INSTALLATION PROCEDURE

For

UNDERGROUND GRP PIPELINES

Shriram SEPL Composites (P) Ltd.
CHENNAI - INDIA.

Ph: 91-44-5218 7877 Fax: 91-44-2445 3287
e-mail: info@shriramsepl.com

Installation Procedure: Underground GRP Pipes

1.0 Introduction

To ensure long life and trouble free service from a piping system, proper application of the essential principles of excavation, laying and jointing, bedding, backfilling and field-testing is required. The recommended practices presented in this guide for the installation of buried GRP pipe should be rigorously followed to obtain best results.

This manual is intended to provide the basic requirements and procedures for the successful handling and installation of GRP pipes in Underground Installations. The manual addresses most common circumstances that may be encountered in the field.

The excellent corrosion resistance and many other benefits of GRP pipe will be realized if the pipe is properly installed.

The installation guidelines outlined in this manual, when carefully followed, will ensure a proper long-lasting installation.

2.0 Fire Safety

Glass-reinforced polyester (GRP) pipe can burn. During installation, care must be taken to avoid exposure of the pipe to welder's sparks, cutting-torch flames or other heat/flame/electrical sources which could ignite the pipe material.

This precaution is particularly important when working with chemicals in making lay-up joints, repairing or modifying the pipe in the field.

3.0 Transporting Pipe

When the pipes are transported from the manufacturer's place to project site, **support all pipe sections on flat or arched timber** spaced on a maximum of 4 meters centers (3 meter for small diameter) with 2 meters maximum overhang. **Locate the pipes** to maintain stability and separation. **Ensure that no pipe-to-pipe contact happens during transportation**, so that the vibrations during transport will not cause abrasion.

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.

The transport loading arrangement is shown in Fig.1.

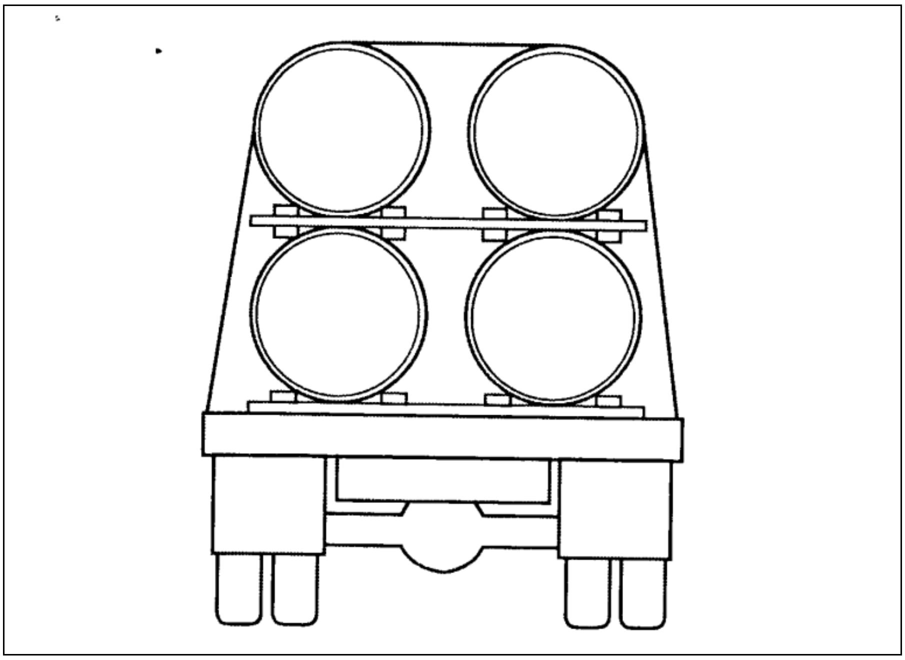


Fig. 1 Transporting Pipe

4.0 Unloading and Handling Pipe

Be sure to maintain control of the pipe during unloading. Guide ropes attached to pipes or packages will enable easy manual control when lifting and handling. Spreader bars may be used when multiple support locations are necessary. ***Do not drop, impact, or bump the pipe, particularly at ends.***

Individual pipe sections can usually be lifted with a single sling (Fig.2), if properly balanced, but two slings, as shown in Fig.3 (located at the pipe quarter points), make the pipe easier to control. Do not lift pipe with hooks or rope inserted through the pipe ends.

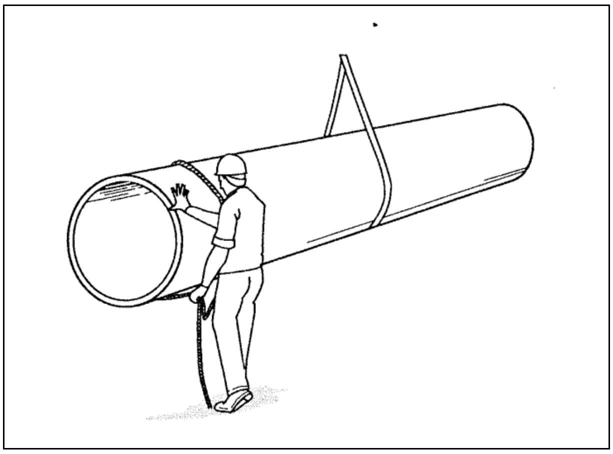


Fig.2 Lifting Pipe at One Support Point

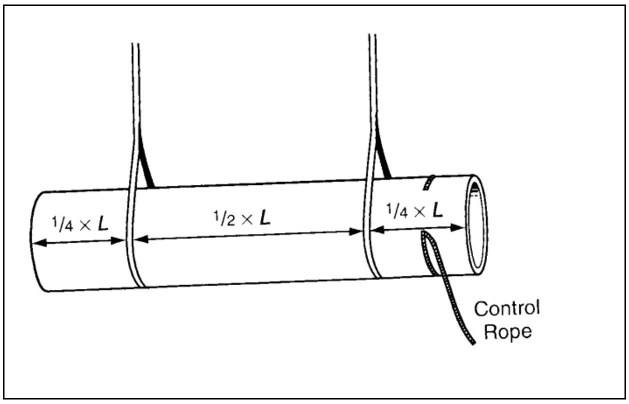


Fig.3 Lifting Pipe at Two Support Points

Packages may be handled using a pair of slings as shown in Fig. 4.

