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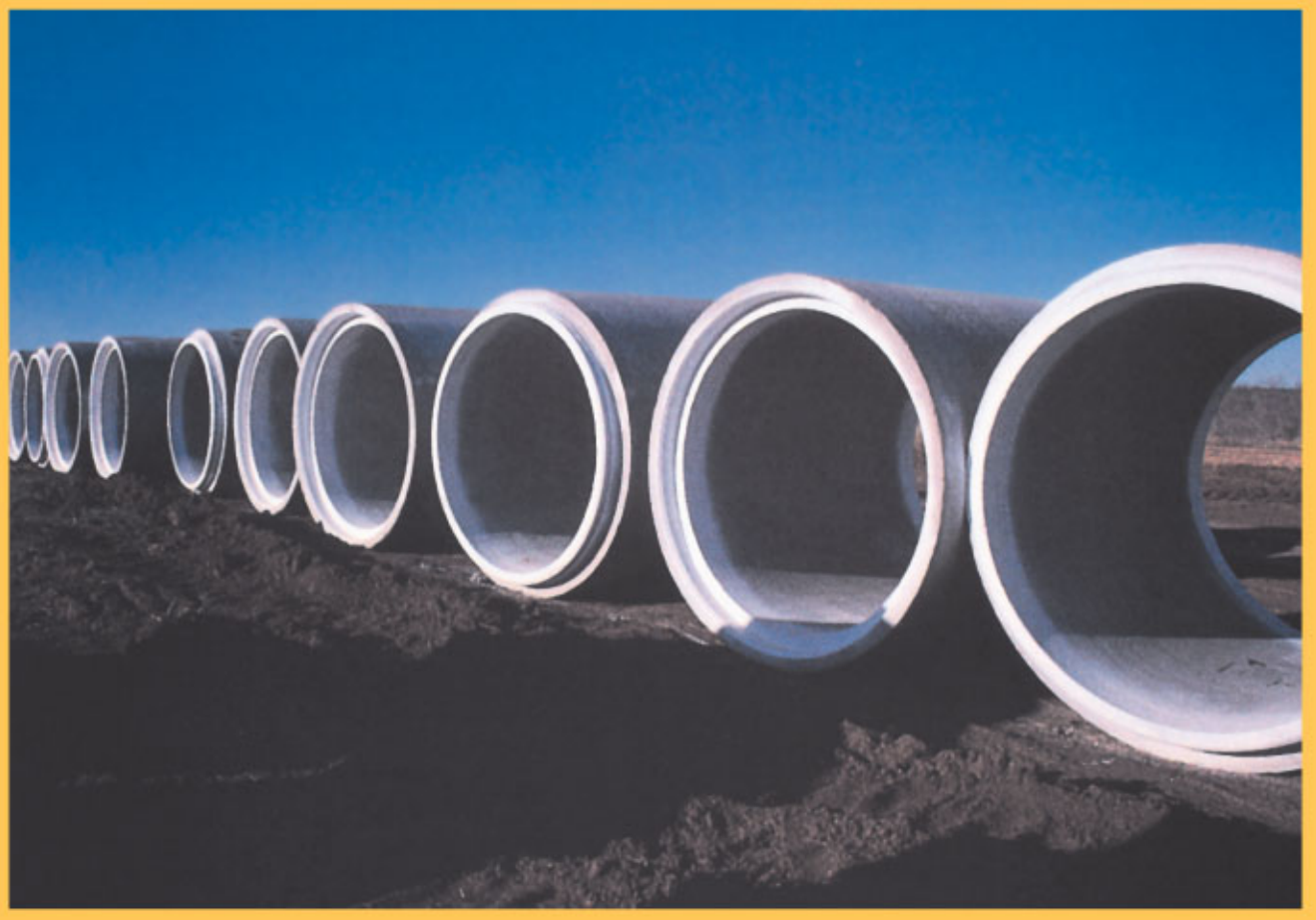
PACIFIC NORTHWEST PRECAST CONCRETE ASSOCIATION



# REINFORCED CONCRETE PIPE

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# THE RELIABLE STANDARD FOR DRAINAGE PIPE

When it comes to strength, durability, and hydraulics, reinforced concrete pipe is unmatched in its reputation for quality. Unlike other types of pipe, concrete gains strength over time. With a proven 100-year service life, concrete pipe is durable under a wide range of installation conditions.

