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Precast Concrete Pipe SPEEDS CONSTRUCTION of Kansas City Speedway



- **Precast Concrete Box Culverts Help Pre-empt Urban Flooding**
- **Utah Sanitary Sewer District Selects Small Diameter Precast Concrete Pipe**
- **Hydraulics — De-mystifying Manning's *n***



This issue:

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Concrete Pipe News is designed to provide a communication forum for the concrete pipe industry to facilitate the exchange of information regarding product use and applications, industry technology and trends among members of the American Concrete Pipe Association, contractors, engineers, vendors, suppliers and other interested parties.

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*Front Cover Photo:
Courtesy of Wieck
Photo Database,
Kenny Irwin Texaco
Havoline car/MSI-
Nigel Kinkade.*

*Inset Photo:
Over 8 miles (13 km)
of reinforced concrete
pipe were installed at
the Nation's newest
NASCAR track in
Kansas City, Missouri.*





John J. Duffy

Standard Products and Special Designs **The ACPA Has The Information That Counts**

When you are searching for information about precast concrete drainage systems, the American Concrete Pipe Association is the place to start. For decades, the Association has built and maintained relationships with federal, state, and provincial standards agencies, universities and businesses to create the leading source of concrete pipe and drainage products information throughout the Americas. ACPA's resource library includes publications, research papers, standards, design software, guidelines, manuals and directories. Businesses and industry associations in countries around the world often approach the ACPA for information to advance the understanding of soil/pipe relationships and materials testing. If your research takes you into the technology of concrete pipe design and installation, your first stop should be the ACPA.

In this issue of *Concrete Pipe News*, we have published three articles that show how precast concrete pipe can be specially designed to suit just about any application. We look at its use in a new high performance motor speedway in Kansas City, Missouri that only allowed concrete storm

sewer pipe in critical areas of the facility. In Henderson, Minnesota, a creek that flowed overland and in conduits beneath city streets and buildings was realigned and channeled in a unique precast concrete box system to pre-empt possible flooding and extensive structural damage to buildings. And in Utah, Sewer Districts in the State continue to specify slightly modified, small diameter concrete pipe for sanitary sewer applications.

There are many myths that continue to cloud the facts about Manning's "n" and the hydraulic performance of precast concrete pipe compared to alternate products. Much has been done in universities and industry to dispel these myths over the past 20 years. The ACPA has an extensive library on Manning's "n" research and case studies to share with engineers, contractors, specifiers, and owners of buried drainage systems. A technical article on Manning's "n" by ACPA staff is a "heads up" for designers to the fact that RCP hydraulic capacity is superior to alternate products in many applications, and should not be overlooked because of misinformation.

Our Industry Spotlight features James (Jim) A. Aumann, Vice President of American Concrete Pipe Company's Green Bay, Wisconsin operation, and Secretary of the firm's Board of Directors. Jim has been an active member of our Association for many years, having served on our Board of Directors on several occasions. Currently he is serving as ACPA's Treasurer on ACPA's Executive Committee. Through the years, Jim has seen quite a bit of change in our industry has championed the need for continuing improvement and automation in manufacturing facilities. His comments in this issue of *Concrete Pipe News* reflect his passion on the value of automation to the industry.

The American Concrete Pipe Association is a world-renowned organization that draws on the strength of its members for the advancement of knowledge related to precast concrete pipe, and materials used for other drainage products. It is a knowledge-based association that relentlessly pursues research and good science on which to build its products and industry. The ACPA has documented 10 decades of history and applied science on buried infrastructure that is frequently sourced and referenced by today's drainage system designers and researchers. The Association is the first place to go when you need to know about buried pipe and drainage systems. ☺



James A. Aumann

The success of companies and organizations that endure for decades share a common characteristic: continuity of focus. This does not happen by chance. It is due, to a large part, to people who have dedicated their careers, and often their lives, to a vision carefully developed by founders and their successors – and by staying involved. James (Jim) Aumann, Vice President of American Concrete Pipe Company, a subsidiary of Spancrete Group, is one such person who has provided stability and continuity of focus for his company and industry. Since the day he started work in the concrete pipe industry in 1955 for Lock Joint Pipe Company, Jim has been a guiding force in the industry. Later in his career, he served the American Concrete Pipe Association, as Committee Chairman, Task Group Chairman and as an Officer on the Board of Directors. He is currently Treasurer of the ACPA.

Jim has also been a leader in determining direction for the Wisconsin Concrete Pipe Association by serving on its Board. As an officer with American Concrete Pipe Company, responsible for plant operations in Milwaukee and Green Bay, he has helped raise the level of technology and quality of products in the concrete pipe industry in that State, and throughout North America. On a personal level, he has championed industry fundraising activities throughout his life to help needy children through the YMCA in the Green Bay area. During the past ten years, almost \$300,000 has been raised for the Partners With Youth program.

It is not easy to draw a person such as Jim into the limelight, for even a few moments. He asks



nothing from his peers, but gives all that he can. Jim has been on the front line of introducing new technology to an industry that has enjoyed great success based on production techniques which have endured for decades. He agreed to provide us with some valuable reflections on plant automation and the new technology being introduced today.

Q: *Automation throughout American industries has been a key indicator of growth. When did it become apparent that the concrete pipe industry was moving into automated production, and what areas of production were first automated?*

Aumann: In 1965, Hurlbut Company bought the first Black Clauson automated cage machine. The unit was stamped with model No. 1 on it, and was a sign of things to come, such as automated batching and mixing. In the 1970s the first pipe machines with automated feeds entered the market through Hydrotile, and in the early 80s the first semi-automated pipe plant appeared in Cleveland, Ohio. But it wasn't until 1988 that the first completely automated plant was established in the USA at American Concrete Pipe Company's plant in Milwaukee using five equipment suppliers.

Q: *What elements have to be in place for successful initiatives to automate plant production processes?*

Aumann: When it is time to update equipment, make a major replacement, or build a new facility, you have to look at automation to reduce man-hours and have consistency of product. With consistency in three-edge bearing tests, absorption, density and pipe joint performance, the results are products that meet stringent infiltration and air testing in the field.

