INSTALLATION MANUAL

1.0 INTRODUCTION

The intent of this manual is to help the contractors laying Superlit properly. This manual is to serve as a guide. Sound engineering practices and common sense should always be followed. Superlit Engineering department will assist the contractor to solve problems dealing with handling and installation to achieve a satisfactory GRP pipe installation. This manual is designed to assist supervisors and field engineers in the installation. It provides suggestions to avoid and solve problems during installation. These instructions are to be used as reference only. Specifications written for a particular project would have priority over the general guidelines mentioned herewith.

2.0 HANDLING THE PIPES ON SITE

2.1 Receiving the pipes.

Upon receiving of the truck on site, the material shall be carefully inspected for any damage during transportation.

The following checks should be made upon receiving the goods.

a) Visually inspect each item.
b) The total quantities of goods should be checked and compared to the delivery note.
c) Report any damage or missing item on the delivery note.

Note: Damage goods should not be used unless inspected and repaired by the factory personnel.

2.2 Unloading pipe.

Care should be exercised when unloading the material. Prevent impact damage with rigid objects (i.e. steel, rocks etc.). Mechanical unloading is needed for pipes ≥ 300mm. It is advisable to use two lifting straps to lift the pipes. It is not allowed to use steel cables or hooks at the end of the pipe. It is also advisable to have guide ropes tied around the pipe ends to exercise manual control over the pipe while it is in the air particularly in high winds.

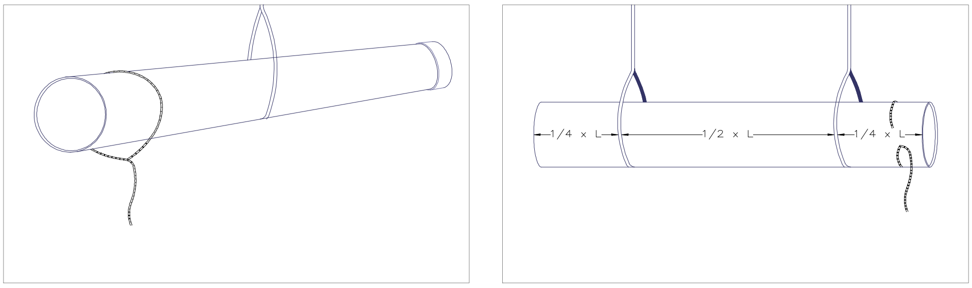


Figure 2.2: Pipe lifting

2.3 Unloading joints.

Usually all Superlit are shipped with one coupling on the end. Only extra couplings needed for the job are shipped separately.
Remove and unload very carefully all sizes of joints. If the joints are bundled from the factory, they can be unload as the pipe.

2.4 Storing pipes in the contractor yard

The storage area should be leveled and clear of rocks or shrap edges. Pipes can be stored in piles to minimize the storage area. Wooden cradles should be placed between the layers of pipes and wooden wedges should be placed to prevent the first layers (portion) from sliding. It is generally advantageous to store pipe on flat timber to facilitate placement and removal of lifting slings around the pipe. Pipe support shall be about ¼ x pipe length from each end.

Couplings, if delivered separately, should be stored in an horizontal position to prevent over deflection.
Make sure that the stuck is stable for conditions such as high winds, unlevel storage area or other horizontal load.
Maximum stack height is approximately two and half meter (2.5 m). Stacking of pipes larger then 1200 mm on site is not recommended. When storing fittings, care shall be taken that no loads are exerted on nozzles, branches and elbows.

Maximum diameter deflection shall be as follows:

Stiffness class SN	Maximum deflection % diameter
2500	2.5
5000	2.0
10000	1.5

Table 2.4 Maximum storage deflection

Another way to express the storage height is by defining the number of layers

Nominal Pipe	Maximum number of layers	
Dia DN (mm)	SN 2500	SN 5000 and 10000
200 – 450	4	5
500 – 700	3	4
700 – 900	2	3
1000 – 1200	2	2
> 1500	1	1
It is advisable to use pyramid stacking for SN 2500 N/m²		

Table 2.4.1 Maximum storage layers

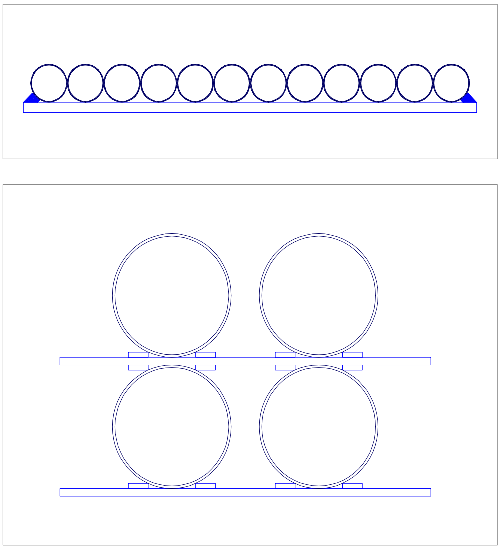


Figure 2.4: Storing pipes

2.5 Handling nested pipes.

Pipes to be shipped long distances may be nested (smaller diameter pipes inside of larger sizes) to reduce the transportation cost. These pipes generally have special packaging and may require non-standard procedures for unloading, handling, storing and transporting. Non –standard practices, if required will be supplied prior to shipment, Regardless, the following general procedures should always be followed:

1. Always lift the nested bundle using the least two pliable straps. Limitations, if any, for spacing between straps and lifting locations will be specified for each project. Insure that the lifting slings have sufficient capacity for the bundle weight.

2. Nested pipes are usually best stored in the transport packaging. Stacking of these packages is not advised unless otherwise specified.

3. Nested pipe bundles can only be safely transported in the original transport packaging. Special requirements, if any, for support, configuration and/ or strapping to the vehicle will be specified for each project.

4. Package removal and denesting of the inside pipe (s) is best accomplished at a denesting station. Typically, this consists of three or four fixed cradles to fit the outside diameter of the largest pipe of the bundle. Removal of the pipes may be also done using forklifts… Inside pipes starting with the smallest size may be removed by lifting slightly with a inserted padded boom to suspend the section and carefully move it out of the bundle without touching the other pipes. When weight, length and / or equipment limitations preclude the use of this method,

procedures for sliding the inside pipe (s) out of the bundle will be recommended for each project.

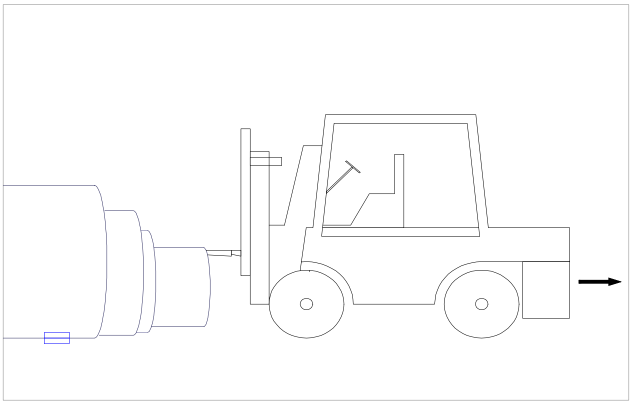


Figure 2.5: Denesting with padded boom on forklift truck.

2.6 Storing of lubricant.

Lubricants should be carefully stored to prevent damage to the container. Partially used buckets should be resealed to prevent contamination of lubricant.

2.7 Transporting Pipe.

If it is necessary to transport pipes at the job site, it is the best to use the original shipping dunnage when loading the truck. If this material is not longer available, support all pipe sections on flat timbers spaced on a maximum of 4 meter centers (3 meters for small diameter) with a maximum overhang of 2 meters. Chock the pipes to maintain stability and separation. Insure no pipes contact other pipes, so vibrations during transport will not cause abrasion (figure 2.7).
Maximum stack height is approximately 2.5 meters. Strap pipe to the vehicle over the support points using pliable straps or rope never use steel cables or chains without adequate padding to protect the pipe from abrasion. Also, maximum diametrical deflection must not exceed the values in Table 2.4 Bulges, flat areas or other abrupt changes of curvature are not permitted. Transport of pipes outside of these limitations may result in damage to the pipes.

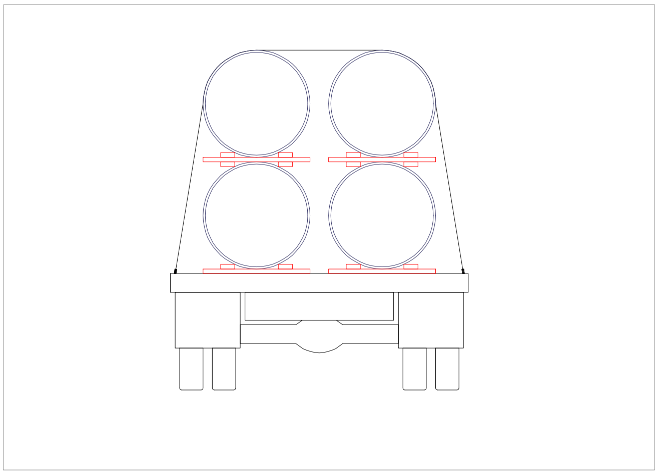


Figure 2.7: Transporting of pipes

3.0 INSTALLATION GUIDELINES.

The type of installation appropriate for Superlit pipe varies with pipe stiffness, cover depth, native soil characteristics and available backfill materials. The native material must adequately confine the pipe zone backfill (see figure 3.1) to achieve proper pipe support. The following installation procedures are intended to assist the installer in achieving an acceptable pipe installation. However, regardless of soil conditions and installation method, the initial and long-term deflections must not exceed the allowable values given in section 4.8. Pipes installed outside these limits may not perform as intended.

