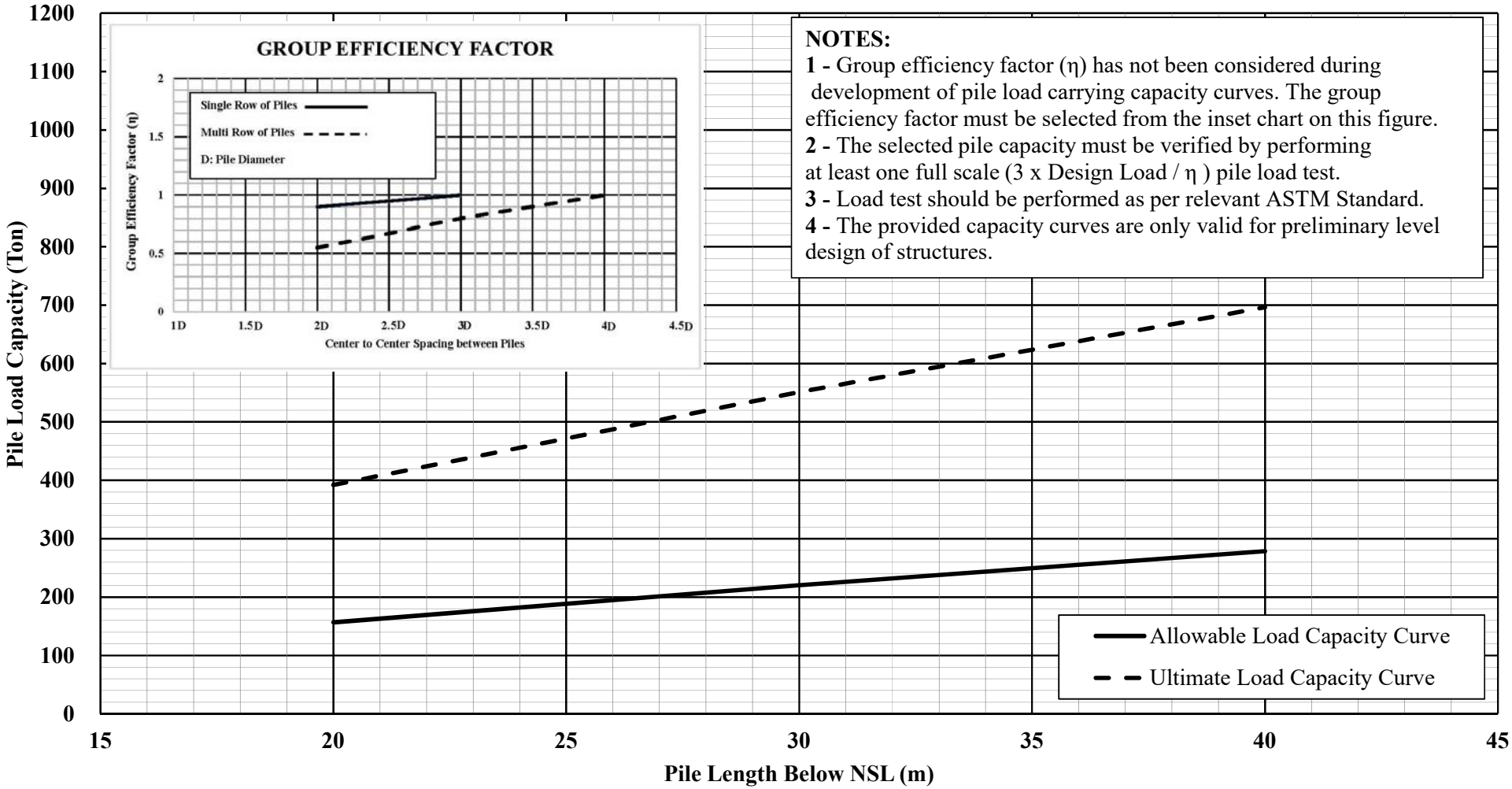
**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES FOR URBAN ROAD INITIATIVE PROJECT**
(Interchange and Retaining Walls at ICI Bridge Intersection)

Load Capacity Curves for 760 mm Diameter Piles under Compression Loading



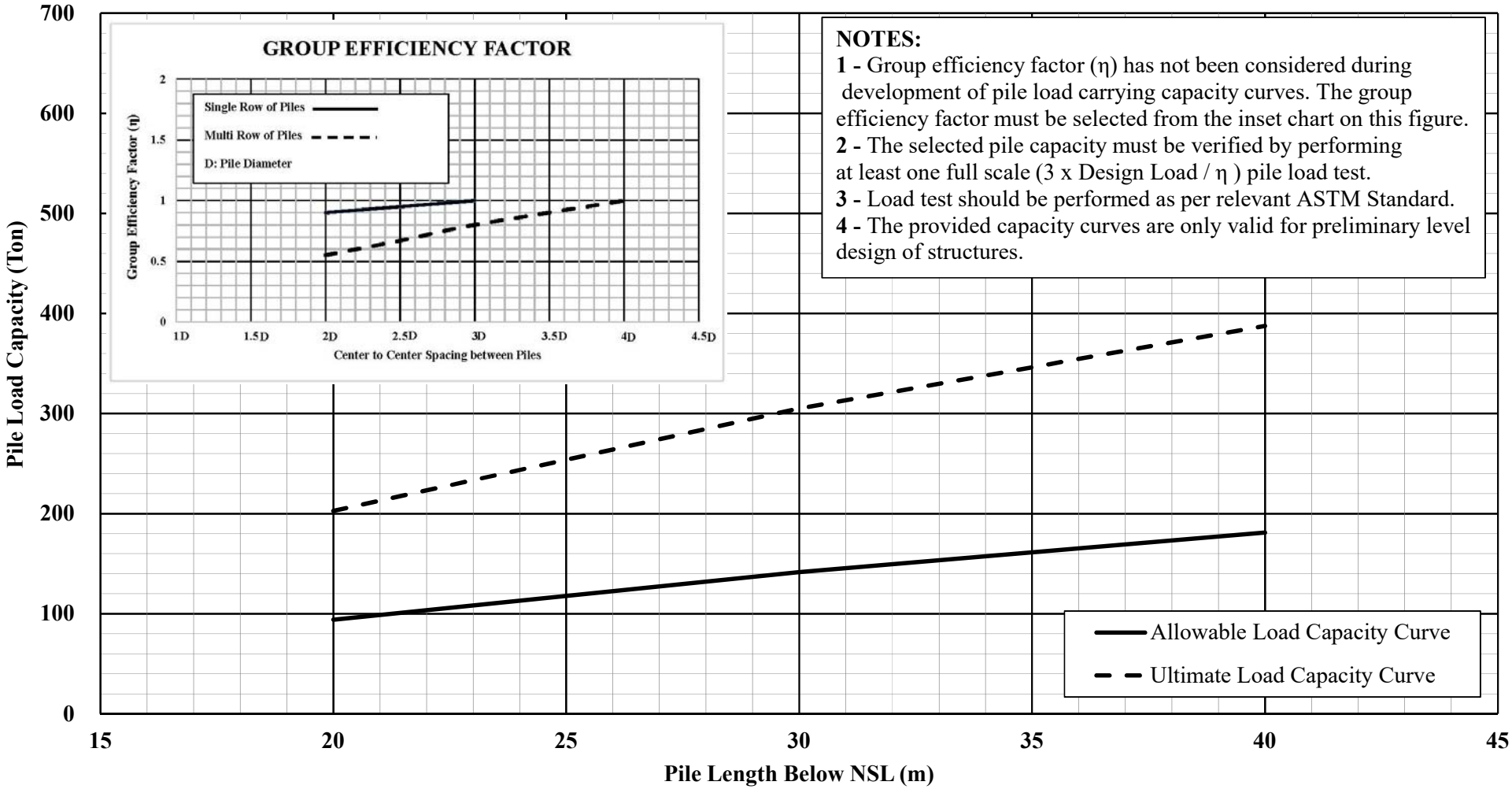
**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES FOR URBAN ROAD INITIATIVE PROJECT**
(Interchange and Retaining Walls at ICI Bridge Intersection)

Load Capacity Curves for 900 mm Diameter Piles under Compression Loading



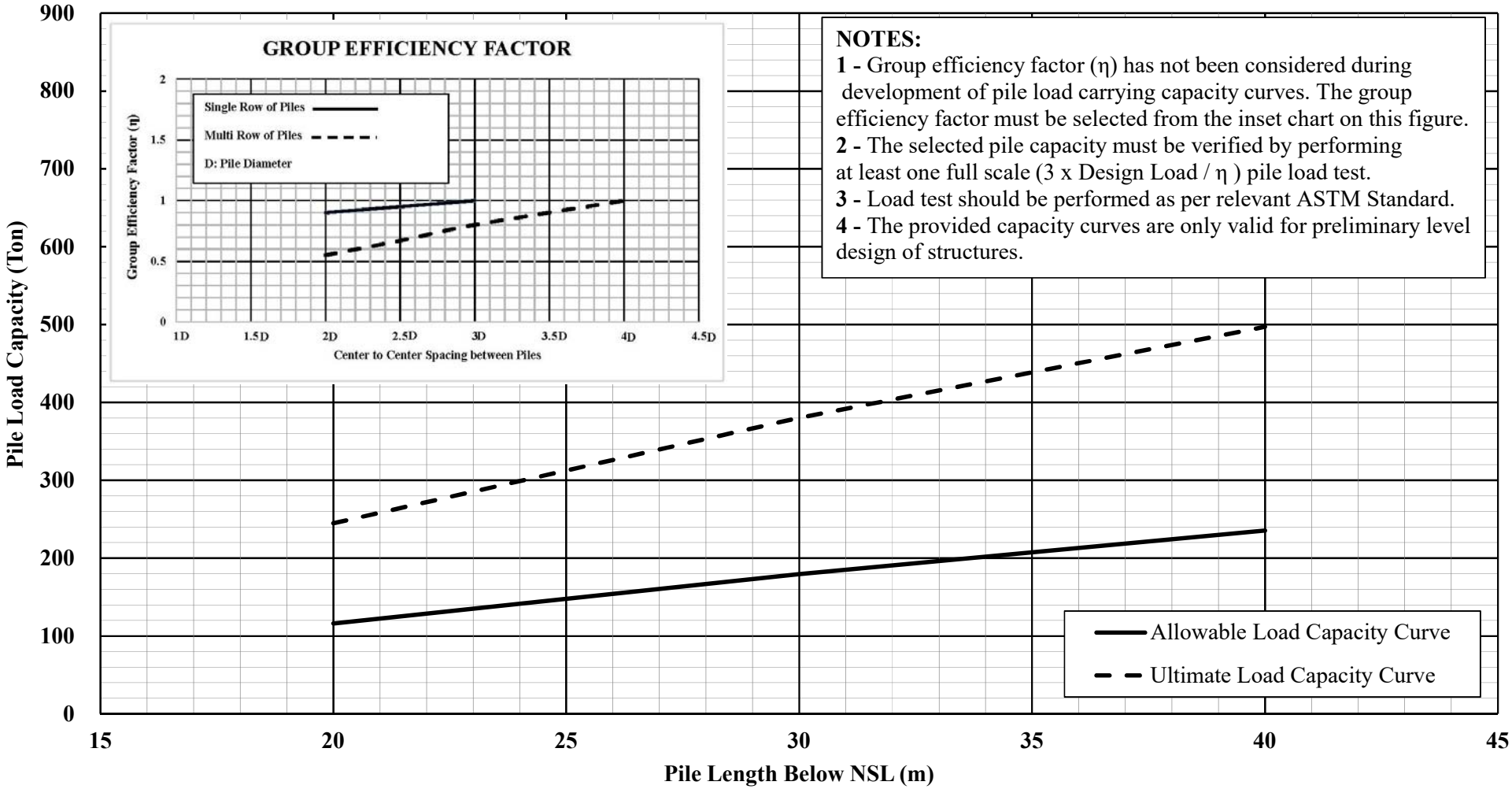
**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES FOR URBAN ROAD INITIATIVE PROJECT**
(Interchange and Retaining Walls at ICI Bridge Intersection)

Load Capacity Curves for 760 mm Diameter Piles under Tensile Loading



**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES FOR URBAN ROAD INITIATIVE PROJECT**
(Interchange and Retaing Walls at ICI Bridge Intersection)

