ADVANCED PIPING SOLUTIONS
حلـــول الأنابيـــب المتـطـورة

RCP Product Guide

INDEX

1. INTRODUCTION

APS established a Reinforced Concrete Pipe(RCP), Reinforced Concrete Jacking Pipe(RCJP) and Reinforced Concrete Manhole(RCMH) facility in Rabigh area, western province of the Kingdom of Saudi Arabia. The plant manufactures RCP,RCJP and RCMH by using two types of technology called, dry cast and wet cast.

Backed by highly skilled engineering staff and spe cialized equipment procured from worldwide recognized manufacturer. ACWAPIPE produces custom designed pipeline systems ranging in diameter from 300 mm. to 3500 mm.

Diameter and class options available make precast concrete pipes and manholes an attractive, economical and practical structure for a broad range of pipeline applications. These include storm drain, gravity sewers and culverts.

The company produces at this facility plain reinforced concrete pipes, jacking pipes with or without differ-ıt kinds of lining such as GRP,HDPE and PVC. The estimated total annual production capacity is 150,000 tons of concrete products.

2. APPLICATIONS

Reinforced Concrete Pipe (RCP) is recognized by engineers, contractors and specifying agencies as the most resistant and economical of all piping products. (RCP) is specially designed and used for the following applications:

- Storm drains
- Sanitary sewers
- Culverts
- Industrial waste
- Irrigation
- Gravity water supply
- Jacking & Micro tunneling operations

3. BENEFITS

(RCP) is one of the strongest pipes available in the market. It can be designed and tested to resist live and dead loads. Accurately placed steel reinforcements and densely compacted concrete wall, RCP can withstand substantial live and dead loads.

(RCP) is one of the most durable and long-lasting pipes that has been used extensively throughout the globe. Properly installed, the service life for concrete culverts, storm drain and sanitary sewer can exceed more than 100 years.

(RCP) has a relative smooth interior wall surface which means capacity specified is the capacity achieved.

(RCP) required little or no maintenance and offers the greatest long-term value.

(RCP) is not combustible and therefore will not hold flame after fire has been introduced into the drainage system.

(RCP) has a high impact resistance. It won't crush, buckle, split or deflect.

4. MATERIALS

Materials used in the manufacturing of precast concrete pipe consist of locally available materials. The basic materials of concrete pipe are

- Steel reinforcement
- Coarse aggregate
- Portland cement
- Water
- Admixture

The materials for concrete are combined in a systematic manner, using quantities and proportions specially designed for each product. Mix designs are developed to provide optimum strength and density, and actual proportioning is controlled by precision batching equipment.

The steel cage is an assembled unit of steel reinforcement consisting of circumferential and longitudinal bars or wires. A cage machine uses reels steel wire. By means of adjustable guides, it positions the longitudinal wires while wrapping the circumferential wire helically.

Ancillary items such as inner lining with Glass Reinforced Plastic, High Density Polyethylene and others, external coating can be applied in accordance with project specifications.

5. PRODUCTION PROCESS (DRY Cast)

DRY CAST PROCESS

Dry cast system is concrete with relatively low water/cement ratio. The production process is based on the space between inner and outer mould, which will be filled without segregation with zero slump concrete while the inner core vibration take care of the compaction. After compaction and forming of the spigot, the complete pipe will be demoulded immediately, and covered to avoid evaporation of water out of the concrete (curing).

1- Outer mould picking up the pallet with reinforcement cage

2- Forming the pipe spigot

3- Press-head removed from mould with formed spigot

4- The outer mould removed from pipe (demoulded or stripped)

6. PRODUCTION PROCESS (WET Cast)

WET CAST PROCESS

Wet casting of the concrete pipe, as the name implies, uses concrete mix that is wet relative to the mixes used in the other processes. The mix usually has a slump of less than four inches. The wet cast process is most commonly used for the production of large diameter pipes up to 3500mm and more where it is manufactured, cured and stripped at one location. Inner and outer forms are most commonly mounted in a vertical position

With vertical forms a cone attached to the inner form is used to direct the concrete mix. The mix is transported to the form by crane. As the mix is placed in the mould it is vibrated using external vibrators. After the annulus of the forms has been filled, the cone is removed, and the pipe cured in the form. Following the curing period, usually overnight, the forms are removed and the pipe moved to the storage area.

1 – A Pouring cone used to distribute fresh concrete into the forms

2 – Concrete is placed in the bucket and transported by crane

3 – Pouring concrete

4 – Protective coating is being applied by airless spray

7. PIPE CURING

Depending on the production method, the pipe is either cured while in the form or immediately removed from the form and cured. Curing is accomplished by a variety of procedures. In some case, the pipe is placed in a permanent enclosure, and in other case, the pipe is covered by, canvas, plastic or other material which function as an enclosure.

As soon as the concrete pipe is formed, the curing process begins. Curing is optimized by control heated chambers conditions and thus, accelerates hydration of cement. Steam, water, and sealing membrane. In the concrete industry, low pressure steam predominates as a curing method.

