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M CON Products Inc. Manufactures Large Span Three-Sided Culvert for Mattamy Homes Development

Jennifer Ailey, P.Eng.
Project Manager
DSEL (David Schaeffer Engineering Ltd.)
Ottawa, ON

Precast Producer: **M CON Products Inc**

A new development in Barrhaven, Ontario (just south of Ottawa) needed a bridge structure to allow for both vehicular and pedestrian traffic to access this new subdivision, as well as maintain the integrity of an outlet channel for the Clarke Stormwater Management (SWM) Pond to the Jock River.

Mattamy Homes, the developer, selected DSEL (David Schaeffer Engineering Ltd.) as the prime consultant for this project.

This project contained several interesting challenges:

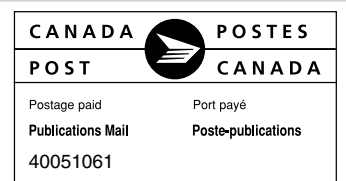
- The Clark SWM Pond services a drainage area of 123.41 ha. and treats flows for quality control prior to discharge to the Jock River.
- The outlet channel was sized to convey the maximum 100-year flow of approximately 22m³/s.
- The outlet channel was part of a Department of Fisheries and Oceans (DFO) Authorization for the Barrhaven South Community, where it represents a portion of the compensation for loss of fish habitat. As such, the channel was designed using principles of natural channel design.



Open bottom culvert installation

- Natural channel design consists of a low flow meandering channel with riffles and pools, designed by a fluvial engineer.
- There is a trunk sanitary sewer that was planned along Perseus Avenue, across the channel, in the overall servicing plan for the Barrhaven South area (per the Barrhaven South Master Servicing Study (MSS). The downstream outlet was constructed/ existing and there were no opportunities to lower the sanitary sewer.
- There was limited clearance between the bottom of the channel (low flow channel per fluvial design) and the fixed sanitary crossing, resulting in insufficient clearance to incorporate a four-sided box culvert.

continued on page 2



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M CON Products Inc. Manufactures Large Span Three-Sided Culvert

continued from page 1

- There were challenges in determining the final design of the three-sided culvert as the footing was deeper than the fixed sanitary trunk elevation.

To address the challenges with respect to the sanitary trunk crossing the footing of the three-sided culvert, the following design modifications were incorporated into the final design:

- A 1.0m gap in the footing was provided to allow for the installation of the sanitary sewer which is contained in a steel sleeve.
- The rise of the culvert (leg length) was increased to allow for a reduction in the elevation of the top of the footings.
- Due to the low bearing capacity of the in-situ soil, the culvert was designed to be supported by a cast-in-place concrete strip footing that was to be supported on a granular pad. This design was provided by the Paterson Group (geotechnical engineer).

M CON Products, located west of Ottawa in Carp, Ontario, was chosen as the precast concrete producer for this project. M CON was awarded the structural design, fabrication and delivery of the three-sided culvert.

While ensuring that the structure met the required 9.144m span, 3.048m rise and total run length of 33.54m, M CON optimized the number of pieces to be produced while maximizing their size. Respecting weight limits as well as ensuring safe and efficient delivery were key factors in determining the maximum size of each piece.

The final structure was designed to have 17 pieces. Each piece weighed in at approximately 38 metric tonnes. Another advantage of having M CON provide the structural design permitted them to optimize the production by ensuring the steel reinforcement detail would provide efficient fabrication of the structural elements. The structure's 17 pieces were produced in 34 days.

In conjunction with Vanson Transportation, M CON was able to coordinate the logistical requirements to allow for the structure to be installed in two days.

Utilizing the advantages of precast concrete and working with the M CON team on the engineering, manufacturing and logistics provided this project with a high-quality structure that addressed some very challenging site conditions while keeping this project on schedule.



