



# OSP Fiber Optics Civil Works Guide



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*Like all standards, this document only offers guidelines for design, installation and testing of fiber optic networks. The owner, contractor, designer or installer is always responsible for the work involved. Mr. Botha and FOA assume no responsibility or liability for the use of these standards nor for any projects using them.*

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## **An introduction to Optical Fiber and Why Fiber?**

Since the introduction of fiber in the 1970s, optical fibers have revolutionized communications, transmitting more information over greater distances than could ever be achieved in copper wires. We live on the continent (Africa) that gave birth to the concept of the 'Digital Divide'. But this being said, fast forward a few years, and today, the uncompromising amount of bandwidth we demand from Internet services is nearly insatiable. Why then do we need all that bandwidth? The past 10 years have seen a tremendous increase in Internet bandwidth requirements ("Moore's law" springs to mind), driven by high-capacity business data services, increasingly powerful 3G/4G wireless smartphones and video-intensive Websites such as YouTube, Netflix, etc. And of course, let's not forget the Periscope and Meerkat live-streaming video apps.

Buoyed by the surge in demand for digital data, local telecommunication companies are looking to reinvent themselves to support the need for faster data rates and smarter network architectures, potentially hamstrung by the predicament of having to handle unpredictable and fast-changing traffic patterns. Optical fiber technology provides a higher capacity data transfer at extremely high speeds, enabling the facilitation of video content on networks. In this context, community or service providers can now supply a wide range of services and applications, such as High Definition TV (HDTV), Video on Demand (VoD) and high-speed data and on top of this, provide for the basic fundamentals of voice connectivity. Who would have dreamed that operator's largest revenue component voice, might in the not-too-distant future, be surpassed by data and content provision services?

Switching a laser beam on and off at high speeds is how we communicate now over fiber. A laser flashes on and off in a sequence that represents the information being sent. The quicker the lasers can flash on and off, the quicker the information can be transferred. The speed of transfer is known as "bit-rate" and is usually talked about in terms of bits per second - bps or bit/s (which effectively is the number of flashes possible per second). Modern networks typically transmit at a minimum of 10 Gigabits per second from a single laser, which amounts to 10 billion flashes per second.

And goodness me, Alcatel-Lucent recently (Jul 16, 2013) transmitted as much as 31 Terabits per second over 7200 km on a single fiber i.e. 155 x 200-Gbps channels. This link featured amplifiers every 100 km and as far as I know, the highest sub-sea capacity ever transmitted on a single optical fiber.

### **Fibre Advantages - a brief summary**

- It has exceptional bandwidth and is virtually "future proof"
- It has the ability to carry many signals concurrently
- It is immune to electromagnetic interference and has no electromagnetic emissions
- It does not corrode like copper based cabling does
- It is resistant to eavesdropping
- It has the capability to operate in conjunction with any current, or proposed, LAN/WAN standard
- It is light weight and easy to handle and its pulling strength is higher than that of copper cables
- ...and, on it goes

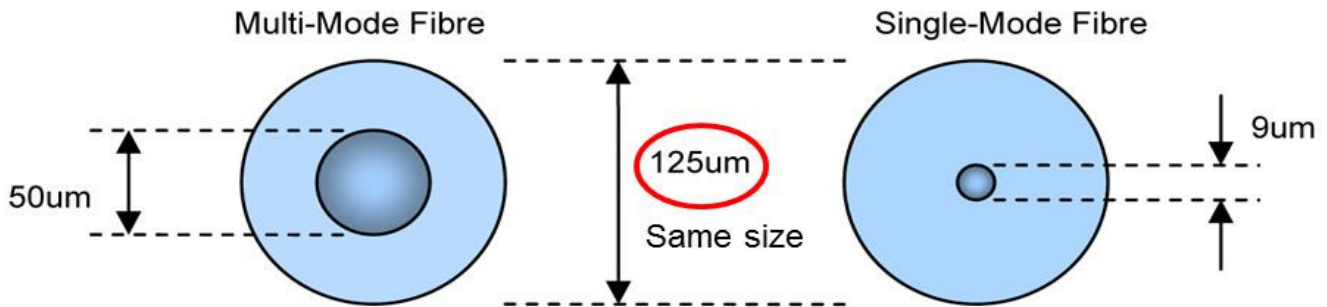
What happens to Johannesburg in spring? It sprouts leaves and changes from somewhat bare and dry conditions in winter, to lush vegetation in spring. Sadly, radio waves struggle to penetrate vegetation. So along with spring, come slower download speeds, poor signals and of course, disgruntled customers. The solution? More fiber?

### **Skilled Labor**

Some service providers may have their own labor while others rely exclusively on contractors. The trouble is that skilled labor is not always readily available. Because performance is so clearly measurable and apparent, FOA trained labor remains an important requirement, particularly for guaranteeing that a good end product is delivered. Even with the much more resilient and robust bend-insensitive varieties, optical fiber is still glass and requires both skill and knowledge to install.

## Fibre Geometric Parameters

Fibre can either be single-mode (SM) or multimode (MM). Fibre sizes are expressed by using two numbers e.g. 9/125. The first number refers to the core size in microns and the second number refers to the core and cladding size combined in microns. It is impossible to differentiate between SM and MM fiber with the naked eye. There is no difference in the outward appearances; both are 125 microns in size - only the core size differs.

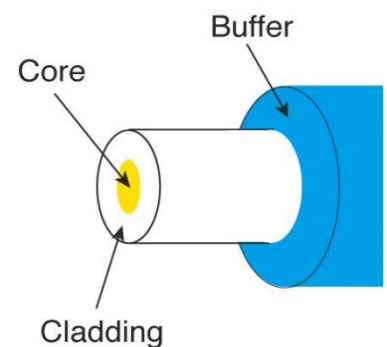


### Fibre Construction:

**Core:** The optical core is the light-carrying element at the center and is usually made up of a combination of silica and germanium.

**Cladding:** Cannot be removed! The cladding surrounding the core is made of pure silica and has a slightly lower index of refraction (i.e. less dense) than the core. This lower refractive index causes the light in the core to reflect when encountering the cladding and remain trapped within the core.

**Buffer coating:** This is removed during stripping for splicing or connectorization and acts as a shock absorber to protect the core and cladding from damage.



### Cable Jackets

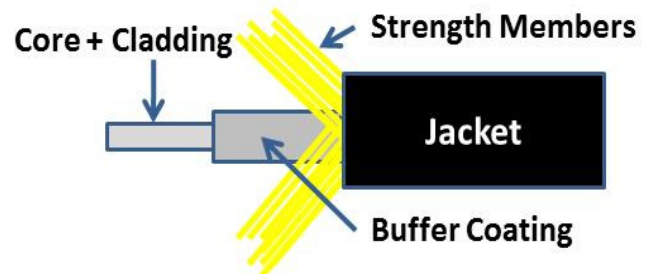
Polyethylene (PE) is the material of choice for use as an Outside Plant (OSP) cable jacket. The performance of raw PE can degrade rapidly through exposure to Sunlight. For this purpose, Carbon Black is combined with the PE and is used to absorb the UV light and subsequently dissipates. Jacket colors other than black are used for reasons of enhancing identification.

Cable jackets shall be marked with manufacturer's name, month and year of manufacture, sequential meter markings, fiber type, the number of fiber's, along with a telecommunications handset symbol. Cables without these markings will not pass inspections and should not be installed.

### Strength members

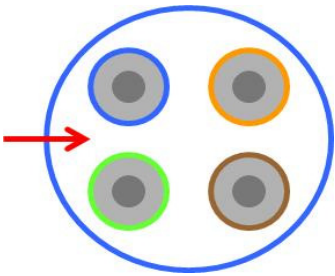
Aramid fibers (Kevlar - a very strong, very light, synthetic compound developed by DuPont - is used when a cable is pulled into a duct, with the tension being applied to the Kevlar. The Kevlar is used as a draw string to pull the cable into the duct so as not to put stress on the fibers.

The term is also used for the fiberglass or steel rod in some cables used to stiffen it. Impact resistance, flexing and bending are other mechanical factors affecting the choice of strength members.



**Moisture/Water-blocking**

In a loose tube cable design, a filling compound, water swell-able yarns or gel (a soft, gooey, substance) are commonly incorporated in the cable. This minimizes the chance of water or moisture penetrating the length of the tube in the event that the tube is damaged. When water freezes it expands by approximately 9% - therefore, water in a cable can cause repeated freeze and thaw cycles.



**Micro Technology**

Since SM fiber was first introduced in the early 1980s, not too much has changed in its basic geometric parameters. The SM core size has remained somewhere between 8 and 10 µm - the core / cladding diameter has remained at 125 µm. The outside plant (OSP) fiber coating is now either 200 or 250 µm. Most notably, standardizing these dimensions has greatly improved interoperability and consistency across optical networks.

Microcables offers a great deal more density. Only a few years ago, a cable diameter of ± 12 mm was required for a 48-fiber cable design. Today, cables with only an 8 mm diameter has a capacity of 144-fibres. This is achieved by using 200µm coated fibers. The 200 µm coated fiber’s cross sectional area is ± 46% smaller than that of the conventional 250 µm coated fiber.

A new-ish component to the system is microducts made of high-density polyethylene (HDPE) material. They are typically installed as bundles in larger ducts. It’s generally accepted, that deploying microducts is an economically sensible option, helping to avoid the costs of subsequent civil works.

Micro cables are designed for jetting, with high-density polyethylene (HDPE) outer sheaths in order to minimize friction with the inner surface of micro ducts. Perhaps more significantly, these cables also have optimal stiffness properties to help prevent buckling and easily negotiate modest changes in direction of the micro duct along the jetting route.

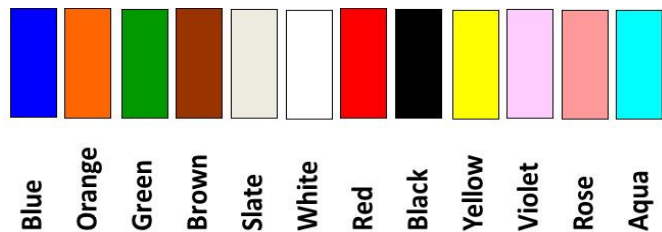
The central tube micro cable design also provides the highest fiber density, yielding a relatively small cable OD. The individual fibers are bundled into groups of twelve within the cable’s central tube, and the bundles are easily identifiable with colored binders in accordance with EIA/TIA-598B, "Optical Fibre Cable Colour Coding".



- Microduct Colour Code**
- 1. Blue
  - 2. Orange
  - 3. Green
  - 4. Brown
  - 5. Slate
  - 6. White
  - 7. Red

NB, color codes differ from supplier-to-supplier.

**EIA/TIA-598B, "Optical Fiber Cable Colour Coding"**





## **Environmental Considerations**

It is the Contractor and/or Client's responsibility to prepare a site-specific Environmental Management Plan (EMP). And, as ever, each site is unique and therefore the environmental issues to be considered will vary from site to site.

## **Environmental Control Officer (ECO)**

- 1 A good place to start with, is the appointment of an Environmental Control Officer (ECO).
- 2 In order for all to sleep easily at night, without having to furrow the brow much with care, the ECO shall:
  - Prior to work commencing, the contractor shall unravel the requirements of the EMP to team members, to ensure understanding and conformity
  - Visit the site weekly
  - Review and approve all areas that have been rehabilitated by the Contractor
  - Keep a record of findings
  - Attend all project meetings
  - Produce a monthly report, for the client, with commentary on compliance and/or non-compliance
  - Keep an Incident Log of non-compliance
  - Maintain a record of complaints from the public and communicate this to the client
  - Where necessary, issue a non-compliance report to the Contractor
  - Where serious environmental infringements have occurred, introduce a Temporary Work Stoppage
  - Liaise with the appointed Occupational Health and Safety Officer of the client

## **The Contractor's Environmental Management Plan (EMP) must include:**

In what follows, is a brief summary of what an EMP might contain, but is not limited to:

1. Statement of Commitment
2. List of activity-specific environmental issues related to your site and their likely impact
3. Incorporating the above, write a series of simple work instructions to ensure compliance
4. Determine the actions required to manage each work instruction
5. A list of tangible contingency and mitigating actions to be implemented if required
6. Provide training to staff and create awareness
7. An organizational chart setting out respective roles and responsibilities
8. Monitoring and Reporting

## **Contractor Responsibilities (not limited to):**

- 1 Be familiar with and comply with the procedures contained in the EMP.
- 2 Ensure that all personnel are trained, qualified and experienced enough, to undertake their work in an environmentally responsible manner.
- 3 Create an awareness of the Environmental work requirements and the need for them amongst the workforce.
- 4 Procedural briefings to be given before personnel carry out key activities for the first time.
- 5 Ensure that personnel who have formal responsibilities under this plan, are trained in the requirements of this EMP.
- 6 Undertake daily site inspections to monitor environmental performance and compliance.
- 7 Immediately notify the ECO in the event of infringements.
- 8 Notify the ECO and in advance of any activity he has reason to believe that may potentially have an adverse environmental impact.
- 9 It is desirable for Environmental matters to be included as a standard agenda item at all project meetings.

## A few Activity-specific Guideline Examples:

In what follows, are a few activity based examples an EMP must contain, but is not limited to:

### Water

- 1 Storm water must be contained in the storm water system to avert flooding.
- 2 Measures must be implemented to distribute storm water as evenly as possible to fend-off soil erosion.
- 3 Material from any stockpile must not be allowed to spill or be washed into a gutter or drain.
- 4 The execution of any work shall not block and subsequently unsettle the existing overland water flow or the existing system of drains.
- 5 No person may, without prior written permission release water onto a public road.
- 6 No person may, without prior written permission raise the water level of a river, stream or dam which can spill-over onto a public road.
- 7 Any water that is present in a trench shall be pumped out before backfilling.
- 8 Water shall be pumped into the storm water system and never into a sewer manhole.
- 9 No work shall be carried out within 32m of any natural water source without permission from the ECO.

### Dust / Air Pollution

- 1 Where necessary, issue workers with washable dust masks for protection against dust inhalation.
- 2 Dust shall be controlled onsite, especially when windy.
- 3 Minimize or even cease activity during periods of high wind.
- 4 Dampen surfaces to prevent dust from becoming airborne.
- 5 Cover materials being transported with plastic sheeting or a tarpaulin to prevent them from flying off the vehicle. Dampening of the transported material may also be necessary.
- 6 Cover onsite stockpiles with plastic sheeting or tarpaulins during high wind.
- 7 Regular maintenance of generators, compressors, etc., is essential for controlling exhaust emissions.

