APG 13

CITY OF TUCSON, ARIZONA
DEPARTMENT OF TRANSPORTATION

ENGINEERING DIVISION
ACTIVE PRACTICES GUIDELINES

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APPROVED BY: [signature] DATE: 1/5/94
City Engineer

SUBJECT: ACTIVE PRACTICES GUIDELINES
THE USE OF CAST IN PLACE PIPE (CIPP) CONCRETE PIPE FOR STORM SEWERS

A. PURPOSE

1. To establish Engineering design criteria governing the design and use of CIPP storm sewers.

2. To specify criteria which may be used to assess the suitability of substituting CIPP for Reinforced Concrete Pipe (RCP) storm sewer pipe.

3. To provide clarification and supplementary information to the 1988 edition of the Joint Pima County. City of Tucson Standard Specifications For Public Improvements.

B. REFERENCES: Section 501 of 1988 Edition of the Joint Pima County/City of Tucson Standard Specifications For Public Improvements (Standard Specifications)

C. GENERAL

1. CIPP installations have provided acceptable service as storm sewers. Factors such as insufficient cover: sandy, collapsing, swelling, or low bearing strength soils; close proximity to other existing or proposed utilities: and the need to excavate adjacent to the pipe at some future time may preclude the use of CIPP.

2. This guide is intended to both serve as an Engineering guideline for the design of CIPP and for the substitution of CIPP for storm sewers of other specified materials, more specifically: reinforced concrete pipe. It is not intended to replace the Standard Specifications.

D. DISCUSSION

1. Properly designed and installed RCP storm sewer installations have an excellent record of service. Factors such as structural strength, favorable hydraulic characteristics, and resistance to corrosion and wear have contributed to the success of RCP installations. However, RCP pipe is relatively expensive, heavy, and requires care in bedding and installation. The availability of larger sizes is often limited and may be subject to an extended waiting period.

2. CIPP has had limited local use as a storm sewer conduit. In certain situations CIPP has the potential for providing an economical substitute for RCP. CIPP is inherently weaker than RCP due to a lack of reinforcing steel and it is typically hydraulically less efficient than RCP. Typically, because of field manufacturing defects, larger nominal diameter pipe sizes will be required to carry the same flow rate. Various site and soil conditions may preclude the use of CIPP. Some of these factors may only become evident upon excavation preparatory to the CIPP placement.

E. RECOMMENDED ENGINEERING CONSIDERATIONS GOVERNING THE USE OF CIPP

1. Minimum compressive strength of the concrete at time of backfill: 2000 PSI. Minimum 28 day strength 3000 PSI.

2. Required curing time prior to backfill: As required for access requirements, 2 to 3 days preferred. In certain situations, 4 to 7 days may be acceptable. The specified curing time should be determined on a case by case basis, and may affect the concrete mix design.

3. Minimum cover: The greater of: 4 feet to finished grade or 3 feet to top of subgrade. Lesser cover depths are acceptable only if: A) An analysis presented by a Registered Engineer demonstrates that the CIPP is competent to support design loads with reduced cover and no other utilities cross over the CIPP. or B) The CIPP is located in a median, parkway or other location not subject to traffic loads and no other utilities cross over or will be located above the pipe.

4. Maximum cover: 15 feet unless a specific analysis and design by a Registered Engineer supports a deeper cover.

5. Minimum nominal pipe wall thickness: The minimum nominal pipe wall thickness shall be one twelfth (1/12) of the nominal inside pipe diameter plus 1 inch. Allowable variations from this size are indicated in section 501 of the Standard Specifications.

6. Design hydraulic characteristics: Use a minimum Manning's "n" value of 0.017.

7. Lateral separation from other utilities: A minimum lateral separation from other utilities and CIPP storm sewers of twice the nominal inside CIPP diameter, with a maximum of 12 feet, is required.

8. Vertical relationship to other utilities: The CIPP should be placed below all other utilities whenever possible. Any utilities located below the CIPP should be within a duct or sleeve, or be such that they can be abandoned in place and relocated above the CIPP if utility work becomes necessary.

9. Soil conditions: The soil must be able to hold a slope appropriate to permit the placing of the CIPP. Soil must be non-swelling, non-collapsing and have a minimum unconfined bearing strength of 1500 PSF. Other requirements are included in the Standard Specifications.

10. Other specifications contained in the Standard Specifications should be followed.

F. SUMMARY

1. CIPP is not an equal to RCP in: uniformity of section, strength, installation requirements, hydraulic characteristics, or quality control.

2. Long term performance and durability of CIPP is unknown.

3. CIPP is typically not suited for use in close proximity to other utilities.

4. CIPP has the potential to save significant amounts of money in certain situations compared with RCP.

5. The use of CIPP eliminates the waiting period frequently encountered with larger dimension RCPs.

6. A variety of soil conditions may preclude the use of CIPP.

7. Limitations in access may be longer in projects with CIPP installations than in RCP installations due to the required curing time.

