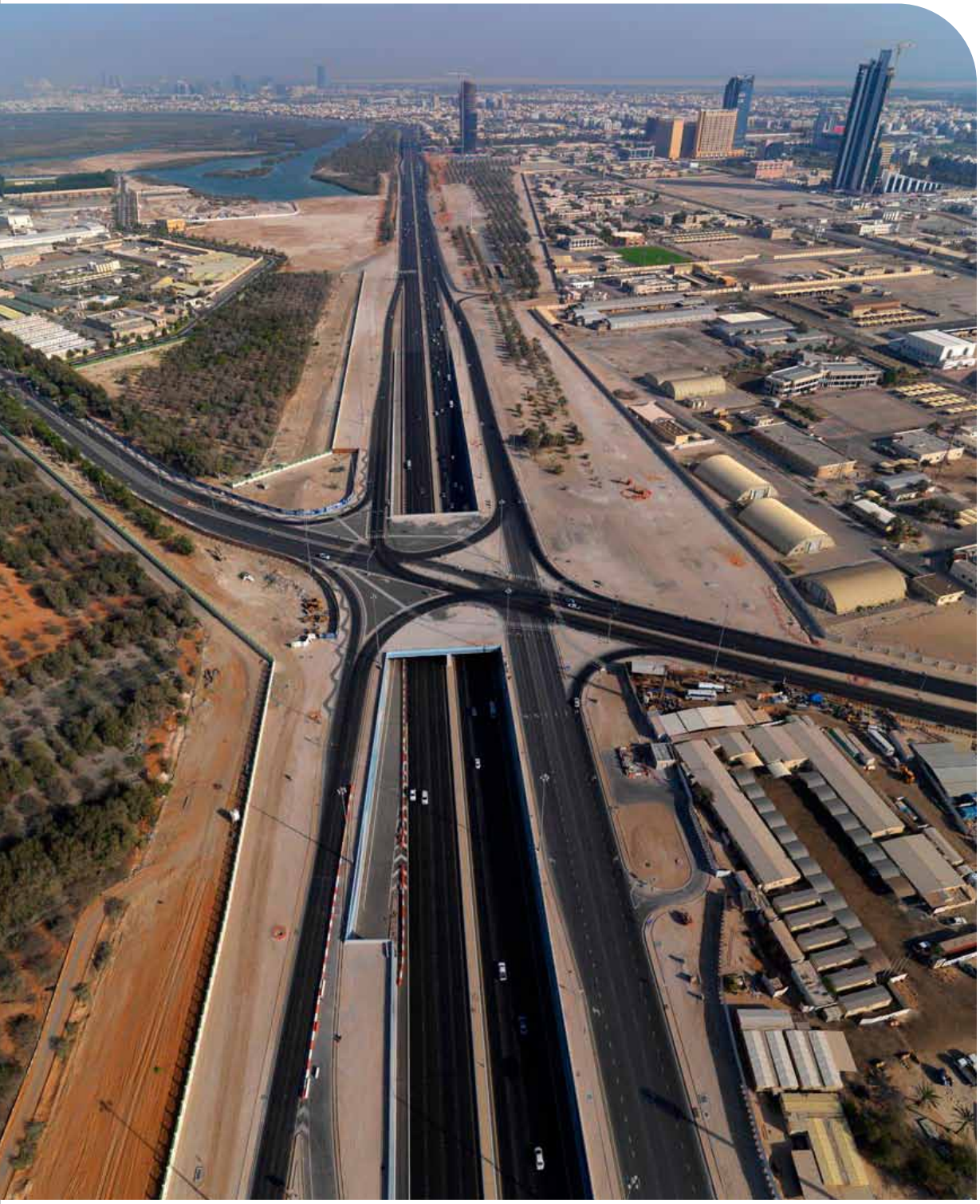
بلدية مدينة أبو ظبي
MUNICIPALITY OF ABU DHABI CITY



REQUIREMENTS AND RECOMMENDATIONS FOR NONDISRUPTIVE ROAD CROSSINGS

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REQUIREMENTS FOR NONDISRUPTIVE ROAD CROSSINGS

REQUIREMENTS FOR NONDISRUPTIVE ROAD CROSSINGS

The following subsections describe the Abu Dhabi Municipality Road Department's requirements for construction of nondisruptive road crossings (NDRC).
These requirements do not cover the require-ments of other agencies with jurisdiction for works adjacent to or already existing beneath the roadway. Contractors are responsible for procur¬ing any other required permits or approvals from agencies with jurisdiction over such surface or subsurface works.

