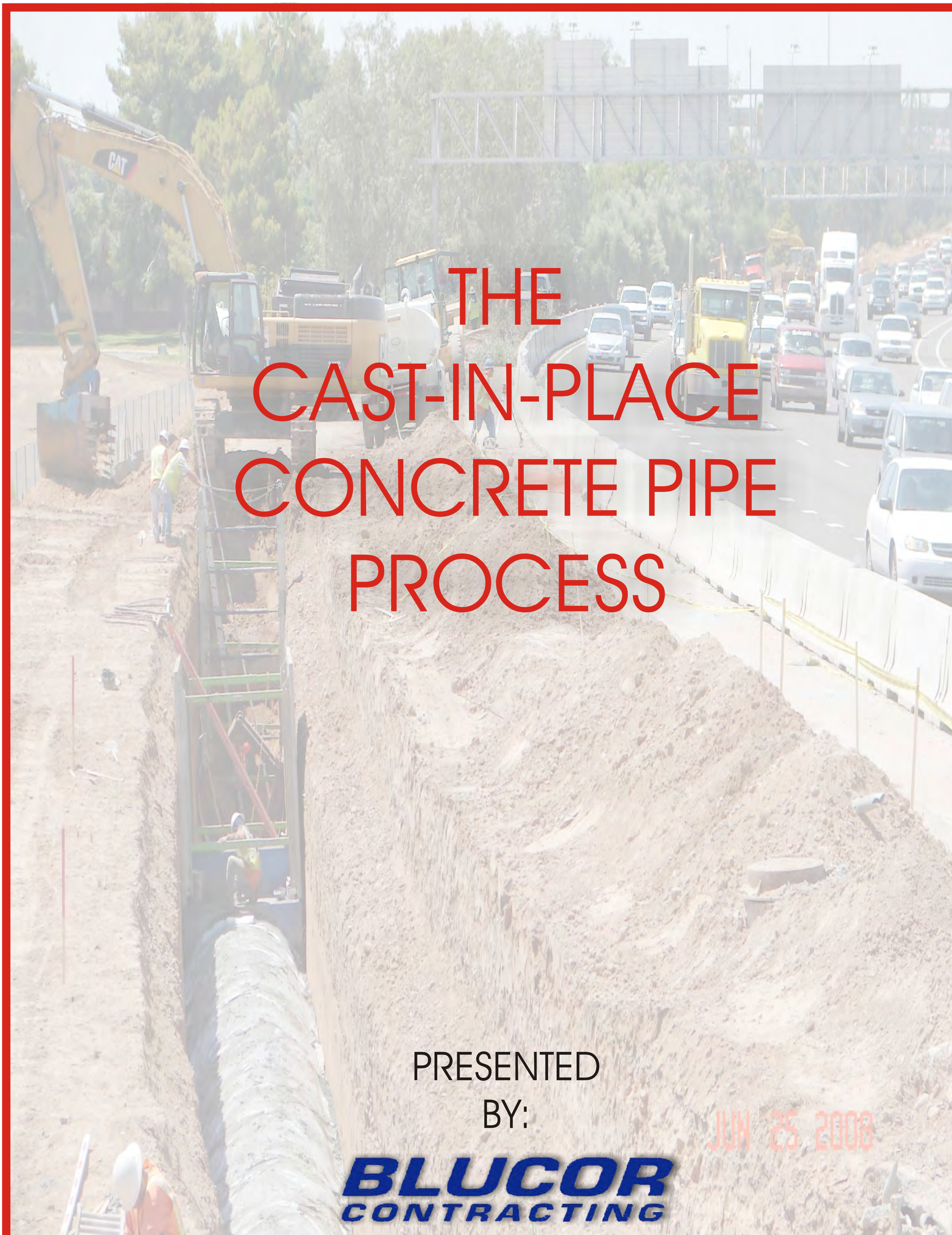
THE CAST-IN-PLACE CONCRETE PIPE PROCESS



PRESENTED BY:

BLUCOR CONTRACTING

We cast concrete pipe right in the trench –

And save you about 30%

It's as easy as 1 – 2 – 3.

Dig the trench.

Pour the pipe.

Remove the forms.

Cast-In-Place Concrete Pipe (CICPC) from Blucor Contracting, Inc. Is available in 6" increments from 24" – 120" I.D. CIPCP works with a maximum hydrostatic head of 15' and can be installed in most soils. The jointless, monolithic pipeline exceeds normal highway load requirements, getting its strength by design from bonding with the trench. And compared to precast pipe or box culverts, CIPCP costs much less.

We have skilled crews that pour pipe regularly. Call us today to find out more about the advantages of Cast-In-Place Concrete Pipe from Blucor Contracting, Inc.

BLUCOR CONTRACTING

Grading • Paving • Water • Sewer

Cast in place pipe

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Office: 6939 E. Parkway Norte, Mesa, AZ 85212

Mailing: 21738 E. Orion Way, Queen Creek, AZ 85242

www.blucor.com

Cast-in-Place
Process

THIS IS A CUSTOM MADE BUCKET THAT EXCAVATES THE TRENCH TO FORM THE OUTSIDE OF THE PIPE.

NOTES: ______________________________

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____

EXCAVATING THE TRENCH.

NOTES:

BLUCOR CONTRACTING

THE LAZER IS SET IN THE TRENCH WITH THE APPROPRIATE GRADE DIALED IN.

NOTES:

THE TRENCH HAS BEEN EXCAVATED
TO FORM THE OUTSIDE OF THE PIPE.

NOTES: ____

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THE ANCHOR OR “DEADMAN” IS USED TO ASSIST THE FORWARD MOVEMENT OF THE BOAT.

NOTES: ______________________________

BLUCOR CONTRACTING

THE "BOAT" IS PLACED IN THE TRENCH AND IS PULLED FORWARD BY THE WINCH.

NOTES:

ALUMINUM FORMS ARE THEN LOWERED INTO THE BOAT.

NOTES:

BLUCOR CONTRACTING

NOTES: ______________________________

BLUCOR
CONTRACTING

AN ALUMINUM FORM BEING LOWERED INTO THE BOAT.