Contrast this with the performance of other types of pipe under the ground. Flexible pipe products derive most of their strength from the surrounding compacted soil. Whether the result of poorly compacted soil or insufficient cover, other types of pipe are more susceptible to damage than concrete pipe. Poor installation, poor results. It's that simple!

## ABOUT REINFORCED CONCRETE PIPE (RCP)

### STRUCTURAL PERFORMANCE

- High inherent strength of concrete pipe
- D - Load = Strength verified
- Supporting strength from pipe
- Five (5) standard strength classes and special designs

### HYDRAULIC PERFORMANCE

- Consistent Manning's "n" value
- Rigid pipe maintains designed line & grade
- Laboratory "n" = 0.010
- Design $"n"_{storm}$ = 0.012
- Tapered inlet geometry minimized culvert headwater

### QUALITY

- Known long-term material properties
- ASTM material standards for **ALL** pipe sizes and strengths
- Quality Assurance/Control on all aspects of RCP (raw materials, testing, etc.) is verified by physical tests of materials and finished product

### DESIGN FLEXIBILITY

- Standard pipe sizes from 12-inch to 144-inch diameter
- Joint performance matched to your project requirement
- Specialty fittings provide same structural integrity as straight run pipe

### DURABILITY

- Documented service life greater than 100 years
- Unaffected by ultraviolet degradation, corrosion, and thermal variations

### ECONOMICS

- Narrow trench widths
- Minimal field inspection and testing required
- Proven low cost with Least Cost (Life Cycle) Analysis

### RISK MANAGEMENT

- Time Proven
- Established Design Procedures
- Installation/Contractor Friendly
- Independent of contractors ability to build pipe supporting structure in the trench

# WHY YOU WIN WITH RCP!

## 1. ECONOMICS

When using standard installation practices Reinforced Concrete Pipe (RCP) can save in the use of backfill materials over that of other pipe products.

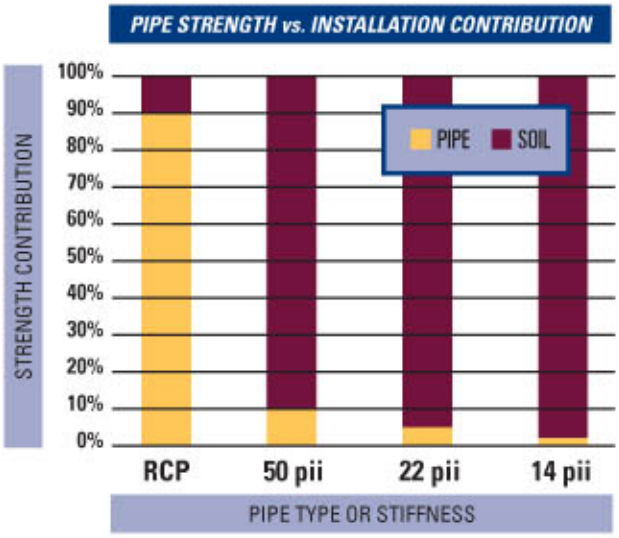
## 2. DURABILITY

The US Army Corp of Engineers (COE) recognizes the following pipe life cycle durations:

| PIPE MATERIAL | LIFE CYCLE DURATION |
|---|---|
| RCP | 70 years minimum |
| Corrugated Metal | 50 years minimum |
| Plastic | 50 years minimum |

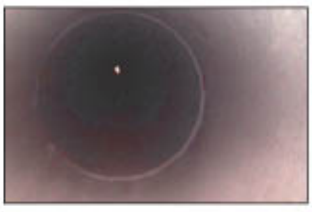
## 3. STRUCTURAL PERFORMANCE

RCP arrives at the job site with most of it's structural integrity built in. Compared to that of other products.




## 4. HYDRAULIC PERFORMANCE

RCP has a smooth interior wall surface which means the capacity specified is the capacity achieved. RCP has the same "N" value as other smooth wall pipe products.



RCP: n=0.012

## 5. DESIGN FLEXIBILITY

RCP covers a wide range of site conditions by using different combinations of installation, pipe strength and class.

## 6. RISK MANAGEMENT

RCP is tested for strength at the manufacturing facility and requires minimal onsite inspection and post installation testing. If problems occur during the installation they can be repaired right in the field. Also, in high ground water situations, buoyancy is rarely an issue, due to its weight over other types of piping.

| PIPE MATERIAL | PIPE WEIGHT, lb./ft. | WATER WEIGHT, lb./ft | UPLIFT FORCE, lb. |
|---|---|---|---|
| RCP | 524 | 658 | 134 |
| CMP | 36 | 441 | 405 |
| HDPE | 18 | 554 | 536 |
| PVC | 54 | 486 | 432 |

## 7. QUALITY

RCP has three times the American Standards Testing Methods (ASTM) specifications for raw material, installation and product than other piping materials.