Load Capacity Curves for 900 mm Diameter Piles under Tensile Loading



**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES FOR URBAN ROAD INITIATIVE PROJECT**

**(Interchange and Retaining Walls at ICI Bridge Intersection)**

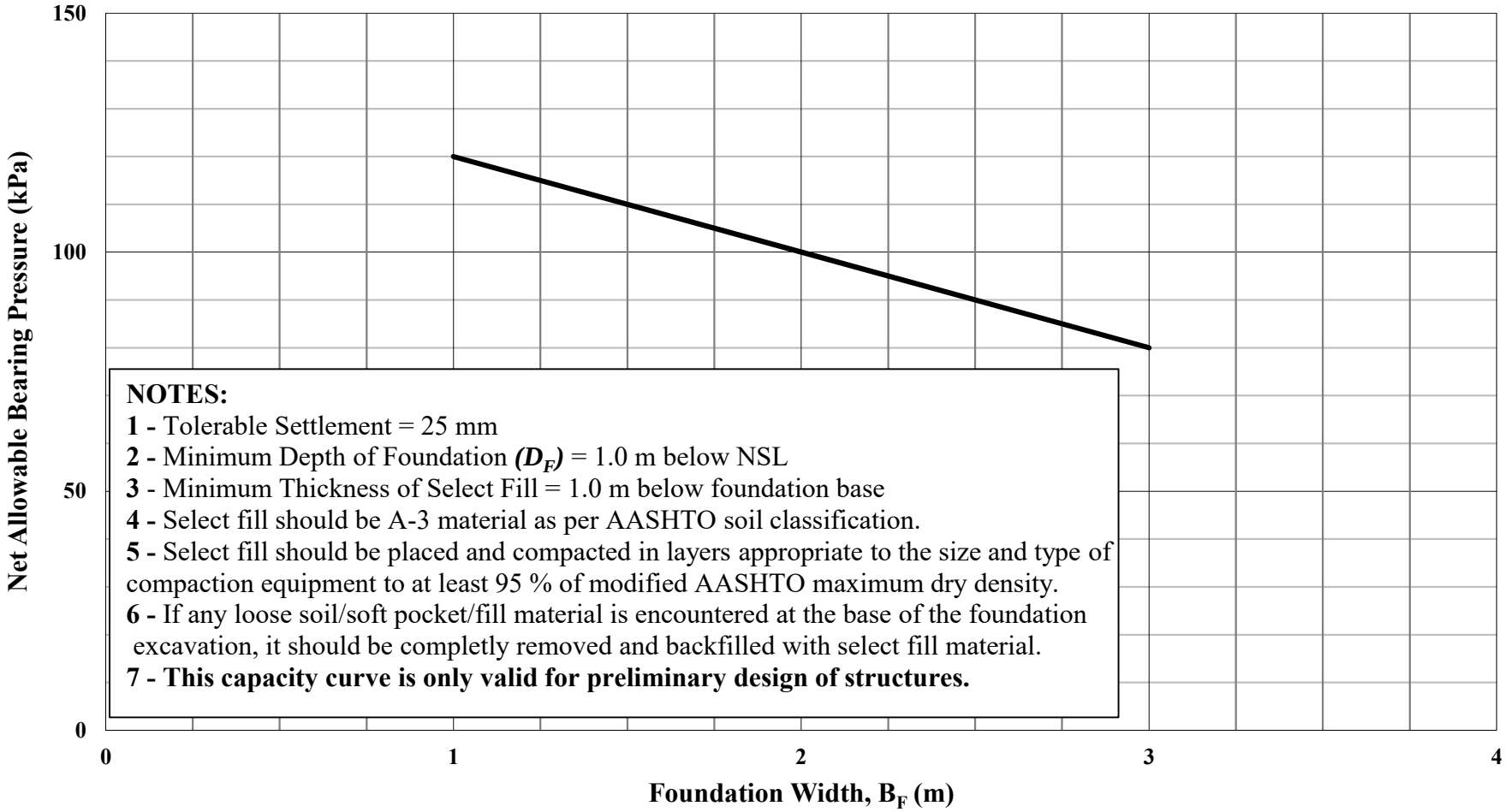
**Soil Spring Stiffnesses**

| Pile Length below NSL (m) | Pile Diameter = 760 mm | | | Pile Diameter = 900 mm | | |
|---|---|---|---|---|---|---|
| | Horizontal Soil Spring Stiffness ($K_{Horizontal}$) | Vertical Soil Spring Stiffness ($K_{Vertical}$) | Soil Spring Stiffness at Pile Tip ($K_{Tip}$) | Horizontal Soil Spring Stiffness ($K_{Horizontal}$) | Vertical Soil Spring Stiffness ($K_{Vertical}$) | Soil Spring Stiffness at Pile Tip ($K_{Tip}$) |
| | $kN/m^3$ | $kN/m^3$ | $kN/m^3$ | $kN/m^3$ | $kN/m^3$ | $kN/m^3$ |
| 1 | 912 | 100 | - | 770 | 150 | - |
| 2 | 1823 | 200 | - | 1540 | 250 | - |
| 3 | 2735 | 300 | - | 2309 | 350 | - |
| 4 | 3646 | 400 | - | 3079 | 450 | - |
| 5 | 4558 | 500 | - | 3849 | 550 | - |
| 6 | 5469 | 600 | - | 4619 | 650 | - |
| 7 | 47858 | 900 | - | 40413 | 1045 | - |
| 8 | 54695 | 1000 | - | 46187 | 1165 | - |
| 9 | 61532 | 1100 | - | 51960 | 1285 | - |
| **10** | **68368** | **1200** | **-** | **57733** | **1405** | **-** |
| 11 | 75205 | 1310 | - | 63507 | 1525 | - |
| 12 | 164084 | 1420 | - | 138560 | 1645 | - |
| 13 | 177758 | 1530 | - | 150107 | 1765 | - |
| 14 | 191432 | 1640 | - | 161653 | 1885 | - |
| 15 | 205105 | 1750 | - | 173200 | 2005 | - |
| 16 | 218779 | 1860 | - | 184747 | 2125 | - |
| 17 | 232453 | 1970 | - | 196293 | 2245 | - |
| 18 | 246126 | 2080 | - | 207840 | 2365 | - |
| 19 | 259800 | 2190 | - | 219387 | 2485 | - |
| **20** | **273474** | **2300** | **40000** | **230933** | **2605** | **70000** |
| 21 | 287147 | 2410 | 40500 | 242480 | 2725 | 70500 |
| 22 | 300821 | 2520 | 41000 | 254027 | 2845 | 71000 |
| 23 | 314495 | 2630 | 41500 | 265573 | 2965 | 71500 |
| 24 | 328168 | 2740 | 42000 | 277120 | 3085 | 72000 |
| 25 | 341842 | 2850 | 42500 | 288667 | 3205 | 72500 |
| 26 | 355516 | 2960 | 43000 | 300213 | 3325 | 73000 |
| 27 | 369189 | 3070 | 43500 | 311760 | 3445 | 73500 |
| 28 | 382863 | 3180 | 44000 | 323307 | 3565 | 74000 |
| 29 | 396537 | 3290 | 44500 | 334853 | 3685 | 74500 |
| **30** | **410211** | **3400** | **45000** | **346400** | **3805** | **75000** |
| 31 | 423884 | 3510 | 45500 | 357947 | 3925 | 75500 |
| 32 | 437558 | 3620 | 46000 | 369493 | 4045 | 76000 |
| 33 | 451232 | 3730 | 46500 | 381040 | 4165 | 76500 |
| 34 | 464905 | 3840 | 47000 | 392587 | 4285 | 77000 |
| 35 | 478579 | 3950 | 47500 | 404133 | 4405 | 77500 |
| 36 | 492253 | 4060 | 48000 | 415680 | 4525 | 78000 |
| 37 | 505926 | 4170 | 48500 | 427227 | 4645 | 78500 |
| 38 | 519600 | 4280 | 49000 | 438773 | 4765 | 79000 |
| 39 | 533274 | 4390 | 49500 | 450320 | 4885 | 79500 |
| **40** | **410211** | **4500** | **50000** | **346400** | **5005** | **80000** |

**NOTE:** The provided soil springs are only valid for preliminary level design of structures.

**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES FOR URBAN ROAD INITIATIVE PROJECT**
**(Light Poles for Interchange at ICI Bridge )**

**FOUNDATION PROPORTIONING CURVE FOR SQUARE FOUNDATION**




**NOTES:**
**1 -** Tolerable Settlement = 25 mm
**2 -** Minimum Depth of Foundation ***($D_F$)*** = 1.0 m below NSL
**3** - Minimum Thickness of Select Fill = 1.0 m below foundation base
**4 -** Select fill should be A-3 material as per AASHTO soil classification.
**5 -** Select fill should be placed and compacted in layers appropriate to the size and type of compaction equipment to at least 95 % of modified AASHTO maximum dry density.
**6 -** If any loose soil/soft pocket/fill material is encountered at the base of the foundation excavation, it should be completly removed and backfilled with select fill material.
**7 - This capacity curve is only valid for preliminary design of structures.**

*APPENDIX-F*

# SITE PHOTOGRAPHS

**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES,**

**'URBAN ROAD INITIATIVES IN KARACHI'**

**(Sub Project 3: Interchange at ICI Bridge)**

**Plate-1: Location of BH-01 at ICI Bridge**

**Plate-2: Performance of Standard Penetration Test (SPT)**

**Plate-3: A View of Soil Sample Recovered in Split Spoon Sampler**


**Plate-4: Performance of Field Density Test in Base Course Layer**

**FEASIBILITY STUDY AND TRANSACTION ADVISORY SERVICES,**

**‘URBAN ROAD INITIATIVES IN KARACHI’**

**(Sub Project 3: Interchange at ICI Bridge)**


**Plate-5: Performance of Field Density Test in Subgrade Layer**


**Plate-6: A View of Core Box at BH-01**

# ANNEXURE – 4

# ICI BRIDGE , MAURIPUR ROAD KARACHI

# VISUAL INSPECTION REPORT

**JANUARY, 2021**

National Engineering Services Pakistan (Pvt) Limited
13TH Floor N.I.C. Building, Abbasi Shaheed Road, Off Shahra-e-Faisal, Karachi 74400.
Phone: +92-21-99090000& 99225277 – 84 (08 Lines), Fax: +92-21-35651994, 99225366.
**Email:** karachi@nespak.com.pk, nespakkh@gmail.com
**http://www.nespak.com.pk**

| Clearance Code | | Doc No. | 4188-01 | Rev No. | 00 |
|---|---|---|---|---|---|

VISUAL SITE INSPECTION REPORT OF ICI BRIDGE KARACHI

# SITE INSPECTION REPORT

## TABLE OF CONTENTS

**Page No.**



**ANNEXURES**

# 1. INTRODUCTION

The Local Government of Sindh has initiated urban road projects under PPP mode, to mitigate the congestion problems and provide quick and safe access to the commuters of Karachi. The projects activity includes a new bridge proposed to be constructed over ICI intersection which commute the traffic as a right turn from Mauripur Road to Ghulam Ali Allana Road.

In this regard, Government of Sindh has appointed the consortium led by the KPMG (Lead and Financial Consultant), NESPAK (Technical Consultant) and LEX FIRMA (Legal Consultant) to conduct the feasibility study and transaction advisory services to implement the urban road initiative projects in Karachi.

The proposed flyover shall begin with end abutment followed by a retaining wall at Mauripur Road, whereas the other end of the flyover has been planned in a way to match with the existing ICI Bridge near railway crossing. In this regard, a condition assessment of the existing ICI bridge has been required by the client to inspect the condition of the existing bridge to serve the traffic from the proposed bridge.

In this connection, NESPAK structural engineers visited the ICI bridge on January 14, 2021 and a detailed visual inspection of the bridge was carried out. All the bridge components were visually inspected against any apparent distress/damages and deterioration. Non-destructive test were also carried out at selected locations of accessible elements of the bridge using Schmidt hammer test to assess the strength of concrete of the bridge elements at present.

Results of Non-destructive tests have been attached at Annexure-1 to this report.

Photographs were also taken during the detailed visit and have been attached as Annexure-II to this report.

Our observations, findings and recommendations have been given in the following sections.

## 2. OBSERVATIONS AND FINDINGS

Our observations and findings during the visual inspection are as follows:

a. The structure of ICI bridge is composed of deck, pre-stressed girders resting on transoms over bearings and transoms are supported by multiple piers which transfer the load to the subsoil.

b. Generally, the bridge seems to be in good condition, except at few locations where spalling and cracking of concrete have been observed due to corrosion of reinforcing bars.

c. The girders and deck were observed to be in good condition throughout the length

d. The footpath planks were found to be damaged at various places along the length of the bridge and beams/girders which support the planks were also observed to be damaged. Some of the planks and the supporting beams were found to be fallen from the bridge which might have been occurred due to road accidents.

e. The side rails of bridge were composed of cast-in-place vertical posts with precast wall elements. Side rail were generally observed to be in good condition except at some locations where these were found to be damaged perhaps due to road accidents.

f. The bearing pads of the bridge were very thin and hence could not be inspected.

g. Spalling of concrete, detachment of concrete cover and honey combing were observed in transoms at few locations, specially near the existing railway line. Reinforcement bars were also observed to be corroded at location of spalling and detachment of concrete cover.

h. Surface deteriorations, cracks and detachment of concrete were observed in some piers at location of ground as shown in pictures attached as annexure II.

i. Cracks were observed in concrete along the length of the expansion joints at some locations. However, the expansion joints were generally found to be ok.

j. The result of Non-destructive tests have been summarized in Table 1 below. However, the detailed results have been attached as Annexure-I to this report.

Table-1: Summary of Non-Destructive Test Results

| S.No. | Structural Elements | Average Cubical Strength of Concrete (Psi) | Average Cylindrical Strength of Concrete (Psi) |
|---|---|---|---|
| 1. | Deck | 8833 | 8480 |
| 2. | Girders | 8659 | 8315 |
| 3. | Transoms | 8905 | 8550 |
| 4. | Piers | 8579 | 8236 |

# 3. CONCLUSION AND RECOMMENDATIONS

Based on our observations, findings and Non-destructive testing carried out during the visual inspection, it is concluded that the major load carrying structural components of the bridge apparently seem to be in good condition except at some locations where repair works are required. Following are our recommendations for the required repair works.

a. All the loose, deteriorated and cracked concrete of structural elements should be removed. The corroded reinforcement should be cleaned with sand blasting. For severely corroded reinforcement where cross sectional area of rebars has been reduced by more than 30 percent of the original cross-sectional area of the rebars, new steel rebars of same diameter shall be installed. Corrosion inhibiting protective coating as approved by the engineer shall be applied on the exposed and new rebars. Epoxy bonding agent shall be applied on existing exposed concrete surface. Shotcreting shall be carried out with micro concrete of strength equal to or greater than the original strength of the structural component.
b. All the damaged footpath planks should be replaced with new planks.
c. Damaged and fallen beams supporting the footpath planks should be removed and new beams should be recast along with the railing posts. The railing posts and planks shall be installed to match with the existing railings.
d. Cracked and eroded concrete in either side of the expansion joint should be removed and to be filled with high strength cementitious grout after application of epoxy bonding agent on the exposed concrete surface. New expansion joint shall be installed with high strength cementitious grout where the existing expansion joint is broken, missing or deteriorated.

It is suggested that all the repair works should be carried out preferably in non-operational condition of the bridge and supports/shoring shall be installed around the member under repair to support the load carried by the same.

However, if vehicular movement on the bridge is inevitable during the repair works then special arrangements shall be undertaken and proper formworks/shoring shall be installed below all the girders of both the adjacent spans of transom/pier under the repair work.

# ANNEXURES

# ANNEXURE-I

# NDT RESULTS

**NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED**
13TH Floor N.I.C. Building, Abbasi Shaheed Road, Off Shahra-e-Faisal, Karachi 74400.

# REBOUND HAMMER TEST RESULT

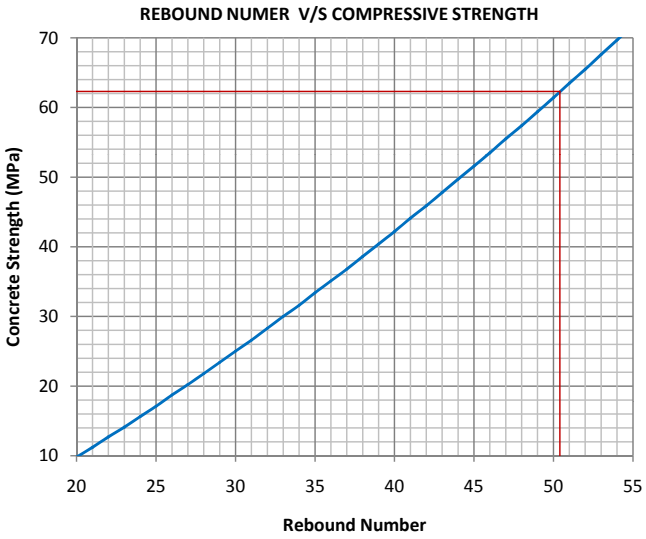
**DEVICE:** **PROCEQ SCHMIDT HAMMER**
**MODEL:** **N-34**

**TEST ID:** 30INCHES DIA
**LOCATION:** ICI BRIDGE
**MEMBER TYPE:** COLUMN
**INSTRUMENT ORIENTATION:** HORIZONTAL

## REBOUND READINGS:

| S.No. | READING |
|---|---|
| 1 | 50 |
| 2 | 50 |
| 3 | 48 |
| 4 | 54 |
| 5 | 52 |
| 6 | 50 |
| 7 | 50 |
| 8 | 50 |
| 9 | 50 |
| 10 | 50 |

## GRAPH




**AVERAGE REBOUND READING:** 50.4

**CONCRETE STRENGTH:** **62.3** **MPa**
**9079** **PSI**

**NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED**
13TH Floor N.I.C. Building, Abbasi Shaheed Road, Off Shahra-e-Faisal, Karachi 74400.

# REBOUND HAMMER TEST RESULT

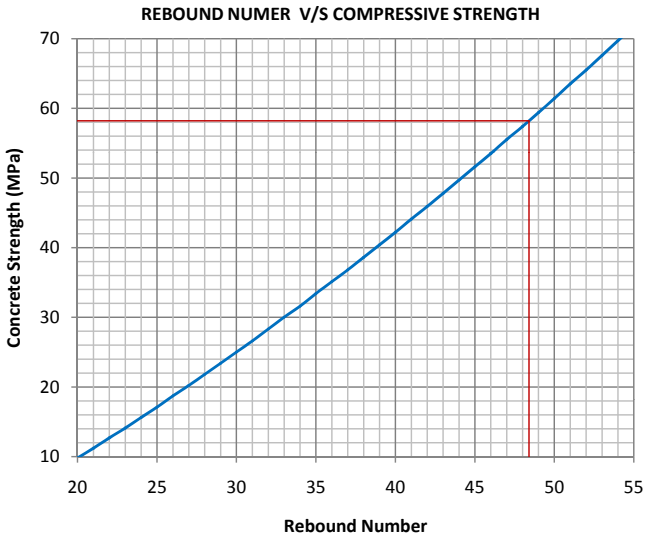
**DEVICE:** **PROCEQ SCHMIDT HAMMER**
**MODEL:** **N-34**

**TEST ID:** 36INCHES DIA
**LOCATION:** ICI BRIDGE
**MEMBER TYPE:** COLUMN
**INSTRUMENT ORIENTATION:** HORIZONTAL

## REBOUND READINGS:

| S.No. | READING |
|---|---|
| 1 | 50 |
| 2 | 48 |
| 3 | 50 |
| 4 | 52 |
| 5 | 40 |
| 6 | 42 |
| 7 | 48 |
| 8 | 48 |
| 9 | 50 |
| 10 | 56 |

## GRAPH




**AVERAGE REBOUND READING:** 48.4

**CONCRETE STRENGTH:** 58.2 **MPa**
8079 **PSI**

**NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED**
13TH Floor N.I.C. Building, Abbasi Shaheed Road, Off Shahra-e-Faisal, Karachi 74400.