NOTES:

AN ALUMINUM FORM BEING PLACED AND SECURED.

NOTES:

BLUCOR
CONTRACTING

THE CONCRETE TRUCK LOADS THE
HOPPER WITH CONCRETE.

NOTES:

BLUCOR
CONTRACTING

AS THE CONCRETE ENTERS THE HOPPER, THE "STOMPERS" AGITATE AND CONSOLIDATE THE CONCRETE ALL THE WAY AROUND THE FORMS.

NOTES: ______________________________

AS THE BOAT MOVES FORWARD, THE FORMS
ARE ATTACHED TO EACH OTHER AND STAY IN PLACE.

NOTES: ______________________________

____

____

ARCHES ARE INSERTED TO SUPPORT THE FORMS AND THE INVERT OF THE PIPE IS HAND FINISHED.

NOTES: ______________________________

BLUCOR CONTRACTING

HAND FINISHING LEAVES A SMOOTH SEAMLESS INVERT.

NOTES: ______________________________

____

____

BLUCOR CONTRACTING

HAND FINISHING LEAVES A SMOOTH SEAMLESS INVERT.

NOTES: ______________________________

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THE PIPE IS FINISHED BY HAND AND COVERED WITH PLASTIC.

NOTES:

PLACING PLASTIC OVER THE FRESHLY POURED PIPE WILL HELP THE CONCRETE CURING PROCESS.

NOTES: ______________________________

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____

BLUCOR CONTRACTING

THE "DEADMAN" IS MOVED FORWARD TO CONTINUE THE POUR.

NOTES: ____________________

BLUCOR CONTRACTING

THE PIPE BECOMES SEAMLESS.

NOTES: ____

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____

THE PIPE WILL SOON BE READY FOR BACKFILL.

NOTES: ____

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BLUCOR CONTRACTING

CAST IN PLACE CONCRETE PIPE HAS A PROVEN TRACK RECORD IN MARICOPA COUNTY AND THROUGHOUT THE SOUTHWESTERN U.S.

NOTES: ______________________________

BLUCOR CONTRACTING

Casting
Success

Casting Success

+ Blucor has been laying cast-in-place concrete pipe for more than 10 years, stressing its cost savings and better quality over pre-cast pipe.

"Success comes from experience."
> Blucor Contracting

Blucor is one of only two contractors in Arizona to have cast-in-place concrete pipe equipment, and the only one to have a full set of it.

Blucor Contracting
www.blucor.com
Headquarters: Gilbert, Ariz.
Services: Piping contractor
Employees: 125

In the construction industry, there are only three ways customers want a job to get done: better, cheaper and faster. That's easier said than done, of course, but a contractor who can deliver on even just one of those promises has an advantage over the competition. Blucor Contracting says it is a contractor that can deliver on all three, thanks to its use of cast-in-place concrete pipe (CIPCP).

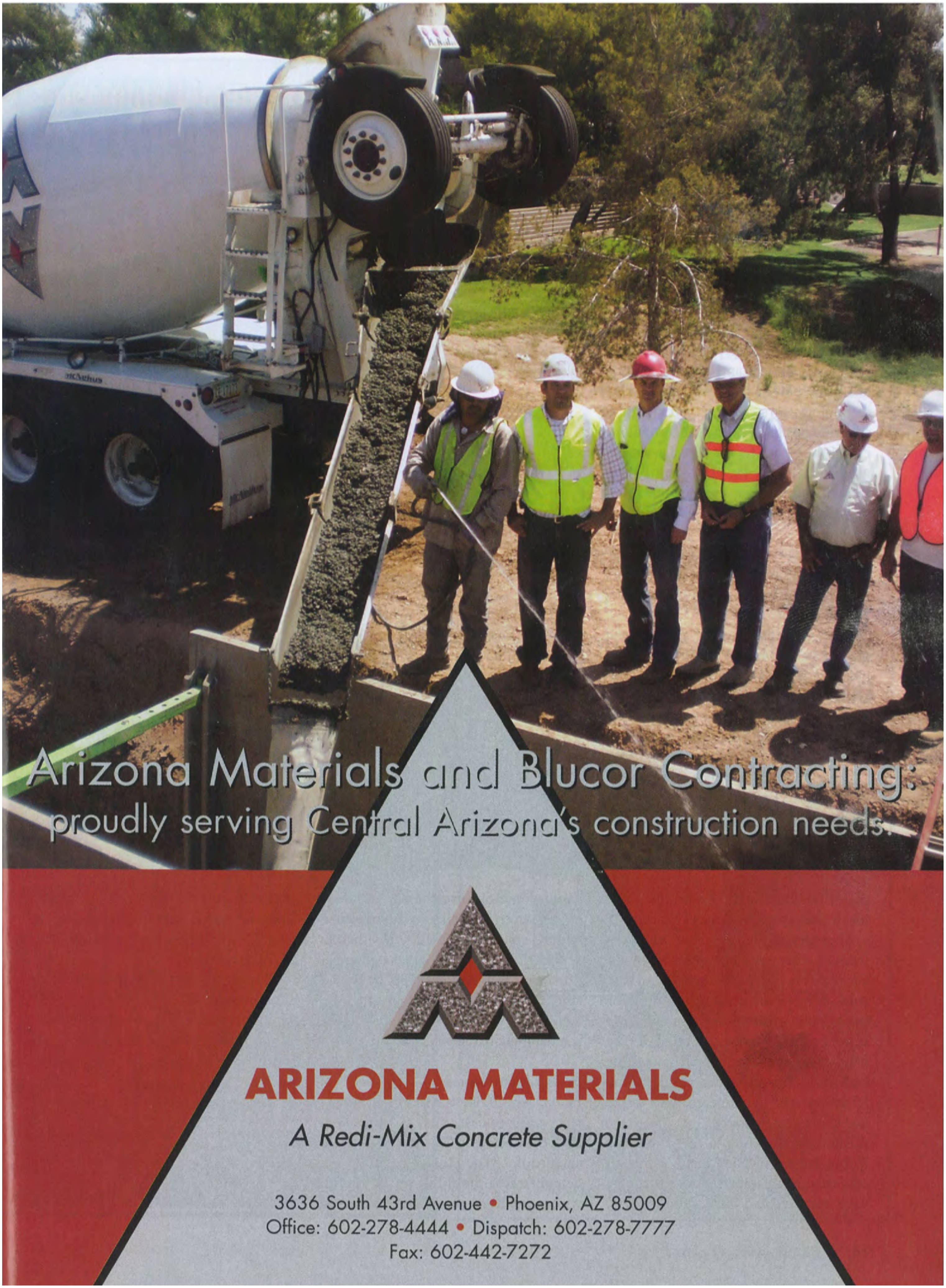
The company has been laying CIPCP for more than half its lifetime now, having been founded in 1989. The company has testimonials from customers that show the benefits CIPCP has as an alternative to pre-cast, it says, and customers are looking for alternatives.

