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INNOVATIONS IN PRODUCTION OF CORRUGATED PIPES

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ABSTRACT

A very tight-fitting bell-and-spigot inline coupler, minimizing the gap between connecting pipe segments, and a space efficient pulsating corrugator, requiring just three mold block pairs, were developed.

KEYWORDS

Coupling, bell-and-spigot, pulsating, corrugator

INTRODUCTION

The author of a recent article in New York Times [1] claims that some 300 Billion dollars are needed to repair the crumbling infrastructure of pipes for water distribution and sewers. He goes on to describe the lobbying efforts and epic battles between the various professional groups and associations advocating iron or plastic for drinking water. The main competitor to large diameter corrugated plastic pipes is concrete. In articles and reports [2-4] the supporters of concrete have tried to portray plastic as having significant disadvantages, in comparison to concrete, most of them unsubstantiated. They cite liability issues for the engineers, higher Manning roughness coefficient, stress cracking, leakage in the joints and inferior load bearing capacity, without providing any documentation. They claim also that the initial cost advantage of plastic pipes, disappears in the long run. The competition is undoubtedly very stiff. Only significant improvements in corrugated plastic pipe properties and performance, accompanied by cost reduction, will convince the various stakeholders of the superiority of plastic. In this paper, we describe two innovations which are likely to have a lasting impact on plastic pipe corrugation technology. One innovation is the development of a new tight-fitting virtually seamless inline coupler capable of reducing the gap between connecting pipe segments, in case of soil movement after installation. Another innovation is a new production method suitable for large diameter pipes based on a pulsating corrugator, which requires as few as three mold block pairs, for forming the corrugations.

COUPLING OF CORRUGATED PIPES

Double (or sometimes triple) wall corrugated pipes made of High Density Polyethylene (HDPE), Polypropylene (PP) or Polyvinyl Chloride (PVC) are used extensively for sewer and rainwater applications. The inside wall is smooth and the roughness coefficient in the Manning formula is usually reported in the range of 0.009 to 0.015, depending on whether a safety factor is included for joint misalignment, debris accumulation, vegetation growth and other defects. The outside wall is corrugated for increased stiffness. Pipe joints can be made watertight with just one sealing ring and with very low tolerances in the dimensions. There still remains an important problem at the joints: Due to either imperfect installation, earthquakes or other ground movement, relatively large gaps and deep cavities may form, as shown schematically in Fig.1. Actually, even poor bedding support and inadequate stiffness, of the soil surrounding a buried pipe, may result in significant stresses, strains, deflections and separation at the joints. Moore et al [5] reported performance problems related to HDPE pipe joints in culverts and Sheldon et al [6], in their study on joint response, also in culverts, stated “Failure of a joint may allow water and soil to seep through it, potentially resulting in loss of soil support and, ultimately, collapse of the pipe and pavement damage”. Pipe culverts are typically installed by placing corrugated pipe into the ground and used as small bridges. Consequently, culverts are subjected to significant loadings as cars and perhaps heavy trucks drive over them.

