October for Plastic Pipes
Hebeish Group

A Brief Guide on Careful Pipeline Execution Procedures

Sherif A. Y. Akl

Professor of Geotechnical Engineering

Faculty of Engineering
Cairo University

Amr F. El-Hakim

Professor of Geotechnical Engineering

Faculty of Engineering
Cairo University

November 2022

Executive Summary

This document describes the procedures of careful execution of plastic pipelines according to the Egyptian Code for the Design and Execution of Pipelines used for Drinking Water and Sewage – Code (102)/1. The document describes the requirements of performing an adequate site investigation program and the expected recommendations from a geotechnical factual report. Then, the document discusses the suitable dimensions of the trench and the compaction requirements for bedding, sidefill, and top cover to have adequate backfilling around the pipe. Finally, the document lists the needed field activities such as dewatering and quality control.

Table of Contents

List of Figure Captions

List of Tables

1 Introduction

Executing a pipeline and guaranteeing pipe adequate long-term performance involves several earthwork activities such as excavation, side support construction, slope stability, and backfilling. These activities require the specialized knowledge and expertise of geotechnical engineers due to the complexity of soil behavior compared to other engineering materials. Dealing with soils is more complex because soils are described as a particulated medium rather than a continuum. Other engineering materials (e.g., steel and concrete) are considered to be solids with uniform predictable properties. Such engineering materials are manufactured to have certain properties regarding strength and deformations. Thus, structures are constructed using these manufactured materials with a high degree of confidence.

On the other hand, soils are composed of three distinct phases: solids, fluid (typically water) and gas (typically air). The behavior of soil is affected by the interaction between these different components. Several factors govern this behavior which include:

- Shape and size of soil particles.
- Soil structure.
- Density.
- Mineralogy.
- Degree of saturation.

It is important to obtain the input of an experienced geotechnical engineer on the operation of backfilling and excavation of pipeline trenches from the beginning of the project till its completion. Geotechnical designs are conducted using soil properties obtained from subsurface ground investigations and factual report recommendations. This document gives the important provisions from the Egyptian Code of Practice on the matter of excavating trenches with suitable geometry and the process of adequate backfilling.

2 Subsurface Ground Investigations for Pipelines

The purpose of a subsurface ground investigation is to characterize the soils and rocks at the location of the pipeline and associated industrial works. Typically, the field investigations include surveying works, drilling boreholes and test pits to extract soil / rock specimens at different depths. According to the Egyptian Code for the Design and Execution of Pipelines used for Drinking Water and Sewage – Code (102)/1, the minimum requirements for the number and depths of the boreholes are listed below:

a) The depths of the boreholes shall extend a minimum of 3-m below the pipe excavation level. The minimum depths of boreholes for water and sanitary pipelines are 7-m and 10-m, respectively.

b) For narrow streets in villages or unplanned districts, the depths of the boreholes / trial pits may be reduced to 5-m.

c) In case of groundwater table that needs to be lowered, the depth of the boreholes shall extend to a minimum depth equal to three times the excavation depth. It is preferable for the boreholes to penetrate the water bearing layer.

d) For old neighborhoods, the spacing between boreholes shall not exceed 300 m. In new developments, the maximum spacing between boreholes is 500-m or 300-m for homogenous and non-homogeneous ground profiles, respectively.

Relevant field tests (e.g., SPT) shall be performed on site. Laboratory tests are to be conducted on representative soil specimens to classify the soil and determine the relevant strength, deformation and flow properties as appropriate. Chemical tests are to be performed on water/soil samples to make appropriate durability material recommendations. The groundwater level shall be measured in the boreholes.

3 Geotechnical Report Recommendations

The geotechnical report recommendations shall include (as a minimum) the following items:

a) Foundation recommendations which may include soil replacement (as applicable).

b) Material durability requirements based on the chemical analyses of the groundwater / soil.

c) Trench detailing.

d) Recommendations for slope stability and / or side support system (as needed).

e) Recommendations for pipe crossing under different structures (e.g., roads, waterways, railway, etc.).

4 Geometry of Excavation

4.1 Excavation sides

During excavation works, the stability of the side slopes shall be ensured during the different working conditions. Proper slopes and/or side support are to be applied in accordance with geotechnical recommendations and project specifications.

4.2 Trench width

The width of the excavation shall be sufficient for the installation of the pipes and accessories according to the below conditions

4.2.1 One pipe in the excavation

The minimum excavation width should be chosen according to Table 1.