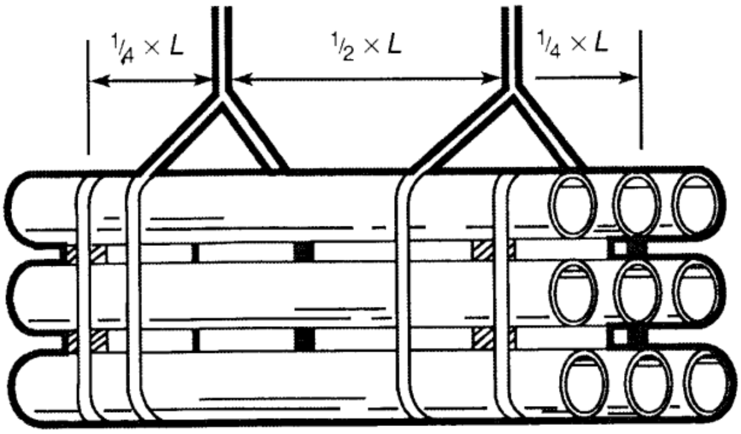


Fig. 4 Lifting Pipe Package

4.1 Handling Instructions

- Pipe and fittings should never be thrown or dropped under any circumstances.
- Pipe lifting is done with slings of adequate strength and of such construction as not to damage pipe. Running of lifting rope inside the pipe shall never occur. Pipe assemblies fabricated of multiple sections may require two points lifting.
- While handling the pipes, impacts must be avoided, particularly of pipe ends.
- Whenever pipe or fittings in contact with wood or metal, rubber sheet padding should be used.
- The pipe should be securely fastened with tie-downs consisting of nylon straps or manila rope. Avoid over-tightening, which may cause excessive localized deformation in the pipe.
- GRP pipe is a light load, particularly with larger diameter pipe. Therefore, reduce speed on rough loads to minimize bouncing.

Caution: Do not place supports under bells, spigots or factory made joints.

5.0 Handling of Nested Pipes

GRP pipes may be delivered nested (i.e. one or more small pipes inside a larger pipe). Nested pipes must always be lifted using at least two straps or slings. De-nesting is accomplished by inserting a forklift/mobile crane boom. Proper padding is essential on the boom. Rubber or wraps of corrugated cardboard sheets over the boom are suitable options to avoid damaging the inside of the pipes. The operator should lift the innermost pipe above the pipe around it sufficiently so the pipes do not touch each other when the inner pipe is being pulled out.

Always lift the nested bundle using at least two pliable straps (Fig.5). 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. This may be calculated from the approximate pipe weights.

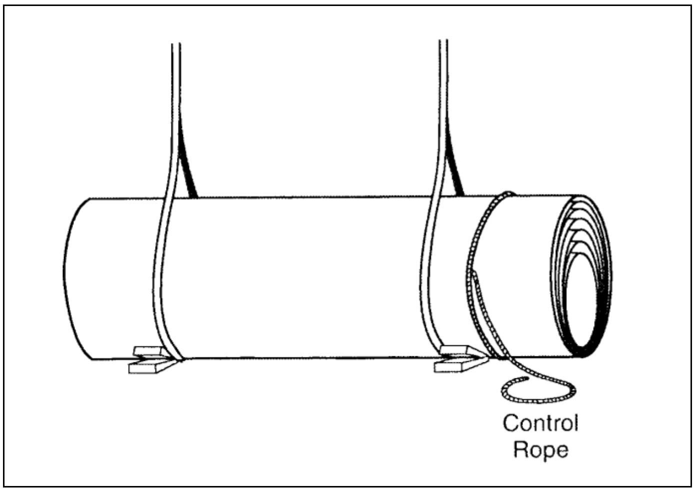


Fig. 5 Double Support Point

a. Nested pipes are usually best stored in the transport packaging. Stacking of these packages is not advisable unless otherwise specified.
b. 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.
c. De-nesting of the inside pipe(s) is accomplished, starting with the smallest size by lifting slightly with an inserted paddle boom to suspend the section and carefully moving it out of the bundle without touching the other pipes (Fig. 6). When weight, length and/or other equipment limitations preclude the use of this method, procedures for sliding the inside pipe(s) out of the bundle will be recommended depending on the pipe sizes for each project.

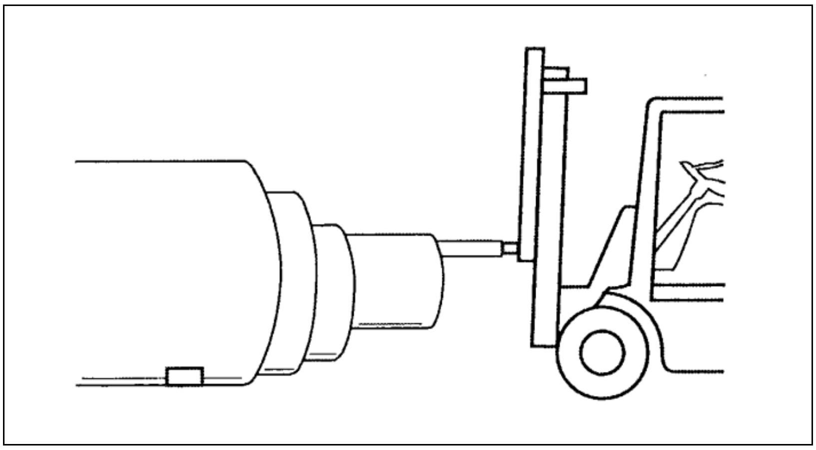


Fig. 6 De-nesting With Padded Boom

6.0 Storage

GRP pipes may be stored outside for extended periods provided the following procedures are observed.

a) GRP pipes may be stored on the plain ground or on wooden logs acting as supports. In case of pipes kept on supports, supports should have a minimum 100 mm wide bearing surface and spaced evenly.

b) It is generally advantageous to store pipes on flat timber to facilitate placing and removal of lifting slings around the pipe.

c) When storing pipe directly on the ground, be sure that the area is relatively flat and free of rock and other potentially damaging debris. All pipes should be located to prevent rolling in high winds.

d) If it is necessary to stack pipes, it is best to stack on flat timber supports at maximum 6 meter spacing (3 meter for small diameter) with chocks (Fig. 7).

e) GRP pipes may be stacked upto a maximum of 3 stacks or to a stack height not exceeding 3.0 m. Stacking shall be provided with side supports or blocks to prevent rolling or slipping in the stack.

f) Protective end coverings on machined spigot surfaces should be left in place until the time of installation to protect the pipe ends and to prevent dirt or other material coming in contact with machined surfaces.