Q: *What parts of a plant's operations are most in need of constant attention to changing technology? Please explain.*

Aumann: The entire plant operations need constant attention including aggregate storage, cement storage, batching and mixing, handling concrete mix, the cage machines, pipe machines, handling pipe in and out of curing, de-palletizing, testing

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NATION'S NEWEST NASCAR TRACK SPORTS PLENTY OF RCP

By Ed Sexe, P.E., Sales Engineer and Steve Rowland, Sales Representative Kansas City Concrete Pipe Company Shawnee, Kansas 913-422-3634

Construction continues on Kansas City's new NASCAR motor speedway using reinforced concrete pipe in all critical areas, including the infield, racetrack, and major roadways accessing the facility. The \$200 million Kansas City Speedway will host the Winston Cup, Busch Grand National and IRL races in 2001. The 1.5-mile tri-oval track and accessory buildings cover more than 1,100 acres. It will initially seat 75,000 fans and provide parking for over 65,000 vehicles, and could be expanded to seat 150,000.

Safety of spectators and race drivers tops the list of design requirements for the facility, considering that anticipated qualifying speeds for the Winston Cup cars will be 175 to 185 mph. A very high-grade polymer-modified asphalt was used to pave the track to ensure that the surface was as smooth as possible.

Over 8 miles (13 km) of reinforced concrete pipe (RCP) were installed at the speedway. Sizes ranged from 12-inch (300-mm) diameter to 132-inch (3300-mm) diameter pipe. Strengths included Class III, Class IV, Class V and one D-Load special design. O-ring gaskets were used for the joints of many of the installations. Tongue and groove joints were used on pipe in smaller quantities.

Included in the inventory of reinforced concrete

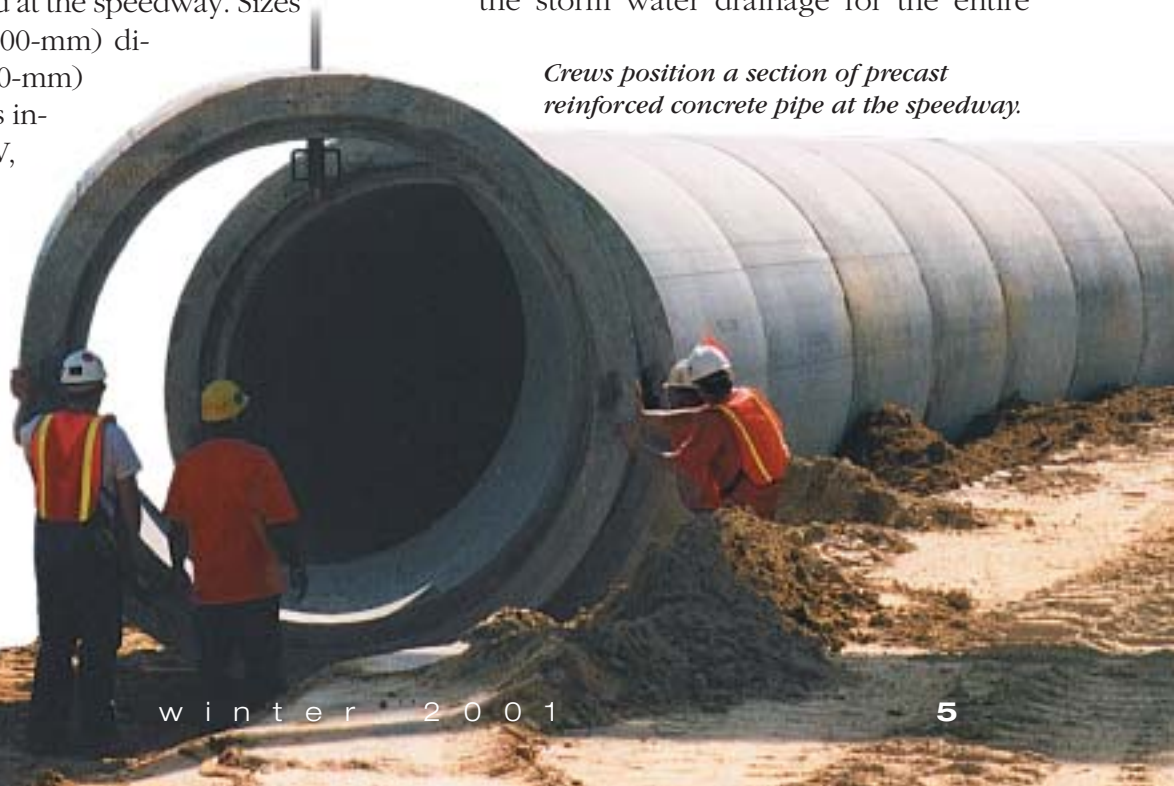
pipe products were elliptical pipe, box units and precast arch structures (CON/SPAN) for a 36-foot wide x 16-foot high vehicular tunnel. The products were supplied to the speedway by ACPA member, Kansas City Concrete Pipe Company (KCCP), Shawnee, Kansas. KCCP is a member of The Cretex Companies, Inc., headquartered in Elk River, Minn. Another ACPA member, CSR Hydro Conduit in Riverside, Mo., also supplied a portion of the precast concrete pipe products for the speedway construction.

Early in the design phases, Kansas City Concrete Pipe Company provided input into the design of the infrastructure related to precast concrete products. Many design options were discussed with regard to the entrance tunnel, pedestrian tunnel, and storm sewer piping. One of the more complex design components was the 96-inch (2400-mm) 3800D-Load pipe. Under 80 feet of fill, the installation incorporated an imperfect trench design and heavy wall pipe.

Precast Concrete Pipe Selected

This line of specially designed pipe carries the storm water drainage for the entire

Crews position a section of precast reinforced concrete pipe at the speedway.



infield of the racetrack. Although alternate drainage pipe materials were also used, the design engineers were directed to use reinforced concrete pipe in all critical situations where pipe failures could not be tolerated.

The precast concrete arch structure for the vehicular tunnel carries traffic in and out of the infield. The original design was for three (22-foot diameter) metal arch plates set side by side. When significant savings were realized by using a single 36 ft. span by 10 ft. rise precast arch CON/SPAN system set on pedestal walls, the original design was changed. Savings came in the form of rock excavation, elimination of special backfill, placement costs, and miscellaneous other items.

