

CIVIL WORKS FOR FIBER DEPLOYMENT

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1. INTRODUCTION

1.1 GENERAL

This document describes in detail the technical specifications for the construction of pipeline systems for the optical fiber deployment of Unsere Grüne Glasfaser (UGG) regarding the work to be performed.

The Contractor must comply with all the requirements that are written in this document.

The construction of the optical fiber plant must be carried out in accordance with the executive project, the legislation and the recommendations included in this document regarding:

- The methods used for carrying out civil excavation works,
- The method of laying the pipes,
- The methods of creating infrastructures for special environments

The following indications must be considered:

- All materials must conform to UGG specifications and approvals
- Materials must be protected by suitable packaging both during transport and for the established storage period.

Before to start any civil work or excavation, the contractor should have all the necessary permits from the competent authority.

1.2 REVISIONS

EDITION	DATE	REVISED SECTIONS	CHANGES	OBSERVATIONS
1 st	OCTOBER 2020			The document is created.
2 nd	APRIL 2021	The entire document is revised and modified.	The document is restructured to include more sections and information.	There are corrections and changes along the entire document.
		2. Earthworks-Description	The different techniques for duct laying are moved to a new description chapter.	It is included the impact mole as an alternative to cross streets (not only for customer connections). There are defined more boring hole diameters for HDD and Impact mole.
		3. Soil classification	A new section of soil classification is included.	
		4 Backfilling of the trenches	A new section is included.	It is included some examples of the RStO normative, to understand the different layers that must be respected and the

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EDITION	DATE	REVISED SECTIONS	CHANGES	OBSERVATIONS
				compaction requirements that are included. It is included the different materials that must be used for the trench backfilling and restoration.
		5 Compaction	A new section of compaction methods and measurements is included.	It is included some description of the compaction task and the different machinery that can be used depending on the layer and the wide of the trench. It is included methods to measure the compaction degree, including devices designed for narrow trenches.
		6 Trenching General Requirements for duct laying	The section is restructured. It is included a new sub-section with the definition of the Warning tape that should be used.	The warning tape defined has the UGG logo included.
		7 Trench Dimensions and Sections	The trench dimensions and sections are moved to a new section.	There are included new sections to have more flexibility in the deployment.
		8 Recommended Techniques and trenches for each situation	A new section is included.	Include recommended techniques and trench sections for different situations.
		10 Other civil works for elements installation	A new section is included.	It is explained (overview) the installation of the handholes and the street cabinets.
3 rd	MAY 2021	10.2 Installation of the street cabinets	Details about depth and burial requirements	
4 th	JUNE 2021	4.6 Temporary restoration	New section included	This section mentions general specifications that must be considered when restoring the surfaces temporary
5 th	JANUARY 2024	All	Errata are corrected. New codification of the document	There are little corrections and changes along the document. The document is codified with the document code: TEF-NORM-00001. The logo of UGG is updated in the page header.
		6.3 Warning Tape in trenches	Figure 54 is actualized with new logo. Figure 55 (photo) with old logo is removed	

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EDITION	DATE	REVISED SECTIONS	CHANGES	OBSERVATIONS
5 th	JANUARY 2024	7.1.2 Mini trench (15x45cm) sections examples	A note is included allowing reduce the horizontal separation	
		9.2.1 Bundle rubber end caps at constructions works	New section	
		9.8 Installation approval test on ducts	The tests are re-named.	
		10.1 Installation of manholes	The dimensions of the manholes are changed according to the new models approved (OC and TC). Paveable covers are included	
		10.2 Installation of street cabinets	New cabinets are included	
		10.3 Installation of the centralized distribution point	New section	

1.3 REFERENCE NORMATIVE

The following normative and standards must be considered (even above what is described in this document) for any civil engineering work necessary to be carried out in the fiber deployment in Germany.

This list is not pretended to be complete. All conditions published by administrations must be respected.

The contractor has the obligation to know the current version of each one.

In the case of naming an European law, for example DIN EN 1991 or part of them, there are automatically included their national applications.

- TEF-NORM-00009 – Microduct Quality Tests
- TEF-INST-00002 – Installations of Manholes
- TEF-INST-00004 – Installations of Street Cabinets
- TEF-INST-00005 – Installations of Centralized Distribution Pints (CDPs)
- TEF-INST-00008 – Installation of Urban DPs
- DIN EN 124 Gully tops and manhole tops for vehicular and pedestrian areas
- DIN 483 Concrete kerb units - Shapes, dimensions, marking
- DIN 825 Signs, plates and labels – Dimensions
- DIN 1054/A3:2020-02 Subsoil - Verification of the safety of earthworks and foundations - supplementary rules to DIN EN 1997-1
- DIN 1076 Engineering structures in the course of roads and bridges (monitoring and Exam)
- DIN 1164 Special cement compositions, requirements and conformity Evaluation
- DIN 1211 DN 1212 Step irons with upstand for staggered manhole steps

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- DIN 1229 Gully tops and manhole tops for vehicular and pedestrian areas - Securing of the cover or grating within the frame
- DIN EN 1338 Concrete paving blocks - Requirements and test methods
- DIN EN 1340 Concrete kerb units; Requirements and test methods
- DIN EN 1343 Kerbs of natural stone for external paving - Requirements and test methods
- DIN EN 1344 Clay pavers - Requirements and test methods
- DIN EN 1424; DIN EN 1463; DIN EN 1790 Road marking materials
- DIN EN 1627 Pedestrian doorsets, windows, curtain walling, grilles and shutters - Burglar resistance - Requirements and classification
- DIN 1995 Bitumen and bituminous binders - Requirements for the binders
- DIN 1996 Testing of Bituminous Materials for Road Building and Related Purposes
- DIN 1998 Housing of lines and systems in public areas (guidelines for planning)
- DIN 4020 Geotechnical investigations for civil engineering purposes - Aids to application, supplementary information
- DIN 4022 - Subsoil and groundwater; Designation and description of soil types and rock
- DIN 4030-1 Assessment of water, soil and gases for their aggressiveness to concrete - Part 1: Principles and limiting values
- DIN 4030-2 Assessment of water, soil and gases for their aggressiveness to concrete - Part 2: Sampling and analysis of water and soil samples
- DIN 4045 Wastewater engineering – Vocabulary
- DIN 4102 Fire Behaviour of Building Materials and Building Components; Definitions, Requirements and Tests
- DIN 4123 Excavations, foundations and underpinnings in the area of existing buildings
- DIN 4124 Excavations and trenches - Slopes, planking and strutting breadths of working spaces
- DIN 4220 Pedologic site assessment - Designation, classification and deduction of soil parameters (normative and nominal scaling)
- DIN ISO 10381-3:2002-08 Soil quality - Sampling - Part 3: Guidance on safety
- DIN EN 12350 Testing fresh concrete
- DIN EN 12390-2 Testing hardened concrete - Part 2: Making and curing specimens for strength tests
- DIN EN ISO 12404 Soil quality - Guidance on the selection and application of screening methods
- DIN EN 13101 Steps for underground man entry chambers - Requirements, marking, testing and evaluation of conformity
- DIN EN 13422 Vertical road signs - Portable deformable warning devices and delineators - Portable road traffic signs - Cones and cylinders
- DIN EN ISO 14688-1 Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description (ISO 14688-1:2017)
- DIN EN ISO 14688-2 Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification
- DIN EN 15651 Sealants for pedestrian walkways
- DIN 18125 Soil investigation and testing - Determination of density of soil - Field tests
- DIN 18127 Soil; Investigation and testing - Proctor-test
- DIN 18134 - Plate load test
- DIN 18195 Waterproofing of buildings
- DIN 18196 Earthworks and foundations - Soil classification for civil engineering purposes

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- ATV DIN 18299 German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) - General rules applying to all types of construction work
- ATV DIN 18300 German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) – Earthwork
- ATV DIN 18301 Drilling works
- ATV DIN 18302 Work on the expansion of boreholes
- ATV DIN 18303 Installation work - Timbering to trenchwork
- ATV DIN 18304 Piling, vibrating and pressing work
- DIN 18305 German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) - Groundwater lowering
- ATV DIN 18309 Press-in work
- ATV DIN 18315 Traffic route construction work - superstructure layers without binders
- ATV DIN 18316 Traffic route construction work - track layers with hydraulic binders
- ATV DIN 18317 Road construction works - Track layers made of asphalt
- ATV DIN 18318 Paving and paving, edging
- DIN 18319 German construction contract procedures (VOB) - Part C: General technical specifications in construction contracts (ATV) - Trenchless pipe laying Pipe jacking work
- ATV DIN 18320 Landscaping
- ATV DIN 18322 Cable line civil engineering work
- ATV DIN 18323 Clearing of unexploded ordnance
- ATV DIN 18324 Horizontal directional drilling
- ATV DIN 18382 Electrical, Safety and Information Technology Systems
- ATV DIN 18421 Insulation and fire protection work on technical systems
- AVV - Regulation on the European Waste List (Waste List Regulation)
- BaustellV - Construction Site Ordinance: Planning and coordinating Occupational Safety and Health
- DIN 18533 Waterproofing of elements in contact with soil
- DIN 18915 Vegetation technology in landscaping - Soil working
- DIN 18920 Vegetation technology in landscaping - Protection of trees, plantations and vegetation areas during construction work
- DIN 19657 Protection of Watercourses, Dikes, and Coastal Dunes; Guidelines
- DIN 19662 Soil quality - Field tests - Determination of soil penetration resistance by means of a hand held penetrometer
- DIN 19682 Soil quality – Field tests
- DIN 19695 Transport and storage of pipes, fittings and prefabricated manhole components made of concrete and steel reinforced concrete
- DIN EN ISO 25177 Soil quality - Field soil description
- DIN EN ISO 28258:2020-02 Soil quality - Digital exchange of soil-related data
- DIN 43629-2 Cable distribution cubicle; base, mounting dimensions
- DIN 52096 Testing of filler for road construction - Stiffening effect of filler on bitumen
- DIN EN 60794 Generic specification - Optical cable elements

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- DIN EN 61034 Measurement of smoke density of cables burning under defined conditions; Part 2: Test procedure and requirements
- DIN EN 61386 Conduit systems for cable management - Part 1: General requirements
- DIN EN 61386-24 Conduit systems for cable management - Part 24: Particular requirements - Conduit systems buried underground
- DIN EN 61439 Low-voltage switchgear and control gear assemblies
- DIN FB 101 - DIN technical report
- DVGW GW 304/ DVGW GW 321 Pipe jacking
- Eurocode 7 Geotechnical design - Part 2: Ground investigation and testing
- FTZ-Norm 548464 TV1 Alignment warning tape
- General technical regulations for the use of roads by telecommunication lines (ATB Tele-Stra)
- Guideline for laying and attaching cables to bridges (Ri-Lei-Brü)
- Guidelines for the construction of roads (RAS), part: landscaping (RAS-LG), Section 4: Protection of trees and shrubs around construction sites (RAS-LG4)
- H-Trenching - Instructions for using the trenching process when laying fiber optic cables in traffic areas using asphalt construction
- H ZFSV, FGSV-No. : 563 - Instructions for the creation and use of self-compacting filling materials that can flow at times in earthworks
- Laga M20 Federal / State Working Group on Waste - country-specific regulations for the implementation - Requirements for the recycling of mineral waste
- RLBP - Guidelines for the accompanying landscape maintenance planning in road construction
- RLP - State building regulations
- RSA Road safety guidelines
- RStO 01 Guidelines for the standardization of the superstructure of traffic areas
- RStO 12 Guidelines for the standardization of pavement structures of traffic areas
- Town ordinances and general agreements between the contractor and the town council
- TP BF StB Teil B8.3 - Technical test regulations for soil and rock in road construction. Part B 8.3: Dynamic plate load test with the light drop weight device.
- TP BF StB teil B8.4 - Calibration Rules for the Light and Medium Drop-Weight Tester" of the "Technical Testing Regulations for Soil and Rock in Road Construction
- TP BF StB Teil B11 - Suitability test for soil treatments
- TP Fug-StB - Solely refers to a joint filling with permanently-elastic paving-joint compounds
- TL Asphalt-StB - Bituminous mixtures - Test methods for hot mix asphalt
- TL Beton-StB - Technical delivery terms for materials and material mixtures for base courses with hydraulic binders and concrete pavements
- TL BuB StB 09 Guidelines for earthworks in road construction
- TL Gestein-StB-The technical delivery conditions for aggregates in road construction
- TL SoB-StB-Technical delivery conditions for building material mixtures for the production of layers without binding agents in road construction
- ZTV-TKNetz 10, Civil engineering works for trenches and excavations
- ZTV-TKNetz 11 Underground installation of cables and cable pipes
- ZTV-TKNetz 11, Burying of cable and cable conduit

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- ZTV-TKNetz 12 Construction, maintenance, and demolition of cable pipes
- ZTV-TKNetz 13 Installation, fabrication, and demolition of manholes
- ZTV E-StB 17 - Additional technical conditions of contract and directives for earthworks in road construction
- ZTV-TKNetz 20 Installation of outdoor cabinets
- ZTV-TKNetz 40 Pull out and put in of cables, blowing of fiber optic cables and calibration of pipes
- ZTV-TKNetz_41 Connect outcoming cables with copper pair cables, pre-installation
- ZTV A-StB Additional technical contract terms and guidelines for excavations in Traffic areas
- ZTV Asphalt-StB-09 Superpave system for Superior Performing Asphalt Pavements
- ZTV-BEA-StB ← part of ZTV Asphalt above
- ZTV E-StB 94/97 Pavers with paving slabs and slabs (MFP 1) for earthwork in road construction
- ZTV Pflaster-StB-06 Additional technical contract conditions and guidelines for the production of paving slabs, slab coverings and borders
- ZTV-LW - Additional technical contract conditions and guidelines for the paving of rural roads
- ZTV - SoB- Stb for layers without binders for the construction of asphalt pavements (ZTV Asphalt-StB-07)
- ZTV-SA Additional technical contract conditions and guidelines for securing work on workplaces on streets
- ZTV Verm-StB 01 - Additional technical conditions of contract and guidelines for construction surveys in road and bridge construction

1.4 SECURITY MEASURES

The Contractor must take particular care in carrying out the excavations in order to avoid landslides and damage, providing, where necessary, the implementation of suitable yawning. In the course of road works, the Contractor must prepare the site by delimiting it and indicating it adequately in accordance with the relevant regulation (local, federal, etc.), ensuring circulation road and keeping transits and driveways or pedestrian accesses accessible by laying suitable structures (walkways, etc.); the Contractor, moreover, must install at the edges of the excavations, in order to protect the safety of all pedestrians, the necessary protections. Excavations can be done by hand or with mechanical equipment.

In the case of excavations near tunnels, in the crossing of walls, pedestrian passages or driveways, etc. or when the excavations run parallel and in a short distance from walls or foundations, the Contractor must take all the measures needed to guarantee the stability of the pre-existing works.

1.5 CONSTRUCTION SITE

The longitudinal excavation in the roadway will be carried out in sections whose maximum length will be determined, in agreement with the staff of the competent body. As for the construction sites, long state roads, it will be necessary to operate in compliance with the rules of the relevant regulation (local, federal or national).

1.6 INTERFERENCE WITH EXISTING PLANTS

The Contractor must identify, by agreement with the civil works supervision officials of the competent authority and the owners of the underground service networks (water network, gas distribution network, sewer network, electricity and signalling networks, telephone and data transmission, etc.), the presumed position of such services unless such presumed position is already in the documentation prepared by UGG and in the possession of the Contractor.

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The Contractor must also identify the position on site, before starting the works, the exact interference with metal pipes and underground cables existing on the laying path using suitable instrumentation and carrying out the necessary surveys to identify the non-metallic pipes and sewer works. The Contractor must carry out the temporary relocation or removal of elements, obstacles and wrecks that do not require the direct intervention of the owners, subject to the authorization of themselves.

The Contractor must immediately report to the Entities, Companies or Third-Party owners concerned, for the necessary interventions, any failure found or caused to underground cables and pipelines, etc. These notifications must also be given to UGG at the same time.

IMPORTANT: during the design phase all the crossing with other services must be avoided if it is possible.

1.7 GENERAL CRITERIA

The excavation operations must be carried out always with the appropriated means, considering all the rules and regulations in force.

The excavations must be kept dry, with the use of pumps if necessary.

When the traffic requirements require it, the Contractor, upon request of the entity land manager, must provide the means for the immediate transport of the material to authorized landfills. The demolition must be limited to the strictly necessary surface.

The unravelling of the conglomerate flooring, whatever its constitution, must be preceded by cutting performed with suitable equipment, in compliance with the prescriptions of the owners. The Contractor is responsible for the failure to comply with the prescriptions of the owners.

All the resulting material deriving from excavations and demolition must be taken to landfills authorized by competent bodies for the area, except paving stones and cubes to be reused.

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2. EARTHWORKS - DESCRIPTION

The methods for carrying out the civil works for pipelines installations are described below, divided into:

- Traditional excavations
- Excavations in mini trenches
- Excavations in micro-trenches and nano-trenches
- Ploughing excavations
- No-dig techniques:
 - HDD: horizontal directional drilling.
 - Soil displacement method (Impact mole).

In general, the following considerations apply to all methods:

- The presence of existing underground utilities and their nature must be determined along the route of the excavations of the land, carrying out all the required checks in advance with the local authorities, investigations, and subsoil essays.
- The Contractor, during the execution of the works, must ensure that the opening of the excavations do not damage neighbouring buildings or trees. Any damage will be fully charged to the responsibility of the Company.
- The Contracting Company must immediately inform the Works Management and the owner / manager of any faults caused or found in the existing plants.
- The means used must be such as not to damage the entire road body, nor during transport nor during the execution of the works.
- The excavated waste materials that are not intended to be reused for backfilling must be immediately removed from the site and transported to the appropriate waste dumps authorized and indicated by the competent local authorities.
- Regardless of the technique used, pedestrian transit must always be ensured and vehicular and access to private properties.
- Changes in the layout of the infrastructure with respect to the executive design, must be reported in the as-built documentation; in particular, each derogation from the depths of excavation and installation of infrastructures must be authorized in advance by the Works' Management.

Carrying out the excavation, the following requirements must be considered:

- Comply with the rules established by the regulations and provisions of the bodies concerned as far as it concerns the request for permits, the periods allowed for the opening of the excavations, etc.
- Place the protective barriers and road signs in a clearly visible position by the bodies concerned and by the laws and regulations in force. If the excavation must remain open or the roadway is still obstructed at night or in conditions of poor visibility, the signals must be supplemented by luminous devices colour, shape, and size in accordance with the regulations in force.

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- Any damage caused to infrastructures or services present in the subsoil must be immediately reported to the respective owners who manage the services, to the supervisory authorities' officers and the construction management of UGG.

2.1 PREPARATION WORKS

Geo-radar or radio-detection survey (if required) on the route affected by the related excavations to the infrastructure.

Note: The determination of the correct installation site must be evaluated based on the presence of services, to their position (defined by the cartographic documentation available from the entities owning the road or services) and by geo-radar surveys.

The Geo-radar is one of the most common systems used for surveying land geophysics and its fields of application are many and varied: it can be used successfully for the identification of geological structures, for the localization of groundwater surfaces, karst cavities or networks of underground services, for archaeological investigations and for anything else that implies the knowledge of differentiations in the materials of the subsoil.

Note: Along the route of the excavations, the company can resort, where necessary, to soil tests for ascertain the type of existing substrate or to further verify the presence of any obstacles.

2.2 TRENCHING METHODS

This section is intended to give a description of the different methods to be applied, and how must be done their execution. However, the construction details (backfilling, compaction, etc) and the cross sections of the trenches are included in other chapters in the document.

2.2.1 TRADITIONAL TRENCHING

The traditional trench is a method in which the pipeline is installed buried. The earth's surface is opened, and a trench is dug. The open trench construction comes in all topological scenarios and is fundamentally also feasible for all types of surfaces.

For the trench construction specific equipment (e.g. mini excavator) and milling could be used. After the lines have been laid, the excavated trench is backfilled, the soil is compacted in layers and the surface restored.

Cable protection pipes are laid out in one layer on the trench bottom at a standard laying depth of approximately 60 cm.

A standard trench is usually 30 cm wide and 60 cm deep (30/60 cm). Depending on the requirements of the municipality and other circumstances, other dimensions such as 40/60, 40/80 or 40/100 cm are also common.

NOTE: With mini excavators with the appropriate bucket, also is possible to make thinner trenches with a 20-25 cm wide.

In all cases the depth of the excavation must remain as constant as possible to avoid sudden slope changes.

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Protective clearances must be kept to live cables and gas lines. Warning tapes should be placed 30 cm above the cable protection tubes. If the service underpass at a distance such as not to guarantee the safety of the installation, is required to add an adequate protection, such can be a concrete case at 15 N/mm², iron boxes or other.

The set of pipes must be embedded in a thickness of sand that does not exceed the extrados of the pipes for more than 10 cm.

Backfilling must be carried out with suitable material conveniently compacted in layers (wet layers to assure a good compaction). The filling of the excavations must be carried out with the technical characteristics and in the quantities indicated according the environmental laws and rules of each government.

Restoration of road pavements (surface layers) must be carried out by reconstructing the pre-existing technical characteristics (thickness, quality, and quantity of materials, etc.), in compliance with the environmental laws and rules of each government.

To make the trench it may be necessary to use an excavator.



Figure 1: Excavator for traditional trenching

The traditional method offers the following advantages:

- The applications are very well known, so that no further training of the employees is necessary.
- The works can be carried out with un minimum risk for the existing installations.
- The capacity of the trench can be large enough to install all the ducts and microducts that could be required in each part of the network.
- It is possible to achieve big depths that is translated in a more secure network for the future.
- It is easier to achieve in the refill of the trench the levels of compaction required by the regulations normative.

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The most important disadvantages are:

- The trench is bigger, so that the backfilling will be more expensive.
- The methods need always permits to be carried out and takes more time.
- The disturbs to the citizens is bigger than other alternatives.

2.2.2 MINTRENCHING

The most accepted definition of mini trench is the execution of a continuous longitudinal cut with a width between 12 and 20 cm and an average depth between 30 cm and one meter deep.

This procedure is based on the realization of a trench by means of a disc trencher or a chain trencher, which literally saws the pavement and prepares a clean cut, flush and with a layer of detritus at the bottom where place flexible ducts.

NOTE: It can also be done with a small excavator adapted with the tools or means necessary for the size of the mini trench (in this case the trench could be a little bit wider up to 20 cm).



Figure 2: Machinery for mini trenching based on cut chain



Figure 3: Machinery for mini trenching based on cut disc



Figure 4: Examples of Mini trenching

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The mini trench is applicable on routes that generally include asphalted surfaces such as roads and sidewalks having a compact substrate and is limited when the subsoil has a high presence of material gravelly.

The placement of the duct that is housed in the trench can be carried out simultaneously with the opening of the trench, this reduces handling and coordination work, since the section of the cut made is adjusted as much as possible to the final diameter of the service to install, the detritus that is generated can be easily removed due to its small volume.

This circumstance also favours the continuity of road traffic, avoiding street cuts and the risks inherent in the existence of an open ditch in a populated area where vehicles and pedestrians circulate. Lastly, the concreting of the trench carried out continuously allows high performances and finish impossible to achieve with other trench techniques.

These are the main features of mini trenching:

- It is not limited by distance or precision
- Can make very small diameters in very long runs
- It is fast and effective when precise information about the services in handled
- It must go above existing services
- It is limited in depth and requires replacement of the road

With capable and resistant equipment, it can run between 250 and 500 meters a day of installation that includes, opening of the trench, laying of ducts, concreting and removal of material included.