### Noise Pollution

- 1 Contractors must abide by the National Noise laws.
- 2 Develop a noise mitigation plan before starting with construction.
- 3 The level of noise and the duration thereof must be agreed upon and monitored.
- 4 Examples of noise: Jack hammers, concrete saws, bulldozers, trucks, generators, compressors, pneumatic tools, power tools, etc.
- 5 When talking to someone 1m away and you have to shout to make yourself heard, then noise levels are definitely too high.
- 6 Hand-held sound meters are lightweight, easy to operate and relatively inexpensive.
- 7 Hearing protection shall be worn at all times when noise levels are suspected of equaling or exceeding 85 dBA.
- 8 Noise PPE:
  - Use disposable earplugs only once
  - Keep reusable earplugs clean
  - Earmuffs must be a good fit
- 9 Where possible, restrict construction work to weekdays and limit work hours from 08:00 to 17:00.
- 10 Should an extension of the work hours be required, the adjacent property owners shall be informed in writing 2-days in advance of any proposed overtime activities.
- 11 Whenever practical, noise levels identified as exceeding 85 dBA, Noise MUST be reduced by using mufflers, barriers, etc. or the following actions must be implemented once the source of the noise has been ascertained:



- Replacement or adjustment of the worn or loose parts
- Balancing unbalanced equipment
- Lubrication of the moving parts
- Use of properly shaped and sharpened cutting tools

## **Trees**

- 1 Trees shall not be cut or trimmed unless consent is obtained in writing from the owner or the relevant authority.
- 2 Cutting shall be confined to what is absolutely necessary.
- 3 Tree roots exposed in the way of the trenching shall not be cut unless absolutely unavoidable.

## **Archaeology and Cultural Heritage**

- 1 Even with no designated sites of archaeological sensitivity being identified along a route, the Contractor will be required to have measures in place to deal with potential finds protected by the Natural Heritage Resources Act, Act 25 of 1999.
- 2 Construction in the vicinity of a finding must be stopped and under no circumstance may any artefacts be disturbed or removed from the site.
- 3 An archaeologist can be called to the site for inspection and the South African Heritage Agency must be advised.

## **Environmentally Sensitive Areas (ESA)**

- 1 An ESA is a type of designation for an agricultural area which needs special protection because of its landscape, wildlife or historical value.
- 2 Such designated areas shall be dubbed “no go” areas and access to, or work in such areas, shall be carefully controlled by the ECO.

## **Concrete / Cement**

- 1 Concrete shall not be mixed directly on the ground.
- 2 All visible remains of excess concrete shall be removed and disposed at an approved disposal site.
- 3 Cement shall be stored in a dry place, protected from rain and raised off the floor.



## General Health and Safety Guidelines

There is little doubt that an approach that minimizes or better still, eliminates possible accidents or incidents is highly advantageous.

It is the responsibility of the user of the following to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

**Responsibility of Management:** It is the responsibility of management to ensure that all team members and supervisors are trained and familiar with applicable safe working practices, and that they take immediate and decisive action when safe and approved work methods are not followed.

**Responsibility of Supervisors:** It is the responsibility of the supervisors to ensure that each member of his team wears the required PPE and to ensure that the work area is protected by the use of the necessary signs, cones, flashing lights, traffic control personnel, etc. Personal protective equipment (PPE) refers to protective clothing, hard hats, safety glasses, or other garments or equipment designed to protect the wearer's body from injury. On top of this, practice safe and approved work methods, as generally outlined in this Manual.

Each Party must at all times comply with health and the safety legislation, regulations and guidelines, which must include, but is not limited to:

- 1 A competent person shall, before the commencement of any construction work, perform a risk assessment which shall be written into the health and safety plan to mitigate risks and shall include:
  - a. Activity-specific hazard and risk identification.
  - b. Assess and evaluate each identified hazard and risk and rank them i.e. high, medium or low.
  - c. The best way to protect people is to eliminate the hazard or risk and second best, minimize it.
- 2 All areas used by the public shall be maintained free from debris or equipment that may constitute slipping, tripping, or any other hazard.
- 3 Adhere to all the health and safety management plan procedures.
- 4 Develop and obtain approval for a Traffic Management Plan (TMP).
- 5 Report and record all Work Site accidents, incidents and property damaged.
- 6 Establishing safe air space requirements prior to the use of lifting and construction equipment.
- 7 All personnel shall be required to wear the following personal protective equipment (PPE):
  - Protective overall (at all times).
  - As a general rule, steel-toed safety boots should be worn at all times.
  - Hard hat (when performing work that requires the use thereof).
  - Safety glasses (when performing work that requires the use thereof).
  - Work gloves help prevent cuts and bruises from sharp or rough edges on pipe/ducts and other objects.
  - Wear high-visibility vests (at all times).
- 8 The contractor shall ensure that all necessary guards, protective structures and warning signs are used to protect both workers and third parties. All necessary barriers and fences shall be erected to guide pedestrians and traffic around the work area.
- 9 A first aid box will be provided and allocated to a trained, certified first aider. Every injury occurring on site must be treated and recorded.
  - Should an injury require professional medical treatment, the supervisor in charge must complete an accident report.
  - Ensure that the first aid kit is available and accessible, correctly stocked and a register exists to account for used/missing items.
- 10 All employees, management personnel and visitors shall undergo induction training carried out by the Site Manager or a designated deputy before going onto site for the first time. Inductions records shall be kept on site for the duration of the project.

## Typical Table of Contents for a Site Safety File

- |                                      |                                |
|--------------------------------------|--------------------------------|
| 1. Notification of Construction Work | 16. Risk Assessments           |
| 2. Letter of Good Standing           | 17. Induction Records          |
| 3. Organogram                        | 18. Toolbox Talks              |
| 4. Health & Safety Policy            | 19. Inspection Registers       |
| 5. Health & Safety Plan              | 20. Visitors Register          |
| 6. Environmental Policy              | 21. Complaints Register        |
| 7. Environmental Plan                | 22. Site Diary                 |
| 8. Waste Management Plan             | 23. Weekly Statistics          |
| 9. Fall Protection Plan              | 24. Safety Minutes             |
| 10. Emergency Plan                   | 25. Audit Template             |
| 11. Emergency Contact Numbers        | 26. Vehicle List               |
| 12. List of Sub Contractors          | 27. Incident Records           |
| 13. 37.2 & 5.3.b Legal Agreement     | 28. Client's SHE Specification |
| 14. Appointments                     | 29. Public Liability Insurance |
| 15. Certificates of Competency       |                                |



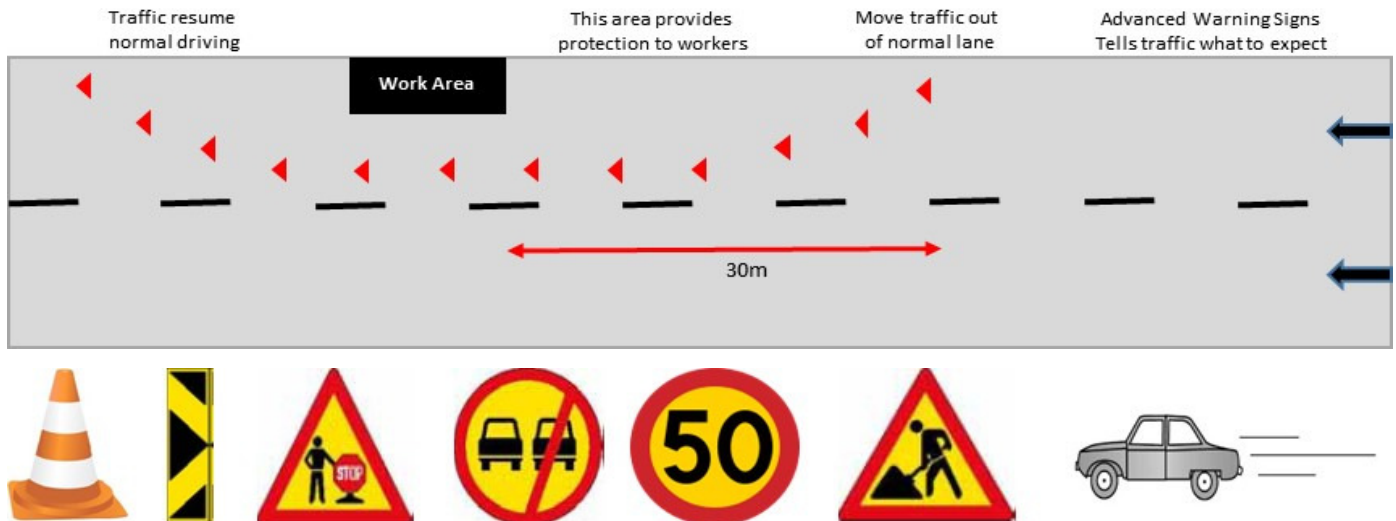
## Traffic Management Plan (examples)

- 1 No work should commence on a public roadway without first obtaining a wayleave from the road authority concerned.
- 2 It is the responsibility of the supervisor/s to ensure that each member of his crew wears the required PPE and to ensure that the work area is protected by the use of the various signs, cones, flashing lights, traffic control personnel, etc.
- 3 Traffic movement shall be inhibited as little as possible. Should this be unavoidable, alternative access to routes must be made available.
- 4 Work carried out on busy roads, should be restricted to outside the following periods; from 06:30 to 09:00 and 15:30 to 18:00, to ensure the free flow of traffic during peak hours.
- 5 Roads shall be kept free of debris or equipment.
- 6 Excavated material unsuitable for re-use shall be removed from site as soon as possible.
- 7 Where cyclists and/or pedestrians are likely to be present, their need for safe and convenient passage must be considered and sufficient, safe crossings shall be planned for.
- 8 Create 'no go' zones around hazardous areas and implement safe work distances.
- 9 Choose signs with messages clearly indicating the actions drivers or pedestrians are required to take.
- 10 Where necessary, traffic control persons shall be used to provide positive guidance to motorists.
- 11 Remember that the visibility of hazards/workers can be greatly diminished in darkness and/or poor weather conditions.

## Selecting Signs

- 1 Choose signs that are appropriate; signs that accurately describe the work situation.
- 2 Start with general sign messages at the beginning of the work zone. Then use signs with more specific messages, stating what action should be taken, closer to the actual work area.
- 3 The overall effect of signs should be to make drivers aware of what they are approaching and what action(s) will be required of them.
- 4 Drive through checks should be made every so often, both at night and day, to ensure that signs are properly located to allow adequate driver response time.
- 5 Use only signs that appear in the local Road Traffic Signs Manual.

6 Signs must be kept clean and well maintained if they are to be effective.



### Flagging PPE and Communication

- 1
  - A high-visibility reflective vest
  - A white hard hat
  - Steel-toed safety boots
  - Full length pants or coveralls - no shorts
  - During rainy weather, highly visible rainwear
- 2 When two flaggers are used, they can communicate verbally or visually if they are close enough to each other.
 

It is desirable to appoint one of the flaggers as the coordinator.

Where the end of a one-lane section is not visible from the other end, the flaggers must communicate via two-way radio.

The safety of workers and the travelling public, while passing through the construction area, depends on the efficient actions of flag persons.
- 3 A Warning Flag Signal may also be used to warn a road user to proceed slowly, and be alert of a hazard in or adjacent to the roadway ahead.
- 4 A good, active flag person can be as effective as any other means of drawing attention to a hazard in the roadway.



600mm x 600mm red flag  
with 1m wooden pole

## **Wayleave's (right-of-way or easement)**

Wayleave's will indicate the positions of other services. This can prove to be as misguidedly optimistic as that of US Civil War general John Sedgwick's last words. "They couldn't hit an elephant at this distance." "Never assume anything!" Fortunately, most of us are somewhat skeptical about the accuracy of the information presented in a Wayleave (a project can have many of them). There is little doubt that a pre-build survey set to verify the exact location of services indicated (or not) in Wayleave's, will do no harm.

A Wayleave is permission to use someone else's property to deploy infrastructure. In other countries this is also known as a right-of-way or an easement.

A Wayleave agreement must be obtained prior to installing any telecommunications equipment.

Companies doing work in a Road Reserve shall at all times keep a copy of the Wayleave on site.

Companies must familiarize themselves with the Standards and special conditions as set out in this permit.

Companies are held responsible and accountable for the quality of work they deliver, as well as any objectionable actions by their workforce. Deep pockets are required for non-conformance fines.

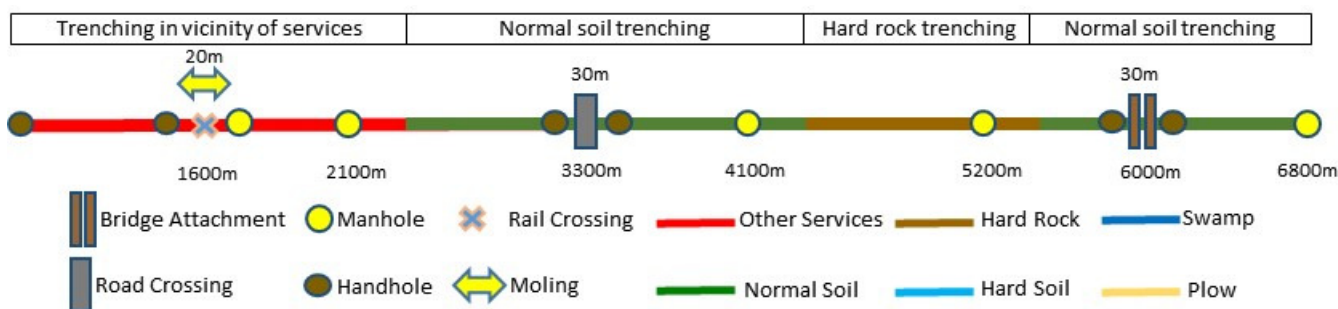
## Pre-Build Procedures

Any fiber installation project is a major undertaking. Responsibility for the oversight of everything from detailed implementation plans to community relations, ensuring sufficient materials are ordered in a timely manner to safety and environmental concerns, means an intense amount of pre-work and ongoing coordination for the life of a project.

- 1 As an unfaltering believer in a pre-build survey: The verification of details contained in pre-build drawings, will ensure that potential problem areas are uncovered before the contemplated work kicks-off and potentially save one a lot of trouble later.
- 2 Using the information available on the pre-build drawings, walk the pegged out route by foot, to determine the following:
  - Verify the soil classification/s by digging a pilot hole every 1km (hard, intermediate, soft)
  - If the soils or soil properties are not what were expected as noted in the contract, the client must immediately be consulted
  - Check and verify above and below ground utility locations
  - Note changes in gradient and/or direction
  - Identify all obvious landmarks where the route changes direction (take photos)
  - Take photos of all obstacles along the route
  - Verify HH / MH positions
  - Note road / rail crossings
  - Record crossings with other services
  - Record the presence of structures near the trench
  - Double-check the recorded details on the return journey
  - The route is typically marked using lime

## Pre-Build Survey Equipment and Tools

- 1 Digital camera and spare batteries.
- 2 GPS with tracking function and spare batteries.
- 3 DCP tester.
- 4 Tape measure.
- 5 Measuring wheel.
- 6 Clip board, note book and stationary.
- 7 Route drawing/s from the client.
- 8 Reflector jacket.
- 9 Personal Identification.



Armed with this information, a meticulous build plan (productivity for day, week, month, etc.) can be developed and the contractor can now ensure that the necessary equipment and resources are in place.

Procedures and processes can now also be developed and put into place to ensure that the contemplated civil build is done to standards and executed within budget and timelines.

### **Contractor's Camp Establishment / Holding Area**

1. On large projects, a contractor may need to provide for a construction site camp / safe holding area, which includes office accommodation.
2. The site location must be at a convenient point and as close as possible to the work site.
3. The contractor must provide for a safe holding area to store all material obtained from the client.
4. The contractor will bear all interrelated costs associated with securing the property and the camp establishment.
5. Must be fittingly fenced 1.8m high.
6. Must have secure lockable gates 1.8m high.
7. Must have a suitable office in compliance with OHASA and local authority requirements.
8. Must provide for sanitary facilities in compliance with OHASA and local authority requirements
9. Must contain telephone and Internet services (mobile and/or fixed).
10. The camp must be sufficient in size to accommodate all material and equipment required for the project.
11. On completion of the project, the contractor shall reinstate the camp establishment to its original state or better.