*The Pacific Northwest Precast Concrete Association is comprised of regional companies and individuals engaged in the manufacture of precast concrete and related products. Our members are based in a three-state and Canadian province region encompassing Oregon, Washington, Idaho and British Columbia. PNPCA exists to exchange industry knowledge and information, secure efficient cooperation between the concrete products industry and engineers, developers and governmental agencies, and to advocate and encourage constant improvements of practices for the purpose of developing high product quality.*

*We are proud of our products and our industry - check us out!*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# RCP DESIGN & INSTALLATION

(in 4 easy steps!)

## 1 EVALUATE HYDRAULIC REQUIREMENTS

Select the pipe size based on Project Hydraulic Requirements. ***See Table 1 on page 5.***

## 2 SELECT STANDARD INSTALLATIONS

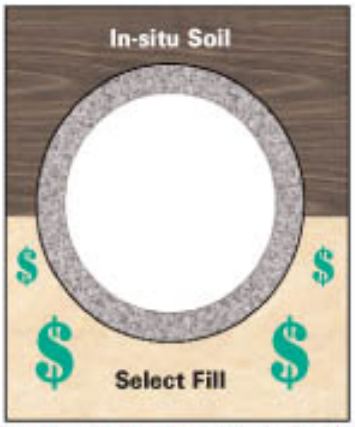
Based on decades of full-scale testing and research, the concrete pipe industry, in conjunction with engineers, transportation officials, and contractors, has developed the following four standard trench installations:

**TYPE 1** Requires the use of compacted gravel/sand in the pipe haunch and outer bedding zones.

**TYPE 2** Allows the use of in-situ sandy/silty soils in the pipe haunch and outer bedding zones.

**TYPE 3** Allows the use of in-situ silty/clay soils in pipe haunch and outer bedding zones.

**TYPE 4** Allows the use of dumped in-situ materials without special compaction efforts.




Type 1 Installation–Money is in the Backfill


Type 4 Installation–Money is in the Pipe

*Table #2* (pg 5) provides a detailed description of the compaction requirements associated with the Standard Installations. *Table #3* (pg 5) provides descriptions of the acceptable backfill materials. *Figure 1* (pg 5) provides a drawing showing typical trench dimensions.

## 3 EVALUATE MAXIMUM & MINIMUM HEIGHTS OF COVER

Select the pipe class for your projects standard installation and max/min covers. Typical maximum and minimum recommended heights of cover are provided in these tables are meant to be used only as a guideline. Project requirements may warrant further detailed analysis. Consult with your local pipe supplier for sizes and backfill conditions not covered in this brochure.

## 4 SPECIFY PIPE SIZE & CLASS

Reference the following ASTM and AASHTO specifications as appropriate:

### ASTM C-76 (AASHTO M 170)

Reinforced concrete culvert, storm drain, and sewer pipe.

### ASTM C-1479 (AASHTO Section 27)

Standard Practice for installation of reinforced concrete sewer, storm drain, and culvert pipe for direct design.