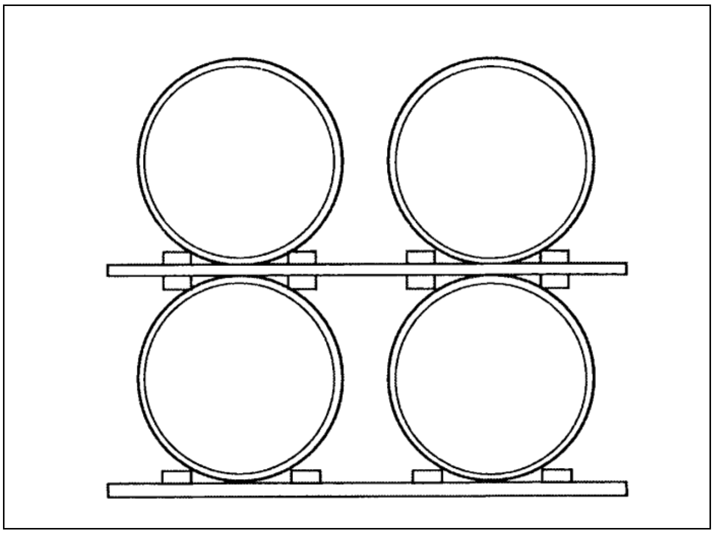


Fig. 7 GRP Pipe Storing Arrangement

7.1 Storing Gaskets, Resin and Field Joint Kits

Rubber ring gaskets for flanges should be stored in the shade and **should not be exposed to sunlight.** The gasket **must be protected from exposures to grease or oils,** which are petroleum derivatives, **and from solvents** and other deleterious substances.

Field joint kits should also be stored in their original packing and should not be subjected to moisture, or contamination.

Resin and catalyst for the joints shall also be stored in shade and in suitable temperature.

8.0 TRENCHING

8.1 Trench Width

The width of the trench, at the top of the pipe should not be greater than is necessary to provide safely and adequate room for jointing of the pipe in the trench and compacting the pipe – zone at the haunches and side of the pipe. Minimum trench widths should be 1.25times the outside diameter of the pipe plus 12in (300mm).

The Minimum trench width = 1.25 x OD of Pipe + 300mm

When butt and wrap joints is executed within the trench, it must be widened by 2 meters for a length of two meters in the joining area, in order to allow proper operations. At the above locations the trench bottom shall be adequately lowered. These joint housings will be filled during backfilling

The trench must always be wide enough to permit the placement and working of compaction equipment to ensure proper compaction of backfill material around the pipe, especially in haunch regions. This may require a wider trench than the minimum specified above, particularly for smaller diameters.

8.2 Trench Depth

The recommended normal cover depth (height of soil above pipe crown) is 1.2m. Cover depth can reduced to a minimum of 600mm; however, engineering check is a must to predict the effects of traffic load and vacuum conditions.

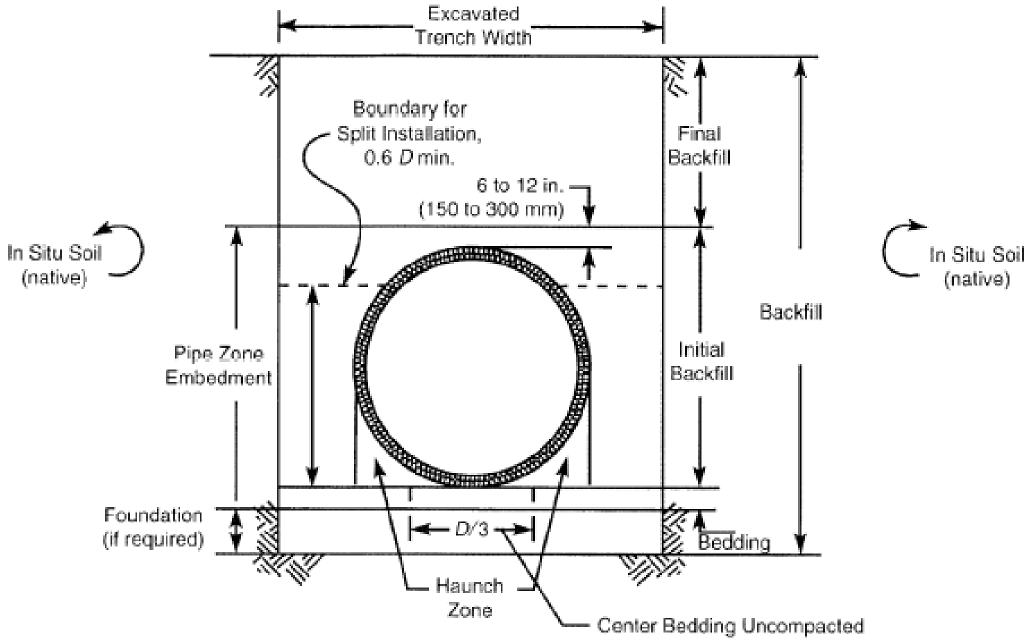


Fig. 8 GRP Pipe Trench Diagram

9.0 BEDDING & BACKFIILL REQUIREMENT

The buried GRP pipes undergo deflection in proportion to the top load and this deflection is resisted considerably by the side restraint provided by the soil around the pipe. The buried GRP pipe deflection primarily depends on the **modulus of soil reaction provided by backfill material.** It is therefore important that GRP pipes are bedded and surrounded by a well-compacted soil, which is capable of providing the necessary restraint to the pipe. The bedding shall provide the continuous support at the bottom over the entire length of the pipe and the backfill material shall provide adequate support around the pipe so that the pipe deflection is resisted under the top soil overburden.