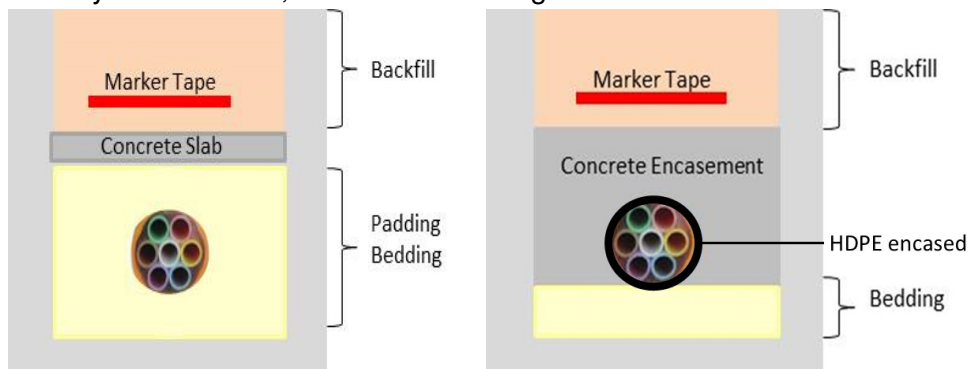


## Trenching

It's immensely important for trenches to be excavated to such a depth that the crown of the duct has at least 800mm of backfill cover, in all soil conditions, except for where hard rock conditions are encountered.

Where it is not possible to obtain the specified minimum trench depth, the client must be consulted.

The trench depth in hard rock conditions can be relaxed (i.e. apply for concession) to a minimum depth of 300mm backfill cover over the uppermost duct. But this being said, it now requires protection in the form of a concrete slab (either pre-cast, or cast in situ) placed on top of the padding material before backfilling. This concrete slab shall have a strength of 20 Mpa reinforced with high tensile wires and measure; 75mm thick by 300mm wide, and 900mm in length.



Concrete encasing is not endorsed enthusiastically by everyone; some argue that it turns a previously flexible duct into a long unreinforced concrete beam of negligible strength, prone to fracture with ground movement. This in turn could potentially damage an encased duct. A view not shared by everyone.

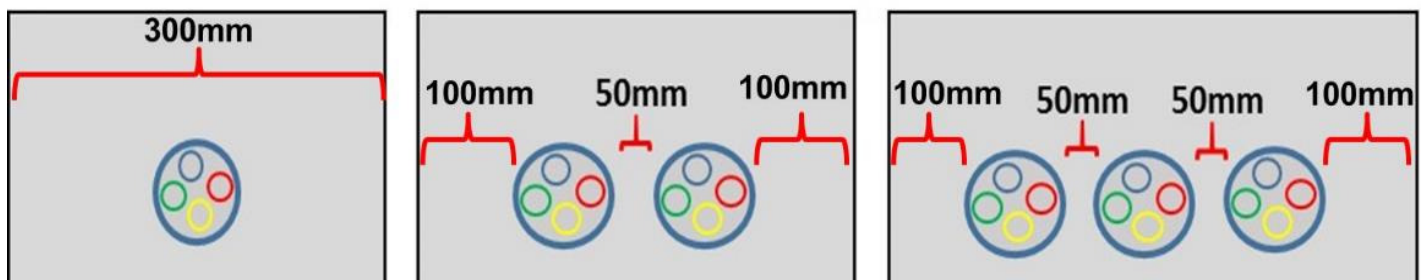
Before pouring concrete, a slump test must be performed (take photos of this procedure). How do we measure the ideal slump? A slump of 10 cm or less is typically deemed acceptable (must not shear-off or collapse) - or as per client spec. Concrete that is poured too wet will be weak, regardless of how it is cured



## Trench Width

One other obvious consideration is the width of the trench, which of course, is dependent on the duct diameter.

Trenches that are too narrow will not allow for proper duct installation, whereas trenches that are overly wide are unnecessarily costly. On top of this, a too wide a trench will allow for too much duct snaking from the reel memory. Below are typical examples:



Areas where work is to be performed shall be cleared of all trees, shrubs, rubbish, and other objectionable material of any kind, which, if left in place, would interfere with the proper performance or completion of the contemplated work.

## Pilot Holes

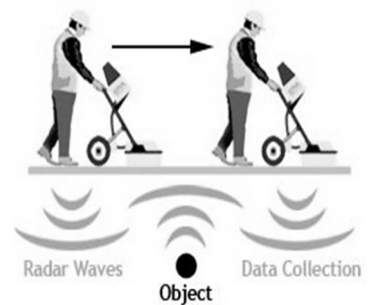
When the trench has been set out, Pilot Holes needs to be dug at 30 - 50m intervals, particularly at points where the new trench crosses existing services. The pilot holes should be at least 150mm deeper and wider than the proposed trench.

Pilot holes are one of the most effective methods utilized not only for the location of services, but also to determine the position of a trench, relative to other services.



## Location of Services

- 1 In my view, investing a few shekels in a Ground penetration radar (GPR) is a ticket to fail-safe trenching. They are used to identify underground services and formations (readings can be affected by the presence of high voltage power cables).
- 2 No excavation work shall commence without having a copy of the approved wayleave/s on site.
- 3 It is the responsibility of the Contractor to locate all existing services.
- 4 A Utility Representative can be asked to point out the position of a service and sometimes even oversee the work.
- 5 Cable Locators can find the exact path and even estimate the depth of the utility service.
- 6 Hand excavating is necessary to uncover known services prior to commencing with mechanical excavation.
- 7 Any trenching done in the vicinity of existing services should be done very carefully to prevent accidental damage to a service.
- 8 The Contractor shall be liable for any damages to existing services.
- 9 Any damage to existing services must be reported immediately to the project manager.



## Trenches Deeper than 1.2 meters

- 1 Where the depth of a trench exceeds 1.2m and workers need to enter the trench, adequate measures must be taken by the contractor to provide support for this trench.
- 2 3 basic methods used for protecting workers against trench cave-ins are:
  - sloping
  - trench boxes
  - shoring... and, a ladder provides a safe means of access
- 3 Barricades and signs are to be used at safe distances from edges to protect unattended excavations.
- 4 No person must work alone in an excavation or trench that is greater than 1.2m deep.
- 5 Machinery must never be placed in or near excavations and trenches where exhaust fumes may contaminate below ground atmospheres that workers are required to occupy.
- 6 Care shall be exercised in the moving or removal of shoring to prevent the caving or collapse of the trench faces being supported.



## Notifications

- 1 Businesses/property owners shall be informed one week (7-days) in advance of any construction activities commencing in the vicinity of their properties.
- 2 Residents, whose property may be blocked-off as a result of construction, shall be given warning 7-days prior to the commencement of any work.
- 3 If a private driveway or footway constructed with non-standard materials is to be excavated, the owner of the property concerned must be informed in advance and in writing of the intended work.

## Private Property

- 1 Where possible, excavations on private property shall not be left open outside normal working hours (08:00 to 17:00). Where unavoidable, the Contractor must take adequate precautions to safeguard such excavations.
- 2 The Contractor shall be responsible for the protection of all trees, shrubs, fences, and other landscape items adjacent to or within the work area.
- 3 The occupants of the properties must be kept informed at all times of how their access will be affected.
- 4 When trenching through entrances to properties, access must be maintained by using steel plates or other temporary bridges of ample strength and well secured against movement.
- 5 The Contractor, on completion of backfilling and compaction, shall restore all surfaces disturbed in the execution of his work. Surfaces shall be reinstated to the original state or better.
- 6 Where a Contractor must undertake tree and bush cutting and/or shrub clearing he must prior to undertaking such work, obtain approval in writing from the relevant authority and/or property owner.
- 7 The Contractor shall dispose of all cuttings and cleared material.
- 8 The Contractor shall be solely responsible and accountable to remedy any damages and/or claims, arising due to his activities.
- 9 All drainage systems must be cleared daily.
- 10 In residential areas the reinstatement of paving, grass or landscaping must be done to the property owner's satisfaction.
- 11 Remove all material and equipment not needed onsite, as soon as possible.

## Suggested Trenching Practices (possibly not mentioned elsewhere)

- 1 All excavation work must be performed under the supervision of a responsible person who must be competent to exercise such supervision.
- 2 Proper excavation and preparation of the trench will inhibit unanticipated longitudinal and cross-sectional strains and stresses on the duct.
- 3 Trench walls shall be vertical for at least the height of the bedding and then as vertical as possible.
- 4 Exercise care when trimming trench floors to ensure that they are level.
- 5 The Contractor shall use trenching equipment that is suitable to excavate to the specified width and depth.
- 6 If any street furniture (street names, traffic signs, bus shelters, etc.) have to be moved, arrangements must be made with the relevant authority for the removal, storage and re-erection.
- 7 A victory for common sense is to have a 'good housekeeping' policy.

## Barricading

- 1 To begin with, provide adequate warning, guidance and protection for motorists, pedestrians, cyclists and workers from all foreseeable hazards.
- 2 In high traffic areas, erect fencing or place barriers measuring at least 1,2m in height -as close as possible to the excavation.
- 3 All barricading shall be well supported.
- 4 An additional precaution is to provide clearly visible boundary indicators at night or when visibility is poor.
- 5 Wear high-visibility vests, safety boots and hard hats when working at or near a public street or





highway or when working at night.

- 6 When excavations are in progress next to the road, ensure proper and sufficient warning road signs placed at distances well before and after the work in progress. To warn approaching traffic, a flag person must be placed at least 40m before a “men at work” sign. Approved road cones must be placed at regular intervals along the whole route where trenching is in progress.
- 7 Backfill as soon as possible.

### **Trenching Near Kerbs, Guttering, Paving and Driveway Crossings**

- 1 Where excavations pass beneath kerbs, guttering or driveways, etc., proper support shall be provided for these structures until tunneling and backfilling is completed.
- 2 Where tunneling is not an option, the existing concrete paving shall be neatly cut with an angle grinder to deliver smooth, uniform edges.
- 3 Where ducts are to be laid beneath existing paving blocks, the pavers shall be carefully removed to be reused. Paving blocks must be re-laid on a bedding of sand and reinstated to its original state or better.



### **Road Crossings**

- 1 The contractor shall inform the relevant road authority 48-hours prior to the commencement of the work.
- 2 Directional drilling is the preferred method for crossing roads.
- 3 It is the responsibility of the Contractor to ensure that every law regarding traffic, safety, traffic signs and barricading is complied with.
- 4 The angle of the crossing should be as near a right angle to the road centerline as possible.
- 5 The edge of the trench must be cut using asphalt/concrete cutters to deliver smooth, uniform edges.
- 6 The minimum depth that any service may be placed under a road is 800 mm.
- 7 The duct/s shall extend a distance of at least 0.5m or 1m beyond the edge of the road.
- 8 All excavated material and equipment must be placed and demarcated in such a way to not inconvenience vehicles and pedestrians.
- 9 No person may off-load on a public road, any materials that are likely to cause damage to a road surface.

### **Stream and River Crossings**

- 1 Before any serious thought is given to the installation of a high-density polyethylene (HDPE) duct at a river crossing, the network designer will consult with a geotechnical expert to conduct a comprehensive study.
- 2 This investigation will reveal the most efficient way to accomplish the crossing in question. Horizontal directional drilling (HDD) (discussed later), has become a popular river crossing option, and as explained later, rightfully so.
- 3 The duct must be sealed at both ends to prevent water or dirt ingress.



### **Bridge Crossings**

- 1 This work is typically undertaken by subject matter experts in this field.
- 2 First and foremost, the use of existing service ducts within bridges must be fully explored.
- 3 The contractor shall inform the bridge owner 48-hours prior to the commencement of the work.
- 4 Ducts attached to the underside of bridges must not affect its load bearing capacity, reduce the clearance or cause other issues.
- 4 Not all bridge structures will have the exact same installation configuration and procedures may vary to accommodate your specific requirements.



- 5 The most common method to be used will involve the use of a hydraulically operated crane fitted with a safety basket be positioned adjacent to the bridge balustrade. From this position, workers wearing safety harnesses can be hoisted over the balustrade and lowered into a working position as required.
- 6 Bracket mounting positions can now marked out on the side or underside of the bridge as directed by the design drawings and instructions. Next, drill the holes, fit the concrete anchors and mounting brackets and firmly secure them.
- 7 The steel or ultra-high-density polyvinyl chloride (UPVC) base carrier duct can now be positioned and firmly secured.
- 8 The microducts can then be hauled through the newly mounted base carrier. Use a continuous length of duct (no joints permitted).
- 9 Where required and as stipulated in the design instructions, both the approach and departure ends may have to be encased in concrete where they traverse the bridge abutments and enter the ground. It is desirable of course, for the end-product to be both safe and visually appealing.

### **Trenching Near Power Cables**

- 1 Where no physical barrier exists, no duct or cable shall be laid within a distance of 600mm measured horizontally, nor cross within a distance of 300mm measured vertically from any high voltage power cable.
- 2 Where this separation is compromised, the duct or cable must be separated by concrete slabs.
- 3 The standard protection slab is 900mm x 300mm x 75mm thick. This slab will be reinforced with 3.55mm high tensile wires.



### **Rock Blasting**

- 1 Blasting for excavation shall not be performed without written permission obtained in advance, from the agency having jurisdiction.
- 2 Procedures and methods of blasting shall conform to all local laws and ordinances.
- 3 It is the responsibility of the Contractor to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to blasting.



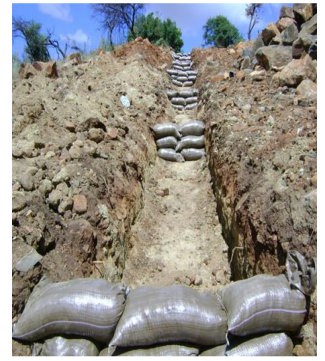
### **Duct Deviation**

- 1 HHs / MHs typically facilitate changes in direction.
- 2 However, ducts may deviate from a straight line provided that:
  - Individual lengths may be offset by no more than 35mm.
  - The offset is in the same direction, this to avoid creating S-bends.
  - The maximum overall deviation between MHs / HHs does not exceed 15°.
- 3 Spacers should be used when placing multiple ducts in a trench. They prevent ducts from twisting over and around each other. By keeping the ducts in straight alignment, cable jetting and/or pulling tensions will be reduced.



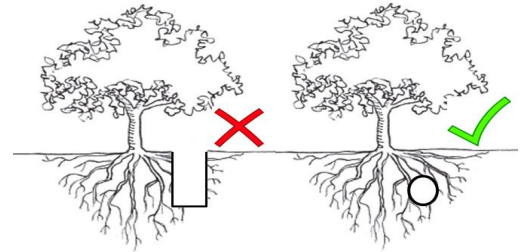
## Steep Gradient Trenching

- 1 Where excavations need to be done on up-hills or declines, a layer of sand bags should be placed at regular intervals (5m apart), to prevent the possible wash away of backfill material.
- 2 Always consider the risks of land stability or earth movement, when trenching on embankments (specialist technical investigation may be required).