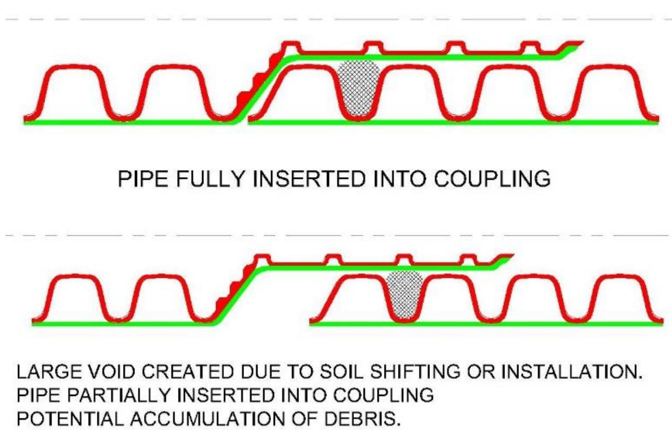

Fig. 1 Double-wall corrugated pipe coupling

The gaps at the joints are responsible for reduction of water carrying capacity due to flow recirculation and formation of vortices as shown on the basis of a computer flow simulation of turbulent water flow in Fig. 2, using the OPENFOAM [7] software package. The results are similar to other publications available in the scientific and technical literature, like Chang and al [8]. On the left side the cavity is deep, while on the right side the cavity is shallow. Corner eddies arise even in laminar viscous flows (Moffatt eddies) and have been the subject of considerable number of publications in the scientific literature [9]. Obviously, reduction of the cavity depth results is reduced amount of recirculating or nearly stagnant water, reduced accumulation of debris and reduced growth of vegetation, which could obstruct the water flow. The pipe walls forming the deep cavities are likely to be subjected to accelerated Environmental Stress Cracking (ESC) due to the accumulation of chemical agents like soaps, detergents, acids, hydrocarbons and other pollutants. ESC is a very complicated phenomenon, but it can be described as slow crack growth in plastic products subjected to stress, due to the migration of chemicals through the polymer crystal structure at the molecular level [10]. ESC is most serious in HDPE, but it also occurs in PP and PVC. However, HDPE grades having high tie molecules content are more resistant to ESC. Tie molecules provide connections between the crystallites in semi-crystalline polymers and reduce brittleness [11]. Also, the higher the molecular weight (lower Melt Flow Index) the more resistance to ESC. Although crack growth is slow, the cracks may eventually become large and cause leakage and structural failure, especially in the areas of high concentration of the stress cracking pollutants and high stress levels that is, in the cavities formed at the joints, at the bottom side of the pipe.