"As cities across the country grow, so does the construction industry," the company says. "However, with the growth comes the need for more efficient means of production. CIPCP is one such alternative to products like reinforced concrete pipe, corrugated metal pipe and high-density polyurethane."

President Gordon Bluth says his company is one of the lone voices touting the virtues of CIPCP. Even engineers at some of the municipalities Blucor has worked for were unaware of the process before hiring the company. "They have to go out and find it; nobody brings it out to them," he says. "There's nobody promoting it." To illustrate how uncommon CIPCP is in the Southwest, Blucor is one of only two contractors in Arizona to have CIPCP equipment, and the only one to have a full set of it.

CIPCP was first used in 1922 to replace open irrigation laterals. "The first pipelines were constructed with flat bottoms, short vertical sides and arched tops formed by wooden planks," the company says. "This process was replaced by a two-step procedure that produced a circular pipe. The top half was constructed after the bottom half. All of the early procedures created undesirable cold joints along the pipe."

In the late 1940s, a machine was developed that could lay the entire circumference of the pipe in one step. "By the late 1950s, cast-in-place concrete pipe was already in use throughout the Southwestern United States," the company says. "Currently, CIPCP is being used for storm drains and irrigation by numerous city, county, state and federal agencies throughout the Western U.S. Blucor has been laying cast-in-place >>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>> concrete pipe for over a decade in Arizona, Nevada and throughout the Southwest." Bluth says CIPCP is an "incredible product" that is adaptable and maintenance-free.

Perfecting the Process

The process for laying CIPCP has become increasingly sophisticated since 1922, understandably, and Blucor has remained at the forefront of the technology. First, an excavator with a specially designed round-bottom bucket digs the trench for the pipe. Lasers are used to calibrate the placement of the trench, and the cast-in-place machine, or "boat," is itself a specially designed machine.

"Each boat is custom-made," Bluth said in a statement. "There is no manufacturer that makes these boats as an industry."

After the trench is dug, the cast-in-place machine is put into the trench, along with anchors on the sides of the trench. "The boat slip forms the pipe in the trench, traveling by means of winch and line hooked to the anchor," the company says.

"Aluminum forms arched at the correct circumference of the pipe are inserted every four feet and hooked together to continuously support the top and sides of the pipe. These form an arch of 270 degrees, or 75 percent of the pipe's circumference. Arches installed inside the pipe then support the forms."

The company explains that the pipe is formed through a combination of automation, natural formation and tool work. "The trench serves as the form for the outside of the pipe," the company says. "As the boat moves along, a worker hand-finishes the inside of the pipe, as well as the top of the outside. After the initial cure of the concrete, the forms and arches are removed."

After the concrete is cured and the forms are removed, Blucor works to take care of any imperfections that may have been created during the process.

Blucor remains at the forefront of CIPCP technology.

"Approximately every 15 to 25 feet, expansion cracks will form," it explains. "These cracks are filled with silicone and patched, creating a water-tight pipe. The result is a jointless pipeline with a smooth interior that facilitates the velocity of the flowing water, keeping the sediment in the pipe to a minimum."

Added Advantages

Blucor says CIPCP is structurally just as strong as pre-cast pipe, and points to tests conducted by Cal State University as proof. "The tests conclusively demonstrated the ability of the pipe to withstand normal traffic loads," the company says. Videos on its Web site show heavy equipment being driven over CIPCP that was cast no more than 24 hours earlier.

"Cast-in-place pipe has been awarded an equivalent of a Class IV pre-cast pipe with an H 20 loading," it says. "Today, Blucor pipe is accepted by most major agencies." >>

CIPCP can hold its own with pre-cast pipe from a structural standpoint, but in other areas it is demonstrably better, Blucor claims. "The most attractive feature of Blucor pipe is the savings that it brings to a job," the company says.

Successful Approach

Customers of Blucor say the company and its CIPCP approach have saved them time and money. Russ Ewers, project director for Westcor, said in a statement that the company brought CIPCP to the Chandler Fashion Center project in Chandler, Ariz.

"As part of this project, we have a storm drain system that we designed that doubles as both a receiver and a collector for the storm water that comes off of this property and we're serving approximately a 125-acre site," Ewers said. "We have seven miles of storm drain, and we were tested during the design phase to determine what the most economical way to do this was. It was significantly less expensive for us and it became the prime choice instead of an alternate."

Ewers went on to say that Blucor was able to keep its promises. "We averaged 300 feet a day or better, they promised us that, and they did that," he said. "It was a concern to us in the beginning about the quality of the pipe, [but] we have had no bad concrete reports, we have had no areas that we have gone back to repair."

VTN Nevada Consulting Engineers Engineer Jim Fitzpatrick said his company used Blucor "on a number of private sector jobs where significant cost savings have been [seen] by our clients."

Experience is Success

Blucor says the 10 years it has spent laying CIPCP have proven to be the difference-maker for the company in the current marketplace.

