



Manufacture & Installation

Reinforced Concrete Pipe – Part 1

Concrete Pipe Association of New Jersey
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Manufacturing

Process – Dry Cast

Packerhead Process

- Dry mix concrete is fed into an outer form for the exterior of the pipe
- The interior of the pipe is formed by a rapidly rising, rotating mechanism called a rollerhead
- Forms may be stripped immediately



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Manufacturing


Production

Dry Cast

- Vibratory
- Packerhead

Wet Cast

	<u>Dry-Mix</u>	<u>Wet-Mix</u>
w/c	0.35	0.42
slump	0 or -	+
initial set	<1 hour	4 hours




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Manufacturing

Process – Wet Cast

Wet Cast Process

- Wet concrete is placed in forms, allowed to cure and the forms are stripped
- Typically only used for very large pipe and end sections
- Requires standard curing time




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Manufacturing

Process – Dry Cast

Vibratory Process

- Consolidate zero slump concrete between an inner core and outer core
- Vibration is used to consolidate the concrete
- Forms may be stripped immediately




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Manufacturing

Raw Materials

- Aggregate
- Portland Cement
- Fly Ash
- Water
- Admixtures
- Steel



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Manufacturing

Mixing the Concrete

Sand and stone are brought into the facility by a conveyor to the batching system.



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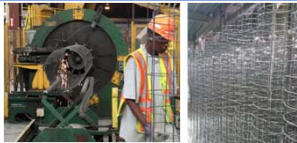
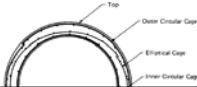
Manufacturing

Reinforcing

Cage Machines & Wire Rollers

Cage machines use reels of cold drawn steel wire and position longitudinal wires while wrapping & tack welding circumferential around.

Wire rollers use welded wire fabric in rolls or flat mats with desired size & spacing.



Cage Machine



Rolled Wire Mesh

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Manufacturing

Mixing the Concrete

- Batching system computer controls the amount of sand, stone, cement and water required for the day's mix.
- Concrete is then distributed to each pipe machine for manufacturing.
- The computer assures consistency.



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Manufacturing

Setting Forms



The wire cage and pallet are then enclosed in the pipe form and brought to the machine for manufacturing.

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Manufacturing

Steps of Production

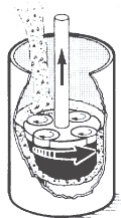
- Build the steel reinforcement cage
- Set the cage in a form
- Manufacture the pipe
- Cure the product



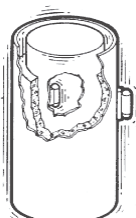
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Manufacturing

Production



Packerhead Machine




Vibratory Machine


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Manufacturing
Production

**Packerhead Machine**



**Vibratory Machine**



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Manufacturing
Curing



Each morning the previous day's production is inspected to identify any defects




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Manufacturing
Production

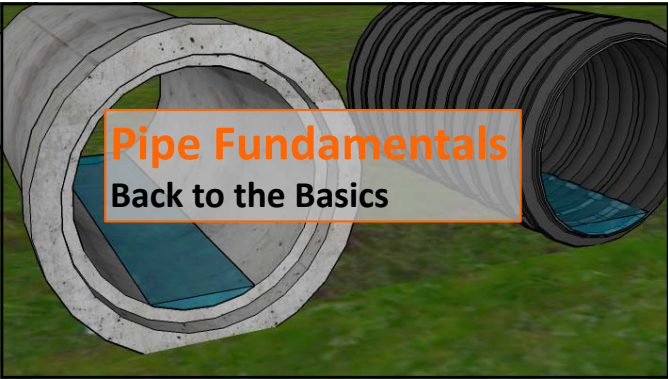
**Packerhead Machine**



**Vibratory Machine**






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Pipe Fundamentals
Back to the Basics

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Manufacturing
Curing



After manufacturing, the pipe is placed in a kiln where the mold is immediately removed. The pipe is then steam cured overnight to complete the process.