1.1 SUBMITTALS REQUIRED FOR PERMIT TO CONDUCT NDRC

Permission of the Road Department (hereinafter, the Department) is required for any NDRC work carried out below property under the jurisdiction of the Department. The following items shall be submitted to the Department when applying for a permit:

- Justification for conducting an NDRC as op-posed to an open cut or using existing ducts.
- A brief description of the NDRC method and equipment to be used.
- The name of the contractor and NDRC sub-contractor conducting the works.
- Letters of approval of the NDRC design, method statement, and subcontractors from the consultant and the concerned agency (client) commissioning the NDRC work.
- A brief statement on the soil conditions in the location of the NDRC.
- A general plan that clearly shows the route and location of the proposed NDRC.
- Clear plan, profile, and section drawings of the proposed drive showing the details (such as internal and external diameter, wall thickness, coupling system, etc.) of the cas¬ing (or sleeve), pipeline (carrier pipe), and intended utility installation and their respec¬tive depths below the road surface. The drawings shall also show the microtunnel (bore) and overbreak details, as well as the construction details of entry and exit pits and their planned location in relation to the road.
- Sketch and schedule of ground surface movement monitoring system and baseline readings for monitoring points collected during initial survey (see next section), as well as predicted ground movement (settlement and/or heave) based on scientific calculations.
- Bank guarantee and associated Departmental forms.

1.2 MONITORING SYSTEM

For purposes of monitoring for ground surface movement on the roadway, the contractor shall install flush-head pins (35.0 millimeters to 50.0 millimeters in length) in the road pavement. These pins shall be the monitoring points. The pins shall be installed in a grid pattern with approximately 2.0-meter centers.

The grid of monitoring points shall cover the entire width of the roadway along the drive and shall extend outwards in each direction from the centerline of the drive to a distance of the drive centerline depth below the road surface.

The contractor shall conduct surveys of all moni¬toring points and provide the Department with drawings and precise survey information on each point three times:

1 Prior to commencement of NDRC construc¬tion (see Section 2.5 for Departmental recommendation on the establishment of monitoring point baseline information).

2 Upon completion of NDRC construction.

3 At a subsequent time after completion of NDRC construction as directed by the De-partment.

Benchmarks for measurement of elevation shall be located a minimum of 50 meters outside of the monitoring area.

All survey work shall be done using equipment capable of an accuracy of ±0.1 millimeter.

1.3 UNACCEPTABLE GROUND SURFACE MOVEMENT

Unacceptable ground surface movement (settle¬ment or heave) shall be defined as movement greater than 6.0 millimeters vertically anywhere in a rectangular area covering the entire width of the roadway along the drive and to boundaries extending outwards from the centerline of the NDRC drive. The distance of these boundaries from the centerline of the drive shall be as follows:

- For an NDRC with a diameter 1.0 meter or less, the boundaries shall be located one meter on each side of the drive centerline.
- For an NDRC with a diameter greater than 1.0 meter, the boundaries shall be located at a distance equal to the drive diameter on each side of the drive centerline.

Any ground surface movement exceeding the above limits that are detected during or after NDRC construction shall be immediately repor¬ted to the Department and proposed remedial measures and/or intended actions shall be stated.

Measurements for ground surface movement shall be taken relative to the finished level of the roadway at the time of measurement.

Ground surface movement limits in the specified area shall remain in effect for 10 years from date of completion of the NDRC, in compliance with Article 16 of the General Conditions of Contract in the Field of Contracts of Civil Works.