2.2.2.1 MINI TRENCH PREPARATION

Carrying out the work of a mini trench requires the same general requirements mentioned before, and also the following instructions must be considered:

- **Marking of the underground utilities present on the excavation route**

Important: The excavation activities with mini-trench systems are characterized using a half cutter, which does not allow the operator to detect in time if the excavation area is crossed by underground services with the consequent danger of damage to existing networks. For this reason, it is essential to carry out the preventive investigations of the subsoil, to verify the possible presence of underground service networks and adopt the appropriate preventive measures.

- **Cutting of the pavement with special machines equipped with disc-cutter in order to optimize the procedures relating to the preparation of the trench and subsequent drafting of the asphalt.** It is absolutely needed to avoid the jagged and irregular shape of the excavation edge.

Note: Abrupt changes of direction of the routes are not allowed; where these are required, they will have to be carried out with angled cuts, such as to allow compliance with the minimum radius of curvature of the pipe.

- Excavation in the ground of any nature at the required widths and depths.
- Possible removal of parts of flooring damaged due to excavation or cleaning the bottom of the excavation.

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- Laying of pipes of the diameter and in the quantities indicated in the individual executive projects.
- Supply and installation of filling materials, according to the requirements.
- Where necessary, supply and installation of adequate protection for the excavation pending hardening filling for subsequent restoration of the road pavement.
- Loading, transport and unloading of waste materials and other materials at their final destinations possibly not reusable for backfilling.
- Restoration of the pavement/surface to the previous state.

In the cases where the mini-trench is made on the side of a road with no sidewalk or curb, excavation must normally be carried out at a minimum distance of about 1,50 m from the edge of the road (possibly along the road white marking line) and, only in special cases, flush with the asphalt.

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2.2.2.2 EXCAVATION OF A MINTRENCH

The mini-trench 15x45 could be performed using suitable disc cutters (or chain cutters) mounted on the operating machine, simultaneously carrying out the undoing of the pavement and an excavation having a section of variable size according to the infrastructure it must contain.

NOTE: the mini trench also can be done with a retro excavator adapted with the means needed for similar dimensions (for example with 20 cm width).

Once the mini excavation has been completed, the following operations must be performed:

- Removal of debris from the edges of the excavation and transport to authorized landfills according to the legal procedures in force
- Removal of the parts of the adjacent pavement damaged by excavation
- Cleaning of the bottom of the excavation

The excavation section must be completely emptied at the end of this activity and the bottom freed of stones.

2.2.3 MICRO-TRENCHING AND NANO-TRENCHING

The Micro-trench is a constructive technique used for the execution of new communication networks with fiber optic cables characterized by an immediate filling of the excavation, up to the rolling surface, without the need for further repairs.

UGG defines the micro-trenching with a dimensions of 8 cm width and 40 cm depth and the nano-trenching with a dimensions of 2 cm width and 15 cm depth (in both cases, the depth is the free distance from the upper duct to the surface).

The execution of this type of installation requires specific solutions with complex equipment but in suitable environments it offers great advantages:

- Minimization of execution times and road space occupation
- Cleaning of the construction site, through the contemporaneity of the excavation and suction phases
- Quick opening and closing of the site

All phases must be, if possible, carried out simultaneously, by operating machines, arranged in sequence or integrated into one or more machines.

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Figure 5: Machinery for micro and nano trenching



Figure 6 :Examples of micro-trenching

These systems are best suited to tackle special areas such as historic urban centres, or environments that are difficult to access with heavy machinery, in which due to their small size and their small impact on the work area are the best choice.

2.2.3.1 EXCAVATION OF A MICRO/NANO TRENCH

These very small cuts (for nano-trenching) can only be carried out with diamond cutters in asphalt or concrete floors. It is only effective when the environment to settle is very compact; the cut cannot be made in disaggregated or loose materials.

This equipment requires a constant and abundant collection of the cooling water so that the cutting element does not wear excessively. So, it is very important to control the coolant and its removal from the construction area to avoid dirt problems and inconvenience to neighbours.

The excavation carried out with the disc cutter must be clean on the surface, absolutely avoiding damage the road pavement near the excavation section. The disc must be inside a protective casing. The walls of the excavation must have an adequate roughness to allow the perfect adhesion with the filling material to be laid later.

The phases of excavation and suction of the resulting material must be simultaneous, in order to accelerate the cleaning of the trench. These operations must be carried out by providing suitable abatement dust methods in order to maintain the cleanliness of the construction site and to contain the inconvenience for citizens and environmental pollution. The cut section must be at the end of this activity completely emptied

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and the bottom freed of protruding stones; the trench itself and the immediate surrounding area must be completely cleaned from the resulting material which could reduce the mechanical characteristics of the filling material. The resulting materials must be disposed at a suitable authorized landfill, according to local legislation.

It is mandatory to make undercut corners because the flexible high-density polyethylene (HDPE) conduit should be installed with gentle bends. Undercutting the corners allows the correct bending radius for the Conduit.



Figure 7: HDPE micro-conduits



Figure 8: Gentle bend for micro-conduits

This technique allows to lay the pipes at the same time as the trench is being opened. Pipelines are generally supplied on a reel which must be located on the machine that follows the cutter and the aspirator, so that the ducts or micro-ducts are unwound and channelled into the excavation as the machine progresses. The configuration and their location inside the excavation must be maintained for the entire length of the route, including through special fixing systems. To protect the inside of the ducts from dust and water, in all operational phases, they must always be protected at the ends with special caps.

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2.2.4 PLOUGHING

Duct Ploughing is an alternative to Trenching or Boring that utilizes a plow system to excavate and bury the duct simultaneously; this method of burring is ideal for minimal disruption to landscape.

The process of duct ploughing uses a blade to split the ground and cut a narrow slit that can be packed as the plow moves along very easily. As the ground is being cut, the duct or duct bundle is placed at the desired depth by feeding it down a chute, which is located on the back of the blade.



Figure 9: Ploughing machinery



Figure 10: Example of real installations of duct laying using the ploughing technique

The duct ploughing process can be completed in a fairly short time, with easy clean-up and minimal disturbance to the original surface area. This method that can be used on meadows, unpaved areas and in the forest.

With a laying plow, a slot is made in one process by displacement, into which one or more empty pipes and a warning tape are inserted in one operation. The laying depth can be up to 120 cm.

UGG defines two different depths for ploughing of 80 cm and 120 cm, in order to comply with the local regulations in the scenarios in which it is needed.

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The laying of buried duct plow can be used if:

- there is no paved path Surface
- there are no significant obstacles in the ground
- the location of external systems is known

Advantages of Ploughing:

- Speed of installation in open areas
- Less ground disturbance than may be caused by trenching

Disadvantages of Ploughing:

- Large size and high cost of equipment
- Requires skilled and good condition equipment
- Needs operators and quality supervision
- Cannot be used for every kind of soil and terrain conditions
- Possibility of damaging ducts or underground utilities

2.2.5 *PLOUGHING PROCEDURE*

Duct plows are generally of two types: static and vibratory. Both types may be used to install fiber optic duct. Steerable plows, which can be offset to place the duct away from the central-line of the duct plow prime mover, are available in both types.

It is needed having equipment powerful enough for terrain conditions. Local soil conditions and duct depth are the two primary determining factors in the correct size of tractor necessary for ploughing. Too much engine power is better than too little.

A crawler tractor is most suitable for static buried duct ploughing. A tractor equipped with a torque converter drive should be used whenever it is available. This will permit smoother ploughing performance by absorbing the shock loads encountered in the ploughing operations.

The drawbar force for soil penetration by a static plow may reach a magnitude of tens of thousands of kilograms. Heavy and large equipment is needed to generate a drawbar force of this magnitude. A plow that vibrates substantially reduces the drawbar force required to plow-in duct when compared with the force necessary to move a static plow of the same size. With drawbar force reduced, the equipment size required for the plow is also reduced.

The reel carrier should allow for easy installation of the reel using such features as hydraulic lift assistance and should accommodate a reel or reels of adequate size for the intended installation. The duct feed system includes all the components mounted on the tractor which supports and guides the duct as it is fed into the plow chute. Typically, it includes a reel carrier, rollers and/or guide tubes. Use of capstan drive units is recommended. Capstan drive units prevent excessive pulling, tension at the duct feed tube entry and exits.

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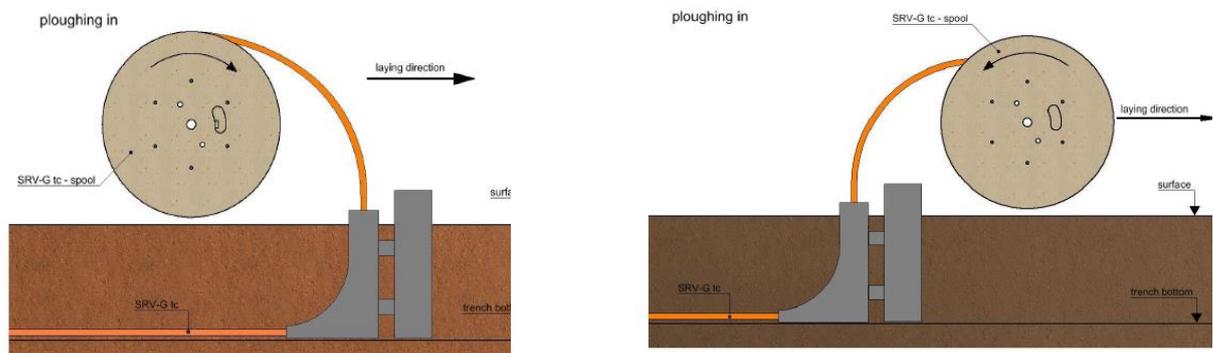


Figure 11: Different plough-in schemes set-ups

All rollers or guides in the duct feed system which cause a change in the direction of the duct path must conform to the minimum bend radius of the duct being placed. Small diameter rollers (fairleads) can be used to guide the duct over the tractor cab, if the feed chute guide and duct reel are positioned so that the duct cannot be tensioned over the smaller rollers. Fairleads should be designed to prevent the duct from becoming wedged between the vertical and horizontal rollers.

Before ploughing begins, a means of communications must be established between the equipment operator and the supervisor monitoring the duct placement and route. The communications link must be able to override the equipment noise.

The starting point for the reel being ploughed should be a pit excavated to the proper depth. Sufficient slack should be reeled off at this point to reach a splice vehicle or splice location. The plow should start at the required depth from the splice pit.

With the plow stopped, remove the duct from the plow's chute. Do not raise the plow to the surface when the plow is not moving. Never back up the plow with a duct still in the chute. The duct to the rear of the feed chute must be excavated and slack pulled to prevent kinking the duct over the exit chute before raising the plow.

When ploughing in fiber optic duct a warning tape is placed 30 cm below the surface of the ground directly above the duct. Both the duct and the warning tape are normally plowed in at the same time.

The plow movement should be started slowly and its speed gradually increased after all duct slack has been taken up from the delivery system. Plow attitude and depth should be changed gradually. Changes should be made only with the plow underway. Never raise the plow to the surface if the plow is not moving. The duct to the rear of the feed chute must be excavated and slack pulled to prevent kinking the duct over the exit chute before raising the plow. Never back up the plow with a duct still in the chute.

Important: The excavation activities by ploughing systems are characterized using a blade, which does not allow the operator to detect in time if the excavation area is crossed by underground services with consequent danger of damage to existing networks. For this reason, it is essential to carry out the preventive investigations of the subsoil, in order to verify the possible presence of underground service networks and adopt the appropriate preventive measures.



Figure 12: Detail of the plow blade digging into the ground



Figure 13: Detail of the micro-duct bundle inside the furrow made by the plow blade



Figure 14: Example of the surface termination after a ploughing laying

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2.3 NO-DIG TECHNIQUES

Generally, the term no-dig technique is used to describe the technique that does not require digging a trench. There are several no-dig methods that are used to lay fibre optic cables or pipelines.

One form to classify these different no-dig methods could be the following:

- **Horizontal Directional Drilling (HDD).** This method allows to control the drilling path, and is valid for a variety of situations, different soils, and different diameters. In this document will be divided this type of technology in 2 subtypes, according to the size and the capacity of the machinery needed to make the drilling:
 - HDD. Up to 500 m. This method can be used to overcome large obstacles, such as rivers, etc. The method has a navigation system that always allows the drilling progress to be monitored.
 - Mini-HDD. Up to 50 m. For shorter distances, a smaller variants of HDD machinery could also be used. As in the other case, the mini-HDD machinery has also a navigation system to control the drilling process. This method could require a launch and a target pit, the dimensions of which depend on the size of the mini-HDD machinery used. There are some cases in which the mini-HDD machines are installed in the launch pit. Other models are out of the launch pit. Its main areas of application are road crossings and the house connection with the distribution pipeline laid in the sidewalk if the soil is a rocky soil, or it some obstacle must be jumped.
- **Soil displacement method (impact rocket or impact mole).** This method is an uncontrolled method, that is very useful for short distances but only can be used if the soil is compactable. If not, other alternatives should be used. This method requires a launch and a target pit, the dimensions of which depend on the size of the impact rocket/mole head used. Its main areas of application are road crossings and the house connection with the distribution pipeline laid in the sidewalk.

The no-dig techniques must be considered as alternatives to other laying ducts techniques for any situation.

In some situations, in which other alternatives like trenching could be more expensive than the no-dig techniques because of the cost of permissions, or the replacement of the surface pavement, due to the regulations of the zone, etc, the use of the no-dig technique should be evaluated and used if it fits.

For the situations in which it is not possible to have the permissions to install ducts crossing a railway, motorway or some area inside a city centre, or no technical alternative to cross a river or a swamp, etc, the HDD technique must be considered.

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2.3.1 HORIZONTAL DIRECTIONAL DRILLING (HDD)

Horizontal Directional Drilling (HDD) is used for the trenchless laying of new conduits and cables. The drill path can be straight or gradually curved, and the direction of the drill head can be adjusted at any time during the pilot drill to dodge obstacles or pass under roads, rivers or railways, to follow the intended path.

Drilling can be carried out from the ground surface, or between previously dug attack pits, positioning the machine so that the drilling begins at a small angle to the surface.

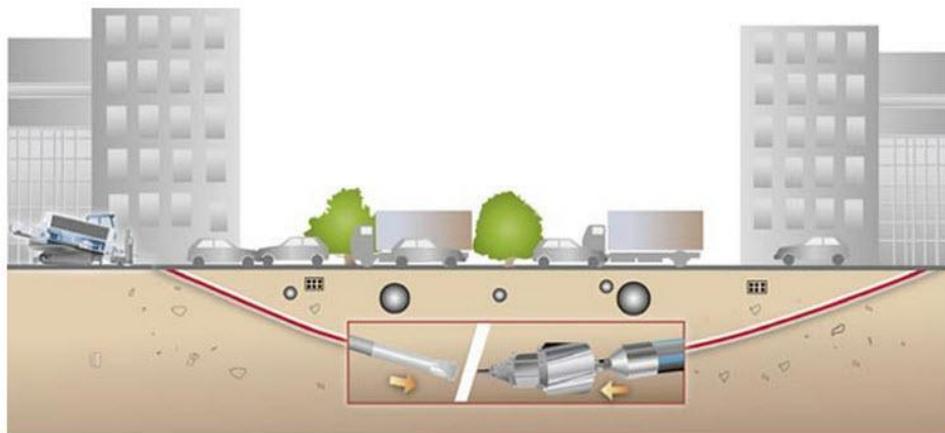


Figure 15: Basic schematic of the HDD method

Pulling capacity, or available force in tons, is the most widely used criterion for classifying HDD systems. The greater the pulling capacity, the larger the machine will generally be, the greater the diameter of the conduit or cable it can install, and the greater the possible drilling length. In any case, it depends on the ground conditions and the diameter of the pipe or cable to be laid.

Laying depths of 3 - 3.5 m are common.

Any HDD machine has two main characteristics.

- The first is a (normally hydraulically) driven stand that pushes the drill bit through the ground to perform the pilot drill, and then pulls it and the pipe to be placed along the pilot drill during the concentric widening process. Generally, the inclination of the support in a machine located on the surface, can be adjusted between 10° and 20° with respect to the horizontal.
- The second feature is a motor and drive system to rotate the drill bit (along with the drill head or the widening head) and provide torque for rotation.

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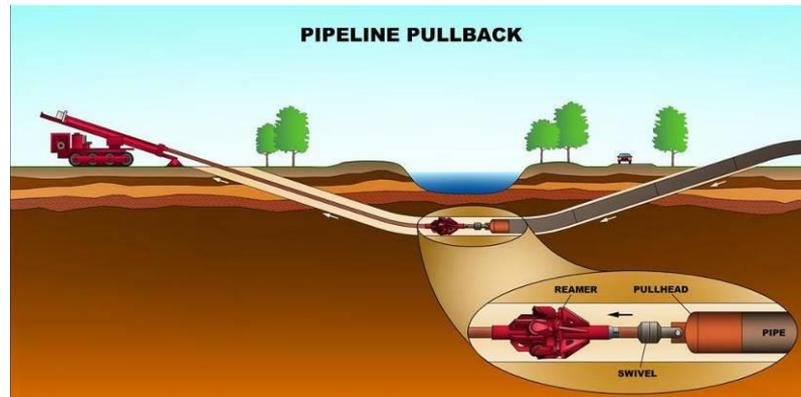


Figure 16: Jacketed tube shot with directed drilling rig

Advantages of HDD:

- The surface under which it is drilled is not affected, damaged or broken
- No replacement or repair of the environment is required
- Avoid traffic diversions
- Reduced implementation and execution times
- It is a solution in the case of riverbank crossings
- Wide range of use
- Known technique
- The position and drilling power exerted can always be known

Disadvantages of HDD:

- Need for precise systems to detect obstacles and avoid accidents
- It poses problems in heterogeneous terrains of low consistency such as gravel or fine sand

2.3.1.1 EXECUTION OF THE BOREHOLE WITH HDD

It is a technique that uses various technologies of:

- Drilling
- Tracking
- Directionality
- Handling of drilling fluids

Required machinery

1. Drilling platform. Rotation and thrust unit.
2. Hydraulic unit to supply hydraulic flow to the platform.
3. Sludge pump to inject the mud with high flow and pressure to the excavation front through the linkage.

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4. Sludge mixer where the bentonite is mixed with the water turning it into the drilling mud.
5. Drilling linkage of variable dimensions transmits the efforts of rotation and push or pull.
6. Guidance system coupled to the drill string, next to the drill head, emits a wave to the surface.

First, a design study should be done. It is necessary to carry out a topographic and geological study of the area to determine the work to be done. It is also necessary to identify existing services in the subsoil using a geo-radar team.

In case of river crossings or seabed bathymetry and electrical tomography is necessary to know the bottom and the different geological units.

Once this information is obtained, the study is carried out to determine technical feasibility.

Machines and guidance systems offer greater precision in position control and monitoring in the right geological conditions.

Duct placement is typically done in two to three phases:

- Firstly, a pilot drilling is performed following the planned route, using a position monitoring equipment that provides the necessary information for guiding,
- Subsequently, the perforation is concentrically widened in the opposite direction to that of the pilot drilling, either at once, or in stages, depending on the conditions of the terrain and the requirements of the project, in order to achieve the appropriate diameter for the pipe to be placed.
- During the draft stage, the duct to be installed is connected to the reamer with an anti-twist and, at the same time, to the linkage, and is pulled along with said drill to lodge it in the enlarged bore.

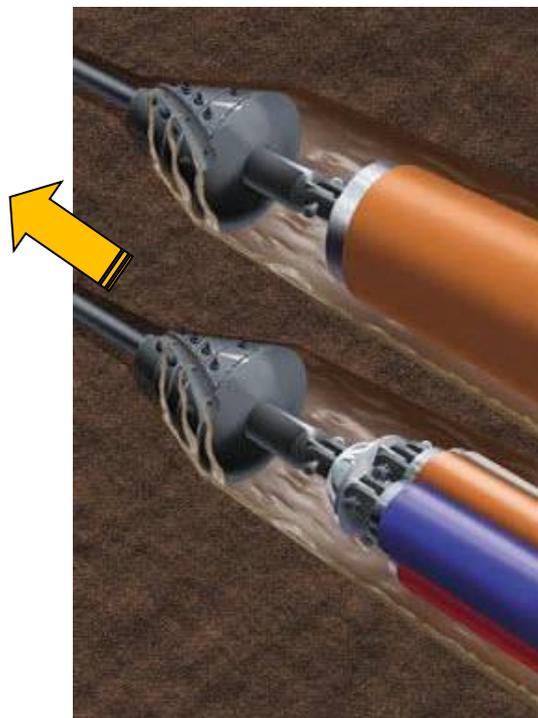


Figure 17: Ducts placed by pulling through the bore

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Type of drills	Maximum strength (kN)	Maximum torque (kNm)	Weight (Tn)
Mini	< 150	< 10	< 10
Midi	150-400	10-30	10-25
Maxi	400-2500	30-100	25-60
Mega	> 2500	> 100	> 60

Table 1: Classification of HDD drilling machines

Normally, machines are located on the surface but there are situations in which the implantation of the machine is required inside a pit.

Machines located on the surface generally move on tracks and can access the working position by their own means. Although they do not need attack or reception pits to place the new duct, it is necessary to carry out small excavations to be able to connect the pipe ends to the front and rear section, wasting the first few meters of the new duct to reach the required depth.

Machines located in a pit require excavation at both ends of the bore but can be operated in a small space. They are intended to drill on relatively short, straight lines with slight deviations, which may limit the ability to avoid obstacles.

Most HDD machines use a fluid-assisted drill head that is pushed through the ground by a drill bit.

The capacities of HDD machines vary considerably depending on the type of terrain they must drill:

- Homogeneous clays: in general, homogeneous clays are the most favourable soils
- Sands: they can present problems, especially if they are below the water table or are not self-supporting
- Gravels: can penetrate at the expense of accelerated wear of the drill head and are very difficult to stabilize
- Rock: Standard machines are not suitable for drilling rock or hard inclusions, and the drill head may lose track if it encounters these obstacles

However, there are several ways to improve performance on hard terrain:

- Rock cutter heads
- Double Rod Systems: System in which the inner tube rotates the rock cutter head, while the outer tube provides the addressability
- Percussion by hammer integrated in the machine: Transmitted through the bits by a hammer integrated in the drilling machine, allowing better penetration and direction control in rocky soils or soft rock, not in hard rock or concrete
- Hammer percussion in the background:

It is used to drill hard rocks, but its limitations are the difficulty of drilling in the face of water or softer terrain and the drilling length.

Typically, a mixture of bentonite and water is used as the drilling fluid or mud, which transports the suspended drilling debris outward. These sludges must be filtered by a recycling system if they are to be recirculated to minimize the amount of product used, and therefore the cost.

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Figure 18: Sludge mixing and recycling unit

After the pilot drilling is complete, the thixotropic sludge stabilizes the walls of the drilling until the concentric widening process begins. In some circumstances, where required by ground conditions or drilling parameters, polymer additives are used together with water and / or bentonite to create the drilling mud mix.



