Rinker MATERIALS™

Building the Foundation
Of The Nation's Infrastructure

Reinforced Concrete Pipe
Storm Drainage Applications

www.rinkermaterials.com

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 minimizes culvert headwater

Design Flexibility

- Standard pipe sizes from 12-inch to 144-inch diameter
- Joint performance matched to your project requirements
- 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

Risk Management

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

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

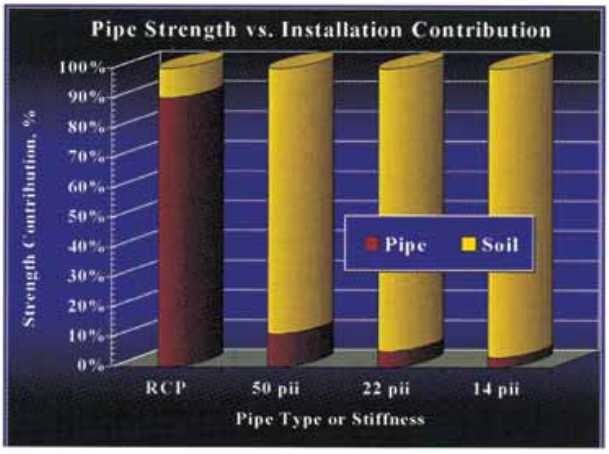
Economics

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

WHY YOU WIN WITH RCP!

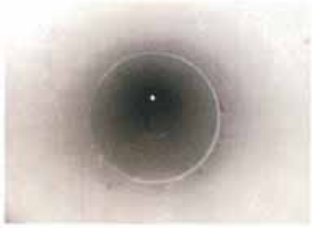
Structural Performance

You do not have to worry about "installation anomalies" since most of the pipe installation's structural integrity arrives on the truck. Compare the structural capabilities provided by RCP versus flexible products with low inherent strengths.



Hydraulic Performance

RCP doesn't depend on "spiral flow" or interior liners to provide superior hydraulics. The answer is simple - it's consistently smooth interior ensures that the capacity you specify is what the owner is provided.



RCP : n =0.012

Flexible : n = ?

Which would you choose?

Design Flexibility

	RCP	HDPE
Combinations of Standard Installations and Pipe Strength/Class	20	1

Does one (1) option cover all site conditions?

Durability

The US Army COE recognizes the following pipe life cycle durations:

Pipe Material	Life Cycle Duration
RCP	70 years minimum
Plastic	50 years maximum

Risk Management

RCP requires minimal on-site inspection and post installation testing. Often it is the things that happen when no one is on-site that can cause problems. For example during heavy rain/high groundwater situations RCP stays put, buoyancy is rarely an issue. Compare the uplift force on a 36"ϕ storm sewer in high groundwater conditions:

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

With about one (1) foot of cover the RCP stays put, compared to the 3-4 feet of cover required by the flexible products.

Quality

There are over three (3) times as many ASTM raw material, installation, and product specifications for RCP versus HDPE pipe.

Economics

Compare the savings in backfill materials generated when using a standard installation with RCP and the recommended installation for plastic pipe given on the following table.

Backfill Comparison : RCP vs. Flexible Pipe

RCP Standard Installation Types 1, 2, & 3

Pipe Dia., in.	RCP yd^3/100 l.f.	Flexible Pipe, yd^3/100 l.f.	Add'l Select Mat'l w/Flexible Pipe, yd^3	Additional Trucks per 100 l.f. w/Flexible Pipe
12	3.43	19.33	15.89	(4)
15	4.66	23.25	18.59	(4)
18	6.07	27.76	21.69	(4)
24	9.38	37.95	28.57	(6)
30	13.39	50.05	36.67	(6)
36	18.07	58.77	40.70	(8)
42	23.45	71.98	48.53	(8)
48	29.51	84.23	54.72	(10)
54	36.26	100.29	64.03	(12)
60	43.70	114.21	70.51	(12)

RCP Standard Installation Type 4

Pipe Dia., in.	RCP yd^3/100 l.f.	Flexible Pipe, yd^3/100 l.f.	Add'l Select Mat'l w/Flexible Pipe, yd^3	Additional Trucks per 100 l.f. w/Flexible Pipe
12	0	19.33	19.33	(4)
15	0	23.25	23.25	(4)
18	0	27.76	27.76	(6)
24	0	37.95	37.95	(8)
30	0	50.05	50.05	(10)
36	0	58.77	58.77	(10)
42	0	71.98	71.98	(12)
48	0	84.23	84.23	(14)
54	0	100.29	100.29	(18)
60	0	114.21	114.21	(20)

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Assumptions

1) Unit Weight of Select Backfill Material assumed to be 120 lbs/ft^3
2) Truckload Maximum Capacity is assumed to be 20 tons = 🚚
3) Trench Details are based on minimum requirements of ASTM
4) Truckloads based on select material imported and unusable material excavated from trench that requires removal
5) **Trench walls are assumed to be vertical. If trench walls are sloped back, flexible pipe would require even more select backfill.**

RCP Design & Installation

4 Easy Steps

1) Select Pipe Size based on Project Hydraulic Requirements.
2) Select Standard Installation that meets your project's requirements.
3) Evaluate Maximum and Minimum heights of cover on the project.
4) Specify Pipe Size, Pipe Class, and reference the appropriate ASTM and AASHTO specifications.