Concrete pipe can be cured in an open air provided temperature are high and constant. It is necessary under these conditions to maintain the pipe in moist condition. A sprinkler system is most commonly used to provide such an environment.

1 – Steam Curing

2 – Sealing membrane

8. QUALITY ASSURANCE & CONTROL

APS is implementing a well established quality assurance and quality control procedures to ensure that all its products meet with relevant international standards as well as customer and project specifications. In-house quality engineers and technicians must perform all routine tests and inspections to assure that finished product comply with quality procedures, project specifications and drawings. Each pipe and specials are given one final inspection before release for delivery.

9. TECHNICAL DATA

Standard Pipes (DRY CAST)

Pipe Ø (mm)	Conc. Vol. (m)	O.D. (m)	Wall thickness (mm)	length (mm)	Approx.Weight (ton.)
300	0.28	438	69	2500	0.5
400	0.31	554	77	2500	0.8
500	0.44	672	86	2500	1.0
600	0.69	788	94	3000	1.5
700	0.77	904	102	3000	1.85
800	1.10	1022	111	3000	2.4
900	1.14	1138	119	3000	2.74
1000	1.47	1254	127	3000	3.3
1100	1.60	1374	137	3000	3.83
1200	1.83	1488	144	3000	4.5
1400	2.51	1738	169	3000	6.2
1500	2.67	1838	169	3000	6.6
1600	2.99	1956	178	3000	7.3
1800	3.66	2188	194	3000	9.0
2000	4.42	2422	211	3000	10.8
2200	5.24	2656	228	3000	12.8
2400	6.11	2888	244	3000	14.9
2500	6.60	3006	253	3000	16.1

Jacking Pipes (WET CAST)

Pipe Ø (mm)	Conc. (m□)	O.D. (mm)	Wall thickness (mm)	Length (mm)	Approx. Weight (ton.)
600	0.89	860	130	3000	2.1
700	0.98	960	130	3000	2.35
800	1.54	1090	145	3000	3.7
1000	1.50	1280	140	3000	3.6
1200	1.84	1490	145	3000	4.5
1400	2.03	1680	140	3000	5.0
1500	2.19	1800	150	3000	6.8
1600	2.83	1940	170	3000	6.9
1800	2.60	2200	200	3000	9.0
2000	4.40	2422	211	3000	10.5
2200	4.89	2630	215	3000	12.0
2400	6.24	2900	250	3000	15.2
2500	6.67	3030	265	3000	16.2
2600	6.71	3100	250	3000	16.8
3000	9.33	3600	300	3000	22.8
3500	9.89	4240	370	2200	24.2

10. PIPE JOINTS

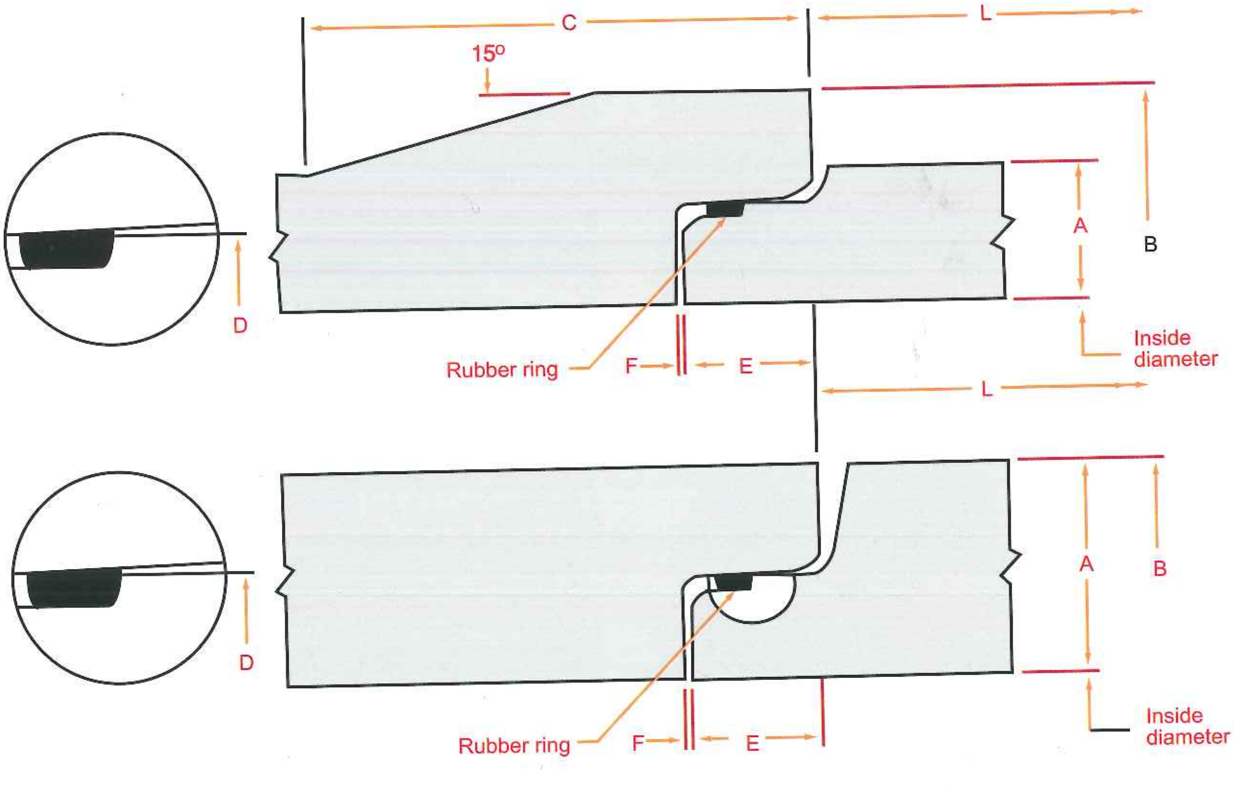
An accurately formed socket and spigot joint sealed by a rubber gasket ring confined in a groove in the spigot.