Figure 19: Reamer, which allows concentric widening of the hole after the pilot

TYPE OF MATERIAL	Weight percent of gravels	Applicability of the Technique
Very soft to very strong clay, with the presence of drying fractures	-	Good to excellent
Very loose to very dense sand with or without traces of gravel	0 a 30	Good to excellent
Lightly grainy sand from very loose to very dense	30 a 50	Marginally acceptable
Gravelly sand from very loose to very dense	50 a 85	Questionable
Gravel from very loose to very dense	85 a 100	Unacceptable
Rock	-	Excellent to unacceptable

Table 2: Applicability of the technique depending on the terrain

In softer terrain, the drill head is generally angled so that constant rotation of the drill bit produces a straight dig, while keeping the head in the same position, pushing without rotating, leads to misalignment.

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Figure 20: Angled head for fluid assisted drilling.

Furthermore, the fluid is pumped to the drill head through the drill bits, which are hollow and connected to it. The return is produced by the annular space between the auger and the walls of the perforation, with the fluid, mixed with the debris of the perforation, pumped to a recycling unit for its separation and reuse.

The simplest drilling fluid is water, and it is usually unnecessary to use something more sophisticated for short or small diameter drilling on suitable soils. However, the water lacks, among others, suspension properties for drilling debris, auger lubrication and cutting tools, and filter reduction. Therefore, if the soil to be drilled requires these properties, this deficiency must be compensated with additives.

The most common type of drilling fluid is a mixture of bentonite and water, forming the "mud". Bentonite is a type of clay with thixotropic properties, making a mud that remains fluid as long as it is kept pumped or stirred, or in the form of a gel at rest. For this reason, the material acts as a lubricant and debris transport during the drilling process but solidifies to stabilize the drilling when it finishes.

Then, during the reaming and tube laying processes, the mud aids lubrication between the installed tube and the walls of the bore, reducing friction and soil regression.

In addition to water and bentonite sludge, there are polymer-based materials and a wide range of additives, which are used to modify the properties of the drilling fluid to suit the media required by the characteristics of the terrain and the nature of the project.

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2.3.2 MINI-HDD

The mini-HDD is based in the same technology presented before (HDD), but with less power and designed to be used to cover lower distance and to be used in urban areas.

With this method, obstacles such (streets, trees roots, etc) can be avoided, and non-compactable soils should not be a problem.

For these reasons this method is recommended to connect houses that are in the opposite side of the street if distribution network pipelines are deployed bellow.

This method is normally used also between two pits (start and finish pit). this method could be used in urban areas to connect houses, or to cross streets, if other alternatives (like impact mole) cannot be used.

For the FTTH customer connections, one pit (the starting pit) should be normally in the sidewalk of the street at the same place in which the distribution bundle of micro-ducts with the drop fiber units for the customers must be accessible, and the other pit (the finish pit) at the border of the house, close to the wall (in the point where the customer has chosen to enter to his house).

In the following picture, two different examples represent the technique that is intended to be explained in this chapter:



Figure 21: Mini - Horizontal Directional Drilling

2.3.2.1 EXECUTION OF THE BOREHOLE WITH THE MINI-HDD

Before starting the execution of this kind of works, the two pits (start and finish pit) should be dig.

If the machine of mini-hdd, should be installed in the starting pit, the size and the depth of the pit must be done according to the characteristics of the machine used.

After that:

First, a pilot borehole is made using controlled driving with permanent location of the drill head. Then this borehole is widened in reverse gear, depending on the required dimension, and a cable protection tube is drawn into the drill channel thus produced.

Drilling installations up to 50 m (100 m are also very common) are possible to be reached with this technique.

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The pilot borehole is made by a drill head that is pushed and rotated by a mini-HDD machine, placed in the starting pit (inside or close to the starting pit, depending on the size and type of the machine). The mini-HDD machine uses steel bars and adds all the bars that are needed to pass all the distance that is necessary to reach the finish pit.



Figure 22. Pit launched mini HDD machine



Figure 23. mini HDD machine

In the reverse way, the machine makes the opposite, pulls the steel bars back, and rotates the drilling reverse gear, and at the same time, the machine pulls and drags the duct or the protection duct that is needed to install in the drill channel created.

Depending on the soil, a water-polymer drilling fluid or a Bentonite drilling fluid is used. This is important, because these kinds of fluids should be treated correctly according the environmental laws and rules of each government.

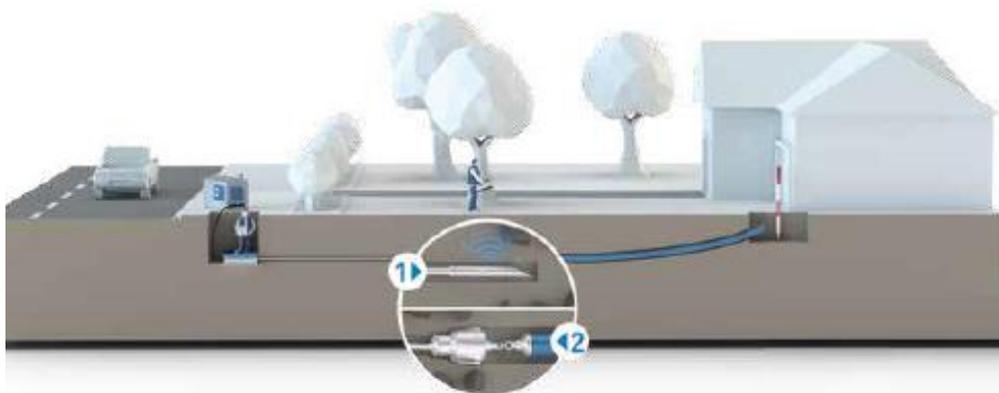


Figure 24: Execution of Mini - Horizontal Directional Drilling

The pipe diameter that is possible to install inside the boring hole made using this technique is from 32 mm to 160 mm.

The bigger diameters could be used to cross streets in several sections of the network, to install pipelines formed by one or more bundles of micro-ducts.

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For the application of the customer connections, it is not necessary to increase the diameter of the borehole in the drive back of the drill head. So, the minimum diameter (32 mm) should be valid, because the micro-duct that it is necessary to pass through is a 7/4 diameter tube. Even if the use of another tube for protection of 14/10, or a different tube of 10/6 were needed (that is also common in Germany), with this diameter of 32 mm it is enough.

Elements needed to be used in this application are: The mini HDD machine, steel bars (normally inside the machine) and drilling heads.

For the transport of this kind of machine, a 3.5 Tons truck is needed.

2.3.3 SOIL DISPLACEMENT METHOD (IMPACT ROCKET OR IMPACT MOLE)

This method could be used **only in situations in which the soil is compactable** (without rocks or concrete layers in the path) because it does not carry out a ground extraction, but rather creates the hole by compacting the soil around the impact rocket head.

Also, this method is only useful if the distance to cover is less than 20 meters. It is an uncontrolled method, so bigger distance has bigger deviations and is possible to not find the destination with accuracy. Also, the length of the hose that transmit the pressure to the impact mole is limited normally to 20 -25 meters by the manufacturers of the impact moles.

To cover bigger distances, this method could be applying in cascade using several pits.

This method is normally used between two pits (start and finish pit).

The pits must have the appropriated dimensions to make possible the insertion of the impact rocket. At least 1 meter length (the impact rocket length is close to 1 meter), and 45-60 cm wide, and the depth, must be according to the distribution pipelines, that should be between 45 cm and 60 cm (depending on the trenching technique and the depth used in the trenches).

This method could be used to cross streets or roads, and also to make customer connections.

To cross streets or roads, one pit should be done in one side of the road, and in the other side must be made the destination pit. after the pass of the impact mole, one protection tube or also directly one bundle or several bundles could be pulled back (like in the HDD method) through the bore made, to connect both pits with the pipelines.

In the following figure the street crossing scheme is shown:

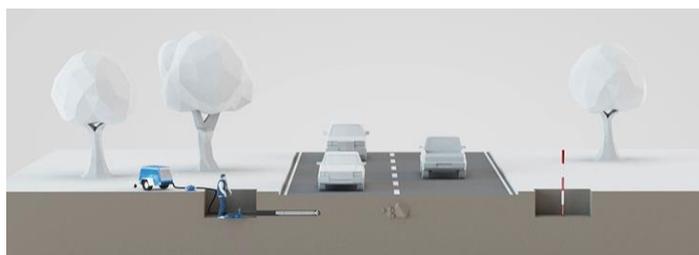


Figure 25: Street crossing scheme (impact mole)

For the customer connection in FTTH, one pit (the starting pit) should be normally in the sidewalk of the street at the same place in which the distribution bundle of micro-ducts with the drop fiber units for the

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customers must be accessible, and the other pit (the finish pit) at the border of the house, close to the wall (in the point where the customer has chosen to enter to his house).

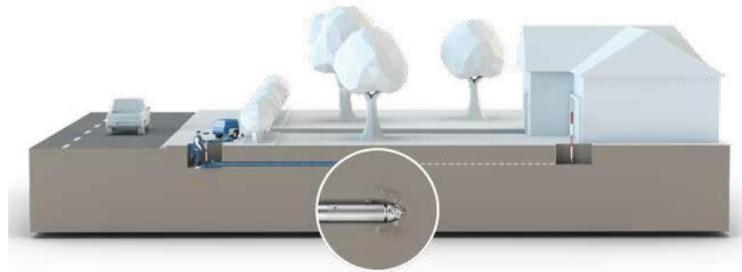


Figure 26: Customer connections scheme (impact mole)

2.3.4 EXECUTION OF THE BORING WITH THE IMPACT MOLE

The impact mole is placed in the starting pit and is oriented to the destination pit to start the borehole path.



Orientation of the impact mole in the start pit



Impact mole reaching the destination pit

Figure 27. Impact mole execution example

The impact rocket is driven through the core borehole to the target pit using a displacement process. The impact rocket is powered by compressed air from the normal construction site compressor. A percussion piston automatically drives the tubular housing through soil, stone or masonry. The soil is displaced, and an earth tube is created, into which a cable protection tube or microtube is often pulled in directly in the same operation by the earth rocket.

The process is an uncontrolled process that can be used up to 20 m. The target accuracy is enough in practice. If more distance is needed to be covered with this technique, more pits could be made, in order to pass from one to the other until the final pit is reached.

The diameter of the boring can go (normally) from **45 mm** to 160 mm.

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The bigger diameters could be used to cross streets and roads if it is needed to pass more than one bundle.

For the application of FTTH house connection (drop section), the diameter that must be used, will be 45 mm (the minimum), because the micro-duct that it is necessary to pass through is a 7/4 diameter tube. Even if the use of another tube for protection of 14/10, or a different tube of 10/6 (that is also common in Germany) were needed, with this boring diameter of 45 mm it is enough.

Elements needed to use this application are: The air compressor, the impact rocket head, the pressure air hoses, and the orientation basement (optional). All items can be transported with a van.



Figure 28: Elements needed in soil displacement method for customer boring

For bigger diameters the use of different impact moles is needed. In the following picture is shown different mole heads with different diameters.



Figure 29. Different impact moles heads with different diameters (values in mm).

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2.3.5 BORING DIAMETERS

The diameter of the perforation must be adapted to the equivalent diameter of the ducts or the group of ducts or bundles that must be laid.

It is not good to use a bigger diameter than necessary because it will make the works slower and is not good for the pipeline after installation.

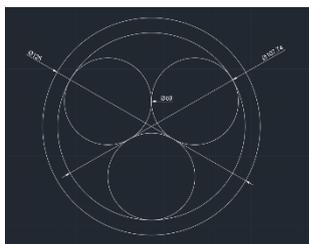
In both main methods (directional drilling, and soil displacement), the following bore diameters could be used:

Boring diameter [mm]	For installation of bundles/ conduits
180	7 ducts or bundles with an outer (or equivalent) diameter of 50 mm
160	4 ducts or bundles with an outer (or equivalent) diameter of 50 mm
125	3 ducts or bundles with an outer (or equivalent) diameter of 50 mm
63	1 duct or bundle with an outer (or equivalent) diameter of 50 mm

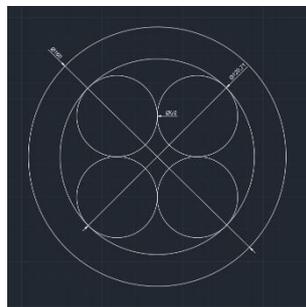
Table 2: Boring diameters in No-Dig methods

NOTE: For the FTTH connections, the minimum diameter that the techniques allows should be used and is not included in the table.

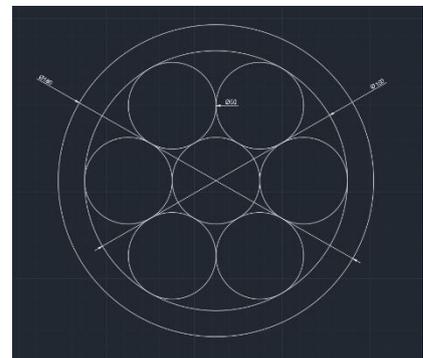
Different boring diameters are defined to cover different situations:



Boring of 125 mm



Boring of 160 mm



Boring of 180 mm

Figure 30. Different boring diameters

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2.3.6 PROTECTION PIPE

In some cases, could be necessary to install a protection pipe in the borehole made.

If the authority demands it, or there is a risk of collapse of the borehole, or if the borehole is made in rocky terrains, it will be necessary to install a protection pipe during the pullback of the drilling process and the ducts or bundles of the network will be deployed afterwards.

It is important to use the correct protection tube, according to the borehole made during the drilling process.

It is important to consider, that could be a difference of the borehole made and the of the protection pipe that should be installed. It is important to follow the recommendation of the manufacturer of the drilling machine (hdd, or impact mole).

Also is important to seal the protection pipe against the bundles or ducts, properly.

These hard types soils that could trigger the necessity to install the protection pipes (in HDD perforations) are the following ones:

- Soil class: BKL 6 - Strongly fissured rock types - Rock types that have an internal, mineral-bound cohesion, but are strongly fissured, brittle, crumbly, chisty, soft or weathered.
- Soil class: BKL 7 - Rock that is difficult to remove - Rock types that have an internal, mineral-bound cohesion and high structural strength.

3. SOIL CLASIFICATION

The soil classification is important issue that should be considered before starts any project of HDD. The type of soil could affect the cost of the project and the type of machinery that should be used (the power).

The following table shows the classification table for earthworks in construction according to ATV DIN 18300. This standard also serves as a binding reference in the VOB.

Soil classification classes	Soil type	Example
BKL 1	Top soil layer	Humus, organic soils
BKL 2	Flowing soil types (scooped soil)	Liquid to viscous nature that give off water with difficulty
BKL 3	Easily detachable soil types	Non-cohesive to weakly cohesive sands, gravel, and sand-gravel
BKL 4	Soil types that are moderately difficult to remove	Mixtures of sand and gravel with a proportion of more than 15% by weight of silt and clay
BKL 5	Soil types that are difficult to remove	As class BKL 4, but with more than 30% by weight of stones
BKL 6	Strongly fissured rock types	Rock types that have an internal, mineral-bound cohesion, but are strongly fissured, brittle, crumbly, schist, soft or weathered
BKL 7	Rock that is difficult to remove	Rock types that have an internal, mineral-bound cohesion and high structural strength

Table 3: Soil classifications according to ATV DIN 18300

4. BACKFILLING OF THE TRENCHES

Generally, after the excavations the soil must be replaced in the same conditions as it was at the beginning of the civil works.

That means that generally, the different layers that has the structure of the street or the sidewalk, must be filled with the same type of materials extracted and also must be compacted according to the requirements of the competent administration and the applicable normative.

4.1 GENERAL CONDITIONS AND COMMON SECTION DEFINITIONS

Generally, the different roads, streets, or sidewalks, has different layers, with different thickness depending on numerous factors, as can be, the traffic load expected, the climate of the zone, the situation of the road, etc.

The following image is an extract from chapter 1.4 of the H-Trenching file, which is translated below. In this image is possible to see, the different layers that normally we could find in a road, street or other and the different categories and how it affects to the thickness of each layer.

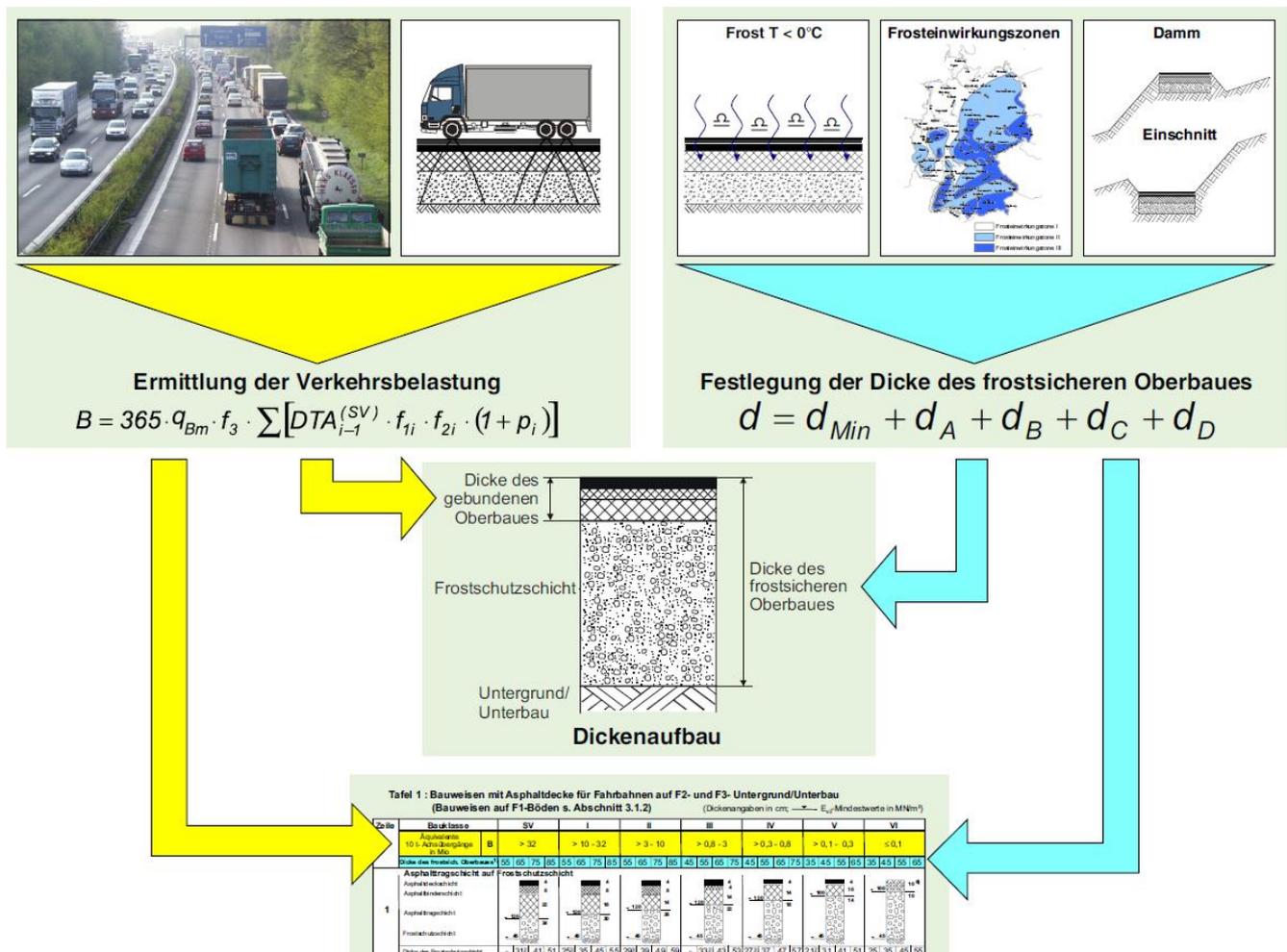


Figure 31: Definition of the common layer dimensions according to RStO

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In the next figure, could be see more clear, examples of different roads with the different layers structure depending on: the load class of the road (marked in yellow), and the thickness of the frost of the zone in which is the road (marked in soft blue).

Zeile	Bauklasse	SV	I				II				III				IV				V				VI							
			Aequivalente 10 t- Achsübergänge in Mio		B		> 32		> 10 - 32		> 3 - 10		> 0,8 - 3		> 0,3 - 0,8		> 0,1 - 0,3		≤ 0,1											
			Dicke des frostsich. Oberbaues ¹⁾				55 65 75 85				55 65 75 85				45 55 65 75				45 55 65 75				35 45 55 65				35 45 55 65			
1	Asphalttragschicht auf Frostschuttschicht																													
	Asphaltdeckschicht		4		4		4		4		4		4		4		4		4		4		4		4		4		10 ⁶⁾	
	Asphaltbinderschicht		8		8		8		8		8		8		14		14		14		14		14		14		10			
	Asphalttragschicht		22		18		14		26		22		18		14		10		10		10		10		10		10			
	Frostschuttschicht		34		30		26		22		18		14		10		10		10		10		10		10		10			
	Dicke der Frostschuttschicht		-		31 ²⁾ 41 51		25 ³⁾ 35 45 55		29 ³⁾ 39 49 59		-		33 ²⁾ 43 53		27 ³⁾ 37 47 57		21 ²⁾ 31 41 51		25 35 45 55		25 35 45 55		25 35 45 55		25 35 45 55					

Figure 32. Example of different load class and anti-frost layers

The English legend of the figure, is the following one:

German	English
Frostempfindlichkeitsklasse	class of frost impact zone
Damm	embankment
Einschnitt	groove
Ermittlung	establishing
Festlegung	definition
Verkehrsbelastung	traffic load/charge
Dicke	thickness
Frostsicher	frost proofed
Oberbau	superstructure
Gebunden	bounded
Frostschuttschicht	anti-frost layer
Unterbau/Tragschicht	subbase
E _{v2}	deformation modulus

Table 4: figure legend of layer dimensions

Depending on the type of road, the thickness of each layer, and the requisites are different. Normally, as the level of road is increased, the thickness of the layers, and the different compaction requisites are increased.

The complete superstructure (anti-frost layer), (the thickness is marked in the previous figure with blue colour), is an important thickness that it is needed to take into consideration, because in many cases the modification of this in the backfilling will not be allowed. That means, that the pipeline, and the sand around it must be below the total of the anti-frost layer.

Depending on the thickness of the anti-frost layer, the depth of the trench will be affected (going deeper), affecting the depth of the pipelines to be deployed.

The anti-frost layer includes several layers, and all of them should be restored as it was before to start the works.

Also, the different layers, must be compacted according to the normative or to the requirements of the competent administration.

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For example in the following figure, that include different sections for sidewalks and cycling roads, could be seen how in two layers, there are a requisite for the compaction of the soil (deformation modulus E_{v2} with the symbol: ▼, and followed by the requisite value in MPa).

This value should be achieved in the backfilling of the trenches and measured in the field.

Zeile	Bauweisen	Asphalt		Beton		Pflaster (Plattenbelag)		ohne Bindemittel	
		30	40	30	40	30	40	30	40
Schotter- oder Kiestragschicht auf Schicht aus frostunempfindlichem Material									
1	Decke								
	Schotter- oder Kiestragschicht	15		15		15		25	
	Schicht aus frostunempfindlichem Material	25		27		27		29	
	Dicke der Schicht aus frostunempfindlichem Material ⁽⁶⁾	-	15	-	13	-	13	-	11
ToB auf Planum									
2	Decke								
	Schotter-, Kiestragschicht oder Frostschuttschicht	10		12		12		4	
	Dicke der Schotter-, Kiestragschicht oder Frostschuttschicht	20	30	18	28	18	28	26	36

Table 5: Sidewalk and bike trail sections

NOTE: The deformation modulus (E_{v2}) is obtained by the plate load test.

The following indications defines the conditions and the dimensioning of the sections.

