The Advantages of Plastic Pipe in a Modern Infrastructure

Daniel Hardin

Tennessee Technological University

Abstract

This paper was written in order to delve into the technical aspects of today's water infrastructure and wastewater systems. The goal is to inform the reader about the advantages plastics hold over previously used materials. In order to intelligently present this topic, sources were gathered from various internet sites that shed light on the different materials that have been previously used in comparison to the plastics that are currently being integrated into today's water infrastructure. A look was also taken at the materials that have been used up to this point; examining their flaws and paying particular attention to how the materials deteriorate with time. As a result of this research, it has been found that plastics are advantageous over the materials that have been used in the past. After assessing the information that has been thus gathered, the only logical conclusion attained is that plastic is not only the more suitable material, but also the future of the world's water infrastructure.

The Advantages of Plastic Pipe in a Modern Infrastructure

Due to the exponential growth of the human population, our planet's demand for more resources has also grown at an astronomical rate. The most essential of those resources in order to sustain life is water; without it mankind would not only be unable to quench its thirst, but would also be unable to grow crops which are vital to the human food supply. In order for water to be properly distributed to various sources, one must have the proper infrastructure of pipes leading the water to its proper place; not only that, but the pipes must also be able to last a considerable amount of time, be cost competitive, and not have a negative impact on the environment, in particular the water in which it is transporting. An American industry and municipality industry group named WIN prepared a study that estimates that the U.S. spends around $61 billion on water and wastewater infrastructure. The challenge lies not only in where to place such pipes, but also the material in which the pipes need to be made out of.

Up until this point, the three main materials that have been used worldwide in designing and building the pipes for a water infrastructure system have been cast iron, steel, and concrete; the reason being is because these are the two materials that have the strength necessary to handle the internal and external pressures that exist in pipes, particularly large diameter pipes. Along with this advantage, these three materials can last a long time, particularly steel. However, out of these materials, the one that is used the most is iron. According to recent studies, in the US, for instance, approximately 68% of potable, buried pipe is either cast or ductile iron. Rick Nelson, who is the senior project manager at CH2M Hill, said "below 54 inches to 24 inches, ductile iron is the traditional favorite, based on experience, crews, equipment" (Cope 2005). Up to this point, it has been a good choice of material to use; the reason that ductile cast iron has been so

abundantly used is because it is both strong and durable, hence the name "ductile cast iron." In addition to these considerable advantages, cast iron is reported to be able to last for over a century when being used in a water infrastructure system.

Although it appears as if the current materials used in the world's water infrastructure are adequate and have no need to be changed, for one to believe such a notion would be far from correct. Even though cast iron is reported to being able to last for over a century, does not mean that it actually will. One of the major flaws of cast iron is that it is vulnerable to corrosion; in previous times, metals were given a coating in order that it would protect the metal and help slow the effects of corrosion. The controller for Ameron, John Garrett, said "we see the market for portable water becoming more and more toward welded steel pipe with a mortar liner to protect the inside from corrosion and a tape wrap on the outside to protect against corrosion and provide cathodic protection," (Cope 2005). Taking extra precautions such as these clearly indicates that the materials that are being currently used are not up to the daunting task of transporting the world's water supply without extra help which is a considerable concern; even with the extra coating, there is no guarantee that the pipes made out of iron will last 100 years. Utah State University performed a study recently in both the United States and Canada on water main breaks; in their estimation the average age of failing water mains is 47 years old and 22 percent of all water mains are over 50 years old.

The reason that this issue is becoming so important now is because the materials that have been previously discussed are beginning to reach their age limit. Many of today's iron pipes are around 100 years old, the majority of these pipes were installed after World War II and need to be replaced; now they have become corroded or have had multiple crack propagations form. The result is that the pipes are starting to burst; according to the Vinyl Institute ,each year, more than

300,000 water main breaks occur in North America, mainly due to the continued use of corrosion-prone iron piping in the country's water systems. Though it is not a very publicly outspoken issue, damaged water infrastructure systems are costing countries a fortune. In the United States alone, more that 2.6 trillion gallons of water are lost annually due to leaking and broken pipes inside of America's water infrastructure. According to the Vinyl Institute, that is enough water to satisfy the drinking water needs of every man, woman, and child on earth for an entire year. Looking at the data, one might assume that after weighing the options, iron is still a good choice material to use provided that it is coated with a corrosion resistant material and that the current pipes would just need to be replaced with new ones; however, it is not such a simple task. Another issue that goes along with repairing and building a water infrastructure is the price. Underground Construction Magazine reported that the US rehabilitation spending on pipe was $3.5 billion in 2004, with new spending amounting to $7.9 billion; this amounted to a total of $11.4 billion, which is approximately 18% of total expenditures. Not only that, but with the increased demand for iron and the U.S. economy in a slump, the immediate future for our water infrastructure proves to be very grave if it continues down its current path. In order for the water infrastructure to improve, the materials used must improve; luckily much progress has been made in the area of materials engineering and an answer is already here.