Gap in footing to allow for sanitary sewer installation

Ten Years of Movember Fundraising by the Langley Concrete Group President

Since 2011, Mark Omelianec, President of the Langley Concrete Group, has personally fundraised through the Movember campaign which raises funds to help eliminate prostate and testicular cancer as well as raise awareness of these diseases.

Over these ten years of fundraising Mark has accumulated a total of \$305,000 in donations.

Well done, Mark!

Mark included the following words in a thank you message to all of his contributors: "We all know



Mark "Sean Connery" Omelianec

of someone who has passed or is fighting one type of cancer or another, and campaigns like this raise awareness and result in research and programs that reach beyond the specific 'type' it is focused on. I just wanted to say 'stay strong' to those who are fighting the battle against cancer. On a personal note, I would like to acknowledge Greg Henderson, a long term LCG employee who lost his battle this year. A great employee, friend and a person who cared about the safety of others every day. R.I.P. Greg."

Kon Kast Products Joins CCPPA

Kon Kast Products, based in Kelowna, British Columbia, joined the Canadian Concrete Pipe & Precast Association in January, 2021.

Kon Kast Products (2005) Ltd. is a manufacturer, wholesaler and retailer of precast concrete products and it was incorporated in November, 1969. The company grew from a small producer of precast sidewalks, septic tanks and well rings, serving the Kelowna area, to what it is

today; a large, sophisticated and innovative manufacturer of various precast components and systems, sold throughout B.C. and western Canada.

Kon Kast handles sales requirements from its head office in Kelowna, B.C., as well as maintaining dealers in Prince George and Castlegar.

We welcome Kon Kast Products (2005) Ltd. to the CCPPA.

Large Span Skewed Box Culvert Addresses Challenging Site Conditions

Gary Leonard, C.E.T., rcca.

Construction Administrator – Major Mackenzie Extension Project (Section 3)

York Region Transportation Services, Capital Planning and Delivery

Precast Producer: DECAST Ltd.

The Regional Municipality of York (located north of Toronto, Ontario) is investing in building a safe, efficient and reliable Regional transportation network for all travelers. To support growing communities and enhance roads and transit, construction is planned and underway at over 80 locations across the Region. Part of this investment is transforming Major Mackenzie Drive from Highway 50 to Highway 400 in the City of Vaughan. This three-year project will widen the road to six lanes with additional improvements, including sidewalk, multi-use path, storm sewers, street lighting and landscaped medians.

The Major Mackenzie Drive extension project is split into four sections. The third section, which runs from Huntington Road to Islington Avenue, was primarily realigning Major Mackenzie Drive to eliminate the jog at Highway 27. One of the key structures in this section is a large span, over 9m, skewed (21 degrees) box culvert.

Dufferin Construction was the general contractor for this project and awarded the precast concrete skewed box section to DECAST Ltd. The site requirements provided some significant challenges.

This culvert would be required to support up to 8m of earth cover. The property limits required a skew of 21 degrees on the ends of the culvert. The technical/engineering team at DECAST worked closely with Dufferin Construction, AECOM and York Region to provide a structure that met these challenging requirements.

The resulting design was a skewed box culvert with a 9148mm span, 2440mm rise box culvert for installation just east of Highway 27. To complete the structure, 77 pieces were required, with each piece weighing in at 39,100kg. The significant dead load and the large span resulted in a roof/bottom slab of 550mm in thickness.

All logistical requirements were handled through DECAST Ltd. in coordination with Dufferin Construction with respect to the installation. All 77 pieces of this culvert structure were installed in five days which highlighted the accelerated construction capability of using precast elements.

The Regional Municipality of York consists of nine local cities and towns and provides a variety of programs and services to 1.2 million residents and 54,000 businesses with 650,000 employees.

More information about the Region and Transportation Services is available at www.york.ca.