Design type	Road category	Load classification
Street without buildings	VS II, VS III	Bk 10 to Bk 100
Linking road	HS III, HS IV	Bk 3,2/Bk 10
Industrial street	HS IV, ES IV, ES V	Bk 3,2 to Bk 100
Commercial street	HS IV, ES IV, ES V	Bk 1,8 to Bk 100
City main street	HS IV, ES IV	Bk 1,8 to Bk 10
Village comercial street	HS IV, ES IV	Bk 1,8 to Bk 10
Village entrance road	HS III, HS IV	Bk 3,2/Bk 10
Village main street	HS IV, ES IV	Bk 1,0 to Bk 3,2
Neighbourhood street	HS IV, ES IV	Bk 1,0 to Bk 3,2
Junction street	ES IV	Bk 1,0 to Bk 3,2
Built up street	ES V	Bk 0,3/Bk 1,0
Built up path	ES V	Bk 0,3

Table 6: Typical loads according to RStO for usual design criteria according to RAS

Additionally, the loads in bus transited areas are indicated.

Traffic loads	Load classification
>1400 daily buses	Bk 100
425 – 1400 daily buses	Bk 32
130 – 425 daily buses	Bk 10
65 – 130 daily buses	Bk 3,2
<65 daily buses	Bk 1,8

Table 7: Traffic loads in bus transited areas

Frost resistance class	Layer thickness as a function of load class [cm]		
	Bk 100 bis Bk 10	Bk 3,2 bis Bk 1,0	Bk 0,3
F2	55	50	40
F3	65	60	50

Table 8: Minimum frost layer thickness as a function of traffic load

4.2 FROST IMPACT ZONES IN GERMANY

In the following figure are presented the frost impact zones in Germany:

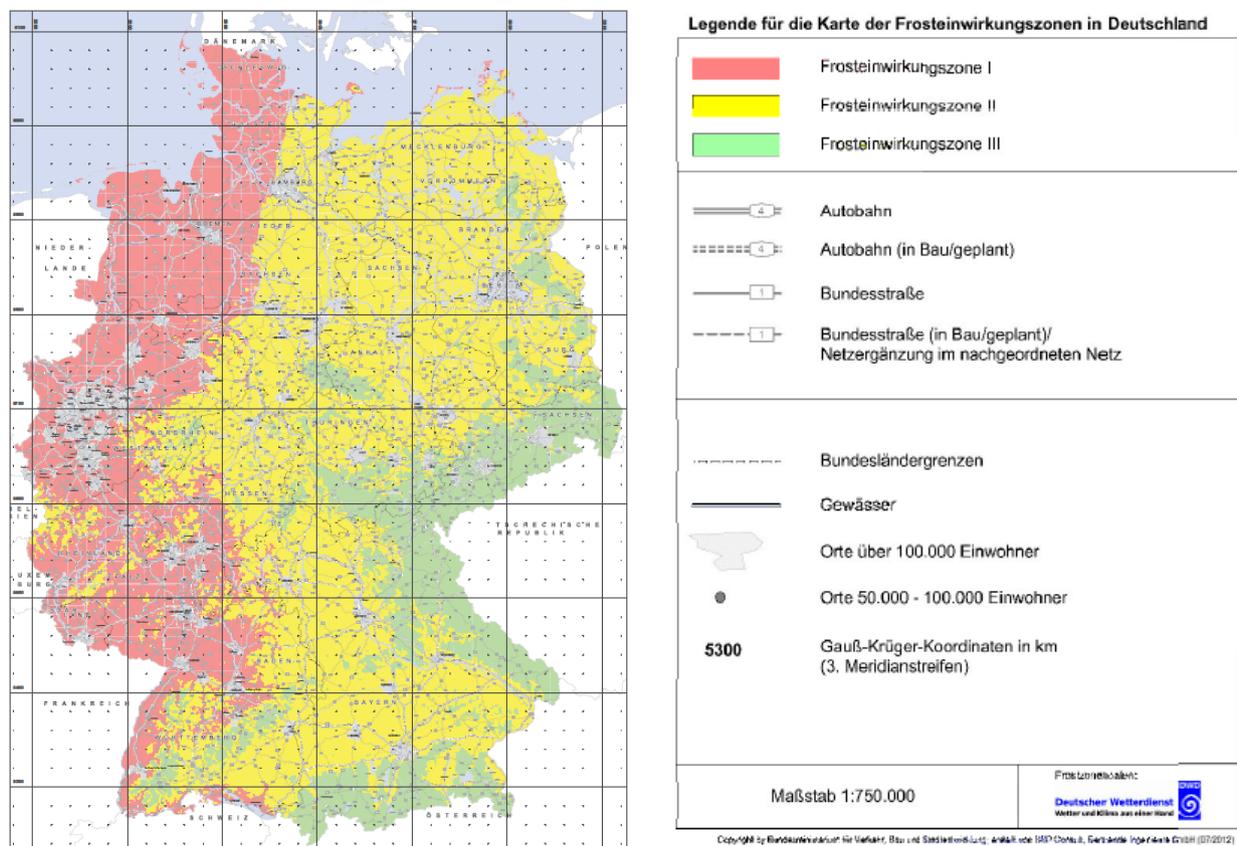


Figure 33: German frost impact zones

4.3 BACKFILLING AND RESTORING MATERIALS

In this section, the materials commonly used for backfilling the trenches will be described.

Both the individual sections, which are subdivided according to surface type (road, sidewalks, etc.), and their structure are shown graphically.

A brief definition of the required grain size is given on the right-hand side in the illustration.

The following figure shows the properties of the different layers:

Trench sections

Surface structure

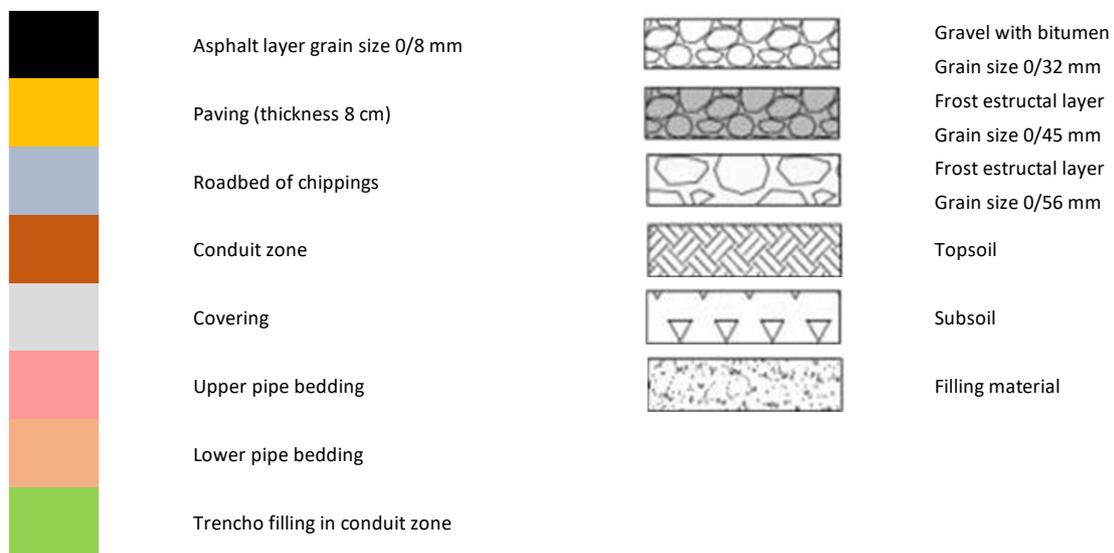


Figure 34: Layer characteristics

These layers are distributed in the different cross-sections as follows:

Standard trench structure

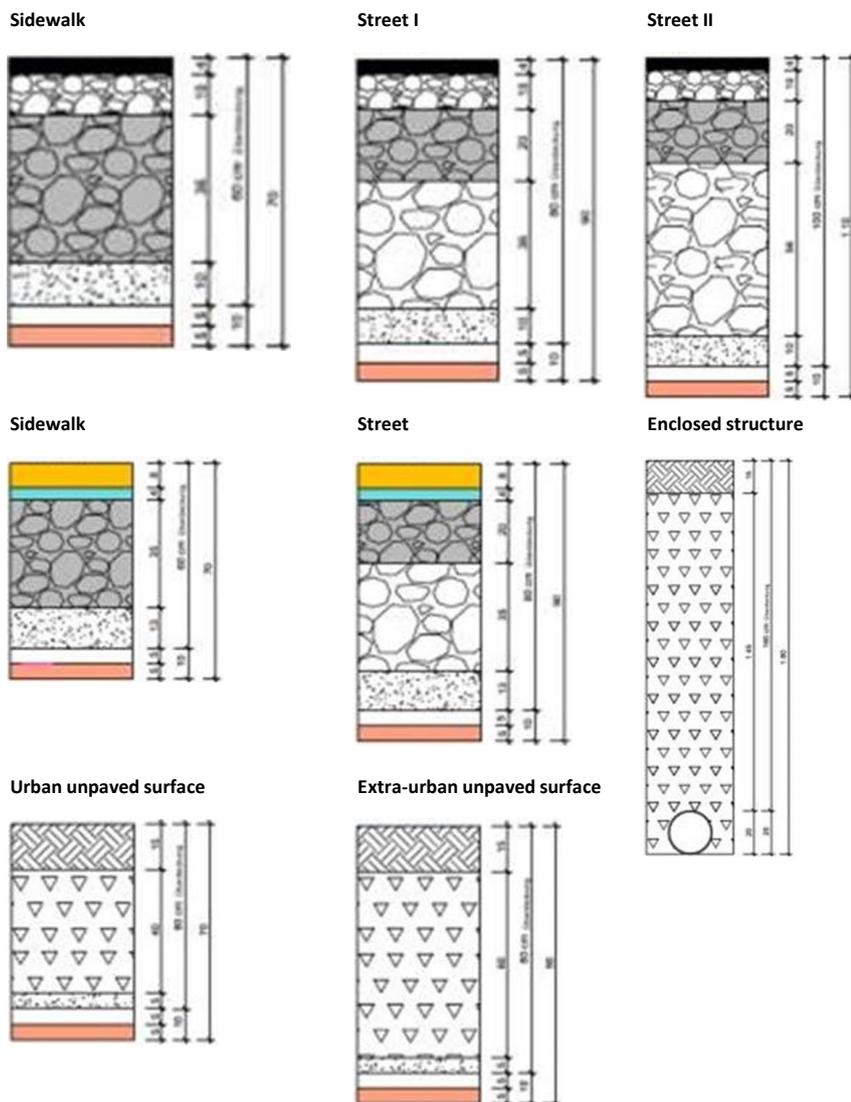


Figure 35: layer assembly according to the Surface utility

The materials used in road construction always depend on the type of load and the associated road category.

A distinction must always be made between two cases, the installation of an asphalt surface course and the application of paved surfaces.

Basically, the following materials are used:

1. Asphalt surface

- Bituminous gravel (0/32)
- Frost structural layer (0/45)
- Frost structural layer (0/56)
- Filling material

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The composition and resistance of the asphalt to be used is always determined on the basis of the expected traffic loads.

The following table shows the nomenclature:

AC	Asphalt concrete
SMA	Stone Mastic Asphalt
PA	Porous Asphalt
National supplement for asphalt mix type	
T	Asphalt base course mixture
B	Asphalt binder
D	Asphalt for asphalt wearing courses
TD	Asphalt base layers
National supplement for load	
L	Light
N	Normal
S	Heavy
Upper sieve size	[mm]
Example: AC 32 TS := Asphalt concrete for asphalt base courses with upper sieve size of 32 mm in surfaces with heavy traffic loads	

Table 9: Nomenclature of asphalt

The following table shows the asphalt specifications according to the traffic loads:

Construction class	Asphalt sub-base layers	Asphalt base layers	Asphalt surface layer		
			Asphalt concrete	Stone Mastic Asphalt	Porous Asphalt
SV&I	AC 32 TS	AC 22 BS	--	SMA 11 S	PA 11
II	AC 22 TS	AC 16 BS	AC 11 DS	SMA 8 S	PA 8
III		AC 16 BS			
IV	AC 32 TN	(AC 16 BN)	AC 11 DN	(SMA 8 N)	
V	AC 22 TN		AC 8 DN		
VI		--	AC 8 DL AC 5 DL	(SMA 8 N) (SMA 5 N)	
Cicle track & sidewalks	AC 32 TN AC 22 TL			--	

Table 10: Asphalt specifications according to the traffic loads

A distinction is made between three categories of bituminous gravel. The following information on aggregates:

- Coarse aggregates: > 2 mm
- Fine aggregates: 2 mm – 0,063 mm
- Filler: < 0,063 mm

The binders commonly used in road construction are either road bitumen or polymer modified bitumen.

Road bitumen is classified using the needle penetration test according to DIN EN 1426. For example, bitumen 50/70 means that the penetration depth of the test needle is between 5 and 7 mm.

The following table lists the common varieties depending on the place of use:

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- Road bitumen

Type	Application	Load class
70/100 softer	Cycle track & sidewalks	Bk 0,3 bis Bk 1,0
50/70 harder	Roads, according to load	Bk 1,8 bis Bk 100
30/45 hard		Bk 0,3 bis Bk 100
20/30 very hard		Bk 3,2 bis Bk 100

Table 11: Road bitumen properties

Polymer-modified bitumens (PmB) are factory-produced mixtures of bitumen and polymers in which the polymers modify the elastoviscous behaviour of the bitumen, making the binder more suitable for special stresses.

- Polymer-modified bitumens

Sorte	Application	Load class
45/80-50 A softer	Roads, according to load	Bk 3,2 bis Bk 100
25/55-55 A hard		Bk 3,2 bis Bk 32
10/40-65 A very hard		Bk 100
40/100-65 A (Highly elastomer-modified)		Bk 3,2 bis Bk 100

Table 12: Polymer modified bitumens

Underneath the asphalt layer and the bituminous gravel, two different layers of frost layer and base layer are laid.

The lower layer consists of a coarser grain mixture, i.e. the upper sieve size is larger than in the layer above.

Frost protection layers are installed as the bottom layer during the construction of roads, paths and squares and usually consist of gravel or a gravel-chip-sand mixture. In this case, it is a combination of base and anti-frost layer, where the upper layer has a grain mixture of 0/32 mm, while the lower layer consists of a grain mixture 0/56.

Furthermore, it is possible to install a hydraulically bound base course that meets both climatic and static requirements.

Their properties are listed in the following table as examples:

Grain size	Grain fractions of mixture of aggregates in M.-%			
	< 0,063 mm	>2,0 mm	Coarsest grain class	Oversize grain
0/32 und 0/45	≤ 15	55 - 84	≥ 10	≤ 10

2. Paving stone covering

In cases where a paving stone surface is envisaged, various types of paving can be considered.

- Natural stone pavement

Natural paving stones are made from natural stones that have sufficient strength. These include in particular granite, gneiss, basalt, greywacke and porphyry.

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- Concrete paving stones

Concrete paving blocks are industrially manufactured from a mixture of cement, aggregate and water. The resulting fresh concrete can then be poured into any mould. A w/c ratio of 0.35-0.40 should be aimed for. The cement content is 300-350 kg/m³ with a rock composition of 50-60 % sand and 40-50 % chippings or gravel. Furthermore, the stones must be made resistant to frost-de-icing salt damage by means of appropriate concrete additives. Concrete blocks consist of two types of concrete. The concrete on the underside of the stone (so-called core concrete) is supplemented with a top layer (so-called facing concrete). By colouring the facing concrete or by adding crushed natural stone, the surface of concrete blocks can be changed.

Another important point is the proper selection of bedding materials and their correct application.

Basically, three types of bedding can be considered:

- Limestone chippings with these properties:
 - Grain group 2/5 according to TL Gestein-StB, section 2.2.2, table 2, category Gc90/10.
 - Impact crushing value according to TL-Gestein-StB, section 2.2.9, table 12, category SZ22
 - Frost resistance according to TL Gestein-StB, section 2.2.14, table 19, category F1
 - Water permeability in compacted state $\geq 540 \text{ l}/(\text{s} \times \text{ha})$.
- Mixture of natural aggregates of the rock types greywacke, granite, basalt, porphyry or diabase with these properties: Korngruppe 0/5 nach TL Gestein-StB, Abschnitt 2.2.2
 - Fine fraction according to TL Pflaster-StB, section 3.2.2, category UF5
 - Oversize according to TL Pflaster-StB, section 3.2.3, category OC90
 - Grain size distribution according to TL Pflaster-StB, section 3.2.4, category GU,B
 - Flow coefficient according to TL Pflaster-StB, section 3.2.5, category ECS35
 - Impact crushing value according to TL Gestein-StB, section 2.2.9, category SZ22
 - Frost resistance according to TL Gestein-StB, section 2.2.14, category F1
 - Water permeability in compacted state $\geq 540 \text{ l}/(\text{s} \times \text{ha})$
- Mixture of natural and industrially produced aggregates of grain group 0/5 in composition and properties deposited with DIBt; otherwise in accordance with DIN EN 13285* and TL Gestein-StB.

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4.4 BACKFILLING IN MICRO-NANO TRENCHES

The restoration material is the most critical consideration in micro-trenching and nano-trenching. There are many different types of restoration materials to choose from and each product should be evaluated to comply with local regulation.

The filling of the micro-trench/nano-trench must be carried out by pouring into the mortar seat fluid consistency cement based on high strength cements, selected aggregates, and special additives. The material must have grip characteristics such as to allow the release of a driveway roadway and suitable for use in a very short time (within 2-4 hours of installation). **It is forbidden to use the debris material for backfilling.** The filling material, in addition to blocking the infrastructure must also guarantee mechanical protection of the same. Even during the stage of filling, the geometry of the infrastructure must be ensured and must not unwanted elevations of the same occur. Any special systems for fixing the infrastructure to the bottom of the excavation must ensure optimal penetration of the filling material.



Figure 36: Backfilling

4.5 RESTORATION OF THE SURFACE

The surface of road (carriageways) and sidewalk (walkways, foot ways) must be restored to the previous state according to the local Standard Specifications for road works and to the full satisfaction of the owner of private ways.

Carriageways are areas that are built for heavy vehicle traffic. House entrances, residential parking areas and bicycle paths are considered footways.

Generally, the thickness of the various layers of different material (sub-base, base, bituminous mix base etc.) must be provided as excavated initially.

The surface was carefully cut earlier before excavation works.

The surface to be restored shall be of equivalent or better quality than the neighbouring existing surface. However, a minimum standard must be applied to allow and ensure good workmanship.

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Replacement material must be of the same or equivalent quality and size than those removed. All required materials must be included.

All reasonable steps must be taken to prevent damage to paving outside the excavation area, and protect paving, backfilling material from contamination from fuel and/or oil from the equipment.

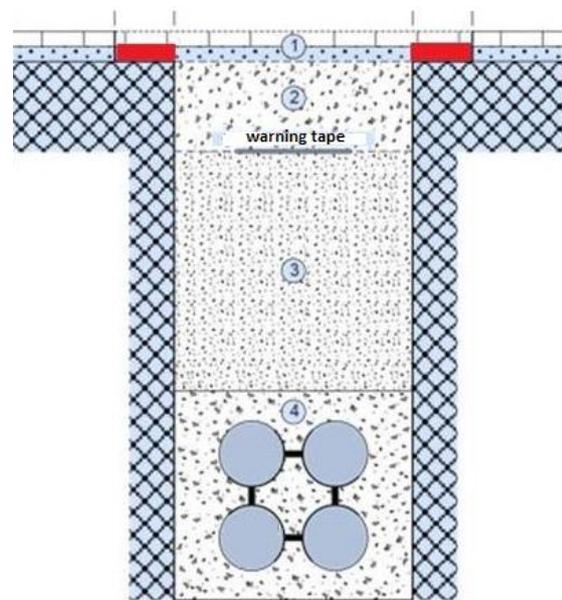


Figure 37. Illustration showing the need to replace additional bands on both sides of the trench

These bands, marked in red colour in the last figure, usually have a wide of 10 to 15 cm, and is needed to retire during the execution of the trench and must be restored to the original state after the works.

4.6 TEMPORARY RESTORATION

4.6.1 INTRODUCTION

This section mentions general specifications that must be considered when restoring the surfaces temporary.

When final works will be carried out, the previous section 4.5 applies.

4.6.2 RESTORATION SCENARIOS

4.6.2.1 GENERAL ISSUES

Always install the material required by the city/municipality for a temporary restoration of the surface.

All materials must be installed flush with the floor without a trip hazard (less than 1 cm) and, as this is a temporary measure, it must be checked regularly. Traffic safety remains with the contractor / provider.

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If the surface courses can no longer be laid due to cold weather, expected major settlements or other reasons, there are three options after consultation with the road authority:

- Pave base course to slab height, at a later stage mill off the flush base course to the lower edge of the slab and then pave the final slab.
- Seal the excavation provisionally with bound materials, e.g. concrete (to stop the excavation) or paving stones. Remove this layer later and install the final layer.
- Lay base course without wearing course and wedge edges (only if traffic safety is technically possible).

4.6.2.2 STREETS AND ROAD RESTORATION

- CONSTRUCTION MATERIALS
 - Gravel base course



Figure 38: Example of temporary backfilling with gravel

- Paving stones or bricks
- Covering steel plates
- Cold asphalt (DSK).
- Dolomite sand and broom gravel with binder.
- First layer of asphalt paved up to 4 centimetres below the existing asphalt, a small layer of sand of half a centimetre applied, followed by a provisional layer of coarse aggregate hot asphalt. Then remove and the final wearing course could be laid.

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Figure 39: Example for a backfilling with the cold asphalt method

- TRAFFIC SAFETY
 - Cordon off the construction site
 - Covering the trenches with steel plates

4.6.2.3 INTERSECTION

- Paving stones or bricks.
- Secured by means of steel plates for bridge class 60 and secured with asphalt on both sides.

Approval from the road construction agency is required.

4.6.2.4 BIKE PATHS RESTORATION

Temporary restoration on bike paths should be avoided as much as possible because of a potential risk of stumble. It is preferable to carry out a full closure or an emergency route using traffic signs and barriers. The necessary crossing points should be secured with metal plates.

In case there is no option for emergency route:

- First layer of asphalt paved up to 4 centimetres below the existing asphalt, a small layer of sand of half a centimetre applied, followed by a provisional layer of coarse aggregate hot asphalt. Then remove and the final wearing course could be laid.

Approval from the relevant authorities is required.

4.6.2.5 SIDEWALKS RESTORATION

- Dolomite sand or similar.

Approval from the relevant authorities is required.

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5. COMPACTION

In general, the RStO standard must be complied with. However, the main rule that should be followed is to leave the structure of the roads or sidewalks in which the trench is made in the same condition as was found before starting the civil works.

Sometimes, the values required in the normative (such as RStO) were not achieved in the original execution, so it doesn't have sense to have to improve after executing the civil works for the fiber deployment.

Because of that, it is mandatory to measure the degree of compaction of the terrains **before** starting the digging works. **After**, once the trench is backfilled, several measurements must be carried out in the same positions as the measurements made before start, to check if the compaction value is the same or superior. Both results (before and after) are saved and subsequently included in the corresponding report.

There are also the following two points to consider:

- Make several test pits along the route and measure the compaction beforehand.
- To match that value (in case it is difficult to reach the RStO12 but maybe they were not met before either). So, we match what was there.

5.1 MACHINERY FOR COMPACTION

As shown in chapter 4. "BACKFILLING OF THE TRENCHES" all the backfilling works have to be carried out in an appropriate way to guarantee the indicated resistance in the sections (in all the layers, according to the RStO normative or other normative that could apply).