## Tree Roots

- 1 Tree roots exposed while trenching must not be cut unless absolutely unavoidable.
- 2 Prior to undertaking tree/bush/shrub clearing/cutting as may be necessary for trenching, approval in writing from the relevant authority and/or property owner needs to be obtained.
- 3 Never cut roots over 25mm in diameter, unless advice has been sought from the local authority.
- 4 Ducts are to be sleeved in a HDPE pipe, if not 100mm away from existing tree roots.



## Surface Material

- 1 Surface material (paving slabs, soil, grass, etc.) must be kept apart by placing them on opposite sides of a trench, where they are least likely to interfere with traffic, pedestrians and drainage systems.
- 2 Mow-able lawn shall be cut in square blocks and put aside and be kept moist until reinstated.
- 3 Where trenches pass through gardens, the contractor shall seek direction from the owner.



## Duct Un-Coiling and Installation Process

- 1 Ducts shall not be un-coiled without the use of a Vertical or Horizontal De-Coiler. De-coilers will prevent twisting, bending or kinking from occurring during the installation process.
- 2 Duct un-coiling can be accomplished by pulling the conduit straight into a trench from a stationary rotating de-coiler or by laying the conduit into the trench from a forward moving de-coiler positioned on a trailer.
- 3 Once the duct coils are secured inside the de-coiler, only then can the containment straps on the duct coil be cut. Next, rotate the de-coiler slowly to unwind the duct out in one plane.
- 4 Generally, the ducts are placed in the trench, one length at a time and joined on the floor of the trench using couplers.
- 5 Ducts shall be laid in a straight line between MH/HHs. It is never ideal to have directional changes, but if unavoidable - keep the bending radius as big as possible and offset is in the same direction.
- 6 As the ducts are laid and jointed, install end caps on ducts at all MH/HHs to prevent water and dust from entering.
- 7 Care shall be taken to ensure that no dirt collects between the duct and coupler to deliver an airtight seal.
- 8 At MHs or HHs where the duct goes straight-through, allow for sufficient slack for the duct to be secured against MH or HH walls.





### Duct Installation - Moving Trailer Method

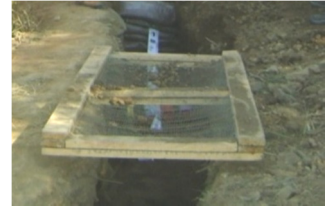
- 1 This method is most efficiently used where the path to be followed does not contain any obstructions that require the duct to be placed under. Move the trailer slowly along the trench route while unwinding and placing the duct in the trench. Take care not to over spin the reel.

### Duct Installation - Pulling Method

- 1 The duct can also be pulled and placed by hand or by a mechanical pulling machine with the help of a Pulling Device that is fitted in-between duct and mechanical pulling machine. The two types of pulling attachment devices most commonly used are a Pulling Grip or Basket Grip.

### Bedding and Padding

- 1 Bedding is the material constituting the even (rake if necessary) floor of an excavated trench onto which ducts are laid.
- 2 It is desirable to pass both bedding and padding through a sieve. The material used for bedding and padding must be of a granular, non-cohesive nature, graded between 0.6 mm and 13 mm, or as per client spec.
- 3 Care shall be taken to place padding material simultaneously on both sides of the duct to prevent lateral movement.
- 4 The compaction of padding shall be executed manually using a hand tamper. Duct buckling is much more probable when the padding material does not provide adequate side support.



### Backfill

- 1 After padding tampering / compaction, backfilling of the trench can be done.
- 2 Material excavated from trenches may be used as backfill, provided that it contains stones no greater than 150mm in diameter, trash, or organic matter that could potentially damage ducts.
- 3 Backfill material is to be installed in layers not exceeding 300 mm, with each layer compacted before the next is added.
- 4 After compacting the first layer of backfill, the warning/marketing tape is placed. Take photos of this procedure as proof of existence.



### Backfilling (Concrete)

- 1 Check the consistency of the concrete (slump test).
- 2 Tamper the concrete using special care not to damage the ducts.
- 3 Check for cavities.
- 4 Allow for the concrete to set - takes 2-3 hours (NOT cure, which takes  $\pm$  28-days).
- 5 As mentioned earlier, concrete backfill turns a once flexible duct into a long unreinforced concrete beam of negligible strength, very likely to fracture with ground movement. This in turn could potentially damage the duct. I ought to point out though, that this view is not shared by everyone.



### Trench Compacting

- 1 Once a poorly compacted layer is in place, it is difficult if not impossible to achieve good compaction in the layers above. This is a key point; a consequence of poor backfill compaction is high % air voids. This potentially makes the duct vulnerable to veld fires.
- 2 Moisture conditioning of the backfill material shall be carried out by the contractor. If not specified by the client, the following Field Tests for Optimum Moisture Content (OMC) can be used:



- 3 A handful of backfill tightly squeezed in the hand, shall be wet enough so that it binds together with no more than slight crumbling when the hand is opened. When well shaken in the hand, it shall not weep water.

In the case of clayey material; roll it into a 2mm in diameter worm and when an attempt is made to bend it, it must break without any obvious effort.

- 4 Manual compaction is performed until the ducts are covered by both a 150mm layer of padding and 300mm of backfill, at which point a vibratory plate compactor can be used.
- 5 The compaction of the final backfill layer shall be by means of a compaction machine and shall be compacted to a density higher than or at least equal to that of the virgin soil parallel to the trench.
- 6 After completion of the backfill, a DCP test must be done. This test must be documented.

### Dynamic Cone Penetrometer (DCP) Testing

- 1 All excavations are subject to compaction tests - which must be documented.
- 2 8 tests per km, is recommended.
- 3 Uses a free-falling 8-kg hammer which strikes a cone, causing the cone to penetrate the soil, and then measuring the penetration per blow, called the penetration rate (PR), in mm/blow.
- 4 Always keep the DCP vertical and watch where you place your fingers.
- 5 The trench density must be better or at least equal to that of the virgin soil parallel to the trench.
- 6 A 25mm PR is typically deemed acceptable.



### Direct-Buried Installations

On paper, direct-bury is fairly simple and very cost-effective - you dig a trench, install the cable and re-instate. However, once in the ground, the cable is perhaps more susceptible to damage from unrelated digging activities than cable in a duct, and much more importantly, it is more difficult to access and repair. In Africa, these issues are greeted with a philosophical shrug.

- 1 On all direct-buried installations, Armored Cable must be deployed - which provides for both crush and rodent protection.
- 2 In general, the most desirable and economical method of cable placement in open or rural areas is ploughing- where there likely to be fewer obstacles to impede the progress of the ploughing equipment. In urban or sub-urban areas where there can be many obstacles such as underground utilities, sidewalks, road crossings etc., trenching by hand has its advantages.
- 3 Should only an armored cable be placed, a trench no wider than 375mm will do.
- 4 The trench shall be 1.2m deep or as stipulated in the wayleave.
- 5 Grade off abrupt changes in terrain ahead of the plough.
- 6 Excavate at least 5m at the starting point, to allow for the plough to immediately lay the cable at the correct depth.



- 7 Always start the plough tractor's movement slowly and increase speed gradually only after the cable slack is taken up from the cable delivery system.
- 8 Ploughing operations must be observed continuously for: obstructions, proper feeding of the cable, specified depth, following of the marked route, and the safety of the crew.
- 9 Stoppages in the plough-in process should only be for the loading of cable or marker tape and when the terrain demands for this.
- 10 Warning Tape must be placed approximately 300mm below the ground surface, directly above the cable.
- 11 It is critically important for MHs and HHs to be built only after the plough in of the cable. Pre-fabricated HHs are often utilized.
- 12 Each section, after ploughed-in, must be checked with an OTDR for possible damage.
- 13 After the plough in process is completed, the trench must be levelled by one of the following methods:
  - Back blading with the plough-in machine.
  - Using a TLB to level the disturbed areas.
- 14 The National Electrical Code (NEC) recommends that non-current carrying armor shields and metallic strength members be bonded and grounded.

### Earthing, Bonding and Surge Protection

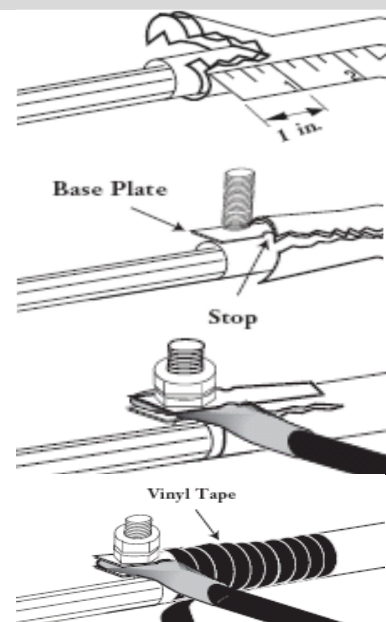
- 1 The armoring of optical fiber cables shall be lugged and bonded to an earth bar using a soft multi-stranded 6mm<sup>2</sup> green / yellow insulated bonding cables. Bonding cables shall be kept as short as practically possible and must contain no sharp bends.
- 2 Proper grounding and bonding is required for the safe and effective dissipation of unwanted electrical current, and it promotes personal and site safety. Typically, optical fiber cables do not carry electrical power, but the metallic components of a conductive cable are capable of transmitting current.
- 3 When the armored cable is correctly bonded and grounded, it minimizes the risk of unwanted electrical current that could potentially harm personnel, property or equipment.
- 4 Required...By electrical codes and equipment manufactures | To protect personnel and equipment

### The difference between the terms bonding and grounding:

- 1 **Bonding** is the multiple connections to metallic parts (at every joint), required to form a continuous electrical path.
- 2 **Grounding** is the act of connecting that path to an earth.

### The Procedure

- 1 Use a cable knife to score the outer sheath of the armored cable approximately 25 mm (1 inch) long. Take care not to damage the inner sheath.
- 2 Slide the base plate under the armor.
- 3 Place the top plate over the base plate and tighten down the lock nut.
- 4 Cover the grounding clamp and split portion of the sheath with vinyl tape and connect to the ground system or bond thru.





## Markers

- 1 Underground routes must be marked with identifiable markers.
- 2 GPS coordinates of all MHs /HHs must be taken and documented to form part of the as-built documents.
- 3 These markers shall have a length of not less than 1.8m and a diameter of not less than 100mm.
- 4 The MH and HH markers shall be planted 600 mm deep, opposite them and be well compacted.
- 5 A passive marker can be buried at key points during construction or used to mark existing facilities.



## Manholes and Handholes

- 1 MHs and HHs shall be positioned as far away as possible from road junctions.
- 2 MHs and HHs must be built according to prescribed dimensions and specifications.
- 3 Before any concrete is placed the Contractor shall examine the shuttering for firmness and correctness of position and remove all dirt and other foreign matter.
- 4 Hand mixing of concrete is permitted in exceptional cases but only with written permission of the client.
- 5 Concrete mix shall be such that a strength of 20MPa (2.5:2.5:1) is obtained 28 days after pouring.
- 6 Duct entry points into HHs / MHs must be drilled, without cracking or damaging the surrounding structure.
- 7 Ducts shall enter and exit HHs / MHs in line with the direction of the route, for them to be coupled thru without any obvious effort, as a continuous duct.
- 8 Ducts must never enter and exit on the same wall.
- 9 HH / MH external labeling should be done on the coping and NOT the lid, as lids can get damaged and be replaced. GPS coordinates must be recorded.
- 10 On completion of a HH / MH, the Contractor shall re-instate the area around the HH / MH to its original state or better.
- 11 HH / MH covers shall be finished flush with the surface area.
- 12 The concrete coping must protrude a little, this to eliminate water entering around the lid.



## Where bricks are used to construct HHs the following must apply:

- Written permission obtained from the client.
- Use only baked quality clay bricks sourced from an approved manufacturer.
- Re-enforce every third layer of bricks.
- The wall thickness must be double brick or better.
- The outer wall must be waterproofed.
- Use an approved footway-type or roadway-type frame and cover.

## HH / MH Inspection

- 1 Splice closures are secured.
- 2 Cable slack neatly stored and secured with no compromise to the bending radius.
- 3 Left tidy and clean.
- 4 Ducts sealed in-between wall.
- 5 End Caps fitted to empty ducts.
- 6 Used ducts sealed in-between cable and duct.
- 7 Cables and ducts are clearly labelled.

- 8 HH / MH clearly marked on the coping.
- 9 Locating disk in position.

### **Handhole Installation**

- 1 All duct entries and exits at the HHs must be a watertight seal.
- 2 All ducts in HHs shall be coupled through.
- 3 Incoming ducts must have a watertight seal.
- 4 Ducts must be sealed with a watertight coupling that is cast or inserted into the wall of the HH
- 5 HH covers must be watertight or must have at least a double seal.
- 6 HH covers should be 150mm above natural ground level with the fill shaped back to natural ground
- 7 level in a 2m radius around the HH cover.
- 8 On paved sidewalks or verges, next to roads or streets, a cast in-situ concrete or asphalt backfilling shall be sloped to not impede pedestrian traffic. In these instances the HH installation shall be such that it is not more than 50mm higher than the surrounding paved sidewalk.
- 9 The inside surface of the HH shall be sealed using an approved bituminous product.

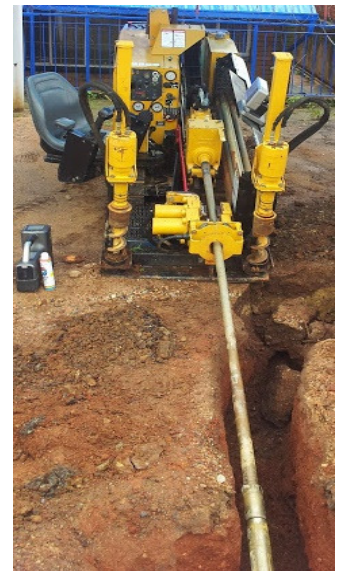
### **Safe HH / MH Working Procedures**

- 1 Obtain a HH / MH entry ref for the work to be undertaken.
- 2 At least 2-persons must be present before entering a MH.
- 3 Ensure that the vehicles are parked in such a manner that they do not create an obstruction or hazard to traffic and/or pedestrians.
- 4 Use barricades and cones that are clearly visible around the HH / MH.
- 5 Pour water around the lid of the HH / MH, to prevent creating a spark when opening it.
- 6 Lift HH / MH covers using your legs and place the cover at least 2m away from the opening.
- 7 Before entering the confined space, test at 3-levels (bottom, middle, and top) for:
  - Oxygen content
  - Flammable or explosive gases
  - Hydrogen sulphide
  - Each level must be tested for a minimum of 60 seconds.
  - Use only an approved calibrated gas detector.
- 8 Ensure that the gas detector is in operation the entire time spent in the MH.
- 9 An aluminum ladder in good operating condition must be used to enter the MH.
- 10 Raise or lower tools and/or equipment into a MH using a rope or bucket.
- 11 Never place equipment or tools near the edge of a HH / MH.
- 12 Constant ventilation is required when performing work within a MH.
- 13 Water in a MH (not containing object-able content) shall be pumped-out into the storm water system. If not possible, or onto area, a suitable distance away, with positive drainage.
- 14 Never fusion splice in a HH or MH.