Completed installation of skewed box culvert

Forterra Pipe & Precast Announces New Wet Cast Plant Addition in Cambridge, Ontario



Forterra Pipe and Precast Manufacturing Plant – Cambridge, Ontario

Forterra, a world-class manufacturer of water and drainage infrastructure which includes concrete pipe, precast concrete box culverts and a variety of concrete products in Eastern Canada and the United States, announced on October 27th, 2020 their intentions to invest \$5M+ to increase the capacity of the Cambridge manufacturing facility.

This investment will allow for a diversity of specialty precast concrete structures.

Regarding this investment, Shane Eagan, General Manager of Forterra Canada, commented, “The addition of the wet cast facility will increase our manufacturing capacity to better meet our customers’ needs. The capital project will allow Forterra to further develop our extensive product line to meet market demand”.

Over the past several years, the precast industry has witnessed continued growth with respect to cast-in-place structures now being produced as precast concrete structural elements.

Precast concrete allows for:

- The prefabrication of the structural elements prior to their requirement on the job site
- Facilitates accelerated construction
- Improved durability due to higher concrete strength as well as their fabrication in a controlled environment
- The precast concrete structures to be assembled with minimal effect from inclement weather helps ensure the project remains on schedule.

With this investment Forterra, will create a new wet cast facility, install wet cast manufacturing equipment and develop a state-of-the-art workspace.

The new Forterra wet cast facility is expected to be in operation by mid-2021.



City of Toronto – Area 18 (in North York) Basement Flooding Protection Project

Mark Swan, P.Eng.

Water Practice Lead, GTR

Parsons (Prime consultant for the project)

Will Cowlin, P.Eng., CAN-CISEC

Water Resources Engineer

Aquafor Beech Ltd. (Subconsultant to Parsons)

Precast Producer: M CON Pipe & Products Ltd, Ayr, Ontario.

In recent years, significant rain events have produced an increase in basement flooding issues in the larger municipalities across Canada. Toronto is one of the municipalities working to address this challenge. To address the flooding problem, the city identified various areas where flooding, particularly, basement flooding, needed to be alleviated.

Study Area 18 is located in the central portion of the city within North York and covers an area of approximately 249 hectares. The area is divided by Bathurst Street and is roughly limited by Highway 401 to the north, Lawrence Avenue to the south, Allen Road to the west, and Avenue Road to the east.

In early 2016, Parsons and Aquafor Beech Ltd. were successful in being awarded the design and contract administration of Area 18 in North York of the Basement Flooding Protection Program. The project required inline storage to protect downstream sewers against surcharging, thus potentially causing basement flooding. The design utilized precast structures to help accelerate the project and ensure that the installation could be completed in the summer of 2019.

In October 2018, the contract for this project was awarded to Trisan Construction. Trisan then turned to their longtime precast supplier, M Con Pipe & Products, to handle the design, production and delivery of these precast box structures.

The design for this project required approximately one kilometer of precast concrete boxes in various sizes from 1800x900mm up to 3000x2400mm to create storm inline storage and reduce the risk of basement flooding in this residential area of North York.

The required precast box culvert sizes and linear meters are as follows:

- 195m of 3000x2000 Box Culvert
- 65m of 2400x1800 Box Culvert
- 115m of 2400x1500 Box Culvert
- 277m of 2400x1200 Box Culvert
- 202m of 1800x900 Box Culvert
- 150m of 3000x2400 Box Culvert



Box culvert installation

M CON Pipe & Products was given the go ahead in the fall of 2018 to start producing the required structures. This was done in order to take advantage of the capability to produce the required box structures over the winter months and have them ready to ship to the jobsite in early summer 2019. One of the advantages of designing with precast structures is that it allows for the structures to be prefabricated and ready to be shipped before they are required on the job site which helps reduce project delays.

The designers utilized the standards sizes included in the OPSS 1821 specification that provides predesigned box sizes from 1800x900mm up to 3000x2400mm. Since these sizes are standard for precast producers, M CON Pipe & Products was able to have a high rate of production for these structural elements.