To achieve these compaction values required different machinery for the different layers could be used. For example, inside the trench vibratory rammers should be used.

Standard vibratory rammers are useful normally for the trenches defined in this document (traditional trenches) with 30 cm wide or more. Nevertheless, for the narrowest trenches (like the mini trench of 15 cm wide), thinner ramming shoes should be used.

In the following figure can be seen different vibratory rammers with different ramming shoes, one of them with a ramming shoe of 8 cm wide, that makes it useful for narrow trenches, as for example the mini trench of 15 cm wide that could be used in the deployment.



This kind of machines can be handled by just one person and be powered by fuel or electricity

Figure 40: Vibratory rammers with different ramming shoes (width of 20 cm and 8 cm)

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If the dimensions of the trenches are reduced, in some cases, it can be necessary to compact the soil manually with sledgehammers. This method can be used, but due to the manual execution, it is possible to not achieve the compaction conformity along the trench.

This method should also apply for the first layers of the backfilling of the trenching (close to the ducts) to avoid damaging the micro-ducts pipeline.

To compact the upper surface if it is asphalt, paving roller machinery could be used.



Figure 41. Small paving roller

5.2 TEST METHODS TO VERIFY THE COMPACTION DEGREE

As shown previously in the document, there are different compaction values that must be achieved when the trench es backfilled. Because of that, is necessary to measure in the field the compaction values achieved before and after finishing the works.

There are different types of tests to measure the compaction degree. The most interesting for our application is one of the indirect methods presented (the dynamic plate load test), but others are described also in this chapter.

The regulation to be applied is the following:

1. ZTVE-StB 94.
2. DIN 18125 - Soil, investigation, and testing - Determination of density of soil.
3. DIN 18127 - Soil, investigation, and testing - Proctor-test.
4. DIN 18134 - Soil - Testing procedures and testing equipment - Plate load test.
5. DIN 4094 - Subsoil - Field investigations - Part 1: Cone penetration tests.
6. Technical testing regulations for soil and rock in road construction.
7. TP BF StB.

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5.2.1 PROCTOR TEST (DIRECT METHOD)

One of the direct methods to measure the compaction degree in a terrain is the Proctor test. The Proctor compaction test is a laboratory method of experimentally determining the optimal moisture content at which a given soil type will become most dense and achieve its maximum dry density.

The advantages of this kinds of tests are the following:

- A direct reference to the Proctor density can be given (unambiguous assessment).
- No construction site vehicle required to carry out the test.
- Can also be used in deeper pipe trenches.

Disadvantages:

- Evaluation usually takes 1 day if 1 proctor trial is already available from the soil, otherwise 1 - 2 days.
- Only the current installation position can be checked (if necessary, up to approx. 0.30 m below ground level).
- Statements on load-bearing capacity are only possible to a limited extent.

In the following figure a Dynamic Cone Penetrometer used in the proctor test is shown:

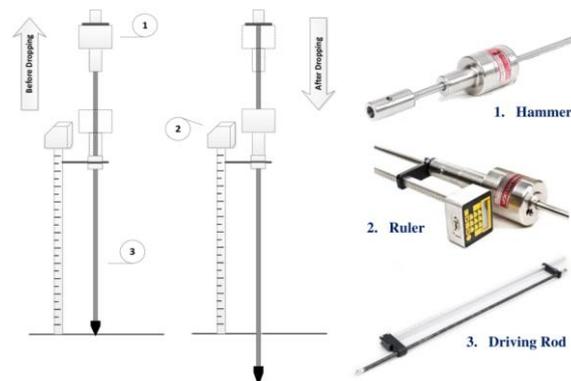


Figure 42: Dynamic Cone Penetrometer

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5.2.2 PLATE LOAD TEST (INDIRECT METHOD)

Other way to verify the degree of compaction of a terrain is the plate load test (an indirect method).

This method consists in the application of a force to a flat plate to the ground. The static method requires a counterweight of a truck, excavator or similar, which can be a problem in urban areas with confined spaces.

A plate with a diameter of 300 mm or 600 mm is needed.



Figure 43: compaction measurement with the method of static plate load

The advantages of the indirect methods (such the plate load test) are the following:

- The test directly provides a result on the construction site
- The result can usually be compared with predefined target values (assessment based on predefined limit values).

Disadvantages:

- not applicable in more heavily soaked soils (e.g. soft stiff loams, wet sands) (ground failure).
- Requires a counterweight (a truck, excavator, etc).
- A distinction is made between the test with the 300 mm and the 600 mm load plate. The 600 mm plate is mainly used for coarse-grained rock fills. The 300 mm load plate is used as standard.
- The method doesn't fit in some narrow trenches. However, in recent times, a method has been developed for the homologation of smaller plates (less than 300 mm). For this reason, there is no counterweight required anymore and the method can be used also in smaller trenches according to the TP BF StB part B 8.3 and part B 8.4.

5.2.2.1 DYNAMIC PLATE LOAD TEST (INDIRECT METHOD)

The dynamic plate load test applies to smaller plates, very easy-to-use and applicable dishes without counterweight. This determines in-place the E_{vd} module with whose application in relation to the static test previously run in a sample obtains the degree of compaction quickly.

The dynamic plate load test can be carried out in addition to the tests to ensure comprehensive quality assurance. For the assessment of the dynamic modulus of deformation 'E_{vd}', comparative values with other test methods are usually required. The maximum test layer thickness is approx. 0.30 m.



Figure 44. Example of measurement with the dynamic plate load test and example of the equipment needed

Typically, the manufacturer of the measurement equipment gives a table with the relationship between the different E_{vd} and E_{v2} modules, as shown in the following image:

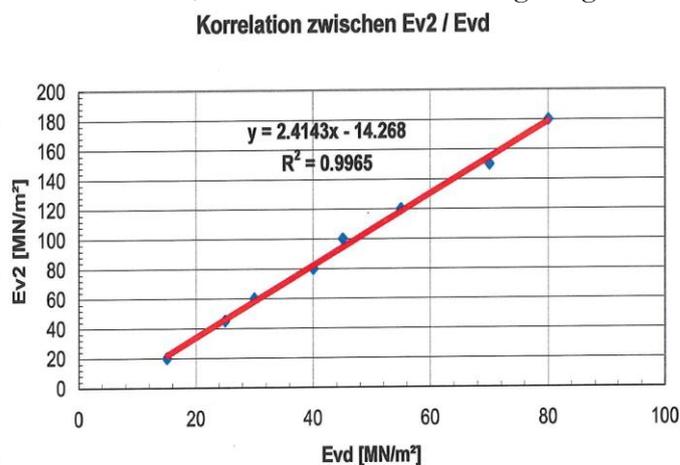


Figure 45: Example of the relation between E_{v2} and E_{vd}

The results of the measurement must be recorded in a test report, that should include the information about the values obtained, the graphic of the test made, and information about the position in which the test was made.

Also, the results of the test could be printed in the field in a ticket if it is necessary.

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Figure 46. Ticket printed with the test results

In the following image, an example of a compaction test report can be seen:

Setzung s4 (mm)	Setzung s5 (mm)	Setzung s6 (mm)	Mittelwert (mm)	Evd (MN/m ²)	Geforderter Evd (MN/m ²)	Differenz Evd (MN/m ²)	s/v-Wert (ms)	Geforderter Evd2 (MN/m ²)
0,513	0,465	0,471	0,483	46,6	0,0	46,6	2,721	0,0

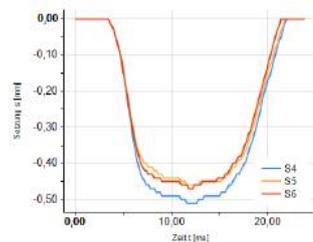


Figure 47. Example of an compaction measurement test report

As the common size of the test plates is a diameter of 30 cm, there has been designed also a smaller version. In these cases, an approved **Light Drop-Weight Tester** is applied. This one works with a 10 cm wide plate and 5 kg weight.

In the following figure an applicable model is shown:

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Figure 48: Example of equipment to measure the compaction in the field (with a small plate of 10 cm) (model: Terratest 4000 Trench)

The advantages and disadvantages of this methods are the followings:

Advantages:

- Rapid feasibility.
- No additional devices required.
- Good for use in pipe trenches.
- Result is available directly.
- The test is very well suited for supplementary tests in a narrower grid or if the test conditions only show minor differences.

Disadvantages:

- Substrate and test conditions must be relatively constant (e.g. soils with the same grain size and approximately the same water content).
- The test only provides orders of magnitude, a specification of limit values is only possible under constant test conditions.
- Reference values from other test methods (e.g. Proctor density or load plate compression test) are always required for assessment.

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5.2.3 *RAMMING SOUNDINGS METHOD*

There is also the Ramming soundings method used in many cases, especially in cable trenches.

They are mainly used for subsequent compaction testing of sandy channel trench fillings or higher fills. They do not provide a result that can be directly compared with target values. An assessment must be made for each individual case by the subsoil expert.

Advantages:

- Rapid feasibility.
- No construction site vehicle required to carry out the test.
- Almost unlimited depth range with rammable soils.
- Insufficient compaction can also be detected at greater depths.

Disadvantages:

- The coefficients of impact are dependent on various influencing parameters (grain size distribution, water content, storage density / compaction).
- In borderline cases, a reliable assessment is difficult or not possible (building materials and water content must be known).
- The test only provides orders of magnitude, no exact specification of limit values possible.
- Soundings can only be carried out after the backfill has been completed. If insufficient test results are obtained, subsequent compaction in deeper zones is no longer possible.

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6. TRENCHING GENERAL REQUIREMENTS FOR DUCT LAYING

6.1 TRENCH PREPARATION

While cable protection tubes are very robust to handle due to their size, special requirements must be taken with microtubes and microtube bundles.

When installing a direct bury micro-duct bundle, the bottom of the excavation must be flat and free of roughness. Stones or rocks in contact with micro-duct bundle are not allowed, because the subsequently compaction of the soil could damage one or more of the micro-ducts making a restriction bore.

Micro pipe bundles that can be laid underground should be laid as straight as possible in a sand bed (of 10 cm) under light pull.

The next picture shows how a bundle of micro-ducts must be laid:

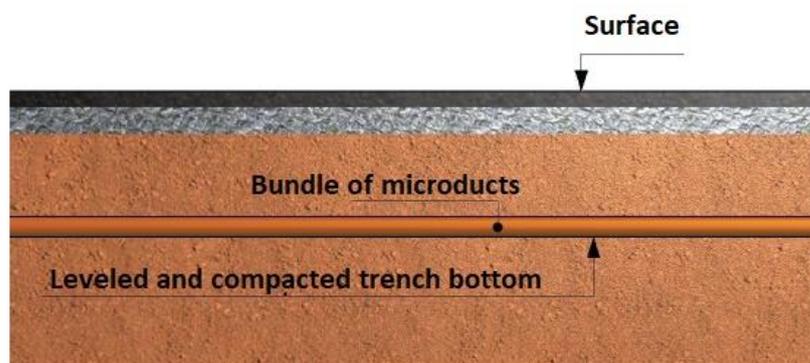


Figure 49: Bundle of micro-ducts laid

The trench bottom must be plane, and if it has undulations produced by, for example, the excavator or because there are some points with rocks, **the bottom must be compensated by adding a bed of sand, levelled and compacted.**

Only stone-free (grain-size < 63 mm), compactable material may be used for the trench bottom and the pipe bedding. The trench bottom must be shaken off with a light compacting device before the laying process. It is necessary to ensure that the compaction is even. Mechanical compaction devices above the microtubes may only be used after they have been covered 30 cm.

NOTE: Sand subjected to sub-zero temperatures can develop hard lumps that behave like rocks.

After laying the ducts or the bundles of micro-ducts, the embedment shall be filled with at least 10 cm of sand above the upper bundle of micro-ducts.

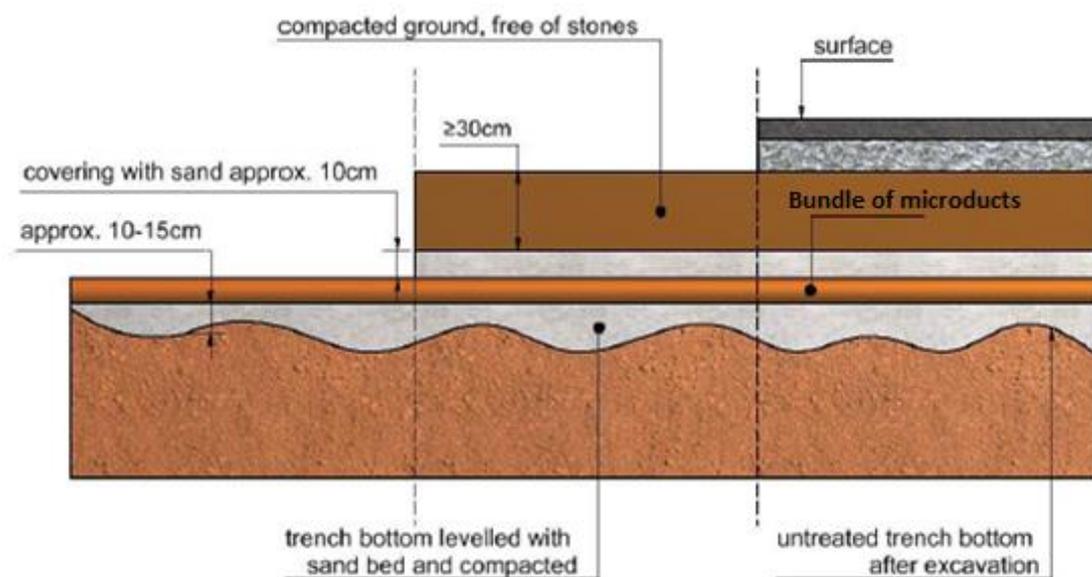


Figure 50: Embedment of bundles of micro-ducts

NOTE: If the bottom of the trench is not compensated, the undulations of the trench will be transmitted to the micro-ducts, and it will decrease considerably the blowing performance.

6.2 PLACING MULTIPLE CONDUITS

In the installations where multiple conduits are installed, these should be placed in separate layers with the spacing in accordance with the following advices.

6.2.1 SEPARATION OF CONDUITS

Once all the conduits in the bottom layer have been laid and properly aligned, they should be secured in place by suitable means to prevent movement during backfilling.

Conduits that touch vertically may be structurally unstable. Unless otherwise specified a minimum of 3 cm separation should be maintained between the conduits vertically and 3 cm between the outside conduits and the sides of the trench. Backfill material shall be placed over and around the layer of conduits, care shall be taken to ensure that all voids above, below and around the individual conduits are properly filled.

This procedure should be continued until each of the layers has been properly placed in position and surrounded. The final levelling of the surrounding materials should be checked out to ensure that the correct thickness has been maintained throughout.

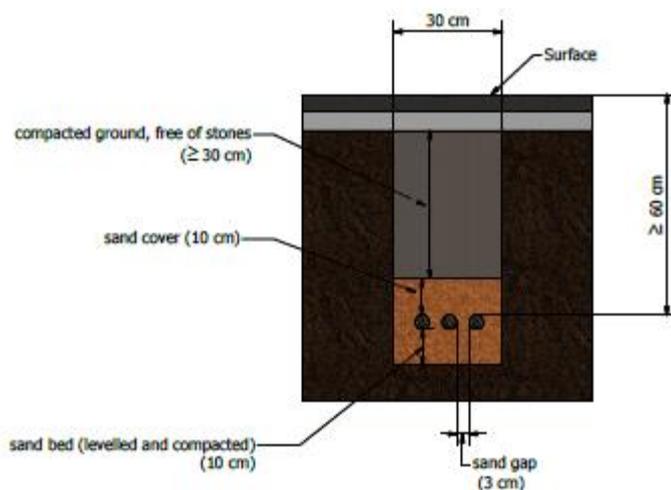


Figure 51: Laid of conduits

If more than one layer of ducts or micro-ducts are needed to be laid in the trench, it is necessary to make the trench deeper to maintain the covering distance of the upper duct to the paved surface.

It is necessary to add a sand gap between layers about 3 cm.

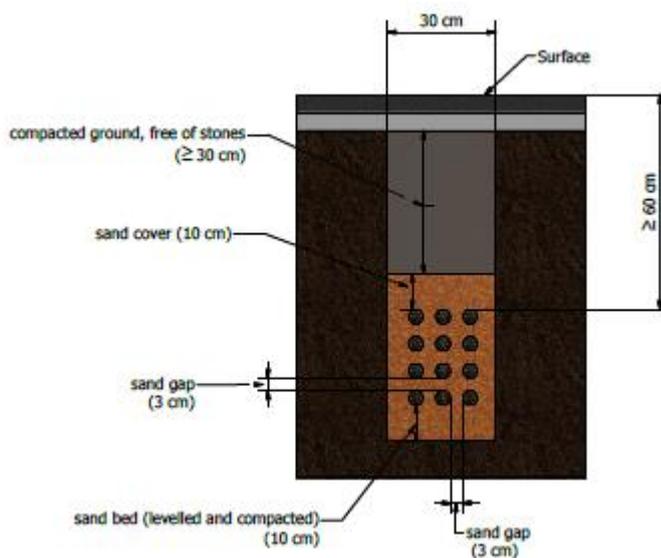


Figure 52: More than one layer of conduits laid

Each layer must be manually compacted (never use machinery for compacting between layers).

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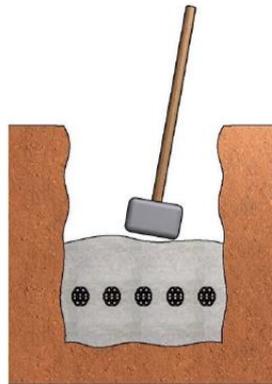


Figure 53: Manual compaction of layers

6.3 WARNING TAPE IN TRENCHES

It is mandatory to add a warning tape in the upper part of the trench 30 cm over the upper duct in all the trenches.

The warning tape that should be used should comply the following specification:

- **Width of the tape:** 4 cm.
- **Colour of the tape:** Yellow.
- **Colour of the letters:** Black.
- **Text in the tape:** [UGG LOGO] + ACHTUNG - GLASFASER KABEL (LWL – KABEL)



Figure 54: Example of warning tape

NOTE: To protect the pipeline from future excavations, if the width of the trench require it is necessary to install more than one warning tape.

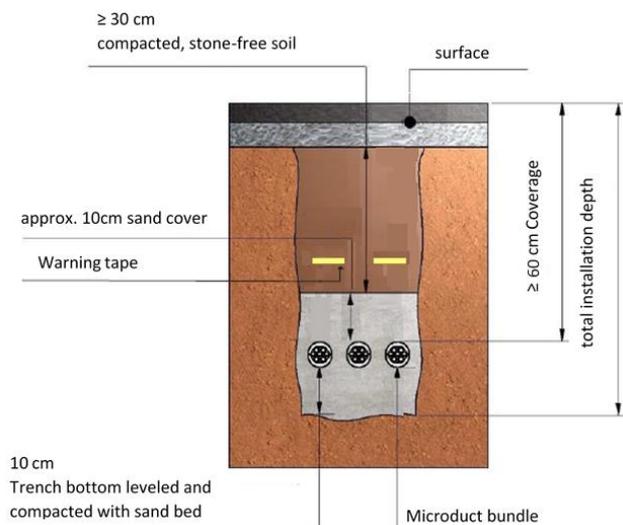


Figure 55: Example of warning tape positioning

6.4 CHANGE OF DIRECTIONS

It is important to avoid unnecessary turns, or changes in level and direction. Changes in direction must be kept as gradual as possible to assure ease of cable installation.

In general, a grade or direction change of no more than 10:1 must be maintained (one metre of length change for each 100mm of elevation or direction change). Advice from the conduit or cable manufacturers shall be taken on pulling and bending radius when planning the route.

6.5 BENDING RADIUS

The minimum bending radius of microtube bundles depend on the laying temperature and should be at least 1 meter at 20 °C, but no less than 2,5 meters at 0°C. Due to that, the recommendation is to avoid bending radius less than 2,5 meters.

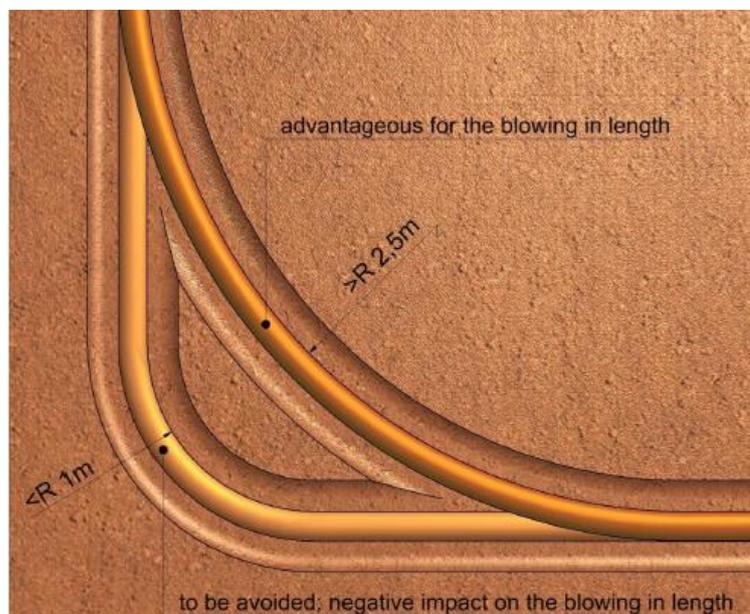


Figure 56: Bending radius of conduits

Likewise, only gentle height offsets with a 5% maximum gradient should be achieved by levelling with sand.

Any steep height difference will have a negative impact in the blowing performance.

6.6 HEIGHT DIFFERENCES

In the following figure is shown an example how to avoid strong height differences in the laying of the cables. The figure aims to be just a guideline how to work it out correctly.

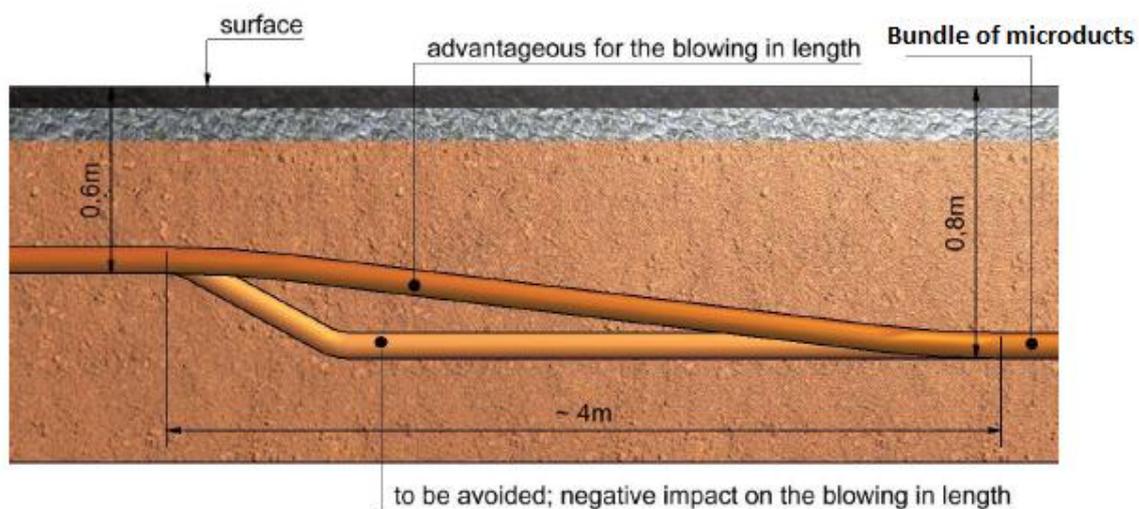


Figure 57: Height differences in conduits to be avoided

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7. TRENCH DIMENSIONS AND SECTIONS

In this section are going to be defined different trench dimensions and sections for the main trenches sizes that are going to be used in the deployment of UGG.