## Trenchless Methods

### Horizontal Directional Drilling (HDD)

- 1 In very simple terms, HDD is a drilling process where a drill head is steered underground. This method is adopted by all companies but habitually, sub-contracted to specialists.
- 2 HDD is the preferred method to cross roads, highways, railway lines, rivers and all other services that may prove to be too dangerous or costly to cross using conventional methods like trenching and/or ploughing.
- 3 The depth of any hole drilled for the installation of a new service, must be at least 800mm below surface of the road, or as per client spec.
- 4 In what follows, a brief overview on the 3 installation stages:
  - I. Pilot drilling
  - II. Reaming the initial pilot hole
  - III. Pulling back the duct in the reamed hole
- 5 The course of the drill is monitored and can be controlled as rods progress following an upward sloping path, before emerging at an intended point.
- 6 The drill head is then removed and replaced with a back reamer,  $\pm 20\%$  larger than the duct or cable to be pulled into the hole.



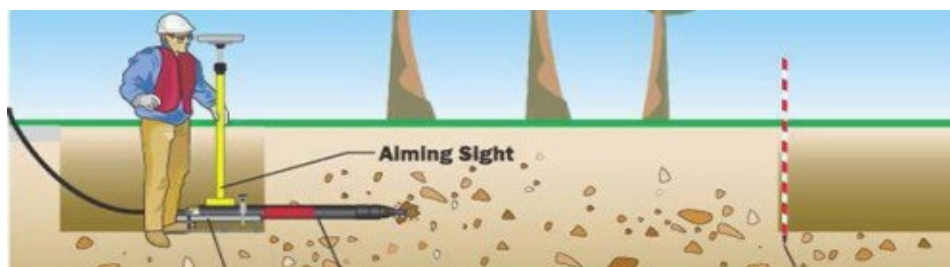
The duct is attached to a swivel connection on the back reamer. The drill-rods and reamer are rotated and pulled through the hole, enlarging it and pulling-in the duct at the same time.

The whole operation is carried out with pressurized drilling mud, which both carries away the spoil and supports the hole.

- 7 Rigs capable of drilling up to 300 meters in one drill are available and various sizes of ducts can be installed with this equipment.
- 8 The covering must not be less than three times the final diameter of the drilling hole and at a minimum of 1.5m.
- 9 At river crossings the distance between the bottom of the water and the drilling hole should be 10-times the diameter of the pipe and not less than 3m.
- 10 Soil removal during the drilling process is the responsibility of the contractor.
- 11 If the accuracy of the drilling is not specified in the wayleave, the area in which the drilling may wander should not exceed a 40mm diameter around the predetermined axis.
- 12 As always, the location and depth of underground services must be pre-determined before drilling can commence - as sudden deviations are not possible to bypass obstacles.

### Hammerhead Mole

- 1 Hammerhead Moles provide a cost effective alternative to HDD (sometimes referred to as mini-HDD). They are apparently easy to use, simultaneously boring and installing a duct.
- 2 To begin with, both an entrance and exit trench or hole must be dug at the allocated positions.
- 3 The Hammerhead Mole is then inserted into the abovementioned hole in the direction of boring and the boring process commences. A duct-pulling attachment allows for the duct to be installed at the same time the bore is made.





## Reinstatements

- 1 Reinstatement work must be done by The Roads & Storm Water Department unless a wayleave indicates otherwise.
- 2 Should the wayleave holder do the permanent reinstatement, a 12-month guarantee period commences from the date of completion.  
OR  
Should the wayleave holder do a temporary reinstatement, a 2-week maintenance period commences from the date of completion.
- 3 Grassed areas shall be reinstated using the original turf, replacement turf or an equivalent seed.
- 4 Any constructed footway must be reinstated with the same surfacing materials that existed originally (e.g. concrete blocks, slabs, etc.). Material may be reused if undamaged, or else replaced with similar material.
- 5 Remedial work will be required if any of the following defects exists: depressions (resulting in standing water), humps (crowning), edge depression or cracking.
- 6 The performance of any trench permanently reinstated by the authorized person will be monitored for twelve (12) months, during which period the authorized person will be held responsible for any remedial work that may be required.
- 7 Any excavation left unattended for a period of more than 5-days can be made safe by the road authority and charged to the contractor.



## Road Reinstatement

- 1 The permanent reinstatement of the surfacing typically consists of 100 mm hot-mix asphalt. The lower 70 mm must be compacted and rolled asphaltic black base (26.5 mm nominal stone size, continuously graded) and the top 30 mm (4.75 mm nominal stone size, continuously graded). Cold-mix may be used only for temporary reinstatement.
- 2 The reinstated surfacing must be at least 100 mm wider than the trench on both sides to accommodate any edge breaks.
- 3 On completion of the work concerned the authorized person must fill in a completion notice and return it to the road authority within twenty-four (24) hours.
- 4 The road authority will then arrange a site meeting to do an inspection and to issue a certificate of completion if all requirements have been met.
- 5 A twelve (12) month guarantee period for permanent reinstatement by the wayleave holder, or the fourteen (14) day maintenance period for temporary reinstatement by the authorized person, commences on the day after the issue of the certificate of completion.
- 6 Rubbish, and other objectionable material of any kind, must be legally disposed of, absolving the client from any liability connected therewith.

## Cable Pre-installation Procedures

The following items are key considerations:

### Pre-test with an Optical Time-Domain Reflectometer (OTDR)

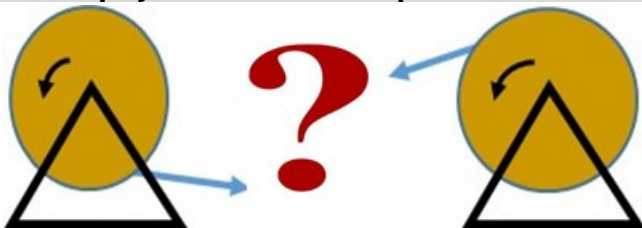
- 1 All optical fiber cables must be tested while on the drum, prior to deployment. A Bullet or Divot Bare Fibre Adapter is to be used to connect fibers to the OTDR.
- 2 Testing shall be done on all fiber's in one direction at 1550nm, using a pulse width of 30ns. Traces must be stored and an electronic copy submitted to the project manager.
- 3 Should a cable be installed without an OTDR pre-test, the smart money is on the supplier not accepting a return on a faulty cable. This is because a supplier can claim that the installer assumed liability upon installation (i.e. responsible for the damage).



### Pre-installation Cable Inspection

- 1 Always wear protective gloves and safety boots (with steel toe caps) when handling drums.
- 2 Check that the cable specified has been procured.
- 3 Inspect the cable drum for signs of excessive weathering and/or damage.
- 4 Drums must be transported or stored with their battens intact.
- 5 Do not accept delivery of an optical fiber cable should the drum is damaged.
- 6 The plastic foil wrap must remain in place until cable placement.
- 7 When removing the plastic foil wrap on the cable, do not use sharp tools that could potentially damage the cable jacket.
- 8 Ensure that the cable drum bolts are all tightened.
- 9 Verify that nails, bolts or screws on the inside surface of drum flanges are counter-sunk to avoid damage to the cable during placement.
- 10 Place the cable drum in line with the intended direction of deployment, in order to prevent the cable from rubbing against the reel flange.
- 11 Cable ends must always be sealed – using pre-formed or heat shrinkable end caps. Using tape for sealing cable ends is considered unsuitable.
- 12 Should the drum be rolled for some reason, always do so following the direction of the arrow.
- 13 Drums on site, must be chocked to prevent them from moving or rolling.

### Cable pay-off - over the top or from the bottom? "Oh, oh, I know".



- Jetting / blowing cable
- Hauling cable
- Figure-eighting cable
- Erecting cable

As for me, over the top makes much more sense. However, advocates of from the bottom, when jetting / blowing cable do exist. This simply reinforces our conviction that ultimately, faced with this choice, a Contractor must determine which option is favored by the Client.

## Introduction to Air-Assisted Installations

Few (if any) would dispute that the foundation of the value proposition associated with blown fiber systems, is the low cost fiber upgrade capability it offers i.e. adding fiber cables to unused micro-tubes.

**Jetting** and **blowing** are two probable air-assisted cable installation techniques. Both methods require pushing the cable with a tractor mechanism while blowing compressed air into a preinstalled duct along the cable being installed. Both rely on air flow to help “float” the cable inside the duct and as a result, minimizing sidewall pressures and reducing friction between the cable and the duct.

When jetting or blowing, you're combining a pulling force (compressed air) with a pushing force (hydraulically or pneumatically driven tracks) during the installation, providing an efficient, stress-free deployment in far greater increments than possible when hauling cable.

Jetting and blowing differ in how pulling force is applied to the cable. Jetting uses a missile at the front end of the cable. A differential pressure across the missile head creates a pulling force on the cable. Blowing does not use a missile - instead, the pulling force on the cable is due to fluid drag of air rushing along the cable - this pulling force is distributed along the cable length. A mechanical pushing device is common in both methods.



It is common wisdom that hydraulics can give you higher forces than pneumatics. Mindful of this, a blowing machine with a pneumatic drive is recommended for cables up to 15mm in diameter and a blowing machine with a hydraulic drive is recommended for cables with a diameter in the range from 14 - 32mm.

The key parameters when installing fiber cable in ducts are blowing distance and time. 1000 to 2000m is a typical blowing length. Typical installation speeds are 40-50 meters per minute under an air pressure of 10 bars. Most routes can be blown with a 10 bar supply.

Smaller diameter and lower weight cables make possible larger blowing distances. The maximum cable push force will decrease as the duct inside diameter increases, reducing the achievable blowing distances.

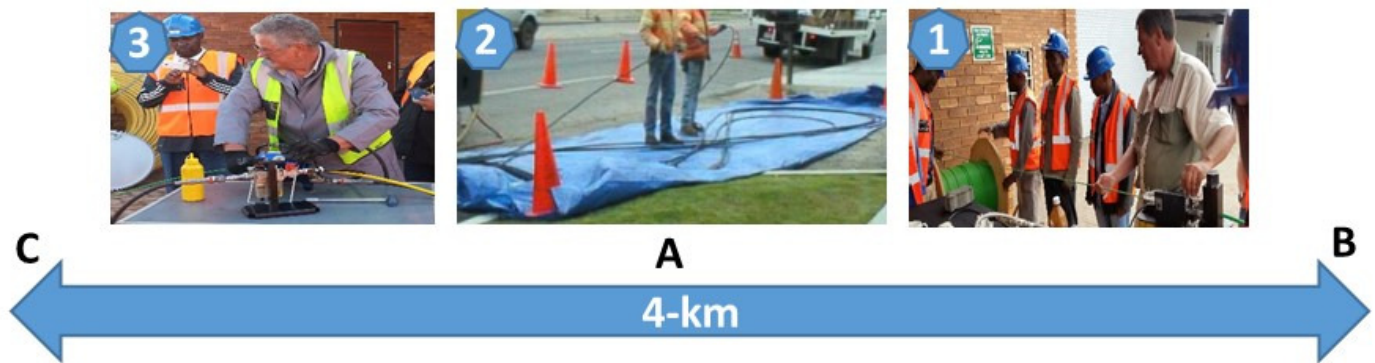
### Survey the complete route prior to blowing in order to determine:

- 1 The location of HHs / MHs.
- 2 Determine distances between HH and MHs.
- 3 Determine where coupling of ducts are necessary.
- 4 Accessibility of terrain for the use of the intermediate (mid-point) fiber blowing equipment.
- 5 Identify specified ducts to be utilized.
- 6 Be sure to consider the accessibility of HHs / MHs to the splicing vehicles.

### Jetting / Blowing the right cable

- 1 Choosing the right cable is extremely important for any installation. Strictly speaking, the purpose of the cable is to protect the fibers during installation and the service lifetime. Cables share some but not all characteristics and you need to ensure you install the cable type appropriate for the application.
- 2 Micro cables are designed with high-density polyethylene (HDPE) outer sheaths to minimize friction with the inner surface of micro ducts. They are also designed with the necessary stiffness properties to resist buckling forces and to negotiate changes in direction.
- 3 The cable on the drum must be covered until just prior to installation to protect the jacket from exposure to the sun.

## Suggested Air-Assisted Installation Practices



Cable drums are typically supplied containing 4-km of cable. Mindful of this, drums are placed midway of a 4-km length. There's plenty of evidence suggesting that the most efficient cable installation would involve two 2-km jetting shots (A to B followed by A to C). After jetting A to B, a 'figure-8' will be created at the midway point, to gain access to the end point of the cable previously on the drum. Next, the figure-8 end will be jetted in the other direction. This figure-8 puts a half twist in on one side of the 8 and takes it out on the other, preventing twists.

With a little bit of good fortune, we ought to be able to install 4-km of cable in one placement of the cable drum and blowing equipment... consisting of; 2-km of cable jetting - 2-km of "figure-eighting" - concluded with 2-km of cable jetting. If so, great. But wait, what if at some point the cable movement slows down during the blowing process - then instead of taking a 2-km shot, the jetting shot could for example, be reduced to only 1-km. This of course, would call for a second 'figure-8' to be made at the 1-km mark. Jetting machine settings such as air pressure, flow rates, speed, grip wheel tension etc. will be determined and provided by the blowing equipment supplier.

## Duct Integrity Testing (DIT)

All team members **MUST** wear eye protection during DIT testing as small particles can be blown out of ducts through the holes in the DIT catcher.

### 1 Air Test

- Fit a DIT catcher on the far side and equip personnel with two-way radios.
- Allow the air to flow through duct for at least one minute, to remove all loose particles and/or moisture.
- Now proceed with the sponge test.

### 2 Foam Sponge Test - cleaning the duct:

- A sponge is typically 100mm in length and 2 x the duct ID.
- Wet the sponge slightly with blowing lubricant.
- Place the tight-fitting foam sponge inside the microduct.
- At a pressure of 10bars, blow the sponge through the microduct.
- If excess water or dirt exits the microduct, repeat the process.
- Have a DIT catcher in place at the far end to catch the sponge when it emerges.



### 3 Mandrill Test - check for bends, kinks or blockages:

- The sponge test **MUST** precede this test - a mandrill can damage a dirty duct.
- Use a 40mm long mandrill made from Nylon or Teflon.
- The OD must be no more than 85% of the microduct ID
- At the receiving end, a DIT catcher must be used.
- Note that a flying shuttle can cause injury and/or damage!
- Always inspect the condition of the emerged mandrill, visible grooves is an indication of duct indents.

### 4 Pressure Test - check for coupler leaks or microduct punctures:



- Fit a high-pressure end-cap to the duct under test on the far-side.
  - Gradually build the pressure up to 10 bars.
  - Test all coupling used for this test for leaks, using soap, water and a sponge.
  - Connect the air feed and leave this open until the pressure in duct stabilizes at 10 bars.
  - Close the air valve on the test assembly and monitor the pressure gauge for 5min.
  - Losing 1 bar in 5min is acceptable – any leak greater than that, must be found and fixed.
- 5 If the duct fails DIT tests, consult with the relevant authority on whether to use an alternative duct or to repair of the designated duct.

### Micro Duct Fill Ratio

- 1 For optimum jetting / blowing performance, ensure that your cable-to-duct diameter fill ratio does not exceed 76%. This is determined and provided by the microduct supplier. It is wise to always verify this by checking the provided spec sheet.

