The return of vitrified clay pipe

A new generation of engineers is learning why their predecessors specified more than 5 billion feet for the nation's sewers.

For some time, Portland's Bureau of Environmental Services had been interested in modern clay pipe. Each material offers advantages and disadvantages for different applications, but the long life cycle of vitrified clay was attractive.

The city, however, faced two major constraints: supply and experience. Without a local supplier, clay pipe hadn't been able to overcome added transportation costs to compete for the bureau's work. As a result, local contractors lacked experience and confidence in bidding the material.

Fortunately, communities in the Seattle area were building projects with vitrified clay pipe (VCP). A new supply hub began operating near Tacoma, which meant that pipe was now passing through Portland from California and other out-of-state suppliers on its way to the Seattle area.

To take advantage of this, the bureau contacted the National Clay Pipe Institute to find out what could be done to improve availability in Portland. Over the course of several months, institute experts spent several days in Portland training bureau employees who reworked the presentation into in-house training programs for specifying, educating contractors, and inspecting installations.

The bureau's design group was asked to create an opportunity in a $1.7 million sewer rehabilitation project that would give suppliers, contractors, and employees experience working with the material. To that end, part of the bureau's training program was visiting suppliers and familiarizing key employees with the material.

"Pallets from two prospective clay pipe suppliers for our area were ordered and delivered to our maintenance yard," says Senior Engineering Associate Colleen Harold. "All design and construction staff, including inspectors and material testers, was invited to participate in becoming familiar with the pipe. They were able to ask questions, and observe cutting of the pipe, installing Inserta-Tees [a product of The Royal Group's Pipe Systems division], and handling and installing couplers.

"We learned how to work with pipe so that we were the experts, not the contractor. We found out, for example, that we couldn't use chains and nylon straps to handle the pipe because it was too slick and that grippers worked best."

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VITRIFIED CLAY PIPE SUPPLIERS FOR ...

Open-cut (new construction and combined sewer separations):

The Logan Clay Products Co.
www.loganclaypipe.com

Superior Clay Corp.
www.superiorclay.com

Gladding, McBean LLC
www.gladdingmcbean.com

Trenchless (stainless steel collar on one end facilitates jacking):

Mission Clay Products LLC
www.missionclay.com

Can Clay Corp.
www.canclay.com

In March 2010, 384 feet of no-bell clay pipe was installed for rehabilitation; the rest of the project — a total of 6,208 feet of 12-inch bell-and-spigot clay mainline — was installed as new construction. All 205 laterals were replaced with 6-inch PVC.

"For contractors, clay compares best to concrete, not plastic," Harold says. "The best part is that it comes in short lengths, so pipe can be installed right up to manholes without additional cutting of the pipe. This allows the contractors to lay more pipe in a day."

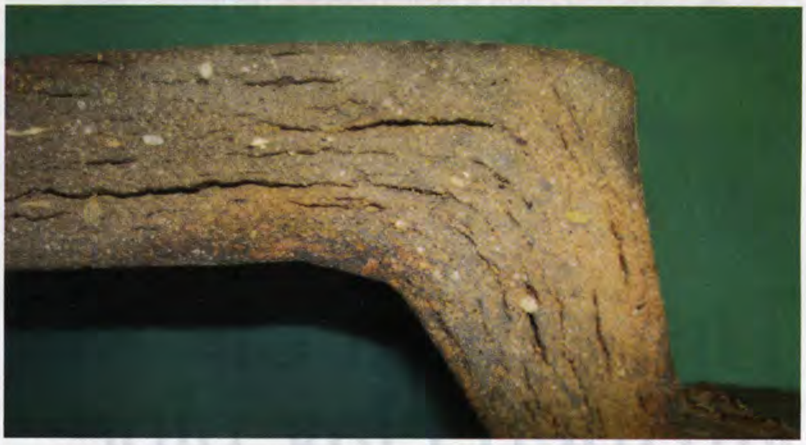
Overcoming misperceptions

As the grandfather of modern sewer pipe, vitrified clay is overcoming a number of myths.

Until the 1950s the pipe was placed in hand-dug trenches without joints, or joints were fabricated in the field by the installer. Sometimes joints were made from cement mortar and sometimes from tar, both of which were readily available on jobsites. Thus, the earliest installations "were only as good as the guy in the trench on any given day," says Jeff Boschert, civil engineer with the National Clay Pipe Institute. "Engineers considered infiltration and inflow (I&I) to be a benefit to the system because the lines were flushed and cleaned during rain events. But with the onset of wastewater treatment in the 1950's, I&I became undesirable due to increased treatment costs and environmental impacts."

Manufacturing technology of the late 1800s and early 1900s produced pipe with both laminations and voids that compromised strength. Steam-driven extrusion equipment limited lengths to 3 feet. Today, laminations and voids in the pipe body are nonexistent due to the development of high densification extruding equipment.

In the early 1900s the soil removed from the trench was placed back around the pipe by hand and carefully compacted. A "lamp test" verified alignment, but not pipe integrity and joint tightness after backfill. The dynamics of load development weren't as thoroughly understood as they are today. As a result, trench width and depth weren't designed properly, placing excessive pressure on the pipe. The four bedding classes — influenced by pipe strength, the unit weight and type of backfill, and the width of the trench at the top of the pipe — weren't developed until the late 1960s.