Precast reinforced concrete pipe joints are easily assembled, which helps minimize the time needed for pipe installation.

Concrete pipe offers a variety of joints from soil tight to pressure. Joint performance must be demonstrated at the plant prior to pipe installation and joint integrity can be field tested in a variety of ways.

Gasket leak resistant Reinforced Concrete (RCP) withstand a minimum hydrostatic internal head of 13psi according to ASTM C443.

Profile gaskets are used on storm water culverts and (RCP) storm drainage and sanitary sewers. Open trench pipe is produced with a single offset spigot joint according to ASTM designation C443.



11. STANDARD SPECIFICATIONS

These Specifications cover reinforced concrete pipe intended to be used for the transmission of sewers, storm waters, industrial waste, and for the construction of culverts:

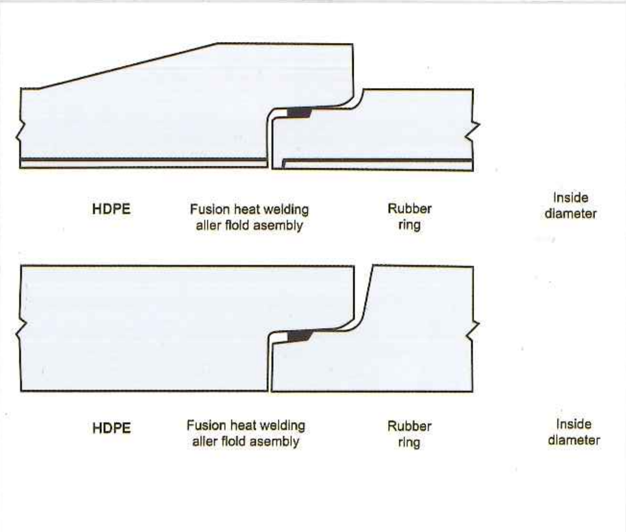
- ASTM C76M : Reinforced Concrete Culvert, Storm Drain and Sewer Pipe
- ASTM C478M : Precast Reinforced Concrete Manhole section
- BS 5911-1:2002+A2:2010: Specification for unreinforced and reinforced concrete pipes(including jacking pipes) and fittings with flexible joints
- BS EN 1916:2002 : Concrete pipes and fitting, unreinforced, steel fibre and reinforced

12. HDPE LINED REINFORCED CONCRETE SEWER PIPE(RCP)

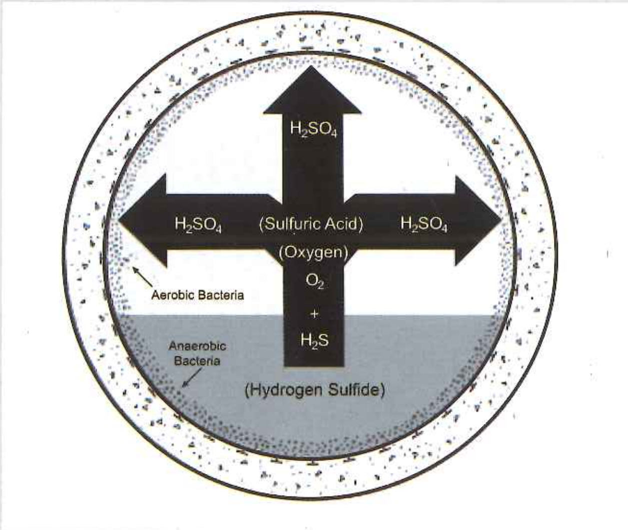
When the application entails the transmission of concentrated sewage of corrosive industrial wastes, reinforced concrete pipe with a HDPE lining should be used. Its manufacturing process and dimensions are similar pipe(RCP).

Durability , long life, economy, resistance to acids, alkalis and salts, all are combined in reinforced concrete pipe lined with HDPE lining.
This substantial High Density Polyethylene mechanically locked into the wall of precast concrete pipe has proved to be the most successful method ever devised for protecting concrete from the corrosive effects of sanitary and industrial waterwaste.