"Success comes from experience," the company says. "Blucor pipe has helped many dreams become reality with the efficiency it brings to a job. Gordon Bluth is often asked, 'What is the secret to pouring good pipe?' His reply? 'Experience. The more you pour, the more efficient you'll be, which means savings to the customer, and a higher quality of pipe.'"

Looking ahead, Bluth says he sees bright spots for the company.

"I'm now 53 years old, but I have nephews and sons who are in their 20s and they are really excited about the industry," he says.

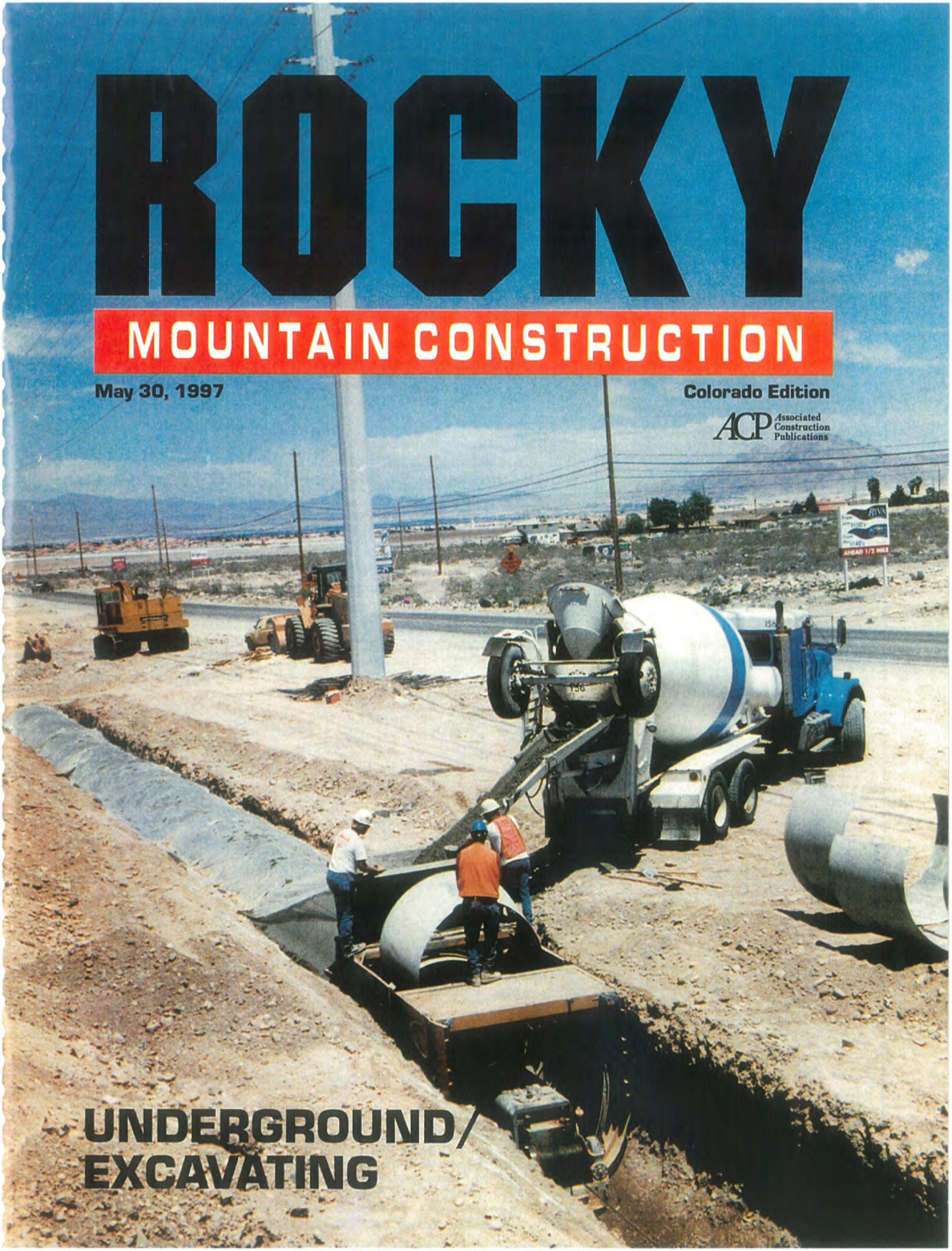
Rocky Mountain
Construction

ROCKY
MOUNTAIN CONSTRUCTION

May 30, 1997

Colorado Edition

ACP Associated Construction Publications



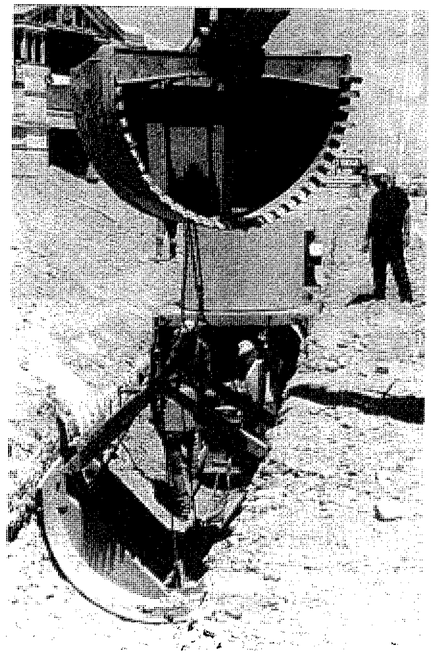
UNDERGROUND/ EXCAVATING

Cast-in-place concrete pipe common on wide variety of flood control projects

CASTING CONCRETE in place to control flows of water has been around since the early 1920s, when governments began developing systems of irrigation channels to serve the agriculture industry. Today, slipforming continuous lengths of concrete pipe in the trench is quite common on flood control and storm drain projects, as well as irrigation projects, in Mountain America. When conditions are favorable for casting in place, many feel it is far and away the best option.