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Pipe Fundamentals
Principals of a Culvert



What functions must an underground pipe perform?

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Rigid Pipe

Rigid pipe cannot deflect more than 2% without cracking.

Rigid pipe is designed on the basis of cracking strength.

$\Delta y < 2\%$

What's the difference?

Deflection:

Flexible pipe can deflect more than 2% without cracking.

Flexible pipe is designed on the basis of acceptable deflection.

$\Delta y > 2\%$

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Pipe Fundamentals

D-Load

ULT: 10.6 X 4.5 X 1.2 X

F250 (6,000 lb) African Elephant (14,000 lb) CAT 966M (52,000 lb / 70,000 lb)

48" ASTM C-76 Class IV:

$D_{Service} = 2000 \text{ lb/ft/ft}$

$D_{ULT} = 3000 \text{ lb/ft/ft}$

Total Load Required:

$D_{Service} = (48"/12)(8')(2000)$

= 64,000 lbs.

$D_{ULT} = (48"/12)(8')(3000)$

= 96,000 lbs.

3 Edge Bearing Test

ASTM C76 & C497

D-Load_{0.01}

D-Load_{Ultimate}

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A buried pipeline works as a **structural system** when it incorporates **the properties of what two things?**

Pipe

Backfill Envelope

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Standard Installations

Rigid Pipe Strength:

3x

RCP Dia	D-Load	D-Load LF
12"	16,000 lb	2,000 lb
24"	32,000 lb	4,000 lb
36"	48,000 lb	6,000 lb
48"	64,000 lb	8,000 lb
60"	80,000 lb	10,000 lb
72"	96,000 lb	12,000 lb
84"	112,000 lb	14,000 lb
96"	128,000 lb	16,000 lb
108"	144,000 lb	18,000 lb
132"	176,000 lb	22,000 lb
144"	192,000 lb	24,000 lb

ASTM C76 Class	D-Load _{Design}	D-Load _{ULT}
V	3000 lb/ft/ft	3750 lb/ft/ft
IV	2000 lb/ft/ft	3000 lb/ft/ft
III	1350 lb/ft/ft	2000 lb/ft/ft
II	1000 lb/ft/ft	1500 lb/ft/ft
I	800 lb/ft/ft	1200 lb/ft/ft