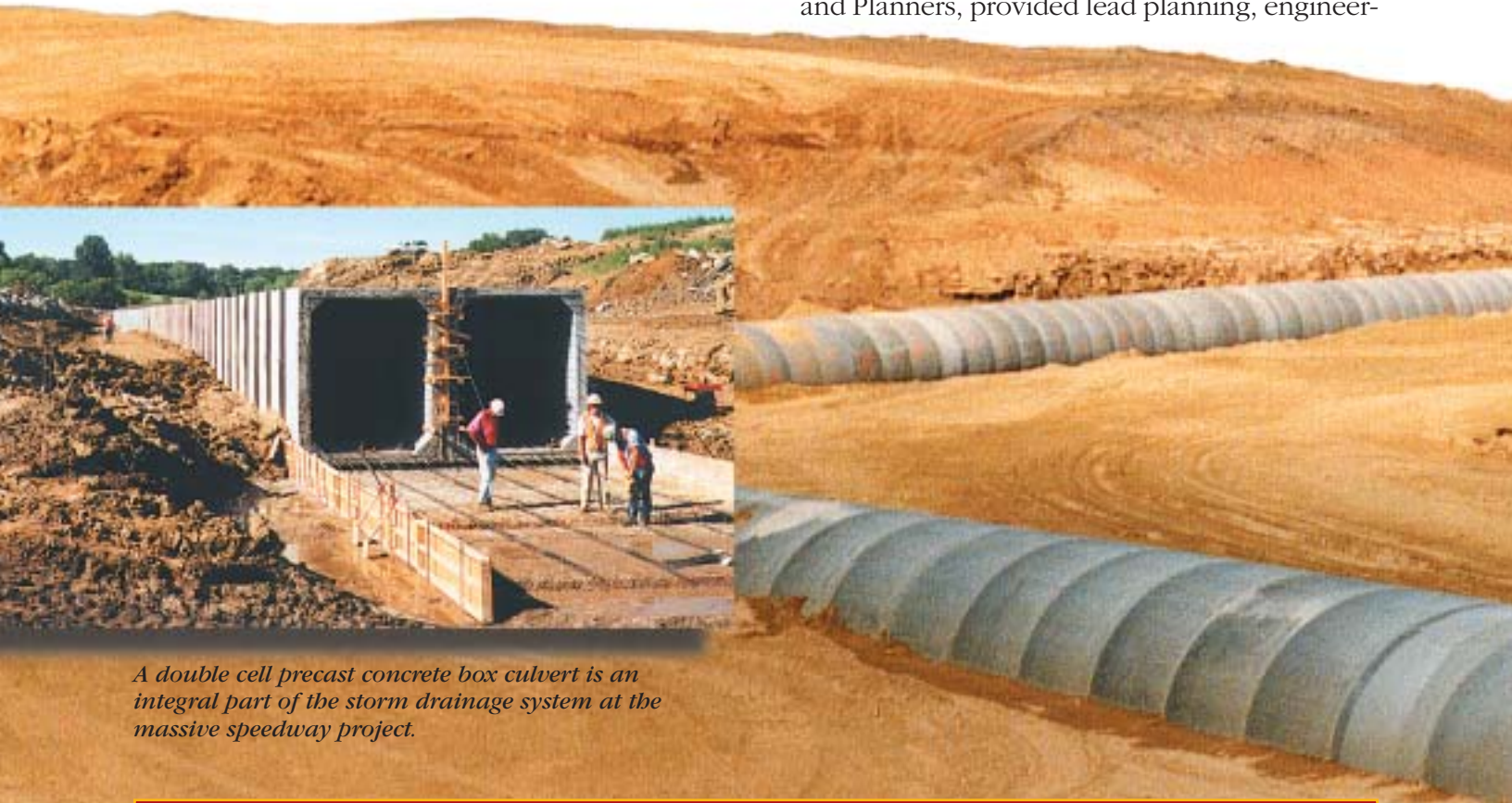
When completed, the new speedway will be the largest tourist attraction in the state. It is

located at the intersection of I-435 and I-70 — the largest intersection in the State of Kansas, providing 12 lanes of traffic to access the facility. The intersection allows easy access from all directions. In addition to the construction for the complex itself, arterial work on Parallel Parkway, 110th Street, New Jersey Avenue and I-70/I-435 was necessary to accommodate the expected traffic.

The size and scope of the project is massive. In addition to over 8 miles of precast concrete pipe used on the project, eleven million cubic yards of earth (or enough earth to fill an NFL stadium five times), was moved for construction.

Close Coordination Required

Design partners HNTB, Architects, Engineers and Planners, provided lead planning, engineer-



A double cell precast concrete box culvert is an integral part of the storm drainage system at the massive speedway project.

Kansas City Concrete Pipe Company (KCCP) built a new manufacturing facility in Bonner Springs, Kansas in 1997 to better provide RCP and precast products to the Kansas and Missouri market areas. In addition to pipe, a full range of precast box culverts and CON/SPAN short span bridges are also produced at this facility. KCCP became part of the Cretex Companies in 1978 when Ramsey Concrete Pipe Co. in Merriam, Kansas was purchased. This acquisition expanded Cretex into the Kansas City area. Cretex was founded in 1917 in Elk River, Minnesota, the current site of their corporate headquarters. In addition to the Kansas City plant, Cretex also operates production facilities in Montana, Wyoming, the Dakotas, Minnesota, Iowa and Wisconsin. For a further look at the affiliate companies of Cretex and their respective product lines, go to www.cretexinc.com.