With the increasing load placed on urban wastewater systems, HDPE lining offers the most effective solution to total pollution control at the lowest cost based on service life of the systems.
HDPE lining is a continuous sheet backed with integral ribs which are permanently locked into the concrete pipe wall as the pipe is manufactured. HDPE lining provides 360° coverage of the pipe interior. Continuity of the pipe lining is assured by fusing each individual pipe liner with the next. This results in a lining which is permanently flexible, withstands temperature as high 83°c, has lower friction coefficient than concrete, a minimum elongation factor of 200 % and offers no sustenance to either fungal or bacterial slimes. The simple fusion heat welding of the sheets across the joint during pipe installation provides complete, permanent protection against the destructive elements found in sanitary sewers and industrial waste systems.



Joint sections of HDPE lined reinforced concrete sewer pipe



Generation of corrosive acids from sewer gas

13. PIPES INSTALLATION

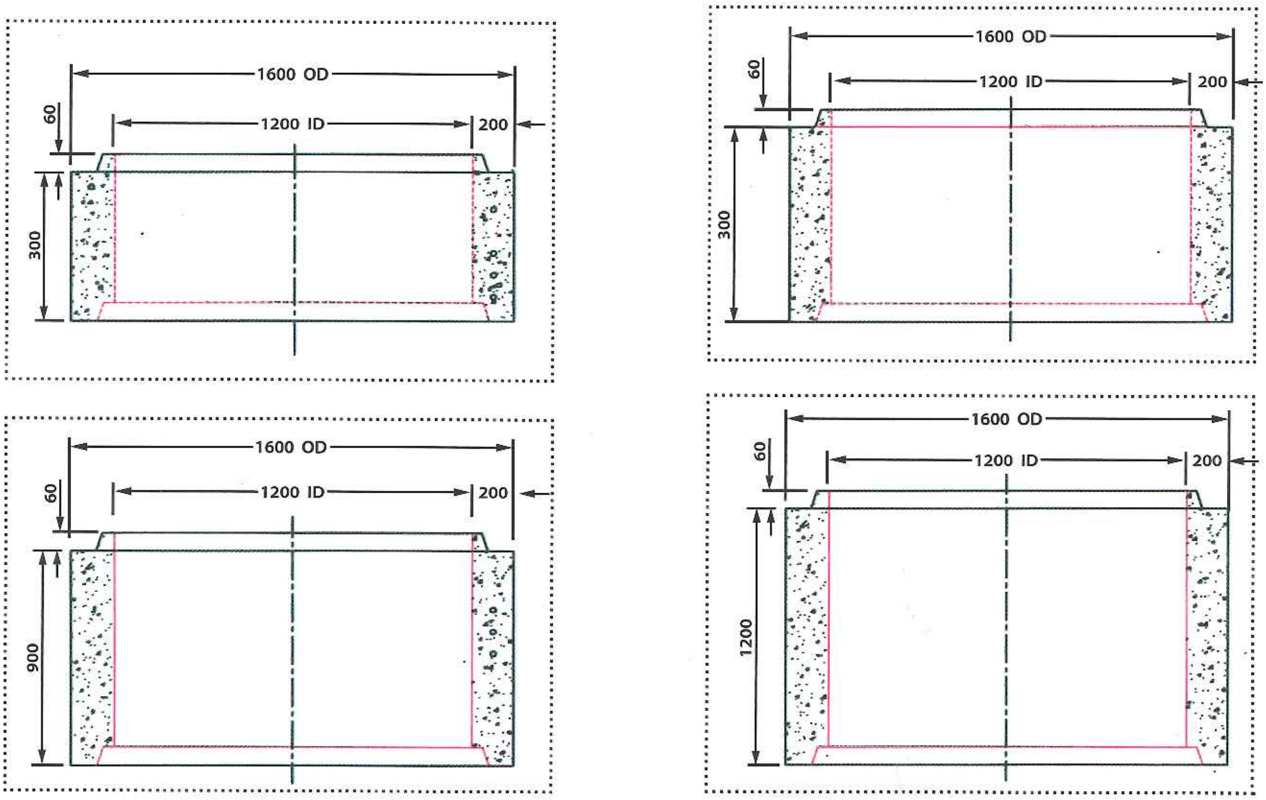
13.1 - Jacking & micro tunneling installation.

Jacking or micro-tunneling concrete pipe is an increasingly important construction method for installing concrete pipelines without interrupting commerce, road transport, or disturbing the maze of utilities, services buried under the surface of our streets and roadways. It is good check on projects regarding tight construction space, long-term responsibility for road cuts and the removal and disposal of spoil materials.