Table 1 Minimum excavation width

Nominal Pipe Diameter (mm)	Minimum Excavation Width	
	Fine Soil (mm)	Rock (mm)
100	600	500
150-200	800	600
250-300	900	D + 600
350-600	D + 900	D + 700
Larger than 700	D + 1200	D + 800

D = outer pipe diameter

4.2.2 More than one pipe in the excavation

In case more than one pipe is placed within the same excavation, the excavation width depends on several factors which include pipe diameter and pipe spacing. The spacing shall be sufficient to install the pipes, ensure the stability of the excavation sides and allow proper compaction of the surrounding soil, as presented in Figure 1.

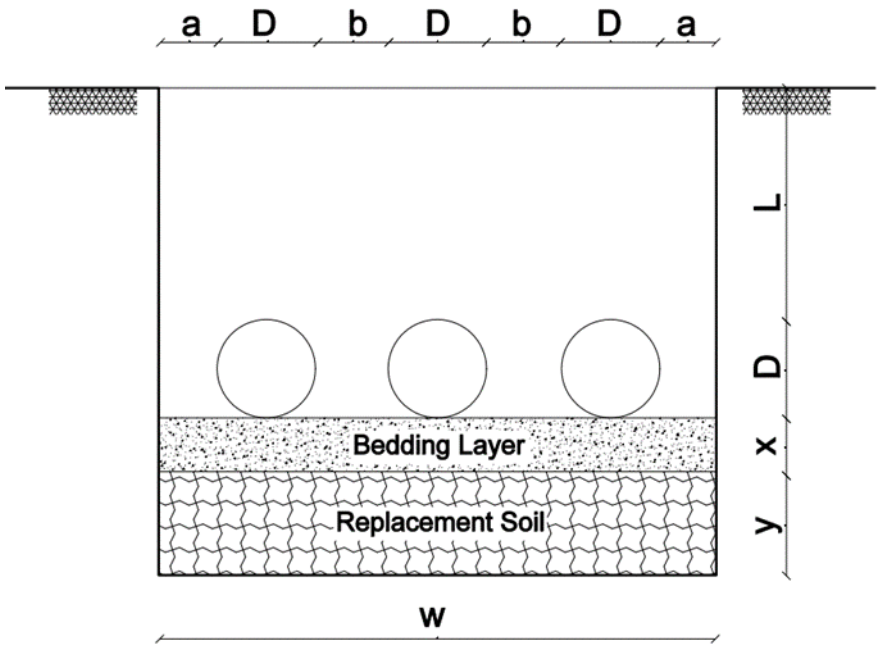

Figure 1 Excavation cross-section with more than one pipe

Where

L = minimum 1meter from the natural ground surface.

D = pipe diameter.

x = thickness of the base layer according to the geotechnical report.

y = thickness of the soil replacement layer according to the geotechnical report.

a = 30 cm, the minimum distance between the pipe edge and the excavation side.

b = minimum spacing between pipes

= 50 cm for pipes with diameters less than 50 cm.

= pipe diameter for pipes with diameters up to 2 meters.

= 2 meters for pipes with diameters equal to or greater than 2 meters

w = excavation width

= 2 a + number of pipes x D + number of spacing between pipes x b

4.3 Trench Depth and Pipe Cover

a. Excavation for pipe trenches shall follow the plans, elevations, and dimensions presented in the project contract documents and drawings.
b. An adequate fill cover shall be placed to reduce the effects of the different loads on the pipe (e.g., traffic load, concentrated loads, impact loads, etc.).
c. The depth of the excavation should be deep enough such that the minimum thickness of the fill above the top of the pipe is 1 meter.

5 Backfilling around Pipes

5.1 Trench examination and preparation

a) The bottom of the excavation shall be inspected by a competent geotechnical engineer prior to placement of the pipes.

b) The foundation soil shall be well compacted, stable, and free from clay and mud, such that the bottom of the excavation is not affected by the feet of the laborers during the execution and pipe testing.

c) The bottom of the excavation shall be flat, free from hard protrusions/bumps, rocks, and any built-up structures. In case such formations exist, the excavation shall extend 10 cm below the excavation level. The extra excavation shall be filled with sand to form a level surface for the pipe to rest on.

d) In case the foundation soil is unsuitable, the natural soil shall be excavated to the required depth (as per the geotechnical recommendations). The excavation shall extend along the whole width of the excavation.

e) Any treatment of the existing foundation soil (recommended by the geotechnical report e.g., compaction, flooding and compaction, replacement) shall be performed before any fill works. All works should be performed in accordance with the geotechnical recommendations, project specifications and code requirements.

f) A decision must be made if the excavated material can be used for backfilling or borrowed material will be used as structural fill around the pipes. This decision is made by a geotechnical engineering consultant and a report must be given to explain the decision and present the evidence supporting it such as field and laboratory tests.