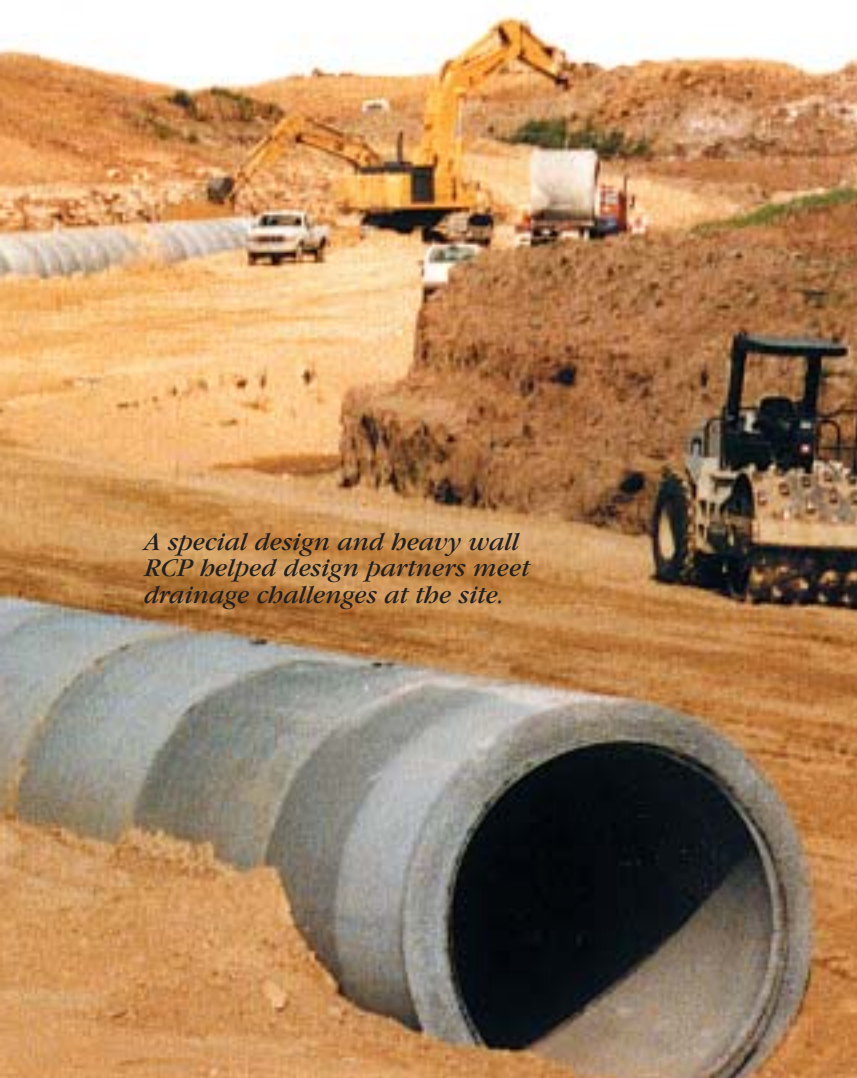
ing, design and construction services for the track, track facilities and access roads. The DLR Group, provided architecture, mechanical, electrical, and some structural engineering. Continental Engineers, Delich Roth and Goodwillie, and Transystems Inc., provided design and construction services for the external roadways.

Turner Construction provided the full-service construction management for the construction process. Morrison Knutson (MK) was selected as the contractor for the mass-grading package. The mass-grading package is to include all infrastructure work done on the complex itself. Clarkson Construction Company from Kansas City, Mo., constructed surface drainage, bridges, and paving for the State Avenue Relocation, 110th Street, and I-70/I-435 widening, and Amino Construction from Kansas City, Kan., constructed the widening of New Jersey Avenue.

Max Riekie Construction from Shawnee, Kan., participated in the work involved for State Avenue Relocation.

Other subcontractors for MK were The Garney Companies, from Riverside, Mo., who did work on the pedestrian tunnel and vehicular tunnel. Carney Construction from Kansas City, Mo., also performed work on the pedestrian and vehicular tunnels.

The new Kansas City Speedway will be one of the State's major attractions. Precast reinforced concrete pipe and structures are major assets of the site's infrastructure that will function efficiently and safely over the design life of the facility. Visitors will enjoy major race events knowing that the design and construction team understood the value of working with quality products. ☺



A special design and heavy wall RCP helped design partners meet drainage challenges at the site.

| | |
|---|--|
| Project: | Kansas City International Speedway |
| Owner: | Kansas International Speedway Corporation |
| Designer: | HNTB, Architects, Engineers and Planners Kansas City, Missouri Project Consulting Engineer |
| Construction | |
| Manager: | Turner Construction Kansas City, Missouri |
| Reinforced Concrete Pipe (Speedway Site) | |
| 21,434 feet | (12-inch to 48-inch) diameter Class III to V (O-Ring) |
| 569 feet | 54-inch diameter Class III (O-Ring) |
| 1,679 feet | 60-inch diameter Class III (O-Ring) |
| 374 feet | 78-inch diameter Class III (O-Ring) |
| 144 feet | 84-inch diameter Class III (O-Ring) |
| 266 feet | 96-inch diameter Class V (O-Ring) |
| 1,556 feet | 96-inch diameter 3800 D (O-Ring) |
| 138 feet | 24-inch diameter Class III (T&G) |
| 174 feet | 30-inch diameter Class III (T&G) |
| 350 feet | 36-inch diameter Class III (T&G) |
| 272 feet | 102-inch diameter Class V (T&G) |
| 228 feet | 132-inch diameter Class V (T&G) |
| 300 feet | 36-foot span x 10-foot rise CON/SPAN (access tunnel) |
| Reinforced Concrete Pipe (External Roadways) | |
| 15,208 feet | (12-inch to 48-inch) diameter Class III to V (O-Ring) |
| 396 feet | 54-inch diameter Class III (O-Ring) |
| 311 feet | 66-inch diameter Class IV (O-Ring) |
| 709 feet | 72-inch diameter Class IV (O-Ring) |
| 546 feet | 84-inch diameter Class V (O-Ring) |
| 168 feet | (34-inch x 53-inch) Elliptical Class III |
| 35 feet | (43-inch x 68-inch) Elliptical Class III |
| 858 feet | (8-foot x 10-foot) C-789 Double Cell Box Culvert |

PRECAST CONCRETE BOX CULVERT USED TO PRE-EMPT URBAN FLOOD DAMAGE

*By James P. Loaney
Director of Marketing
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Potential major flooding and structural damage in historic Henderson, Minnesota, located 50 miles southwest of Minneapolis-St. Paul, has been averted with the use of a unique precast concrete box culvert system. The new culvert redirects flow from Mill Creek, that meanders in an open channel through residential areas, and under streets and buildings in various drainage structures, to its outfall into the Minnesota River. The Minnesota River flows to the Mississippi River.

The idea for the box culvert drainage system came from Henderson officials and engineering staff that had successfully installed a precast concrete box culvert under a highway within the city in 1998-99. They realized that a precast box system could solve the problem of a deteriorating portion of the Mill Creek conduit that channeled flow under several buildings.

The consulting engineering firm, Short Elliott Hendrickson Inc. (SEH) of Gaylord, Minn., worked

with Sibley County Public Works staff on the preliminary design and funding application through a Minnesota DOT (MnDOT) bridge bonding program. Flow from Mill Creek would be redirected from beneath buildings to a line and grade following a street and alley in the immediate vicinity, to its outlet in the existing open channel that crosses the back yards of a residential neighborhood. When it came time to consider design details, SEH worked with staff of Hancock Concrete Products, Minneapolis, Minn., and Sibley County to develop the final design.

The 10-foot x 5-foot box culvert system has three bends, each negotiating a seventy-five degree turn in the alignment of the channel. Each bend required five special box sections. These bend sections were cast in the Hancock plant at Cannon Falls, Minn. A special form was used to produce the sections with a two-step pouring operation that facilitated the tight completion schedule of the project. The potential for high velocities in the line required that the entire joint of each section had to be double sealed with a preformed mastic. A 3-ply water proofing material (24 inches wide) was used along the top and sides of each joint, instead of commonly used filter fabric. Manufacture of the 10-foot x 5-foot sections also had to account for storm sewer side entrances.