Proven advantages of earth-reinforced cast-in-place concrete pipe include a typical 30% savings over steel-reinforced precast concrete pipe. The reason seems obvious: cast-in-place eliminates the precast manufacturing process. No manufacturer margin, no double handling, no transportation costs. And no cost for steel rein-

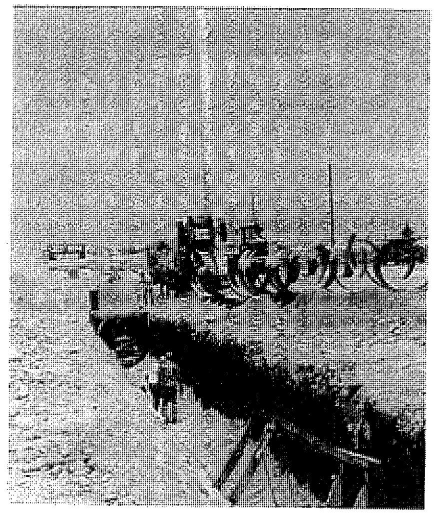
Excavator with rounded bucket digs trench to exacting size and grade in preparation for casting concrete pipe in place. On this four-barrel job in Las Vegas, Blucor Contracting crews had to first excavate the rocky soil with an excavator equipped with a standard bucket, then screen, backfill and compact the native material before the special bucket could cut the trench. Even with this extra effort, the cast-in-place option was still the low bid.



Excavator prepares to lift and move deadman farther back in the trench to continue the day's pour.

forcement, since cast-in-place concrete pipe doesn't require it.

All that adds up, of course. But what brings everything together to make this lower cost option pre-



With the deadman in position, the pour continues as forms await their use. Note laser on tripod to ensure grade and direction.

ferred is the simple efficiency of the cast-in-place procedure. Blucor Contracting of Gilbert, Ariz., is one company specializing in cast-in-place concrete pipe.

"Blucor has poured miles of cast-in-place pipe in Arizona, Nevada and New Mexico each year for the last eight years," says Gordon Bluth, company president. "The popularity of the product has allowed us to assemble skilled crews that do cast-in-place jobs regularly, which is the key to pouring good pipe."

The technique hasn't changed much since its refinement some 30 years ago. An excavator with a special bucket digs a trench with straight sides and a rounded bottom to grade. Once dug, the cast-in-place machine, or boat, goes into the trench, along with a second unit that serves as a deadman by anchoring against the sides of the trench. The boat slipforms the pipe in the trench, traveling by means of winch and line hooked to the deadman. Aluminum forms, arched to the correct circumference of the pipe, are inserted every four feet and hooked together to continuously support the top and sides — about 280° — of the pipe. The forms are supported by arches installed inside the pipe.

The trench serves as the outside form for the pipe. As the pour begins, a concrete consolidator on the boat ensures that there are no voids. As the boat moves along, a worker finishes the inside bottom of the pipe to match the smooth top and sides that will be left by the forms. The outside top of the pipe is also finished, even though it will eventually be covered with backfill. As the pour continues, the finished pipe is covered with plastic to help retain heat and humidity, which will foster the curing process. After the initial cure of the concrete, the support arches are removed and the forms are pulled out of the pipe by the excavator. What's left is a jointless pipeline with a smooth interior that facilitates the velocity of the flowing water, keeping the accumulation of sediment in the pipe to a minimum.

"The trench must be right," explains Bluth, whose company does all types of water and sewer pipeline work as well as a variety of grading and paving jobs. "Since the trench serves as the outside form, the trench must be cut to the exact grade. The boat distributes and consolidates the concrete thoroughly against the trench, forming a jointless, monolithic pipeline that exceeds normal highway load requirements."

The strength of cast-in-place concrete pipe is derived from the nearly perfect bonding of the concrete with the bottom and sidewalls of the trench. Loads on the pipe's top are transmitted by arch effect primarily into the bottom 135° of the monolithic pipe, and thus into the supporting ground. The design also helps resist expansion and contraction of the pipe.

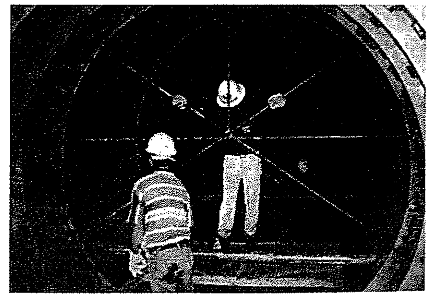
"Though cracks from expansion and contraction are inevitable," Bluth says, "the pipe's ability to withstand pressure and maintain its load is not affected. Cracks in cast-in-place concrete pipe occur to relieve stresses in the pipeline, and should be viewed the same as bells and spigots in a precast pipeline because they serve a similar purpose."

Cast-in-place concrete pipe works with a maximum hydrostatic head of 15 ft., limited because of its lack of steel reinforcement but still suitable for many projects. Though stable soil conditions are preferred, it is estimated that cast-in-place concrete pipe can be installed in 80% of all soils. Blucor can cast-in-place concrete pipe from 24-in. through 120-in. I.D. in 6-in. increments.

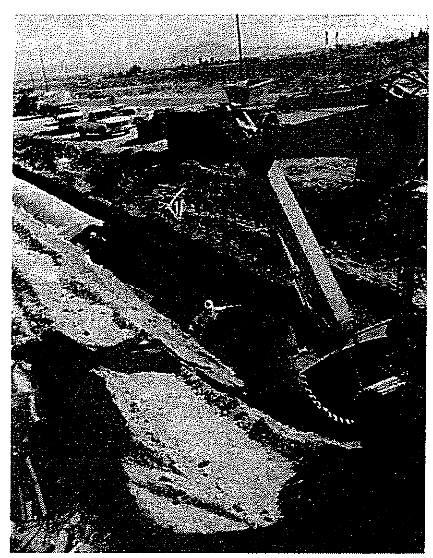
"Some projects require that runoff actually be stored in the pipe for a period of time," Bluth explains. "A pump station may need 36 hours to handle runoff from a downpour. The water sits in the pipe as it's slowly pumped out."

Construction of box culverts is an expensive, time-consuming

Cast-in-place boat slipforms the concrete pipe. Forms are inserted manually from above.


Inside the pipe, arches are installed to support the forms.