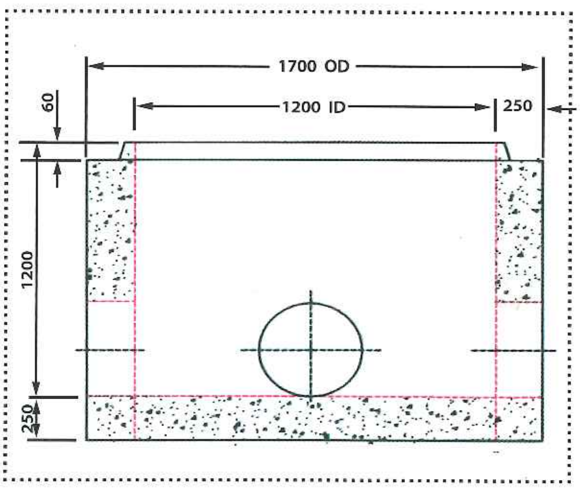
13.2 - Trench pipe installation.

(RCP) storm drain pipe is easy and simple to install and is rugged. The pipe is rigid and can withstand substantial live and dead load. An advantage on other pipe material is its resistance to crashing, buckling, slitting and deflection, regardless of the service condition. Ordinary excavated material free of large rocks is suitable for use as back fill material. (RCP) can be installed under road crossing without the need of special bedding or protection.

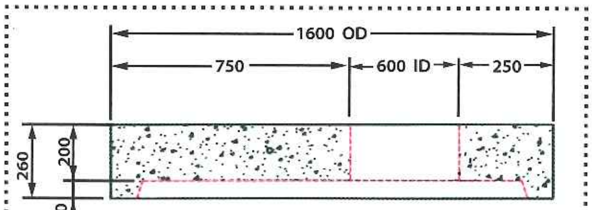
The typical precast concrete manhole consists of riser section, top section, grade rings and in many cases, a precast base section or tee section. Riser sections are of uniform circular cross section, usually 1200 mm. in diameter, but are also manufactured in larger diameters. Precast manholes are constructed with flat top slab.



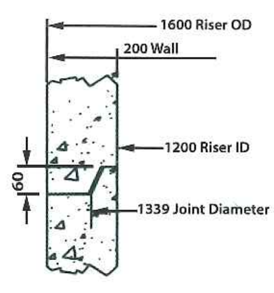
Manhole Risers



Manhole Base



Manhole Flat Top



JOINT DETAIL

15. HYDROSTATIC PRESSURE TEST

Hydrostatic pressure test on joints shall be made on a section of pipe, properly connected in accordance with the joint design. Suitable bulkheads shall be provided both ends. After the pipe section is fitted together with the gasket in place, the assembly shall be subjected to an internal hydrostatic pressure head of 13 psi for 10 mins.

16. THREE-EDGE BEARING TEST

Acceptability of the pipe in all diameters and classes shall be determined by the results of D-Load tests for either the load to produce a 0.3 crack, or the ultimate loads as per ASTM C 76M table 1-5.

17. PIPE DESIGN

Reinforced concrete pipe for gravity flow pipelines in 300 through 2500mm sizes may be specified by D-load strength classification in accordance with ASTM C76M or by class in accordance with BS 5911, Part 1. As an aid to designers, external loads by diameter are given in Table 4 for various heights of earth cover.D-load strength is classified as the 0.3mm crack strength, D03, or the ultimate strength, Dult. The required D-load strength in the three-edge bearing test for reinforced concrete pipe is

$$D_{0.3} = \left[\frac{W_E}{L_E} + \frac{W_L}{L_L}\right]\frac{1}{ID}$$

$$D_{ult} = \left[\frac{W_E}{L_E} + \frac{W_L}{L_L}\right]\frac{FS}{ID}$$

Where

- W_E = earth cover load (kN/m)
- W_L = Live load, (kN/m)
- L_E = load factor for earth load bases upon class of bedding selected
- L_L = load factor for live load (LE = or 1.5, whichever is less)
- ID = pipe inside diameter, (m)
- FS = the realtionship between Dult and D0.3

The relationship between ultimate D-load and the 0.3mm crack D-load is specified in the ASTM Standard C655M as

For $D_{0.3}$ equal to 100D or less

FS = 1.5

For $D_{0.3}$ equal to 150D or more

FS = 1.25

For D0.3 more than 100D but less than 150D

$$FS = 1.5 - \left[\frac{W_E}{L_E} - \frac{W_L}{L_L}\right](0.25)$$

The D-load strength required for any external cover load may be determined by

a) selecting method of installation

b) determining the external load (see table 4)

c) calculating the required D-load strength

d) selecting the class of pipe.

17 1 Design example

ID: 1000mm

Depth of of cover: 3m

Installation condition: trench conduit with "Class B" bedding

Load factor 1.9

Earth load: 80.2 kN/m (from Table 4)