# REBOUND HAMMER TEST RESULT

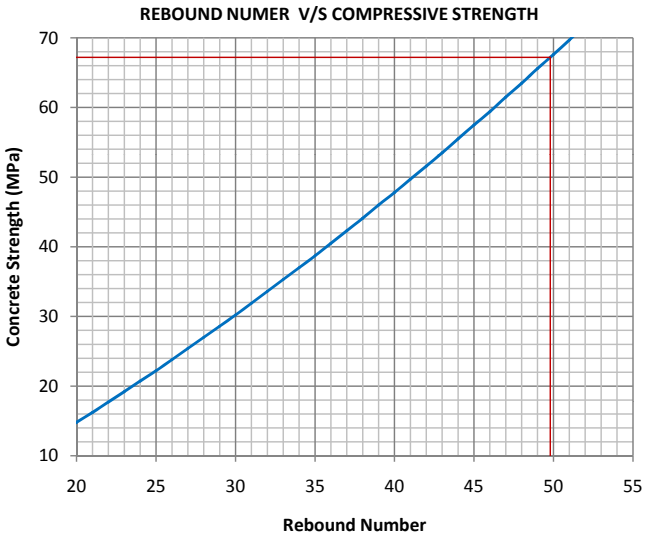
**DEVICE:** **PROCEQ SCHMIDT HAMMER**
**MODEL:** **N-34**

**TEST ID:** DECK
**LOCATION:** ICI BRIDGE
**MEMBER TYPE:** SLAB
**INSTRUMENT ORIENTATION:** VERTICAL (DOWNWARD)

## REBOUND READINGS:

| S.No. | READING |
|---|---|
| 1 | 50 |
| 2 | 46 |
| 3 | 52 |
| 4 | 52 |
| 5 | 48 |
| 6 | 50 |
| 7 | 50 |
| 8 | 50 |
| 9 | 50 |
| 10 | 50 |

## GRAPH




**AVERAGE REBOUND READING:** 49.8

**CONCRETE STRENGTH:** 67.2 **MPa**
8833 **PSI**

**NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED**
13TH Floor N.I.C. Building, Abbasi Shaheed Road, Off Shahra-e-Faisal, Karachi 74400.

# REBOUND HAMMER TEST RESULT

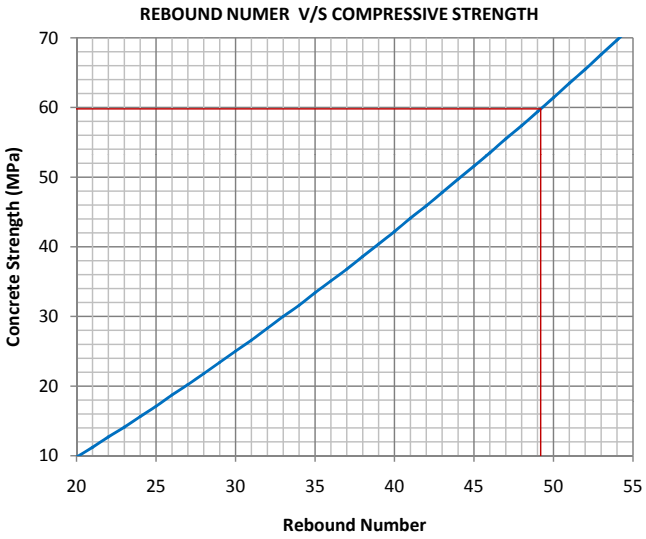
**DEVICE:** **PROCEQ SCHMIDT HAMMER**
**MODEL:** **N-34**

**TEST ID:** GIRDER
**LOCATION:** ICI BRIDGE
**MEMBER TYPE:** BEAM
**INSTRUMENT ORIENTATION:** HORIZONTAL

## REBOUND READINGS:

| S.No. | READING |
|---|---|
| 1 | 50 |
| 2 | 48 |
| 3 | 48 |
| 4 | 48 |
| 5 | 50 |
| 6 | 50 |
| 7 | 50 |
| 8 | 48 |
| 9 | 50 |
| 10 | 50 |

## GRAPH




**AVERAGE REBOUND READING:** 49.2

**CONCRETE STRENGTH:** 59.8 **MPa**
8659 **PSI**

**NATIONAL ENGINEERING SERVICES PAKISTAN (PVT.) LIMITED**
13TH Floor N.I.C. Building, Abbasi Shaheed Road, Off Shahra-e-Faisal, Karachi 74400.

# REBOUND HAMMER TEST RESULT

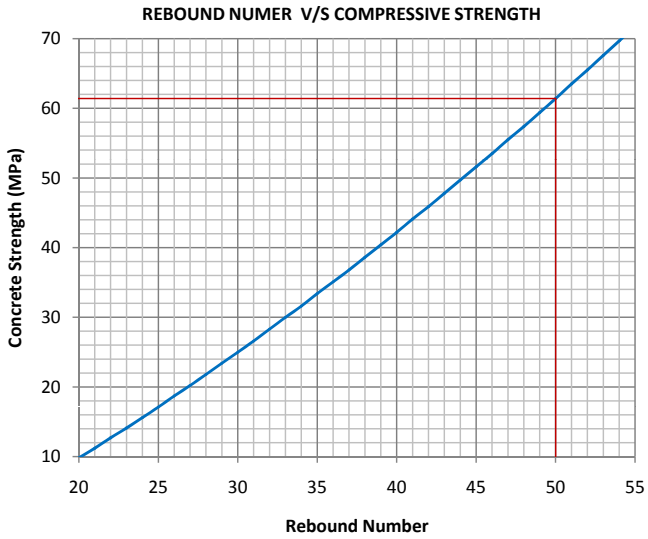
**DEVICE:** **PROCEQ SCHMIDT HAMMER**
**MODEL:** **N-34**

**TEST ID:** TRANSOM
**LOCATION:** ICI BRIDGE
**MEMBER TYPE:** BEAM
**INSTRUMENT ORIENTATION:** HORIZONTAL

## REBOUND READINGS:

| S.No. | READING |
|---|---|
| 1 | 50 |
| 2 | 50 |
| 3 | 52 |
| 4 | 48 |
| 5 | 50 |
| 6 | 50 |
| 7 | 50 |
| 8 | 50 |
| 9 | 50 |
| 10 | 50 |

## GRAPH




**AVERAGE REBOUND READING:** 50

**CONCRETE STRENGTH:** 61.4 **MPa**
8905 **PSI**

# ANNEXURE-II

# PHOTOGRAPHS

# Visual Inspection Report

**ICI Bridge , Karachi.**

## Photographs

**01**

**02**

**03**

**04**

**05**

**06**

# Visual Inspection Report

**ICI Bridge , Karachi.**

## Photographs

**07**

**08**

**09**

**10**

**11**

**12**

# Visual Inspection Report

**ICI Bridge , Karachi.**

## Photographs

**13**

**14**

**15**

**16**

**17**

**18**

# Visual Inspection Report

**ICI Bridge , Karachi.**

## Photographs

**19**

**20**

**21**

**22**

**23**

**24**

# ANNEXURE – 6

**LOCAL GOVERNMENT & HTP DEPARTMENT**
**GOVERNMENT OF SINDH**

GOS

**Feasibility Study and Transaction Advisory Services, 'Urban Road Initiatives in Karachi'**

**Sub Project 3: Interchange at ICI Bridge**

# Design Criteria Report

**April 2020**

**National Engineering Services Pakistan (Pvt.) Ltd.**
**13th Floor, N.I.C. Building, Abbasi Shaheed Road, Off. Shahrah-e-Faisal, Karachi**
**Phone: (0092 21) 99207277-84**
**Fax : (0092 21) 35651994**
**E-mail : nespakkh@khi.wol.net.pk**
**Web: http://www.nespak.com.pk**

| | | | | | |
|---|---|---|---|---|---|
| Clearance Code | 38035/50W/PD/18 (20) | Doc No. | P-38035/50P/DC/00 | Rev No. | 01 |

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## List of Tables

**Design Criteria for Sub-Project 3, "Interchange at ICI Bridge"**

# 1 Introduction

## 1.1 Background

Karachi is the largest city, main seaport and the financial center of Pakistan, as well as the capital of the province of Sindh. The metropolitan area of Karachi is spread over 3,500 sq km and has an estimated population of over 18 million. It is one of the world's largest cities in terms of population. It is Pakistan's premier center for banking, industry, economic activity and trade and is home to Pakistan's largest corporations, including those involved in textiles, shipping, automotive, entertainment, the arts, fashion, advertising, publishing, software development and medical research.

The commercial activities generate large volume of traffic within the city. Considerable volume of heavy freight traffic is generated to and from the Karachi Port and Korangi Industrial Area to the rest of the country.

In 1947 Karachi was populated on an area of 83 sq. km. which has presently expanded to 2500 sq. km. Due to the growth in population and the size of the city, the developments led to phenomenal increase in the road vehicles population.

The tremendous increase in population, industrialization and commercial activities in the city has resulted in rapid increase in all kinds of motorized traffic, and it became imperative to avert further aggravation of the problems of the residents.

Karachi maintains a 7,000 km road network. This limited road space combined with poor maintenance, delayed repair work, poor quality construction, and absence of essential support functions creates problems in satisfying the traffic demand. There are many places where large numbers of commuters move at the same time from one location to another, however, the access roads and links offer very few choices and hence there is considerable congestion on the roads specially during the peak hours.
The urban transport needs of a city are cyclic in nature and largely depend on the travel behavior of the citizens. Although the trips made by private and para transit vehicles are increasing, the noticeable feature is that the buses/minibuses still continue to cater to over 50% of the travel demand.

To mitigate the traffic congestion problems and provide quick and safe access to the commuters of Karachi, the local Government of Sindh has initiated three (03) urban road projects under Public Private Partnership (PPP) mode. These three projects are:

a) Sub-project 1: Link Road from Korangi (From KPT Interchange to PAF Airmen Academy),

b) Sub-project 2: Expressway from Mauripur Road (End of Lyari Expressway) to Y Junction (Kakapir Rd/Mauripur Rd Intersection), and
c) Sub-project 3: Interchange at ICI Bridge/Intersection.

In this regard, Government of Sindh has appointed the consortium led by the KPMG (Lead and Financial Consultant), NESPAK (Technical Consultant) and LEX FIRMA (Legal Consultant) to conduct the Feasibility study and Transaction advisory services to implement the urban road initiative projects in Karachi.

## 1.2 Report Purpose

This document provides information related to the design basis, which has been adopted / formulated by different engineering design specialties, to finalize technical data, design assumptions, codes of practice, methods and procedures for Sub-Project 3, Interchange at ICI Bridge of Feasibility Study and Transaction Advisory Services, 'Urban Road Initiatives in Karachi' Local Government & HTP Department, GOS.

## 1.3 Brief of Sub Project 3, “Interchange at ICI Bridge”

ICI intersection is located along Mauripur Road between Jinnah Flyover and Lyari Expressway. It is one of the busiest intersections which carries a large number of heavy vehicles from the East and West Wharves of Karachi Port. Cross street traffic from Kharadar constitutes private vehicles (motorcycles, rickshaws, small cars), which mostly serve the needs of residential area of Kharadar.

The intersection of Mauripur Road with Ghulam Ali Allana Road, commonly known as ICI Bridge Intersection due to its location at the approach to ICI Bridge over Karachi Circular Railway, is among the most congested road junctions in the southern part of the city. It serves the heavy traffic moving between Karachi Port, SITE area and other parts of the country through the Motorway, M10 / Northern Bypass and Site Avenue in addition to the city traffic moving along Mauripur Road from Mai Kolachi Bypass and M.T. Khan Road via Jinnah Bridge and from other areas of the city through Lyari Expressway.

Besides it serves the localized traffic the densely populated adjoining areas of Lyari and other old city areas and the recreational traffic towards the Hawkesbay, Sandspit and Manora beaches.

Heavy traffic congestion is witnessed during most of the day due to non-working signals and high number of heavy vehicles. The major movements at this intersection are the thru movements along Mauripur Road and right-turning traffic from Mauripur Road towards West Wharf Road.

The proposed solution envisages to reduce the overall delays witnessed at this intersection thru construction of flyover (s). Due to non-availability of adequate right-of-way for construction of a high-level interchange at the present at-grade intersection, it may be necessary to acquire land and relocate the adjoining residents to a suitable location. Therefore, land acquisition and resettlement of people (including arrangement of alternate residence for the affected people) shall be an integral component of this proposed project.

## 1.4 Project Location, Proposed Alignment and 3D Views

- Project Location is shown in Figure 1 and Figure 2
- Proposed Alignment is shown in Figure 3
- 3D views are shown in Figure 4, 5 and 6
- Proposed Road Rehabilitation Plan is shown in Figure 7