The structural design of the culvert system was a MnDOT Specification (MnDOT SPEC. 2412) for fill cover of less than two feet. This design accommodates

AASHTO HS 25 truck loading required for vehicles servicing adjoining businesses from the alley. The MnDOT standard for precast concrete box culverts is a modified BOXCAR design developed by the American Concrete Pipe Association.

The hydraulic design of the culvert was affected by existing utilities and

Precast concrete box sections stand ready to help prevent potential flood damage.



conditions that limited the maximum height of the structure. An open flume entered the culvert by first flowing into a six-foot high culvert, and then a five-foot mainline culvert. To maximize the structure height, a vertical bend was constructed to lower the grade line of the culvert. The vertical bend also increased flow velocities and reduced flow depths, thereby allowing the designer to downsize the mainline culvert. A precast reducer section, located 30 feet (9.14 meters) downstream from the six-foot inlet was used at the inlet to the five-foot high system to accommodate transition from the six-foot high structure to the five-foot high structure. Manhole and catch basin connections throughout the mainline also affected the design.

Selly Construction Inc. of LeCenter Minn., was awarded the contract for the work. The company was prepared to deal with the complexities of the installation that included working with existing utilities, maintaining the flow of Mill Creek during construction, and restricted work areas. There was also an overall concern that a heavy summer rain, and subsequent runoff, would set back the construction schedule. A precast concrete box culvert system was the only choice that would meet the challenges to the contractor, and satisfy the scheduling and economic considerations.

To allay fears of a sudden summer storm, the contractor constructed the precast portion of the system first, comprised of 300 linear feet (91.44 meters) of structure. Connections to the existing upstream and downstream open flume were left to the end of the construction schedule. The cast-in-place connections at both ends of the new culvert required precise alignment of the new precast concrete culvert to minimize any abrupt change in channel alignment. The old tunnel in the street areas was removed, and

sections beneath buildings were filled with pressure grout and plugged at the ends.

Construction of the culvert progressed rapidly, taking 13 days from start to finish. Savings in time and cost, by using precast concrete sections, were major features of the project. Limited traffic disruption and associated costs to residents and businesses were great benefits to the community. Now, the City can enjoy decades of progress knowing that flooding of Mill Creek is highly unlikely, due to a unique precast concrete box culvert channeling a section of Mill Creek below its streets. ☺

| | |
|-----------------------------|---|
| Project: | Mill Creek Precast Box Culvert |
| Owner: | City of Henderson, Minnesota Lon Berberich, City Administrator |
| Designer: | Sibley County Public Works Gaylord, Minnesota Nathan Richman, P.E. Public Works Director |
| Consulting Engineer: | Short-Elliott Hendrickson Inc. Gaylord, Minnesota John Wingard, P.E. Project Engineer Tom Stearns Resident Project Representative |
| Contractor: | Selly Construction Inc. LeCenter, Minnesota Bob Selly Dan Selly Jerry Selly |
| Quantities: | 270 linear feet (10-foot x 5-foot) reinforced concrete box sections (including several feet of bends and 6-foot transition-reducer section) 30 linear feet (10-foot x 6-foot) reinforced concrete box sections |
| Producer: | Hancock Concrete Products Company, Inc. Cannon Falls Plant |



Precast concrete box sections allowed crews to complete the project in 13 days, with limited traffic disruption and inconvenience to businesses and residents.

Hancock Concrete Products Company, Inc., a long time member of the American Concrete Pipe Association, has been manufacturing and supplying precast drainage products to Minnesota, Iowa, Wisconsin, and the Dakotas since 1917. Hancock Concrete Products operates five manufacturing facilities in Minnesota and Iowa. It maintains a comprehensive line of precast products, utilizing the latest in manufacturing and production technologies for manufacture of reinforced concrete pipe, precast box culverts, arch pipe and a variety of associated products including manholes, catch basins, inlets, and end treatments. For details, see www.hancockconcrete.com.

S M A L L D I A M E T E R

RCP Passes Rigorous Tests For Sanitary Sewer System

By Van Fuller
Sales Representative
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Owners of sanitary sewer systems in Utah recognize the value of precast concrete pipe, especially small diameter reinforced concrete pipe (RCP) for sanitary sewers. Many miles of small diameter concrete pipe have been installed since 1999 (see *Concrete Pipe News* Vol. 51, No. 2, Fall 1999) to serve residential and industrial users in and around Salt Lake City. Now an installation in nearby Clinton City is adding to the inventory of concrete pipelines.

The North Davis County Sewer District is overseeing the installation and performance testing of more than a mile of 21-inch Class III RCP buried at depths up to twenty feet. Included in the system are 28 (48-inch and 60-inch diameter) manholes, complete with precast concrete bases, pipe connectors, cones, steps, frames and covers. The precast reinforced concrete pipe was provided by Amcor Precast in Ogden, Utah, a member of the American Concrete Pipe Association. Amcor is a division of Oldcastle Precast, with headquarters in Auburn, Washington.

The sanitary sewer is needed to accommodate rapid residential growth in Clinton City that is nearing a population of 14,000. In 1990, the population was 7,945. Located about 30 miles north of Salt Lake City and 15 miles from Ogden, Clinton

City has been proclaimed by its Mayor as the “finest bedroom community in the State of Utah”. The installation ran through a residential neighborhood and along a roadway. Reconstruction of the road was required where the sanitary line was located under the pavement.

Each concrete pipe was sealed with rubber compound gaskets with a bell and spigot joint design conforming to the requirements of ASTM C 443. The specification also required that the pipe be manufactured with sulfate-resistant Type II modified cement. The contractor for the “2700 West Relief Sewer” project is Whitaker Construction of Brigham City, Utah. The project was completed in the fall of 2000.

Judd Hamson, Project Manager with Whitaker Construction, said that the

North Davis-2700 West Relief Sewer project presented a real challenge with the installation of over a mile of 21-inch diameter RCP through a residential neighborhood at depths ranging from 12 to 20 feet, but commented that the project went very smoothly – thanks in large part to the quality of the pipe.

