How Standard Installations Can Help Reduce Project Cost

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The Powell Street Overpass Project is a major road and rail infrastructure enhancement in Vancouver's Downtown Eastside for a section of Powell Street just west of Clark Drive. In April 2013, BA Blacktop, using a design carried out by McElhanney Consulting Services, was awarded the design-build contract. BA Blacktop brought on Pedre Contractors as a subcontractor for the underground work including 2,200 tonnes of precast concrete pipe which, in turn, was awarded to Ocean Pipe.

Included in the precast award was approximately 140m of 1800mm diameter pipe that was to be designed for two conditions: the weight of 13.5m of earth cover above the pipe or the load from a bridge footing that the pipe would cross directly under. In British Columbia, reinforced gravity pipe is designed and manufactured to ASTM C76, *The Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe*. Use of ASTM C76 was thought to be incapable of handling the massive expected earth or surcharge load on the 1800mm pipe, therefore, Ocean Pipe's engineers created a custom pipe designed specifically for the expected loading conditions instead of the typical method of testing to a relatable D-load. Soon after receiving the award to supply the concrete pipe, Ocean Pipe approached Pedre with an alternative pipe design that was more expensive. Pedre readily, and quickly, accepted.

Why did Pedre accept a more costly concrete pipe?

The answer is because the alternate pipe design required lower quality bedding materials and less compaction effort during backfilling.

Therefore, the cost of the pipe-soil system as a whole actually decreased.

As a designer, specifier, owner, or installer it is important to understand that the cost of the pipe-soil system includes more than just the cost of the pipe material itself. It also includes other costs such as digging the trench, removing the native material, joining the pipes, bringing in bedding material, backfilling the trench, compacting the embankment, and performing post-installation inspection testing.

Many of the above factors that affect the pipe-soil system are typically functions of the embedment type. It is always good practice to choose an embedment type that will minimize the overall cost of your project while still performing to the project requirements.

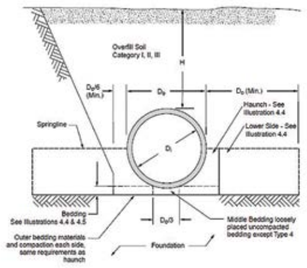
For concrete pipe, the ASTM C1479 Standard Installations (Type 1, Type 2, Type 3, and Type 4) are commonly specified embedment types that provide both the designer and the installer with practical, quantifiable, and versatile installation options.

The Standard Installations are based on a long-ranged research program the American Concrete Pipe Association (ACPA) carried out on the interaction of buried concrete pipe and soil in the 1970s. The research resulted in the comprehensive finite element computer program SPIDA (Soil-Pipe Interaction Design and Analysis) that was used to develop the Standard Installations based on the following practical construction considerations:

1. A flat foundation and bedding simplifies construction. In addition, bedding cannot be shaped within sufficient tolerance to provide uniform support to the outside of the pipe over a shaped bedding angle.
2. It is difficult to compact embedment soil in the lower haunch area up to about 40 degrees from the invert. Therefore, voids are assumed to exist in the haunch zones and are accounted for in the Standard Installations.
3. Requirements for compaction with or without the use of high-quality embedment soils should be limited to those zones around the pipe where the embedment provides beneficial vertical or lateral support to the pipe. Therefore, because concrete is a rigid, load bearing pipe, the soil types and compaction levels specified are only required up to the springline of the pipe. This differs from flexible pipe installations in which extending the embedment material 300mm above the crown of the pipe is a requirement.

Because the Standard Installations were created based on the above practical construction consideration, the Standard Installation detail (Figure 1) conforms to standard construction techniques, thus allowing for better prediction of the loads and pressure which a pipe may experience during its life.

Figure 1: Standard Installation Detail



Another advantage of the Standard Installations is that they are quantifiable. As shown in Table 1, the Standard Installations have specific material requirements and accompanying compaction levels resulting in definite and measurable levels of acceptance. This is a significant improvement over many classic installations that rely on qualitative requirements such as "well-compacted granular material" which can be interpreted many different ways. By quantifying the requirements it makes it easier for the designer and installer to be confident they both understand exactly what is required.