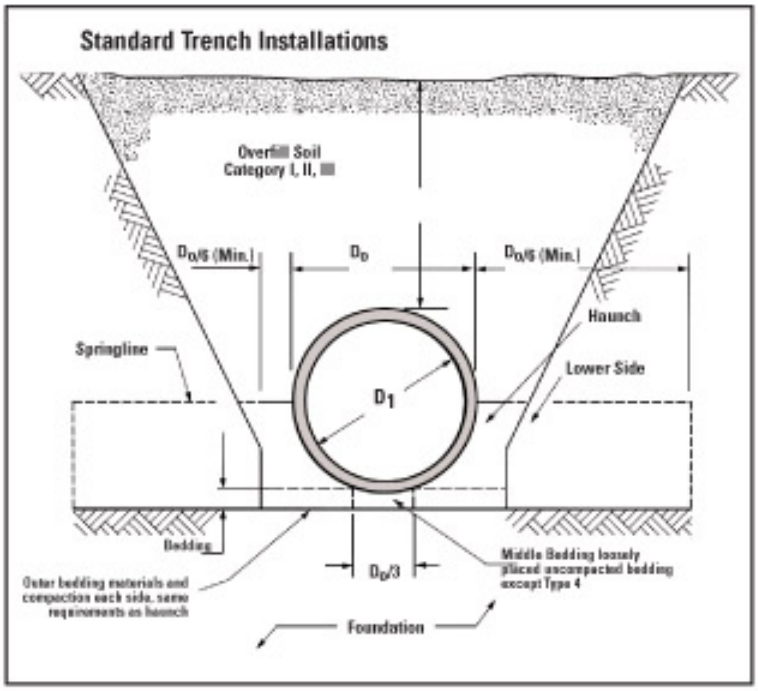
# RCP TABLES & INSTALLATION

## Table #1
## Full Flow Discharge Coefficients

Flowrate, $Q_{efs} = C \times S^{1/2}$ $\quad C = \frac{1.486}{n} \times A \times R_h^{2/3}$

| Pipe Dia. (inches) | Area. $A.ft^2$ | Hydraulic Radius, $R_h$.ft | n=0.010 | n=0.011 | n=0.012 |
|---|---|---|---|---|---|
| 12 | 0.785 | 0.250 | 46.4 | 42.1 | 38.6 |
| 15 | 1.227 | 0.312 | 84.1 | 76.5 | 70.1 |
| 18 | 1.767 | 0.375 | 137 | 124 | 114 |
| 21 | 2.405 | 0.437 | 206 | 187 | 172 |
| 24 | 3.142 | 0.500 | 294 | 267 | 245 |
| 27 | 3.976 | 0.562 | 402 | 366 | 335 |
| 30 | 4.909 | 0.625 | 533 | 485 | 444 |
| 36 | 7.069 | 0.750 | 867 | 788 | 722 |
| 42 | 9.621 | 0.875 | 1,308 | 1,189 | 1,090 |
| 48 | 12.566 | 1.000 | 1,867 | 1,698 | 1,556 |
| 54 | 15.904 | 1.125 | 2,557 | 2,325 | 2,131 |
| 60 | 19.635 | 1.250 | 3,385 | 3,077 | 2,821 |
| 72 | 28.274 | 1.500 | 5,504 | 5,004 | 4,587 |

## FIGURE 1
## Standard Installation Trench Detail






## Table #2
## Standard Installations

| Installation Type | Bedding Thickness | Haunch and Outer Bedding | Lower Side |
|---|---|---|---|
| Type 1 | $D_o/24$ minimum, not less than 75 mm (3"). If rock foundation, use $D_o/12$ minimum, not less than 150mm (6"). | 95% Category I | 90% Category I<br>95% Category II<br>or<br>100% Category III |
| Type 2 | $D_o/24$ minimum, not less than 75 mm (3"). If rock foundation, use $D_o/12$ minimum, not less than 150mm (6"). | 90% Category I<br>or<br>95% Category II | 85% Category I<br>90% Category II<br>or<br>95% Category III |
| Type 3 | $D_o/24$ minimum, not less than 75 mm (3"). If rock foundation, use $D_o/12$ minimum, not less than 150mm (6"). | 85% Category I<br>90% Category II<br>or<br>95% Category III | 85% Category I<br>90% Category II<br>or<br>95% Category III |
| Type 4 | No bedding required, except if rock foundation, use $D_o/12$ minimum, not less than 150mm (6"). | No compaction required, except if Category III, use 85% Category III | No compaction required, except if Category III, use 85% Category III |

Notes:

1. Compaction and soil symbols - i.e. "95% Category I" - refers to Category I soil material with minimum standard Proctor compaction of 95%. See Table 3 equivalent modified Proctor values.
2. The trench top elevation shall be no lower than 0.1 H below finished grade or for roadways its top shall be no lower than an elevation of 0.3 m (1') below the bottom of the pavement base material.
3. Soil in bedding and haunch zones shall be compacted to at least the same compaction as specified for the majority of soil in the backfill zone.
4. The trench width shall be wider than shown if required for adequate space to attain the specified compaction in the haunch and bedding zones.
5. For trench walls that are within 10 degrees of vertical, the compaction or firmness of the soil in the trench walls and lower side zone need not be considered.
6. For trench walls with greater than 10 degree slopes that consist of embankment, the lower side shall be compacted to at least the same compaction as specified for the soil in the backfill zone.