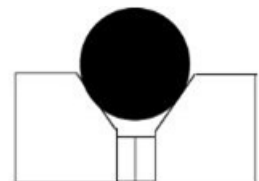
### Cable Blowing Lubricants

- 1 Adding a small amount of lubricant to a tight-fitting foam carrier (sponge) before blowing it through the duct, will provide an open and lubricated pathway. It is argued to give better results compared to coating both the duct and cable with lubricant. Odd, huh? Let me try to explain. Lubricant on a cable jacket apparently makes it too "slippery" for optimal laminar-flow jetting.
- 2 Let's not forget that the air "pushes" on the jacket through friction. A too low friction jacket will not easily be pushed with air. Normally, as little as 0.25 liter of lubricant is required to coat 2km of cable.



### Suggested Air-Assisted Installation Practices

- 1 It is desirable to blow downhill wherever possible.
- 2 DIT results must be available prior to blowing the cable.
- 3 Always measure the cable diameter before jetting, to select the correct spacers. The cable must lie snug in the V-groove between the drive rollers.
- 4 To ensure that the cable is not prone to slipping, push and pull the cable through the machine by hand a few times to ensure that the cable is seated properly in the drive rollers.
- 5 The cable must always enter the jetting machine under no tension and in a straight line.
- 6 The cable must be clean as it enters the blowing equipment to allow for effective gripping of the driving wheels. Contamination of the cable will cause unwanted friction and result in a reduced blowing distance.



Spacers used



- 7 Monitor the speed and torque of the blowing machine as the cable is blown to ensure that the cable jacket is not damaged by the driving wheels.
- 8 One person must control the cable reel and be prepared for emergency stops.
- 9 Always note the meter reading on the cable and zero the blowing machine distance meter, prior to blowing.
- 10 Always establish two-way communication during the fiber deployment process at crucial points along

the cable route.

- 11 The blowing machine should have an automatic shut-off feature that controls the push force applied to the cable. With this feature, cable and duct damage can be prevented should the cable stop abruptly within the micro duct.
- 12 Ensure that when connecting the transportation duct to the blowing machine, it is not entangled with the new or existing cable/s.
- 13 The 'figure-8' must be laid on a ground sheet and care must be taken to ensure that the cable does not touch the ground as it is fed into the machine.
- 14 To protect the end of the cable and also to guide the cable along its desired route, a bullet must be used.
- 15 As mentioned, blowing lubricant reduces the frictional drag on both cable and in the duct thus increasing the achievable distance.
- 16 To ensure that the blowing equipment remains in good working condition - after a week of continuous blowing - machine maintenance must be performed.

### Management of Cable Slack

- 1 When handling cable, always wear; a protective overall, gloves and safety boots.
- 2 Never exceed the recommended cable bend radius:  
**10 x Cable OD - No Tension** (installed)  
**20 x Cable OD -Under Tension**(being installed)

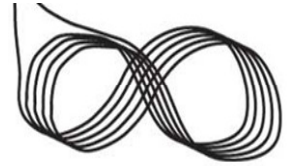


- 3 What is the minimum bend radius of your microducts?  
There is a simple formula:  $\text{Radius min} = 10 \times \text{OD}$   
Therefore, if you have microduct has a OD of 10mm, your Radius min =100mm
- 4 A total length of 17m (15m for slack and 2m for splicing) of cable slack is traditionally required in a HH or MH housing a splice enclosure. Be sure to consider the accessibility of HHs / MHs to splicing vehicles.
- 5 Install slack brackets on HH / MH walls to secure cables.
- 6 The slack in the HH or MH needs to be tied together using a tie wrap or PVC tape at 1m intervals.
- 7 The fiber cable slack inside the HH / MH must be coiled in a 'clock-wise' direction with minimal back tension.
- 8 Ensure that the slack of one splice closure does not become inter-twined with the slack of other splice closures in the HH / MH.
- 9 Bundle cables together in groups of relevance.
- 10 Do not route cables in such a manner that they block ducts.
- 11 Used ducts must be sealed between cable and duct.
- 12 Cable slack typically adds 2% to the overall distance. Thus a 100-km link is likely to contain as much as  $\pm 102$  Km's of cable.



## Figure-eighting

- 1 The preferred size of a figure-8 is about 5m in length, with each loop about 2.5m in diameter. To start with, set up two traffic cones 5m apart – then pay the cable off the top of the reel and loosely weave it around the cones in a figure-8 pattern - on top of a groundsheet. Large relaxed loops will help prevent the cable from becoming entangled.
- 2 Continue to figure-8 the cable until the remainder of the reel is played off.
- 3 In order to pull from the figure-8 - it is necessary to flip it over, a task that requires a minimum of three people -one at the center and one at each end. The required cable end will now be at the top of the figure-8.



## Micro Duct Tools and Accessories

### Tools

Ensure that installers are fully educated on the proper use and operation of any tool before starting a job.

It is essential to always use the prescribed cutting tools to produce a clean and straight cut to a microduct, before inserting a coupler.



### Bullet

Fixed to the end of the fiber cable before blowing starts, to guide the cable through the microduct.



### Sponge

Used for removing dirt and/or moisture from a microduct.



### Shuttle

Used to check the microduct for bends, kinks or blockages.



### Caps & Plugs

Used for the permanent or temporarily sealing of unused microducts to prevent water and dust from getting in.

Use only the prescribed connectors and end-plugs.



### Couplers

Used for the air-tight coupling of microducts.



### De-bur Tool

Allows for one to round-off a microduct after cutting - before adding a coupler-this will produce an air-tight connection.



### Locking Tool

Used to firmly lock the microduct into a connector.



### Cable Carriers

Parachutes capture the air within a duct, tugging along with it the cable. In the absence of air pressure, they collapse allowing for easy pullback. An alternative is to use an Inflatable Carrier.



## Aerial Works

Deploying fiber above ground removes the need for digging and particularly useful when the ground is undulating, rocky or both - and has become an increasingly popular option in both urban and rural environments.

Fibre in a duct solutions have a major aesthetic advantage - this because once installed, they are invisible, leaving no mark on the landscape. However, there are a number of reasons for choosing an aerial solution, such as:

- Aerial fibers are typically much faster and cheaper to deploy than buried networks.
- The planned route may be undulating, rocky or both, making digging less appealing.
- All-Dielectric Self Supporting (ADSS) cables can be erected in close proximity to power transmission lines. This of course, allows for pole sharing, which of course, reduces installation costs and speeds-up deployment.

## Cable Jacket Coloring

- Polyethylene (PE) is the material of choice for use as an aerial OSP cable jacket.
- The performance of raw PE can degrade rapidly through exposure to Sunlight - Carbon Black absorbs the UV light and subsequently dissipating this energy as harmless heat.
- Jacket colors other than black are used for enhancing identification only.



## Pole Handling PPE

- 1 Safety boots with steel caps.  
Protective clothing with long sleeves.  
Shoulder pads.  
Gloves.  
Hardhat.

## Transportation of Poles

- 1 Poles must never exceed the 0.5m vehicle overhang and must have a red flag secured on the overhanging end.
- 2 Poles that are loaded onto a pole carrier must be secured to ensure that the cargo does not move while it is in transit.

## Pole Off-Loading Procedure

- 1 Ensure that the removal of any one pole will not cause shifting or rolling of any of the remaining poles.
- 2 Step 1: Unfasten the poles.  
Step 2: Slide one pole at a time towards the rear end of the vehicle.  
Step 3: When the pole reaches its equilibrium point, the persons on the vehicle must raise their end slowly.  
Step 4: The persons on the ground slowly pull the pole until 1m of it is left on the back of the vehicle bed.  
Step 5: The persons on the ground receive the pole and gently place it on the ground.
- 3 A pole must never be dropped on the ground, as this could damage the pole and/or cause injury to team members.

## **Pole Handling Ratios**

- 1 7mpole =4 people
- 8m pole =6 people
- 9m pole = 8 people or a mechanical aid
- 10m pole = mechanical aid.
- 11m + pole = mechanical aid

## **Climbing Ladders**

- 1 Keep hands free of tools or materials when climbing or descending a pole or ladder.
- 2 Workers climbing up or down ladders must always face the ladder and maintain a 3-point contact. This effectively means that 2-hands and 1-foot or 2-feet and 1-hand must be on the ladder at all times.
- 3 Ladder must be positioned correctly (1-4 ratio).
- 4 Ladder must be properly secured (lashed and held).
- 5 Ladder must be in a good condition.
- 6 The ladder must suit the application.
- 7 A worker must be correctly positioned on the ladder.
- 8 A safety harness must be worn and secured to the pole once the working position is reached.
- 9 Never climb intermediate poles if the span they support is being placed under tension.

## **Survey**

- 1 Survey rods must be planted in line at selected pole positions so that, when erected, the poles will be in a straight line.
- 2 A spirit level must be used to verify that there is no lean to the rods.
- 3 As the survey advances, the rear rods used for lining up - will be withdrawn and survey pegs driven into the ground in the exact position previously occupied by the survey rod.
- 4 The location of the poles to be erected along roads shall be in accordance with the way leave drawings and conditions stipulated by the authorities concerned.
- 5 Square wooden pegs shall be used to mark the position of every pole, stay or strut.
- 6 The numbering (or other details) and marking of the wooden pegs shall be done as agreed upon by both the client and contractor.
- 7 The tops of pegs that show the positions of angle poles must be marked with blue lumber crayon crosses.
- 8 A survey peg for a strut position must show the approximate spread of the strut.



## **Survey Equipment and Tools**

- 1 Digital camera spare batteries.
- 2 GPS with tracking function and spare batteries.
- 3 DCP tester.
- 4 Tape measure.
- 5 Measuring wheel.
- 6 Survey pegs and hammer
- 7 Road cones.
- 8 Clip board, survey sheet/note book and stationary.
- 9 Construction vehicle – with signage and an orange light mounted on the rooftop.
- 10 Road map and/or proposed route detail drawing/s from the client.
- 11 Reflector jacket.
- 12 Personal Identification.

## **Survey - Gather Route Information**

- 1 The information on this route must accurately indicate distances.
- 2 Take photos of all obstacles on the route (existing services, bridge crossings, rocky areas, buildings, built-up areas, paved/tarred areas, wetlands, overhead obstacles, etc.).
- 3 Identify all obvious landmarks where the route changes direction (take photos).
- 4 Note down any road repair work necessary - record distances and GPS coordinates.
- 5 Provide for a series of DCP test readings along the route and document the exact positions.
- 6 Description of the topography along the route (sloping, edge of cliff, adjacent to lake, forest surroundings, rivers, swampy areas, etc.) - record distances and GPS coordinates.
- 7 Description of the ground condition along the route and distances (rocky, sandy, grassy, clay, etc.) - record distances and GPS coordinates.
- 8 Indicate the distance to the nearest town, where the civil works material (sand, cement, stone, water, tools, etc.) can be sourced from.
- 9 Locate possible warehouse/camp sites where material can safely be stored.
- 10 Indicate the availability of hospitals / clinics / police stations along the route - in case required during operational activities.
- 11 Plan the route to allow for projected road or rail deviations.
- 12 Double-check recorded details on the return journey.

## **Pre-Install Meeting**

A pre-install meeting or meetings must be held to discuss the survey results, the optimum pulling sites, span lengths, installation equipment and hardware requirements, logistics, splice locations, terrain and other vital installation topics.

## **Checks to be undertaken prior to commencing with the planned aerial work**

- 1 Does the contractor have approved aerial route drawings, signed by the client?
- 2 Do the drawings show the alignment of the aerial route within the wayleave specification?
- 3 Are the wayleaves in place? (copies must be kept on site at all times).
- 4 Have the locations of existing services been marked and shown on drawings?
- 5 Are the aerial route drawings being marked indicated on which side of existing road/pathway to stay?
- 6 Has the accessibility of poles to splicing vehicles been considered?
- 7 Does the cable have a UV resistant cable jacket?

## **Wooden pole inspection (prior to planting)**

- 1 Correct type of pole supplied? (length and thickness)
- 2 Excessively bent or cracked poles should never be used. Horizontal cracks perpendicular to the grain of the wood may weaken the pole. One large knot or several smaller ones at the same height on the pole may be evidence of a weak point on the pole.
- 3 Inspect the pole for evidence of termites or ants.
- 4 Ensure that all poles are fitted with 'end plates' and strapping at both ends.
- 5 The poles should never be off loaded and stacked on the ground for long periods as this could cause damage to the poles as well as the environment.
- 6 Hammer Test (existing poles): Rap the pole sharply with a hammer weighing about 1kg, starting near the ground line – then continue upwards around the pole to a height of approximately 1.5m. The hammer will produce a clear sound and rebound sharply when striking sound wood. Decayed areas will be indicated by a dull sound or a less pronounced hammer rebound.

## Hole-digging Tools

- 1 The tools provided for hole-digging include picks, shovels, earth augers, crowbars, drills and sledge hammers. The tools to be used for any particular work are determined predominantly by soil conditions.
- 2 On large projects and wherever ground conditions permit, hydraulically powered Earth Augers can be used. It looks much like a corkscrew and produces extremely clean holes.



## Pole Holes

- 1 All excavations for pole holes will be such that the survey peg indicates the center of the hole.
- 2 If the holes are too large, the soil will be unnecessarily disturbed and the poles will not be supported by solid earth. (A diameter of approximately 400mm is recommended).
- 3 Where a hole is dug on sloping ground, the depth of the hole shall be measured from the lowest point on the ground surface.
- 4 In extreme rocky conditions where holes cannot be excavated to the specified depth, an arrangement between contractor and client can be reached for poles to be set in concrete.

Length of Poles	Plant Depth
6m and shorter	0.9m
7m to 8m	1.2m
9m and longer	1.5m

## Poles set in Concrete

- 1 Where poles are planted in soil that is difficult to compact, such as sand and swampy areas and in extreme rocky conditions, the poles can be cast in concrete.
- 2 Only new wooden poles can be set in concrete.
- 3 The hole must be circular in shape. The hole diameter must be kept to a minimum, but be sufficiently wide to accommodate at least 85mm of concrete between the sides of the pole and the undisturbed ground.
- 4 The concrete to be used must be made from a mixture of 1 part cement, three parts sand and three parts crushed stone (1:3:3 mix - 15MPa).
- 5 Concrete must not be compacted around the poles, but thoroughly tamped around the pole with a suitable wooden stick, until the hole is filled.
- 6 The bottom of the pole must be allowed to “breathe” – therefore, backfill with 10cm of soil before pouring concrete.



## Pole Spacing

- 1 It is advisable to maintain a uniform span length and depart from this only when it is rendered necessary by conditions such as: (1) uneven ground (2) sharp bends (3) or to avoid dangerous positions. This may necessitate the planting of additional poles or omitting of poles.
- 2 Steel measuring wires for standard span lengths should be made up locally. When the length of span has been chosen the appropriate wire should be used to determine the distance between successive poles. A steel tape measure should be used for checking the length of the measuring wire daily during the survey.

### Local ADSS Span Lengths

Type of route	(m)
Short span	83
Medium span	250
Long span	500



## Pole Planting Process

- 1 Ensure that all holes necessary for pole dressing are drilled prior to erection.
- 2 A pole should be erected by laying it on the ground in such a position that by raising the top section,
- 3 the base should slide into the hole.
- 4 Backfilling and ramming must take place in 300mm intervals.
- 5 Where stones are available they should be used to stiffen the holding.
- 6 During the backfill and ramming process, always ensure that pole plumbness is maintained.