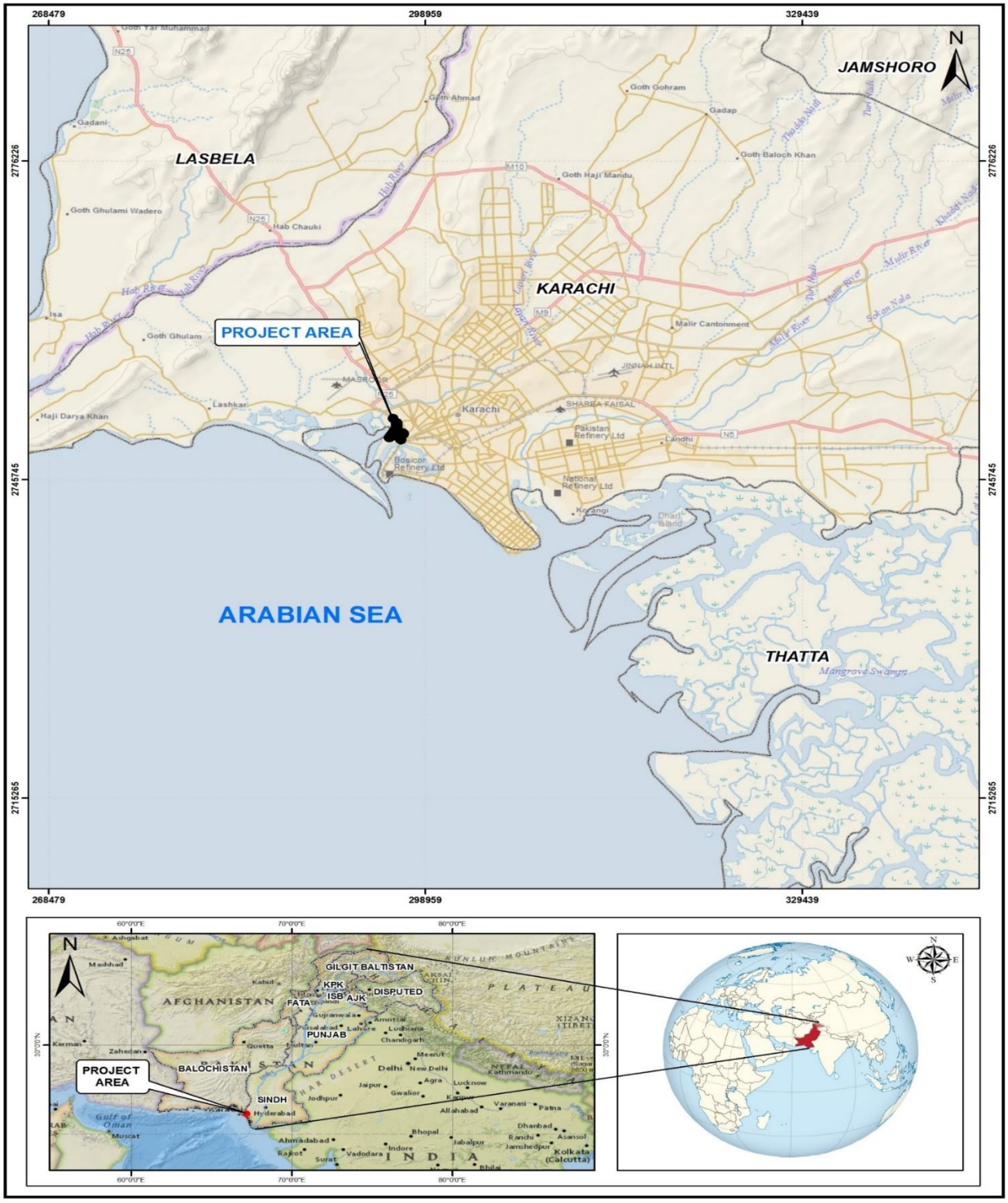



***Figure 1: Project Location***


***Figure 2: Project Location***

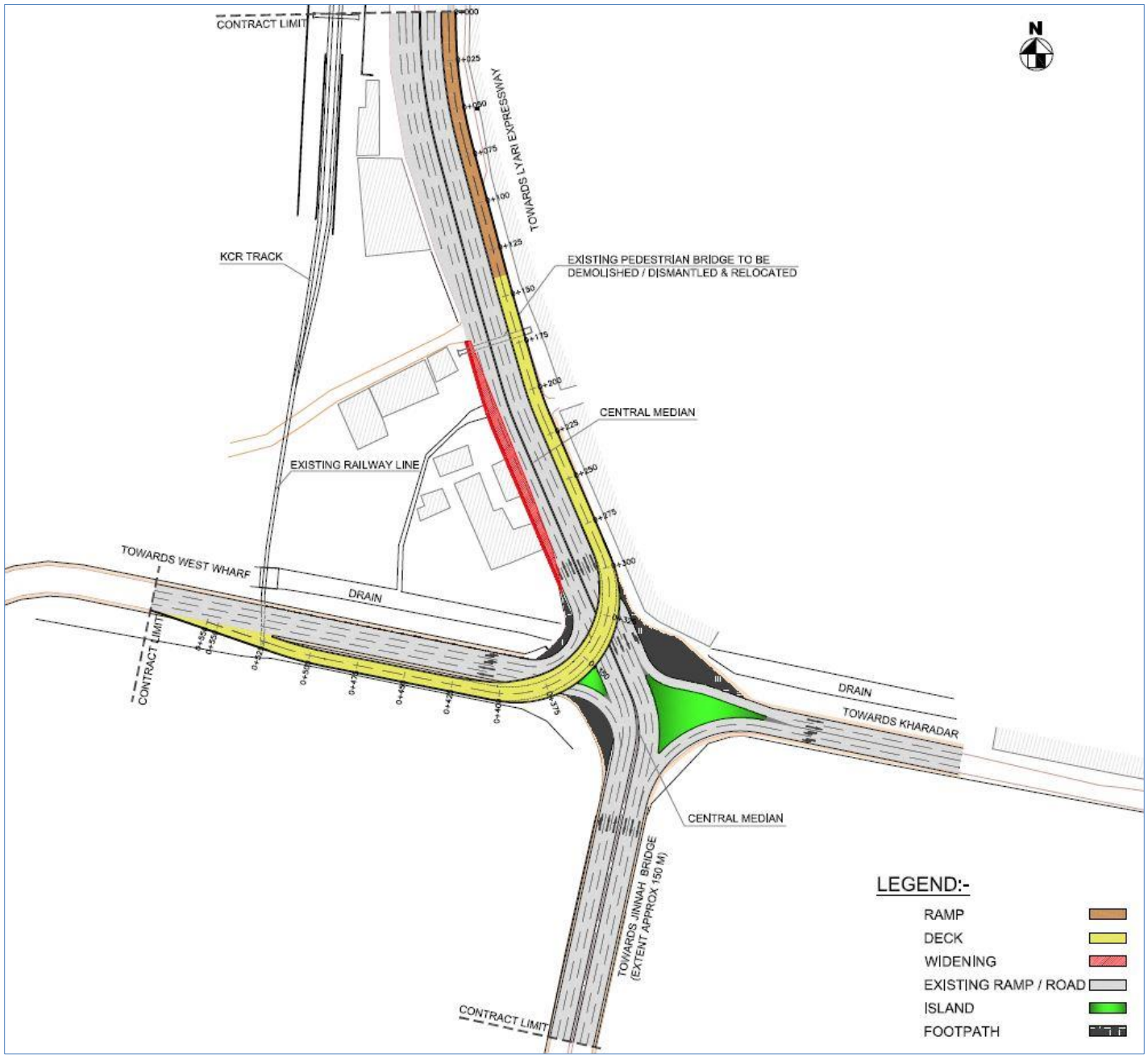



***Figure 3 Proposed Alignment (ICI Intersection)***


***Figure 4: 3D View - I***


***Figure 5: 3D View - II***

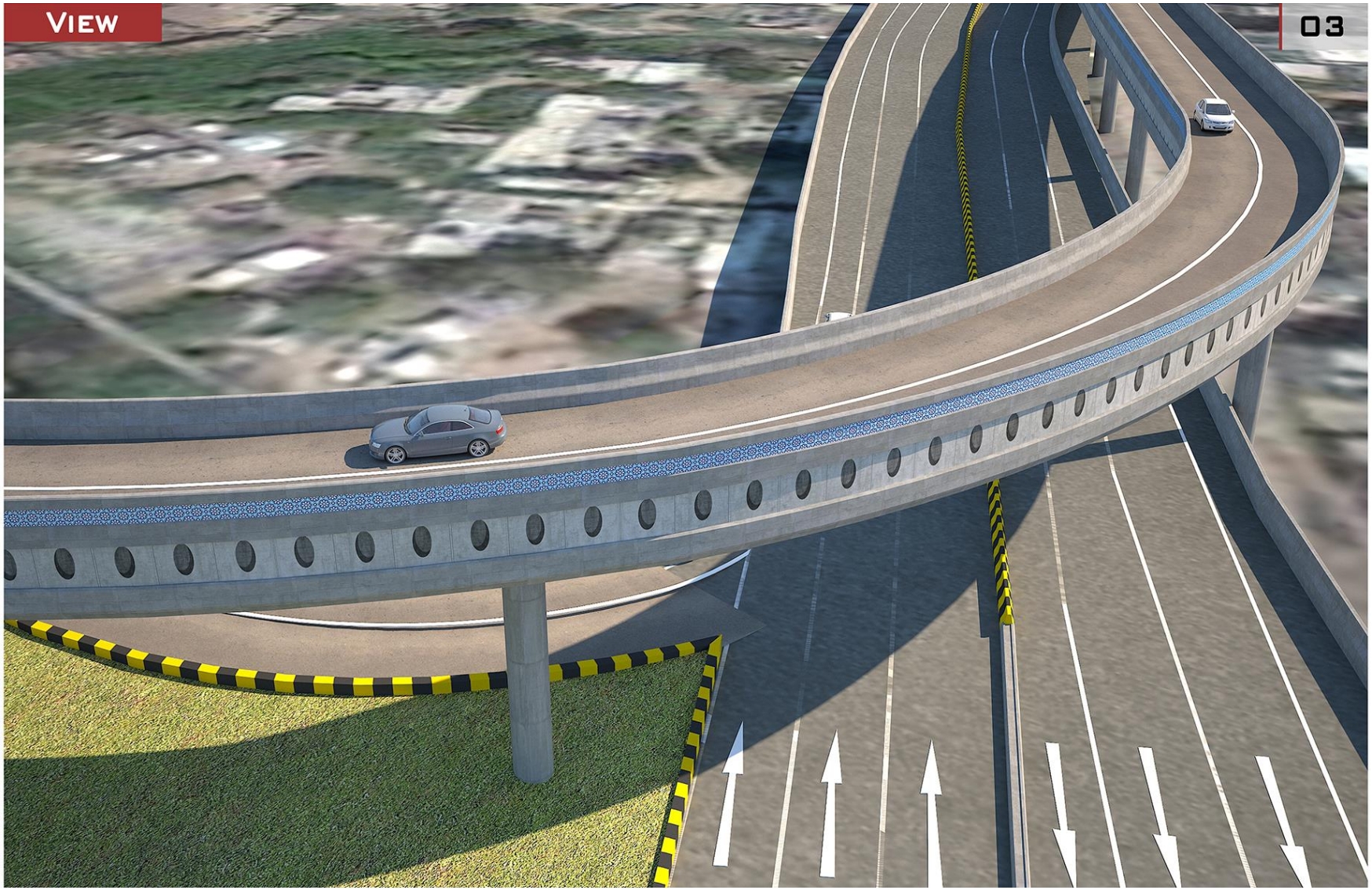



***Figure 6: 3D View - III***

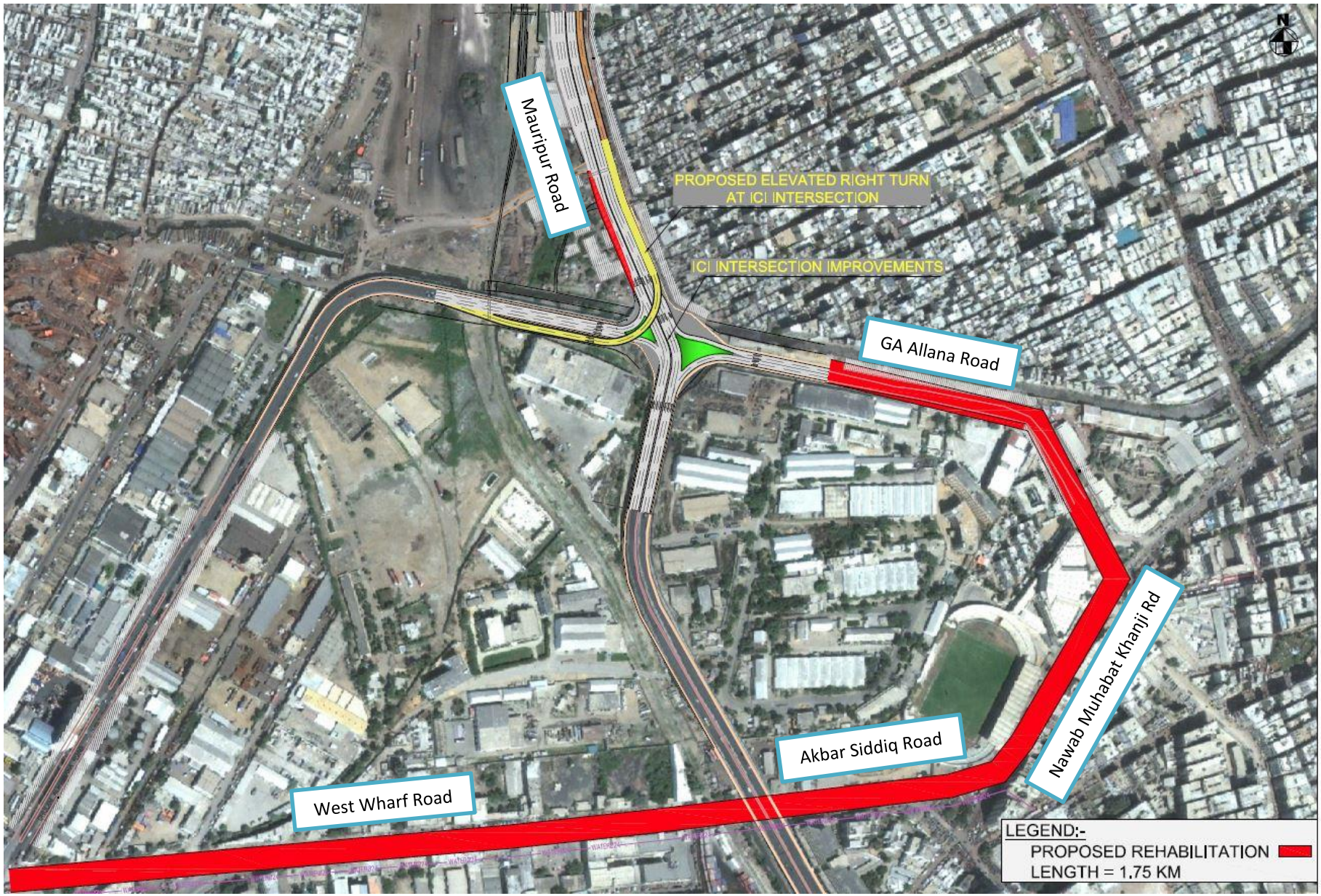



***Figure 7: Road Rehabilitation Plan***

# 2 Topographic Survey

## 2.1 Introduction

The methodology covers details of locations of survey control network, instruments used, measurement details, position fixation and coordinates and layout of the above defined scope of works.

## 2.2 Location & Extents of The Project Site

The project area for which survey has been carried out includes ICI intersection and connecting roads. The survey data within the project area has also been collected for the study.

The location map of the subject project is shown in Figure-1 and 2 appended in section 1 of this report.

## 2.3 Scope of Survey Work

Survey is required to obtain basic information regarding topography, terrain, drainage pattern, profile etc. of the project area.

The survey detail is inclusive of, but not limited to the elements listed below;

- Site Reconnaissance visit of the Project area.
- Establishment of survey Bench Marks (BM) in the project area.
- Topographic survey of entire project area.
- Inventory of existing structures.
- Processing of the observed data.
- Preparation of Topographic Survey Map and related report of project area.

The above-mentioned scope of the work has been completed by using the following methodology;

## 2.4 Work Plan and Site Reconnaissance Visit

A comprehensive work plan has been established and implemented in the field by qualified survey team during execution of survey works.

Site reconnaissance survey of the project area has been carried out to assess the field conditions and general topography to finalize the survey activities/ implementation plan.

## 2.5 Establishment of Survey Bench Mark (Bm)

Establishment of local control points is an essential activity which is to be carried out prior to actual commencement of surveying and mapping of the project area. New

technology Global Navigation Satellite System (GNSS) makes it more efficient and effective to establish a primary control bench mark. Often National Geodetic Survey (NGS) vertical control is not readily available within the project area, thus the new procedures allow for establishing a vertical height easily, efficiently, and economically using GNSS.

Next activity is selection of a project control point and utilization of vertical data derived from GNSS observation processed through Online Positioning User Service (OPUS) as our primary control bench mark.

The values obtained in World Geographic System (WGS) can easily be transferred to local or Universal Transverse Mercator (UTM) Systems.

This Bench Mark has been used as a reference point for further establishment of horizontal and vertical control network, within the project area, to carry out the topographical and cross-sectional survey work.

The coordinates & location of established control points are presented in Table-1 and Table-2 in WGS-84 and UTM coordinate system respectively and shown in Figure-8.

## 2.6 Selection of Control Points Location

Quality is a characteristic of comparable things that allows us to decide that one thing is better than another. In the context of geographic data, the ultimate standard of quality is the degree to which a data set is fit for its effective use.

Selection of location for control points (Established Bench Marks) were based on three elements i.e. stability for the soil conditions encountered for each point set, safety of the established point and ample clear view to the sky, which are crucial for GNSS observations. In order to mitigate errors and to increase accuracy, the control network was planned and designed to form triangles wherever possible.

## 2.7 Establishment of Horizontal and Vertical Control Networks

Horizontal and vertical project control survey has been established for the project. Whenever feasible, the horizontal and vertical control is based on high-precision GNSS observations.

In order to achieve maximum possible accuracy and minimal spatial variations in both horizontal and vertical planes, control network was established by using state of the art "GNSS" equipment encompassing the entire project area.

For base line computation, three (3) GNSS instruments have been used simultaneously. To receive the signals from satellite, the receiver should have minimum obstructions like building, trees, power lines etc., around it.

In case of weakening of signals due to unfavorable weather conditions like rainfall, clouds and vehicle noise, the observations have repeatedly been noted till obtaining satisfactory readings/data.
For all time observations, at least four (4) satellites should be available with Geometric Dilution of Precision/Position Dilution of Precision (GDOP/PDOP) value of less than five (5).

The availability of satellites and `GDOP value can be known in advance with the help of computer program for given time, date and point of observations. Each instrument is set to work at least 30 minutes for simultaneous observations.