When unstable or highly expansive soils are encountered in the trench bottom, it may be necessary to increase the depth of the bedding layer or a concrete foundation may be provided so that a uniform and continuous pipe support is available for the pipeline.

For buried GRP pipelines, the long-term vertical pipe deflection must not exceed 5% on the diameter. The initial pipe deflection is limited between 3 to 4%. Pipes installed outside these limits may not perform as intended.

9.1 Bedding & Backfilling Material Classification

Soil type used in GRP pipe embedment includes the coarse graded soils as well as the natural, manufactured and processed aggregates. Most gravels, sands and crushed stones are acceptable for GRP pipe zone installation. Excavated trench soils can also be used. If native soil is used, it must be free from foreign object. Soils, according to AWWA M45 are classified in 5 soil stiffness category (Table.1). The symbols GW, GP, SW, SP, GM, GC, SM, SC, ML, CL etc., are in accordance to ASTM - D2488.

Table 1 Soil Stiffness Categories

Soil Group	Soil stiffness Category
Crushed rock and gravel with < 15 % sand ≤ 5 % fines	SC 1
GW, GP, SW, SP, dual symbol soil containing one of these designation such as GW – GC Containing 12% fines or less	SC 2
GW, GP, SW, SP with mare than 12 % : and ML, CL , or border line soil beginning with one of these designations, as ML /CL , with 30 % or more retained on the NO. 200 sieve	SC 3
ML, CL, or border line soil, beginning with one of these designations such as ML/ MH, with 30 % or more retained on the NO. 200 sieve	SC 4
CH , MH , OL , OH, PT, CH / MH, and any frozen materials	SC 5

SC1 materials provide maximum pipe support for a given density due to low contents of sand and fines. With minimum effort, SC1 material can be installed at relatively high soil stiffness over a wide range of moisture contents.

SC2 materials, when compacted, provide a relatively high level of pipe support; however, open graded groups may allow migration and the sizes should be checked for compatibility with adjacent material.

SC3 materials provide less support for a given density than SC1 and SC2 materials. Higher levels of compactive effort are required and moisture content must be controlled. These materials provide reasonable levels of pipe support once proper density is achieved.

SC4 materials require a geotechnical evaluation prior to use. When properly placed and compacted, SC4 materials can provide reasonable levels of pipe support; however, high energy level vibratory compactors and tampers, do not use where water conditions in the trench prevent proper placement and compaction.

9.2 Material for Bedding

Properly graded material meeting the soil stiffness categories from SC1 to SC3 shall be used with required level of compaction as per the recommendation given in Table 3. Native soil shall normally be used on meeting the above requirement.

9.3 Material for Initial Backfill (Pipe Zone Embedment):

Soil categories, SC1 through SC4 shall be used as per the recommendations of Table 3.

9.4 Material for Final Backfill (Covering):

Native soil is normally used for the final backfill.

Table 2 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[a]				Soil Classification: Group Symbol	Soil Classification: Group Name[b]
Coarse-grained soils More than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	**Clean gravels** Less than 5% fines[c]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[e]	GW	Well-graded gravel[f]
			$Cu < 4$ and/or $1 > Cc > 3$[e]	GP	Poorly graded gravel[f]
		Gravels with fines More than 12% fines[c]	Fines classify as ML or MH	GM	Silty gravel[f,g,h]
			Fines classify as CL or CH	GC	Clayey gravel[f,g,h]
	Sands 50% or more of coarse fraction passes No. 4 sieve	**Clean sands** Less than 5% fines[d]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[e]	SW	Well-graded sand[i]
			$Cu < 6$ and/or $1 > Cc > 3$[e]	SP	Poorly graded sand[i]
		Sands with fines More than 12% fines[d]	Fines classify as ML or MH	SM	Silty sand[g,h,i]
			Fines classify as CL or CH	SC	Clayey sand[g,h,i]
Fine-grained soils 50% or more passes the no. 200 sieve	**Silts and clays** Liquid limit less than 50	**Inorganic**	PI > 7 and plots on or above "A" line[j]	CL	Lean clay[k,l,m]
			PI < 4 or plots below "A" line[j]	ML	Silt[k,l,m]
		Organic	(Liquid limit—oven dried) / (Liquid limit—not dried) < 0.75	OL	Organic clay[k,l,m,n]; Organic silt[k,l,m,o]
	Silts and clays Liquid limit 50 or more	**Inorganic**	PI plots on or above "A" line	CH	Fat clay[k,l,m]
			PI plots below "A" line	MH	Elastic silt[k,l,m]
		Organic	(Liquid limit—oven dried) / (Liquid limit—not dried) < 0.75	OH	Organic clay[k,l,m,p]; Organic silt[k,l,m,q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

[a] Based on the material passing the 3-in. (75-mm) sieve.
[b] If field sample contained cobbles and/or boulders, add "with cobbles and/or boulders" to group name.
[c] Gravels with 5% to 12% fines require dual symbols:
GW–GM well-graded gravel with silt
GW–GC well-graded gravel with clay
GP–GM poorly graded gravel with silt
GP–GC poorly graded gravel with clay
[d] Sands with 5% to 12% fines require dual symbols:
SW–SM well-graded sand with silt
SW–SC well-graded sand with clay
SP–SM poorly graded sand with silt
SP–SC poorly graded sand with clay
[e] Cu = D60/D10

$$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

[f] If soil contains ≥ 15% sand, add "with sand" to group name.
[g] If fines classify as CL–ML, use dual symbol GC–GM or SC–SM.
[h] If fines are organic, add "with organic fines" to group name.
[i] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[j] If the Atterberg limits (liquid limit and plasticity index) plot in hatched area on plasticity chart, soil is a CL–ML, silty clay.
[k] If soil contains 15% to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[l] If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
[m] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[n] PI ≥ 4 and plots on or above "A" line.
[o] PI ≤ 4 or plots below "A" line.
[p] PI plots on or above "A" line.
[q] PI plots below "A" line.