Live load: 4.2 kN/m (from Table 4)

$$D_{0.3} = \left[\frac{W_E}{L_E} + \frac{W_L}{L_L}\right]\frac{1}{ID}$$

$$= \left[\frac{80.2}{1.9} + \frac{4.2}{1.5}\right]\frac{1}{10}$$

= 45.0

$$D_{ult} = \left[\frac{W_E}{L_E} + \frac{W_L}{L_L}\right]\frac{FS}{ID}$$

FS = 1.5 for D-load 100 or less

$$D_{ult} = \left[\frac{80.2}{1.9} + \frac{4.2}{1.5}\right]\frac{1.5}{1.0}$$

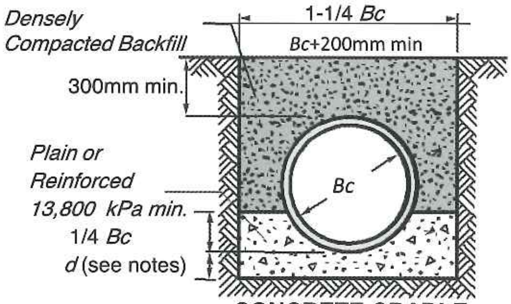
= 67.5

C76M Table 2,

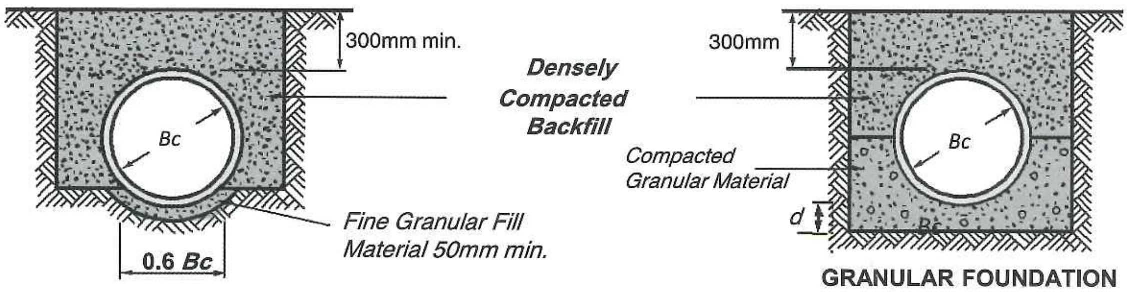
Class II pipe would be selected ($D_{0.3}$ = 50)

17.2 TRENCH BEDDING CIRCULAR PIPE

Notes:
For Class A bedding, use d as depth of concrete below pipe unless otherwise indicated by soil or design conditions. For Class B and C beddings, subgrades should be excavated or over excavated, If necessary, so a uniform foundation free of protruding rocks may be provided. Special care may be necessary with Class A or other unyielding foundations to cushion pipe from shock when blasting can be anticipated in the area

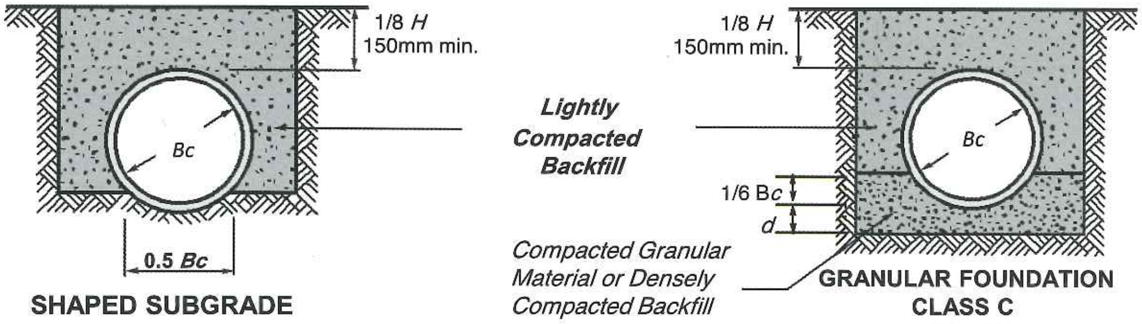


CONCRETE CRADLE
CLASS A
Reinforced As = 1.0% *Bf* = 4.8
Reinforced As = 0.4% *Bf* = 3.4
Plain *Bf* = 2.8



SHAPE SUBGRADE WITH GRANULAR FOUNDATION

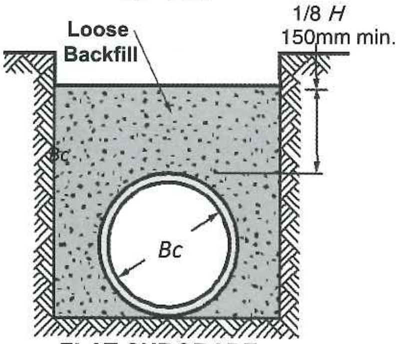
GRANULAR FOUNDATION
CLASS B
Bf =1.9



SHAPED SUBGRADE

GRANULAR FOUNDATION
CLASS C
Bf =1.5

Depth of Bedding Material Below Pipe	
D	d (min)
675mm % smaller	75mm
750 mm to 1,500mm	100mm
1,650mm & larger	150mm



FLAT SUBGRADE
CLASS D
Bf = 1.1

Legend
Bc = outside diameter
H = backfill cover above top of pipe
D = inside diameter
d = depth of bedding material below pipe
As = area of transverse steel in the cradle of arch expressed as a percentage of area of concrete at invert or crown

18. DEFLECTED JOINT (RCP)

Reinforced concrete pipe can be laid around long radius curves and across angle points by deflecting the joint from the normal closed joint position.