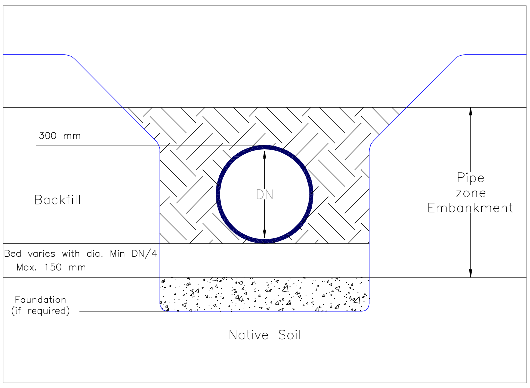


Figure 3.0: Pipe backfill nomenclature.

Appendix A gives detailed definitions for the native soil groups. Testing of native soil should be done frequently and particularly where changes are suspected. Properties of importance are those obtained at the bed and pipe zone elevation. The blow counts or soil strengths must represent the most severe (weakest) condition expected to exist for any significant period of time. (Normally this occurs when the water table is at its highest elevation).

3.1 Basic installation

Long life and good performance characteristics for Superlit can be achieved by proper handling and installation. It is important for the owner, engineer and contractor to understand that glass-reinforced plastic (GRP) pipe is designed to utilize the bedding and pipe zone backfill support from recommended installation procedures. Together, the pipe and embedment material form a " pipe-soil system " that provides support for the installation.
Engineers have found through considerable experience that properly compacted granular materials are ideal for backfilling pipe, including GRP pipes. However, in an effort to reduce the cost of installing pipes, very often the excavated trench soils are used as pipe zone backfill. Recognizing this need, **superlit** technology engineers have developed burial limitations for superlit pipe based on the use of eight different native soil modulus ranging from crushed stone to low plasticity fine-grained soils.

4.0 PIPE TRENCH CONSTRUCTION

4.1 Trench bottom

The trench bottom should be constructed to provide a stable and uniform support for the full length of the pipe. Trench bottom should be compacted to provide support to the pipe. When unstable soil is encountered an additional trench depth should be provided. The bed thickness should be increased. In some cases special foundations may be required.

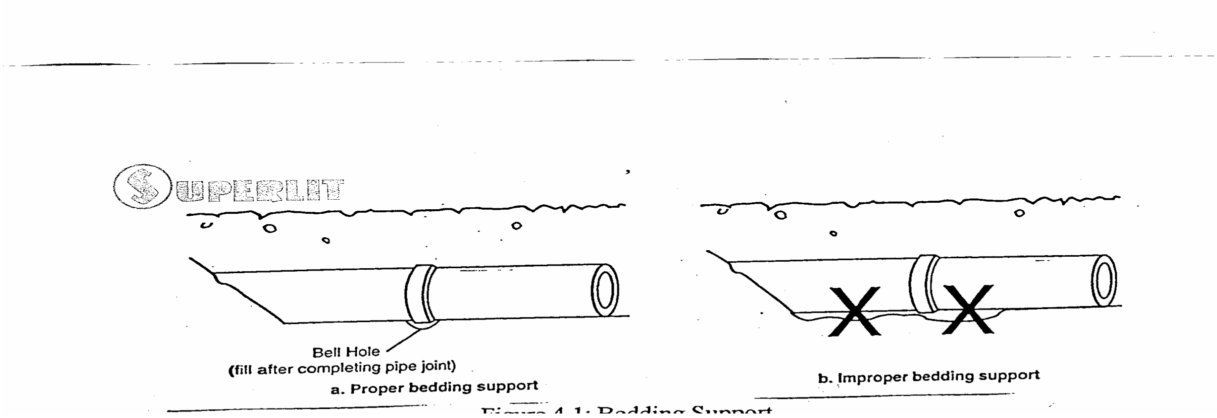


Figure 4.1: Bedding Support

4.2 Trench width

The width of the trench at the top of the pipe need not be greater than necessary to provide adequate room for jointing the pipe in the trench and compacting the pipe zone backfill at the haunches. The standard trench clearance b' (see figure 3.1) is given in table 4.2. In poor nature soil conditions and depending on the pipe stiffness and burial depth, the trench width may be increased.

Normal pipe size DN	b' mm
200<DN<300	150
300<DN<500	200
500<DN<900	300
900<DN<1600	450
1600<DN2400	600
Note – Wider trenches may be necessary for deep burials for reasons of safety owing to soil instability.	

Table 4.2 Standard trench clearance

4.3 Multiple pipes in one trench.

When more than one pipe is installed in one trench a minimum distance should be kept to provide sufficient work place to ensure good compactors of the backfill material under the pipe haunches for pipes of the same diameter, the suggested minimum distance between the follows.

Diameter in mm	Minimum distance between pipes (X) in mm
200 – 600 mm 700 – 1200 mm 1300 – 2400 mm	300 mm 600 mm 1000 mm

Table 4.3: Minimum distance between pipes.

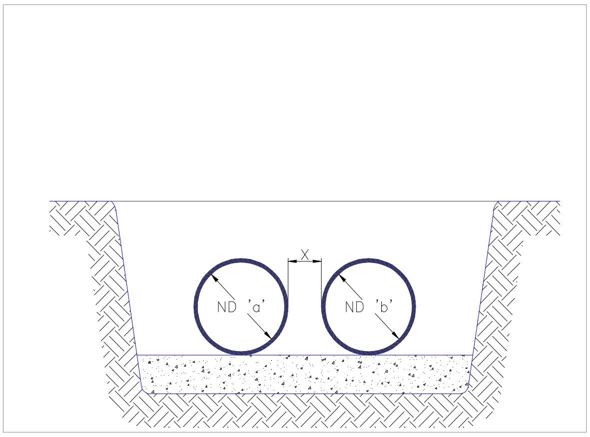


Figure 4.3: Pipes in the same trench

4.4 Cross-Overs

When two pipes cross, so that one passes over the other, vertical spacing between pipes and installation for the bottom pipe shall be as per Figure 4.4.
In some cases, it is necessary to lay a pipe under an existing line. Extra care should be protected by fastening it to a steel beam crossing the trench. It is advisable to also wrap the pipe in order to protect it from impact damage. When the new pipe is laid, selected backfill material must be placed back into the trench and hand compacted in order to completely surround both pipes and also achieve the required density.

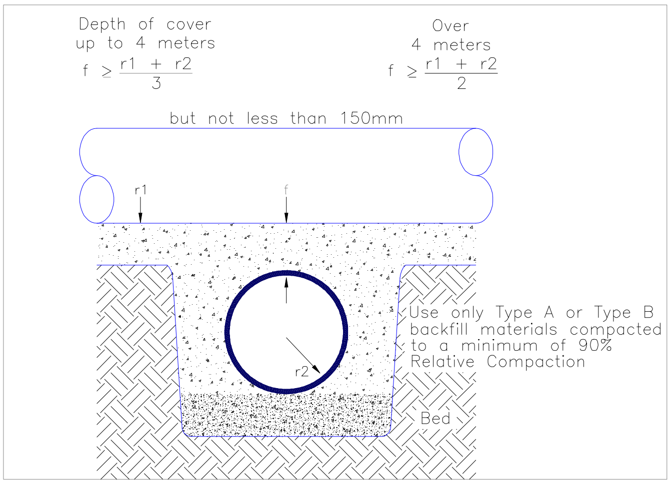


Figure 4.4: Crossing pipes

4.5 Trench depth.

Determine the trench depth by considering the pipeline design, intended service, pipe properties, size of pipe and local conditions such as the properties of soil and combination of static and dynamic loading. Take care to ensure that the burial depth is sufficient to prevent the conveyed fluids from being affected by frost penetration. Provide sufficient cover to prevent accidental pipe flotation in potentially high ground water areas.

4.5.1 Minimum trench depth

A minimum depth of cover above the pipe should be always observed.

- 0.6 m with no traffic loads
- 1.0 m AASHTOH – 20 Truck loading
- 1.5 m with BS 153 HA or ISO H I 60 loading and when compactor equipments are used above the pipe.

When the ground water table is high and in order to prevent pipes from floating a minimum burial depth equal to one diameter should be kept. The cover layer should be placed before the dewatering systems are turned off.

Alternatively the installation may proceed by anchoring the pipes. If anchoring is preferred, retaining straps must be a flat material, minimum 25mm wide placed at maximum 4.0 meter intervals.