Table 3 Recommendation for Pipe Embedment

	SC 1	SC 2	SC 3	SC 4
General recommendations and Restrictions	Acceptable and common where no migration is probable or when combined with a geotextile filler media.	Where hydraulic gradient exists, check the gradation to minimum migration	Do not use where condition in trench prevent proper placement and compaction	Difficult to achieve required soil stiffness. Do not use where condition in trench prevent proper placement and compaction
Pipe zone embedment	Suitable as restricted above. Work martial under pipe to provide uniform haunch support		Suitable as restricted above. Difficult to above place and compact in the hunching zone.	
Embedment compaction: Minimum , SPD	Required density typically achieved by damped placement	85 %	90%	(5 %
Relative compactive effort required	Low	Medium	High	Very high
Compaction method	Vibration or Impact	Vibration or Impact	Impact	Impact
Required Moisture control	None	None	Maintain near optimum to minimize compactive effort	Maintain near optimum to minimize compactive effort

9.5 Bedding and Backfilling Procedure

9.5.1 Backfilling

The bed must be compacted until reaching 90% Standard Proctor Density before the pipe installation. Where rock, hard pan, soft, loose, unstable or highly expansive soils are encountered in the trench bottom, it may be necessary to increase the depth of the bedding layer to achieve adequate longitudinal support.

9.5.2 Backfilling

Backfilling shall be placed in singly compacted layers 250-300 mm high in the primary backfill zone.

Compaction can be made by using an impulsive compactor or any other suitable equipment. Backfill should be compacted to 90 – 95 % Proctor. **It is important to ensure that the material is completely filled and well compacted under the haunches of the pipe**.

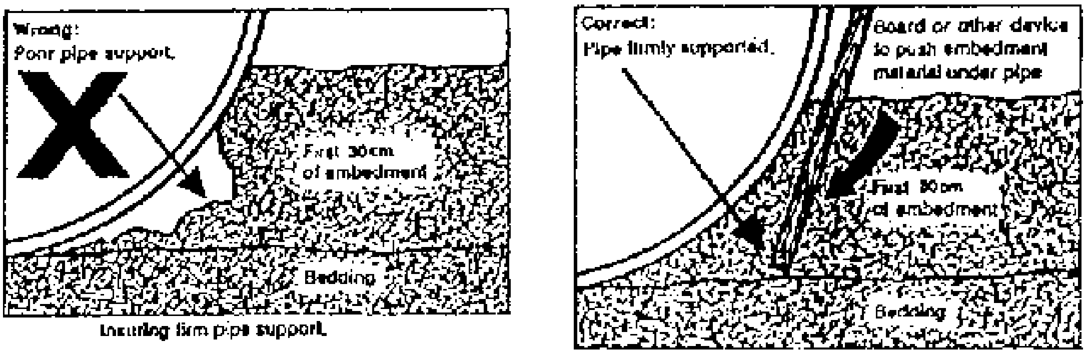


Fig.9 Haunching

10.0 BELL & SPIGOT WITH RUBBER SEAL JOINT

Bell and Spigot with elastomeric seal joint is used to connect two GRP pipes mainly used for underground application. Bell & Spigot joint has a groove on the Bell end to retain an elastomeric seal that shall be the sole element of the joint to provide the water-tightness. This flexible joint allows for axial movement of the spigot in the Bell and some angular deflection.

The schematic arrangement of Bell & Spigot with rubber seal is shown in the sketch. The GRP pipe will have one end provided with Bell and other end provided with a matching Spigot. The essential requirements to accomplish this jointing are:

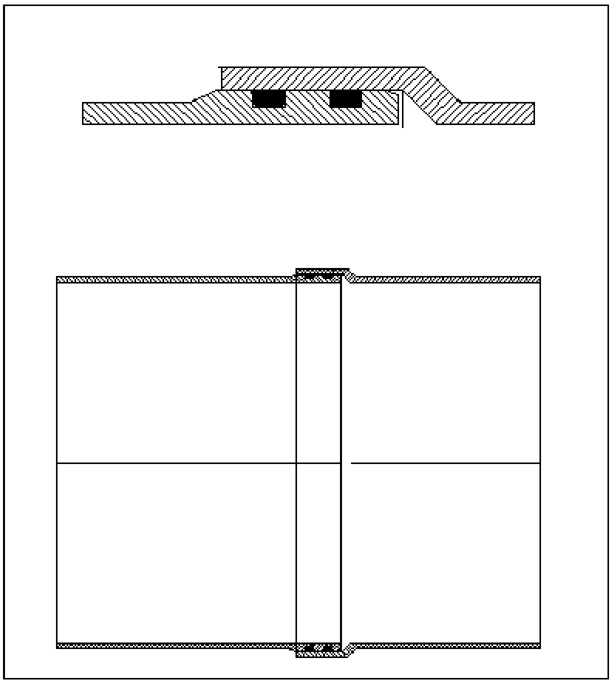


Fig. Bell & Spigot Joint with Elastomeric Seal.

- Bell provided at one end of the pipe
- Spigot provided at other end of the pipe
- Elastomeric seals made of rubber

Bell End: The Bell end is an integral filament wound part of the pipe. The inner diameter of the bell end is manufactured perfectly to suit the spigot end with required tolerance.

Spigot End: The other end of the pipe will have the spigot. The spigot end is accurately machined to the required tolerance.

Rubber Seal: The rubber seal is made up of EPDM rubber. This rubber seal provides a very tight leak proof joint.

10.1 Joint Assembly

Tools required for assembly of joint

1. Chain pulley block
2. Nylon slings.
3. Wooden supports

Accessories / consumables required

1. Cloth
2. Vegetable based lubricant.

10.2 Joining Method

Step 1: Clean the Bell & Groove

Thoroughly clean the inside of Bell end and Groove with clean cloth. Make sure that any dirt or oil left on the surface. *Do not use cotton waste* in order to prevent thread or fibers stick on the sealing surface.

Step 2: Install Gaskets

Insert the O-Rings into the groove. Do not use any lubricant in the groove or on the gasket at this stage of assembly. Water may be used to moisten the gasket and groove to ease positioning and insertion of the gasket.

- With uniform pressure, push the rubber O-rings into the spigot groove.
- When installed, pull carefully on the gasket in the radial direction around the circumference to distribute compression of the gasket.