Out of three (3) receivers, one acted as reference (for which coordinates of the observing point are known) and the other two (2) as rovers (coordinates to be computed). The observed point coordinates served as reference for further observing points to make a triangle or large polygon. CPs has been engraved at the permanent structures.

**Table-1: List of Control Points Coordinates in World Geographic System (WGS) 84**

| Sr. No. | Control Point | Latitude (DMS) | Longitude (DMS) | Elevation (m) |
|---|---|---|---|---|
| **1** | P3/CP01 | 24° 51' 26.186" N | 66° 59' 11.681" E | 10.712 |
| **2** | P3/CP02 | 24° 51' 14.751" N | 66° 59' 18.354" E | 6.708 |

***Table 1 List of Control Points in WGS 84***

**Table-2: List of Control Points Coordinates in Universal Transverse Mercator (UTM) Zone 42N**

| Sr. No. | Control Point | Easting (m) | Northing (m) | Elevation (m) |
|---|---|---|---|---|
| **1** | P3/CP01 | 296564.844 | 2750646.992 | 10.712 |
| **2** | P3/CP02 | 296746.976 | 2750292.384 | 6.708 |

***Table 2 List of Control Points in UTM Zone 42N***

The accuracy of the survey control points in static mode is as follows:

Horizontal ……... ± 3 mm +1 ppm RMS
Vertical……... ± 5 mm +1 ppm RMS

## 2.8 Instruments Used

Leica Viva GS 10, GS 15 and Trimble R2, R9 were used to establish the control points. Also, these systems with one base and receivers (rovers) were used to collect the survey data in RTK mode.

The topographic survey has been carried out by using the GNSS in Real Time Kinematic (RTK) mode. The base station was placed on the known control point and the rover has been used for collecting the survey points. The accuracy of the GNSS equipment in RTK mode is as follows:

Horizontal ……. ± 10 mm +1 ppm RMS
Vertical……... ± 20 mm + 1 ppm RMS

## 2.9 Measurement Units

The linear measurement units used in survey and mapping work are in metric system of units and the angular measurement are in degrees, minutes and second of arc.

## 2.10 Field Data Processing

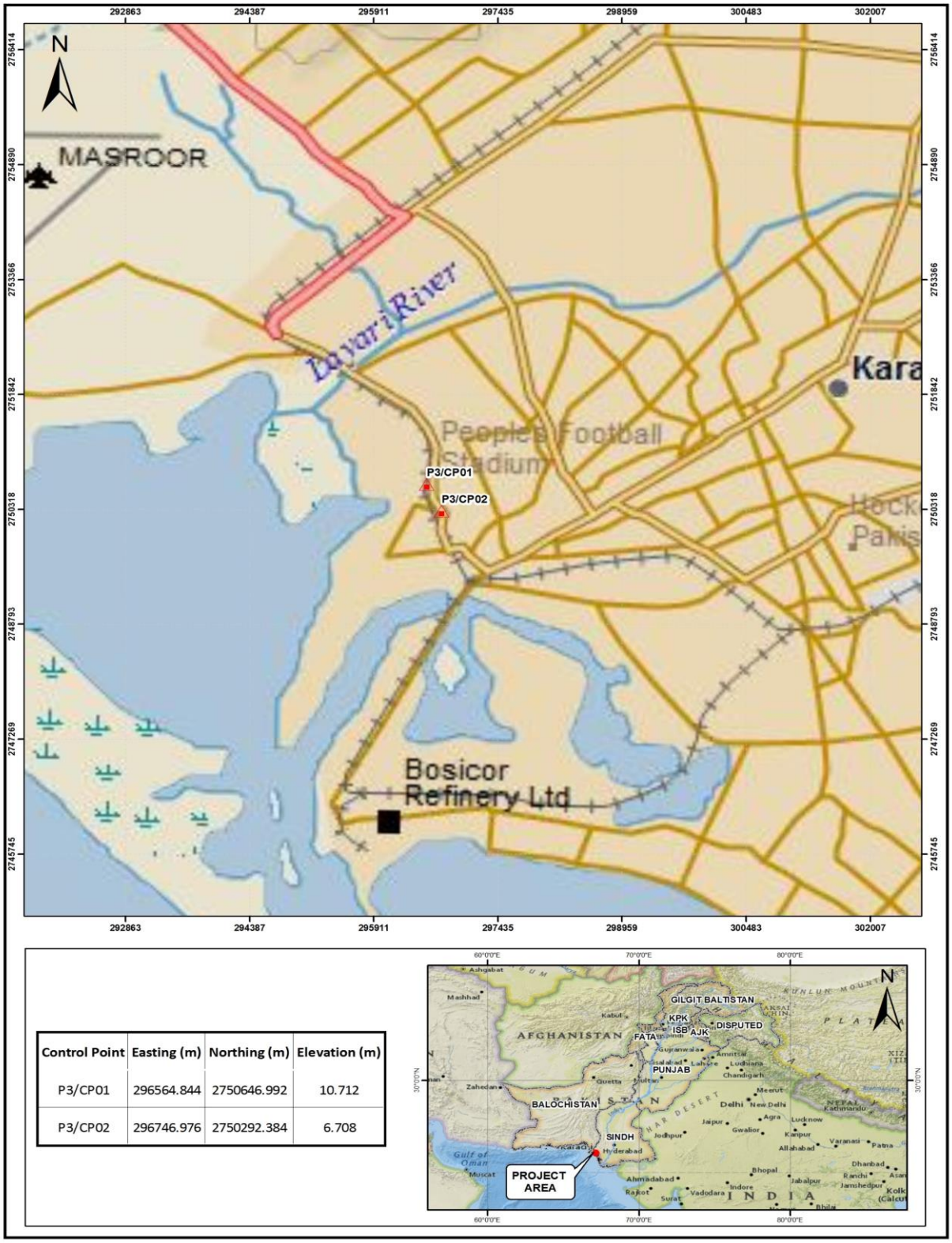
The data observed was downloaded to laptop which always remain available with survey team at the survey site. The data has been processed and checked at the site for quality and gaps, if any. The GPS baselines were processed using Leica Geo Office (LGO) and Trimble Business Centre (TBC) software. The default acceptance criteria for baselines were used in LGO & TBC. Any baseline not fulfilling the acceptance criteria has been repeated. As the GNSS reading is based upon the WGS-84, the data was converted into UTM Zone 42.

## 2.11 Software Used

All the observed data has been processed using LGO, TBC and ArcGIS software which are widely used for field data processing. AutoCAD and Eagle Point software have been used for preparation of the topographic survey layouts using the field survey data.

## 2.12 Data Post Processing and Production of Drawings

The observed data was digitized using AutoCAD software in the form of points, lines and polygons. The digitization of features has been done in different AutoCAD layers. The feature layers have unique style and symbols so that these can be well distinguished from other features.




| Control Point | Easting (m) | Northing (m) | Elevation (m) |
|---|---|---|---|
| P3/CP01 | 296564.844 | 2750646.992 | 10.712 |
| P3/CP02 | 296746.976 | 2750292.384 | 6.708 |

***Figure 8 Location Map of Established Survey Bench Marks***

# 3 Geotechnical Investigations/Studies

## 3.1 Introduction

Geotechnical investigations are aimed at revealing the general subsurface soil / rock types at the site for the purpose of efficient and cost-effective feasibility level design of proposed development works for Interchange at ICI Bridge

The following Sections provide our work plan and methodology for undertaking the conceived geotechnical investigations.

## 3.2 Planning

The subsoil / rock investigations have been planned through execution of boreholes, excavation of test pits, field testing and sampling followed by appropriate laboratory testing for the purpose of feasibility level design of proposed development works. The investigations have been planned in such a way as to provide sufficient information about the condition and the strength of various sub-strata.

## 3.3 Field Investigations

After finalization of scope of work, a specialist drilling Contractor be engaged on the basis of competitive bidding as per PPRA Rules. Upon award of work, the field investigations be directly supervised by NESPAK staff on full time basis. The Contractor mobilize to the site with straight rotary drilling / percussion boring equipment along with all necessary allied accessories for testing and sampling.

The following field investigations are envisaged / planned to be carried out:

- Execution of boreholes up to a maximum depth of 40 m below NSL or up to rock strike level, whichever is met earlier, by straight rotary drilling / percussion boring method including backfilling of boreholes to their original position by cement: sand: bentonite mix.
- Continuous core drilling (NX size in general) in bedrock up to a minimum depth of 3 m below rock strike level, including preservation of core samples in core boxes, waxing of core samples, photography of rock cores and transportation of core samples to the laboratory.
- Performance of standard penetration tests (SPTs) in the boreholes in overburden soils, generally at 1 m depth interval, including collection and preservation of spilt-barrel samples as per ASTM D - 1586.
- Collection of relatively undisturbed soil samples (UDS) from boreholes through Shelby/Denison/Pitcher sampler.
- Excavation of test pits up to a maximum depth of 2 m or up to subgrade, whichever is met earlier, exposing of road / pavement layers and backfilling of pits to their original condition along with collection of bulk composite samples, wherever considered necessary.
- Performance of field density tests (FDTs) through sand replacement method at the selected horizons in test pits.

- Collection of groundwater sample, if encountered in the boreholes/test pits.
- Logging of boreholes/test pits
- After completion of the field investigations, the site shall be restored to the condition existing before the work started, including backfilling of boreholes with cement-sand- bentonite slurry, unless otherwise directed.
- Establishment of coordinates and ground elevation of all the boreholes and test pits using Total Station.

## 3.4 Laboratory Testing

The laboratory testing be carried out at an approved laboratory. Selected representative samples of soil / rock and water obtained during site investigations will be subjected to appropriate laboratory tests to evaluate the following engineering properties:

- Classification
- Shear strength of soil / rock
- Moisture-density relationship
- Compressibility characteristics
- Chemical characteristics
- Other relevant engineering characteristics

## 3.5 Analysis and Report

After completion of the field work, subsurface soil / rock profiles shall be developed for each project site, separately on the basis of the information obtained from boreholes. These shall be studied in conjunction with the laboratory test results and state-of-the-art literature, to formulate soil / rock parameters. The following pertinent engineering studies shall be carried out on the basis of the formulated parameters and the field and the laboratory investigation data:

- Evaluation of subsurface materials and subsurface soil / rock profiles
- Considerations for appropriate foundation system
- Bearing capacity analysis
- Settlement analysis
- Geotechnical recommendations for feasibility level design of foundations
- Geotechnical recommendations for feasibility level design of road network
- Aggressivity of subsoils / rocks and groundwater on buried R.C. works and any special measures required for their protection

These studies shall be summarized in the form of comprehensive geotechnical investigation report for each project site, separately. The reports shall include but not limited to a general description of the site and field activities, location of all boreholes & test pits, groundwater elevation measurements, disturbed/undisturbed soil sample details, rock core details, field/laboratory test results and geotechnical recommendations for feasibility level design of foundations and road network.

## 3.6 Geotechnical Design Criteria

The foundations of all the structures and road network should meet the following design criteria:

- These should be safe against shear failure of the supporting ground. A factor of safety of 3.0 will be adopted for this purpose during bearing capacity evaluation of shallow foundations. However, a safety factor of 2.5 will be considered during pile load carrying capacity evaluation.
- All the foundations should not settle excessively under the service loads. A limit of 25 mm will be put on the total settlement of strip / square foundations and 50 mm on the total settlement of mat foundations. Similarly, the angular distortion between the edge and the center of the foundations should not exceed 1/500.
- The soil for sub-grade and embankment construction should be at least A-3/A-4 type as per AASHTO soil classification and minimum CBR value of 7 and 5 respectively at 95% Modified AASHTO density.

## 3.7 Geotechnical Investigation Report

Based on above criteria, Geotechnical Investigation Report has been established and shall be submitted accordingly.

# 4 Infrastructure Development (Roads and Drainage) Works

## 4.1 Introduction

The design of interchange at ICI and Road Rehabilitation Works is based on a set design criterion that represent the best internationally accepted engineering practice. At the same time, the specific local site conditions have also been effectively considered in the interpretation of these 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. As such the design criteria represent the performance objective, while satisfying the economic constraints.

## 4.2 Geometric Design Criteria

Interstate Semi-Trailer, WB 20, have been used as the design vehicle;

### 4.2.1 Design Speed

- Mix Traffic = 60 Kph
- Elevated Right Turn = 40 Kph

### 4.2.2 Design Elements

Design Elements have been highlighted in Table-3 below

| Sr.No. | Description (m) | Speed kph | | |
|---|---|---|---|---|
| | | 40 | 50 | 60 |
| 1 | Stopping sight distance (m) | 50 | 65 | 85 |
| 2 | Passing sight distance (m) | 140 | 160 | 180 |
| 3 | Minimum Curve Radius (m) | 47 | 86 | 135 |
| 5 | Maximum super-elevation rate | 4% | | |
| 6 | Maximum Allowable Gradient = 3-4% | 4% | | |
| 8 | Minimum K (at Crest)<br>Minimum K (at Sag)<br>For stopping sight distance | 4<br>9 | 7<br>13 | 11<br>18 |
| 9 | Minimum K (at Crest)<br>For passing sight distance | 23 | 30 | 38 |

***Table 3: Design Elements***

### 4.2.3 Design Vehicle

- Length = 23 m
- Width = 2.6 m
- Height = 4.15 m
- Central Turning Radius = 12.6 m
- Minimum Turning Radius = 13.66

### 4.2.4 Cross Section Elements

- **Width**

- Elevated Right Turn lane = 3.5 m
- Mix Traffic lanes = 3.5 m
- Footpath = 1.2 m to 2 m

- **Elevated Right - turn**

- Vertical Clearance = 5.1 m
- Gradient = Max 4% (3.5% adopted)

## 4.3 Pavement Design

The existing road pavement at ICI intersection, only require overlay on most of the section, for which 50 mm wearing course is considered, however widening and damaged areas near proposed elevated structure is taken as full depth flexible pavement to accommodate future construction damages and to maintain infrastructure quality.

The pavement structure should be able to provide a surface of acceptable riding quality, adequate skid resistance, favorable light reflecting characteristics, and low noise pollution for which AASHTO design guidelines and NHA specifications are the design basis. The flexible pavement and design procedure are defined below.

### 4.3.1 Flexible Pavement

The road flexible pavement is a layered structure to distribute concentrated loads to the sub-grade. The performance of pavement structure is directly related to the physical properties and conditions of the road bed soils and traffic which the pavement can be expected to carry from time of construction to the time of service-ability. The pavement, which is the vital component in the road design, must be structurally sound and at the same time economical and cost effective. Realistic assessments of traffic and soil properties are necessary to design the technically sound and economical pavement.

### 4.3.2 Design Procedure

The following procedure has been adopted for the design of the flexible pavement structure for the road:

- The traffic data has been projected for 20 years using the traffic growth factors obtained from different studies.
- Projected traffic has been converted in to equivalent standard axle load (ESAL's) for 10 years using standard ESA factors recommended by AASHTO and NTRC.
- The cumulative standard axle load has been computed for 10 years. For the design load calculations and total cumulative standard axle load was multiplied with directional distribution factor and lane factor recommended by AASHTO Guide for Design of Pavement Structure 1993.
- Designed California Bearing Ratio (CBR) value have been taken as 10%.
- Using the AASHTO Guide for Design of Pavement Structures, the flexible pavement design has been completed. For the flexible pavement design, the governing factors are Equivalent Standard Axle Load (ESALs) and CBR values of sub grade soil.
- Finally, the pavement layer thickness has been decided by using AASHTO Guide for Design of Pavement Structures 1993.

### 4.3.3 Design Life

The design life for flexible pavement has been taken as 20 years.