1.4 REPAIR AND REINSTATEMENT

If ground movement as measured on the roadway surface exceeds the Department's stated limits (Section 1.3, above) or if damage is apparent in adjacent areas, the contractor shall repair and

reinstate the roadway and/or adjacent areas to their original line, level, and condition. The expense for the repair and reinstatement shall be borne by the party responsible for the project. Repair and reinstatement shall be done in accordance with the Road Department's

Standard Specifications for Road and Bridge Construction and is subject to the Department's approval.

1.5 PROTECTION OF ADJACENT AREAS AND WORKS

Upon completion of construction, curbs, sidewalks, or other surface areas adjacent to the roadway shall not show any visible sign of disturbance or stress.

Any immediate or delayed damage occurring to Department property that is an indirect result of utilities damage inflicted as a result of the NDRC installation shall be the responsibility of the contractor. Damage caused to other services or utilities shall be dealt with separately with the concerned agency.

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2.1 PURPOSE AND SCOPE

This section provides general recommendations for planning, design, and execution of NDRC works below property under the jurisdiction of the Department.

NDRC works conducted below Abu Dhabi road-ways under the jurisdiction of the Department by and at the behest of other entities are subject to the performance requirements of the Department. It is the responsibility of the contractor, consultant, client (concerned agency), and any other parties involved in the construction of an NDRC under an Abu Dhabi roadway to ensure that road pavement, pertinent services, and adjacent areas such as sidewalks are not damaged and that any effects are within the acceptable tolerances stated in the Department's NDRC requirements (Section 1 of this document).

These are recommendations of good practices for the planning, design, and execution of successful NDRC works. Parties conducting an NDRC are expected to have a sufficient level of knowledge and expertise to carry out the construction successfully.

2.2 PRELIMINARY NDRC PLANNING

Based on initial site reconnaissance and available soil as well as utility information, a desk study should be conducted to plan the method and route most appropriate for the purpose in the given soil conditions. The desk study should accommodate the existing constraints and all sur¬rounding conditions. At this stage, preliminary analysis is useful in checking the suitability of the proposed NDRC method.

The presence of surface and underground works in the area of the proposed NDRC should be thoroughly investigated at this stage. Structural and pavement elements must be considered, as well as utilities. Confirmation of the presence or

absence of underground utilities is best achieved by "excavate to locate." As-built drawings alone may not be sufficient for this purpose.

If utilities are located in the immediate vicinity of the NDRC work, contractors should coordinate with the concerned department or agency. Approval by the utility provider may be required, and the provider may demand specific measures be taken to protect its assets.

2.3 GEOTECHNICAL INVESTIGATION

If insufficient geotechnical information is available for the area where an NDRC is proposed, then a thorough geotechnical investi-gation should be conducted.

2.3.1 PURPOSE

A number of objectives can be achieved by a geotechnical investigation:

2.3.1.1 ROUTE SELECTION

The investigation should provide sufficient grounds for defining the line and level of the route, as the optimum Z/D ratio (Z=depth to crown of drive, D=diameter of drive) depends on the type of soil strata encountered and the NDRC method used. The Z/D ratio, local ground conditions, and the NDRC method have a direct relationship to the magnitude of surface defor¬mation (settlement or heave) and breadth of the area affected.

The soil investigation should target specific routing considerations such as to avoid driving through weak/strong soil boundaries, weathering interfaces, and groundwater surfaces.

2.3.1.2 NDRC METHOD SELECTION AND OPTIMIZATION

The soil investigation analysis should be used as the basis for the selection of the optimum NDRC method and relevant tunneling machinery (pipe¬jacking, microtunneling, jet drilling, directional drilling, auger boring, etc.), as well as for defi¬ning the optimum operational variables (RPM, axial feed rate, torque, flush and lubricant rate

and specifications, face pressure, etc.) for the chosen technique.

2.3.1.3 DETERMINATION OF DESIGN PARAMETERS

The investigation should result in properly obtained, reliable soil parameters, which are necessary for adequate design of the drives, shoring, and dewatering details. Analysis and design (calculations for jacking forces, stress analysis on the pipeline, ground surface settlement and heave analysis, etc.) should be based on such parameters.