The centerline radius of curvature for any case of deflected joint can be calculated by the following equation:

$$R = \frac{L}{2 \sin(\Delta/2)}$$

Where :

R = centerline radius (m)

L = centerline laying length of pipe section (m)

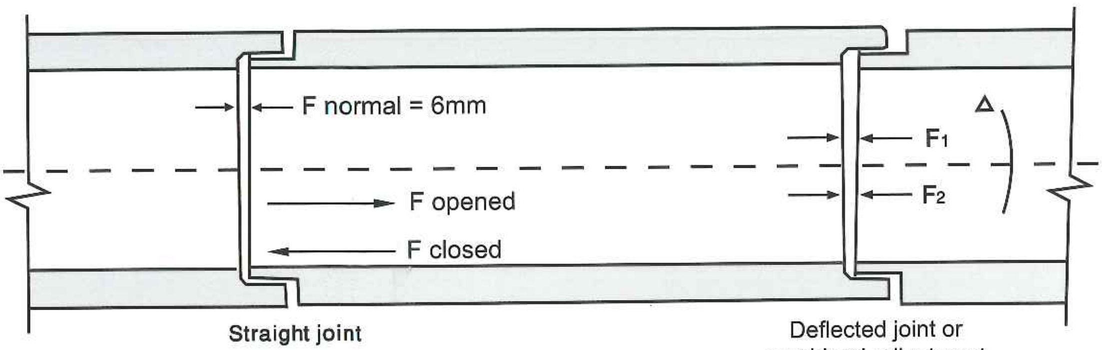
Δ = angle turned at pipe joint(deg) for max joint deflection.

Straight pipe may be installed with joint spaces different from the normal position by deflecting the joint or by opening or closing the space (F) or a combination of deflecting and opening or closing. These methods are used to lay pipe around curves, through angle points or for adjustment of line and grade.

To deflect the joint during installation, insert the spigot into the bell to the normal joint closure position and rotate the pipe by maintaining the normal inside joint space width(F) on one side of the joint and increasing the inside joint space width on the opposite side of the joint.

To open or close a joint for station adjustment, insert the spigot into the bell to the normal joint closure position and then push the joint space width, or open by increasing the inside joint space width.

Both the sum and difference of the measured widths of the total inside joints spaces, measured at the widest point(F1) and the closest point(F2) around the circumference, shall not exceed the values in the diagram below.



Straight joint
F max = 18 mm

Deflected joint or
combined adjustment
Maximum deflectiaon=F1 - F2 = 25mm
Maximum Sum of =F1 + F2 = 37mm

Table 3 External loads for trench conditions (All Pipes)

(continued next page)

Cover Metres	External Load	300	500	600	800	1000	1200
0.5	Earth Load	5.0	7.2	8.0	10.1	12.3	14.4
	Live Load	23.2	37.1	41.5	54.5	67.4	76.6
	Total	28.2	44.3	49.5	64.6	79.7	91.0
1.0	Earth Load	11.5	16.9	18.2	22.4	26.7	30.9
	Live Load	7.4	11.8	13.2	17.3	21.4	25.5
	Total	18.9	28.7	31.4	39.7	48.1	56.4
1.5	Earth Load	17.4	24.4	26.6	33.0	43.5	49.8
	Live Load	4.2	6.8	7.6	9.9	12.3	14.6
	Total	21.6	31.2	34.2	42.9	55.8	64.4
2.0	Earth Load	21.7	30.5	33.4	41.9	57.7	66.2
	Live Load	2.8	4.4	4.9	6.5	8.0	9.5
	Total	24.5	34.9	38.3	48.4	65.7	75.7
2.5	Earth Load	25.0	35.8	39.4	49.8	69.4	80.0
	Live Load	1.9	3.1	3.5	4.6	5.6	6.7
	Total	26.9	38.9	42.9	54.4	75.0	86.7
3.0	Earth Load	27.8	40.4	44.6	56.9	80.2	92.8
	Live Load	1.4	2.3	2.6	3.4	4.2	5.0
	Total	29.2	42.7	47.2	60.3	84.4	97.8
3.5	Total Load	31.3	46.2	51.2	65.9	93.3	108.5
4.0	Total Load	33.0	49.4	54.8	71.1	101.8	118.7
4.5	Total Load	34.4	52.1	58.1	75.8	109.7	128.4
5.0	Total Load	35.7	54.6	60.9	80.1	117.1	137.5
5.5	Total Load	36.7	56.7	63.5	84.1	123.9	146.1
6.0	Total Load	37.6	58.6	65.8	87.6	130.3	154.1
6.5	Total Load	38.3	60.2	67.8	90.8	136.2	161.5
7.0	Total Load	38.9	61.7	69.5	93.7	141.6	168.5
7.5	Total Load	39.4	62.9	71.1	96.2	146.6	174.9
8.0	Total Load	39.8	64.0	72.4	98.6	151.2	181.0
8.5	Total Load	40.1	64.9	73.6	100.7	155.5	186.6
9.0	Total Load	40.4	65.7	74.7	102.6	159.4	191.8
9.5	Total Load	40.7	66.5	75.6	104.2	163.0	196.7
10.0	Total Load	40.9	67.1	76.4	105.8	166.4	201.2

Design Criteria

General – Load values given in Table 3 are for field conditions described in these criteria. For conditions other than those indicated appropriate adjustments must be made or new calculations are required.

