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Irrigation District Observations on Large Diameter, Low Pressure Pipeline Materials

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Background

There are approximately 1,400 miles of low pressure non-reinforced cast-in-place ("monolithic" or "CIP") concrete pipe in California irrigation districts. Cast-in-place pipe was irrigation districts' material of choice for large diameter pipelines from 1930 to at least 1980. Many of these pipelines were installed in the early 1900's. They are predominately found on the east side of the San Joaquin Valley, from Manteca in the north to Visalia in the south. Most of these pipes are deteriorating and will need to be replaced within the next 10-20 years.

Irrigation districts have attempted to find new ways to repair these pipes. However, their uneven dimensions (they were often made with crude local installation equipment), high density of repairs (meaning that the pipe wall thicknesses and cross sections now vary), numerous connections, and non-linear placement have ruled out using available pipe liner technology. The cost to line these pipes is about the same as the cost to completely replace them.

Due to the high replacement cost and need for repair, the last decade has seen a switch away from cast-in-place pipelines to pipelines of other materials. However, up until now there has been no general consensus as to the best replacement option. In November 2002, the California Polytechnic State University (Cal Poly) Irrigation Training and Research Center (ITRC) met at

Madera ID with representatives from eight irrigation districts and one engineering firm to discuss reasons for switching types of pipes, and what alternative materials might be available.¹

Challenges of a Changing Environment

Agricultural Areas

Many old pipeline easement agreements stated that the surface area over pipelines could be farmed as long as nothing interfered with the pipeline operation and maintenance. This is not a problem with traditional crops in this area such as cotton, grains, and pasture. However, according to several districts, in recent years more farmers have started planting trees and vines. Accessing a pipeline under trees and vines is much more difficult since digging up these crops would have a significant financial effect on the farmer. One representative also reported that the shaking used to harvest almonds can damage nearby pipelines. One district's solution to these problems was to specify in new pipeline agreements that no agricultural crops could be planted over the pipeline unless approved by the district.

The factor that will probably have the greatest effect on the future choice of pipeline materials for agricultural settings is the expanding use of drip/micro irrigation systems. Farmers using these systems require a pressurized water supply. Most farmers achieve pressurization today by pumping from a well or an irrigation canal. However, as more farmers switch to drip/micro irrigation, irrigation districts may need to start pressurizing their water delivery systems. This will require a pipeline material that can withstand high internal pressure without leaking.

Urbanization Issues

Several irrigation districts said that they first began pipelining open canals at the request of cities that were concerned about the safety of having open canals in populated areas, especially near schools. Most urban pipelining done now is the result of the development of agricultural land into new industrial, residential or commercial areas. Almost all irrigation districts require developers to pipeline any of their existing canals, if feasible. One district requires that if a canal can fit within a 54-inch pipeline, it must be piped. The district also provides cost-sharing incentives for developers to pipe larger canals. Another district requires flow up to 100 CFS to be piped, but feels that piping flows above 500 CFS is not feasible. A third district doesn't allow any open canals in developed areas, no matter what size.

The expense of pipelining an open canal in a newly developed area is usually the responsibility of the developer. However, the irrigation district almost always provides maintenance and repair. Accessing and repairing buried pipelines in urban areas can be very complicated. "Exclusive" pipeline easement agreements often end up running through people's backyards and often apply only to a limited underground area. Many objects are installed or constructed on top of the pipeline, including sidewalks, gas lines, electrical lines, trees, swimming pools, parking

¹ This paper recounts topics and products discussed during the November 2002 meeting, which was intended as a brainstorming session. In no way does mention of any specific process, product, or service by manufacturer, trade name, trademark, or otherwise imply endorsement or recommendation of use by either Cal Poly, ITRC, the California Energy Commission, or any other party mentioned in this document. No party makes any warranty, express or implied, and assumes no legal liability or responsibility for the accuracy or completeness of any apparatus, product, process, or data described.

lots, roads, etc. These installations may damage the buried pipelines and/or hinder the district's access to the pipeline for repair. This has caused many legal problems for some irrigation districts.