8. Due to the typically larger nominal diameter pipe required and thicker pipe wall associated with CIPP relative to RCP clearance problems at utility crossings should be examined prior to specifying CIPP as an alternate.

9. In cases where the use of CIPP may be appropriate, CIPP should be included in the proposal as an alternate. Appropriate changes in the Special Provisions shall also be included.

10. Specialized equipment and techniques involved in the placement of CIPP may limit the number of contractors able to bid on a project where CIPP has been specified. As specified in the Standard Specifications, Sec. 501-3.07(A): evidence of the successful operation of the equipment on other prior work may be required. This requirement shall be met with the requirement that any contractor (or his designated subcontractor) who is the successful bidder on a CIPP project will be required to install a 50 foot long test section of CIPP which meets the requirements of section 501-3.07 Nonreinforced Cast-In-Place Concrete Pipe of the 1988 edition of the Pima County/City of Tucson Standard Specifications for Public Improvements. The installation of additional CIPP will not proceed until an acceptable test section shall be removed from its trench and disposed of in an approved manner at the Contractors expense prior to the placement of another test section.

TABLE 15-1. Velocity and Discharge of Circular Sewers Flowing Full

$S^{1/2}/N = 1$ in the Manning Formula.

Diameter, D, in.	*Area*, A, sq ft	*Velocity*, V_0, fps	*Discharge*, Q_0, cfs
6	0.1963	0.3715	0.07293
8	0.3491	0.4500	0.1571
10	0.5455	0.5222	0.2848
12	0.7854	0.5897	0.4632
15	1.2272	0.6843	0.8398
18	1.7671	0.7728	1.366
21	2.4053	0.8564	2.060
24	3.1416	0.9361	2.941
27	3.9761	1.0116	4.026
30	4.9087	1.0863	5.332
36	7.0686	1.2267	8.671
42	9.6211	1.3594	13.08
48	12.5664	1.4860	18.67
54	15.9043	1.6074	25.56
60	19.6350	1.7244	33.86

For given values of S and N multiply velocity V_0 and discharge Q_0 by $S^{1/2}/N$ in order to obtain V and Q respectively.

Like the selection of C in the Hazen-Williams formula, the choice of a suitable value of the roughness factor N is of utmost importance but must usually be left to the judgment of the designer. Of assistance in this connection can be the values in Table 15-2 which are taken from a list compiled by Horton [3] from reliable experimental data.

TABLE 15-2. Values of the Kutter Coefficient of Friction N for Different Conduit Materials (*after Horton*)

	Condition of interior surface			
Conduit material	*Best*	*Good*	*Fair*	*Bad*
Tile pipe, vitrified (glazed)	0.010	0.012	0.014	0.017
unglazed	0.011	0.013	0.015	0.017
Concrete pipe	0.012	0.013	0.015	0.016
Cast-iron pipe, coated	0.011	0.012	0.013	.....
Brick sewers, glazed	0.011	0.012	0.013	0.015
unglazed	0.012	0.013	0.015	0.017
Steel pipe, welded	0.010	0.011	0.013	.....
riveted	0.013	0.015	0.017	.....
Concrete-lined channels	0.012	0.014	0.016	0.018

[3] R. E. Horton, "Some Better Kutter's Formula Coefficients," *Eng. News*, 75, 373 (1916).

FLOW IN SEW

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TABLE 15

Diameter, in. 6

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Q, cfs 0.3

$S \times 10^3$ 6.5
Q, cfs 0.4

$S \times 10^3$ 9.2
Q, cfs 0.5

15-4. Flow i
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[4] E. R. Wilcox.
[5] D. L. Yarnell
[6] "Report of C
J. Boston Soc. C

Table 3-12 Effective Absolute Roughness and Friction Formula Coefficients (7)

	Conduit Material	Manning n (ft ⅙)
	Closed conduits	
	Asbestos-cement pipe	0.011-0.015
	Brick	0.013-0.017
	Cast iron pipe	
	Uncoated (new)	—
	Asphalt dipped (new)	—
	Cement-lined & seal coated	0.011-0.015
	Concrete (monolithic)	
Precast	Smooth forms	0.012-0.014
Cast in place	Rough forms	0.015-0.017
	Concrete pipe	0.011-0.015
	Plastic pipe (smooth)	0.011-0.015
	Vitrified clay	
	Pipes	0.011-0.015
	Liner plates	0.013-0.017
	Open channels	
	Lined channels	
	a. Asphalt	0.013-0.017
	b. Brick	0.012-0.018
	c. Concrete	0.011-0.020
	d. Rubble or riprap	0.020-0.035
	e. Vegetal	0.030-0.40
	Excavated or dredged	
	Earth, straight and uniform	0.020-0.030
	Earth, winding, fairly uniform	0.025-0.040
	Rock	0.030-0.045
	Unmaintained	0.050-0.14
	Natural Channels (minor streams, top width at flood stage < 100 ft.)	—
	Fairly regular section	0.03 -0.07
	Irregular section with pools	0.04 -0.10