The traditional trenching must be considered the following regulations near to streets and highways:

- Inner city street crossing: 1,20 m
- Distance to the border: 0,80 m
- Other streets outside of the villages/cities: min. depth: 1,20 m, up to 1,50 m distance to the bord
- In larger distances, the depth can be reduced up to 0,80 m

7.1 MINI TRENCHES AND TRENCHES WITH LOW DEPTH

7.1.1 MINI TRENCH (15 X 45 CM)

The transversal section of the standard mini trench of UGG should follow the dimensions of 15 cm wide, and 45 cm deep (free distance from the upper duct to the surface).

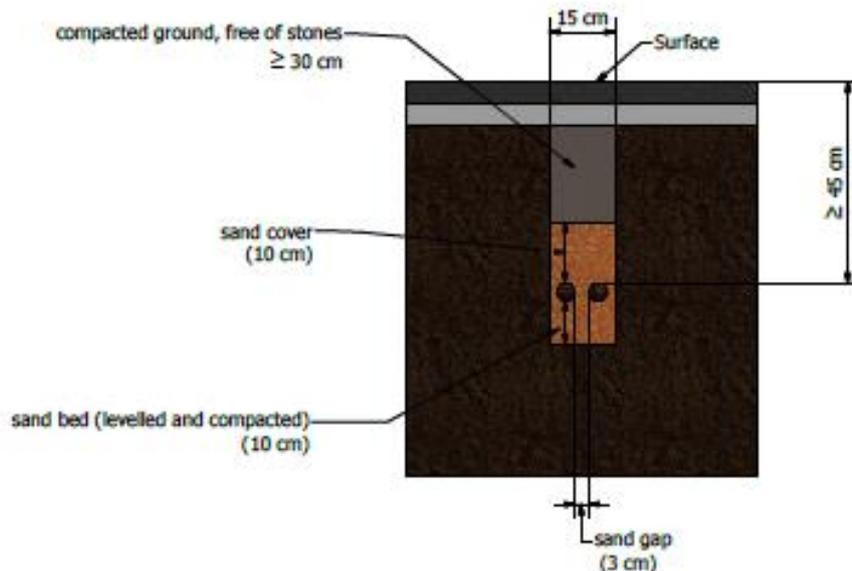


Figure 58: Mini-trench dimensions for UGG

This kind of mini trench with the dimension of 15x45 is expected to be done with a trencher machinery based in the use of a disc cutter or a chain blade cutter.

If there are difficulties to get the permits to execute the works, due to the use of a disc cutter or similar, but could be solved using a small excavator, the wide dimension could be lightly modify in order to make possible the execution with the appropriate bucket of for example 20 cm wide.

This kind of mini trench should be limited for the deployment up to 4 ducts or bundles, installed in layers of 2 ducts or bundles each.

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If the quantity of ducts needed to be deployed, makes to use the mini-trenching technique not possible, a traditional trenching should be made instead.

NOTE: The part of the feeder network close to the Distribution Points (DPs) and the outputs of them for the distribution network, where the number of bundles to be deployed is not too high, are the part of the network more appropriated to use the mini trench to deploy the pipelines.

7.1.2 MINI TRENCH (15 X 45 CM) SECTIONS EXAMPLES

The mini-trench dimensions allow the installation of ducts only in layers formed by 2 bundles as maximum.

The depth of each trench is based in the following characteristics that must be comply:

- The sand bed must be at least 10 cm
- The distance between ducts or bundles layers, must be at least 3 cm
- The distance from the upper duct or bundle to the surface must be at least 45 cm

The width of each trench is based on the following characteristics that must be complied:

- The distance from the trench wall to the ducts or bundles must be at least 3 cm
- The distance between ducts or bundles must be 3 cm

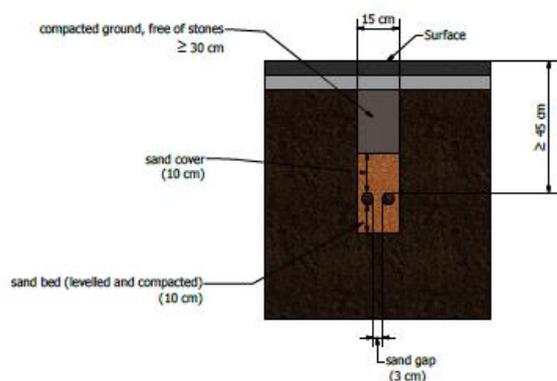


Figure 59: Trench for 2 bundles

Width: 15 cm

Depth: 60 cm (approx.)

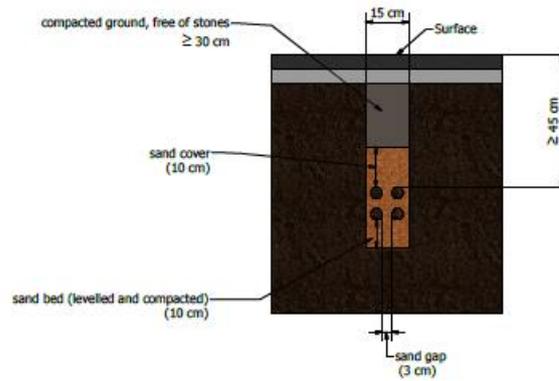


Figure 60: Trench for 4 bundles

Width: 15 cm

Depth: 70 cm (approx.)

NOTE: If due to the dimensions of the bundle it is not possible to comply with the horizontal separation distance of 3 cm, it should be reduced to 2 cm.

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7.1.3 MINI TRENCH (20 X 45 CM) SECTIONS EXAMPLES

The section is almost the same as the previous one of 15x45 cm, but in this case the width of the trench is 20 cm. The quantity of ducts to be installed and the depths necessities are the same in both cases.

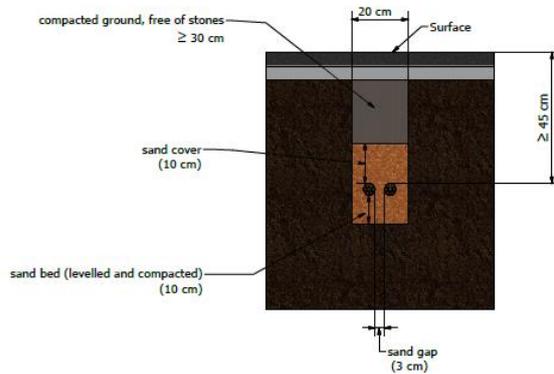


Figure 61: Trench 20x45 for 2 bundles

Width: 20 cm

Depth: 60 cm (approx.)

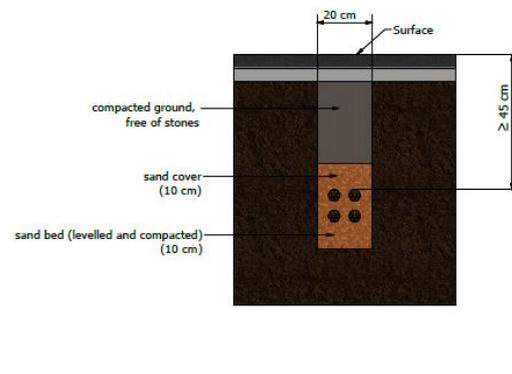


Figure 62: Trench 20x45 for 4 bundles

Width: 20 cm

Depth: 70 cm (approx.)

7.1.4 MICRO TRENCH (8 X 40) OR MINI-TRENCH (15 X 40 CM) (FOR CUSTOMER CONNECTION)

For the customer connection (drop section), an exception of mini trench is proposed with different requirements.

- The depth of the duct must be 40 cm (5 cm less than other cases).
- The sand bed is reduced to be at least 5 cm (reduced from other cases).
- The distance from duct to the surface must be at least 40 cm.
- The width of each trench is the minimum possible (8 cm or 15 cm)

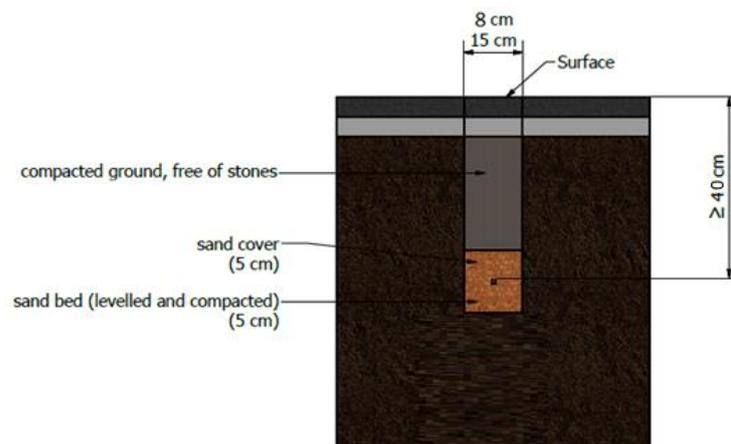


Figure 63: Trench for customer connection (exception)

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7.1.5 TRENCH (30 X 45 CM) SECTIONS EXAMPLES

This trench of 30 x 45 cm is an alternative exception of the traditional trenches that will be presented in the next chapter, that could be used only in some cases.

The section is like the traditional trench of 30 x 60 cm, with the only change of the free distance from the surface to the upper duct, reduced to 45 cm. The ducts could be installed in layers of 3 ducts.

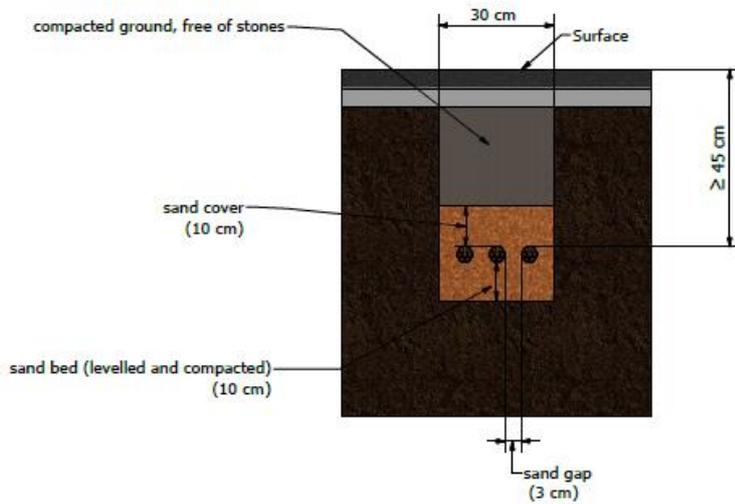


Figure 64. Trench of 30 x 45 cm

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7.2 TRADITIONAL TRENCHES

The transversal section of the traditional trenches in the UGG deployment should follow the standard dimensions of 30 cm wide, and 60 cm deep (covering the upper duct of the pipeline with 60 cm).

In the cases, in which with this depth is not possible to save the anti-frost layer, or it is not possible to get permits to execute the works, the depth could be increased for example up to 80 cm, 100cm or 120 cm.

Also, the width could be increased (for example to 40 cm) if is not feasible to achieve the deep with the narrow trenches due to the conditions of the soil.

7.2.1 TRENCH (30 X 60) SECTIONS EXAMPLES

The trench 30 x 60 could be used to install up to 12 bundles. The width dimension will be fixed to 30 cm, and the only difference will be the total depth of each case depending on the quantity of layers needed to deploy all the ducts or bundles.

The bundles will be installed in rows formed by 3 bundles each. In case one of layer must be left incomplete, it must be the upper layer.

The depth of each trench is based in the following characteristics that must be complied:

- The sand bed must be at least of 10 cm
- The distance between ducts or bundles layers, must be at least 3 cm
- The distance from the upper duct or bundle to the surface must be at least 60 cm

The width of each trench is based on the following characteristics that must be complied:

- The distance from the trench wall to the ducts or bundles must be at least 3 cm
- The distance between ducts or bundles must be 3 cm

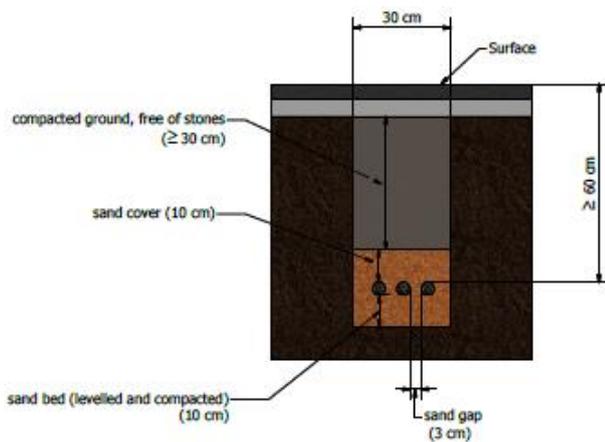


Figure 65: Trench for 3 bundles

Width: 30 cm

Depth: 75 cm (approx.)

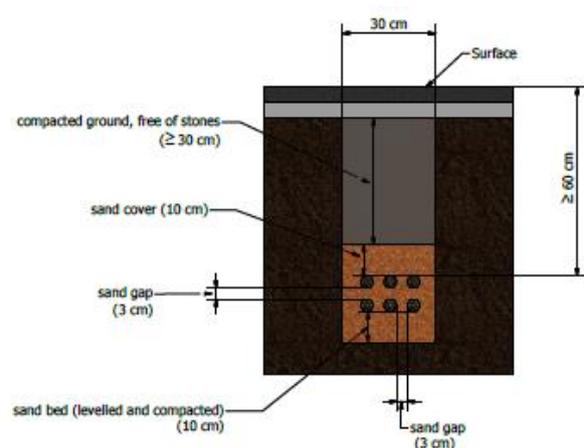


Figure 66: Trench for 6 bundles

Width: 30 cm

Depth: 85 cm (approx.)

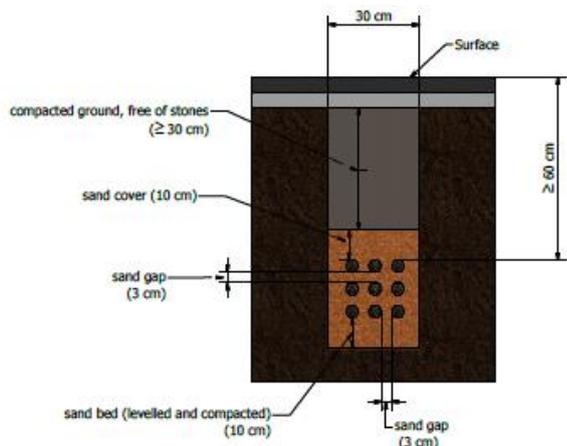


Figure 67: Trench for 9 bundles

Width: 30 cm

Depth: 90 cm (approx.)

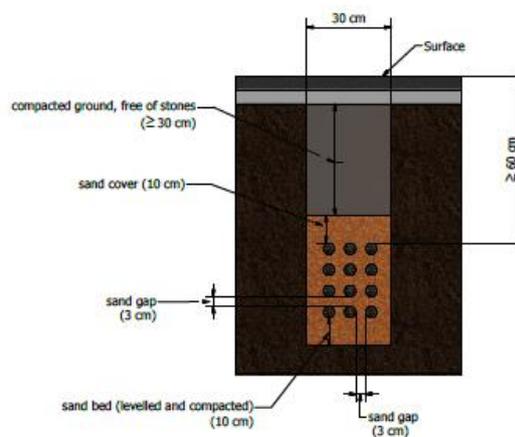


Figure 68: Trench for 12 bundles

Width: 30 cm

Depth: 100 cm (approx.)

7.2.2 TRENCH (40 X 60 CM) SECTIONS EXAMPLES

The trench of 40 wide could be used if the trench of 30 cm is not suitable for the installation of the ducts at bigger depths.

The width dimension will be fixed to 40 cm, and the only difference will be the total depth of the trench that will depend:

- The requisite of the competent administration or normative (free distance from the duct to the surface), and
- the quantity of layers needed to deploy all the ducts or bundles.

The bundles will be installed in rows formed by 4 bundles each. In case one of layer must be left incomplete, it must be the upper layer.

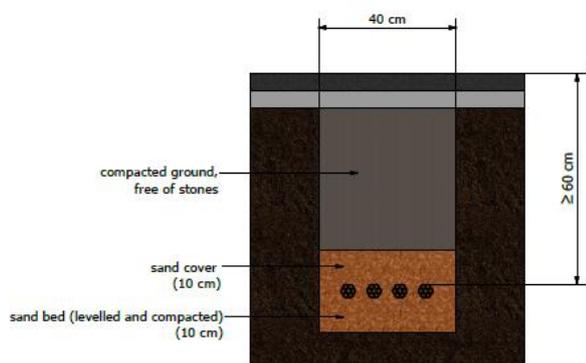


Figure 69: Trench for 4 bundles

Width: 40 cm

Depth: 75 cm (approx.)

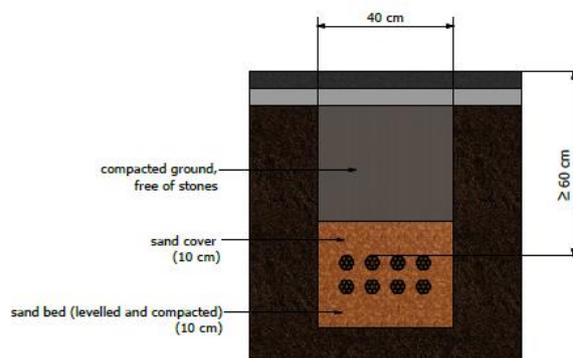


Figure 70: Trench for 8 bundles

Width: 40 cm

Depth: 85 cm (approx.)

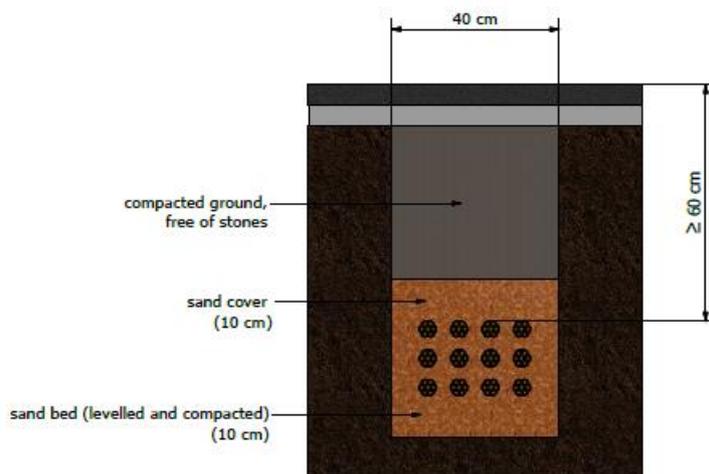


Figure 71: Trench for 12 bundles

Width: 40 cm

Depth: 90 cm (approx.)

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7.2.3 TRENCHES WITH A DEPTH OF 80 CM, 100 CM, OR 120 CM

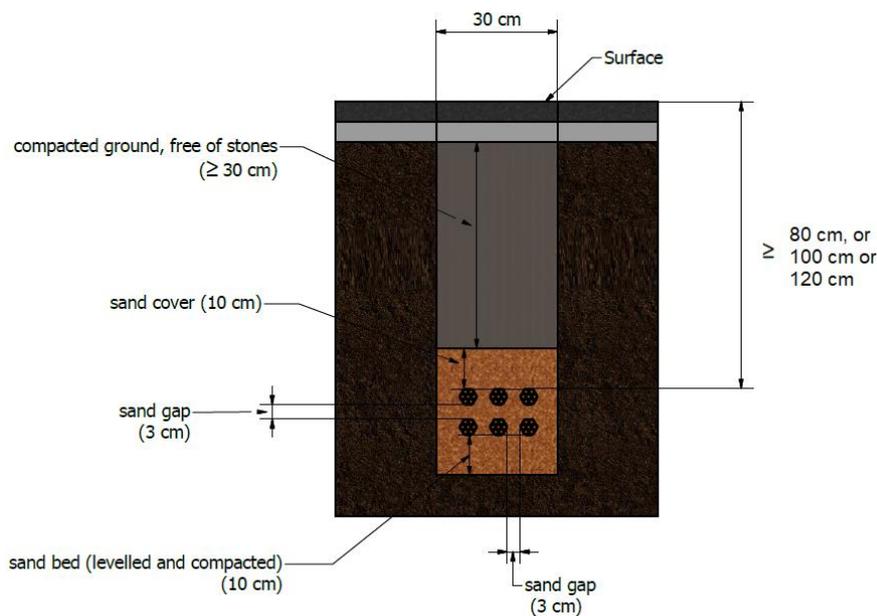
If, due to the regulation is needed to install the pipelines deeper (near to roads, or in street crossings), the trench should be made deeper increasing the free distance from the surface to the upper duct.

The free distance should be increased to reach the requirement (change from 60 cm to 80 cm, or to 100 cm, or to 120 cm).

The section of pipeline prism is basically the same as the previous figures, the only difference is that the distance from the surface to the upper duct.

Logically the total depth of the trench is increased with the additional depth (20 cm, 40 cm or 60 cm), for each case.

As an example, is show a representation of the trench with 6 ducts or bundles with 30 cm wide and with different free distance to the surface.



NOTE: The total depth for these trenches, is approximately (105 cm, 125 cm, and 145 cm)

Figure 72. Example of the section of a trench with a depth of 80 cm or 100 cm or 120 cm (free distance)

If there are difficulties to achieve bigger depths with the 30 cm wide trench is also possible to use the wider trench of 40 cm.

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8. RECOMMENDED TECHNIQUES AND TRENCHES FOR EACH SITUATION

8.1 RECOMENDATION FOR BACKHAUL AND LOCAL BACKBONE NETWORK DEPLOYMENT

The backhaul network and the local backbone network architecture, deployed to join different points located in different cities or villages, has normally similar requirements.

Normally the quantity of ducts and bundles is not so high, and these types of networks are usually deployed in parallel to a road or similar in a straight way.

The technique that must be used to deploy the backhaul and the local backbone ducts is **the ploughing method (if it is possible)**. It is the cheapest and fastest technique but, in some cases, depending on the situation it is necessary to use other alternatives.

If the soil doesn't permit the use of the ploughing method, due to the rocky conditions of the soil or because the obstacles found in the path, the traditional trench could be used. Also, the HDD could be an alternative to be used, even to run in parallel to the road. The decision to use one alternative or the other, should be based in which solution is the better from the cost-effective point of view.

The HDD technology could be an alternative to cover big distances, instead of using a traditional trench to lay the ducts.

The depth that should be used for the deployment of the backhaul network and for the local backbone should be more than **80 cm**. In some cases, if the path pass through agricultural lands or in cases in which the normative applicable (close to roads o railways) require deeper installations, **120 cm should be used**.

NOTE: Only in some justified cases, in which could be demonstrated that is not possible to achieve this minimum depth of 80 cm, could be considered reduce to 60 cm if this reduction not suppose an additional risk of network failure in the future, and if it doesn't infringe the normative applicable near roads.

If in the path are founds some roads or trails to be crossed, the cross of the road must be solved with boring hole methods under the roads. For that, as in other many situations, if it is possible, the first option will be the use of **the impact mole** with the appropriate diameter to pass all the ducts to be deployed through the boring hole. If the impact mole is not suitable, the mini-HDD should be used.