Backfill – Earth loads are base on marston's trench load curve for saturated topsoil, when $K\mu' = 0.150$; the table is conservative for sands, gravels and cohesionless materials. The earth load should be recomputed for clay backfills, when $K\mu'$ is less than 0.150, using the correct coefficient. The table has been 1900 kg/m^3, the correct earth load can be calculated by multiplying the earth load shown in the table by the desired unit mass and dividing by 1900.

Trench width – The earth loads given for all pipe diameters for covers of 0.5, 1.0 and 1.5 metres are independent of trench width. This condition is true because the trench width generally exceeds the calculated transition width for these covers; i.e, the calculated earth load for the trench condition exceeds the maximum load as calculated for the positive projecting condition. The assumptions are for rsdp to equal 0.5 and the backfill $K\mu$ is 0.192 for all soil types.

Loads given in the table for covers of 2.0 metres and greater are based on trench widths (at top of pipe) of pipe OD plus 400 mm. for pipe diameters 800 mm. or less; and pipe OD plus 600 mm. for pipe diameters greater than 800 mm. Pipe ODs are based on wall thicknesses given in the dimensional data table for pipe

Load in kN/m

Pipe Diameter in Millimetres

1400	1500	1600	1800	2000	2200	2400	2500	Cover Metres
16.6	17.7	19.5	21.4	23.5	25.7	27.8	28.9	0.5
76.6	76.6	76.6	76.6	76.6	76.6	76.6	76.6	
93.2	94.3	96.1	98.0	100.1	102.3	104.4	105.5	
35.2	37.4	41.0	44.7	48.9	53.2	57.6	59.7	1.0
29.6	31.7	35.1	38.6	42.6	46.7	50.8	52.9	
64.8	69.1	76.1	83.3	91.5	99.9	108.4	112.6	
56.1	59.3	64.6	70.1	76.4	82.9	89.3	92.6	1.5
17.0	18.1	20.1	22.1	24.4	26.8	29.1	30.3	
73.1	77.4	84.7	92.2	100.8	109.7	118.4	122.9	
74.9	79.1	86.3	93.7	102.1	110.8	119.4	123.8	2.0
11.1	11.8	13.1	14.4	15.9	17.5	19.0	19.8	
86.0	90.9	99.4	108.1	118.0	128.3	138.4	143.6	
90.7	96.0	104.9	114.2	124.7	135.5	146.2	151.7	2.5
7.8	8.3	9.2	10.2	11.2	12.3	13.4	13.9	
98.5	104.3	114.1	124.4	135.9	147.8	159.6	165.6	
105.5	111.9	122.5	133.5	146.1	159.0	171.9	178.4	3.0
5.8	6.2	6.9	7.6	8.4	9.2	10.0	10.4	
111.3	118.1	129.4	141.1	154.5	168.2	181.9	188.8	
123.9	131.6	144.4	157.7	173.0	188.6	204.1	212.1	3.5
136.0	144.6	159.0	174.0	191.0	208.6	226.1	235.0	4.0
147.5	157.0	173.0	189.6	208.6	228.1	247.5	257.4	4.5
158.4	168.9	186.4	204.6	225.4	246.9	268.3	279.2	5.0
168.7	180.1	199.1	218.9	241.6	265.0	288.3	300.2	5.5
178.4	190.6	211.2	232.6	257.1	282.4	307.6	320.5	6.0
187.6	200.6	222.7	245.6	271.9	299.1	326.2	340.1	6.5
196.1	210.1	233.5	257.9	286.0	315.1	344.1	358.9	7.0
204.2	218.9	243.8	269.7	299.5	330.4	361.2	377.0	7.5
211.8	227.3	253.5	280.8	312.4	345.0	377.7	394.4	8.0
218.9	235.1	262.7	291.4	324.6	359.1	393.5	411.1	8.5
225.5	242.5	271.3	301.5	336.3	372.5	408.6	427.2	9.0
231.7	249.5	279.5	311.0	347.4	385.3	423.2	442.6	9.5
237.6	256.0	287.3	320.1	358.0	397.5	437.1	457.4	10.0

Live loads – Live load distribution is calculated from the dimension for two AASHTO HS-20 trucks passing at a distance of 1.22 metres between centers of the dual-tired wheels. The force exerted by each dual-tired wheel is 72 kilonewtons(kN). For different wheels forces, correct live loads can be obtained by multiplying live loads shown by the desired wheel load in kN and dividing by 72. The live load at 0.5 metres is increased by 20 percent for impact. For covers 3.5 metres and greater, the small effect of live loads is included in the tabulated earth load.

References

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