## Suggested Pole Planting Work Practices

- 1 Avoid dongas, culverts, drains or water channels.
- 2 Avoid obstructing private roads and entrances.
- 3 Restrict road crossings to a bare minimum, and if possible, stick to the same side of the road throughout.
- 4 Avoid trees and where not possible, select a position which will minimize interference from trees – even at the expense of construction costs being increased slightly by this action.
- 5 Along national and other proclaimed roads the poles and stays should be located in the position agreed to by the Road Authority and as indicated on the wayleave.
- 6 Keep the route as far away as practically possible from power lines.
- 7 Where the ground is very soft, poles may be planted 300mm deeper than specified, but only if the necessary vertical clearance is maintained.
- 8 Ensure that all holes necessary for pole dressing are drilled prior to erection.
- 9 Maintain a distance of at least 1m from trig beacons and stations.
- 10 The principle to be followed in all cases is that neither stays nor poles are to be planted where they are likely to cause obstruction or to be dangerous to users of the road, or where they are likely to interfere with ordinary road maintenance such as the clearing and trimming of the edges of the road or the cutting of drains, gutters, etc.
- 11 In railway reserves, the poles should be located as close as possible to the boundary fence.

## Types of Stays

### Terminal stays

Provided where the route starts and ends. This stay must be on the side of the pole opposite to the direction of the cable route.

### Line stays

Installed at every 13<sup>th</sup> pole along the route or spaced alternatively as per specification. Line stays must be installed on poles either side of rivers and road crossings where normal span lengths are exceeded.

### Angle stays

Used to counter-act a change in direction of the cable route by more than 15° or as per client specs.

### Wind stays

Used to stabilize a cable route against wind. Fitted at 90° against the direction of the cable route and on either side of a pole.

### Stay Guards

Stay guards (225mm wide painted black and white bands) must be fitted on all stays, potentially exposed to pedestrians and/or vehicles.

### Struts

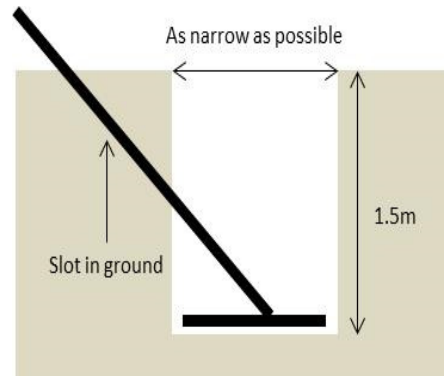
Struts can be used as an alternative to where stays create traffic hazards, block roads or where a property owner objects to the fitting of a stay.

Struts must be installed on the opposite side of the pole to where the angle stay would have been fitted, to counter-act cable strain.



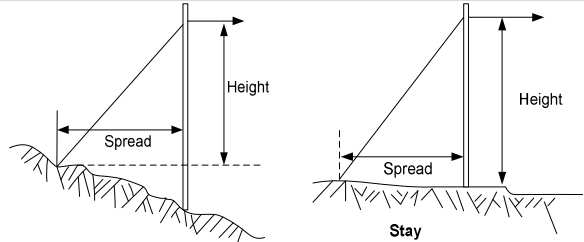
## Stay Holes

- 1 The cross-section of the hole shall be confined to the smallest size necessary to accommodate a stay plate.
- 2 The depth of stay holes shall be 1.5 meters or at such a depth where the unthreaded portion of the stay rod protrudes by no more than 25mm above ground level.
- 3 Stay rods without plates may be used where solid rock is encountered. The stay rod is now inserted in a hole drilled into the rock and secured with cement.
- 4 In difficult to dig ground conditions shallower holes are allowed subject to approval and shall then be backfilled using concrete.



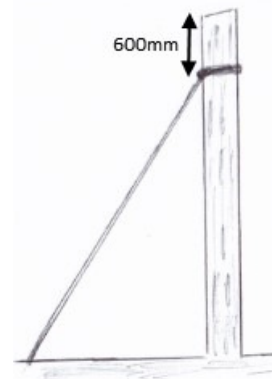
## Spread/Height Ratio

- 1 The spread is the distance from the foot of the pole to the point to where the stay enters the ground.
- 2 The height is the distance from the ground to the pole attachment.
- 3 Wind stays shall have a spread/height ratio of 0.6:1
- 4 Terminal and line stays has a spread/height ratio of 1:1

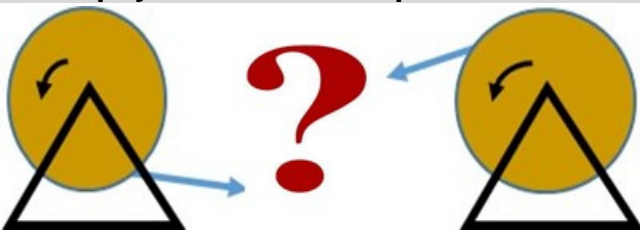


## Termination of Stay Wire to Pole or Crosshead

- 1 Wrap the top pre-formed "make-off" without overlapping around the pole twice at the prescribed height with ends meeting.
- 2 Twist the top of the preformed "make-off" around the stay wire.
- 3 Cut the stay wire at the correct length to ensure that the proper spread/height ratio is maintained.
- 4 Place the bottom of the preformed "make-off" through the crosshead eye.
- 5 Then pull tight and cut the suspension wire in line with the crosshead and twist the bottom preformed "make-off" around the stay wire (ensure that the crosshead is threaded to the outer most of the stay rod).



## Cable pay-off - over the top or from the bottom?



- Jetting / blowing cable
- Hauling cable
- Figure-eighting cable
- Erecting cable

As for me, over the top makes much more sense. However, advocates of from the bottom, when jetting / blowing cable do exist. This simply reinforces our conviction that ultimately, faced with this choice, a Contractor must determine which option is favored by the Client.

## Pre-Installation Cable Drum Inspection

- Always wear hardhats, gloves and safety boots (with steel toe caps).
- Check that the cable specified, has been procured.
- Inspect the cable drum for signs of excessive weathering and/or damage.
- Drums must be transported or stored with their battens intact.
- Never accept delivery of a cable should the drum is damaged.
- Plastic foil wrap must remain in place until cable placement.
- To remove plastic foil wrap on a cable, do not use sharp tools.
- Ensure that all cable drum bolts are all tightened.
- Verify that nails, bolts or screws on the inside surface of drum flanges are counter-sunk to avoid damage to the cable during placement.
- Place the cable drum in line with the intended direction of deployment, to prevent reel flange-cable rubbing.
- Cable ends must always be sealed - using pre-formed or heat shrinkable end caps.
- Using tape for sealing cable ends is considered unsuitable.
- Always roll the drum following the direction of the arrow.
- Drums must be chocked to prevent them from moving or rolling.

## OTDR Pre-Test

- It is vital that an OTDR is used to test all fiber's before the installation begins.
- Testing shall be done on all fiber's in one direction at 1550nm, using a pulse width of 30ns.
- Traces will be stored and an electronic copy submitted to the client.
- Should a cable be installed without an OTDR pre-test - a supplier can claim that the installer assumed liability upon installation.



## Aerial Cable All-Dielectric Self-Supporting (ADSS) Installation

To be cost-effective aerial deployments require access to existing poles, which may be restricted or need to be strengthened. Self-supporting aerial cables are reinforced with internal strength members to support their own weight.

### 2 ADSS Installation Methods

#### 1. Installation Process (Conventional Method)

- 1 To start with, a UV resistant cable jacket is required for all aerial applications.
- 2 Orientate the drum so that the natural payoff direction faces the pulling direction.
- 3 To eliminate possible cable contact with the ground, play the cable off from the top of the drum.
- 4 Fit specially designed cable pulley boxes to every pole on the route, for the length of cable to be erected.
- 5 Feed the pulling rope through the pulleys. It is extremely important that the pulling rope and the ADSS cable have the same diameter.
- 6 Make a hauling eye at the end of the cable by removing a piece of the cable sheath (250-300mm). Next, the Kevlar of the cable is then wound around the cable and attached to the cable using a 25/8 heat shrink sleeve.
- 7 Place the drum at least 50m away from the pole where the cable is to go through the first pulley. This will prevent the cable from bending too much while being pulled.
- 8 Attach a break-away swivel to the end of the hauling rope and then attach the other end of the



**Pulley Box**

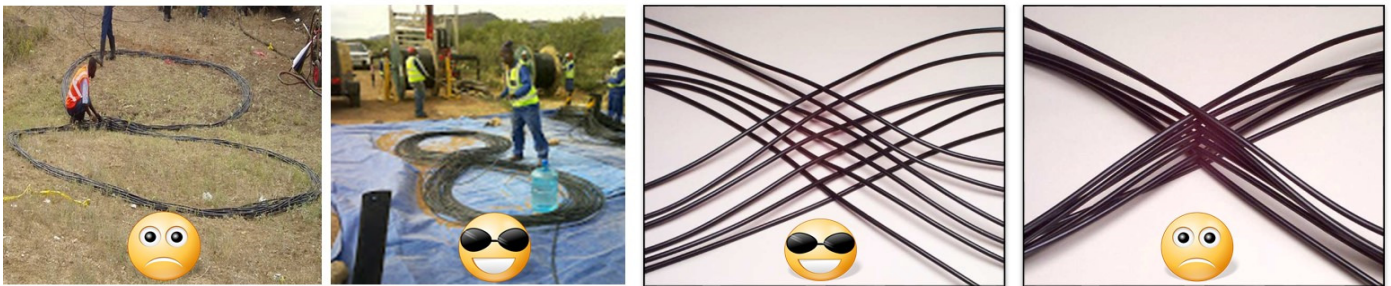
break-away swivel to the hauling eye of the cable - erecting can now begin.

- 9 Cable lengths of up to 6000m can be erected with one haul, if the terrain allows for it.
- 10 Radio Communication between persons at the drum, alongside the cable-end and the hauling team must be maintained.
- 11 When hauling the cable, a person with a two-way radio must walk alongside the cable-end to ensure that the cable is not twisting with the rope, especially at angle-poles.
- 12 The hauling team must haul the cable evenly and prevent jerking. The person(s) at the cable drum must "feed" the cable off the drum at the same speed at which the cable is being hauled. There must be no strain on the cable between the drum and the first pulley.
- 13 A good rule of thumb is to keep the pulling tension to  $\frac{1}{2}$  that of the sagging tension (see sagging).
- 14 When removing a pulling grip, 3-5 meters of adjacent cable must be cut-off and discarded.

## 2. Installation Process (Figure 8 method)

- 1 This method should be used only when the terrain is such that the conventional method cannot be used. Place the drum approximately halfway along a long hauling section.
- 2 Follow steps (1) to (8) as described above (Conventional Method).
- 3 The one half of the cable length is hauled in the one direction.
- 4 The balance of the cable is then completely run off the drum into a figure 8 on a tarpaulin, after which it is hauled in the opposite direction.
- 5 The figure 8 method should not be used for cables longer than 4000m as it becomes risky to manage a coil longer than 2000m, without potentially damaging the cable.

**Figure-8**



1. A figure-8 puts a  $\frac{1}{2}$  twist in on one side of the 8 and takes it out on the other, preventing twists.
2. Set up two traffic cones  $\pm 5$ m apart – then pay the cable off the top of the reel and loosely weave it around the cones in a figure-8 pattern.
3. In order to pull from the figure-8 - it is necessary to flip it over, a task that requires a minimum of 3-people.

Ground Clearance		Clearance (m)
1	Non-electrified railways	6.1
2	National road	6.5
3	Abnormal provincial roads	7.5
4	Other provincial roads	6.1
5	Public roads	6.1
7	Private roads or railway tracks to in or near towns	4.9
8	Country roads or railway lines, or over veiled or private lands other than (10)	3.7
9	Cultivated farmlands and across points of entry in cultivated lands	4.9



## Local Thimble Type Dead-End Sizes

Cable Dia. (mm)	Colour Code
9.2 - 9.5	Black
10.4 - 10.8	Red
11.5 - 12.2	White



In order not to damage the cable jacket, it is immensely important to use the correct size dead-end, NB, color codes differ from supplier-to-supplier.

## ADSS Terminations and Support Types

- 1 Where an aerial cable ends (i.e. goes underground or into a splice joint), it is a True Termination. If the span continues (i.e. the cable is not cut) and is called a False Termination.
- 2 Where do we find False Terminations? On either side of road crossings | Every 500m (or as per client spec) |  $\leq 10^\circ$  angles (or as per client spec).
- 3 At False Terminations, a 100mm loop (goose neck, drip loop) in the cable, must be left at the pole between the two dead-ends.
- 4 At an angled pole, the cable must always pass on the front of the pole - never behind.
- 5 To support the cable at intermediate poles, attach a tangent support or a support clamp to the S-hook.
- 6 After a cable is terminated, wait for a while ( $\pm 10$ min) to allow the cable to stabilize, before securing the cable in the tangent support or support clamp, for intermediate support.



## Securing of Cable to Poles (Termination)

- 1 Break-away swivels are used alone or in conjunction with dynamometers to ensure that the maximum pulling tension is not exceeded.
- 2 To terminate the cable at a terminal pole (beginning or end of route), a preformed dead-end, is wrapped around the cable and hooked onto a single S-hook.
- 3 With several sizes available, ensure that the correct size dead-end is used.
- 4 The (17m or so, on each cable) splicing slack is then coiled in a 500mm coil and secured to the pole as high as possible from the ground. Start coiling by rolling the slack cable like a wheel. This will ensure that no twists are put in the slack, which could result in the fiber's being damaged.



- 5 When a route deviates with an angle  $\leq 10^\circ$ , the cable must be terminated as explained below:
  - a. Fit a double S-hook on the angle-pole.
  - b. Wrap a temporary dead-end around the cable beyond the angle-pole.
  - c. A number of workers must then pull on the rope until the desired tension is obtained.
  - d. While the tension is held steady, a person on top of the pole wraps a dead-end around the cable and hooks it onto the S-hook.
  - e. Remove the temporary dead-end from cable.
  - f. A dead-end is then wrapped around the cable in the opposite direction and hooked onto the termination hook.
  - g. As mentioned, a 100mm diameter loop (goose neck, drip loop) in the cable, must be left at the pole between the two dead-ends.



Swivel



Break-away swivel



Dynamometer

### ADSS Sagging- Line of Sight Method

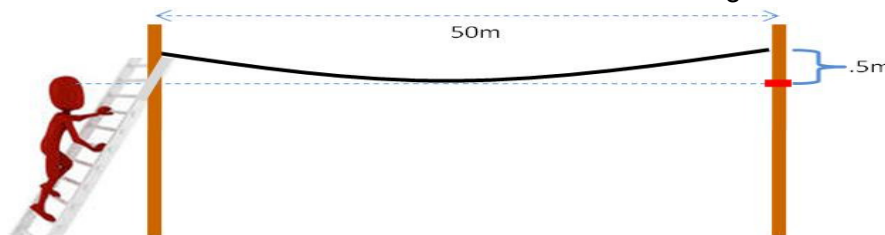
- 1 The installation sag is typically 1% of a span length. Less sag will require stronger cables.
- 2 To my knowledge, the 'line of sight' method is our best option.

The approach taken here requires for the exact distance between poles to be established. 50m as shown in the example below. In essence, the far-side pole is marked using bright colored tape with the appropriate mid-span sag distance from the attachment height i.e. .5m (1% of 50m).

Next, the installer returns to the first pole and places his/her line of sight at that same height as the marker tape on the second pole, to line-up the mid-span sag distance.

This person must have radio contact with the team tensioning the cable and give instructions of how much to tighten the cable, for the belly of the sag to rise and match the colored tape mark on the opposite pole.