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Pipe Fundamentals

Proof of Design

3 Edge Bearing Test

ASTM C76 & C 497

D-Load_{Service}

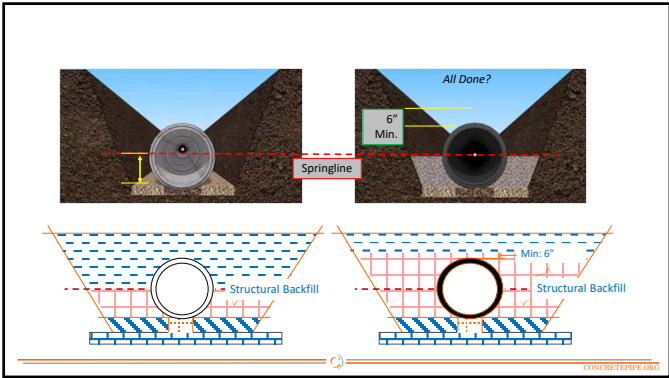
D-Load_{Ultimate}

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Trenches

Introduction to Trenches

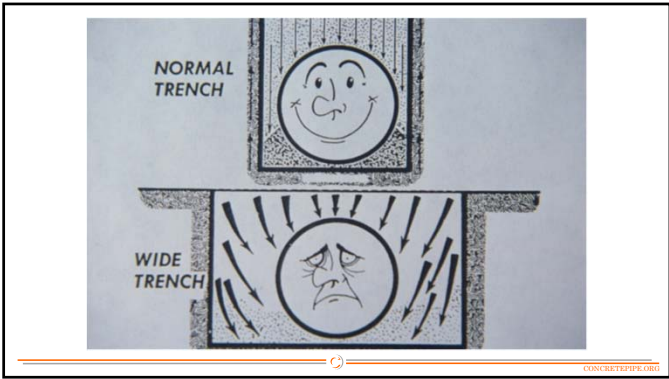
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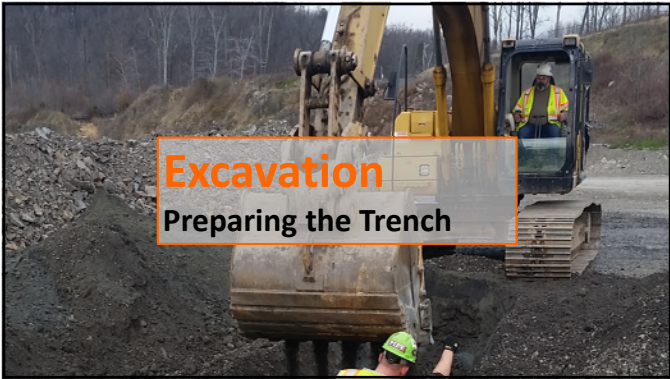
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AASHTO Minimum Trench Widths			
Pipe Dia (in)	AASHTO 27 RCP Trench Width (min)	AASHTO 30 Plastic Trench Width (min)	AASHTO 26 CMP Trench Width (min)
12	40	34	
15	43.5	39	
18	47	44	
24	54	54	
30	61	65	
36	68	74	
42	75	83	
48	82	93	
60	96	113	
66	103		
72	110		
78	117		
80	119.5		
90	131		
96	138		
102	145		
0.0 = +24"		1.5 x O.D. + 12"	

*As Required in Contract Documents
AASHTO Section 26.5.1

26.5—INSTALLATION
26.5.1—General
For trench conditions, the trench shall be excavated to the width, depth, and grade shown in the contract documents.
27.8
The minimum width of a sub trench for Type I through Type II installations shall be: $D_p + 24$ in. or 1.5 D_p , whichever is greater, or wider if required for adequate space to install the specified components in the trench and building areas.
28.5.2—Trench Widths
Trench width shall be sufficient to permit working room to properly and safely place and compact backfilling and other backfill materials. The space between the pipe and trench wall should be wider than the compaction equipment used in the pipe zone. Minimum trench width shall not be less than 1.5 times the pipe outside diameter plus 17.0 in. Trenches shall be larger to the head to the pipe. Structural backfill shall be composed of well graded, granular material, and as AASHTO A-1, A-2-4, and A-2-5 soils, to facilitate better consolidation around the pipe and to minimize the possibility of soil migration and piping of the in situ soils.

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Excavation Dewatering

- Control of surface and subsurface water is required so that dry conditions are provided during excavation and pipe laying.
- Ground water conditions should be investigated before they are encountered during the course of excavation.

Three photographs showing dewatering equipment and trench excavation. The first photo shows a dewatering pump and hose. The second photo shows a trench being excavated with a backhoe. The third photo shows a trench with a pipe installed, with backfill material being added.

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Excavation
Dewatering

Buoyancy:

Relative Densities

$\gamma_{H_2O} = 62.4 \text{ pcf}$

$\gamma_{HDPE} = 60 \text{ pcf}$

$\gamma_{RCP} = 150 \text{ pcf}$

$\gamma_{SOIL} = 120 \text{ pcf}$

$\text{Flotation Force} \leq \text{Soil Resistance} + \text{Pipe Weight}$



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Bedding
Cushion/Load Distribution



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Foundation
Supporting the Structure

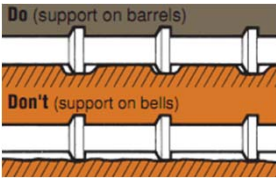


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Bedding
Cushion/Load Distribution

American
Concrete Pipe
Association

Set bedding to grade, and provide bell holes in bedding for flared bell pipe to keep bearing on pipe barrel



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Foundation
Support the Structure

- The foundation must support the bedding, pipe, embedment, and backfill.
- The foundation is either suitable or unsuitable for pipe installation.