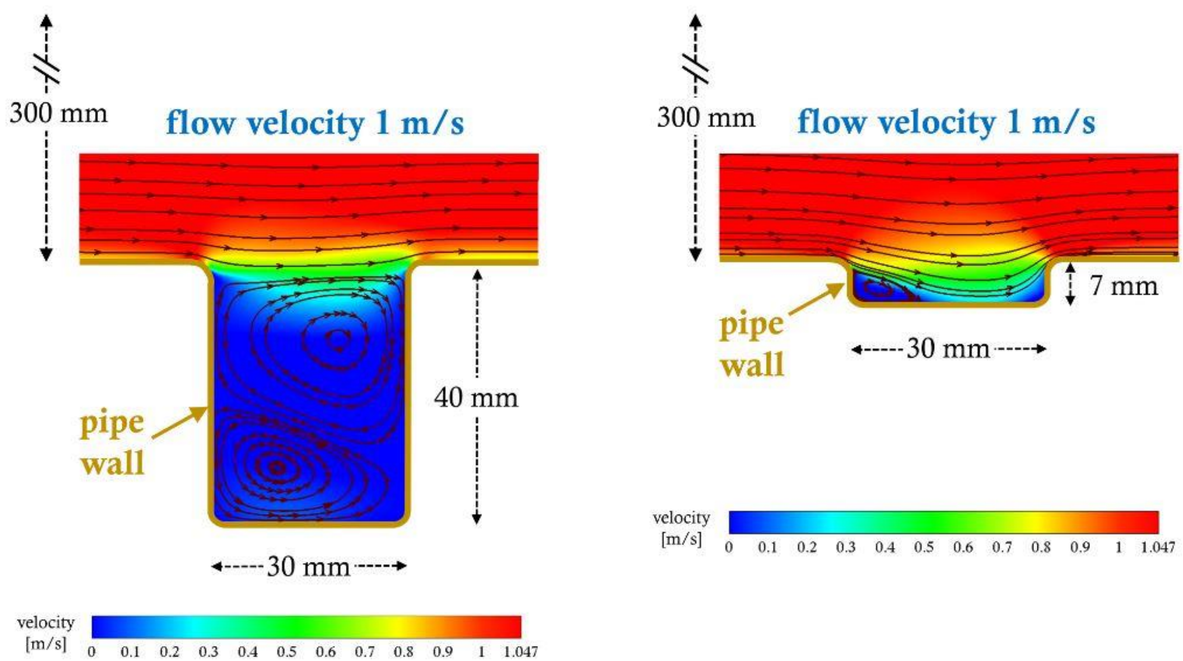

Fig. 2 Computer simulation of turbulent water flow over a gap

Recent developments enable the making of a tight-fitting bell-and-spigot coupling on any double walled pipe. Corrugated pipe can be produced at high speeds and cut at desired lengths at increments of one corrugation. Fig.3 shows the production steps: (a) Pipe and coupling are extruded (b) A transition piece is cut-off and it is subsequently recycled, so there is no waste. Fig. 3(c) shows a partially inserted spigot and Fig. 3 (d) a fully inserted spigot.

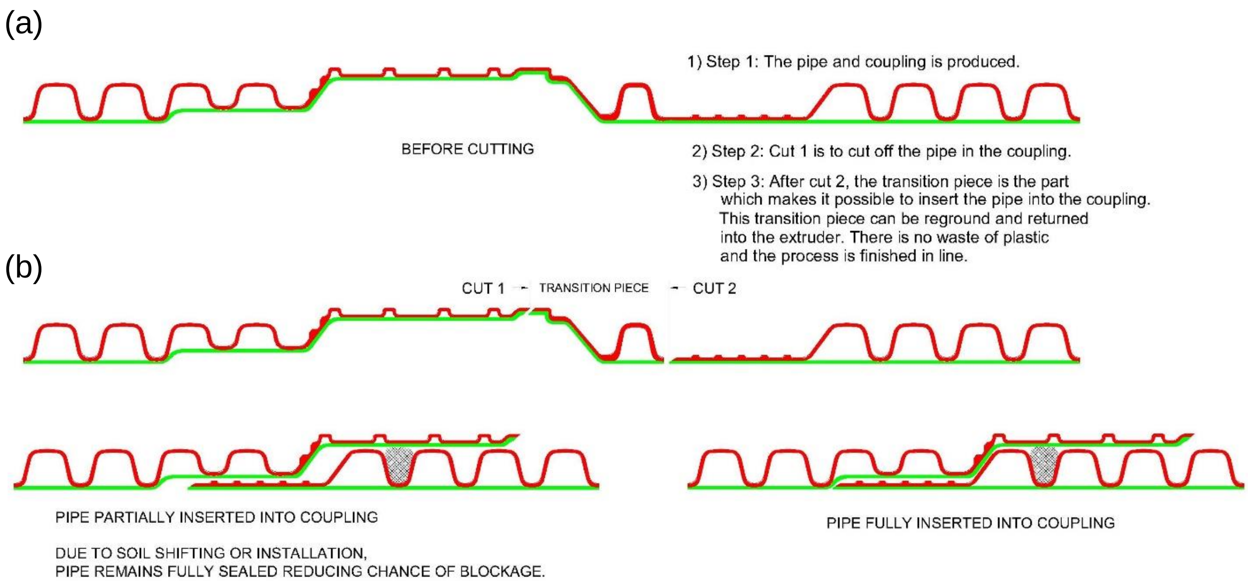

Fig. 3 Sequence of steps in production of the tight-fitting bell-and-spigot coupling

Obviously, the fitting between two connected pipe segments is very tight. There is hardly any gap in case of soil shifting or potential imperfect installation and any debris accumulation, vegetation growth, leakage and stress cracking chemical agent concentration is minimized. Leakages between connecting pipe segments lead to sub-soil erosion, which may remain unnoticed over a long period of time and result in sink-holes. Such situations are virtually eliminated with the present tight-fitting inline coupler. The development of the tight-fitting coupling creates a product which gives a virtually seamless joint between the two pieces of pipe being connected. Furthermore, the overlapping pipe sections on the inside diameter give the coupling a capability to resist ground movement (for example earthquakes) and still have a very high “hermetic” quality joint.