One or two spans between dead-end locations should be checked using this method.



- 3 If the sagging operation takes place from the pulling end back to the payoff end, then the maximum amount of cable can be recovered.
- 4 When removing the pulling grip, 3-5 meters of adjacent cable must always be cut-off and discarded.

### Cable Slack

- 1 When a splice is completed and fitted into a Joint Enclosure, the cable slack must be coiled into a glass fiber re-enforced plastic box or onto a slack cross which is mounted to an arm or on the pole.
- 2 The slack must be coiled before the joint is secured to the pole/arm. Start the slack coiling process with the joint as the leading end (rolled like a wheel). This will ensure that no twists are imparted to the cable.
- 3 On completion of the coiling, place the coil into the slack box or onto the slack cross and secure the joint closure at a suitable position on the arm/pole.

### **Damage by veld fire to aerial-cables**

- 1 Once installed, aerial cables are impacted by the conditions of the environment they are in.
- 2 A fact often overlooked, is that grass or bush under aerial-cable routes create a fire hazard when dry. Such grass or bush must be cut before it dries during autumn.

## Cable Hauling

If we can rewind a bit, the advantages of using air-assisted installation techniques over cable hauling include; longer installation distances possible, less force is exerted on the cable, etc. However and sure enough, all too often we are still required to haul cable. And, if so, Heavy Duty Duct is the recommended pull-able cable used for hauling.

### Pre-Installation Check

- 1 Prior to any hauling, the following must be confirmed:
  - a. Maximum allowable pulling tension
  - b. Minimum allowable bending radius during installation
  - c. Minimum allowable bending radius after installation
  - d. Cable length
  - e. Cable length required at the splicing locations

### Duct Rodding

- 1 Rodding is used to clear the duct passage and install the pulling rope, using fiberglass pushrods. An alternative is to use air-blowing device.
- 2
  - a. Push the rod into the duct until the front end of the rod reaches the adjacent HH / MH.
  - b. Attach the pulling rope to the end of the rod at the adjacent HH / MH.
  - c. Next, pull the rod and pulling rope back through the duct
- 3 If the air pressure method is preferred, the pulling rope will be blown through the duct until it reaches the adjacent HH / MH.



### Duct Testing and Cleaning

- 1 To clean the duct, attach a cylindrical brush or close-fitting mandrel and a second rope to one end of the installed pull rope and pull this through the duct.
- 2 If the cable sample or mandrel cannot pass through the duct, consult with the Client on whether to switch to an alternative duct or to repair the designated duct.

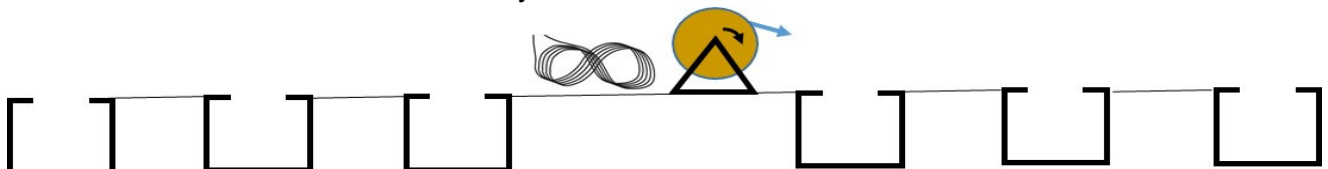


### Centre-Pulls and Back-feeding

One is often more hopeful than optimistic to install a whole drum of cable in one operation, when faced with hauling a long length of cable. Lubrication helps but more than often, does not completely resolve this issue. To assist with alleviating this issue, specialized techniques, such as Centre-Pulls and/or Back-feeding, can be used and applied with either the manual pull or winch methods.

#### Centre-Pulls

- 1 Communication, directed by a team leader with team members positioned at each HH / MH is essential, for that the pulling action to be achieved in a synchronized manner. Communication via the use of either a walkie-talkie or two-way radio is desirable.



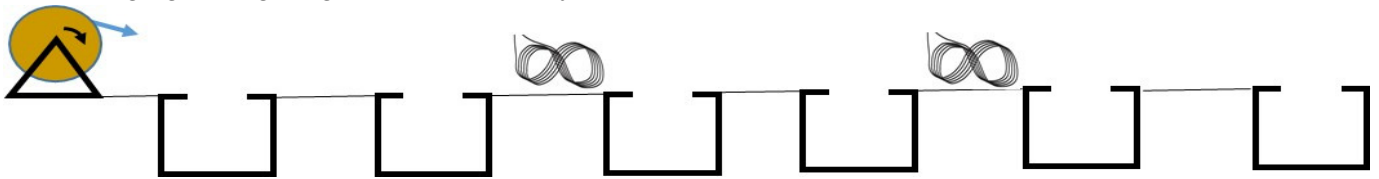
- 2 In a center-pull operation, set up the cable reel near the center of the duct run to be pulled.
- 3 To avoid cable rubbing against drum flanges keep the drum level - orientate the drum so that natural payoff direction is towards the pulling direction. Always use cable jacks or a cable trailer to lift the drum during the hauling process.
- 4 Align the cable drum so that the cable can be routed from the top of the reel into the duct in as straight

a path as possible.

- 5 Make use of a flexible cable guide – placed between the HH / MH lid and duct to be used.
- 6 Ensure that there is a swivel between the cable sock and the hauling rope.
- 7 Pull the cable in one direction to the intended HH / MH.
- 8 Uncoil the remaining cable in a figure-eight configuration.
- 9 Flip-over the figure-eight so that the pulling-eye end of the cable is on top. As mentioned previously, this can be accomplished by 3-installers, one at each end of the eight, and one at the center.
- 10 Pull the exposed end of the cable in the opposite direction to complete the pull. Hand-feeding of the cable paying off from the figure-eight is required.
- 10 A warning marker (colored tape or similar material) may be attached to the pull-line at  $\pm 10\text{m}$  in front of the pulling grip to alert observers at HHs / MHs that the cable is approaching.
- 11 Place an end cap on all bare cable ends in HHs / MHs, to prevent moisture and/or dirt intrusion.

### Back-feeding

- 1 In a nutshell, back-feeding is used to provide a series of shorter, lower-tension pulls in one direction – utilizing figure-eighting, where necessary.



### Pulling Tension

- 1 The maximum allowable pulling tension on fiber cable can vary and is dependent on the cable construction. The maximum tension for a particular cable can be found on the cable spec sheet.
- 2 Except for short runs or hand-pulls, tension must be monitored.
- 3 A dynamometer is to be used to monitor tension in the pull-line
- 4 The use of a breakaway swivel can be used to ensure that the maximum tension of the cable is not exceeded and should be used as a fail-safe rather than a primary means of monitoring tension.
- 5 Cable lubricant is recommended for most fiber optic cable pulls as a means of lowering pulling tension.
- 6 Pulling a new fiber optic cable over an existing one is never recommended due to the possibility of entanglement.

### Pulling Grips

- 1 Pulling grips provide effective coupling of pulling loads to Kevlar strength members or cable jackets.
- 2 On cables with no Kevlar strength members, a wire mesh pulling grip and swivel can be used during cable pulls.
- 3 A swivel must always be fitted between the hauling rope and cable sock to prevent the cable from being twisted by the hauling rope.
- 4 When removing a pulling grip, 3-5 meters of adjacent cable must be cut-off and discarded.



### Hauling Rope

- 1 An 8mm polyester or polyaramid pull rope must to be used for optical fiber cables that are to be pulled in by hand.
- 2 When using a hauling winch, a 12,5mm or thicker polyester or polyaramid rope must be used as hauling rope.
- 3 Ski-ropes manufactured from nylon are not suitable, as their stretch factor is too high and they can potentially cut into ducts.
- 4 Steel hauling rope or galvanized wire must never be used as they can damage ducts and/or cables.

## Duct Fill Ratios for hauling

- 1 Fill ratios are calculated by comparing the area of an inner diameter cross-section of the inner-duct to the outer diameter cross-section area of the fiber optic cable. For optimum hauling performance, it is recommended that the cable-to-duct diameter fill ratio does not exceed 65%, or as per cable spec sheet.

## Duct Fill Ratio

$$\frac{\text{Cable Diameter}}{\text{Inner Duct Diameter}} < 65\%$$

## Access Build

By now, we are familiar with the popular and conventional installation practices (which do apply here) - however, each last drop (the final connection to a home or building) is unique. Traditionally fraught with deployment challenges to be overcome and the usual suspects are:

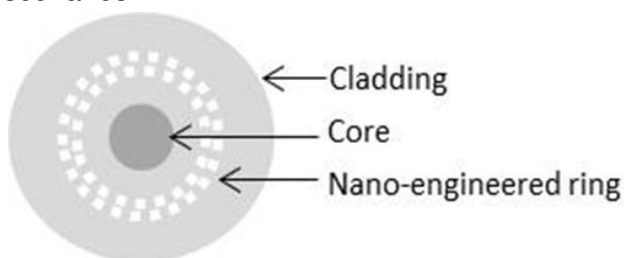
- Multiple tight bends
- Space constraints

This of course is why the last bit of an installation is normally the most expensive and time consuming part of any overall fiber project. This pickle is traditionally met with an echoing yawn from customers and gnashing of teeth from contractors.

## Bend-insensitive Fibre

It has been long understood that an inherent limitation of optical fiber is macro bend attenuation. Put simply, installers face increased loss with tight bends. The focus of this limitation has been amplified as optical networks continue to move closer to where people work and live.

Bend-insensitive SM fiber (ITU-T G.657A) has an innovative design (a lowered refractive index in the cladding area) that enables it to significantly reduce macro bend loss even in the most challenging bend scenarios.



SM fiber's complying with ITU-T G.657A was developed with the purpose of use at FTTH sites. G.657A category fibers are compatible with the standard G.652D fiber, it was designed to replace.



## The Deployment of Optical Fibre Infrastructure on Dolomitic Land

The deployment optical fibre infrastructure involves the installation of sub-surface ducts, HHs and/or MHs. On dolomite land, the installation must comply with the requirements of SANS 1936-3 for dry services. These installations differ from the typical projects envisaged by the code writers due to the widespread nature of the work and the low impact that such services have on both dolomitic stability and public safety, if correctly installed and managed.

### Appointment of a company competent person:

This person must be a registered Professional Engineer or Professional Technologist who:

- a) Complies with the requirements for a competent person given in clause 3.3 b) and c) of SANS 1936-1:2012
- b) Has achieved Competence Level 3 (Experienced Professional) given in Figure A.1, Annex A, SANS 1936-1:2012

### The Risk

With a dry engineering service, the biggest risk to be considered is the possibility that the service may become a conduit through which water can be introduced into the ground. The most likely points where water can gain access to the system are:

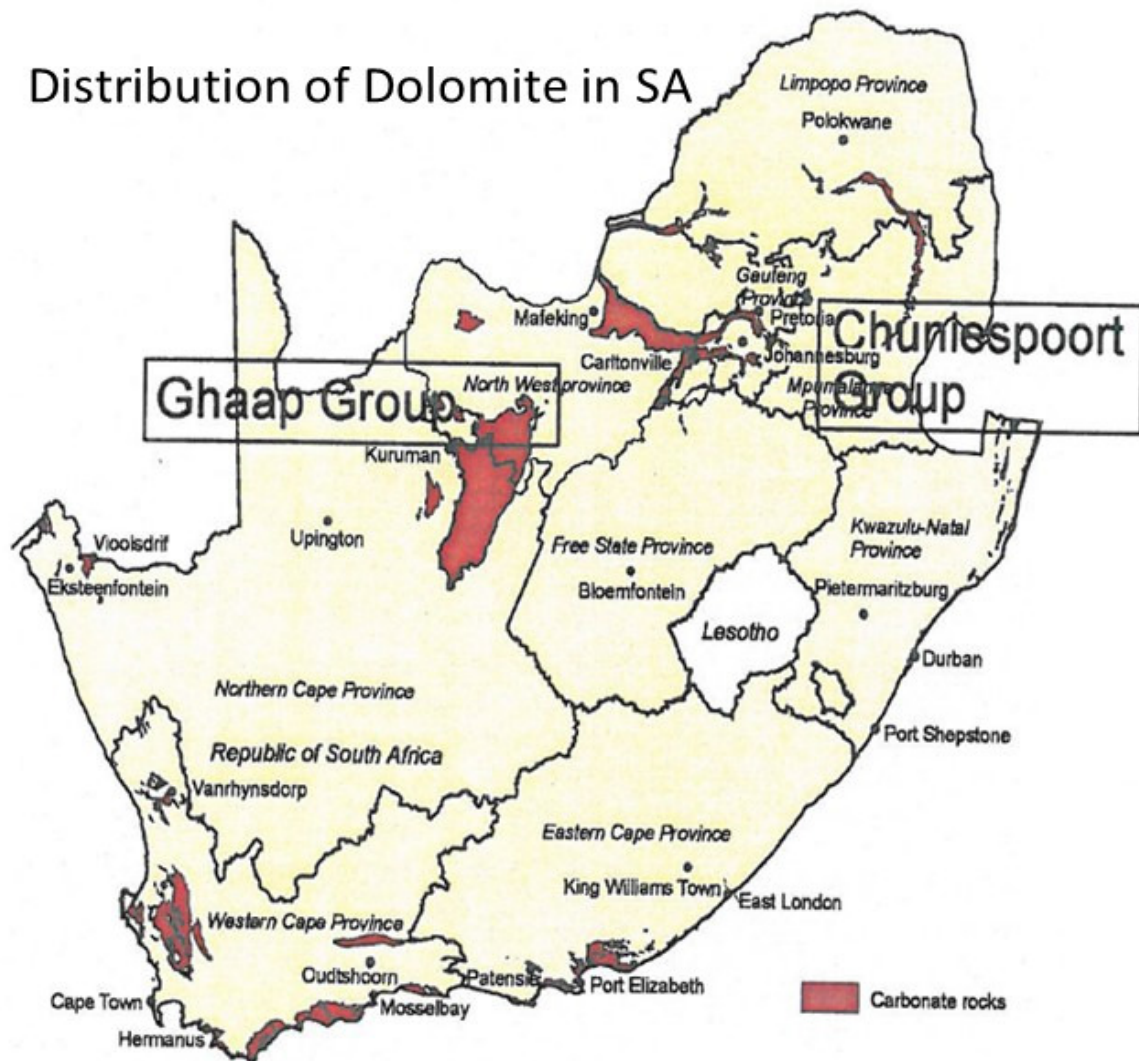
- a) Through non-water tight HHs / MHs.
- b) At the point where the duct enters the HHs / MHs.
- c) By interception of leakage from other services.
- d) By infiltration of water from the ground surface through the backfill of both trenches and HHs / MHs.

### Mitigating Risk

- a) Ensuring that the HHs / MHs themselves, their covers and the connection of the ducts into the HH / MH walls have an acceptable degree of water tightness.
- b) Ensuring that existing water bearing services are not damaged during the laying operation and that any existing leakage from such services is reported to the relevant authorities.
- c) Ensuring that the backfill to service trenches and HHs / MHs comprises of the same excavated material compacted to a higher density than that of the surrounding ground thereby reducing its permeability.
- d) By ensuring that the ground surface above the trench is finished level with the surrounding areas to prevent surface drainage being impeded.



## Distribution of Dolomite in SA





**The End**

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