1) Evaluate Project Hydraulics

Reference Table 1 to determine the required pipe size.

2) 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.

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

Type 1 Installation -- Money is in the Backfill

Type 4 Installation -- Money is in the Pipe

3) Evaluate Maximum & Minimum Heights of Cover

Select the pipe class for your project's standard installation and max/min covers. Typical maximum and minimum recommended heights of cover are provided on Table 4. The values provided in these tables are meant to be used only as a guideline. Project requirements may warrant further detailed analysis. Consult with your Rinker Materials™ technical services representative 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

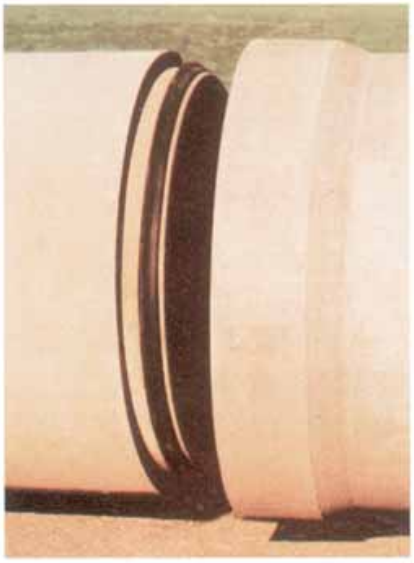

Table 1 : Full Flow Discharge Coefficients

Flowrate, Qcfs = C x S $^{1/2}$			$C = \frac{1.486}{n} \times A \times R_h^{2/3}$		
Pipe Dia., in	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

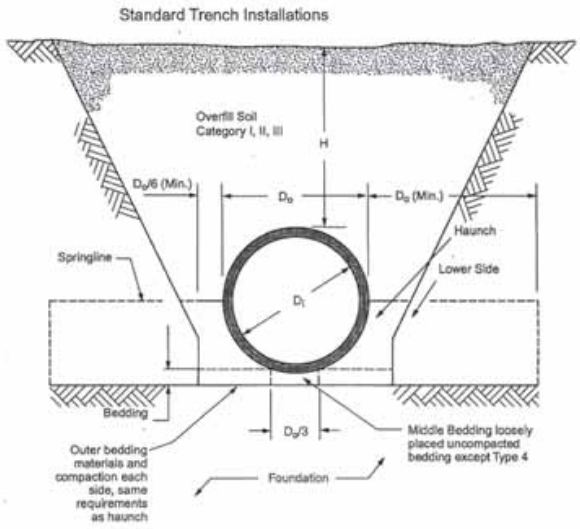

Table 2 : Standard Installations

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 150 mm (6").	95% Category I	90% Category I, 95% Category II, or 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 150 mm (6").	90% Category I or 95% Category II	85% Category I, 90% Category II, or 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 150 mm (6") .	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	No bedding required, except if rock foundation, use D_O/12 minimum, not less than 150 mm (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 1)	SW, SP, GW, GP	A1,A3	100 95 90 85 80 61	95 90 85 80 75 59
Sandy Silt (Category II)	GM, SM, ML, Also GC, SC with less than 20% passing #200 sieve	A2, A4	100 95 90 85 80 49	95 90 85 80 75 46
Silty Clay (Category III)	CL, MH, GC, SC	A5, A6	100 95 90 85 80 45	90 85 80 75 70 40

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Table 4

Trench : Maximum Cover, ft.

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

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 Rinker Materials™.

RCP Pipe Dimensions

Pipe Dia., in.	Pipe Outer Dia., in.	Pipe Weight, lb/ft.	Minimum Trench Width, in.
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

Assumptions

1) Backfill Unit Weight = 120 lbs/ft^3
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"ϕ

Note : RCP (ASTM C 76) has the following standard D–Load strengths. Consult with Rinker Materials 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

Products – Meeting Your Project Needs!

Rinker Materials™ provides the products that meet the challenges of your project. You do not have to change a thing about your design – we provide products that conform to ***Your*** requirements for superior storm drainage performance. Consider the following questions on your next project:

- Am I confident that a flexible pipe will be properly installed to ensure long term performance, **or does concrete pipe provide more performance confidence, if there is improper installation?**

- Can I afford to inspect every foot of a flexible pipe installation, **or is concrete pipe the wiser use of my customers inspection dollars?**

- Am I comfortable specifying and professionally certifying a plastic material that has a highly variable service life, **or should I go with the reliable history of concrete pipe?**

- Am I convinced that material certification sheets provided by plastic pipe producers are adequate to ensure compliance to AASHTO specifications, **or should I go with a concrete pipe that comes with post manufacturing test results confirming finished product compliance?**

- Can I ensure that the hydraulics of my design will not be impacted by flexible pipe deflection, corrugation growth, separated joints, or misalignment, **or should I count on concrete pipe's stable structure for hydraulic performance?**

Technical Resources

Contact your Regional Technical Services Representative for the following:

- Technical Info Briefs/Series
- Design Data Series
- Software (Design & Typical Details)
- CEU/CPD/PDH Seminars
- ACPA Manuals (www.concrete–pipe.org)

Or other product information:

- Sanitary Sewer Pipe
- Concrete Pipe (non–reinforced)
- Reinforced Concrete Boxes
- Elliptical & Arch Pipe
- Structures
- Three Sided Bridges
- Mega–Box Culverts
- Stormceptor
- Specialty Fittings
- Manholes