2.3.2 SCOPE OF THE GEOTECHNICAL INVESTIGATION

The information collected in the geotechnical in¬vestigation may include:

- Typical soil profiles and groundwater levels.
- Index and phase parameters, such as:
  - Soil classification.
  - Phase parameters, such as unit weight ( ), relative density (Dr), moisture content ( ), saturation (S), void ratio (e), porosity (n), and any other parameters that may be useful.
  - Shear strength parameters, such as cohesion (c), friction angle ( ), and unconfined compressive strength (qu).
  - Elastic constants such as the elastic modulus (E), Poisson Ratio ( ), and sub-grade reaction coefficient (K).
  - Soil compressibility and collapse coef¬ficients, such as volume compressibility (mv, av, M) constants parameters; com¬pression indices (dc, dr, etc.), and pre-compression pressures (pp).
  - Permeability (k) and erodability para¬meters.
  - Any other relevant parameters.

2.4 DESIGN

During this stage, a detailed engineering analysis should be carried out applying the results of the geotechnical investigation to the design of the systems proposed in the preliminary planning stage.

2.4.1 ENGINEERING ANALYSIS

Engineering analysis includes general geotech-nical analyses of the various aspects and components of the proposed NDRC system as well as a check on the effects of the drive on the existing roadway and adjacent areas. This includes, but is not limited to, the following:

2.4.1.1 GENERAL ANALYSIS OF THE NDRC DRIVE

An NDRC system should be developed using available factual soil data and surrounding

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constraints. The system should include recom-mended route (line and level), boring size, NDRC method, pipeline details, equipment, and operational variables, all of which, in combina-tion, will achieve the required tolerances. The proposed system should then be analyzed for:

- Jacking/pulling forces.
- Lubricant characteristics.
- Face stability.
- Thrust reaction elements.
- Structural design of pipe and joints.
- Ground surface movement (settlement and heave).

2.4.1.2 GROUND SURFACE MOVEMENT

As ground surface movement is the chief risk and problem faced in attempting a successful NDRC, its prevention is discussed in more detail in the following subsections.

a. Ground Surface Movements Caused by NDRC Method and Pipeline

The combination of NDRC drive methods and pipeline details are key to preventing excessive surface movement, which may be related to:

- Diameter and depth of drive.
- Boring method and practice.
- Stiffness of pipe and joint system and struc-tural integrity.
- Joint alignment.
- Maximum jacking/pulling forces.
- Lubrication and flush details.
- Pipe/soil interaction.
- Overbreak and its management.
- Face support details.
- Groundwater control details.

b. Ground Surface Movement Due to Unfavorable Ground Conditions

Regardless of drive method or details, sur-rounding soil may be susceptible to excessive movements when disturbed by the drive (bore). The following conditions can influence ground movements:

- Residual or swell stresses leading to radial-elastic or time-dependent movements.
- Weak soils or shear failure of the face.
- Loose compressible soils around or above the drive leading to densification and hence ground movement upon disturbance.
- Internal erosion of loose, noncohesive soil due to uncontrolled groundwater movements.

c. Movement Analysis Methods

Using one or a combination of numerical mod-eling methods, theoretical and empirical

methods may be needed to sufficiently analyze potential ground movement.

Since tolerances against ground surface move-ments are small, the Department recommends that very conservative assumptions and methods be used and that total, not fractional, movements be determined.

Modes of analysis should include all relevant principles, which include, but are not limited to:

- Elastic, elastoplastic, and viscoplastic defor¬mational behavior.
- Immediate, short-term, and long-term move¬ments.
- Consolidation, collapse, and swell.
- Volumetric compression and expansion.
- Volume loss, soil piping, internal erosion, and hydrocompaction.
- Fractional and total ground movements.

2.4.1.3 SHORING FOR ENTRY AND EXIT PITS

Proper shoring analysis and design should be conducted to meet the allowable shear forces, bending moments, deflections, and minimum penetration (socketing) requirements of the wall system. Likewise, proper analysis and design of the proposed support systems (anchors, bracing, strutting, waling, etc.) should be carried out in accordance with internationally acceptable practice.

Where design against full or partial external hydraulic pressures is assumed, watertight shor-ing construction should be specified to satisfy this condition. This construction should preclude soil erosion (soil piping behind shoring) and ground settlement around the pits. Hydraulic pressures behind shoring should never be allowed to exceed values considered in the design calculations.