PULSATING CORRUGATOR

The most common method of production of corrugated plastic pipe is by pressure assisted vacuum-forming of a continuously extruded tube as the mold blocks rotate mounted on two vertical or horizontal chain-like oval tracks. A second method involves a small number of mold blocks which go back and forth on rails and is known as the shuttle technology. Recently, a pulsating corrugator was developed, which involves only three pairs of mold blocks as shown in Fig.4.

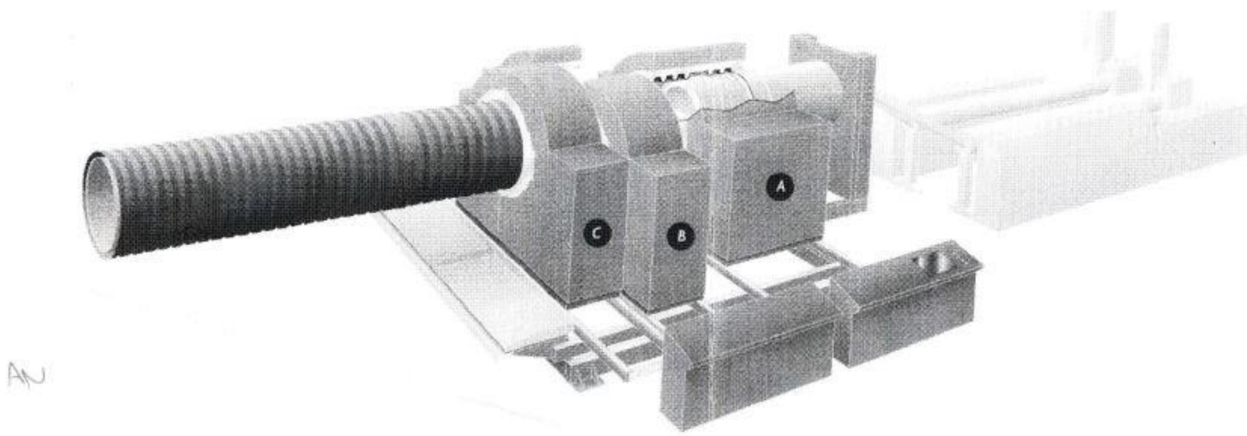

Fig. 4 Descriptive sketch of the pulsating corrugator

The pulsating corrugator operates as follows: As the mold blocks travel downstream along the molding track, at a specific point the pair of mold blocks (A) closest to the extruder quickly opens, returns towards the extruder and closes over the last formed profile. Two other pairs of mold blocks (B and C) continue at production speed holding and cooling the pipe. As the first mold block has closed the second mold block will open, return and close, followed by the third and so forth. The pulsating corrugator is a space efficient system particularly well suited for large diameters (1000 mm to 3000mm). Production speeds are lower than the conventional corrugators with vertically mounted mold blocks. However, more pairs of blocks can be added to the pulsating corrugator to increase cooling and consequently line speed, if desired. Fig.5 shows the production of ID=1800 mm / OD=2000 mm (stiffness Class SN2 at a weight of approximately 100kg/m) double-wall corrugated pipe at a speed of 0.22 m/minute, which corresponds to approximately 1300 kg/hour.

Fig. 5 Production of double-wall corrugated pipe

CONCLUDING REMARKS

Gaps between connecting corrugated pipe segments can easily be formed due to soil movement after installation. Such gaps promote vegetation growth and debris accumulation in sewers and reduce water and sewage flow. They also accelerate environmental stress cracking, due to accumulation of pollutants in relatively deep cavities. The virtually seamless bell-and-spigot inline coupler minimizes the gap and depth between connecting pipe segments. A new pulsating corrugator was developed, which is very space efficient. It requires just three pairs of mold blocks and it is ideally suited for the production of very large diameter pipes. If needed, for increasing cooling and production speed, more pairs of mold blocks can easily be added.

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