4.5.2 Maximum trench depth

The maximum allowable burial depth depends on the nature soil, the backfill material and the degree of compactors, pipe stiffness and trench construction.
As " Superlit " are flexible conducts, they depend on the support of the surrounding soils.
A standard installations is shown in this document.
In general, pressure pipes are burried 3m deep.
Section 7 gives the values of the maximum burial depth in relation with the type of soil and the combined soil modulus.

4.6 Unstable trench bottom

Where the trench bottom has soft, loose or highly expansive soils, it is regarded as unstable. An unstable trench bottom must be stabilized before laying pipe or a foundation must be constructed to minimize differential settlement of the trench bottom. Gravel or crushed stone is recommended for use in foundation layers.
The depth of the gravel or crushed stone material used for foundation depends upon the severity of the trench bottom soil conditions, but should not be less than 150mm. The normal bedding must be placed on top of such foundations. The use of filter cloth to completely surround the foundation material will prevent foundation and bedding materials from migrating into one another which could cause loss of pipe bottom support.
Additionally the maximum pipe section length between flexible joints shall be 6 meters.

4.7 Flooded trench

When the ground water table is above the trench bottom, the water level must be lowered to at least the trench bottom (preferably about 200 mm below) prior to preparation of the bed. Different techniques may be used depending on the nature of the native material.
For sandy or silty soils, a system of well-points to a header pipe and a pump is recommended. The spacing between individual well-points and the depth at which they will be driven depends on the ground water table. It is important to use a filter around the suction point (coarse sand or gravel) to prevent clogging of the well-points by fine grained native material.
When the native material consists of clay or bedrock, well-points will not work.
Dewatering is more difficult to achieve in this case if the ground water table is high. The use of sumps and pumps is recommended.
If the water cannot be maintained below the top of the bedding, subdrains must be provided, the subdrains shall be made using single size aggregate (20-25 mm) totally embedded in filter cloth. The depth of the subdrain under the bed shall depend on the amount of water in the trench. If the ground water can still not be surround the bed (and if necessary the pipe zone area as well) to prevent it from being contaminated by the native material. Gravel or crushed stone shall be used for bed and backfill. The following cautions should be noted when dewatering:

- Avoid pumping long distances through the backfill materials or native soils, which could cause loss of support to previously installed pipes due to removal of materials or migration of soils.
- Do not turn off the dewatering system until sufficient cover depth: has been reached to prevent pipe flotation.

5.0 BEDDING AND BACKFILLING SELECTION

The installation type, bedding and backfill material is based on stiffness of pipe, maximum burial depth, vacuum and native soil conditions.

5.1 Bedding and backfilling material

The following materials are generally acceptable for the bedding and pipe zone backfill.

Soil group 1
Gravel, gravel-sand mixtures (GW, GP)
Sand, sand-gravel mixtures (SW, SP) at least 40% of particles larger than 2,0 mm and a maximum of 5% silt.

Soil group 2

Gravel-silt mixtures (GM)	maximum 15% silt
Gravel-clay mixtures (GC)	maximum 15% clay
Sand-silt mixtures (SM)	maximum 15% silt
Sand-clay mixtures (SC)	maximum 15% clay and less than 40% of particles larger than 2,0mm

Soil group 3
As group 2 (GM, GC, SM, SC), but the amount of silt or clay may be up to 40%

Note: The letters in brackets are the group symbols used in the unified soil-classification system.

Soil group moduli
Constrained backfill-soil moduli Ms for various soil groups at 1 m

Soil Group	Standard proctor density (SPD)						
	85	90	92	95	97	100	102
1	3.8	5.3	6.0	7.2	8.2	10.0	11.4
2	2.1	2.9	3.3	4.0	4.5	5.0	6.3
3	1.3	1.8	2.1	2.5	2.9	3.5	4.0
4	0.9	1.2	1.4	1.7	1.9	2.3	2.6

Long-term reduction factors for ATV-A 127 soil groups

ATV soil group	Reduction factor
1	0.90
2	0.85
3	0.80
4	0.75

Note: Native-soil moduli do not normally need to be reduced
For details refer to Appendix C

Make sure that the Haunches are filled with approval material. The backfill material should extend 300mm above the pipe crown, native material excavated from the trench may be used to complete the backfill to grade. No compaction is required for the final layers.

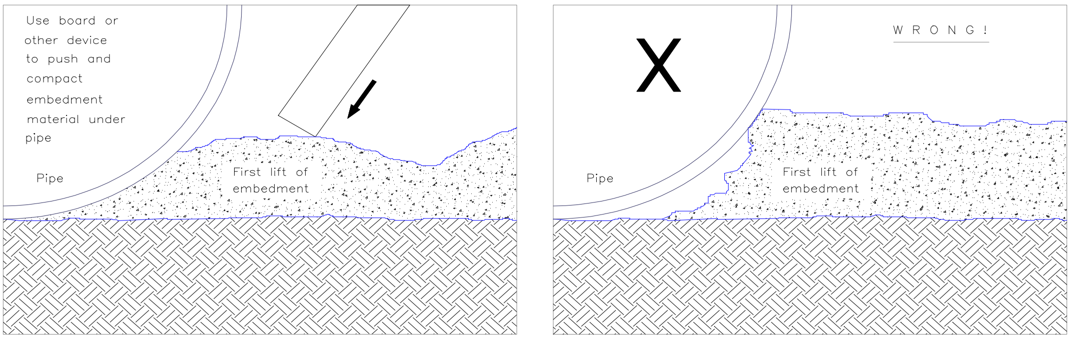


Table 5.1: Compaction at the haunches

5.2 Migration

Where ground water conditions are such that running or standing water occurs in the bottom of the trench, or are such that the soil in the bottom of the trench exhibits a quicksand tendency, remove the water by suitable means, such as well points or underdrains, until the pipe has been installed and the trench back-filled to a height great enough to prevent flotation of the pipeline.

The gradation of the pipe zone backfill, bedding and foundation material shall be such that, under saturated conditions, fines from these areas will not migrate into the adjacent soil of the trench bottom or walls, and material from the trench bottom walls will not migrate into the pipe zone material. Any migration or movement of soil particles from one area to another can result in the loss of the necessary foundation or side support of the pipe, or both. The migration of the materials can be prevented by use of filter fabric.

Significant hydraulic gradients may arrive in the trench during installation when water level is controlled by various pumping or well pointing methods. Gradients may also arise after construction when permeable under chain pipes or when the age graded bedding and backfill material acts as a chain under high ground water levels in general gravel and crushes stone backfill material should be avoided when the native soil is a fine type unless geotextile filters fabric is used in the trench bottom and sides. The following grading criteria may be used to restrict the migration of fines into a courses material under a hydraulic gradient.

From AWWA M-45 page 80-

- D 15/d85 < 5 where D 15 is the sieve opening size passing 15 percent by weight of the coarser material and d85 is the sieve opening size passing 85 percent by weight of the finer material.

- D 50/d50 < 25 where D 50 is the sieve opening size passing 50 percent by weight of the coarser material and d50 is the sieve opening size passing 50 percent by weight of the finer material. This criterion need not apply if the coarser material is well graded (see ASTM D2487).

  If the finer material is a medium to highly plastic clay (CL or CH), then the following criterion may be used in lieu of the S15/D85 criteria: D 15 < 0.02 in. (0.5mm) where D15 is the sieve opening size passing 15 percent by weight of the coarser material.
  The aforementioned criteria may need to be modified if one of the materials is grap graded. Materials selected for use based on filter gradation criteria should be handled and placed in a manner that will minimize segregation.

5.3 Using temporary sheet piles

If sheet piles are with drawn after compaction hollow spaces may be left and the backfill material support may be reduced or lost.
Sheet piles should be **removed in stages** as backfilling and layer compaction progresses. In this case all hollow spaces left behind the sheets are filled with compacted material. This lifting must be done progressively so that the pipe bedding and pipe zone material can be compacted hard against the native trench side up to 300mm above the pipe crown. Note: If water and /or native soil are seen to escape between sheets then it is sure that there are voids. In this case fill them with compacted backfill.

5.4 Maximum size of gravel and crushed stones

The particle size depend on the pipe diameter observe the table.

Nominal pipe size DN	Maximum particle size mm
DN<300	10
300<DN<600	15
600<DN<1000	20
1000<DN<1500	25
1500<DN	32

Table 5.4: maximum particle size

5.5 Installation on slopes

The risk of unstable conditions increase with slope angle. In general pipes are not installed in a standard way when the slope is more than 15 degrees, in this case special precautions should be taken. One alternative is to install the pipe above ground on a steep slope as pipe supports are easily defined and the quality of installation and settlement are easier to mention.

5.6 Alternative installation

If the burial depth requirement for the selected pipe stiffness, installation types and native soil group exceeds the limits given in section7, alternative installation procedures must be considered.
Three alternative installation methods are available:

- Wider trench
- Permanent sheeting
- Stabilized backfill (Cement)

5.6.1 Wide trench

Increasing the trench width distances the poor native soil farther from the pipe allowing a deeper installation and higher allowable negative pressures (vacuum).

5.6.2 Permanent sheeting

Use permanent sheeting of sufficient length (at least 30 mm over pipe crown) to appropriately distribute the pipe's lateral loads and of sufficient quality to last the design life of the pipe (see figure 5.6.2).
Note that backfilling procedure and maximum cover depths are the same as for standard installations. Permanent sheeting can be assumed to a "group 1 native soil".