Discussion

Polyvinyl chloride (PVC) and polyethylene (PE) pipe are leading the way in replacing the various other materials that have been previously used in pipe construction; they have only been scarcely used in the past, however over the past 30 years they have proven themselves to be more than worthy replacements for the conventional materials such as steel and iron. One of CH2M-Hill's senior project managers, Rick Nelson, acknowledged plastic's growing presence in the

water infrastructure arena by saying "Although ductile iron is also popular at this size, you see more plastic in new construction" (Cope 2005). In fact, they are actually better suited materials for today's water infrastructure and should end up replacing the materials of old altogether.

Plastics have a myriad of advantages over traditionally used materials. For starters, PVC and PE pipe are very durable materials; they are just as strong as iron, which is crucial due to pipes' exposure to both internal and external pressures. However, arguably two of their most important attributes are that they neither corrode, nor do they have a buildup of minerals on the insides of the cylindrical walls. These last two attributes are very critical, especially when these pipes are transporting water across a very large distance. The reason being is because the pumping process is very energy intensive; when water passes through conduits, energy is lost due to the friction between the flowing water and the surface texture of the cylindrical wall. As the water's flow velocity increases, its energy loss does as well; this is especially apparent in places where the inside surface of the pipe is rough from corrosion or has a narrow flow space due to the buildup of minerals. In areas where leaks are present, more water has to be pushed through that pipe so in order to compensate for the water that has been lost; this strategy potentially presents a problem in areas where a leak is present because the water that is lost can potentially erode the soil and nearby infrastructure could be damaged. By using plastic, this issue is reduced considerably; they are polymer based which means that corrosion is not a factor and leaks are less likely to happen. Those two advantages alone would help reduce the amount of energy needed to move water across great distances and also reduce the amount of water that is lost in the process.

Another big advantage in using plastics instead of various other materials is the cost considerations; due to the condition of today's economy, this could arguably be the biggest reason that companies switch to plastic when designing a waster infrastructure or wastewater system. When designing a water infrastructure both the cost of the material and the cost of installing that material are pivotal, and one responsibility of an engineer is to find a way to complete the task both effectively and efficiently. The difference in cost between plastic and steel is staggering. For example, the cost of polyethylene piping that is 12 inches in diameter costs around $15 per foot; on the other hand, steel piping that is 12 inches in diameter can cost more than twice that amount. Along with the cost of the material comes the cost of installation; to install that same 12 inches in diameter polyethylene piping, it would cost $70 per foot to install. Shockingly, the comparable 12 inches in diameter steel piping would cost over $600 per foot to install. The amount of money that would be saved by just the installation alone is prodigious; in fact it would amount to a savings of about $2.8 million per mile. For this reason, more companies are starting to take a liking more to plastic; Rick Nelson, who is one of the senior project managers with CH2M Hill said "From 24 inches down to 6 inches, plastics are very popular because they are light, easy to install and easy to repair" (Cope 2005). However, when making a cost comparison, one should not just look at the cost of installation, but also the cost to maintain the infrastructure. With the current materials used, the cost of maintaining the water infrastructure has reached a critical point. According to a congressional survey, corrosion costs U.S. drinking water and wastewater systems more than $50.7 billion annually. This is due to pipes leaking, along with both the cost of materials needed to replace the corroded pipes and the labor costs that go with it.

Another advantage that plastic has over other materials is its impact on the environment; this is important because environmental consciousness has really come to the forefront of people's minds in recent years. When looking at a product's economic footprint, many people look to how that material interacts with its surrounding environment in order to assess how economically friendly that material is. However, one of the biggest places that people usually forget about is where that material is manufactured; not only does the material itself have to have a non-negative impact on its surrounding environment, but the process in which the material is made must not be one that is so pollutant-producing that it renders the purpose of making that material pointless. For example, the process in which is vastly detrimental to the mankind's environmental footprint; the cement industry is the world's third largest emitter of greenhouse gases. Such is not the case with the manufacturing of PVC pipe; if one were to observe a facility that makes PVC pipe, one would notice that such facilities do not contain smoke stacks along with the fact that the finished product is completely recyclable. The manufacturing process for PVC pipe is extremely efficient; nearly the entire compound to make PVC pipe is used. Not only that, but making PVC pipe takes only a fourth of the energy necessary to make concrete pipe and only half of the energy needed to make iron pipe.

Although these numerous advantages prove that plastic is the superior material in application with water infrastructure, at the end of the day the consumer is more concerned with convenience. An extra benefit that plastic holds over other competing materials is that plastic does a much better job of reducing noise; this is due the plastics properties which are better suited for sound and vibration absorption. Though issues such as this are not the most critical when an engineer is making his or her decision on what material to use, it is a very reassuring

fact to know that the material chosen was not only the best one, but was also the one that is readily accepted by society.

After reading over the facts that have been given, the obvious truth is clear; plastics are a superior choice over traditionally used materials and should be used in the future of the world's water infrastructure and wastewater systems. The use of plastic is important for today's water infrastructure because it can replace the system that is currently crumbling under old age and corrosion. Though plastic has not been around as long as traditional materials and has not withstood centuries of constant critiquing and refining, it has been around long enough to prove that it is durable and can get the job done just as well with less hassle and at a fraction of the cost. The American Water Works Association Research Foundation performed a study that put the life expectancy of PVC pipe at more than 110 years. By acting now and using plastic instead of previously used materials both money and peace of mind are saved knowing that corrosion will not be a considerable worry and that our environment will have been spared in the process.

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