- Check also that both sides of the gasket protrude equally above the top of the groove around the whole circumference.
- Tapping with a rubber mallet will be helpful to accomplish the above

Step 3: Lubricate Gasket

Using a clean cloth, apply a thin film of lubricant to the rubber gaskets. Always use vegetable based lubricants, *never use petroleum based lubricants*.

Step 4: Clean and Lubricate Spigot.

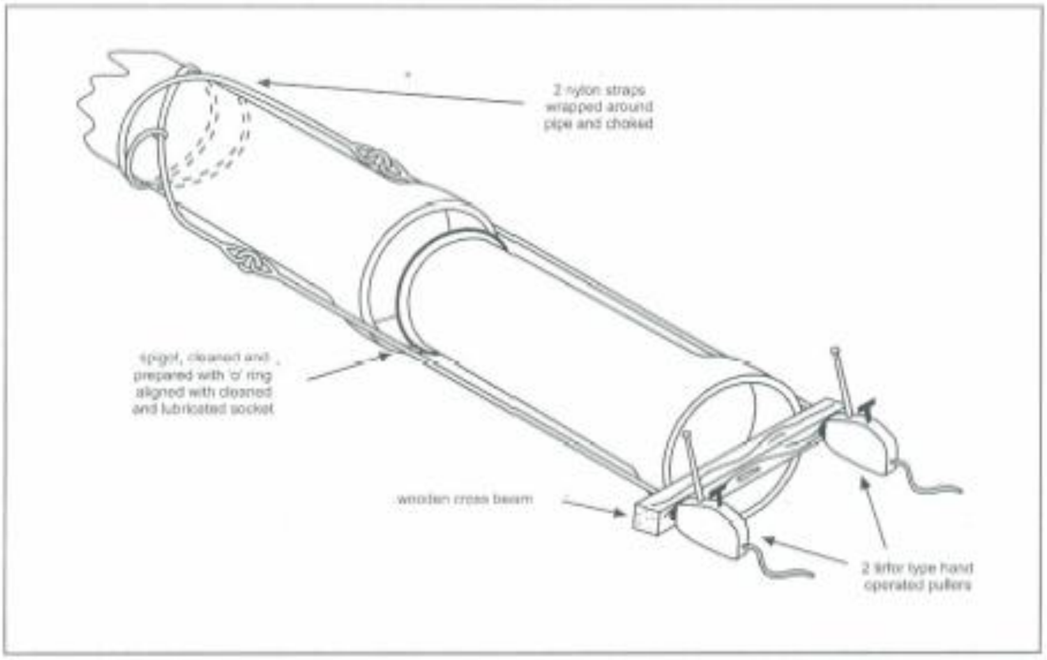
Thoroughly clean pipe spigot to remove any dirt, grit, grease, etc. Using a clean cloth, apply a thin film of lubricant to the spigots from the end of the pipe. After lubricating, take care to keep the bell and spigot clean.

Step 5: Fixing of Clamps

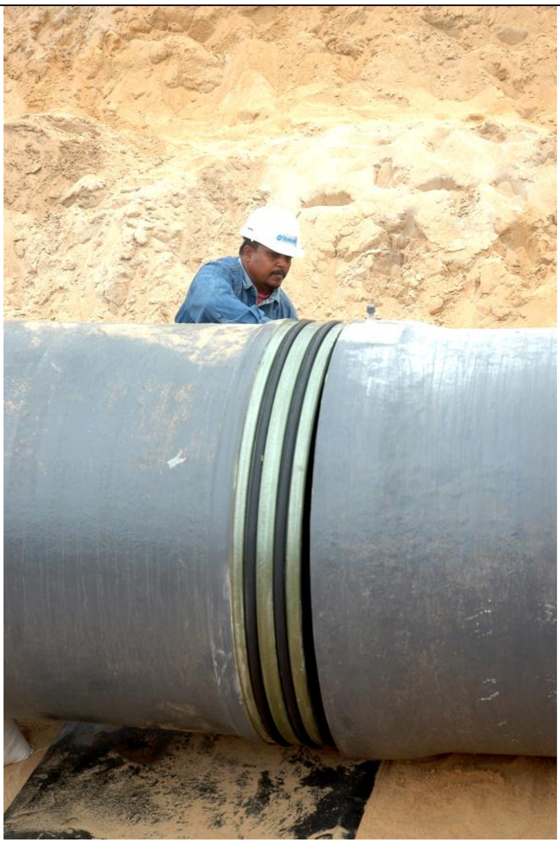
Fix first clamp near to the bell end of one pipe or at the left in position to next joint. Fix Clamp B on the pipe to be connected in the correct position.

Step 6: Pipe Placement

The pipe to be connected is placed on the bed with sufficient distance from previously joined pipe to allow lowering the coupling into position.



TYPICAL PIPE INSERTION IN THE FIELD

	
PIPE ALIGNMENT BEFORE INSERTION – A FIELD VIEW	**CLOSER VIEW OF PIPE INSERTION IN THE FIELD**

After backfill is completed on a section of pipe, test for sufficient support by measuring deflection. Vertical inside diameter measurement is taken at least 1.0 m behind the joint of the installed pipe.

$$\text{Deflection} = \frac{\text{Original ID} - \text{Installed Vertical I.D}}{\text{Original ID}} \times 100$$

Fig.11 Lowering with Ropes

11.0 Field Repair procedure

When damage occurs or is revealed during an inspection, the appropriate method of correction or repair shall be decided. The repair method will depend on the extent of the damage. Typically, damaged pipe can be repaired quickly and easily by qualified personnel at jobsite. The repair procedure based on the extent of damage is described below.

Normally, pipes with minor damage can be repaired quickly and easily at the job site by a qualified individual.

The Field Service Engineer shall determine whether repair is required and weather it is possible and practical. He shall obtain the appropriate repair specification from the technical services department and organize the repair job. Repair designs can vary greatly due to pipe thickness, wall composition, application, and type and extent of damage. ***Therefore, do not attempt to repair a damaged pipe without consulting SSCPL first. Improper repaired pipes may not perform as intended.***

11.1 Minor Repair

Minor repair to pipe and fittings may be repaired on site. The damaged outer layer shall be ground, cleaned and resin/hardened mix applied as per recommendations. Damages in GRP pipes and Fittings are to be repaired as follows.