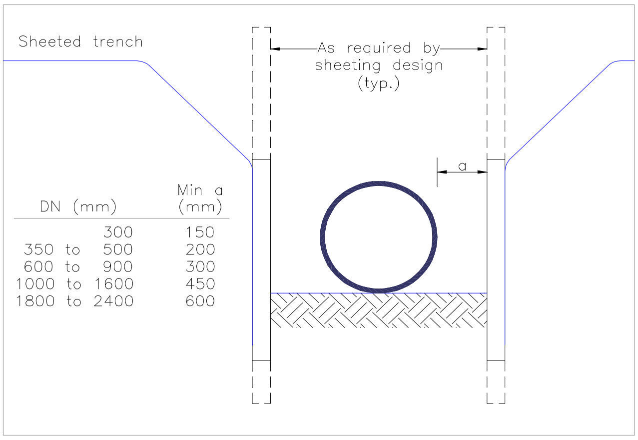


Figure 5.6.2 Permanent sheeted trench

5.6.3 Stabilized backfill (Cement)

Typically, 40-50 kg of cement per ton of sand (4-5% cement) will be sufficient. The sand shall have a maximum of 15% passing a 200 sieve. Seven – day strength of the stabilized material should be 690-1380 kPa.
The stabilized backfill should be compacted to 90 SPD in layers of 150 to 200 mm. The stabilized material must be allowed to "set" 24 hours at maximum initial cover before backfilling to grade. Maximum initial covers.
1.0 meter for SN2500
1.5 meter for SN5000 and SN10000
The pipe must be surrounded in stabilized backfill as shown Figure 5.6.3. Maximum pipe length is 6 meters.
Over – excavation must be filled with compacted stabilized material, and as trench boxes or temporary sheeting is pulled the stabilized backfill must be compacted against the native soil. Maximum total cover depth is 5 meters.

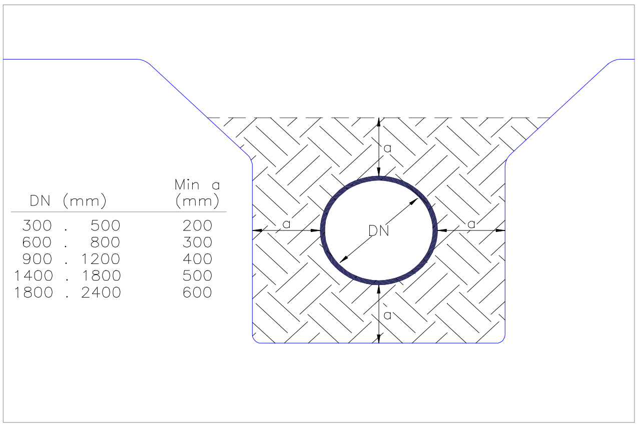


Figure 5.6.3 Stabilized backfill

6.0 CLASSIFICATION OF NATIVE SOILS

Soils are classified into four main groups for details see annex A.

7.0 INSTALLATION TYPE

Installation selection shall be specified based on native soil properties, pipe stiffness and burial depth. The standard type of installation is described here after.

General description of standard installation

Gravel or crushed stones or sand compacted at 90% proctor density up to 300m above the pipe (compacted at 70% RD).

The maximum burial depth shown in the table below is applicable to gravity pipes. Pressure pipes are usually installed to a maximum burial depth of 3.0 m

Standard Trench Width Installation
Type 1 with traffic load (AASHTO H20)
Trench width of about 1.75 x DN water table 1 m below grade level.

E'b E_2/ Mpa	Native soil modulus 20.7	10	7	5	2	1	0.5
	5000 STIS						
20.7	13.5	10.2	8.5	7.3	5.3	3.8	
13.8	12.0	9.2	8.0	7.2	5.2	3.8	Installation
10.3	10.9	8.6	7.5	7.1	5.2	3.8	not
6.9	9.3	8.0	7.3	7.0	5.1	3.7	recommended
4.8	8.0	7.5	7.2	6.7	5.0	3.5	for
3.4	7.5	7.2	7.0	6.5	4.5	3.3	SN 5000
2.1	7.0	6.5	6.5	6.0	4.3	2.8	
1.4	5.3	5.0	5	4.5	3.5	2.8	
	10000 STIS						
20.7	16.3	11.8	10.5	9.5	6.3	4.5	2.8
13.8	14.7	11.5	10.5	9.3	6.2	4.5	2.8
10.3	13.0	11.3	10	9.2	6.2	4.5	2.8
6.9	12.5	11.0	9.5	9.0	6.1	4.4	2.8
4.8	11.5	10.0	9.0	8.5	6.0	4.3	2.8
3.4	11.0	9.5	8.5	8.0	5.5	4.3	2.8
2.1	9.5	8.5	8.0	7.5	5.0	4.2	2.8
1.4	7.2	6.5	6.3	6.0	4.5	3.5	2.8

8.0 JOINTS

8.1 Jointing preparation

When installing pipe, provide jointing holes beneath the joint to allow for proper assembly of the joint and to prevent the weight of the pipe from being carried on the joint. Each jointing hole shall be no larger than necessary to accomplish proper joint assembly. When the joint has been made, carefully fill and compact the jointing hole with bedding material to provide continuous support of the pipe throughout its entire length.

8.2 Joint Rotation.

The recommended angular deflection distributed equally on both sections of the joint is given in the bellow table.

Diameter (mm)	Joint deflection in (degrees)
200 to 350	3
400 to 500	3
600 to 900	2
1000 to 1800	1
above 1800	0.5

Table 8.2: Maximum joint rotation

It is recommended that the above values are not reached during the installation to allow for long term settlement. Always joint the pipe in straight alignment and then rotate to the desired angle.

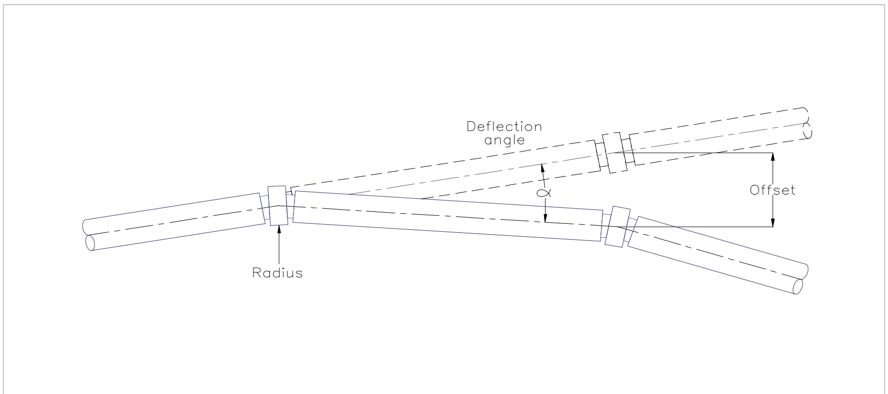


Figure 8.2 Pipe joint deflections

8.3 Lubricant

Use only vegetable base lubricant. Do not use petroleum grease, or automotive oils. For indication the quantity need is as follows

Pipe diameter	Quantity of lubricant used
200 to 600 m	0.2 kg
700 to 1200 m	0.4 kg
1300 to 2000 m	0.7 kg

Table 8.3: Quantity of lubricant per joint

8.4 Joint and pipe assembly

The coupling joint is a filament wound joint wrapped and locked to an internal full-face EPDM elastomeric membrane. The sealing is achieved by the compression of the compression areas.

The pipes are usually delivered with a coupling attached. Clean the pipe end with a fine brush, lubricate the pipe end by means of a dry clean piece of cloth and sponge. **Inspect the pipe ends for delamination.**
Use a come-along type puller to push the pipe in the coupling of the already installed pipe see figure 8.4. The pipe is pushed until it touches the middle center of the rubber sleeve in the coupling. Backhoe may be used for pipe joining as figure 8.4.1.

<u>Note:</u> For intake pipe underwater, the ends of the pipes are provided with steel angle lugs to allow the drivers to assemble the standard pipes under water. It is possible to assemble on the barge 3 – 4 lengths of pipe and to lower the assembled section into the seabed trench. (See offshore intake and outfall section). See section 11.