### 4.3.4 Design Parameters

Following parameters have been used to analyze the pavement structure.

| | | |
|---|---|---|
| Design Period | : | 20 Years |
| Reliability (%) | : | 95 |
| Overall standard deviation | : | 0.45 |
| Initial Serviceability (Po) | : | 4.2 |
| Terminal Serviceability (Pt) | : | 2.5 |
| Subgrade CBR % | : | 10% |
| Resilient Modulus (psi) (2555xCBR0.64) | : | 11000 |
| Drainage Coefficient (m) | : | 1.0 |
| Layer Coefficients | | |
| - Wearing Course | : | 0.44 |
| - Binder Course | : | 0.42 |
| - Base Course | : | 0.14 |

- Subbase Course : 0.11

The basic design equation used for flexible pavement Design by using AASHTO Guide of Pavement Standard (1993) is as follows:

$$Log10(w18) = ZR \times So + 9.36 \times log10 (SN + 1) – 0.20 + log10 ((\square psi/ 4.2- 1.5) (0.42 + 1094/ (SN + 1)5.19) + 2.32 \times log10 (MR) – 8.07$$

Whereas,

(w18) = Predicted number of 18 kips equivalent single axle load.

ZR = Standard normal deviate

So = Combined standard error of traffic prediction and performance prediction.

□psi = The difference between initial design serviceability index Po and the design terminal serviceability index Pt

MR = Resilient Modulus (PSI)

SN = Structural number indicative of the total pavement thickness required

Using the above inputs and design equation layer thicknesses in a flexible pavement have been determined.

## 4.4 Storm Drainage System

The storm water drainage of the area has been studied considering the construction of the flyover from the mauripur road to existing ICI bridge. Although the drainage pattern of the area will remain same but for a segment the existing storm water drains will be shifted considering the locations of the bridge with required intake arrangement for rain water so that the efficient drainage can be ensured. Contractor shall ensure the Storm drainage scheme as per existing site conditions and nearby disposal for the works at ICI intersection as well as road rehabilitation works

# 5 Structural Works

## 5.1 Introduction

This structural design criteria describes the details and design parameters considered for Sub Project-3. Sub Project-3 includes a new bridge proposed to be constructed over ICI bridge intersection.

The flyover has been planned in a way so as not to disturb the intersection space and that the pier / piles be located in such a manner that the piles will not create any hindrance to the existing nallah flowing under the interchange. Further, the curvature at this location does not allow pre-cast pre-stressed girders to be placed. Hence, a four span continuous box girder of around 57m span each has been planned at this location.

The Contractor to be hired by the Employer/GOS for this project should keep in mind to leave space for traffic flow in design of the scaffolding and formwork for the box girder.

At one end of the flyover the bridge ends at abutment followed by a retaining wall, whereas, the other end of the flyover has been planned in a way to match with the existing ICI Bridge. Here at this location there is an existing railway line for which piers of the proposed bridge have been planned in a way to maintain the clearance to the track and its right of way.

For rest of the length of bridge pre-cast I-girders have been planned for fast track construction. Seismic analysis be carried out as per code requirements (AASHTO). Abutment is provided keeping the height that will allow maintenance work to be carried out underneath.

## 5.2 Earthwork

The flyover is proposed over an existing road and hence no major earth work is anticipated at this site.

## 5.3 Foundation

### 5.3.1 For Flyovers

Successful bidder shall arrange for confirmatory soil investigation before proceeding with the detailed design and construction works. However, 760mm dia piles have been assumed for designing purpose at this stage as per recommendations of available Geo-Technical investigation report carried out by NESPAK. Further, design of all structural components of bridge and allied facilities shall be based on the results / recommendations of confirmatory Geo-Technical investigation to be carried out by the contractor.

### 5.3.2 For Pole Foundations (Max 12m high)

Isolated foundations for at grade locations of pole have been planned at 1.0m depth below NSL as per recommendations of Geo-Technical investigation report carried out by NESPAK.

## 5.4 Superstructure

### 5.4.1 Flyovers

The super-structure for flyovers comprises pre-cast pre-stressed I-girders; however, some portions of superstructure at the curvature will be continuous box girder as described in detail in salient features. All girders will be simply supported on laminated elastomeric bearings resting on reinforced concrete transoms, whereas pot bearings have been planned to support box-girder.

## 5.5 Loading

### 5.5.1 Types of Loads

- **Dead Loads**

| | | | |
|---|---|---|---|
| - Structural Dead Weight | : | Reinforced Concrete | = 24 KN/m3 |
| - Earth Fill | : | Compacted Soil | = 19 KN/m3 |
| - Wearing Surfaces (50+50) mm | : | Load Carpeting | = 23 KN/m3 |
| (50mm Future Provision is kept in design) | | | |
| - Soil Fill | : | Compacted Soil | = 19 KN/m3 |
| - Concrete Barrier Load | : | Reinforced Concrete | = 24 KN/m3 |
| (As per actual) | | | |
| - Foot Path Load | : | Concrete/Fill/planks | =24/19 KN/m3 |
| (As per actual) | | | |

- **Transient Loads**

  - Vehicular Load : Class A & AA loading of West Pakistan Highway Code.
    (Except vehicular load, all loads will be applied in accordance with AASHTO LRFD Bridge Design Specifications 2012; such as)
    - Vehicular Dynamic Load Allowance (WPHC)
    - Live Load Surcharge
    - Tractive force
    - Centrifugal force
    - Pedestrian Load : 3.6 kN/m$^2$

- **Environmental Loads : Ref: Aashto Lrfd 2012**

  - Seismic Loads
    - Seismic Zone : 2B as per BCP 2007
    - Soil Profile Type : $S_D$ or $S_E$ as per Geotechnical Investigation
    - PGA : 0.16 – 0.24
    - Seismic Performance Zone : 3

  - Wind Loads : N/A

    Since Seismic analysis is governing the design, therefore case of wind load needs not to be considered for flyover concrete structure, however, pole foundation has been designed for wind loading.

    - Basic wind speed (Fastest mile) : 100mph
    - Exposure : B
    - Wind Importance factor (Iw) : 1.0

  - Water Loads : N/A

  - Equipment Loads : N/A

  - Piping Loads : N/A

  - Construction Loads : As per actual

## 5.6 Limit States Used

- **Bridge Design:**
  - STRENGTH – I : Normal vehicular use of Bridge.
  - EXTREME – I : Including load due to earthquake.
  - SERVICE – I : Normal operational use of bridge.

- **Other Structures' Design:**
  - STRENGTH COMBINATIONS : As per UBC-97
  - ALTERNATE BASIC LOAD COMBINATIONS : As per UBC-97

## 5.7 Construction Materials

### 5.7.1 Concrete

All concrete shall be tested in accordance with ASTM standards C31, C39, C172 & specifications and the minimum cylinder specified strength of concrete at 28 days shall be as per Table 4 and 5.

| CLASS* (NESPAK Standard) | MIN. CYLINDER CRUSHING STRENGTH AT 28 DAYS (MPa). | Equivalent NHA Class |
|---|---|---|
| A2 | 42 MPa | D2 |
| A1 | 31 MPa | - |
| A | 28 MPa | A3 |
| B | 21 MPa | A1 |
| C | 17 MPa | B |
| D | 08 MPa | - |
| E | 05 MPa | Lean Concrete |

***Table 4: Concrete Strength***

** Concrete strengths shall be as per NESPAK's standard specifications.*
*** Maximum Aggregate Size shall be 20 mm*

Class and Strength of concrete for different constructions/Structure shall be as follows unless noted otherwise.

| Type of Construction/Structure | Class | CLASS* (NESPAK Standard) | Equivalent NHA Class |
|---|---|---|---|
| Pre-cast I-Girders/Box Girders | A2 | Ordinary Portland Cement | D2 |
| Deck, Pre-cast Planks, Approach slab, diaphragm, shear key | A | Ordinary Portland Cement | A3 |
| Columns of Bridge | A1 | Ordinary Portland Cement | - |
| Piles, Pile caps and Abutments | A1 | Modified Cement | - |
| Retaining walls, Abutments | A | Ordinary Portland Cement | A3 |
| Fill | C/ D | Ordinary Portland Cement | B |
| Lean Concrete | E | Ordinary Portland Cement | Lean Concrete |

***Table 5: Cement Type***

### 5.7.2 Reinforcement

Reinforcing steel shall comply with ASTM A706. ASTM A615 grade 60 reinforcement shall be permitted if:

- The actual yield strength based on mill tests does not exceed fy by more than 18,000 psi; and
- the ratio of the actual tensile strength to the actual yield strength is not less than 1.25.

All pre-stressing steel shall conform to ASTM 416 and the ultimate tensile strength of pre-stressing steel shall not be less than 1860 MPa.

### 5.7.3 Cement

Type of Cement shall be as follows

Modified Portland Cement, Modified Portland Cement with the following limitations shall be used for all concrete works, except for transoms, girders and deck slab where Ordinary Portland Cement shall be used.

- $C_3$ A shall neither be less than 5% nor more than 8%
- $C_4$ AF + $2C_3A$ shall be less than or equal to 25%
- $AL_2$ $O_3$ shall be less than or equal to 6%

Ordinary Portland Cement conforming to ASTM C 150 and meeting the above requirements may also be used in lieu of modified cement.

All concreting shall be done by Batching plant and no hand mixing shall be done.

## 5.8 Special Considerations in Design

a. Modified Portland Cement: Minimum 4.5 ksi (31 MPa) concrete cylindrical strength is assumed considering the high chloride and sulphate contents as given in chemical test reports of soil and water.

b. Relocation of Existing Structure: There is an existing pedestrian bridge and a drain crossing at proposed location of retaining wall for this flyover, both of these structures have been planned to be re-located and hence no provision in design is kept at this stage for these obstructions.

c. Cracking of Bridge decks have been observed to be one of the major problems in prestressed concrete bridges.

   Polypropylene fibers have been proposed in the bridge deck to cater for the fatigue crack formation due to vehicular live load and shrinkage & temperature cracks. The fibers provide the three-dimensional reinforcement to increase impact resistance, toughness, ability to delay crack initiations and crack propagation.

   Polypropylene fibers shall extend the service life of the deck and decrease the maintenance cost and traffic inconvenience for reparation.

## 5.9 Design Methods

- USD: Concrete elements
- WSD: Checking Bearing Capacity, Design of Bearings and Stress analysis of Pre-stressed Girders

## 5.10 Codes and Standards

- AASHTO LRFD Standard Design Specifications for Highway Bridges 2012
- Building Code of Pakistan (Seismic Provisions-2007)
- American Concrete Institute ACI 318 Building Code requirements for Reinforced Concrete
- American Institute of Steel Construction Specifications AISC.

## 5.11 Software Used

- CSi BRIDGE 20
- SAP 2000
- SAFE
- In house developed Software and Excel Sheets

# 6 Electrical System

## 6.1 Introduction

This section describes the basic design guidelines, pertains to electrical works for Feasibility Study and Transaction Advisory Services, Urban Road Initiatives in Karachi' Local Government & HTP Department, GOS.

## 6.2 Applicable Codes and Standards

The design, manufacturing, installation and commissioning of all Electrical systems shall conform to the following international and local standards / codes:

- IEC - International Electro technical Commission
- EN - European Standards
- BSI - British Standards Institutions
- NEC - National Electric Code
- IEEE - Institute of Electrical and Electronics Engineers
- ANSI - American National Standards Institute
- ASA - American Standards Association
- NEMA - National Electrical Manufacturers Association
- ISO - International Standards Organization
- DIN - Deutsche Industrie Normen (German Industrial Standards)
- Local Electrical Inspector's requirement/regulations
- Local Explosives Inspector's requirements/regulations

Following specialized standards shall be adhered for the related scope of work:

- BS 7671 - IEE wiring Regulation (latest edition)
- ESNA - Illuminating Engineering Society of North America (latest edition)
- BS EN 12464 - Lighting of work places
- BS EN 13201 - Road lighting
- CIE 115 - Lighting of Roads for Motor & Pedestrian Traffic

The electrical products/material used in this project shall be approved to meet the applicable standards by one of the independent test laboratories including following:

- KEMA
- CESI
- ASTM
- UL or other similar laboratories

## 6.3 Power Supply Data

Power supply shall be 0.4 kV, 3 Phase 50 Hz with neutral plus protective conductor. The characteristics of the supply are as follows:

- Power supply voltage : LT 415 V
- Frequency : 50 Hz
- Rated voltage of equipment : 400 V, 3 Phase 230 V, 1 Phase
- Required power factor : 0.9 or higher
- Permissible fluctuation in rated voltage of equipment : ± 10%
- Permissible fluctuation in Frequency : ±2%
- Power Supply System : Neutral Directly / Solidly Earthed

## 6.4 Climatic Conditions:

The electrical power supply and all needed equipment and systems shall be suitable for operation in the ambient conditions, designed for easy operation and shall be purchased new. Switchgear / DBs and all other equipment shall be suitable for the project ambient conditions. Also, applicable derating factors shall be considered while selecting the equipment.

- Temperature - Indoor: 45°C (max) and 0°C (min)
  - Outdoor: 50°C (max) and 0°C (min)
- Relative Humidity - ±90%

Surface treatment of equipment, stainless steel, heavy duty plastic and proper enclosures shall be used. Due to the environmental conditions, equipment shall be properly classified & IP rated accordingly. Moreover, high performance epoxy paint / marine paint shall be applied as an additional protection on the equipment / lighting columns.

## 6.5 Design Provision

- Maximum allowed design voltage - 4% of line voltage
- drop from power source up to final load
  Spare capacity for future expansion - +20%
- Earthing System - TT
- Earth Electrode - Plate type / rod type
- Earth conductor - Insulated/Bare stranded Copper bare
- Degree of Protection - IP 42 for indoor areas
  IP 54 for indoor damp Areas
  IP 65 for outdoor areas

## 6.6 Scope Outlines

The project's Electrical scope of work mainly encompasses the following:

a) Low Voltage Power supply from utility
b) Low voltage power distribution network for Road lighting

c) Road lighting
d) Earthing system

### 6.6.1 Low Voltage Power supply from Utility

It is envisaged that the estimated power demand of the project will be approximately 7 kW, including the road network power supply requirements. However, the final power system demand of the project shall be calculated by the Detail designer based on actual power demand of the road /facility and accordingly the necessary provision would be ensured in the existing K Electric's system.

In this regard, it is proposed that the power supply connection at low voltage (415V) shall be taken from K-Electric's pole /pad mounted transformer, located near the project premises.

There shall be one 415/230V Low voltage power supply intake from K. E's network to cater the low voltage supply at location specified in the preliminary design drawings and mentioned below

- MLTOD-1

The location of Low-Tension Outdoor Distributor marked on the preliminary design drawing is tentative. The Detail designer is advised to design the Low voltage network by investigating services, emphasizing the quality of supply and safe operation of equipment as per the international and local standards.

### 6.6.2 Low Voltage power distribution network for Road lighting

The power supply from the above-mentioned Low-Tension Outdoor Distributor is further routed / distributed to feed the road lighting poles installed on roads & interchanges etc. in the entire project.

### 6.6.3 Road lighting

Road lighting shall be designed as per international standards and local regulations, for all roads through Sub main Low-Tension Outdoor Distributors located at appropriate places.

The light fixtures shall be LED, pole mounted type. Lights provided shall be dust proof/ corrosion resistant, IP rated with cover where necessary and the lux levels shall be as per BS EN 13201-2, CIE 115& BS 5489-1.

The average road surface luminance (L in cd/m2), the overall uniformity of the luminance (Uo), the longitudinal uniformity of the luminance (Ul), the threshold increment (TI) and the surround ratio (SR) shall be calculated and measured in accordance with ME2 lighting Class (as per Table 1a of EN 13201-2) or M2 lighting Class (as per Table 2 of CIE 115) whichever is applicable.

The light fixtures shall be contactor controlled through timer switches and photo sensors, directly from the relevant Sub main LT Outdoor Distributor.

### 6.6.4 Earthing System

The Earthing scheme shall be in accordance with IEC 60634 based on TT system, with the star point at the supply source connected directly to earth.

Dedicated earthing protection shall be provided separately to all Low-Tension Outdoor Distributors, lighting poles, and any metallic structure including all electrical equipment's and apparatus in the entire project.