“The North Davis Sewer District has a

very tough specification for concrete pipe and Amcor Precast was required to air test every pipe at the factory. Another feature of their pipe was painted bells to seal any irregularities in the concrete surface,” Hamson said. “Whitaker Construction feels that the quality control measures imple-



Precast RCP being uploaded for a sanitary sewer project.

mented by Amcor are a big part of the reason why this project went so smoothly.”

Precast concrete pipe was preferred because of its durability and performance. After installation, the City did not want to undertake any unplanned maintenance of the line during its design life. Since it passed under a roadway and through



Rigorous testing, on site inspection and quality installation helped assure a successful project.

a residential area that had inherently wet soil conditions, any potential leakage or infiltration had to be minimized.

Testing of the pipe and inspection of the installation were major considerations of both the consulting engineer, Montgomery Watson of Salt Lake City, and Clinton City officials. Every pipe used on the project had to be air tested before leaving the plant, and certified before acceptance on the job site. In addition to positive pressure air testing, a percentage of the pipe also had to be hydrostatically tested at the plant.

All copies of the test results were submitted to the contractor who then forwarded the results to the consulting engineer. A representative from Amcor Precast was on site to observe air testing between manholes. The contractor was responsible for air testing the line and the consulting engineer’s inspector was also present. These tests assured the owner that the pipe quality would meet their expectations, and together with a quality installation by Whitaker Construction, the sewer line would be water tight.

The field testing consisted of low air pressure according to ASTM C 924. All pipe had to be back-filled before testing, while manholes had to be

tested for leakage before the placement of back-fill.

Small diameter reinforced concrete pipe is a reliable product for sanitary sewers. Concrete mixes can be specially designed for aggressive environments within the pipe and in surrounding soils. There are well-established tests for determining quality of pipe joints and walls. In Clinton City, the consulting engineer and city officials made full use of the test procedures available, and also provided inspection for the installation and testing. The city will continue to grow. With its well-designed buried concrete infrastructure, long-time and new residents of this fast growing community will enjoy safe neighborhoods and a healthy environment for decades to come. ☺

| | |
|-----------------------------|---|
| Project: | Clinton City 2700 West Relief Sewer |
| Owner: | Clinton City, Utah North Davis Sewer District |
| Consulting Engineer: | Montgomery Watson, Salt Lake City, Utah (Designer) Paul Higgins, Inspector |
| Contractor: | Whitaker Construction, Brigham City, Utah Brian Hamson, Project Supervisor Judd Hamson, Project Manager |
| Quantities: | 5,800 linear feet of 21-inch diameter Class III RCP 28 (48-inch and 60-inch diameter) manholes Precast manhole bases, pipe connectors, cones, steps, frames and covers. |
| Producer: | AMCOR Precast (a division of Oldcastle Precast) Ogden, Utah Van Fuller, Sales Representative |

Amcor Precast, Ogden, Utah, a long-time member of the American Concrete Pipe Association, was one of the first acquisitions by the Oldcastle Group as it expanded its presence in the United States starting in 1978. The plant is enclosed for year-round production and has a state-of-the-art automated batch plant. Products available at the plant include concrete pipe, catch basins, utility vaults, grease interceptors, bridges, and a variety of other precast construction products. For details, see www.oldcastleprecast.com.

De-mystifying Manning's *n*

The Hydraulic Advantage of Reinforced Concrete Pipe

*Adapted from a presentation by Al Hogan, P.E.
Sherman Dixie Concrete Industries, Inc.
Compiled and edited by
Matt Childs, P.E., Director of Engineering Services
American Concrete Pipe Association*

Reinforced Concrete Pipe (RCP) has many advantages over its competitors. Most engineers are aware of its advantages in areas of design life, resistance to flotation, inherent strength properties, durability and water-tight joints. Few design professionals, however, are aware of the superior flow characteristics that reinforced concrete pipe has over corrugated metal pipe (CMP) and high-density polyethylene (HDPE) pipe. The methods for determining pipe diameters using Manning's *n* values presented in this article will assist the designer in realizing that RCP will, in many cases, allow a smaller diameter pipe than it's competition.

Selection of the correct value for the coefficient of roughness of a pipe (Manning's *n*) is essential in evaluating the flow through culverts and sewers. An excessively high value may result in over-sizing of pipe, likewise, the selection of a low value, equated with a smoother surface, can result in a hydraulically inadequate sewer system.

The amount of water that a pipe in a gravity sewer can convey (hydraulic capacity) depends on how smooth the interior pipe wall is as well as other factors including pipe size and the slope of the pipe. All other factors being equal, the smoother the wall, the greater the capacity. Research has concluded that projects designed with CMP can be downsized by at least one size in most cases, by using RCP and the correct values for Manning's *n*.

Proper values for the coefficient of roughness of commercially available pipe, has been the objective of continuous research. Consequently, extensive knowledge and data are available on this controversial subject. To the designer, the presently accepted values for the coefficient of

roughness are of great importance. Also important is an understanding of how these values were determined. Research often indicates new *n* values for pipe materials significantly different from those previously used.

The difference between laboratory test values of Manning's *n* and accepted design values is significant. Numerous tests by public and other agencies have established Manning's *n* laboratory values. These laboratory results, however, were obtained using clean water and straight pipe sections without bends, manholes, debris, or other obstructions. The laboratory results indicated the only differences were between smooth wall and rough wall pipes. Rough wall, such as unlined corrugated metal pipe have relatively high *n* values which are approximately 2.5 to 3 times those of smooth wall pipe.

Smooth wall pipes were found to have *n* values ranging between 0.009 and 0.010, but historically, engineers familiar with concrete pipe have used 0.012 or 0.013. This "design factor" of 20 to 30 percent takes into account the difference between laboratory testing and actual installed conditions as well as allowing for a factor of safety. The use of such design factors is good engineering practice, and to be consistent, for all pipe materials, the applicable Manning's *n* laboratory value should be increased a similar amount to arrive at comparative design values. Design values recommended by the ACPA, government agencies and industry are shown in *Table 1*.

| Table 1: Recommended Values of Manning's <i>n</i> | | | |
|---|------------------------------|----------------------------|---|
| Type of Pipe | Values of Manning's <i>n</i> | | |
| | Lab Values | Promoted Values | ACPA Recommended Values |
| Concrete | 0.009 - 0.010 ¹ | 0.010 - 0.012 ¹ | storm sewer - 0.011 - 0.012 ¹ sanitary sewer - 0.012 - 0.013 ¹ |
| Plastic Pipe HDPE smooth wall | 0.009 - 0.015 ² | 0.010 ³ | storm & sanitary sewer - 0.012 - 0.020 |
| PVC smooth wall | 0.009 - 0.011 ⁴ | 0.019 ⁴ | storm & sanitary sewer - 0.011 - 0.013 |
| Corrugated Metal | 0.012 - 0.030 ⁵ | 0.012 - 0.026 ⁶ | 0.021 - 0.029 ⁷ |