## Table #3
## Standard Installation Soil Categories

| | REPRESENTATIVE SOIL TYPES | | PERCENT COMPACTION | |
|---|---|---|---|---|
| SIDD Soil | USCS | Standard AASHTO | Standard Proctor | Modified Proctor |
| Gravelly Sand (Category I) | SW, SP, GW, GP | A1, A3 | 100<br>95<br>90<br>85<br>80<br>61 | 95<br>90<br>85<br>80<br>75<br>59 |
| Sandy Silt (Category II) | GM, SM, ML, Also GC, SC with less than 20% passing #200 sieve | A2, A4 | 100<br>95<br>90<br>85<br>80<br>49 | 95<br>90<br>85<br>80<br>75<br>46 |
| Silty Clay (Category III) | CL, MH, GC, SC | A5, A6 | 100<br>95<br>90<br>85<br>80<br>45 | 90<br>85<br>80<br>75<br>70<br>40 |

# Table #4 Trench: Maximum Cover, ft.

## Full Flow Discharge Coefficients

### 12-INCH THROUGH 30-INCH DIAMETER RCP

| Pipe Class | Installation Type 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | Maximum Cover in feet | | | |
| I | N/A | N/A | N/A | N/A |
| II | 23 | 15 | 11 | 7 |
| III | 51 | 25 | 19 | 13 |
| IV | >100 | >100 | 55 | 29 |
| V | >100 | >100 | >100 | >100 |

### 36-INCH THROUGH 72-INCH DIAMETER RCP

| Pipe Class | Installation Type 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | Maximum Cover in feet | | | |
| I | 11 | 7 | 5 | 3 |
| II | 15 | 11 | 7 | 5 |
| III | 23 | 17 | 13 | 9 |
| IV | 43 | 29 | 23 | 17 |
| V | >100 | 57 | 43 | 31 |

### TRENCH WIDTH

**Trench Width = 1.33 x Pipe O.D.**

### EMBANKMENT : MAXIMUM COVER, FT

| Pipe Class | Installation Type 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| | Maximum Cover in feet | | | |
| I | 10 | 7 | 5 | N/A |
| II | 14 | 11 | 7 | 4 |
| III | 23 | 16 | 12 | 8 |
| IV | 36 | 25 | 19 | 13 |
| V | 56 | 39 | 30 | 21 |

### RCP PIPE DIMENSIONS

| Pipe Diameter, inches | Pipe Outer Diameter, inches | Pipe Weight, lb/ft. | Minimum Trench Width, inches |
|---|---|---|---|
| 12 | 16.0 | 93 | 21.3 |
| 15 | 19.5 | 127 | 25.9 |
| 18 | 23.0 | 168 | 30.6 |
| 21 | 26.5 | 214 | 35.2 |
| 24 | 30.0 | 264 | 39.9 |
| 27 | 33.5 | 322 | 44.6 |
| 30 | 37.0 | 384 | 49.2 |
| 36 | 44.0 | 524 | 58.5 |
| 42 | 51.0 | 686 | 67.8 |
| 48 | 58.0 | 867 | 77.1 |
| 54 | 65.0 | 1068 | 86.5 |
| 60 | 72.0 | 1295 | 95.8 |
| 72 | 86.0 | 1811 | 114.4 |

### Minimum Cover (less than 1 foot)

**12-INCH THROUGH 30-INCH DIAMETER: CLASS III**

**36-INCH THROUGH 72-INCH DIAMETER: CLASS I/II**

***Note:*** *Type 4 Installations with HS 20 loading not recommended for Minimum Cover applications without consulting your pipe supplier.*

**Assumptions:**

1. Backfill Unit Weight = 120 lbs/ft³
2. In-Situ Soil is Saturated Clay (Conservative)
3. Trench Width = 1.33 x Pipe O.D.
4. Highway Loading = HS 20 (i.e. 20 Ton Live Load)
5. Installed per ASTM C-1479 (AASHTO Section 27)
6. Weight of Water included in the Earth D-Load Strength
7. Pipe Outer Diameter based on "B" Wall thickness
8. Class I pipe is not available in diameters smaller than 60"ø

**Note:** RCP (ASTM C-76) has the following standard D-Load strengths. Consult with your pipe supplier about other pipe strengths.

**CL I** ≤ 800 lb/ft/ft **CL II** ≤ 1,000 lb/ft/ft **CL III** ≤ 1,350 lb/ft/ft **CL IV** ≤ 2,000 lb/ft/ft **CL V** ≤ 3,000 lb/ft/ft

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