The day after the pour, the supports are collapsed and removed and forms are pulled from the pipe by the excavator. The forms, which are connected to each other when installed, come out upside down after being released from the concrete. Note how the trench conforms precisely to the size and shape of the bucket.

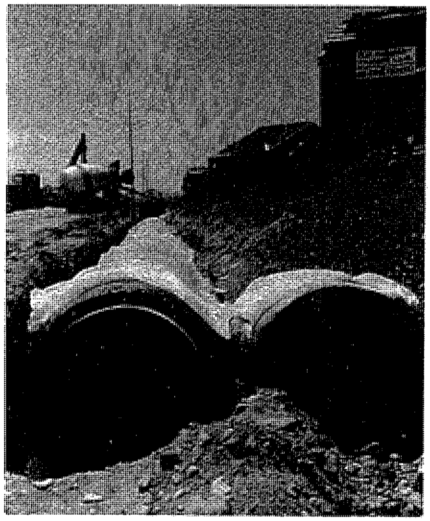


process compared to casting concrete pipe in place. In many instances, Blucor has poured multiple "barrels," providing an even greater available volume than would the box culvert, still at a substantially lower cost.

"If a project calls for 100 ft. of 8x10-ft. box culvert," Bluth says, "we can provide more than enough volume by casting in place two 96-in. diameter pipes. And we can do it at much less cost than installing precast or forming box culvert."

Many government entities encourage value engineering by the contractors that bid their work. If a contractor can provide a cost savings without compromising the specifications, the entity will usually accept the proposal and split the savings with the contractor.

"Naturally, Blucor tries to take advantage of these programs," Bluth says. "Sometimes, people are not familiar enough with cast-in-place to engineer it into the specifications — or, they're just not aware that it could work for them. We promote the process and back up what we say with testimonials from the many different successful projects we've completed throughout the region." ■



Second barrel of a four-barrel job is poured by Blucor Contracting in Las Vegas.

ACI 346-09

Specification for Cast-in-Place Concrete Pipe

An ACI Standard

Reported by ACI Committee 346

American Concrete Institute®

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American Concrete Institute®
Advancing concrete knowledge

Specification for Cast-in-Place Concrete Pipe

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Specification for Cast-in-Place Concrete Pipe

An ACI Standard

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The Architect/Engineer can make this specification applicable to any project by citing it in the Project Specification. Supplements can be made by designating or specifying individual project requirements as needed. This document must be used in conjunction with ACI 301. Inclusion of this document in a Project Specification, with mandatory checklist items, will provide necessary default values for mandatory checklist items in ACI 301.

Keywords: cast-in-place concrete pipe (CIPCP); circumferential cracking; concrete pipe; longitudinal cracking; no-joint pipe.

CONTENTS

(mandatory portion follows)

PART 1—GENERAL

1.1—Scope

1.1.1 This specification covers construction of earth-supported cast-in-place concrete pipe (CIPCP). This specification covers construction of CIPCP with a diameter up to 120 in.

1.1.2 CIPCP shall conform to ACI 301, Section 1 for general concrete requirements, Section 4 for concrete mixture design, and Section 5 for concrete handling or as specified in Contract Documents.

1.2—Definitions

This list supplements ACI 301, Section 1.2. Defined for general use in these specifications are the following:

backfill—fill starting at top of pipe and continuing to surface or finished grade or subgrade.

boulders—rocks having any dimension larger than 12 in.

Contract Documents—a set of documents supplied by Owner to Contractor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

differential displacement—linear offset distance between two pieces of pipe measured along plane of crack.

earth—soil or rock other than flowable granular materials.

jetting—water densification of backfill accomplished by the use of a jet pipe to which a hose is attached, carrying a continuous supply of water under pressure to the lift of backfill material to be densified.

ACI 346-09 supersedes ACI 346-01 and was adopted and published August 2009.

metal finish—finish imparted to interior of pipe by casting machine and hand-troweling devices manufactured from metal.

offset tolerances—difference in pipe thickness, transverse and longitudinal, resulting from metal form used in casting process.

over excavation—process by which material unsuitable for CIPCP is removed and replaced with engineered fill prior to trench excavation.

pipe haunch—either side of pipe, extending to a point vertically approximately 25 degrees above springline.

repair—process by which cracks and defects in concrete surfaces are corrected to bring pipe into conformance with this specification.

sensitive clays—clays with an undisturbed strength that is at least 10 times greater than remolded or reworked strength.

soffit—uppermost portion of inside cross section of pipe.

trench—an excavation in ground engineered for placement of pipe.

trench form—semicircular bed of trench shaped to provide full, firm, and continuous support throughout the bottom of the pipe from pipe haunch to pipe haunch.

trench form envelope—area of soil adjacent to and under pipe, required to provide lateral support and bedding support needed for CIPCP.

trench grade—design invert elevation minus wall thickness of pipe.

1.3—Referenced standards

1.3.1 *ACI standards*

301-05 Standard Specifications for Structural Concrete

1.3.2 *ASTM standards*

A615-03 Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement

C171-07 Standard Specification for Sheet Materials for Curing Concrete

C309-07 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

C497-05 Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile

D698-07^{e1} Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))

1.4—System description

CIPCP shall be constructed underground as a continuous concrete conduit that has no steel reinforcement or seams except as specified. CIPCP is used to convey irrigation water, storm water, or industrial waste under a maximum internal operating head of 15 ft and external loads as subsequently discussed.

1.5—Submittals

1.5.1 *Pipe geometry reports*—Pipe dimensions shall be as specified in Table 1.5.1. When a design differs from Table 1.5.1, provide a pipe geometry report. Report shall specify inside and outside dimensions and include minimum wall thickness and additional sacrificial thickness needed for abrasion.

Table 1.5.1—Pipe dimensions

Pipe diameter, in.	Wall thickness, in.
24, 27, and 30	3
36	3.5
42	4
48	5
54	5.5
60	6
66	6.5
72	7
78	7.5
84	8
90	8.5
96	9
102	10
108	10.5
114	11
120	12

1.5.2 *Concrete mixture*—Submit a concrete mixture report as specified in ACI 301.