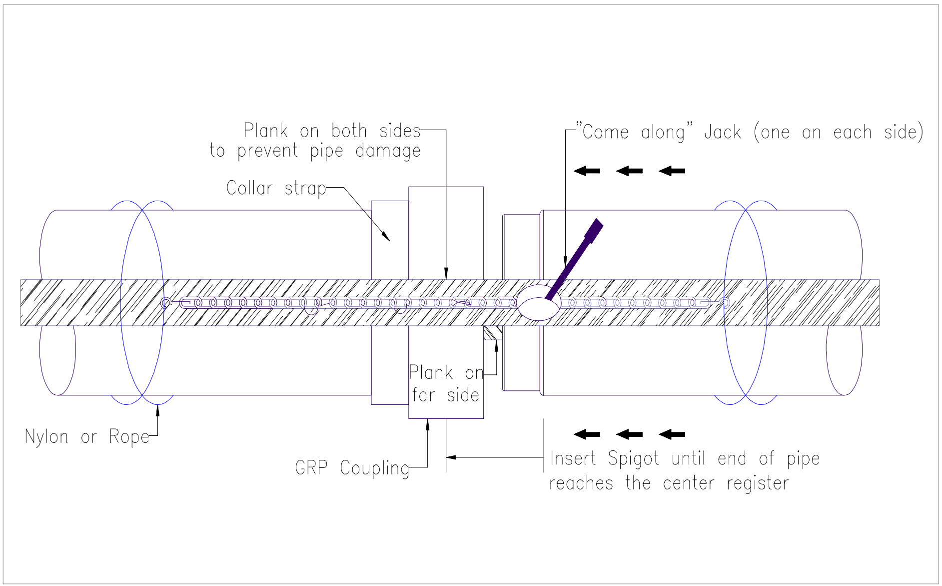


Figure 8.4: Jointing pipes with come-along jacks

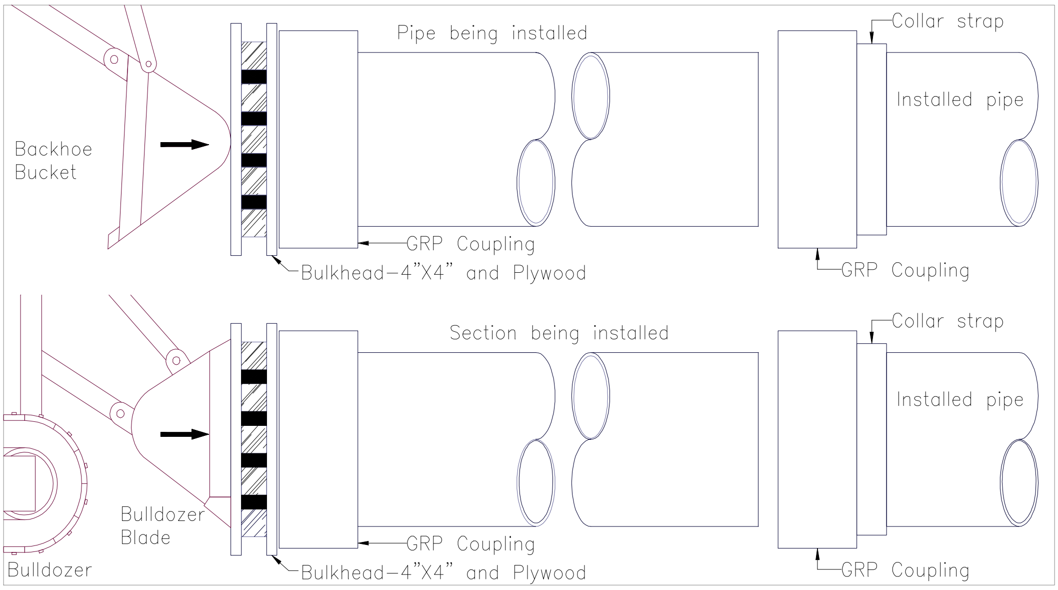


Figure 8.4.1: Jointing pipes with Backhoe or Bulldozer

9.0 THRUST BORING,RELINING AND MICRO-TUNNELING INSTALLATION.

When the ground above and around the pipe cannot be disturbed or when the cost of open trench excavations is excessive, thrust boring and micro-tunneling installation may be used. In this case the coupling and the pipe outside diameters are the same. Typical section is shown hereunder.
There are two types of jacking pipe for this type of application:

- Special jacking pipe with flush coupling for directs jacking. These pipes will be specially designed to take the jacking force.
- Standard GRP pipes provided in short lengths and casted inside a concrete jacket. In this case the surrounding concrete takes the jacking force and the inner fiberglass pipe provides the corrosion resistance and the joint tightened

When pipe is installed in a casing the following precautions should be observed

a) Pipes are installed into the casing by pulling or by pushing.
b) Pipes should be protected from sliding damage by the use of wooden skids attached to the pipe.
c) Plastic spacer unit may also be used. They must provide sufficient height to permit clearance between the coupling joint and the casing wall.

d) The annular space between the casing and the pipe may be filled with sand, gravel or cement grout. The maximum grouting pressure should not exceed the values given in table 9.0.

Pipe stiffness	Max. Grout Pressure
SN 2500	30 kPa
SN 5000	60 kPa
SN 10000	110 kPa

Table 9.0: Maximum Grouting Pressure

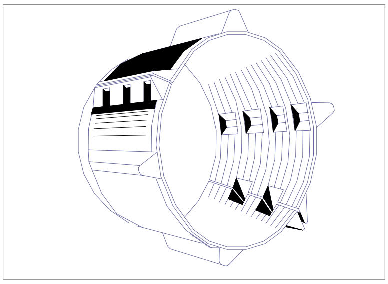


Figure 9.0: Plastic Spacer

10.0 SHORT PIPE LENGHTS – RIGID CONNECTION.

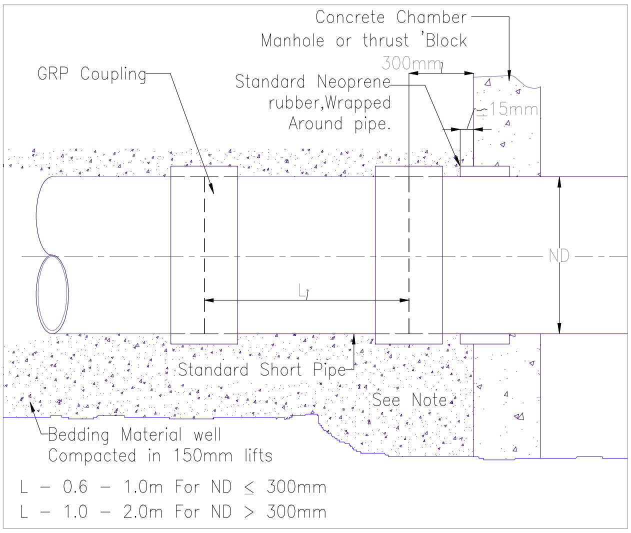
In some areas where differential settlements expected short pipe length are required.

- Outside rigid structures (manholes, valve, chambers etc…)
- Outside thrust blocks.

10.1 Rigid connections.

When a pipe exits concrete structure or is connected to a flange pump, valve or other fixed structures, it is subjected to high bending stresses that may develop when there is a differential settlement (movement) between the pipe and to rigid structures.
Therefore a special installation should be considered to minimize the high discontinuity stresses occurring in the pipe.
Two alternatives are given below as a standard:

a) Use a coupling cast into the concrete at the inter face.
b) Use a short piece of pipe and wrap it with rubber band to minimize the transition effect.



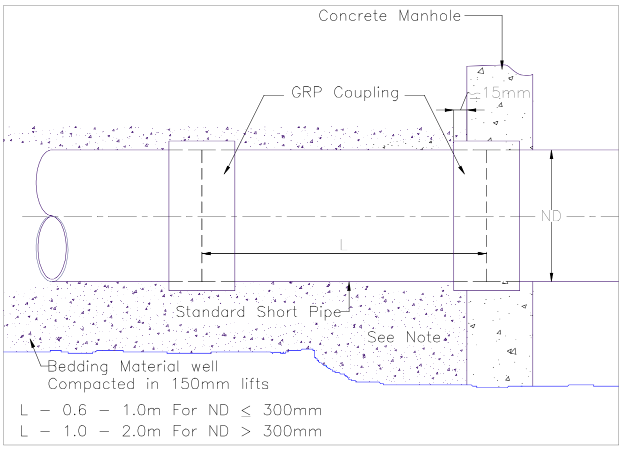


Figure 10.1 illustrate the two methods.

Note: When casting a coupling in the concrete make sure that it keeps it roundness. Otherwise a pipe can not be joined to this coupling. Use a high stiffness pipe adjacent to the concrete. The pipe should not be subjected to high deflections.
When using the compressible material wrap it around the pipe prior to placement of any concrete. Make sure it is protruded 25mm from the concrete.
In all cases make sure that short pieces are used as illustrated in figure 10.1. This rocker pipe section is used to account for some alignment with the concrete when installed. In case of misalignment it should be corrected by rebedding the full pipe sections leading to the rocker pipe.
Extra care and caution must be taken to replace and properly backfill adjacent to the concrete structure. Construction of the concrete structure will frequently require over-excavation for formwork, etc.
This extra excavated material must be restored to a density level compatible with surroundings or excess deformation, or joint rotation adjacent to the structure may occur. It is recommended that a backfill soil modulus (E'b orE1) of at least 6.9 MPa be attained in this region to prevent excessive movements. Use of stabilized backfill (cement) adjacent to large concrete structures has also been found to be very effective in preventing excess joint deformation in very large diameters (DN > 1600 mm).

11.0 OFFSHORE INTAKE AND OUTFALL LINES

This method of installation is applied when sea water is needed for a desalination plant or when a sewer or a storm water drain must be pumped into the sea or when a circuit of cooling water for a power station is built. In these cases the pipe joints are normally assembled underwater. Superlit will provide steel angle irons lugs on the two ends of pipe to allow divers to assemble the standard GRP coupling joints under water. It may be possible to assemble on the barge up to 3 lengths of pipe and to lower the assembled section into the excavated sea bed trench.