5.2 Bedding

The bedding soil shall be placed in layers with a maximum thickness of 15 cm. The fill materials shall be sufficiently granular and compactable. All fill soil shall be free from refuse, organic materials, boulders, pebbles, and large stones. The placed soil shall be compacted to 90-95 % of the maximum dry density obtained. Pipelines shall rest evenly on the trench bottom.

5.3 Sidefill

The stiffness of the sidefill soil plays an important role in determining the magnitudes of pipe deformations and internal stresses. It is always preferable to execute backfilling with target stiffness close to that of the native soil such that any long-term deformations or settlements are avoided. However, when native soil comprises highly plastic fine-grained soil, structural fill is required to provide adequate stiffness around the pipe. In both cases, using borrowed material for a structural fill or using the native material resulting from excavation, the stiffness of the sidefill and backfill in general can be controlled by the degree of compaction. When native soil exhibits higher stiffness values, it is preferable to increase the backfill stiffness by compacting to a higher degree. Compaction level is measured by comparing the resulting fill density to the maximum density achieved during a Proctor test (Proctor Value). The degree of compaction for each case shall satisfy the criteria listed in Table 2.

Table 2 Different degrees of compaction

Compaction Degree	Percentage of Proctor Value (%)
Slightly	85
Moderately	85~95
Highly	>95

The backfill soil shall be placed in a symmetrical manner at both sides of the pipeline. The thickness of the backfill layers shall not exceed 20 cm. It is not advisable to use the compaction equipment directly on top of the pipe. A minimum fill cover of 30-cm should be placed on top of the pipe prior to the use of any compactors. It is advisable to use light compactors to lower the risk of damaging the pipes.

5.4 Cover fill

5.4.1 Partial Filling:

The filling should be executed using clean well-graded sand free from pebbles and unsuitable materials. The fill shall be placed in layers of 30-cm on top of the pipe. Partial filling shall be executed prior to the application of hydraulic pressure in the pipes on site.

5.4.2 Complete Filling:

Filling shall be executed using clean well graded granular soil free from pebbles and unsuitable materials up to the design level. Placed soil shall be compacted in layers in accordance with project specifications and code of practice requirements.

5.4.3 Leveling trench top

After the fill works are completed, the topsoil shall be leveled to the final grades as per the contract drawings. All refuse (garbage, etc.) and excess soils are to be removed promptly from the location.

5.5 General Requirements for fill materials

a) The pipe shall be continuously supported along its length on stable material.
b) The fill on top of the pipeline shall be placed in such a manner to ensure its stability to protect the pipes from damage.

c) The fill materials shall be sufficiently granular and compatible to achieve the degree of compaction/densities specified in the contract documents. Care should be taken to properly compact the fill under the sides of the pipe.
d) All fill soil shall be free from refuse, organic materials, boulders, pebbles, and large stones.

5.6 General Notes

a) Excavated materials shall be placed at a minimum distance of 1 meter from the edge of the excavation.
b) All necessary measures shall be taken to protect surrounding and nearby utilities and structures.

6 Field Activities

6.1 Dewatering (as needed)

The excavation shall be maintained dry at all times until the completion and testing of the pipes. All measures shall be taken to prevent the intrusion of surface water inside the excavation. Precautions have to be made to ensure the safety of surrounding structures, roads, and utilities.

6.2 Quality Control

a. Special Inspections: The Contractor will engage a qualified special inspector to perform the following special inspections:
    i. Determine prior to placement of fill that site has been prepared in compliance with the geotechnical report recommendations and project specifications.
    ii. Determine that fill material and maximum lift thickness comply with requirements.
    iii. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
b. Testing Agency: The Contractor will engage a qualified geotechnical engineering testing agency, approved by the Engineer, to perform tests and inspections.
c. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

d. Testing agency will test compaction of soils in place according to the appropriate specifications in accordance with Egyptian and international specifications. Tests will be performed at the following locations and frequencies:

   i. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 50-m or less of trench length, but no fewer than two tests.

   ii. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.