One district prefers installing pipelines in Public Use Enclosures (PUEs) or landscape easements. Another district has fought to keep their exclusive easements really exclusive and out of road right-of-ways, PUEs, and backyards. This district won't allow anything above or around its pipelines without a written license agreement detailing placement considerations and maintenance responsibilities. The district maintains responsibility for only the underground pipe; the city is responsible for the aboveground area. Sometimes, districts may be responsible for aboveground maintenance, including litter removal.

Pipelines are also more difficult to maintain than open canals from a personnel safety standpoint. Some districts now install manholes or accessible air vents in their pipelines and limit the distance that employees can crawl within a pipeline. Two districts also now install clay plugs at every manhole to help them pinpoint leaks along a length of pipeline.

Pipeline Materials

Cast-in-Place Pipe: Material of the past?

The installation of new cast-in-place pipelines has decreased dramatically in the last 10 years, especially in urban areas. Most interviewed districts still seemed relatively comfortable installing new cast-in-place pipelines in agricultural settings, especially if improvement districts or farmers with flood irrigation want it or if the pipeline will have only 3-5 feet of head. Overall, though, not many new agricultural cast-in-place installations have been undertaken recently, due to financial limitations.

Some irrigation districts are wary of installing new cast-in-place pipelines in "transitional" areas. One representative felt that many of the problems with old cast-in-place pipelines have resulted from a changing environment: roads were widened and ended up on top of pipelines; roads with minimal traffic loads became heavily traveled 10 years later; agricultural areas were developed into suburbs. Other irrigation districts feel that installing cast-in-place in a transitional area is fine since development usually requires existing pipelines to be removed or re-routed anyway.

Urban policies are more stringent. One district still uses cast-in-place for city pipelines over 60 inches and allows it on pipelines over 48 inches if approved by the district's board. However, most districts no longer allow any new installation of cast-in-place pipe in developed areas. As one representative put it, even though installing cast-in-place may be cheaper, the long-term repair bill is not worth it.

When cast-in-place is installed, some districts install it themselves and some contract it out. One district felt that monolithic pipe is much better than double pour, which tends to have thin bottom walls. Another district mentioned the difficulty of pouring monolithic pipe in sandy soil, which can cave in on the pipe and stick to the wet cement. This district now conducts soil testing before installing any cast-in-place pipe. Two districts have tried inserting fiber mesh into new cast-in-place pipes to prevent ring cracks. One district found this did not help, but the other district found that it did.

Most irrigation districts have many miles of aging (30-70 years old) cast-in-place pipeline in need of repair or replacement. However, very few of the districts had official replacement programs. Districts cited economic restraints and difficult pipe placement (in urban areas or under tree or vine crops) as the two major reasons holding back cast-in-place replacement. When districts do replace pipeline, their choice of new material varies. Reinforced Concrete Pipe (RCP) is by far the most popular choice currently, though some districts also use PVC on smaller diameter (36-inch or less) lines.

For now, most problematic cast-in-place pipeline is not replaced, but repaired. The major problem associated with cast-in-place pipelines is leakage. Almost all districts complained of this, whether caused by 10-15 feet of head, overhead construction, or traffic vibrations. Some districts use grout or mortar to repair cracks. Many districts use epoxy products, which they find easy to apply, flexible, and long lasting. Other districts reported that some epoxy brands do not work well in wet conditions and expressed concerns about fumes. One district tried reservoir sealant, which works better in wet conditions, but has horrible fumes.

For badly deteriorated pipelines, two possible solutions were suggested, neither of which have yet been tried in a district pipeline. One was a sewer pipe repair material that is sprayed onto the inside of a cleaned pipeline to seal it. The material was reported to be very effective and long lasting, but very expensive. A similar thought involved lining pipelines with a matted fabric material that is currently used to repair open canals.