Caution: Standard Superlit GRP pipe is not designed to be assembled on-shore in long lengths and then dragged out to the sea.

Installation GRP pipe under water requires a trench just as on land installation except that the trench width needs to be wider. The typical underwater trench width is equal to 2 x ND, but is no case less than ND + 1 meter. The cover over the pipes will generally be around 1 meter above the pipes to the normal sea bed.

Backfilling with excavated granular seabed material should be made by the divers in maximum 300 cm lifts with particular attention being made to placing and compacting the backfill material under the pipe haunches.
Backfilling should be made evenly on both sides of the pipe to avoid displacement of the pipes.

It is normal practice to provide protection to the backfilled sea bed over the pipe trench. Large stones or rocks (rip – rap) may be used for this purpose.

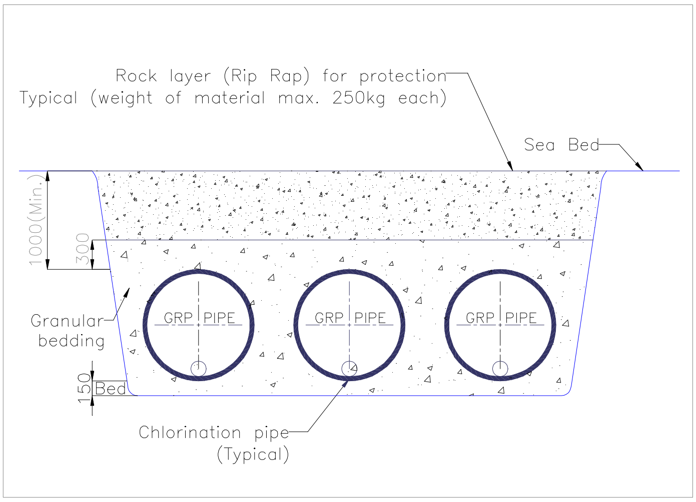


Figure 11.0: Typical underwater installation.

12.0 ADJUSTMENT / CLOSURE LENGTH PIPES

Superlit has a smooth outside surface and do not require calibration for inserting for joints.

The exact dimensions of adjustment pieces could be cut on site. Depending on the installation sequence when you have two crews installing pipes in opposite directions on one line a closure piece is needed.

Two couplings are installed on the end of the closure pieces. The couplings are pushed to the inside. The below figure shows the sequence of installation. It is recommended to use a mechanical coupling such as Staub or Teekay.

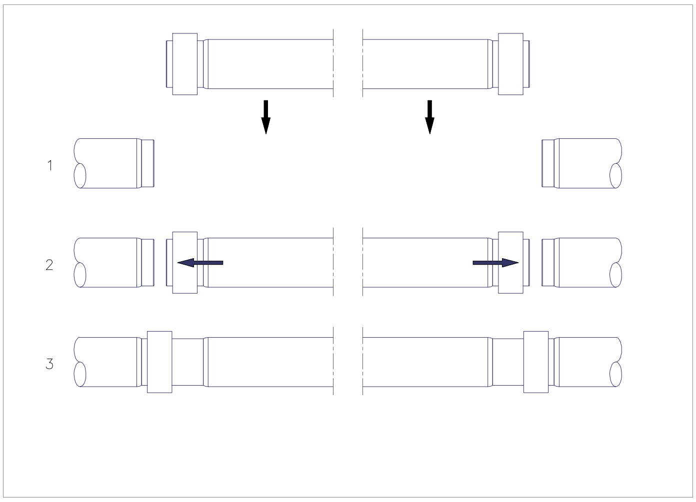


Figure 12: Pipe line closures.

Note: 1- The easiest installation is accomplished when the pipes and couplings are in straight alignment and with an adequate chamfering on the outside edge of the pipes.

2- The length of the closure pipe should be 50mm less than the measured length and centered to achieve an equal clearance .

3- When pulling the coupling, it is necessary to make sure that the rubber slieve of the coupling is not twisted.

13.0 RESTRAINTS AND ANCHORING

Unless the system is designed as restrained system, thrust blocks should be used at:

- Change of direction.
- Change of cross section al areas (reducers).
- Valve chambers.
- Dead ends.

Always provide short pieces near the thrust blocks as per section 10.0. Thrust blocks should be cast against undisturbed soil and must be poured all around the fitting.
In some case thrust pilling may be used. Thrust forces are calculated as follows:

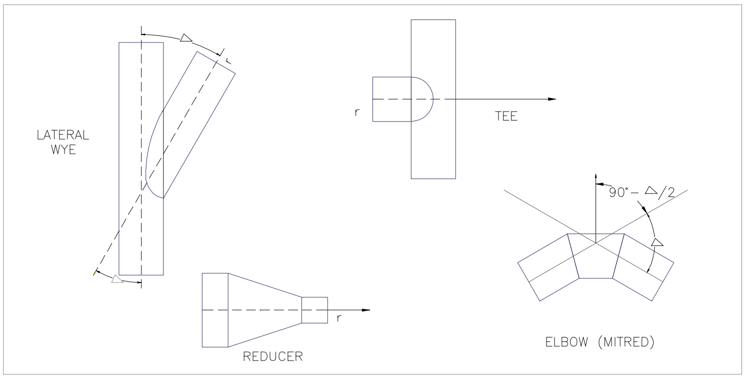


Figure 13.0: Typical fittngs in GRP

13.1 Concrete Encasement

When pipes must be encased in concrete, such as for thrust blocks, stress blocks, or to carry unusual loads, specific additions to the installation procedures must be observed.

Pipe anchoring

During the pouring of the concrete, the empty pipe will experience large uplift (flotation) forces. The pipe must be restrained against movement that could be caused by these loads. This is normally accomplished by strapping over the pipe to a base slab or other anchor(s). Straps should be a flat material of minimum 25mm width, strong enough to withstand flotation uplift forces, spaced not to exceed 4 meters, with a minimum of one strap per section length. The straps should be tightened to prevent pipe uplift, but not so tight that additional pipe deflection is caused (Figure 13.1).

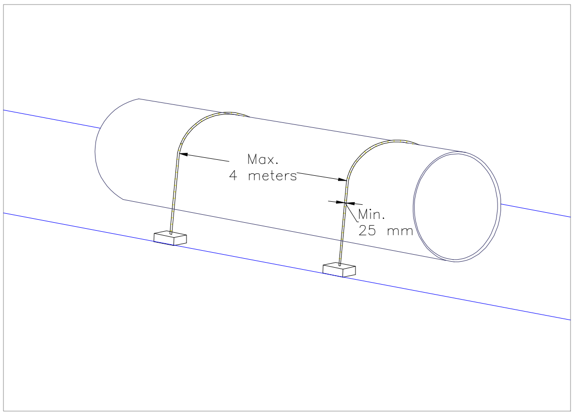


Figure 13.1: Pipe anchoring

Pipe support

The pipe should be supported in such a way that the concrete can easily flow completely around and fully underneath the pipe. Also, the supports should result in an acceptable pipe shape (less than 3% deflection and no bulges or flat area). Supports are normally placed at strap locations (not exceeding 4 meter spacing) (figure 13.2)

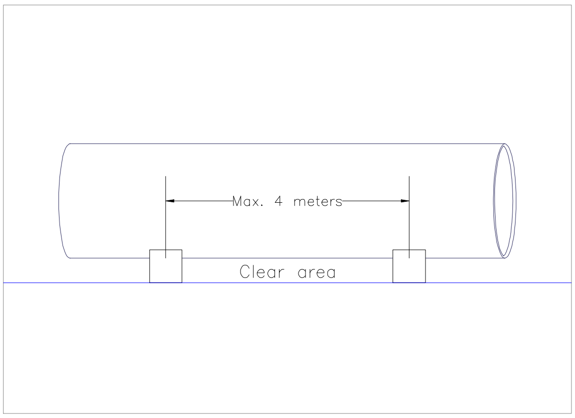


Figure 13.2: Pipe support

Concrete pouring
The concrete surround must be placed in stages allowing sufficient time between layers for the cement to set (no longer exert buoyant forces). Maximum lift height is variable with nominal pipe stiffness:
SN 2500 – larger of 300 mm or ¼ pipe diameter
SN 5000 – larger of 450 mm or 1/3 pipe diameter
SN 10000 – larger of 600 mm or ½ pipe diameter.

14.0 EMBANKMENT INSTALLATION

14.1 Scope

Installing pipe in an embankment condition (above the normal ground grade level) requires consideration of several non-standard factors. While in effect a buried installation, procedures must account for the conditions unique to embankments.

14.2 Backfill materials

The use of rounded gravels (for example, pea gravel) is not acceptable. Rounded materials are too free flowing and cannot be properly confined. Crushed stone or sand materials meeting Superlit's instruction guidelines are acceptable embankment backfills.