M CON Pipe & Products was able to also provide us with a number of precast solutions to help reduce our expected construction schedule. Low flow channels were required inside all of the culvert base slabs. Building these on site, while the culvert was in place, would have been very challenging and time consuming. They were able to cast these channels into the boxes at their manufacturing facility. A number of cast-in-place drop structures were required to allow for storm leads to be connected. M CON Pipe & Products was able to provide precast drop

structures attached to the box sections which reduced the construction/installation time.

The depth of these inline storage units varied from 0.6m of cover to 7m of cover. The standard box sizes included in the OPSS 1821 have a maximum depth of 5.5m for 1800mm span and 3.6m for 2400mm and 3000mm span boxes. M CON Pipe & Products was able to adjust the steel reinforcement design to meet this additional loading due to the increased depth of bury.

Some of the box sections required access. Riser sections needed to be added to these specific sections. For these deep access box culvert sections, they produced precast load slabs that would be doweled into the top slab of the box culvert and also have a spigot incorporated into the slab to allow for a maintenance hole riser section to be added. This allowed for quick install of the complete structure.

Given that this project occurred in a residential neighborhood in the summer of 2019, a key part of the success of this project was the ability of M CON Pipe & Products to provide precast solutions which allowed the project to remain on schedule while minimizing disturbances due to construction.

Enrico Stradiotto – 2021 OPWA President



Enrico Stradiotto

Following the Ontario Public Works Association (OPWA) Annual General Meeting on January 21, 2021, Enrico Stradiotto, of the Canadian Concrete Pipe & Precast Association (CCPPA), accepted the role of OPWA President for 2021. OPWA is one of 63 Chapters of the American Public Works Association (APWA), and the largest of eight Canadian chapters with nearly 600 members. OPWA's membership includes numerous municipalities in the public sector, as well as, consulting engineering companies, industry groups, and supplier companies from the private

sector. The Chapter is centrally based in Ontario, but also includes two Branches: Ottawa Valley Branch (NE Ontario) and West Central Branch (SW Ontario).

Enrico joined the Ontario Chapter in 2010 and began chairing the Education Committee in 2012. He later joined the OPWA Executive in 2014 before

reaching the leadership role as OPWA President. Enrico's objectives for the Chapter in 2021 include: member engagement, advocacy for public works, and Chapter growth throughout Ontario.

In addition to the AGM, the Ontario Chapter recognized individual achievements and innovative projects within public works during its Annual Awards presentation. This was the first-ever virtual AGM & Annual Conference for OPWA. Twenty awards were given out on this day, including the Top Public Works Leader of the Year Award to Laura McDowell from the Region of York. Visit ontario.cpwa.net/ to see all the winners. Event speakers included the Parliamentary Assistant Stephen Crawford, from the Ministry of Infrastructure; and Nancy Watt of Nancy Watt Communications who spoke about "Adaptability Through Improv". This was the first-ever virtual AGM & Annual Conference for OPWA, and although the in-person experience was dearly missed, the event proved very successful.

Enrico would like to thank the Ontario Public Works Association (OPWA) and the Canadian Concrete Pipe & Precast Association (CCPPA) for their support in reaching this achievement.



Announcement: Doug Galloway (M CON Pipe and Products Inc.) and Drew Black (JD Industrial Sales) Retire

As we move into 2021, we would like to highlight two individuals that have decided to retire at the end of 2020. Both Doug and Drew have helped shape the concrete pipe and precast industry during their long careers.



Doug Galloway

Doug Galloway started in the concrete pipe industry in April, 1974 when he joined the Best Pipe Company in Kitchener, Ontario. From his start in the accounting department, Doug has subsequently held a number of management positions with Waterloo Concrete, Centennial Pipe and Products Inc., Hanson Pipe and Products Inc. and finally M CON Pipe & Products Inc (Ayr, ON) where Doug held the position of President.