Root intrusion from trees can also be a problem. Significant root intrusion can severely limit pipeline flow. So far, there does not appear to be a safe prevention technique or an easy removal solution for this problem, especially in smaller pipelines.

Reinforced Concrete Pipe: The New Favorite

Most districts now use primarily Reinforced Concrete Pipe (RCP, or RGRCP if rubber gasketed) for large diameter pipelines, especially in or near cities. The general consensus seemed to be that RCP holds up better under internal and external pressures than cast-in-place pipeline. It is sturdier and less susceptible to being broken from the outside and also can stand more head without cracking and leaking. Some districts install it themselves and some contract the work out. Many districts stated that contractors are more comfortable working with RCP than with other new pipe materials.

There are three types of RCP, all of which have the same external loading capacity.

1. Packerhead –Packerhead is very porous and may seep water under high internal head pressure. All districts agreed that packerhead works well for culverts, etc., where there is no head. One district felt comfortable using packerhead for other applications, as long as it is less than 60 inches and meets their pressure standards. However, many of the districts are more cautious, especially in developed areas. One district specially requests packerhead with a denser concrete mix, on which they allow a maximum 6-foot head. Another district requires pipe to be field tested first with 11 feet of head. Several of the districts do not allow packerhead at all in subdivisions and under parking lots, roads, etc. One representative commented that, if placed under asphalt, seepage from packerhead pipe could cause settling and sinking of the asphalt.
2. Wet cast – This type of pipe is installed and then watered.

3. Spun – This type of pipe is centrifugally spun so that the outside of the pipeline is denser and will not allow water seepage. Spun pipe is more expensive and available only up to 60 inches. Many districts require the use of centrifugally spun RCP in developed areas to ensure that no seepage occurs.

Most districts did not report problems with root intrusion on RGRCP, though one district did report a complete pipe blockage when eucalyptus tree roots intruded through RCP gaskets. To prevent root intrusion, one district tried a product that wraps around the outside of the bell and gasket, but the product only has a life of 10 years. Another possibility may be the use of gasket joints infused with an herbicidal root growth inhibitor. Such gaskets are widely used in drainage pipes and but have not yet been tried in irrigation district delivery pipelines.

Two districts reported problems with people digging into their RCP pipe in urban areas. One district felt a stronger material, such as HDPE, should be used to prevent this. The other district felt that if a pipe was going to be dug into, it was preferable for it to be RGRCP. Therefore, they always use RGRCP when a pipe goes through a backyard.

It was also noted that RCP pipe cannot always be manufactured quickly enough to be used on a job that needs to be completely especially quickly (say, in 4 months).

PVC

In the last few years, large diameter PVC pipeline has become more competitive as more contractors become comfortable with it. In urban areas, irrigation districts generally use PVC only for pipelines less than 24- or 18-inches in diameter. One district found PVC convenient for creative routing around subdivision roads, houses, etc., though they don't use PVC in areas that might later see construction, such as backyards.

PVC is more widely used in agricultural areas, especially when the pipeline is relatively straight and doesn't require too many fittings. In agricultural areas, 30- and sometimes even 36-inch PVC is used. One district runs an incentive program for growers who want to use pressurized irrigation systems to replace their old cast-in-place supply lines with PVC. So far, about 20 projects have been completed. Although these lines are currently used as low-pressure conveyance lines, they have been constructed to support pressurization in the future.

PVC pipe lengths can be connected by gluing or using ordered coupler fittings. Gluing large diameter (over 27-inch) PVC pipe in the field is very difficult because the glue gets dirty easily, and it is hard to turn the pipe and apply the glue fast enough. The glue is also expensive, so for 30-inch and above pipelines, it may be cheaper to order a gasket. However, ordering gaskets can also be expensive if many are needed.

The most common type of coupler is the rubber gasket. Since rubber gasket bells can crack when pipe is pushed under a road, one district uses metal couplers in those situations. Compression fittings are also available, but they tend to deteriorate severely with time.