Table 3-13 Values of Coefficient of Roughness (n) for Standard Corrugated Steel Pipe (Manning's Formula)*

Corrugations	Annular 2⅔ x ½ in	Helical 1½x¼ in (11,12)		Helical 2⅔ x ½ in (13)					
	All Diameters	8"	10"	12"	18"	24"	36"	48"	60" and Larger
Unpaved	.024	.012	.014	.011	.014	.016	.019	.020	.021
25% Paved	.021					.015	.017	.020	.019
Fully Paved	.012					.012	.012	.012	.012

	Annular 3 x 1 in	Helical — 3 x 1 in					
		48"	54"	60"	66"	72"	78" and Larger
Unpaved	.027	.023	.023	.024	.025	.026	.027
25% Paved	.023	.020	.020	.021	.022	.022	.023
Fully Paved	.012	.012	.012	.012	.012	.012	.012

Corrugations 6 x 2 in	60"	72"	120"	180"
Plain—Unpaved	.033	.032	.030	.028
25% Paved	.028	.027	.026	.024

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DRAINAGE & SEWERAGE - HYDRAULIC COMPUTATIONS - I

TABLE A - VALUES OF n, TO BE USED WITH KUTTER OR MANNING FORMULAS.†

SURFACE	CONDITION			
	BEST	GOOD	FAIR	BAD
Uncoated cast-iron pipe	0.012	0.013	0.014	0.015
Coated cast-iron pipe	0.011	0.012*	0.013*	
Commercial wrought-iron pipe, black	0.012	0.013	0.014	0.015
Commercial wrought-iron pipe, galvanized	0.013	0.014	0.015	0.017
Smooth brass and glass pipe	0.009	0.010	0.011	0.013
Smooth lockbar and welded OD pipe	0.010	0.011*	0.013*	
Riveted and spiral steel pipe	0.013	0.015*	0.017*	
Vitrified sewer pipe	{0.010 / 0.011}	0.013*	0.015	0.017
Common clay drainage tile	0.011	0.012*	0.014*	0.017
Glazed brickwork	0.011	0.012	0.013*	0.015
Brick in cement mortar, brick sewers	0.012	0.013	0.015*	0.017
Neat cement surfaces	0.010	0.011	0.012	0.013
Cement-mortar surfaces	0.011	0.012	0.013*	0.015
Concrete pipe	0.012	0.013	0.015*	0.016
Wood-stave pipe	0.010	0.011	0.012	0.013
Plank flumes:				
Planed	0.010	0.012*	0.013	0.014
Unplaned	0.011	0.013*	0.014	0.015
With battens	0.012	0.015*	0.016	
Concrete-lined channels	0.012	0.014*	0.016*	0.018
Cement-rubble surface	0.017	0.020	0.025	0.030
Dry rubble surface	0.025	0.030	0.033	0.035
Dressed ashlar surface	0.013	0.014	0.015	0.017
Semicircular metal flumes, smooth	0.011	0.012	0.013	0.015
Semicircular metal flumes, corrugated	0.0225	0.025	0.0275	0.030
Canals and ditches:				
Earth, straight and uniform	0.017	0.020	0.0225*	0.025
Rock cuts, smooth and uniform	0.025	0.030	0.033*	0.035
Rock cuts, jagged and irregular	0.035	0.040	0.045	
Winding sluggish canals	0.0225	0.025*	0.0275	0.030
Dredged earth channels	0.025	0.0275*	0.030	0.033
Canals with rough stony beds, weeds on earth banks	0.025	0.030	0.035*	0.040
Earth bottom, rubble sides	0.028	0.030	0.033*	0.035
Natural stream channels:				
1. Clean, straight bank, full stage, no rifts or deep pools	0.025	0.0275	0.030	0.033
2. Same as (1), but some weeds and stones	0.030	0.033	0.035	0.040
3. Winding, some pools and shoals, clean	0.033	0.035	0.040	0.045
4. Same as (3), lower stages, more ineffective slope and sections	0.040	0.045	0.050	0.055
5. Same as (3), some weeds and stones	0.035	0.040	0.045	0.050
6. Same as (4), stony sections	0.045	0.050	0.055	0.060
7. Sluggish river reaches, rather weedy or with very deep pools	0.050	0.060	0.070	0.080
8. Very weedy reaches	0.075	0.100	0.125	0.150

Note: Asbestos-Cement Pipe (Transite) use 0.010.

* *Values commonly used in designing.*

† *Adapted from Handbook of Applied Hydraulics [illegible]*