14.3 Installation width

Total installation width is of necessity quite wide adequate slope of embankment (to allow backfill support of the pipe to be developed) to the native grade level must be provided. The installation width will also be a function of the depth of cover.
The minimum cover depth (H) over the pipe crown should be one meter or 0.5 diameters, whichever is greater. For a traffic load of H-20 rating a minimum depth of cover of 1.2

meters is required. Traffic loads should be avoided as the possibilities for error with embankment installation is high.
Attached figures give the width and depth relationships for crushed stone and sand installations.

14.4 Bedding and backfilling

14.4.1 Provide a level, graded surface on which the pipe will lie.

14.4.2 Beneath the pipe, loosen the native soil by raking or spreading to a depth of 150mm.

14.4.3 Place backfill under haunches of the pipe and compact backfill as much as possible without lifting the pipe.

14.4.4 Apply backfill in 150 to 300mm lifts, compacting each lift.

14.4.5 Repeat step 4 until the installation is complete and meets the guidelines established in the attached figure.

14.5 Soft native soils

Soft surface soils, on which the pipe is to be placed, may allow differential settlements, which could interfere with pipe performance. When soft surface soils are encountered, treat them as an unstable trench bottom and follow typical pipe installation practices such as over excavation and filling with select backfill.

14.6 Erosion

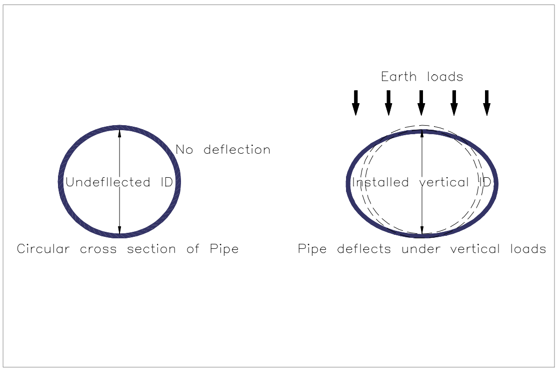
A particular concern with embankment installation is the potential erosion of pipe cover. The cover must be maintained to provide long term performance. Erosion can occur from high ground water, rains, wind, and sand storms.
The granular backfills must be protected in all cases. Typical methods include used of geofabrics, rip-rap (large rocks completely covering the surface), clays, asphalting of oiling. Frequently a combination of methods may be used. Local practices will vary, but erosion protection must be provided in all cases.

15.0 POST INSTALLATION

15.1 Deflection measurements

In order rest to exceed the allowable long-term deflections of the GRP pipe, the initial deflection should be checked. Pipe deflection is the % reduction in the vertical diameter after the installation.

$$\% \text{ Deflection} = \frac{100 \times (\text{Undeflected ID} - \text{Installed ID})}{\text{Undeflected ID}}$$



As it is difficult to measure the long term deflection, (long term deflection are reached within 6 months from the completion of installation and removal of all denaturing system), it is useful to measure the initial deflection immediately after the backfilling reaches the final grade and the systems are turned off for at least 3 days.
It is useful to have the deflection measurement parallel to the pipe layer so that corrective actions can be quickly and reduce term and expenses related to the faulty installation.

Initial deflection limits.

Maximum initial Deflection (%)	3.0	3.0
Maximum long – term deflection (%)	6.0	

Table 15.1: Initial deflection limit

15.1 Measuring the deflection

For pipe sizes 800mm and larger where men can enter safely a pipeline, the installed vertical ID can be measured with a telescopic micrometer at 3m intervals.
For smaller sizes the "pig" method should be used. The pig is a wooden disk with an outside diameter equal to the maximum allowable deflected ID and that may be pulled through the line.

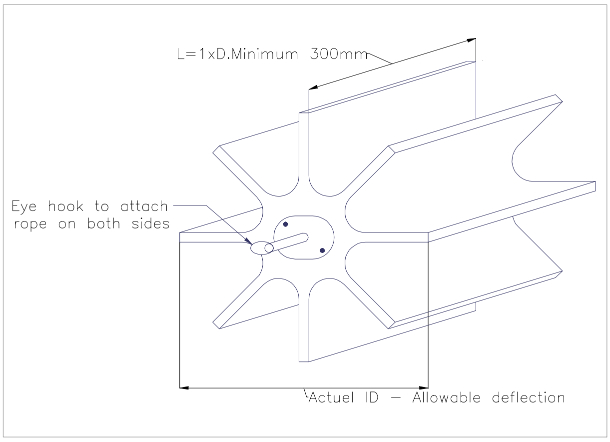


Figure 15.1.1: The pipe pig

If the pig passes freely, the pipe deflection are within the acceptable limits.
Deflection meter are also available to measure vertical deflection is small pipe at different intervals.

15.2 Line hydro test

GRP pipelines can be tested either by water or by air (gravity application only)

15.2.1 Hydrostatic testing

Before starting the hydro test, the following points should be checked.

a) As it is difficult to locate a leak on long sections and the cost of filling and emptying the line is high, it is advisable to limit the test section to 1000m.
b) All thrust blocks and concrete structures are well cured (poured at least 7 days before the start of the test).
c) All testing equipments are operational and in good condition.

d) The end of the pipeline or the section to be tested is sealed with testing end caps. Those caps should have an inlet placed at the bottoms or the low end of the line and the outlet on the top of the end cap at the high end.
e) All end caps, must be braced during hydrotest to prevent line displacement due top the thrust developed.

15.2.2 Filling the line

The line should be filed from the lowest point. Air inside the pipeline should be expelled from the air released valves located at high points. Additional outlet should be added the inlet end caps when it is not possible to fill the line from the lowest point.
Slowly fill the line. (Filling water velocity does not exceed 0.3 m/sec). Air inside the pipeline is usually released through the air valves.

- Increase the pressure to 2 - 3 bars.
- Leave the line at this pressure for 12 hours for stabilization.
- Following the stabilization period and when the entrapped air is released, the release valves should be isolated.

15.2.3 Completing the test

- After the stabilization period the pressure shall be gradually increased up to 2 bars every 30 minutes and shall be stabilized at their intervals.
- Continue until the test pressure is reached at the lowest point.
- Maintain the pressure by pumping if necessary for one hour.
- Disconnect the pumps and do not allow any more water to enter.
- The duration of the test shall not be time should be enough to virally inspect the entire pipeline.

After completing the hydraulic test, the line should be flushed.

<u>Allowable leakage.</u>

Most of the project specifications allow for a maximum pressure loss or a water volume loss. BS 8010:section 2.5:1989 allows an accepted loss of 0.02 l/mm of nominal bore of pipeline per 24h per bar.

15.3 Air test

Important: Air test is dangerous. Safety precautions should be taken. Air pressure must always be relieved before attempting to remove the test plugs.

- Air shall be pumped into the line until a pressure of 25 Kpa gage is indicated or the air pressure gage
- Stabilize for 5 minutes.
- Test time shall be 10 minutes for diameters up to 600m.
- The pressure drop shall not exceed 6 Kpa in order to consider that the line have passed the air test.

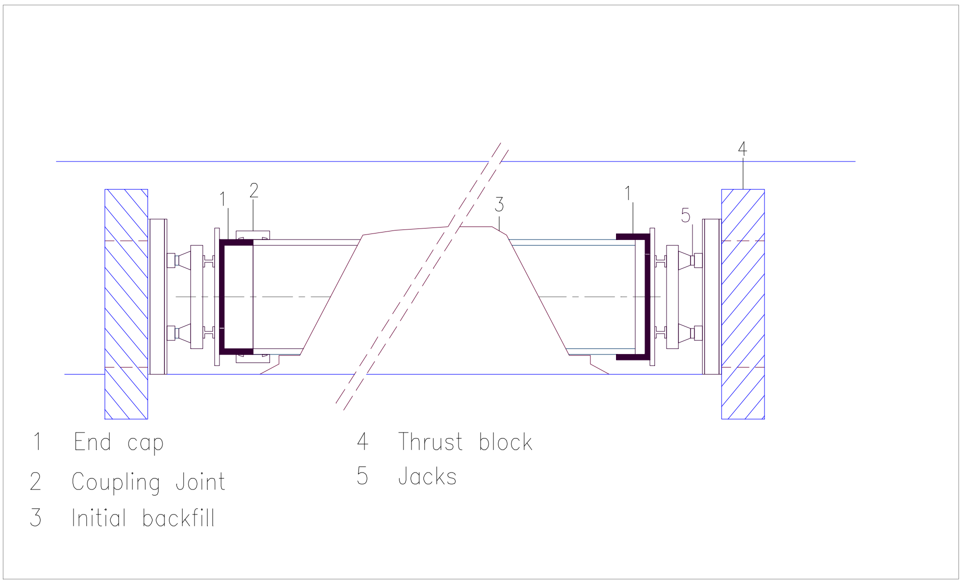


Figure 15.3: Thrust boring pipe ends and site testing set up.

16.0 SAFETY PRECAUTIONS

16.1 Entering into large dia pipes

- All safety precaution should be followed.
- A confined space entry permit must be obtained from Safety Department .
- An approved person must conduct gas test, if required.
- Standby person must be posted.
- Communication must be provided.