Root instruction through rubber gaskets was not mentioned as a problem by any of the districts. Agricultural burn piles were also not reported as a problem, unless located near an air vent. One

district required the use of concrete on exposed sections of predominantly PVC pipelines since people often burn trash in open canals.

There are several varieties of PVC pipe. One district said yellow storm drain PVC was very cheap, but did not have sturdy-looking gaskets. They used it for an open flow pipeline. A spiral wound PVC with T-shaped corrugations is also available, which may have problems in very cold conditions. It has fairly thin walls that are susceptible to damage during installation and may deflect if soil compaction isn't performed carefully. One district said that water-tamping compaction wasn't necessary if narrow trenches are used to prevent the pipe from expanding.

A double walled, spiral wrapped pipe also exists. Though it may be less susceptible to deflection, the pipe lengths are still easily damaged if roughly treated. Gaps at the seams of the spiral wraps have also been observed and leaks can be difficult to trace since water will travel along the spirals. If the pipe is cut, the spiral cells must be filled and sealed.

The solid wall variety seems to be the favorite type of PVC pipe. One district remarked that they now use only solid wall PVC. However, this district cautioned that using PVC with a thin wall (63-psi) could cause problems during backfilling. They recommended using 80-psi gasketed pipe in normal situations, and 100-psi pipe under roadways.

High Density Polyethylene (HDPE)

HDPE pipe is the newest player on the scene, arriving only within the last 3-4 years. Very few districts have tried it yet. One district was especially enthusiastic about HDPE, but overall feelings were uncertain. Several districts expressed major hesitations about trying HDPE on pipelines belonging to growers or improvement districts or in an agricultural setting with lots of control structures, check gates, and connections. One district said they haven't considered using HDPE in subdivisions because local developers and contractors aren't familiar with it. However, another district said that one of their cities has decided that all new pipelines must be HDPE.

Many HDPE lines to date have been installed by district crews. However, the price benefits of HDPE are uncertain. For one thing, the price of HDPE, like PVC, can be affected by changing petroleum prices. Soil type also plays a major role in the installation price for HDPE. Clay soil is especially complicated to compact and often requires the importation of crushed rock or sand, significantly raising the installation cost.

Some HDPE is connected like PVC, with rubber gaskets. One type of this HDPE has a corrugated single wall. Primary complaints about this HDPE include i) the inability to connect cut sections of pipe, and ii) fragile pipe lengths and bells, which are easily damaged during installation, leak during use, and exhibit egg shaping and deflection. The two manufacturers of this kind of HDPE have recently added strengthening straps to strengthen their bells. However, the one district that tried some new bells reported that they still failed field-testing. (*Note that since that time, there have been further major improvements by at least one of the manufacturers*). Another district felt that that corrugated HDPE pipe should only be used in low pressure or open flow pipelines in agricultural situations. They had not used it in urban areas except to sleeve two cast-in-place pipes.

Another rubber gasket-connected HDPE pipe has a single open profile wall with internal and external tubing to give it strength. Although this type of pipe is reported to work very well, it is also prohibitively expensive.

The most successful type of HDPE seems to be double wall fusion-welded HDPE. The four districts that have tried it were satisfied with its performance. With this HDPE, pipe lengths are connected by welding. Steel bands are also available for extra protection at the connections; however, two districts were concerned they might corrode and did not use them, except occasionally under road crossings. These districts weld both the inside and the outside of the pipe instead. One district does use the steel bands and only welds the inside of the pipe. This district has installed over 7,000 LF of fusion-welded HDPE since 2000, all of which are under-pressure flow pipelines between 5 and 7 psi. Only one of these new HDPE lines is agricultural; the rest are all urban. This district uses fusion-welded HDPE for the following reasons:

1. Flexible installation – No need to plan around ordered gaskets. Pipe can be easily cut and welded as desired to install connections, manholes, etc. Is also easily repaired with welding. This appears to be the major advantage of this HDPE.
2. Fast installation – Pipe is lightweight, comes in longer lengths, and can be welded during continuing installation (after initial tack welding).
3. Tough material – It won't be accidentally punctured by a backhoe if it's dug up.
4. No leaky gaskets – Welded joints are strong, watertight, and easy to repair.
5. Easy maintenance – The resin and fusion welding tools are available on the open market and district crews, once trained, can perform all welding.
6. Open for more bids – It can be installed using smaller equipment, opening the door for small contractors and a district's or developer's own crew.

The district also said the following items need to be considered during installation:

1. Resin – The pressure rated welding material must match the manufactured pipeline material.
2. Connection to interfacing structures – HDPE does not adhere to many common construction materials, such as epoxy. It was recommended to use expansive water stops and HDPE anchor rings and at concrete connections, and HDPE extruded solid wall mechanical flanges when connecting to steel and PVC lines. The pipeline must be well anchored and locked at interfacing structures to avoid expansion and contraction or floating due to a high water table.
3. Compaction – Equal backfilling and compaction on either side of the pipe is crucial to prevent egg shaping. The pipeline could be strained if compaction took place less than one foot over it with heavy equipment and inadequate bridging. Backfill and compaction should take place 24 hours after installation.

The only company that makes double wall fusion-welded HDPE has recently closed its California factory and is now only located in Canada. The company hopes to remain competitive, with lower resin and labor prices making up for travel costs.

References

Participating Organizations:

Alta Irrigation District. Represented by Chris Kapheim.
 Cal Poly ITRC. Represented by Charles Burt and Dan Howes.
 Chowchilla Water District. Represented by Doug Welch.
 Consolidated Irrigation District. Represented by Gene Branch.
 Fresno Irrigation District. Represented by Bill Stretch and Mark Unruh.
 Madera Irrigation District. Represented by Don Roberts, Harold Ryan, and Rudy Bustamante.
 Merced Irrigation District. Represented by Hicham El Tal and Scott Porte.
 Modesto Irrigation District. Represented by Bill Ketscher and Dave Bakker.
 Provost and Pritchard Engineering. Represented by Kevin Johansen.
 Turlock Irrigation District. Represented by Todd Troglin.

Manufacturers and Products Mentioned:

RCP Manufacturers

Kristich-Monterey Pipe Co., Inc. Watsonville. 831-724-4186. Manufactures packerhead RCP.
 Rinkler Materials HydroConduit. Fresno. 559-275-2241 Manufactures both packerhead and centrifugally spun RCP.

PVC Manufacturers

Diamond. Manufactures spiral double wall (Pro21) and solid wall PVC.
 J-M Manufacturing Co. Permalock. Manufactures spiral wound and storm drain PVC.

HDPE

ADS. Madera. Manufactures corrugated HDPE
 Hancor. Bakersfield. Manufactures corrugated HDPE.
 Chevron. Manufactures single wall HDPE (Spiralite).
 Weholite. Headquartered in Finland; previous factory in Bakersfield; current nearest factory in Canada. Manufactures both single and double walled HDPE.

Other

BioBarrier. Bell and gasket wrapping to prevent root intrusion.
 Bitumastic. Corrosion-preventive wrapping.
 CIKA-Flex. Epoxy used to repair cast-in-place lines.
 DLT. Compression fittings for PVC.
 Dehydratine. Tar-like material previously used to repair cast-in-place lines.
 Flex-1A. Epoxy used to repair cast-in-place lines.
 HydroPlug. Cement material used to plug holes in cast-in-place lines.
 Teranap. Elastomeric bitumen geomembrane used to line canals.
 Treflan, an herbicidal root growth inhibitor that maybe infused in rubber gaskets. Licensed by Batelle Labs. Washington.
 Zebron. Company that provides a sprayable lining to seal pipelines.

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