1.5.3 *Test reports*—Submit a test report of results and recommendations when load testing, as specified in 3.4.1, or hydrostatic testing, as specified in 3.4.2, is required in Contract Documents.

1.5.4 *Sealants*—Submit sealant material when repair of circumferential cracks as specified in 3.3.2, or longitudinal cracks as specified in 3.3.3, is required in Contract Documents.

1.5.5 *Quality assurance*—Submit a quality assurance plan that addresses pipe geometry, concrete mixture, concrete curing process, geotechnical conditions, test reports, and repair methods as required by the Contract Documents.

PART 2—PRODUCTS

2.1—Materials

2.1.1 *Concrete*

2.1.1.1 *Slump*—Slump shall be within limits shown in Table 2.1.1.1.

2.1.1.2 *Compressive strength—f_c'* shall not be less than 4000 psi except for irrigation pipe, which shall not be less than 3000 psi, unless specified otherwise.

2.1.1.3 *Sulfate resistance*—When sulfate resistance is required, the concrete mixture shall be proportioned as specified in the Contract Documents.

2.1.2 *Reinforcement dowel*—Dowel shall be ASTM A615 Grade 40 or greater.

2.1.3 *Sealant*—Chemically cured elastomeric material as specified in the Contract Documents.

2.1.4 *Polyethylene film*—Polyethylene film complying with ASTM C171 with the exception, nominal thickness of 0.0015 in.

2.1.5 *Curing compound*—Pigmented membrane curing compound shall conform to ASTM C309.

Table 2.1.1.1—Slump requirements

Pipe diameter	Slump
Less than 42 in.	2-1/2 ± 1-1/2 in.
42 to 72 in.	2-1/2 ± 1 in.
Greater than 72 in.	2 ± 1/2 in.

Table 3.2.1.4—Offset tolerances

Pipe diameter	Allowable offsets
Less than 42 in.	1/2 in.
42 to 72 in.	3/4 in.
Greater than 72 in.	1 in.

PART 3—EXECUTION

3.1—Preparation

3.1.1 *Trench*

3.1.1.1 *Excavation*—Excavate trench to establish grade and alignment. Trench shall be shaped to outside diameter of pipe to provide trench form. Trench form shall provide a full, firm, and continuous support by undisturbed earth, rock, or compacted fill. Trench form shall be stable and free of protrusions, mud, debris, and running water. Maintain trench form moisture in a manner such that water does not escape the wet concrete. Remove boulders projecting into the trench to at least 6 in. beyond trench form. Fill the resulting void in accordance with 3.1.1.3 or with concrete.

3.1.1.2 *Unstable soils*—Stabilize or over excavate noncohesive, unstable strata, or lenses of loose sand, silt, or other noncohesive soils within trench form. Reconstruct as engineered fill.

3.1.1.2.a Sensitive clays in trench form shall be stabilized or over excavated and trench form reconstructed as engineered fill.

3.1.1.3 *Trench repair*—Reconstitute the grade by filling voids with sand, pea gravel, crushed rock, or noncohesive soil. Compact material used to reconstitute the grade to a minimum of 95% maximum dry density in accordance with ASTM D698, unless specified otherwise.

3.1.1.4 *Backfill material*—In-place backfill material shall meet compaction requirement, as specified in Contract Documents.

3.2—Construction

3.2.1 *Tolerances and geometry*

3.2.1.1 *Horizontal and vertical alignment*

3.2.1.1.a *Grade*—Departure from and return to a grade shall not exceed 1 in. per 10 linear ft. Maximum departure shall be limited to 1-1/2 in.

3.2.1.1.b *Alignment*—Departure from and return to established alignment shall not exceed 2 in. per 10 linear ft. Maximum departure shall be limited to 4 in.

3.2.1.2 *Wall thickness*—Wall thickness shall be as shown in Table 1.5.1. Grade and alignment shall be controlled so that pipe wall thickness is uniform. Wall thickness tolerance is –0 and +0.07 the inside diameter.

3.2.1.3 *Pipe diameter tolerances*—inside diameter of pipe at any point shall not be less than 98% of design diameter.

3.2.1.4 *Offset tolerances*—Offset tolerances shall be as indicated in Table 3.2.1.4.

3.2.2 *Concrete placement*

3.2.2.1 *Placement method*—Construct the pipe monolithically. Concrete shall be vibrated, rammed, tamped, or worked until thoroughly consolidated. Sufficiently wet soil adjacent to the pipe so that it does not absorb water from the concrete or expand upon additional wetting.

3.2.2.2 *Construction joint*

3.2.2.2.a *Cold joint*—At the end of concrete placement or any stoppage requiring a casting machine to pull away from pipe construction, leave the pipe end in a rough condition at a slope of approximately 45 degrees from soffit to invert, with 24 in. long No. 4 reinforcement dowels embedded around the pipe circumference as specified. Place the dowels at 12 in. intervals for pipe sizes up to 72 in. in diameter and at 18 in. intervals for pipe sizes 78 to 120 in. in diameter. Within 30 minutes before pipe casting resumes, thoroughly clean the pipe end surface of foreign materials, coatings, and loose or defective concrete and thoroughly wet the surface. Cast a tie-in cap over the joint across the top of pipe from trench wall to trench wall. The tie-in cap shall be a minimum length of 24 in. and centered over the joint. Thickness shall be 1.5 times the wall thickness, as indicated in Table 1.5.1.

3.2.2.2.b *Collar*—Make the joint for connections to another pipe or structure by squaring off the end of the CICIP. Excavate the trench form along the sides and bottom of pipe to permit casting of concrete collar. Collar shall be a minimum length of 24 in. and centered on joint. Collar thickness shall be 1.5 times wall thickness shown in Table 1.5.1. Collar shall extend around the full circumference of pipe.

3.2.2.3 *Finish*—Interior surface of pipe shall receive a metal finish.