If the obstacle to pass with the network is too large, like could be a river or a railway or something similar, the HDD is the alternative to be used. As was mentioned before, with this technique long distance could be covered in one single execution, and there is no limitation related to the type of soil found.

8.2 RECOMMENDATION FOR THE FTTH ACCESS NETWORK

The access network is the most complicated part and with greater casuistry and a variety of needs for the deployment of pipelines, with continuous changes of section and direction from the POP to the customer's home.

In the access network the number of fibers to be deployed could be very different depending on the section of the network (feeder, distribution or drop section). Can vary from high count of micro-ducts, in the feeder and the distribution sections, to individual ducts in the final part of the drop section until the customer's house is reached.

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The techniques that should be used for the access network, are the traditional trench and the mini trenching defined along the document. When the quantity of ducts is big (close to the POPs), the traditional trench is needed 30 x 60, or 40 x 60 cm. If the quantity of ducts is less than 4, the mini trench could be used (15 x 45). Typically, in the distribution network will be possible to use mini trenching.

This part of the deployment must be done inside a village or a city, so a lot of difficulties can be found that complicate the pipeline deployment by using traditional trenching techniques, and that finally require the use the HDD technology to solve it.

In this section is going to give different recommendation for the pipelines deployment inside the villages, depending on different situations (in sidewalks, in streets, street crossings, drop sections).

8.2.1 RECOMMENDATIONS FOR SIDEWALKS (COBBLESTONES OR CONCRETE PALETETS)

When 1 to 4 tubes need to be installed, it is best and safest to use a mini-excavator with a 15 cm or 20 cm wide bucket, making a trench with the dimensions of 15x25 or 20x45 cm.

If the affected services are correctly defined in the planes and clearly identified by tastings, both the position and depth thereof, trenching (light trencher with chain sword or disc with carbide tips) could also be used, in this case with dimensions of 15x45 cm.

NOTE: It is very important to use light trenching machinery. The use of heavier machinery near the open trench can cause the adjoining ground to crumble (both debris, cobblestones, or concrete platelets), which can lead to numerous problems with town halls and institutions.

Advantages:

- Small damage to the Surface of the roads or to the sidewalks.
- Better performance (in terms of time) than the traditional trenches (due to the size of the trench). This kind of trench is the fastest way to deploy, that translates in minimize the disturbing to the neighbourhoods.
 - minimize the size of the machinery used and minimize the quantity of material to be used in the refilling.
 - it is a trench size that is used worldwide, and no issues are detected with these techniques if the backfilling is make correctly.
 - if it possible to achieve good levels of compaction even in this narrow trenches. There is machinery adapted for this kind of trenches (vibratory rammers with narrow foot, of for example 13 cm, or less even 8 cm).
 - nowadays, **is possible to measure this compaction with new slim devices designed for trenches with narrow dimensions** (for example, the equipment Terratest 4000 Trench, with a plate with only 10 cm). **NOTE:** This could help to get permits in some municipalities that not allow the use of narrow trenches due to the no possibility to measure the compaction degree.

Disadvantages:

- If the cut of the trench is made by cutting method, is absolutely needed a geo-radar studio before the starting of the works to avoid damage other utilities.
- Small capacity to install bundles of microducts.

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For pipelines with 5 tubes or more, the possibility of using chain sword trench or discs is eliminated, and the mini excavator with the 30 cm or 40 cm scoop would be used, and depending on the number of tubes, the dimensions would be 30x45 cm, 40x45 cm. If it is needed is possible to increase the depth of the trench to 60 cm, 30x60 cm and 40x60 cm.

Note: depending on the municipality authority, the material extracted from the ditch may or may not be reused, but normally not, only in the case, that the strata are well defined and separating stratum by stratum, could be reused. Because of that, it is important to try to make the width of the trench as minimal as possible, because in most cases, the filling material (sand 0-2 mm, "gravel" 0-45 mm,- and gravel 0-5 mm.) must be all new. The larger the area is in the cross section, the greater removal of debris to be carried to landfill will be, and a greater volume of material will be needed to refill the trench.

8.2.2 RECOMMENDATIONS FOR ASPHALT OR COBBLED STREETS

In the case to need to lay ducts in a street, in the same direction depending on the on the municipality, the required depth can vary between 60 or 80 cms or even more, the only viable way to do so is with mini excavator, and depending on the number of tubes to be installed, using the 20 or 30/40 cm scoop.

In the case of being an asphalt road, the dimensions would be the same as with cobblestone, but taking into account, that it would be cut about 20-40 cms., asphalt (depending on the tubes to be installed), since they usually require provisional closed of said trench with cobblestone, while the asphalt equipment does not come, this asphalt equipment has to remove the cobblestones and cut another 15 cms. , on each side of the trench, to fill with gravel, and compact it, so that it does not affect the stability of the roadway.

8.2.3 STREET CROSSINGS

In the cases in which the pipeline needs to cross a street, the fist alternative to be considered to lay the ducts is the **impact mole**. This method (described in the section 2.3.3) has several limitations should be considered before its use (distance limits, no directional boring, etc...).

NOTE: The impact mole is the fastest and cheapest method that could be used, and the one that reduces the problems with the municipalities.

The diameter of the impact mole that must be used, must be adapted to the quantity of ducts to be deployed. In the section 2.3.5 are defined different boring diameters depending on the situation. **NOTE:** There are different impact moles heads, from 45 mm to 180 mm boring diameters (for example in the portfolio of different manufacturers as can be Tracto Technik, TERRA, etc).

Before use the impact mole, is important to review the services that could be affected to be able to carry out the installation of the tube, without the risk of breaking any other service.

If there are any minimum risk to damage a service, the following options should be checked:

- Make an appointment on site with the company owner of the service to certify the exact depth of said service to be able to carry out the boring with the impact mole without any risk.

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- In the event that the company cannot certify 100% the depth of said service, (especially gas, water or high voltage), a pit test must be carried out in the middle of the road to verify its depth and thus to be able to carry out the boring with the impact mole without any risk.
- Make an appointment on site with the municipality, to convince them of the infeasibility of making the boring with the impact mole to get the permission to cut the asphalt, as a general rule the City Council does not want us to make cuts in the asphalt, unless it is a very old street and full of patches.

If it is not possible to cross the street with the impact mole, the economic alternative between a traditional trench or a directional drilling perforation should be used.

If a trench is used, the depth used will follow the municipality (or the proprietary of the road) requirements and could be a minimum of 60 cm or 80 cm in some cases. The wide of the trench, should be the minimum necessary achieve the depth without difficulties (30 cm if it is possible, or 40 cm). The objective is to damage as less as possible the surface.

IMPORTANT NOTE: During the process of clustering by the engineering department of the subcontractor, it is necessary to design the least number of street crossings possible, due to their difficulty and risk.

If there are no possibility to get the permits to execute the works with impact mole or with trenches, only horizontal directional drillings keep as alternative.

8.2.4 RECOMMENDATION FOR DROP SECTION (CUSTOMER CONNECTION)

For the customer connections, the first option, that should be considered to use is the impact mole (if there is no limitation to its use). It is the fastest way, and the technique that less impact has in the customer property.

Generally, for the customer connections:

- First option: impact mole with the minimum diameter.
- Second option: the most economical alternative between a mini trench or the mini horizontal directional drilling.

NOTE: The trench that should be used is one with the minimum dimension possible to put the micro-duct to a depth of 40 cm. The trench could be made with manual equipment (vibratory hammers, or similar). 15 x 40 could be the dimension used for this application. Also is possible to use micro-trenching (8 cm wide) for this application due to the size of the micro-duct that should be laid.

If the house to be connected is in the same side of the distribution bundle (no street crossing needed):

- **If the surface of the drop section path is grass or ground:** (assuming that the soil is compactable): use the impact mole.
- **If the surface of the drop section path is cobble stone:**
 - If the soil under the cobble stones is compactable: use the impact mole.
 - If the soil under the cobble stones is rocky soil or not compactable: trench with the minimum wide (mini trench made manually).

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- **If the surface of the drop section path is asphalt:**

- If the soil under the asphalt is compactable: use the impact mole.
- If the soil under the asphalt is rocky soil or not compactable: trench with the minimum wide (mini trench made manually).

If the house to be connected is in the opposite side of the distribution bundle (a street crossing is needed):

The main objective is to avoid the trench if is possible and keep it as the last alternative.

- If the soil under the cobble stones is compactable: use the impact mole.
- If the soil under the cobble stones is rocky soil or not compactable:
 - First option: use of mini-HDD.
 - Alternative (to be avoided): mini-trenching or trenching with the correct depth according to the municipality rules.

It is important to plan the dates for the different customer connections in order to optimize the use of the mini-HDD equipment (transport, etc), making possible to make several drop sections with the same technology.

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9. DUCTS AND BUNDLES LAYING

The optimal laying temperature is between 5 and 20 °C. At temperatures below freezing, the drums should be stored in a heated environment for one day prior to installation.

Microtubes and microtube bundles must be protected against contamination and mechanical damage during transport, storage and processing. **The ends of the microtubes and microtube bundles must be protected against the ingress of dirt and water with end caps.**

Any damage and deformation of micro tubes (ovalization) leads to a reduction in the blowing range of the fiber optic cables and must therefore be avoided.

9.1 UNCOILING THE DUCTS OR BUNDLES OF MICRODUCTS

The tubes and tube bundles are supplied in coils or on drums. When uncoiling the products, the drums should be slowed to freely rotate (preferably using a drum trailer as shown below), so the products are unwound without any excess coiling.



Figure 73: Uncoiling the tubes and microtubes bundles

Due to physical reasons, the bundles must be **uncoiled from the drum under tension**, in order to lay them as straight as possible, removing the coiling memory that the tubes have because of being stored in the drum. For that reason, the bundle must be controlled decelerated during uncoiling. The braking forces to be applied depend on the temperature and the type of bundle (quantity of tubes and diameters of the tubes). Generally, the braking force must be increased if the laying is made at low temperatures and if quantity of tubes of the bundle is high. Nevertheless, **the braking forces must never exceed the maximum tensile in the datasheet of each bundle or duct.**

To control the braking force, it is needed to use the appropriate equipment and spool breaks, that allow controlling the force constant during all the process and avoid uncontrolled uncoiling.

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Manufacturer: Vetter



Manufacturer: Bagela



Manufacturer: Thaler

Figure 74: Examples of different drum brakes

Never lay the drum or coil on its side and pull the tube bundles ‘off the top’, as this will induce a corkscrew twist (as shown in the photographs below), possible distortion and cause problems during installation and blowing.



Figure 75: Uncoiled to be avoided.

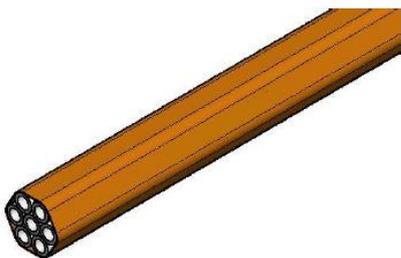


Figure 76: Bundle correctly uncoiled (straight)

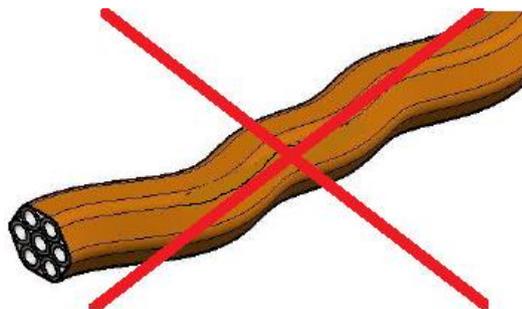


Figure 77: Bundle INCORRECTLY uncoiled

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9.2 LAYING DUCTS OR BUNDLES IN OPEN TRENCHES

A trailer for drums is recommended to be used to lay the bundles into the trench correctly.

The duct must be uncoiled under tension in a controlled manner as described in the previous section and it is important to respect the linear layer. Of course, the bottom of the trench must be plane and with the sand bed correctly compacted and levelled.

The recommended installation should follow the next picture:

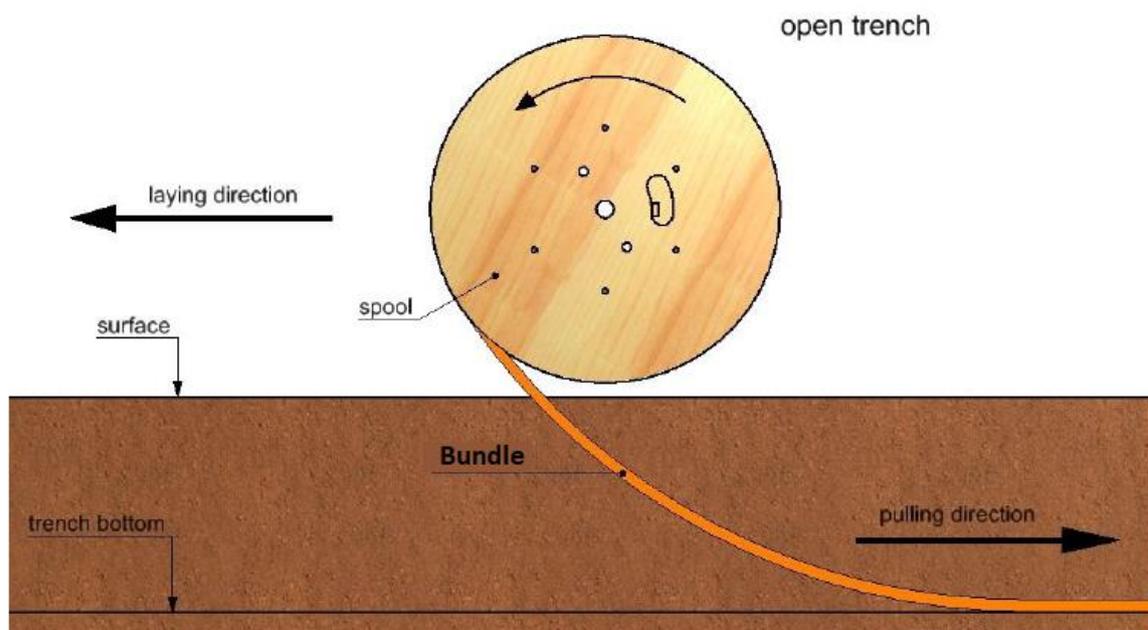


Figure 78: Recommended installation for ducts or bundles

9.2.1 BUNDLE RUBBER END CAPS AT CONSTRUCTION WORKS

During construction work, it is required to protect the duct network from the ingress of contaminants. It is required to protect the ends of the bundles with rubber caps. It is not permissible to wrap the ends of the bundles with adhesive tape, which can be damaged, thus allowing dirt (sand, earth, stones, dust, water) to enter the newly laid duct network.

Rubber caps come in different sizes and materials or colours depending on the manufacturer. They are made of flexible plastic and are available in a variety of diameters.

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Figure 79: Example of rubber bundle end caps at construction works

9.3 DUCT JOINTS

The joints between ducts, must be done according to the recommendations of the manufacturer of the ducts.

It is important to avoid making duct joints in curves, and make always the joints in straight line, after or before the curves.

Also, in straight duct joints of several micro-ducts of bundles, the connections must be done in a staggered manner, avoiding that all the connectors coincide in the same position generating a curve where it didn't exist before.

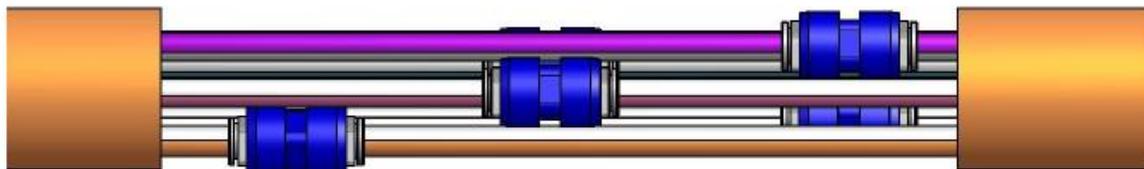


Figure 80: Example of duct bundle joint (the connectors doesn't coincide in the same position)

The connectors used to make the duct joint must allow an installation directly buried.

NOTE: Connectors designed for not buried applications with another protection cover are not allowed.



Figure 81: Example of connector valid for direct buried installation



Figure 82: Example of end-cap valid for direct buried installation

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9.4 BUNDLE OPENING

To open a micro-duct bundle (quit the sheath that aggregate the micro-ducts) is recommendable to use a sheath cutter with sliding guide because there is a lower risk of injury as with the knife for example.



Figure 83: Sheath cutter with sliding guide

It is important to cut the sheath of the bundle, sliding the blade through the free space between the micro-ducts and the sheath in order to avoid affecting the micro-ducts inside the bundle.

It is very important to take care of the micro-ducts avoiding making longitudinal cuts or scrapes that could affect negatively to the duct joint performance.

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9.5 MICRODUCT CUTTING AND PREPARATION FOR JOINT

The cutting of the micro-ducts must be carried out by a straight rectangular cut towards the pipe axis.



Figure 84: Adequate tools for micro-ducts cutting

NOTE: Never use chip-producing tools like a saw to cut the micro-ducts.

Through normal cutting and stripping of micro-duct assemblies and micro-ducts, occasionally a micro-duct may be squashed and made slightly oval, especially if the cutter is no longer sharp.

Not having a circular bore may cause the fiber to stick at the connector during installation. For this reason, a rounding tool is needed to bring the bore back to its original shape.

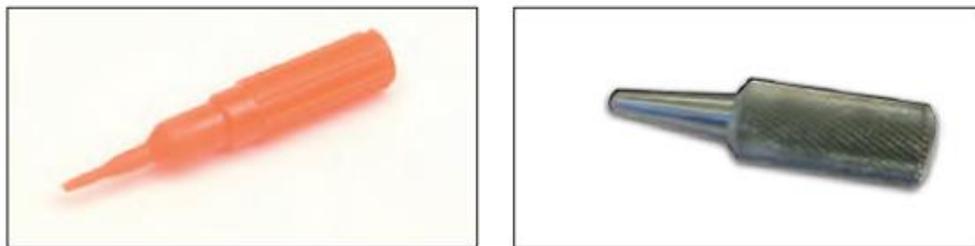


Figure 85: Different rounding tools for different microducts diameters

The procedure to use the rounding tool is the following:

1. Insert the rounding tool into the micro-duct
2. Rotate the rounding tool for 2 to 3 rotations
3. Remove the tool and inspect the bore for circularity

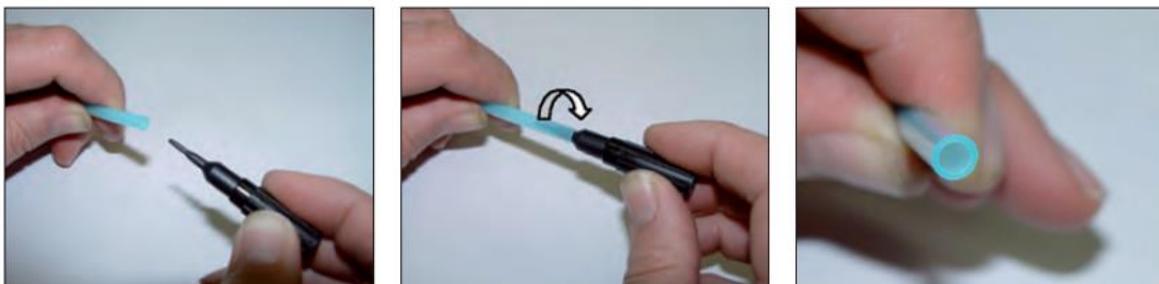


Figure 86: Detail of the use of the rounding tool

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9.6 USE OF CONNECTORS

All connectors that are going to be used are a push-fit system. The following literature gives information and the correct installation method for push-fit connectors. These connectors allow micro-ducts to be joined seamlessly, creating no gaps between the connector and micro-duct for the fiber unit/cable to hit when it is installed afterwards.

It is very important to fit the connectors correctly to avoid any loss of air pressure when the system is pressurised and to avoid creating any gaps.

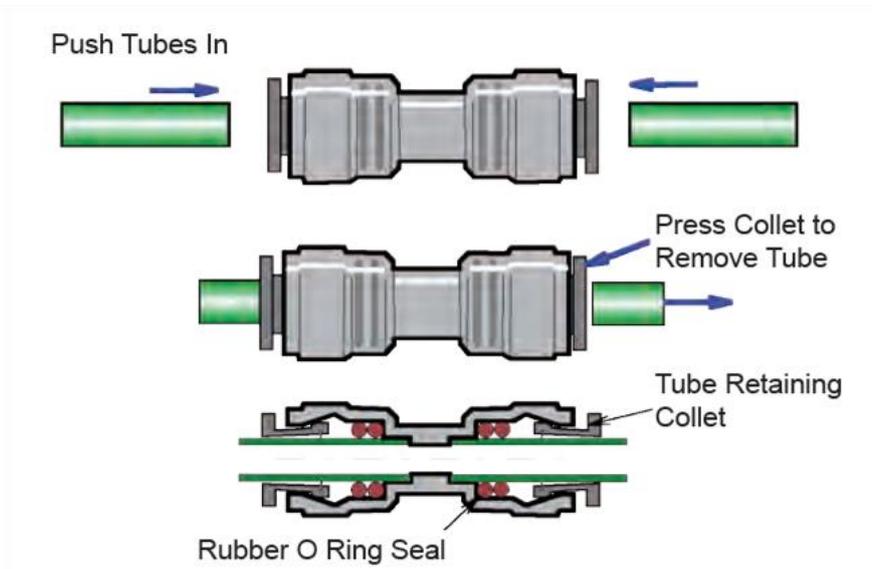


Figure 87: Detail of the use of the push-fit connectors for duct joints

If push-fit connectors aren't installed correctly this can impede the performance of the blown fiber installation.

Causes include:

- Non-rounded microducts (rounding tool has not been used)
- Leaking connectors (microduct not installed up to the 'stop')
- Incorrect connector ID



In this picture the micro-duct has only been pushed up to, and not beyond the 'O' rings. When the air flow is turned on this will have a high chance of blowing the micro-duct out or the fiber bundle/cable hitting the flange and stopping.



The micro-duct has been pushed fully in past the seal up to the flanges. This connector has been installed correctly and will create a good seal.

Figure 88: Example of a good and bad installation of a push-fit connector

9.7 USE OF END-CAPS

If microducts are left open to the environment this can permit dirt and water to enter them, consequently this will impede the fiber installation at a later stage.

For this reason all open ended microducts must be end capped to prevent contamination.

The preparation of the tube, and the placement of the end-cap are the same as for the connectors.



The same method applies for push fit end caps. Not pushing the end cap on up to the stop will not create a good seal around the micro-duct and may allow water and dirt ingress.



This end cap, with the micro-duct installed correctly will create a good seal preventing any water or dirt ingress.

Figure 89: Example of a good and bad installation of an end-cap

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9.8 INSTALLATION APPROVAL TESTS ON DUCTS

The following tests should be done after installation to make sure that the micro-duct and their connections have not been damaged and have been performed correctly.

9.8.1 MICRODUCT CONTINUITY (VERIFICATION) TEST

This test is carried out to make sure that each micro-duct has been coupled to its corresponding micro-duct (it means colour by colour).

This test is carried out with an air compressor, inserting air under pressure between 7 and 15 bars at the beginning of the network and checking that the air comes out at the end of it.

9.8.2 MICRODUCT PRESSURE TEST

This test is carried out to make sure that all the micro-duct connections are airtight and shows that the tube is airtight (any possible damage during the closure installation).