Analytical or empirical approaches may be used, provided the validity and applicability of the sel¬ected approaches are justified.

2.4.1.4 DEWATERING

Dewatering systems, including an appropriate filter around riser pipes, should be carefully considered and designed properly. The filter design should ensure against the possibility of any internal soil erosion that might cause ground settlement and collapse along the drive or around shoring boundaries. Filters can be either conven¬tional soil filters or geotextile filters. The Department prefers and recommends the use of geotextile filters.

2.4.1.5 GROUND IMPROVEMENT

In cases where conventional NDRC methods seem to be unfavorable for a particular appli-cation or given ground conditions, or in cases where extreme sensitivity (in terms of tolerance) of the adjacent existing works do not favor any of the available methods alone, ground improvement, such as soil grouting, may be necessary. The goal of ground improvement is to enhance local conditions along the proposed route. Cementitious or chemical grout systems — applied before, during, or after construction — are possible alternatives, depending on existing ground conditions.

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2.4.1.6 ALTERNATIVES TO NDRC TECHNIQUES

Some situations and configurations are not conducive to or prevent the construction of NDRCs. For example, it may not be feasible to construct a large-diameter NDRC where struc¬tures or other impediments would require entry and exit pits to be located very near pavement boundaries.

Where engineering analysis and design suggest that tolerances can not be practically met with conventional NDRC techniques and where ground improvement is not feasible, alternatives to NDRC systems should be considered. The goal of these systems is to allow placement of the required pipelines while minimizing traffic disruption. Alternative systems available include:

- Placing reinforced concrete slabs (preferably precast) below the pavement layers on pregrouted soil abutments and excavating under the slabs. Traffic disruption in this case would be of limited duration and stabilization by anchoring and bolting would be possible during excavation.
- Open-trench pipe-laying or precast duct installation followed by quick backfilling using low-strength concrete or an approved fluidized quick-setting cementitious backfill material. Disruption to traffic would be very minimal as the duration of the backfilling activity would be short.
- Several other systems as described in engineering and construction methods litera-ture.

2.4.2 GENERAL RECOMMENDATIONS FOR DESIGN OF NDRCS

2.4.2.1 DEPTH

For NDRCs with a diameter of 1.0 meter or less, the Department recommends a minimum depth of 3.0 meters, measured from the road surface to the crown of the drive. For NDRCs with a diameter of greater than 1.0 meter, the Depart¬ment recommends a minimum depth of three times the NDRC's diameter.

In other words, where D=diameter of drive and Z=depth to crown of drive, the recommended criteria are:

- If D 1.0 meter, Z 3.0 meters.
- If D>1.0 meter, Z 3D.

2.4.2.2 LOCATION OF ENTRY AND EXIT PITS

The Department recommends that entry and exit pits for construction of NDRCs be located a minimum of 5.0 meters from the edges of the paved roadway.

2.5 CONSTRUCTION SUPERVISION AND MONITORING

Qualified supervisory staff should be present in the field during the execution of NDRC works to ensure that the approved design and method are being followed.

Once construction has begun, automated or manual recording of all operational variables, progress, drive behavior, etc., should be carried out to ensure compliance with the intended set of operational variables. The record produced should form a continuous log of all

operational variables against the completed driving distance in a properly recorded time frame. This record can be used as a tool and reference for inspection and control, and is a permanent record for troubleshooting and interpretation of a drive›s behavior.

Throughout NDRC construction, existing works (roads, nearby structures, and utilities) should be frequently monitored under the supervision of qualified staff to detect any ground surface movement.

- Before Construction

  The Department recommends that several surveys be conducted of the monitoring points prior to commencement of NDRC construction to establish a baseline level for each point.

- During Construction

  The Department recommends that moni-toring points are surveyed for ground surface movement twice each work shift, and more frequently if any movement is detected.

- After Completion of Construction

  The Department recommends that moni-toring points be surveyed for ground surface movement once per day for a minimum of one week, followed by progressively de¬creasing frequency for several months.

  The Department's requirements for a monitoring system during NDRC work are included in Section 1 of this document.