3.2.3 *Curing, backfilling, and cleanup*

3.2.3.1 *Curing*—Use one of the methods specified in 3.2.3.2 for exterior curing and use the method specified in 3.2.3.3 for interior curing of the pipe.

3.2.3.2 *Exterior curing*—The pipe shall be cured by polyethylene film or pigmented membrane-curing methods.

3.2.3.2.a *Polyethylene film curing method*—Place polyethylene film on exposed top surface immediately after pipe is cast. Anchor the film in place to ensure continuous, adequate curing.

3.2.3.2.b *Pigmented membrane-curing compound method*—Apply membrane-curing compound to exposed exterior surfaces immediately after the pipe is cast. Apply compound at no less than 1 gal. for each 150 ft^2 of exposed concrete.

3.2.3.3 *Interior curing*—Humid atmosphere within pipe shall be maintained for at least 7 days following concrete placement. Measures shall be taken to prevent air drafts from drying pipe. Pipe end openings shall be covered, but not sealed.

3.2.3.4 *Backfill operations*—Backfill operations shall not begin until concrete attains a compressive strength of 2500 psi.

3.2.3.4.a First lift over pipe shall be not less than 2 ft or more than 3 ft before compaction. Backfill material shall be free of all organic material, rubbish, and debris. Backfill shall be mechanically compacted. Jetting shall not be permitted. Second and subsequent lifts shall be placed in horizontal layers of thickness compatible to material being placed and type of equipment used to achieve required compaction specified in 3.1.1.4.

3.2.3.4.b Controlled low-strength material (CLSM) may be used as backfill.

3.3—Repair

3.3.1 *Crack repair*—Crack repair shall not be made until completion of backfill. Determine crack width by penetration to more than 0.25 in. of a standard machinist gauge leaf defined in ASTM C497.

3.3.2 *Circumferential cracks*—Circumferential cracks 0.01 in. or less in width shall not require treatment. Cracks greater than 0.01 in. in width and less than 0.05 in. in width shall be cleaned and filled with cement mortar. Cracks 0.05 in. in width and greater shall be cleaned and filled with a sealant, unless specified otherwise.

3.3.3 *Longitudinal cracks*—Longitudinal cracks more than 0.01 in. in width and less than 0.0005 multiplied by outside diameter shall be cleaned and filled with mortar or a sealant.

3.3.3.1 Longitudinal cracks having differential displacement greater than 0.08 in. or width greater than 0.0005 when multiplied by outside diameter shall be repaired by full-depth epoxy pressure grouting as specified in Contract Documents.

3.4—Field quality control

3.4.1 *Load tests*—Perform load tests as specified in Contract Documents. Test load applied to the top of pipe shall be at least 125% of the maximum earth load plus live load to which pipe will be subjected. Inspect pipe before and after load testing. Load tests shall be made without disturbing earth supporting trench form of pipe. Apply test load in accordance with 3.4.1.1 or 3.4.1.2.

3.4.1.1 *Sandbox test*—Load shall be applied to a 4 ft length of pipe through a sandbox in such a manner that sand forms a bedding over 1/4 of the pipe circumference, measured and centered over the crown. A sandbox shall be made of metal or dressed timber so heavy as to maintain constant soil pressure. A strip of cloth or plastic film may be attached to inside of the sandbox on each side, along the lower edge, to prevent the escape of sand between sandbox and pipe. Bedding depth above pipe at the thinnest point shall be 1/4 inside diameter of pipe. The sandbox shall not contact pipe or sides of trench. Fill sandbox with clean sand containing no less than 5% moisture and passing a No. 4 sieve. Upper surface of sand shall be leveled with a straight edge and covered with a rigid top-bearing plate. Lower surface of plate shall be a true plane made of heavy timbers or other rigid material capable of distributing test load uniformly. Test load shall be applied to bearing plate by piling weights directly on the bearing plate or by moving heavy equipment of predetermined weight onto the bearing plate. Bearing plate shall not be in contact with sandbox.

3.4.1.2 *Wheel load test*—A wheel load equivalent to test load shall be applied to pipe. Maintain 2 ft of compacted fill between pipe and wheel load.

3.4.2 *Hydrostatic test*—As specified by Contract Documents, a hydrostatic test shall be made on completed pipe any time after concrete has reached design strength. Default head is 6 ft, unless specified otherwise in Contract Documents. Pipeline shall be filled with water to specified head above inside pipe crown and kept filled for a minimum of 48 hours before test. Line may be filled in one length or between bulkheads or structures. Water used shall have a temperature above 50 °F. Test shall be for 4 hours. Filtration rate shall not exceed 1000 gal./in. diameter/mile/24 hours.

3.4.3 *Trench grade*—Trench grade shall be constructed using electronically guided equipment.

(nonmandatory portion follows)

NOTES TO SPECIFIER

General notes

G1. ACI Specification 346 is to be used by reference or incorporation in its entirety in the Project Specification. Do not copy individual Sections, Parts, Articles, or Paragraphs into the Project Specification, because taking them out of context may change their meaning.

G2. If Sections or Parts of ACI Specification 346 are copied into the Project Specification or any other document, do not refer to them as an ACI Specification, because the specification has been altered.

G3. A statement such as the following will serve to make ACI Specification 346 a part of the Project Specification:

"Work on (Project Title) shall conform to all requirements of ACI 346-09, 'Specification for Cast-in-Place Concrete Pipe,' published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these Contract Documents."

G4. Each technical Section of ACI Specification 346 is written in the three-part Section format of the Construction Specifications Institute, as adapted for ACI requirements. The language is imperative and terse.

G5. ACI Specification 346 is written to the Contractor. When a provision of this specification requires action by the Contractor, the verb "shall" is used. If the Contractor is allowed to exercise an option when limited alternatives are available, the phrasing "either...or..." is used. Statements provided in the specification as information to the Contractor use the verbs "may" or "will." Informational statements typically identify activities or options that "will be taken" or "may be taken" by the Owner or Architect/Engineer.

FOREWORD TO CHECKLISTS

F1. This foreword is included for explanatory purposes only; it is not a part of ACI Specification 346.