Rule of
Thumb:

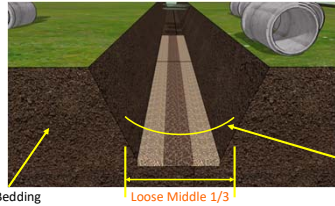
- If a person can walk on the foundation without sinking into the soil, it is acceptable
- If person sinks, or feels the soil quiver underfoot, then it is too soft, and it is unacceptable

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Bedding
Cushion/Load Distribution

AASHTO: 3"-4"-6" thick – middle 1/3 should be loosely placed to cradle pipe invert.



The bedding acts as a cushion/cradle for the bottom of the pipe as it works to distribute the load to the foundation.

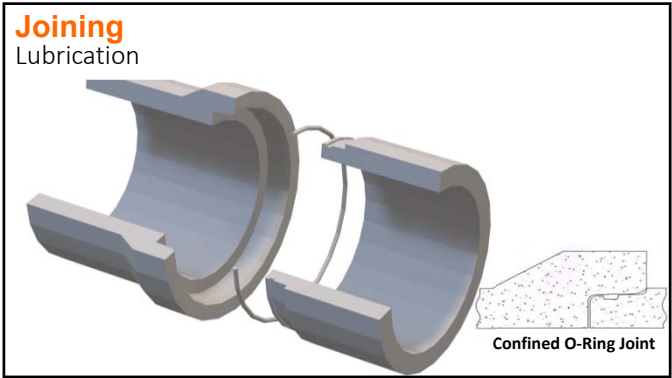


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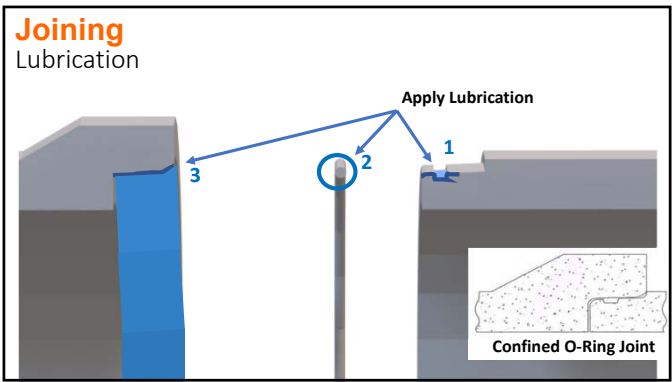
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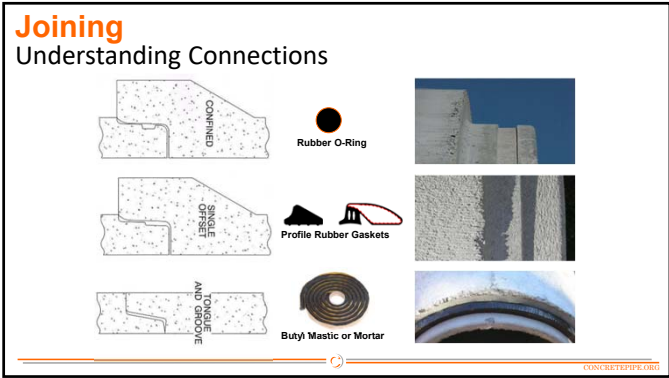
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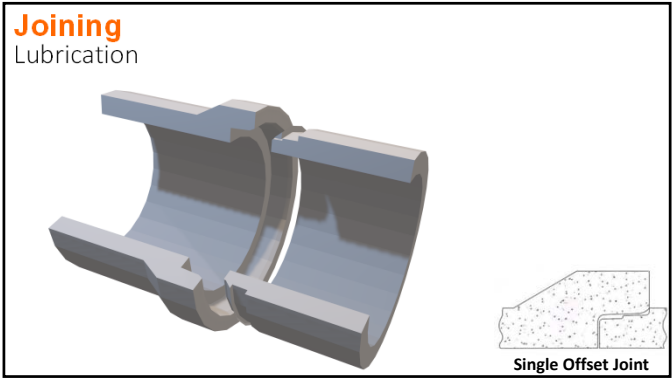
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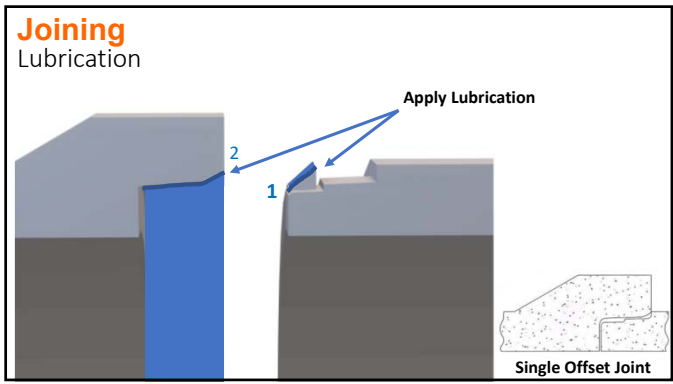
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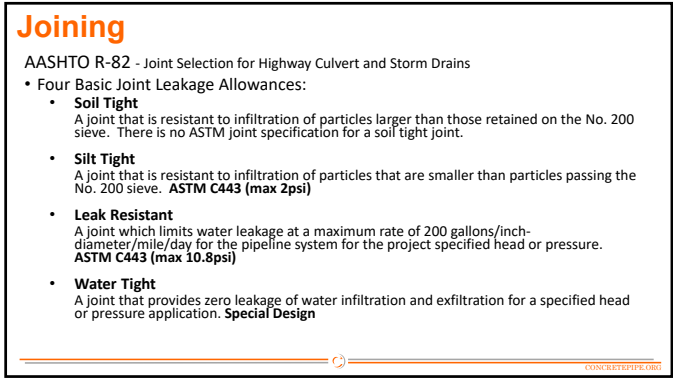
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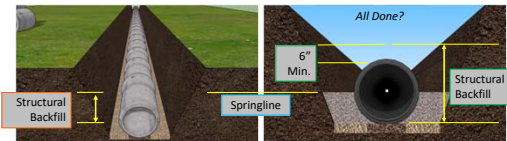
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Embedment
Initial Backfill

- Provides structural support for flexible & rigid products.
- Compaction under haunches is important for rigid products & critical for flexible products.