This test should be carried out with the same pressure that is going to be used to blow the fiber cable (normally about 15 bar).

This test is carried out with an air compressor, inserting air under pressure at the beginning of the network and with end caps at the other ends. Could be done with more than one at the same time using a coupler.

It is needed to stabilize the pressure up for 5-10 minutes (depending upon micro-duct length, number of micro-ducts being tested and compressor output). After the pressure has built up, isolate the air supply so the tubes remain pressurized.

It is acceptable for the pressure to drop less than 2 bar in the first 2 minutes. The air pressure slightly expands the tube creating a pressure drop. If the pressure drops more than 2 bar before stabilizing, it is necessary to pressurize the micro-duct again and check for a maximum drop of 2 bar.

9.8.3 MICRODUCT INTEGRITY (CALIBRATION) TEST

This test is carried out to check that the inside diameter (ID) of the micro-duct is maintained throughout the micro-duct path. It consists of blowing 30 cm long ball chains with different diameters depending on the type of micro-duct.

The following ball chains should be used for the corresponding micro-duct sizes. No ball chain should be used which is less than 60% of the micro-duct bore size.

Microducts	16/12	14/10	12/10	7/4
Ball chain diameter (mm)	10	8	8	3.2

Table 13: Ball chain characteristics

Insert the 30cm length of Ball Chain into each tube to be tested at the air inlet side. Make sure the air is isolated before starting the air compressor.

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Connect the Ball Chain Catcher to the opposite end of the micro-duct. The catcher needs to be strong enough to stop the ball chains at the end of the micro-duct and have a foam piece added to soften the approach of the ball chain. Attach a 250 mm breathing tube (with suitable holes in it to exhaust the air) between the catcher and the end of the chosen micro-duct.

The air pressure used in this test should be up to a maximum of 7 bar. An air preparation kit must be used to remove oil and water from the compressed air.

Once catchers are connected, it is safe to turn the air supply on.

The ball chain should exit the micro-duct within 5 minutes (in a 1000m length).

If after 5 minutes the ball chain has not arrived, release all pressure and reverse the initial configuration by modifying origin and destination.

Once the ball chain has been retrieved, blow it back in from the opposite direction.

NOTE: For more detail of the test techniques applicable for the different situations that can be found in the field and for recommendations and materials needed, refer to the “TEF-NORM-00009 – Microduct Quality Tests” document in which it is included in detail.

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10. OTHER CIVIL WORK FOR ELEMENTS INSTALLATION

In some points of the network other elements are needed to be used and needs also civil works for its installation.

Three important elements are the manholes, the street cabinets and the centralized distribution points.

The manholes could be used in several parts of the network. Is not very common situation because in the UGG deployment all the pipelines and the connections and branch offs of the pipeline will be made if it is possible directly buried but in some situations in which is needed to access several times in the future for maintenance purpose could be installed. For example, in the interconnection with other operators for the backhaul section could be needed and mandatory the use of the manholes.

The street cabinets are a very important element, as this element is used as a distribution point in the FTTH access network.

The centralized distribution point is used in villages or areas with less than 450 households, the street cabinets are directly hung from it.

In this section, is going to be explained the works that should be make for the installation of this elements.

10.1 INSTALLATION OF THE MANHOLES

The geometry of the manholes that is going to be used in the deployment (if is needed), is rectangular and modular, so it can be adapted to the different heights, as shown in the following figure.

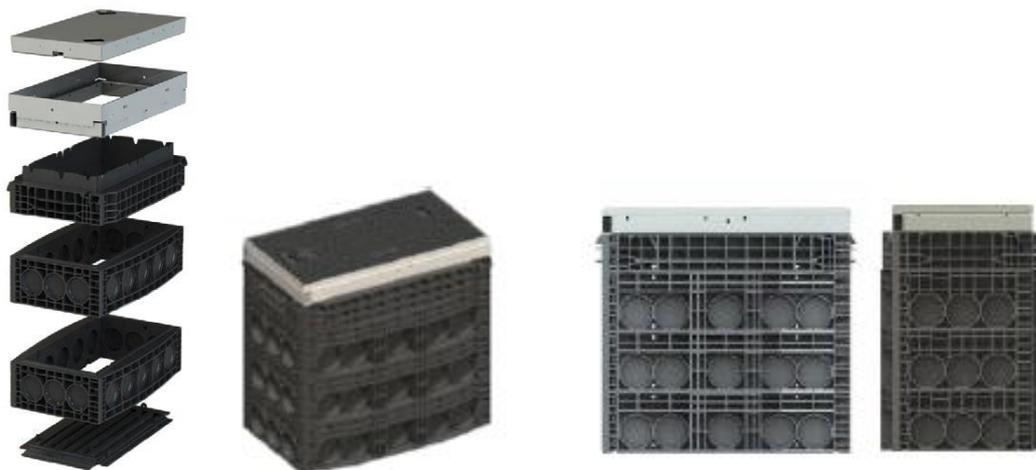


Figure 90: Modular concept of the manholes

The dimensions of the manholes that could be used in the deployment is the following ones:

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	Internal dimensions [MM]	External dimensions [MM]	Min Clearance height [MM]
Manhole OC model	550 x 1165	750 x 1300	900
Manhole TC model	800 x 1165	955 x 1300	900

Table 14: Dimension of the manholes

The following steps must be followed to carry out the installation correctly:

1. Excavate the building pit.
2. Put down a layer of gravel and compact it.
3. If there is an existing cable route, lay the base plate under the existing pipe.
4. Place the frame components on the base plate, one on top of the other. The frame elements can be laid on top of existing pipe routes without any issues.
5. Fix the frame and base plate together with double dowels.
6. Put in place the top frame and steel frame ready to support the manhole covers.
7. Put the covers in place using cover lifters.
8. Backfilling: Fill the trench in layers, and compact.
9. Adjust the height if required. Fill the construction joints with mortar.
10. Superstructure construction according to ZTVA-StB 09 (Supplementary Technical Conditions of Contract, Specifications, and Guidelines, Asphalt Roads).



Figure 91: Finishing the manhole installation in asphalt surface.

There is the possibility to use a paveable cover that is filled on the field to achieve their aesthetic integration into the street scene.

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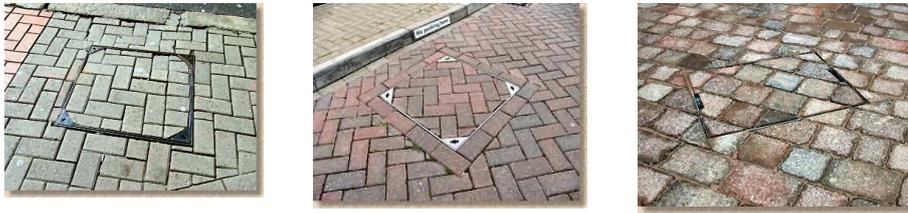


Figure 92: Examples of paveable covers

NOTE: For more detail of the manhole installations applicable for the different situations that can be found in the field and for recommendations and materials needed, refer to the “TEF-INST-00002 – Installations of Manholes” document in which it is included in detail.

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10.2 INSTALLATION OF THE STREET CABINETS

The cabinets can be made of different materials, such as metal or plastics valid for outdoor installation conditions (polyester or polycarbonate, for example). The material the sockets (or plinths) that is going to be used is a plastic valid for direct buried installations (polycarbonate or polyester).

The plinth must be installed directly buried into the ground.

The excavation pit, needed for the installation of the plinth of the cabinet must have a footprint about 40 x 70 cm for the street cabinet for 48 costumers and around 50 x 100 cm for the street cabinet for 96 costumers and the Urban-DP96. A minimum depth of 40% total street cabinet length is required.

After the pit excavation, put down a layer of gravel and compact it.

Once the pit has a compact base, fit the plinth (if separate) or the whole cabinet (if has integrated the plinth) directly into the pit.

Refill partially the pit, in order to fix the plinth and secure the cabinet to the ground.

This operation should not affect the pipeline, and this fixation must be done below the pipeline.

After fixing the plinth to the ground, and before refill the excavation pit, the micro-ducts of the pipelines must be installed into the cabinet and fix them properly.

The space between the cabinet/base and the surface must be refilled with a granulate solution or mortar. This is checked for compaction after backfilling and re-compacted if necessary.

The interior of the underground section of the plinth must be refilled using expanded clay or “Blähton” with a grain size of 4-8 mm, trying to have the least cavities as possible.

In the following figures is shown a schematic assembly of the cabinets:

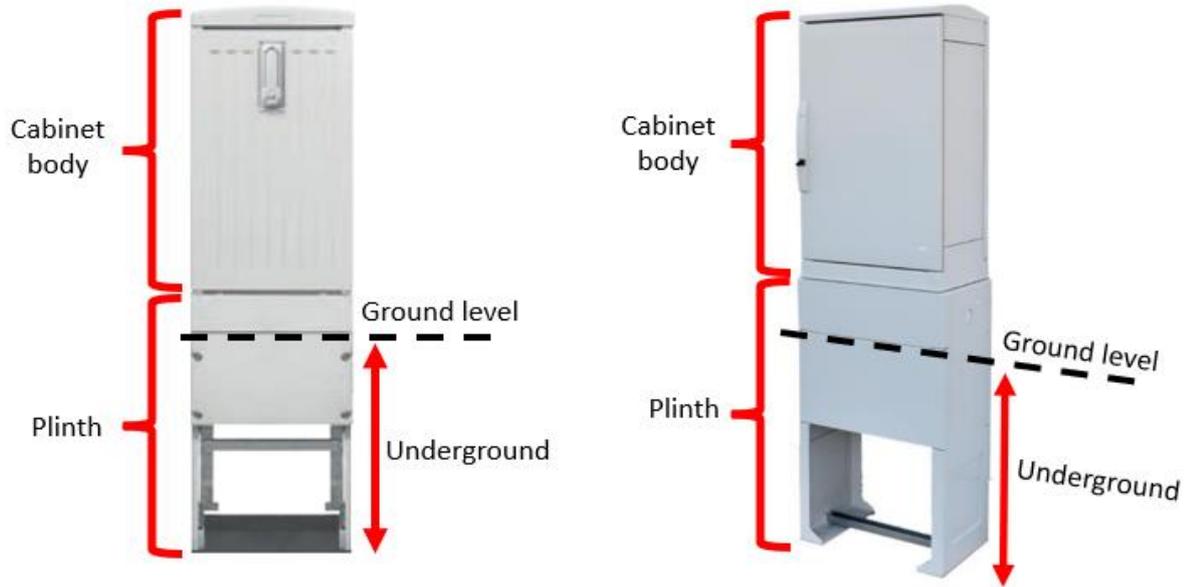


Figure 93: Scheme of the street cabinets for 48 costumers

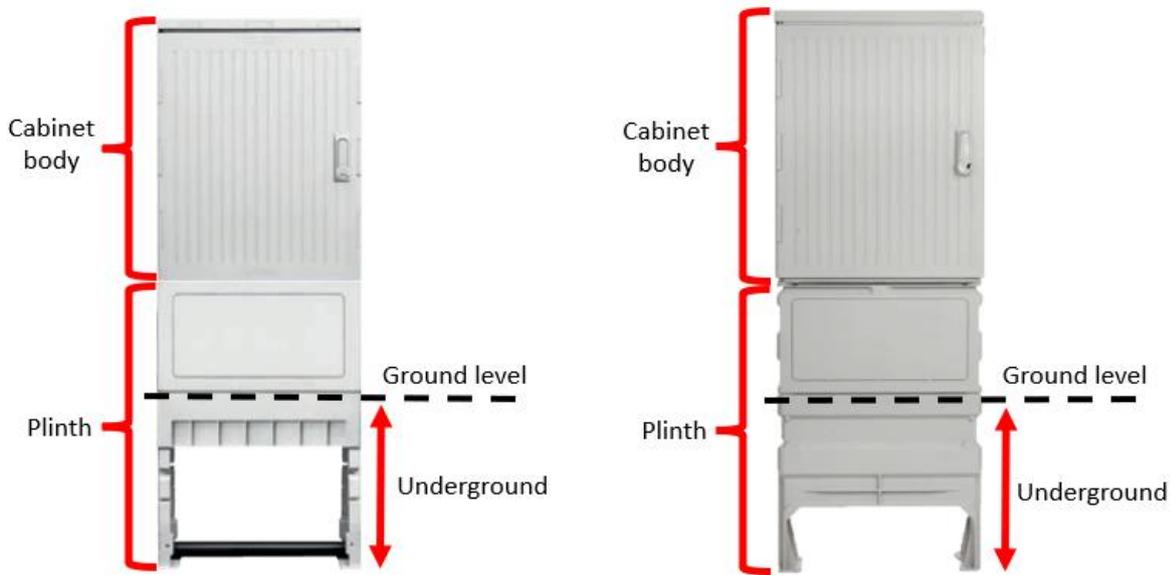


Figure 94: Scheme of the street cabinets for 96 costumers and Urban-DP96

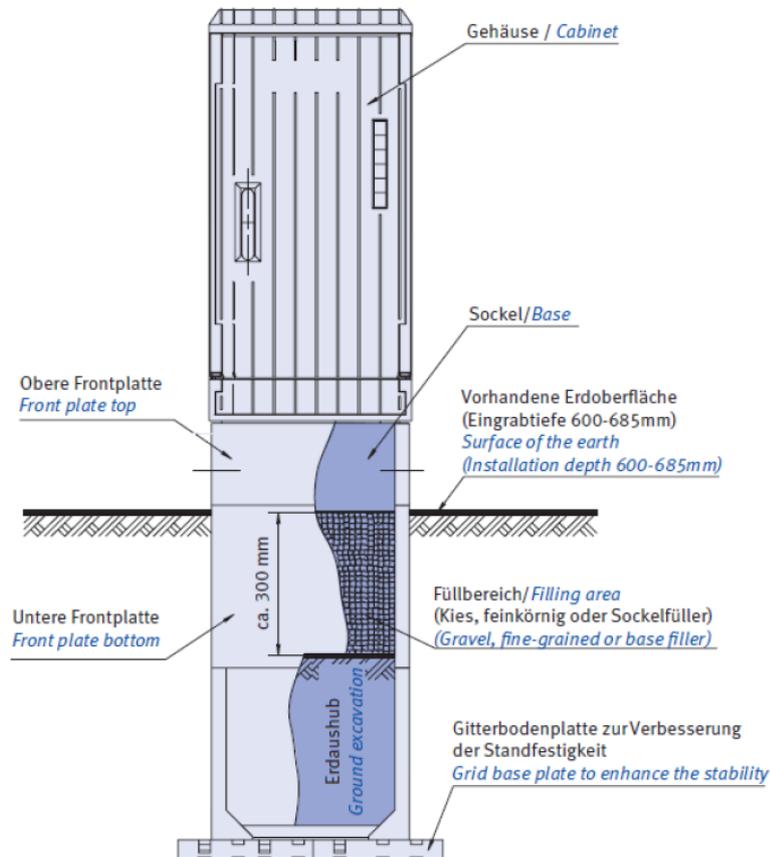


Figure 95: Installation scheme of a cabinet

NOTE: For more detail of the street cabinets installations applicable for the different situations that can be found in the field and for recommendations and materials needed, refer to the “TEF-INST-00004 – Installations of Street Cabinets” and TEF-INST-00008 – Installation of Urban DP’s” documents in which it is included in detail.

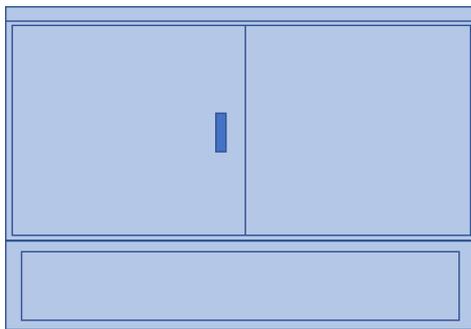
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10.3 INSTALLATION OF THE CENTRALIZED DISTRIBUTION POINTS

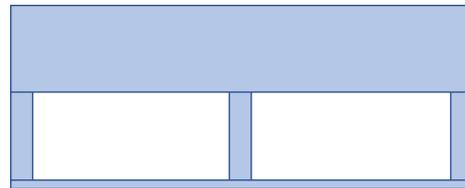
The street cabinet is a strong structure with two doors lockable.

The dimensions of the complete cabinet will not exceed: 2000 x 1600 x 500 mm (Width x Height x Depth). **Note:** The height dimension doesn't include the plinth part that will be buried into the ground.

The cabinet is constituted by different parts: cabinet body with accessible plinth, and underground plinth base to fix it to the ground.



Street cabinet upper part.



Underground plinth base

Figure 96: CDP cabinet structure (main parts)

The size of the plinth of the cabinet are (approximately) the following:

- Length: 2 meters
- Width: 0,50 meters
- Buried height of base: 0,74 meters

The underground plinth includes 4 rotary feet (or grid plates) to assure a good fixation to the ground, these feet must be covered by concrete or other material to avoid sagging in soft soils. The dimension of the feet will not exceed 500 x 300 x 80 mm and they have grids to be correctly filled with concrete.

These feet can rotate in case the street cabinet is placed close to a wall or other obstacle.

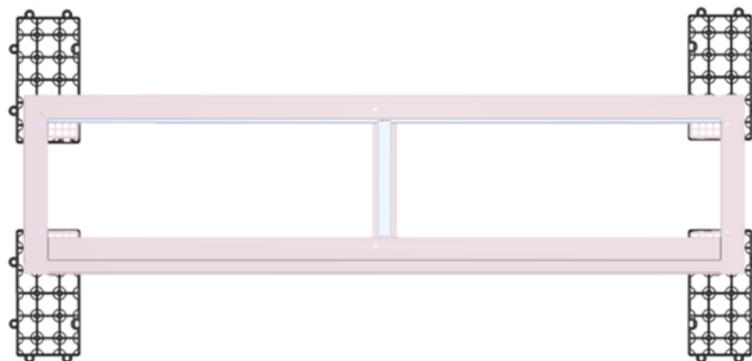


Figure 97: Installation scheme for concrete footings (normal installation)

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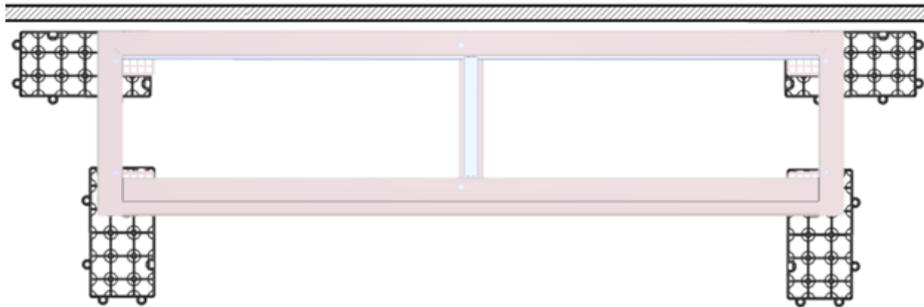


Figure 98: Installation scheme for concrete footings (installation in front of a wall)

In both cases, the volume of excavation will need an over-excavation in width and length to manage the installation.

The following dimensions can be considered for the excavation:

- | | |
|--|---|
| <ul style="list-style-type: none"> • Length: 3 meters • Width: 1,20 meters • Depth: 0,80 meters | <ul style="list-style-type: none"> • Length: 3,60 meters • Width: 0,80 meters • Depth: 0,80 meters |
|--|---|

Normal installation

Installation in front of a wall

The foundation surface must be levelled, consolidated, and compacted to the exact depth. For this purpose, the plinth is placed in the excavation pit aligned and levelled.

Lean concrete must be placed both above and below the supports. The lean concrete used in the concrete footing must have eight units of gravel (grain size of 0-4 or 0-5) for each unit of cement.

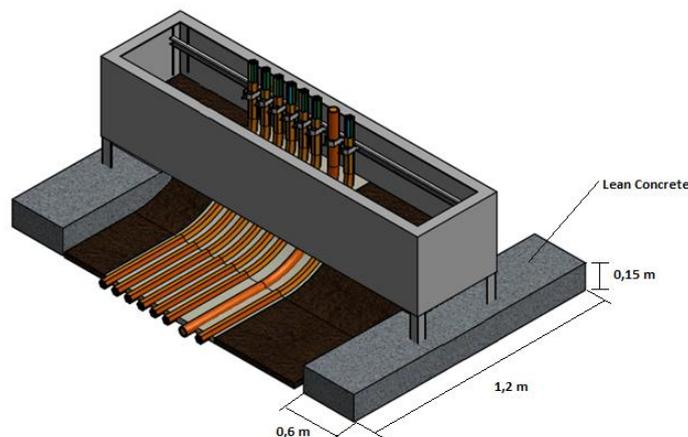


Figure 99: Concrete footings filled.

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The excavation pit and the internal part of the underground base plinth must be backfilled following the next scheme:

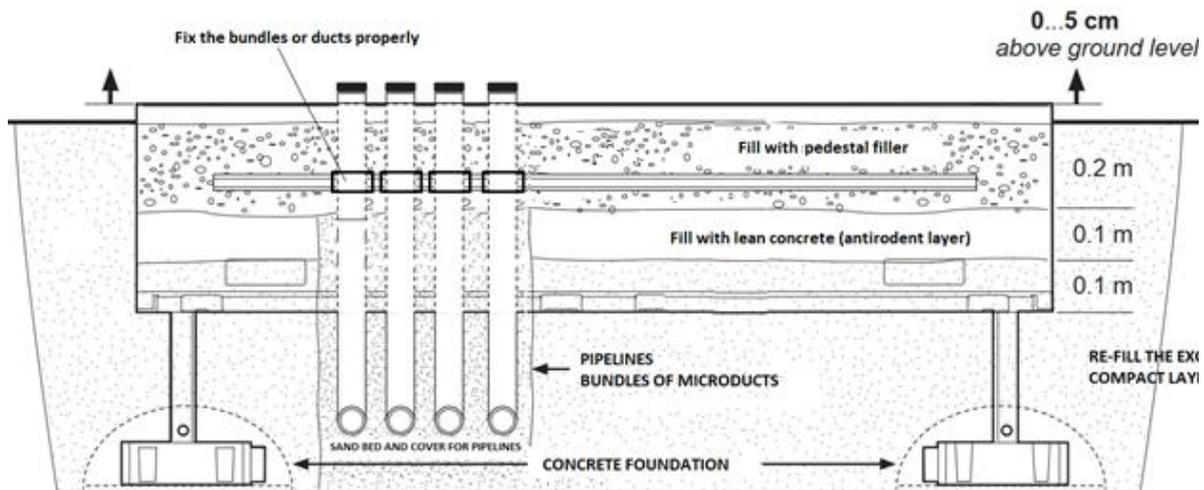


Figure 100: Scheme of backfilling.

The outside of the base will be backfilled with the previously excavated soil, which will be backfilled in compacted layers, always placing the ducts and bundles into a sand bed and cover for their protection.

Inside of the basement, the lower part will be filled with excavated soil or sand to a height of 10 cm. Over this first layer, inside the plinth base, a 10 cm thick layer of lean concrete must be placed, which also serves as protection against rodents.

The last layer, approximately 20 cm, a special pedestal filler (expanded clay or “Blähton”) must be used.

After the plinth installation the cabinet can be fixed firmly according to the manufacturer instructions.

NOTE: For more detail of the Centralized Distribution Points installations applicable for the different situations that can be found in the field and for recommendations and materials needed, refer to the “TEF-INST-00005 – Installations of Centralized Distribution Pints (CDPs)” document in which it is included in detail.

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