11.1.1 Pipe Interior

a) The damaged area is ground upto the end of liner with sand paper or with an electrical grinder.

b) The ground surface is thoroughly cleaned for to remove any dust particles adhered to the surface

c) A thin coat of previously prepared resin is applied with a brush onto the surface to be repaired

d) Chopped Strand Mat (CSM 225 or CSM 300) is applied, saturated with resin using a brush

e) Air bubbles are squeezed out using a roller

f) Steps(d) and (e) must be repeated up to the liner thickness;

g) A glass surfacing "C" veil is applied and saturated with resin using a brush

h) After one hour, the resin will be hardened. The repaired surface is then ground to an even surface and a paraffinated resin (post coat) coat is applied.

11.1.2 Pipe Exterior

a) The damaged area is ground upto the end of liner with sand paper or with an electrical grinder.

b) The ground surface is cleaned for dust removal

c) A thin coat of previously prepared resin is applied with a brush onto the surface to be repaired

d) Chopped Strand Mat (CSM 225 or CSM 300) is applied, saturated with resin using a brush

e) Air bubbles are squeezed out using a roller

f) Steps(d) and (e) must be repeated up to the liner thickness;

g) After one hour, the resin will be hardened. The repaired surface is then ground to an even surface and a paraffinated UV resistant resin coat is applied.

11.2 Major Repairs

It is recommended that damaged sections be replaced, if the damage is large. Replacement of damaged piping sections with new piping sections shall be considered as a new installation and be performed according to the methods and requirements of fabrication. Requirements of pipe fitter and inspector qualifications for replacement of piping shall be identical to the requirements for installing original piping.

12.0 Spacing between Pipes in the Same Trench

Space parallel piping systems laid within a common trench sufficiently far apart to allow compaction equipment to compact the soil between the pipes. The minimum distance that should be allowed between pipes is the average of the radii of the two adjacent pipelines, but not less than 100mm (Fig. 12)

When mechanical compaction equipment is used, a clearance of 150 mm greater than the width of the widest piece of equipment may be considered as a practical clearance between the pipes. Compact the soil between the pipes the same manner as the soil between the pipes and the tench wall, taking special care to compact the soil in the haunch zone of each pipe.

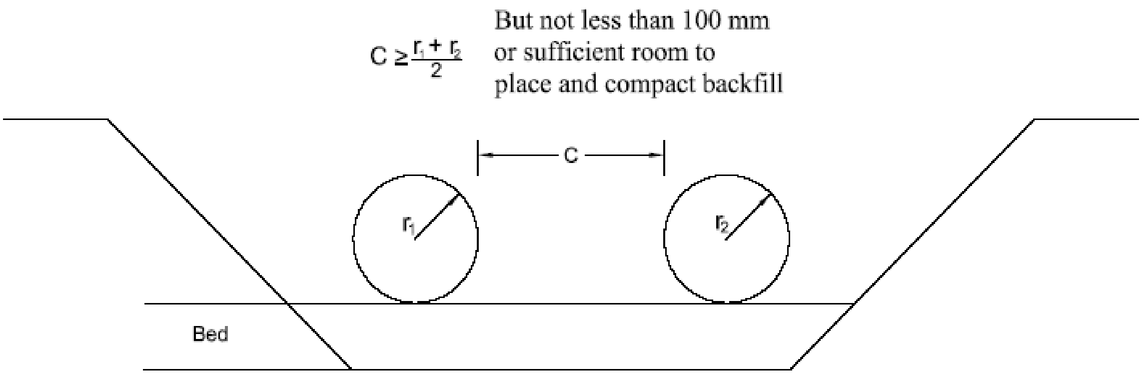


Fig.12 Spacing between Pipes in the Same Trench

13.0 Cross-over of Adjacent Piping System

When one piping system will cross over another, the minimum vertical clear space between the two pipes should be the average of the radii of the two pipes, but not less than 300mm. (Fig.13). The trench in which the lower pipe is installed should be backfilled with SC1 or SC2 material compacted to a minimum of 90 SPD.

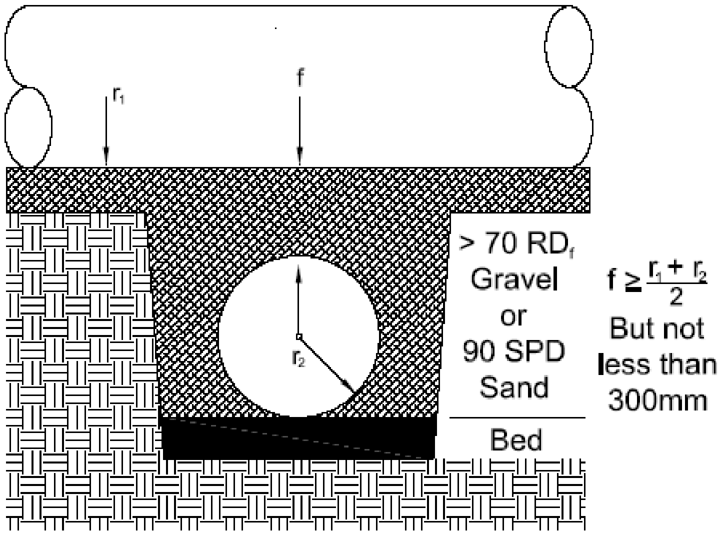


Fig.13 Spacing between Pipes in the Same Trench

14.0 Connections to Manhole, Rigid Structure & Changing Foundation Soils (For Differential Settlement)

When differential settlement can be expected, whenever the pipe enters concrete structures such as manholes, anchor blocks, or where foundation soils change stiffness, provide a flexible system capable of accommodating the anticipated settlement.

This may be accomplished by placing a joint as close as practically possible to the face of the structure and a second joint within one to two pipe diameters of the face of the structure. (Fig.14 & 15). The short length of pipe, called a rocker pipe shall be installed in straight alignment with the short pipe section coming out of the rigid structure. The rocker pipe should have a minimum pipe stiffness of 248 kPa to transition between lower stiffness pipe and the rigid structure. Multiple rocker pipes should not be used.