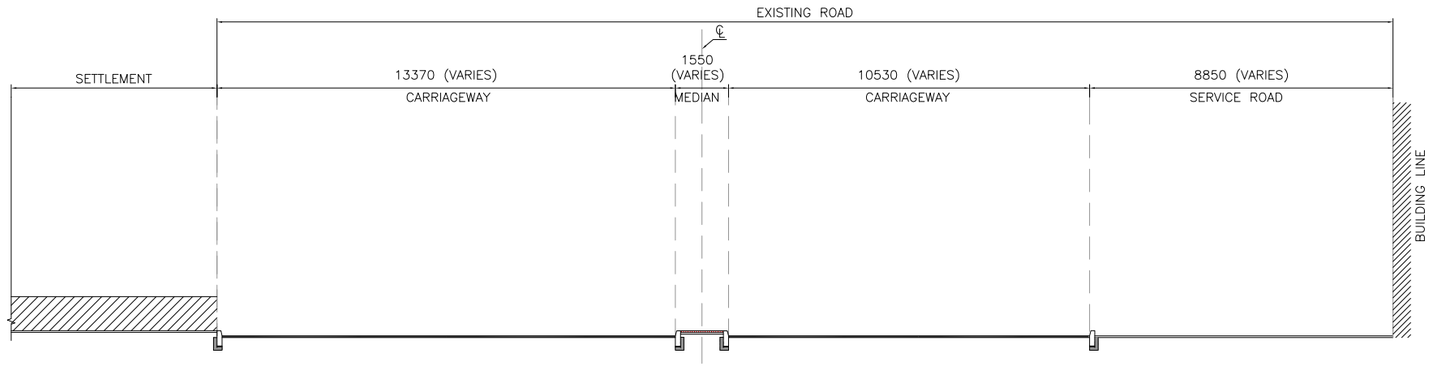
Continuity of protective earthing circuit must be observed. Removal of any equipment due to maintenance reason shall not interrupt the earthing circuit.

The Earthing system shall mainly comprise of the following components:

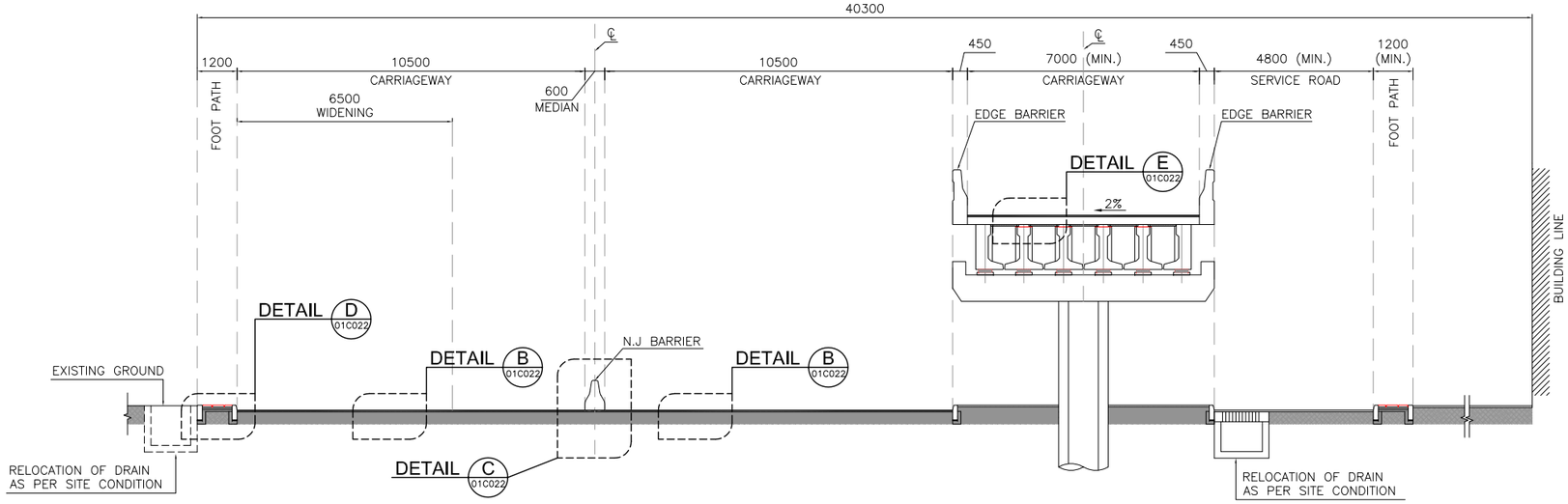
- Earth continuity conductors (ECC)
- Earth connecting point (ECP)
- Earthing leads
- Earth electrodes with concrete inspection pit having suitable type C.I cover

All accessories necessary for the satisfactory operation of the associated electrical system.

# ANNEXURE – 7




EXITING SECTION A 01C014




PROPOSED SECTION A 01C014

PRELIMINARY DESIGN DRAWINGS

LOCAL GOVERMENT & HTP DEPARTMENT
GOVERNMENT OF SINDH

NATIONAL ENGINEERING SERVICES
PAKISTAN (PVT) LIMITED

| REV. | DATE | DESCRIPTION |
|---|---|---|
| D | | |
| C | | |
| B | | |
| A | | |
| 0 | OCT,2020 | PRELIMINARY DRAWINGS |

| | |
|---|---|
| DRAWN | M.A.K |
| DESIGNED | M.S |
| CHECKED | M.A |
| APPROVED | R.Z |

URBAN ROAD INITIATIVES IN KARACHI
SUB-PROJECT 3 : INTERCHANGE AT ICI BRIDGE

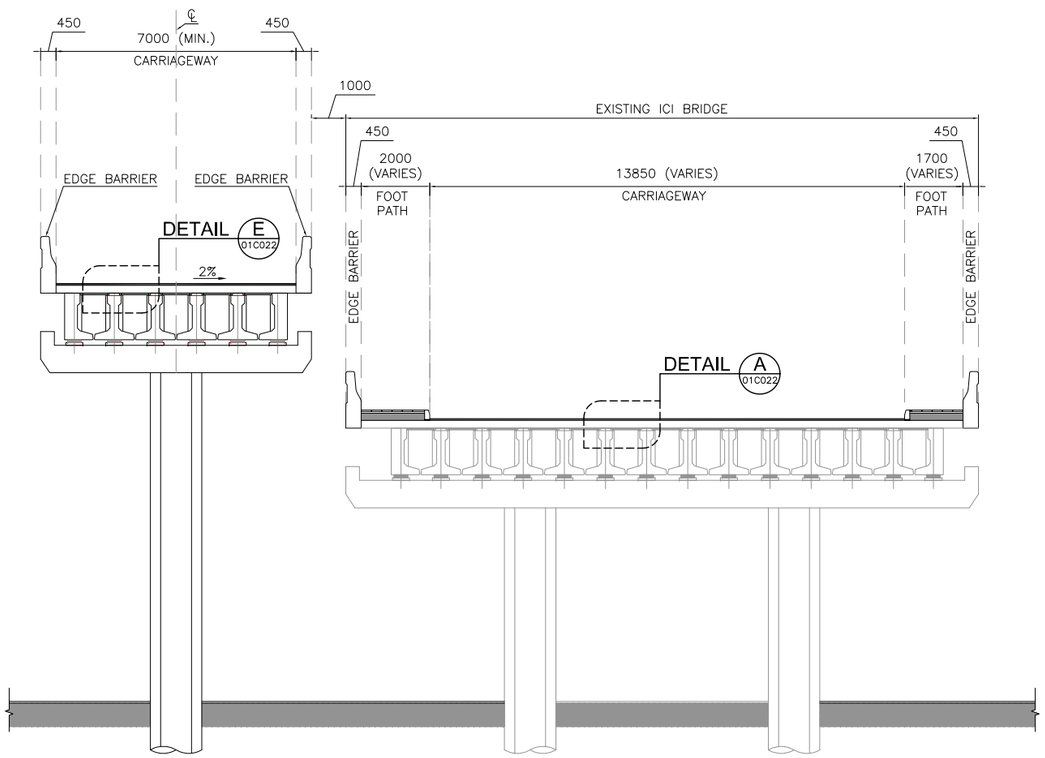
TITLE: CROSS SECTIONS (ICI INTERSECTION) (SHEET 1 OF 2)

SCALE: 1:175

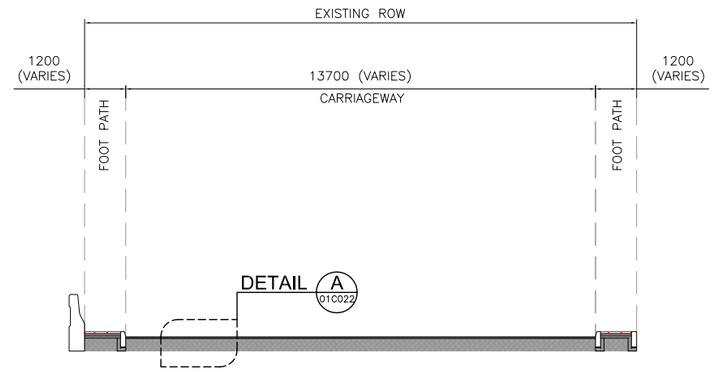
DATE: OCT,20

DWG. No.: P-38035/P3/50P/PD/01C016

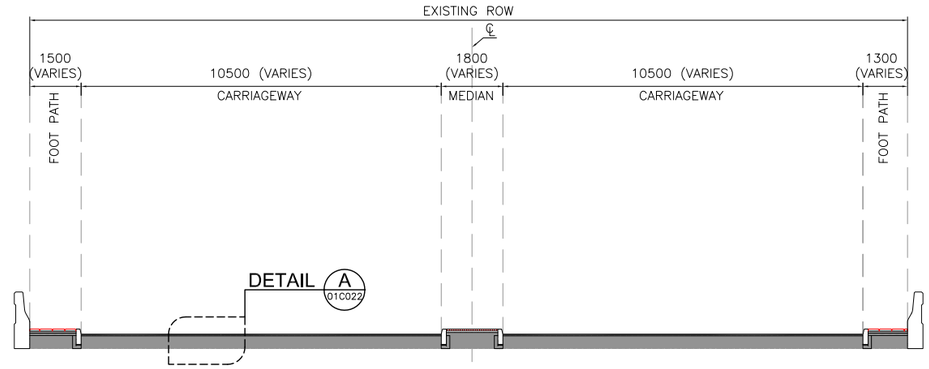
REVISION: 0




SECTION C
01C014




SECTION B
01C014




SECTION D
01C014

PRELIMINARY DESIGN DRAWINGS

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GOVERNMENT OF SINDH

NATIONAL ENGINEERING SERVICES
PAKISTAN (PVT) LIMITED

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| | |
|---|---|
| DRAWN | M.A.K |
| DESIGNED | M.S |
| CHECKED | M.A |
| APPROVED | R.Z |

URBAN ROAD INITIATIVES IN KARACHI
SUB-PROJECT 3 ; INTERCHANGE AT ICI BRIDGE

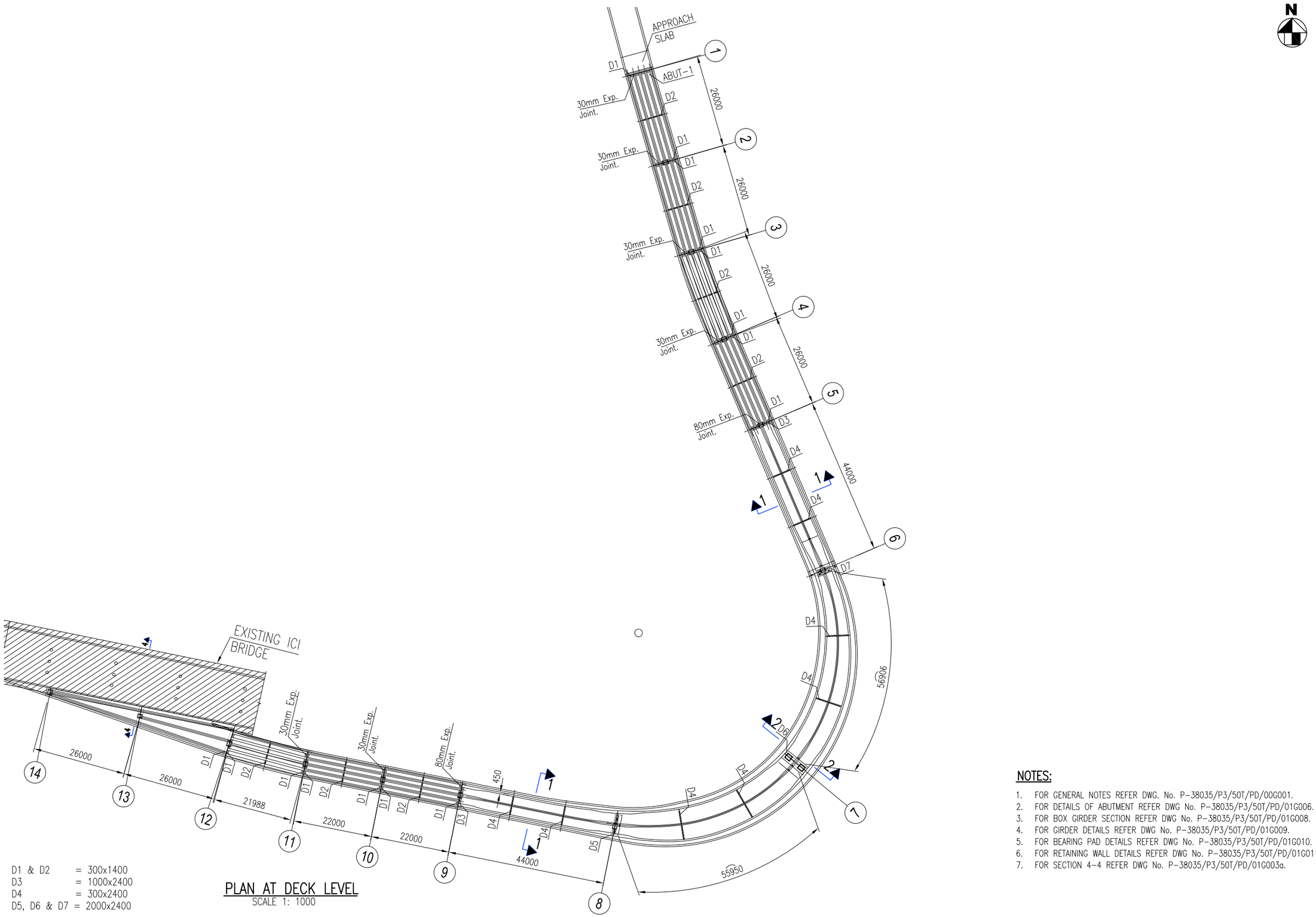
TITLE: CROSS SECTIONS (ICI INTERSECTION) (SHEET 2 OF 2)

SCALE: 1:175

DATE: OCT,20

DWG. No. P-38035/P3/50P/PD/01C017

REVISION: 0




D1 & D2 = 300x1400
D3 = 1000x2400
D4 = 300x2400
D5, D6 & D7 = 2000x2400

## PLAN AT DECK LEVEL

SCALE 1: 1000

## NOTES:

1. FOR GENERAL NOTES REFER DWG. No. P-38035/P3/50T/PD/00G001.
2. FOR DETAILS OF ABUTMENT REFER DWG No. P-38035/P3/50T/PD/01G006.
3. FOR BOX GIRDER SECTION REFER DWG No. P-38035/P3/50T/PD/01G008.
4. FOR GIRDER DETAILS REFER DWG No. P-38035/P3/50T/PD/01G009.
5. FOR BEARING PAD DETAILS REFER DWG No. P-38035/P3/50T/PD/01G010.
6. FOR RETAINING WALL DETAILS REFER DWG No. P-38035/P3/50T/PD/01G011.
7. FOR SECTION 4-4 REFER DWG No. P-38035/P3/50T/PD/01G003a.