Drew Black started his career at Waterloo Precast in April, 1975. In 1981, Drew moved into the sales department and was Sales and Marketing Manager until 1998. Drew then took a posting in Chile where Blue Circle PLC asked him to manage their newly acquired operations. After two years in Chile, Drew took a posting in Sacramento, California as VP/GM for Hanson's California operations. Drew was then transferred back to Canada in 2007, to head the Eastern Canada operations for Hanson. In 2009, Drew started up his own company, JD Industrial Sales, which provided manufacturing equipment to the concrete pipe and precast industry.

The CCPPA would like to thank both Doug and Drew for their support and involvement over the years. Their contributions to the advancement of the association have been numerous and valuable. We wish both of Doug and Drew the best as they embark on this next chapter.



Drew Black

Mafe Pinzon Joins Langley Concrete Group



Mafe Pinzon, P.Eng.

Mafe Pinzon, P.Eng., joined the Langley Concrete Group in British Columbia in January 2021 and has resigned from the Canadian Concrete Pipe & Precast Association.

Mafe was hired by the CCPPA in 2014 in Winnipeg as the Region Engineer for Saskatchewan and Manitoba. She was a solid performer for our industry for over four years in those provinces. Mafe relocated to Calgary in 2019 and was the Alberta and British Columbia Region Engineer with CCPPA for the past two years.

Mafe's new position with the Langley Concrete Group will be as a Technical Marketing Manager.

The Langley Concrete Group has been supplying British Columbia with precast concrete solutions for over sixty years. From their two plant operations, Lombard Precast in Victoria and Langley Concrete & Tile's 150,000 square foot, state-of-the-art production facility in Chilliwack, the Langley Concrete group produces a variety of dry and wet cast concrete drainage products for the construction of underground infrastructure. These products include pipe, manhole, box culvert, catch basins, headwalls, vaults and oil interceptors.

All of us at the Canadian Concrete Pipe & Precast Association wish Mafe well in her new position.



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CON CAST PIPE



Rigid and Flexible Pipe Systems

Camilo Marquez, P. Eng., C.E.T., CAPM
 Region Engineer MB – SK
 Canadian Concrete Pipe & Precast Association

System evaluation

A buried pipeline is a system that integrates the properties of the soil surrounding the pipe and the physical properties of the pipe itself. The pipe is a critical structure that conveys water or other fluid and shall be designed hydraulically capable to transport the content within its walls, but also needs to be capable of withstanding any considerable loads (live loads, dead loads, surcharge loads, construction loads) that can apply to the underground infrastructure. The structural analysis of a pipeline is based on the soil conditions and the construction inspections, which is extremely important when it comes to the success of the project. Construction inspection ensures that all these factors are met on site.

To analyze both rigid and flexible systems, it is necessary to differentiate their behavior and the obvious differences between each other. As per various textbooks and international standards such as ASTM (International Standards Organization) and CSA (National/International Standards organization).

Generally, rigid systems must be supported at the bottom (bedding) of the pipe, and flexible systems, in addition to bedding support, also require soil support on the sides which ultimately controls the pipe deflection. This ensures the pipe will not over-deflect beyond its limits. The inspection of soil support for both systems involves different indicators that should be considered in the design phase, which include but are not limited to:

- Distribution of soil around the pipe
- Type of soil for bedding and backfill
- Interaction of the soil in the trench wall and the foundation
- Water movement within and outside the trench
- Type of trench

For the designer, the selection of the type of trench depends on the disposition of the material, the soil condition, and the area where the project is taking place. There are some limitations, especially when the designer is battling to get extra “space” to adapt the installation (zoning requirements) or perhaps; limitations due to the existence of other “locates” as some contractors call the existing utility lines. Thereby, the installation and the design should be based on the conditions of the native soil and its interaction with the properties of the pipe.

Water movement and migration is another piece of the jigsaw puzzle that needs to be addressed carefully.