Alternatively, attach the pipes to the rigid structure with a flexible boot capable of accommodating the anticipated differential movement. Extra care and caution must be taken to replace and properly compact backfill adjacent to any rigid structure. Construction of concrete structures will frequently require over excavation for form work, etc. This extra excavated material must be restored to a density level compatible with surroundings to prevent excess deformation and/or joint rotation adjacent to the structure. In these areas, compact backfill to achieve the same soil density as specified for all pipe backfill but not less than require to achieve a soil modulus of at least 6.9 MPa. The use of cement stabilized backfills adjacent to large structures has been found to be effective in preventing excess deformation where diameters are larger than about 1500 mm.

Where the GRP pipes entered or leave rigid structures, such as when passing through walls, into anchor block, manholes, valve camber, etc. it is possible for shear stresses to be introduced into the pipe line by differential settlement.

It is thus necessary to follow the established pipeline practice of introducing two flexible joists in close proximity to the rigid structure, so that shear stresses can be minimized by articulation.

The method of connection to the concrete structure is shown in the enclosed sketch. It is also recommended that pipes built into a rigid structure should have a flexible relieving band of rubber, 100 mm wide minimum width, wrapped around the pipe at the point of entry to eliminate localized stress points.

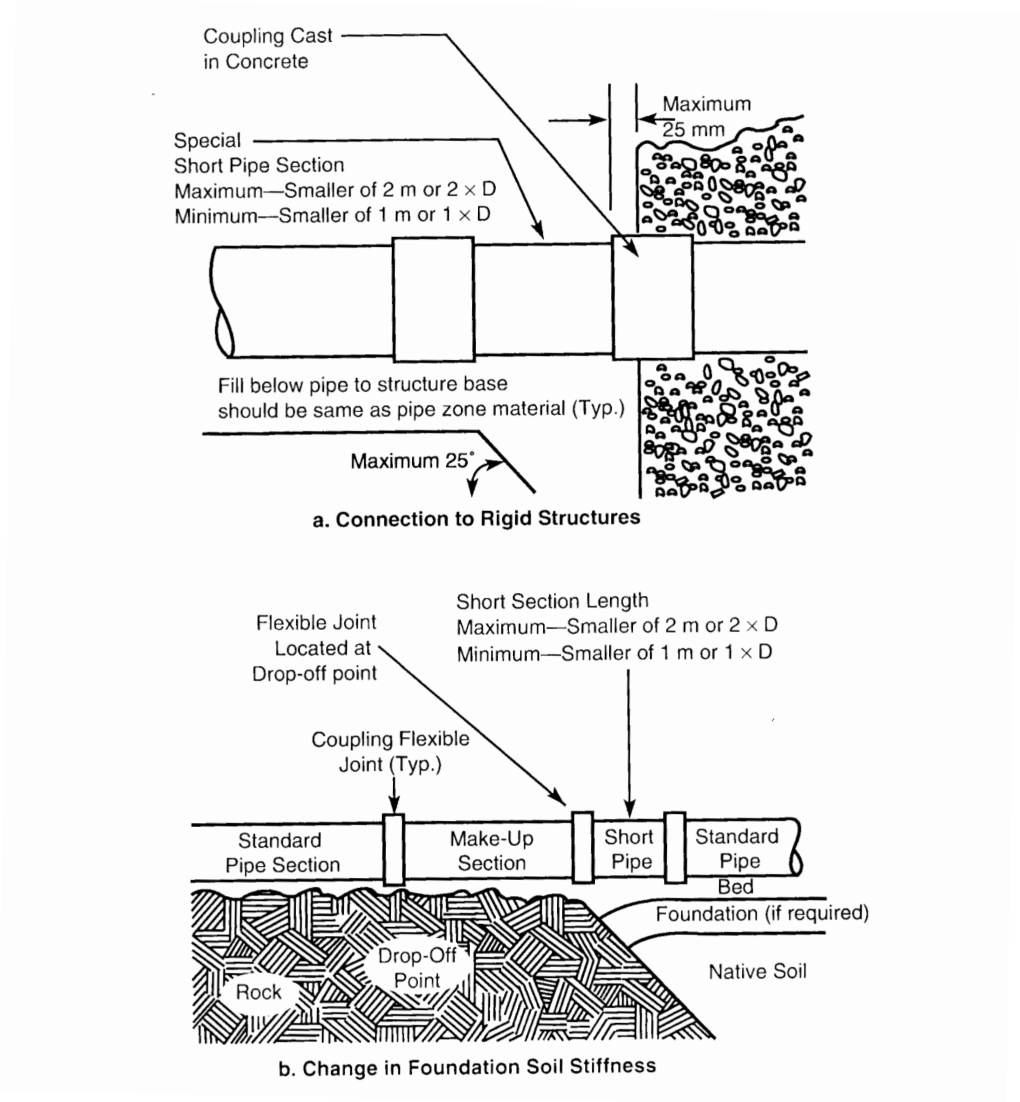


Fig.14 GRP Pipes Connection to Rigid Structures
(SHEMATIC ARRAMEMENT)

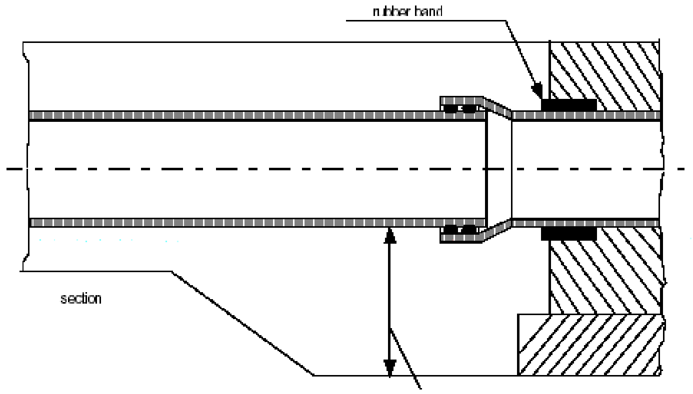


Fig.15 GRP Pipes Connection to Rigid Structures
(SECTIONAL VIEW OF PIPE ASSEMBLY)