16.2 Proper access during lamination & fabrication onto large dia pipe.

- Proper work access (Proper scaffold) shall be provided when personnel to work above 2 meter high.
- When required to work in excavated place, the site safety requirement shall be observed. Such as evacuation permit, isolation permit etc.

16.3 Personal protection

- The company will provide all required PPE (Personal Protective Equipment) to the employees according to the nature of the job.
- Personnel must wear required Personal Protective gears such as Safety spectacle, appropriate face mask and gloves etc. as per the job requirement.
- Training shall be given to the employees on proper use and maintenance of Personal Protective Gears.

16.4 Handling of chemical & other raw material

- All necessary precaution shall be taken when handling chemical for lamination and other maintenance job for GRP pipes.
- SMDS (Safety Material Data Sheets) for all raw material and substances being used at the site shall be made available with work supervisor, Stores and Safety officer.
- Personnel will be briefed of the hazards involved in each substances being used for GRP pipe repair and lamination jobs, prior to commence the work.
- All chemicals and other raw material shall be stored in accordance with the manufacturer's recommendation.

SUPERLIT

16.5 Tools & Equipment

- All tools and equipment being used at site shall be in good condition and may damaged or worn out tools will be discarded from the site and will be replaced with good ones.

- Color code will be done on all tools & equipment according to the site requirement.

- Any equipment, which required to be certified by third party, will be done and the certificates shall be made available with site office.

Annex A

Classification of native soils

A.1 General

Soils are classified into four main groups, of which the first two have two sub-groups (see A2). The soil group is a function of both soil type (classification) and soil density, which together determine the modulus of the soil. Relative quantification for densities may be determined from standard penetrometer blow counts, tested in accordance with [4] (ASTMD 1586, see Annex B). It is recommended to use test method SRS 15 according to OENORM B4419-1 for soils according to group 3 and 4 in this annex, values for native soil modulus shall be taken from table A.7 in ISO/ TR 10465-3 1999(E).
It is also recommended to use the standard the penetration test method as per ASTM D1586 for soil according to group 1 and 2 in this annex. Value for native soil modulus should then be taken from table A.10 in ISO/TR 10465-3 1999(E).
The above mentioned tables are included for reference.
The blow counts shall represent the most severe (weakest) conditions expected to exist for any significant period of time.
(Normally this occurs when the water table is at its highest elevation).

A.2 Group classification

A.2.1 Group 1- Very stable soils

- 1 A: Dense gravel or sand according to ATV Type 1 [5] or ASTM, GW, GP, SW, and SP [(1), (2), see Annex B] containing less than 5% fines;

- 1 B: Hard or very stiff cohesive soils in accordance with tableA1.

A.2.2 Group 2 – Stable soils

- 2 A: Medium (see table A) slightly silty or clayey gravel or sands according to ATV type 2 [5] or ASTM, GM, GC, and SC [(1), (2)] containing less than 15% fines;
- 2 B: Stiff cohesive soils in accordance with table A 1.

A.2.3 Group 3 – Soil mixtures

Typically medium cohesive and/ or loose granular (see table A1 soils according to ATV type 3 [5] or ASTM ML or CL [(1), (2)] with liquid limit less than 50%.

A.2.4 Group 4 – Cohesive soils

Soft and very loose soils according to ATV type 4 [5] or ASTM MH, CH, OL and OH [(1), (2)]

Table A10 – Values of in situ native – soil modulus *E'n* from AWWA M-45

For group 1 and 2

Granular		Cohesive		E'n
Blows/300 mm a	Description	Unconfined compressive strength, *qu* (N/mm²) b	Description	N/mm²
0 to 1	Very very loose	0 to 0,012	Very very soft	0,34
1 to 2	Very loose	0,012 to 0.024	Very soft	1,4
2 to 4	Very loose	0,024 to 0,048	Soft	5
4 to 8	Loose	0,048 to 0,096	Firm	10
8 to 15	Slightly compact	0,096 to 0,192	Stiff	21
15 to 30	Compact	0,192 to 0,383	Very stiff	35
30 to 50	Dense	0,383 to 0,575	Hard	70
>50	Very dense	> 0,575	Very hard	138
Rock				345

a Standard penetration test as per ASTM D 1586
b Unconfined compressive strength of cohesive soils as per ASTM D 2166.

Table A.7 – Native-soil modulus E_3 (in N/mm²)
For group 3 and 4

Number of blows *N*10 (SRS 15)	Non-cohesive soils (groups 1 and 2)	ATV-A 127 soil groups				Cohesive soils (groups 3 and 4)
		1	2	3	4	
> 30	Very dense	20	10	7	5	Hard
> 12	Dense	13	7	5	3	Firm
> 7	Medium	10	5	3	2	Semi-soft
> 2	Loose	5	3	2	1	Soft
= 2	Very loose	4	2	1	0,5	Soft and/ or plastic

Note 1: For the same number of blows, the soil modulus varies with the soil group.

Note 2: n 10 is the number of blows per 10 cm movement using test method SRS 15 in accordance with OENORM B 4419-1.

Annex B

Bibliography

[1] ASTM D 2487: 1990 Standard Test method for classification of soils for engineering purposes.

[2] ASTM D 2488: 1990 Standard practice for description and identification of soils (Visual Manual procedure)

[3] ASTM D 698: 1978 Test methods for moisture – density relations of soils and soil aggregate mixtures using 4.4 Ib (2.49 kg) rammer and 12-in (305 mm) drop.

[4] ASTM D 1586: 1984 Standard method for preparation test and split-barrel sampling of soils (or appropriate ISO standard)

[5] ATV Regelwrek A 127 Gesellschaft zur Forerung der Abwassertechink e.V. Markt (Standthaus) D–5202 St Augustin–1.

Annex C

C.1 Backfill-soil modulus

C.1.1 Austrian standard OENORM B 5012-1

Soil – group definitions
The four groups in OENORM B 5012-1 which may be considered for backfill are defined as follows:

Soil group 1
Gravel, gravel – sand mixtures (GW, GP)
Sand, sand – gravel mixtures (SW, SP) at least 40% of particles large than 2.0mm and a maximum of 5% silt.

Soil group 2
Gravel-silt mixtures (GM) maximum 15% silt
Gravel-clay mixtures (GC) maximum 15% clay
Sand-silt mixtures (SM) maximum 15% silt
Sand-clay mixtures (SC) maximum 15% clay and less than 40% of particles larger than 2.0 mm.

Soil group 3
As group 2 (GM, GC, SM, SC), but the amount of silt or clay may be up to 40%.

Soil group 4
Silty or clayey soils (ML, CL, MH, CH) from low to high plasticity and containing more than 40% of fine grain materials.

Note: The letters in brackets are the group symbols used in the unified soil-classification system.

C.2 Soil group moduli

Based on the soil groups defined in C.1.1.1, the standard gives values for constrained soil moduli which depend on the degree of compaction as shown in Table A.3 and which are considered valid when using a vertical soil pressure equivalent to 1m depth of cover.

Table A.3 – Constrained backfill-soil moduli *M*s for various soil groups at 1 m

Soil Group	Standard Proctor density (SPD)						
	85	90	92	95	97	100	102
1	3.8	5.3	6.0	7.2	8.2	10.0	11.4
2	2.1	2.9	3.3	4.0	4.5	5.0	6.3
3	1.3	1.8	2.1	2.5	2.9	3.5	4.0

For depths of cover other than 1 m (without ground water for soil groups 1 and 2), the constrained soil modulus can be calculated using equation (A.3):

$$M_S = M_{S1} \times (k \times h)^f$$

Where M_{S1} is the value from table A.3.

When ground water is present, the constrained soil modulus for groups 1 and 2 is calculated using equation (A.4):

$$M_S = M_{S1} \times [h \times k \times (1 - 0.39 \times \frac{hw}{h})]^f$$

Where

f is 0.4;
k is the reduction factor (from silo theory);
h is the depth of cover, in m;
hw is the ground-water level above the top of the pipe, in m.

For % SPD values other than those shown in Table A.3, use equation (A.5):

$$M_S = M_{S1} \times 100 \times 10[2.8 \times (\frac{SPD}{100} - 1)]^f$$

Where $M_{s,100}$ is the modulus at 100% SPD.

Note 1: In OENORM B 5012 – 1, the power *f* is equal to 0,5. The value 0,4 has been chosen taking into account other investigations which give values lower than 0,5.
Note 2: In the Austrian Standard, soil pressure is used instead of *k* x *h*.

For the distributed surface load, use equation (A.6):

$$M_S = M_{S1} \times [h \times k \times (1 - 0.39 \times \frac{hw}{h}) + \frac{Po \times ko}{\gamma_b}]^f$$

Where

po is the pressure due to the distributed surface load, in N/mm²;
ko is the reduction factor for the distributed load according to silo theory when the trench angle ω is not 90°;
yb is the bulk density of the backfill material, in MN/m³

C.3 Reduction factors for long-term soil moduli E_1 and E_2

Table A.4 gives the values of the reduction factors to be applied to the backfill-soil moduli in zone E1 and E2 to allow for long-term changes in these moduli

Table A.4 – Long-term reduction factors for ATV-A 127 soil groups

ATV soil group	Reduction factor
1	0.90
2	0.85
3	0.80
4	0.75