- 1 American Concrete Pipe Association's "Concrete Pipe Design Manual"
- 2 Tullis and Barfuss Study-1989
- 3 CPPA Specifications
- 4 Uni-Bell's "Handbook of PVC Pipe"
- 5 University of Minnesota test on Culvert Pipes - 1950
- 6 "Steel Drainage Handbook"
- 7 U.S. Department of Transportation Federal Highway Administration's "Design of Highway Culverts"

The most widely accepted formula for evaluating the hydraulic capacity of non-pressure sewers is the Manning Formula.

$$Q = \frac{1.486 \times A \times R^{2/3} \times S^{1/2}}{n}$$

Where:

- Q = discharge in cubic feet per second
- n = Manning's roughness coefficient
- A = cross-sectional area of flow in square feet
- R = hydraulic radius in feet (equals the area of the flow divided by the wetted perimeter)
- S = slope of the pipe line in feet of vertical drop per foot of horizontal distance

Since the designer is usually concerned with selecting a sewer size for a given design flow of pipe slope, the Manning Formula is more conveniently expressed as:

$$\frac{Q}{S^{1/2}} = \frac{1.486 \times A \times R^{2/3}}{n}$$

By evaluating the values of $1.486 \times A \times R^{2/3}$ for the various types and shapes of pipes available, a pipe size can be selected for any $Q/S^{1/2}$ value. Under any given flow condition, the area A and hydraulic radius R are constant for a particular size and shape of pipe. Therefore, the hydraulic capacity of a pipe is primarily dependent on n, the roughness coefficient.

In general, industry acknowledges that concrete pipe has 96 percent flow capacity of an ideal smooth surface, whereas corrugated steel pipe has only 29 to 40 percent flow capacity of an ideal smooth surface, depending on

corrugation pattern. Most buried pipe system designers recognize the superior hydraulic performance of concrete pipe when compared to corrugated metal, but few understand the hydraulic issues and problems associated with HDPE pipe.

There are several sources to acquire n values. The FHWA research on CMP uses annular n values (spiral flow). The requirements for spiral flow, however, call for a high pressure flow, a straight alignment, adequate length of the installation, no appurtenances, no debris or paving, no pipe deterioration, no rounded ends, and ideal laboratory conditions. These requirements are not found in field installations. The Handbook of Steel Drainage & Highway Construction Products (Fifth Ed. 1994), lists all n values for CMP, and use the Corp of Engineers annular n values. The ACPA's Design Data 14 "Manning's n Values, History of Research," technical sheet, gives an n value of 0.010 to 0.012 for reinforced concrete pipe manufacturer's recommendations. Values for HDPE pipe are located in CPPA specifications and PVC values are documented in Uni-bell's Handbook of PVC Pipe.

Research by Tullis and Barfuss in 1989, presented to the American Society of Civil Engineers reported that tests on corrugated HDPE pipe with a smooth liner show that its laboratory Manning's n value is in the range of 0.009 to 0.015, depending on the smoothness of the liners. The bonding of the liner to the corrugations in many cases, made the pipe interior somewhat wavy, explaining the broad range in n values. Manning's n concerns with HDPE pipe, however, are not widely understood and further research is required. Because of the broad range of n values, an n value of 0.012 for HDPE pipe will not provide a 20 to 30 % factor of safety and is not recognized by the ACPA, PVC and CMP industry, nor by the FHWA.

Once designers are assured that their data sources for n values are valid and reflect most current lab research and field data, then it is easy to calculate full flow capacities of pipe systems using the Manning's equation. By using the ACPA's Design Data 4, "Hydraulic Capacity of

Sewers,” (DD-4) technical sheet, calculations of “Q” are relatively easy.

To begin, you need to know, or have access to:

- Plan Information - Pipe size, pipe type, pipe slope
- Concrete Pipe Design Manual (CPDM) or Design Data 4 (DD-4) and Handbook of Steel Drainage Products
- Flow Capacity Worksheet
- PipePac software (CAPE module)

Example 1

The plans show a design comprised of 14 gage, 18-inch aluminized corrugated metal Type II pipe, over a distance of 98 feet with a 1.2% slope. Find the corresponding size in RCP.

Using the Manning Equation to find flow in 18" CMP:

$$Q = \frac{1.486 \times A \times R^{.67} S^{.5}}{n}$$

$$Q = 1.486 / .024 \times 1.8 \times 0.375^{.67} \times .012^{.50}$$

$$Q = 61.92 \times 1.8 \times .52 \times .109$$

$$Q = 6 \text{ cfs.}$$

Data for the values in the equation are taken from published industry and government data sheets. Data used in the calculation sample above are in Table 3.14 of the Handbook of Steel Drainage & Highway Construction Products. A simple way to find Q is by using constants found in the Concrete Pipe Design Manual or DD-4.

A constant, $C_1 = \frac{1.486 \times AR^{2/3}}{n}$ which depends

only on geometry and characteristics of the pipe enables Manning’s formula to be written as $Q = C_1 S^{1/2}$

C_1 can be found in Tables 3, 4, 5, and 6 (Pgs.114-116 of The Concrete Pipe Design Manual (CPDM)) or Table III of DD-4 and $S^{.5}$ can be found in Appendix A, Table A-1 Pg. 406 of the CPDM, or Table II of DD-4.

Calculations for diameter of RCP using an “n” of .012 and at 1.2% would be as follows:

For Q = 6 cfs,

Find value of C_1 in Table #3 of CPDM or Table

III of DD-4 $C_1 = 55$,

Using Table 3 with n = 0.012, The pipe with $C_1 = 55$ is A 15" RCP.

For “n” = .012, $\phi = 15$ " RCP

Note that the RCP pipe is one size smaller than the CMP selected in the first sample problem.