Migration

This term could be wrongfully disregarded. It is a term that should be subject to analysis thoroughly by designers and inspectors. This problem refers to the particles from the backfill material or trench walls transferring into the bedding material and the embedment material, which ultimately transforms the supporting soil under the pipe and around it to a much weaker and less stiff soil. It is important to analyze the installation procedure and the components of such installation. (Howard, 2015).

Analyzing the soil and the compaction that is used can be extremely important (95% of compaction). Hence determining the percent compaction from the laboratory could play an important role (ASTM D 698, standard proctor compaction test for cohesive soils).

When the soil is not properly compacted, these particles make their way into the voids of the coarser material, degrading the support of the pipe due to the groundwater flow. It is crucial to determine how the water is behaving. Based on that analysis, the designer should determine how to mitigate any possible problems that might affect the installation. Some designers recommend the use of geotextiles for migration issues (non-woven or woven geotextiles) and some other designers use “French drains” as a passageway of water.

Other methodologies can be used to contain migration issues, such as:

- Trench plugs
- Bentonite clay plugs
- Trench breakers

Rigid and Flexible Pipe Systems

A pipe is a conduit, but it is also a structure. Under this concept, both systems regardless of its material can fail if it is not installed properly. **Rigid pipe** is designed to transmit any loads (live load, dead load,

surcharge load, construction loads) that are being applied to the pipe which is contained by the concrete walls and subsequently aided by the steel reinforcement. A **flexible pipe** is designed to support the loads by transferring the aforementioned loads to the surrounding soil.

Flexible Pipe

One of the primary ways to control any possible issues that can be attached to the installation of a plastic pipe is by conducting a deflection test known as *Mandrel Test (ASTM D3034)* which consists of introducing a go-/no-go device through the pipe. Using this methodology can help to determine if the soil surrounding the pipe has been compacted properly or not, and the maximum allowable deflection value of the pipe was met. Values between one to five per cent are considered a standardized range (Howard, 1977).

Flexible pipe deflection is directly proportional to the **stiffness** of the soil pipe and the stiffness of the trench wall, which is comprised of native soil or other backfill material. Buried flexible pipe changes its geometry during installation (elongation, load lag, deflection lag, deformation). It is important to determine any local deformation that could trigger more complicated issues (stress/strain in the pipe-wall).

Flexible pipe by design tends to deflect according to the ratio of the stiffness of its composition and the pressure induced by the soil-pipe system. The stiffness of the pipe can be determined by using a parallel plate test (ASTM F4212).

Thus, the expression can calculate the product of EI:

$$EI = \frac{0.149pr^3}{\Delta y}$$

Where:

E= Modulus of elasticity of pipe wall material

I= Moment of inertia

P= load

r= pipe radius

Δy = vertical deflection

Typically, some equations calculate the deflection of the flexible pipe.

For instance, the most common ones are the **U.S Bureau of Reclamation Equation** or the **Modified Iowa Formula (Spangler, 1941)**.

$$\frac{\Delta x}{d} (\%) = \frac{100DI \cdot KP}{0.149(PS) + 0.061E_{design}}$$

Where:

$$\frac{\Delta x}{d} (\%) = \text{Max.Hz deflection}$$

DI= deflection lag factor

K= angle of contact with the bedding material

P= external load (dead load + live load / pipe diameter)

PS= pipe stiffness

E'design= modulus of soil reaction

The previous equation only calculates the horizontal deflection; therefore, the vertical deflection needs to be considered for a proper calculation of the overall deflection inside of the pipe. Note that the denominator (E'design) refers to the backfill stiffness but also includes the interaction with the native soil material.

In other words, the combination of the soil surrounding the flexible pipe and the maximum allowable deflection are the primary components when it comes to the design and installation of a flexible system.

Proper installation standards must be followed thoroughly. Using the *ASTM D2321* or *CSA 182.11* are the perfect guidelines for the adequate installation of flexible pipe material.