PRELIMINARY DESIGN DRAWINGS

LOCAL GOVERMENT & HTP DEPARTMENT
GOVERNMENT OF SINDH

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LIMITED

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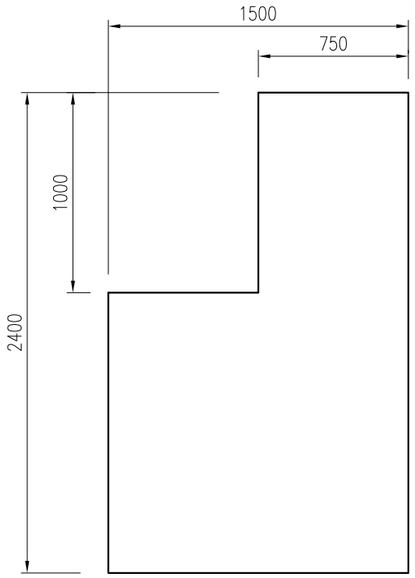
| 0 | OCT.,2020 | PRELIMINARY DESIGN |

| | |
|---|---|
| DRAWN | A.S.R |
| DESIGNED | S.F.H |
| CHECKED | N.F |
| APPROVED | M.Y.U |

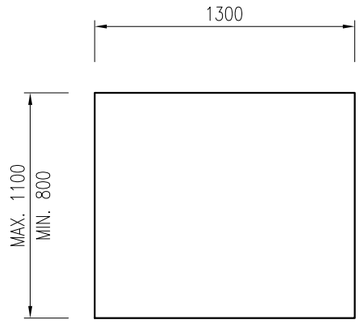
URBAN ROAD INITIATIVES IN KARACHI
SUB-PROJECT 3 : INTERCHANGE AT ICI BRIDGE

| TITLE | SCALE |
|---|---|
| PLAN AT DECK LEVEL | 1:1000 |

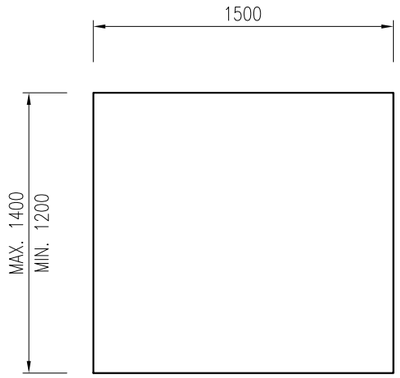
| DATE | DWG. No. | REVISION |
|---|---|---|
| OCT.,2020 | P-38035/P3/50T/PD/01G003 | 0 |



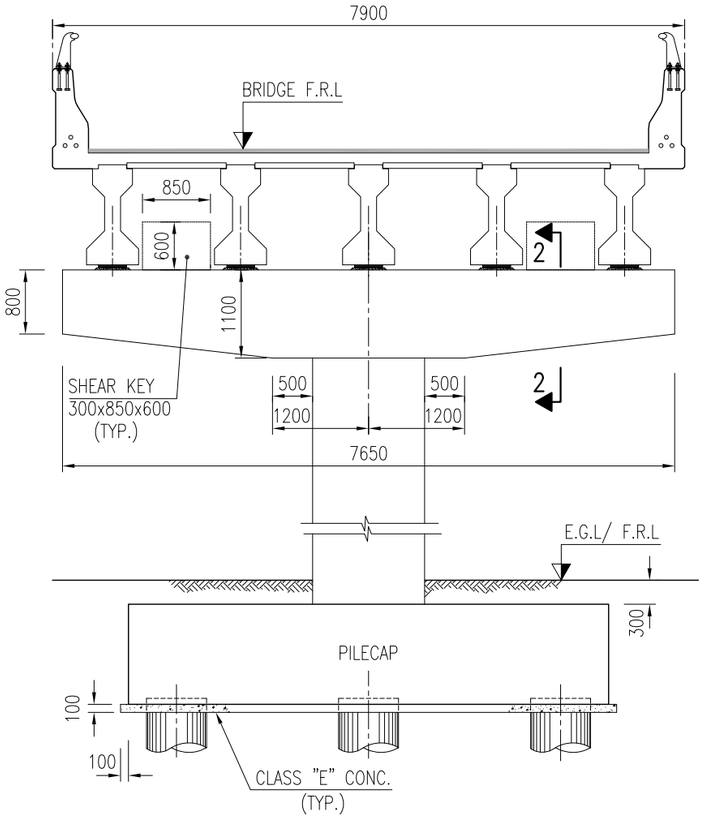

SECTION 1–1
SCALE 1:30



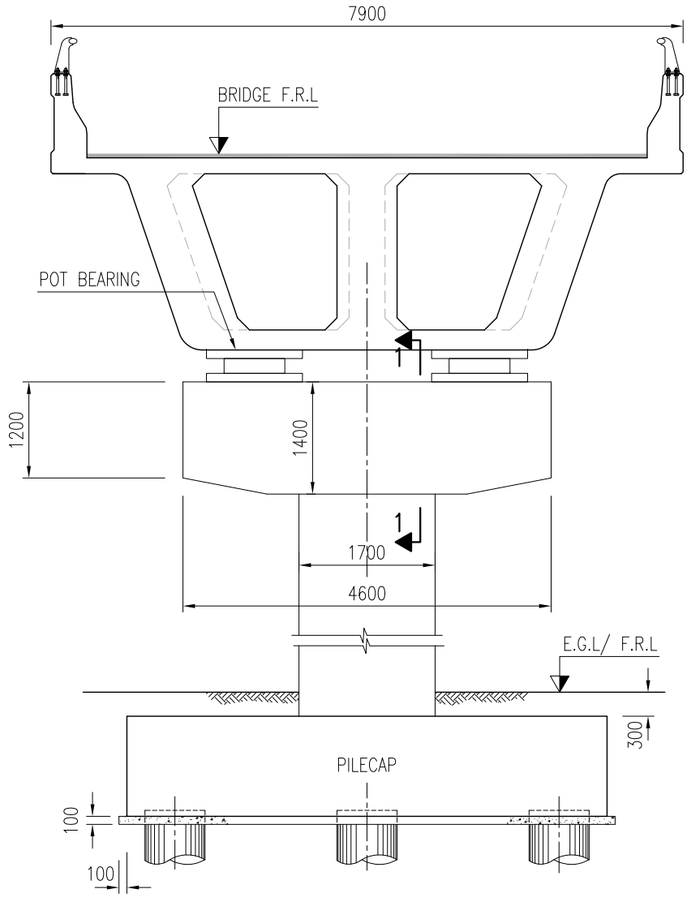

SECTION 2–2
SCALE 1:30



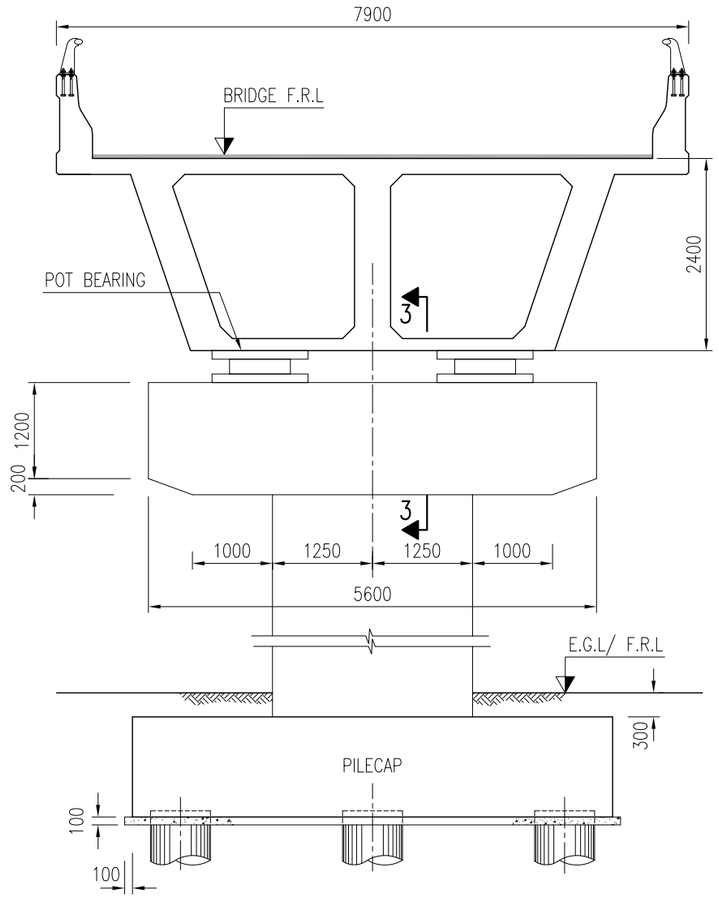

SECTION 3–3
SCALE 1:30




TYP. ELEVATION OF TRANSOM TR–1
SCALE 1:50
*GIRDER SECTION SHOWN IS INDICATIVE




TYP. ELEVATION OF TRANSOM TR–2 & TR–4
SCALE 1:50
*GIRDER SECTION SHOWN IS INDICATIVE




TYP. ELEVATION OF TRANSOM TR–3
SCALE 1:50
*GIRDER SECTION SHOWN IS INDICATIVE

## NOTES:

1. FOR GENERAL NOTES REFER DWG. No. P–38035/P3/50T/PD/00G001.
2. FOR TRANSOM LAYOUT PLAN REFER DWG No. P–38035/P3/50T/PD/01G002.
3. FOR DETAILS OF PILES & PILE CAPS REFER DWG No. P–38035/P3/50T/PD/01G004 & 01G005.
4. ALL EXPOSED CORNER SHALL BE CHAMFERED BY 25mm.
5. FOR BRIDGE FRL AND AT GRADE FRL REFER RELEVANT ROADS DWG.

PRELIMINARY DESIGN DRAWINGS

LOCAL GOVERMENT & HTP DEPARTMENT
GOVERNMENT OF SINDH

NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LIMITED

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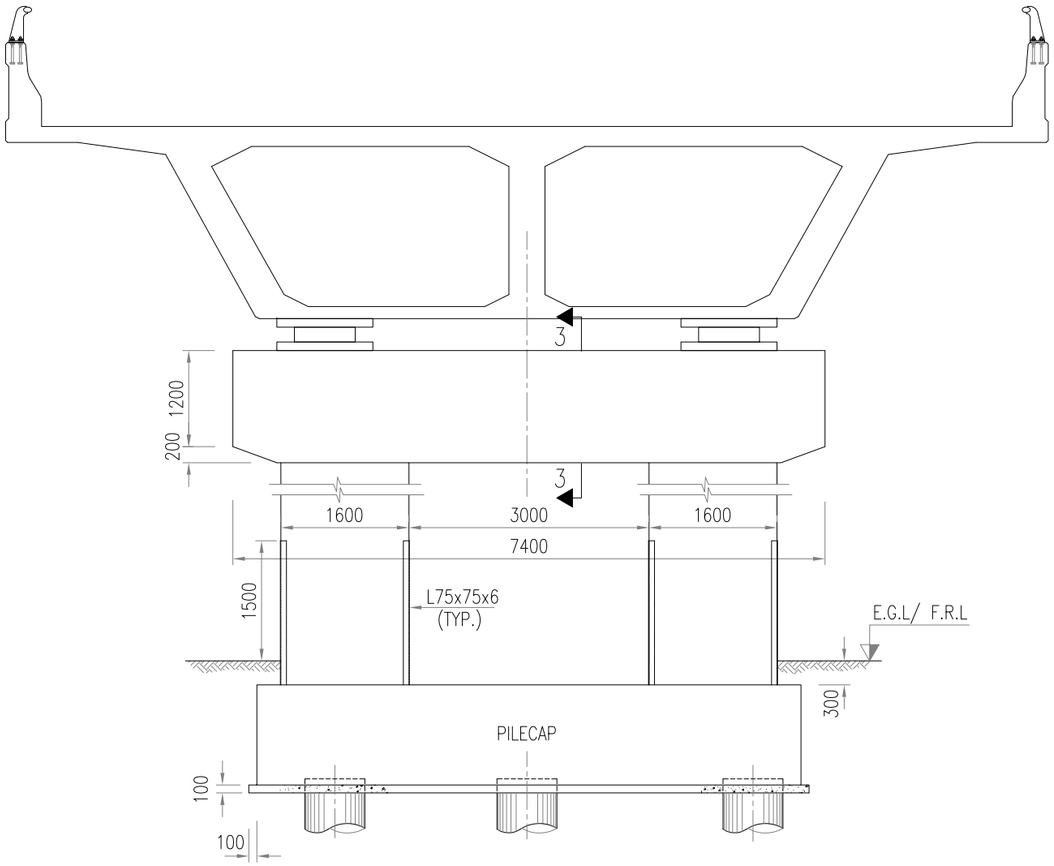
|---|---|
| DRAWN | A.S.R |
| DESIGNED | S.F.H |
| CHECKED | N.F |
| APPROVED | M.Y.U |

URBAN ROAD INITIATIVES IN KARACHI
SUB-PROJECT 3 : INTERCHANGE AT ICI BRIDGE

TITLE: DETAILS OF COLUMN AND TRANSOM

SCALE: AS SHOWN

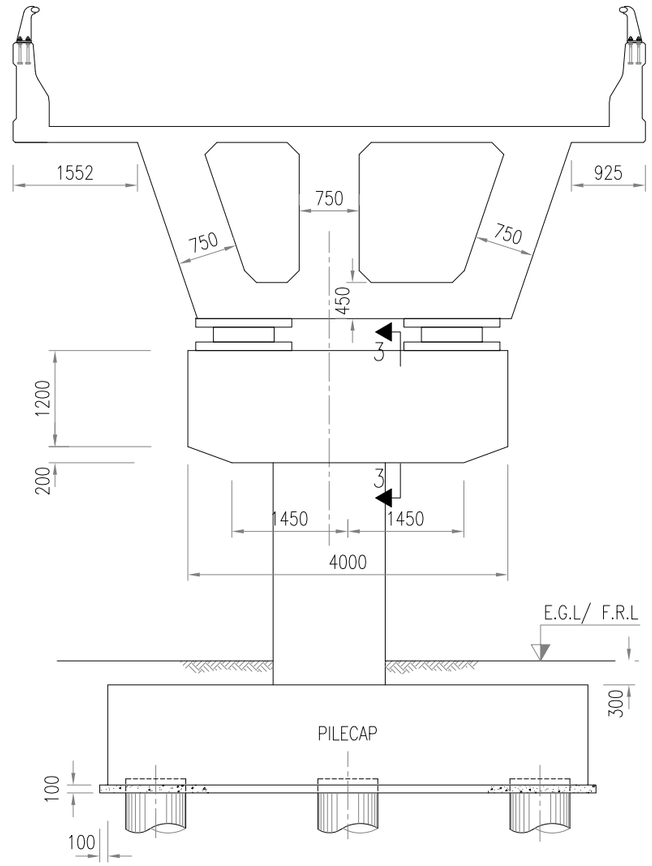
| DATE | DWG. No. | REVISION |
|---|---|---|
| OCT.,2020 | P–38035/P3/50T/PD/01G007 | 0 |




TYP. ELEVATION OF TRANSOM TR-3A

SCALE 1:50

*GIRDER SECTION SHOWN IS INDICATIVE




TYP. ELEVATION OF TRANSOM TR-5

SCALE 1:50

*GIRDER SECTION SHOWN IS INDICATIVE

NOTES:

1. FOR GENERAL NOTES REFER DWG. No. P-38035/P3/50T/PD/00G001.
2. FOR TRANSOM LAYOUT PLAN REFER DWG No. P-38035/P3/50T/PD/01G002.
3. FOR DETAILS OF PILES & PILE CAPS REFER DWG No. P-38035/P3/50T/PD/01G004 & 01G005.
4. ALL EXPOSED CORNER SHALL BE CHAMFERED BY 25mm.
5. FOR BRIDGE FRL AND AT GRADE FRL REFER RELEVANT ROADS DWG.

PRELIMINARY DESIGN DRAWINGS

LOCAL GOVERMENT & HTP DEPARTMENT
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NATIONAL ENGINEERING SERVICES PAKISTAN (PVT) LIMITED

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|---|---|---|
| DRAWN | A.S.R | |
| DESIGNED | S.F.H | |
| CHECKED | N.F | |
| APPROVED | M.Y.U | |

URBAN ROAD INITIATIVES IN KARACHI

SUB-PROJECT 3 : INTERCHANGE AT ICI BRIDGE

TITLE: DETAILS OF COLUMN AND TRANSOM

SCALE: AS SHOWN

DATE: OCT.,2020

DWG. No.: P-38035/P3/50T/PD/01G007a

REVISION: 0