Impurities and imprecise firing methods caused voids and lamination in the terra cotta pipe placed in the late 1800s and early 1900s. Photos: National Clay Pipe Institute

Modern manufacturing is precisely controlled to quickly bring the clay from a drying room temperature up to 500° F before slowly raising it to 1,100° F to burn out impurities. Once the pipe body reaches 1,100° F the firing process can proceed quickly to 2,000° F, the point at which the pipe is vitrified — converted to a hard, glass-like state. To maintain dimensional stability, cooling also is controlled in steps.

Today's consistent firing temperature of 2,000° F turns clay particles into ceramic, producing a new "vitrified" material with twice the three edge bearing strength of pipe manufactured a century or so ago.

Today, pipe designed for open-trench construction utilizes either a bell-and-spigot joint design with a factory-applied elastometic material or straight pipe barrels joined with rubber shear couplings and tightening bands. Similar to jacking pipe or bell-and-spigot pipe, these joints form a "leak-free" flexible compression fit when assembled. The advantages of utilizing a flexible joint on a rigid conduit have been widely demonstrated since these joints were first introduced more than 50 years ago. ASTM International C-425 states "joints shall not leak," and according to Boschert, factory-applied joints manufactured in the last 50 to 60 years don't.

Impervious to virtually anything except hydrofluoric acid, clay requires almost no maintenance. As a result, until 1975 it was the dominant material specified for gravity sanitary sewer construction.

The 1980s ushered in the era of scheduled cleaning and maintenance. While many clay sewer systems are still in service today, others showed signs of leakage. Installed when inflow was intentional, they suffered from what's now

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	12-in. Clay	12-in. PVC	12-in. Concrete
Lay lengths	1-, 2-, 3-, 4-, 5-, and 6 ft. Shorts available	14 ft., 20 ft.	6 ft. Shorts not available
Weight	54 lbs./lf	10 lbs./lf	120 lbs./lf
Costs	$72/lf	$40/lf	$110/lf
Connections	Bell-and-spigot coupled	Bell-and-spigot coupled	Bell-and-spigot coupled
Durability sensitivities	Inert: it's ceramic/glass sensitive to etching materials	UV if left exposed, solvents, industrial waste	pH from sources like dairies and canneries

CLAY VS. THE COMPETITION

Specifiers tout vitrified clay as all-natural as well as corrosion-resistant. Other materials are available in longer lengths, such as 13.5 feet for plastics and more than 20 feet for fiberglass compared to 10 feet for clay. But as a blend of clay and shale with water added, only one chemical — hydrofluoric acid — attacks clay pipe compared to the 150 solvent-based chemicals that attack plastics. Source: Colleen Harold

considered poor installation and poor jointing but was standard practice when they were installed. As new materials, like PVC and high-density polyethylene (HDPE), were introduced and became accepted, clay fell out of favor.

Midwest and East Coast installations

Though it's Portland's first modern installation, it's not the first in the Northwest. Seattle has been specifying vitrified clay exclusively for all new projects, largely because of its durability and performance in the region's dense glacial till.

On the other side of the country, Delaware's New Castle County initiated a program in 2004 to eliminate all combined sewer overflows from Brandywine Hundred, a cluster of villages and towns just south of the state's border with Pennsylvania, by December 2029. Four hundred miles of 8- to 54-inch clay and concrete interceptors are being upgraded with vitrified clay pipe up to 42 inches in diameter and HDPE and fiberglass-reinforced pipe for larger mains.

Compression joints are factory applied and tested to eliminate leaks.

Though the traditional 3-foot length is still readily available and may be used in urban applications, bell-and-spigot pipe is available in 10-foot sections in diameters 21 inches and larger. "Many U.S. cities specify bell-and-spigot for their open-trench sanitary installations because they know how well it holds up," Boschert says. "They want to put material in the ground with physical properties that do not change with age."

Jacking pipe for trenchless installations can range in length from 2 to 10 feet depending on the jacking frame and size of the working shaft. The pipe is made with recessed ends coupled by stainless-steel collars at each joint. "It's the 21st century version of clay," says Boschert. "Trenchless is a growing market for the clay pipe industry because the jacking pipe is cost-competitive in the short joint lengths typically associated with installation methods like slurry microtunneling and pilot tube microtunneling."

Although both are guided trenchless methods used to install systems accurately on line and grade, there are significant differences.

Slurry microtunelling is a one-pass method that uses a tunneling head and water to grind and transport the spoil out of the bore in liquid form; the new pipe advances the cutting head, which is steered by a laser guidance system from a control station above.

Pilot tube microtunneling is a multiple-pass method that first installs a 4-inch tube that's steered from within the drive shaft by the operator; once the pilot tube is placed, a reaming head is attached followed by auger casings that transport the spoil out of the tunnel, creating the bore. Once the tunnel is cut, the new pipe is jacked into place advancing the auger casings into the reception pit.

Pilot tube microtunneling is becoming increasingly popular since its introduction in 1995 because of low equipment costs, a relatively small jobsite footprint, and the only shoring equipment required for an access pit is usually just a trench box. Vitrified clay jacking pipe has been the main material used in this method because of its high compressive strength (18,000 psi average), availability in the typical 1- or 2-meter (roughly 3- to 7-foot) lengths, and low-profile joints.

Omaha, Neb., recently finished installing 2,980 feet of 8- to 15-inch clay pipe via pilot tube microtunneling. A consent decree requires the city to reduce the annual number of combined sewer overflows from 58 to four by 2024, and the project was one of several pipeline separations where clay was specified. Other projects include 100 feet of 15-inch vitrified clay jacking pipe that was tunneled under a high-traffic road to tie into a manhole; 7,087 feet of 8- to 15-inch vitrified clay, and 18-inch vitrified clay jacking pipe in an industrial park. PW

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