- For flexible pipe this zone builds the soil arch – protecting the pipe from distortions due to loading



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Embedment
Initial Backfill



Manual compactors allow contractor to get up close to the pipe without damaging it.

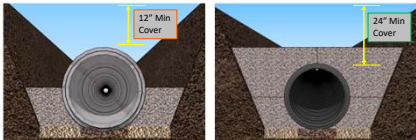
Hoepacks, and other large compaction equipment can do damage to a pipe if there is not enough soil cushion over or around the pipe.

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Final Backfill
Height of Cover



- Does not add to strength of **rigid system** – compact as needed for improvements above.
- **AASHTO**: 2' minimum fill height for thermoplastic pipe.
- **AASHTO**: 1' minimum fill height for thermoplastic pipe.



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Embedment
Completion



Best Practices:

- Prevent Pipe from Shifting
- Compact in Lifts (6" to 4")
- Use Proper Compaction Equipment

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Final Backfill
Height of Cover

WARNING



Table 36.5.5.4—Minimum Cover for Construction Loads

Nominal Pipe Diameter, ft	Minimum Cover, in., for Indicated Axle Loads, kips			
	18.0–30.0	30.0–75.0	75.0–110.0	110.0–150.0
2.0–3.0	24.0	30.0	36.0	36.0
3.0–4.0	36.0	36.0	42.0	48.0
4.0–5.0	36.0	36.0	42.0	48.0

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