Example 2

Check the flow in the 15" RCP:

$$Q = C_1 S^{.5}$$

$$= (70.1)(0.1095)$$

$$= 7.7 \text{ CFS } (> 6 \text{ cfs for 18-inch = CMP})$$

The two sample calculations demonstrate that there is no mystery in using Manning’s n to help determine the most appropriate pipe product for storm or sanitary sewers. It is critical to the calculations, however to have accurate and nationally-accepted values of n, or the roughness coefficient of pipe and pipe materials. The following sources provide excellent references of Manning’s n:

- *Design Data 14* “Manning’s Values, History of Research,” (Available from the American Concrete Pipe Association)
- FHWA “*Hydraulic Flow Resistance Factors For Corrugated Metal Conduits*” (Available from National Technical Information Service, Springfield, Virginia 22161 Ph # 703-487-4639)
- *Tullis - Barfuss Research For HDPE Roughness Coefficient* (Available from the American Concrete Pipe Association)
- *Design Data 4* “Hydraulic Capacity of Sewers,” (Available from the American Concrete Pipe Association)

Designers have access to all of the tools required to design buried pipe drainage systems that will last for the design life of a system. Designer’s may also use software to solve for flow capacities by simply changing the Manning’s n. Using the right pipe products for specific applications and designing systems for specific uses, should be the fundamental consideration of design projects. When carefully compared to alternate products, reinforced concrete pipe will prove itself as the product of choice. ☺

James A. Aumann

continued from page 4

pipe and moving product to storage. The technology in specific areas of the process should not be viewed in isolation. The entire process has to be viewed as a complete system.

Q: *We have focused on the mechanical end of automation. What do you look for in people when staffing your production and management teams who may have to adapt to technological change sooner than expected?*

Aumann: Managers and production employees have to demonstrate mechanical, electrical and computer aptitudes to operate and maintain an automated plant. Continuous training and re-training is one very important element of the operation.

Q: *You are preparing to commission a fully robotic plant operation. Why did you decide to automate with robotics at this time?*

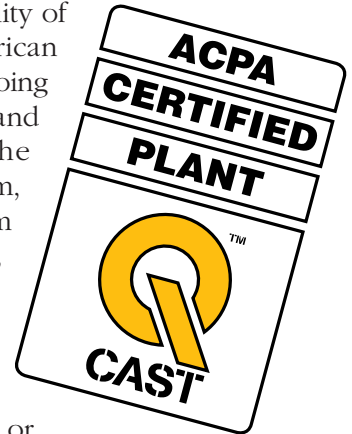
Aumann: Our equipment was dated to the 60s and we wanted to automate to become more efficient with a much-improved consistent product. We wanted a complete system like Schlüsselbauer to meet objectives of reduced cost plus higher quality performance than required by ASTM standards.

Q: *Share with us your vision of our precast concrete pipe industry ten years from now.*

Aumann: Plants will be more automated than they are today to meet customers' demands for quality and performance. Competition in the concrete pipe industry will force the issue. Other competitive pipe products will always be developed and introduced into the pipe market. The concrete pipe industry will continue to make big strides in product and plant design changes to stay ahead of the competition. ☺

“Quality Cast” Certified Plants

In an effort to improve the overall quality of all concrete pipe products, the American Concrete Pipe Association offers an on-going quality assurance program to member and non-member companies. Called the “Quality Cast” Plant Certification Program, the 124-point audit-inspection program covers the inspection of materials, finished products and handling/storage procedures, as well as performance testing and quality control documentation. Plants are certified to provide storm sewer and culvert pipe or under a combined sanitary sewer, storm sewer and culvert pipe program. The following plants have been certified under ACPA’s Quality Cast Certification Program:



Storm Sewer and Culvert Pipe

- Cayuga Concrete Pipe Company (Oldcastle, Inc.), New Britain, PA
Edward Pentecost
- Elk River Concrete Products (Cretex), Billings, MT
Milton Tollefsrud
- Elk River Concrete Products (Cretex), Rapid City, SD
John Tuttle
- Riverton Concrete Products Company (Cretex), Riverton, WY
Butch Miller
- Sherman-Dixie Concrete Industries, Inc., Chattanooga, TN
Earl Knox
- Sherman-Dixie Concrete Industries, Inc., Franklin, TN
Roy Webb
- Tarmac America, Inc., Charleston, SC
Bill Gary

Sanitary Sewer, Storm Sewer and Culvert Pipe

- Advanced Pipes & Cast Company, Abu Dhabi, United Arab Emirates
Poul Jacobsen
- Amcor Precast (Oldcastle, Inc.), Nampa, ID
Mike Burke
- Amcor Precast (Oldcastle, Inc.) Ogden, UT
Tim Wayment
- CSR Hydro Conduit Corporation, Tulsa, OK
Jeff Bassett
- Elk River Concrete Products (Cretex), Elk River, MN
Bryan Olson
- Geneva Pipe Company, Orem, UT
Fred Klug
- Kansas City Concrete Pipe Co. (Cretex), Shawnee, KS
Rich Allison
- N.C. Products (Oldcastle, Inc.), Fayetteville, NC
Preston McIntosh
- Ocean Construction Supplies Limited (Inland Pipe), Vancouver, BC, Canada
Rod Boyes
- W.R. White Company, Ogden, UT
J. P. Conn

Latest ASTM Standards for Concrete Pipe Available from ACPA

A new soft cover Manual and CD-ROM with the latest ASTM Standards for concrete pipe are now available from the American Concrete Pipe Association. The updated reference documents include 29 different specifications from the American Society for Testing and Materials related to the design, installation and testing of concrete pipe.

Titled "2000 Selected ASTM Standards on Concrete Pipe," both the Manual and CD-ROM contain existing ASTM standards, plus new standards that will add value to your drainage projects. For example, ASTM C 1433, "Precast Reinforced Concrete Box Sections for Culverts, Storm Drains, and Sewers" is now included in the new Manual. (This is the ASTM Standard for precast box culverts designed as per the AASHTO Standard Specifications for Highway Bridges.)

Also included in the 2000 Manual and CD-ROM

are ASTM C 1478 "Storm Drain Resilient Connectors Between Reinforced Concrete Storm Sewer Structures, Pipe and Laterals," and ASTM C 1479, "Practice for Installation of Reinforced Concrete Sewer, Storm Drain and Culvert Pipe for Direct Design."

The cost of the Manual and CD-ROM is very economical when compared to the cost of ordering ASTM Standards individually. To order, contact the ACPA Resource Center at (800) 290-2272, fax (972) 291-0622.

Item #09-100 Manual: \$65.00 (ACPA member) \$130.00 (non member), plus shipping and handling. Item #15-200 CD-ROM: \$80.00 (ACPA member) \$160.00 (non member) plus shipping and handling. All orders must be prepaid. Visa, MasterCard and American

Express are accepted. For further information, contact the American Concrete Pipe Association, (972) 506-7216, or e-mail: info@concrete-pipe.org.



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