Table 1: Standard Embankment Installations Soil and Minimum Compaction Requirements

Installation Type	Bedding Thickness	Haunch and Outer Bedding	Lower Side
Type 1	D_o/24 minimum, not less than 3 in. If rock foundation, use D_o/12 minimum, not less than 6 in.	95% Category I	90% Category I, 95% Category II, or 100% Category III
Type 2	D_o/24 minimum, not less than 3 in. If rock foundation, use D_o/12 minimum, not less than 6 in	90% Category I or Category II	85% Category I, 90% Category II, or 95% Category III
Type 3	D_o/24 minimum, not less than 3 in. If rock foundation, use D_o/12 minimum, not less t han 6 in.	85% Category I, 90% Category II, or 95% Category III	85% Category I, 90% Category II, or 95% Category III
Type 4	D_o/24 minimum, not less than 3 in. If rock foundation, use D_o/12 minimum, not less than 6 in.	No compaction required, except if Category III, use 85% Category III	No compaction required, except if Category III, use 85% Category III

One of the greatest benefits of the Standard Installations is their versatility. Designers can choose between installation types and pipe strengths (classes) to suit specific site conditions and budgetary constraints. Type 1 installation, for example, requires well compacted, select granular soil. The result is a soil envelope that provides excellent support to the pipe and reduces the overall load on the pipe, therefore, a relatively lower cost pipe can be used. In areas rich with quality embedment materials and relatively inexpensive labor cost, a Type 1 installation can be very cost-effective.

The other end of the spectrum is a Type 4 installation which has little to no requirement for control of compaction and soil type. The result is in a soil envelope that provides minimal support to the pipe, thus, the system relies more heavily on the inherent strength of the pipe to carry the load and a relatively higher strength (and potentially more expensive) pipe is required. In areas where embedment materials are expensive and labor costs are high, a Type 4 installation which possibly reuses native embedment material can be very cost-effective despite the need for a more expensive pipe.

Much like the 1800mm diameter pipe for the Powell Street Overpass Project, choosing the lowest cost pipe does not necessarily always result in a reduced overall project cost. Therefore, it is imperative to understand the balance between embedment cost and pipe cost when designing a pipe-soil system. More specifically, although this article pertains to options within concrete pipe, this approach to pipe selection also applies to options of different pipe materials.

Plant Tour for City of Brampton

In October 2014, the City of Brampton was invited to tour the Con Cast Pipe manufacturing facility in Aberfoyle, hosted by the OCPA. Following the presentation by OCPA which highlighted the industry's role and contributions in Ontario, and an overview of precast products offered for sewer, drainage and bridge infrastructure, the group of municipal staff were taken through several manufacturing stations in the 80,000 sq.ft plant. This tour helped the municipal designers, inspectors and project managers from the City of Brampton understand, 'from A to Z', the process of manufacturing different precast products. For example, participants had a look at material preparation, formwork setup, pouring concrete, and of course, all quality testing and inspection requirements required by the industry's certification program: the Plant Prequalification Program (PPP).

The tour group was guided through the plant using the Sennheiser Tourguide System. The touring system gives a whole different experience of tour, and ensures all persons enjoy an informative plant tour.

The OCPA would like to encourage your group to come to a plant near you. Come see, learn and experience how precast concrete pipe can offer you the highest level of product quality and performance. **Thank you to all who attended.**

Tour group gathered at coring machine for customizing blank manholes

CCPPA Seminars Across Canada

In the latter part of 2014, the CCPPA travelled throughout Western Canada to deliver five technical seminars to eager engineers and field inspectors wanting to learn more about gravity pipe design and installation. This effort was repeated recently in Ontario with another five seminars. The title of the session was, **"Protecting Yourself as a Gravity Pipe Designer or Inspector"**. Although the main focus was concrete pipe, the content did address considerations for other popular pipe materials used for gravity pipe sewers. It was important to distinguish that the requirements of design, installation, and inspection for all pipes are not all the same.

Enrico Stradiotto, P.Eng. presenting at seminar in Surrey, BC

Attendees also had a chance to learn key aspects that can help minimize the risk to the designers or inspectors. Such topics included: assessment of pipe systems, rigid and flexible pipe design and installation, trenching issues, drainage systems in the Building Code, quality and certification, and lastly inspection. For any sewer project, there is a potential risk to all parties involved if one does not practice proper design diligence, write or reference good specifications, and then enforce the specification. As one attendee stated, "...use of specifications helps his guys understand what exactly needs to be done, but the critical part to having a good specification is enforcing the specification."

In February and March, the CCPPA will be continuing the seminars with sessions held in **Victoria, February 20; Ottawa, March 5; Calgary, March 12; Barrie, March 24; Moncton, March 31; and Halifax, April 1**. Presentations to date have been very well received. Below is the feedback received from an attendee in Surrey, BC,

"Thank you for your presentation/seminar on December 4, 2014; the material was excellent and the delivery was exemplary."

The CCPPA looks forward to having strong attendance at the future seminars, and would like to see you there. If you would like a copy of the registration form, please contact us at resources@ccppa.ca.