Rigid Pipe

Reinforced Concrete Pipe or RCP is manufactured according to the standard *ASTM C76*, *CSA A257* and should be installed as per *ASTM C 1479* or *Concrete Pipe & Precast Installation guidelines (OCPA, 2019)*.

The design of RCP depends on multiple factors. The selection of a pipe-soil system strong enough that it can mitigate any excessive loading condition. The pipe walls must be sufficiently strong, and the configuration of the steel should be adequate to transfer the load to the supporting bedding below the pipe.

Since the majority of the load would be carried by the pipe as opposed to the soil, the rigid concrete pipe then needs to be designed and installed with the right strength classification. The pipe strength is determined in a controlled environment by a test **continued on page 7**

Rigid and Flexible Pipe Systems

continued from page 6

called “three-edge bearing test” (ASTM C76, ASTM C497) this test consists of three loading point conditions (worst-case scenario in real life).

The test is looking to obtain a 0.3mm width by 300mm long crack, which is not a structural problem, it is the practical way to realize the classification according to the standards (CSA A257.2 & ASTM C76).

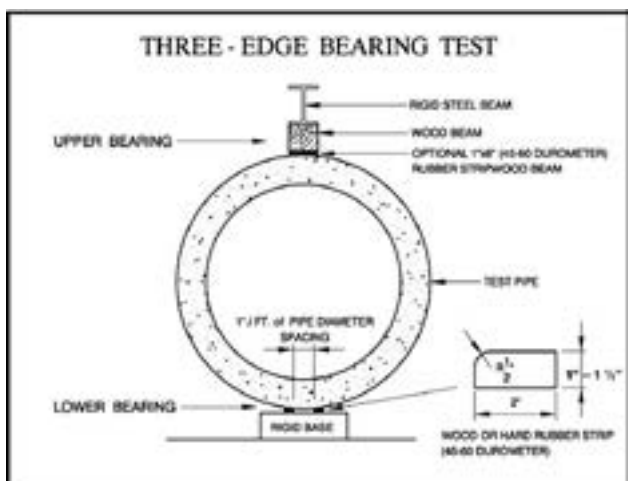


Figure 1 Three-Edge Bearing Test
Courtesy of American Concrete Pipe Association

RCP can be designed by either using:

- Direct design – limit states design*
- Indirect Design – empirical method to determine a bedding factor.

*not covered in this paper

Some design engineers have used first principles that are highly accurate but somehow tedious, or height of fill tables where can be practical as long as the notes of those particular tables are similar to the condition of the site that the project is taking place.

Another alternative could be

the usage of PipePac which is free web-based software that allows the designer to determine the proper strength of the pipe under any given soil condition (CCPPA, 2020).

The installation also plays an important role. The designer should first evaluate the type of trench:

- Confined trench
- Embankment (positive projecting)
- Tunnel

The selection of the type of trench influences the strength classification of the pipe. Having a confined trench would support the load acting on top of the pipe due to the proximity of the trench walls; but having a bigger excavation as the embankment condition, the soil prisms columns acting on top of the pipe are now supported by the pipe itself.

The selection of the bedding factor and the bedding as per standard installations (Canadian Highway Bridge Design Code – CHBDC) offer four types of installations for RCP. This classification depends on the quality effort of the soil compaction and its quality.

$$\text{Pipe strength} = \frac{W_e + W_l}{B_f} * \frac{F_s}{\text{Diam}}$$

Where:

W_e= Earth load

W_l= Live load

B_f= Bedding factor

F_s= Factor of safety

Diam= Diameter of the pipe

As expressed in the previous equation, the bedding factor is in the denominator, therefore, selecting a good bedding factor can reduce the need for a high strength classification pipe.

It is important to reaffirm that the design of the pipe and the design installation for both systems are extremely important. As a designer and practicing engineer is our responsibility to follow the right methodologies and proper standards.

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