KURDISTAN ENGINEERS UNION

Research title

water and sewerage pipe

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Water and sewerage pipes
Pipe Construction and Materials

Waste water Technology

DESCRIPTION

According to material type , There are several different type of pipes available for wastewater collection systems, each with a unique characteristic used in different conditions. The four different pipe materials described in this fact sheet are ductile iron, concrete, , plastic, and vitrified clay.

Pipe material selection considerations include trench conditions (geologic conditions), corrosion, temperature, safety requirements, and cost. Key pipe characteristics are corrosion resistance (interior and exterior), the scouring factor, leak tightness, and the hydraulic characteristics.

Pipe manufacturers follow requirements set by the American Society of Testing Materials (ASTM) or American Water Works Association (AWWA) for specific pipe materials. Specification standards cover the manufacture of pipes and specify parameters such as internal diameter, loadings (classes), and wall thickness (schedule). The methods of pipe construction vary greatly with thepipe materials.

Some new pipe materials and construction methods use the basic materials of concrete pipes with modifications (i.e., coatings). Other pipe manufacturing methods use newly developed resins which offer improvements in strength, flexibility, and resistance to certain chemicals. Construction methods may also allow for field modifications to adapt to unique conditions (i.e., river crossings, rocky trenches, etc.) or may allow for special, custom ordered diameters and lengths.

- **Ductile Iron Pipe**

Ductile iron pipe (DIP) is an outgrowth of the cast iron pipe industry. Improvements in the metallurgy of cast iron in the 1940's increased the strength of cast iron pipe and added ductility, an ability to slightly deform without cracking. This was a major advantage and ductile iron pipe quickly became the standard pipe material for high pressure service for various uses (water, gas, etc.).

- **Concrete Pipe**

Two types of concrete pipe commonly used today are pre stressed concrete cylinder pipe (PCCP) and reinforced concrete pipe (RCP). PCCP is used for force mains, while RCP is used primarily for gravity lines. PCCP may be of either embedded- cylinder (EC) or lined-cylinder construction (LC). The construction process for both the LC and EC begins by casting a concrete core in a steel cylinder. This single process produces the LC pipe. Once the cylinder cures, it is wrapped with a pre stressed steel wire and coated with a cement slurry and a dense mortar or concrete coating to produce the EC pipe. The manufacturing process for reinforced concrete cylinder pipe (RCCP) is similar to embedded- cylinder, however, a reinforcing cage and the steelcylinder are positioned within a reusable vertical form and the concrete is cast instead of using the pre stressed wire. RCCP can be cured by using either water or steam.

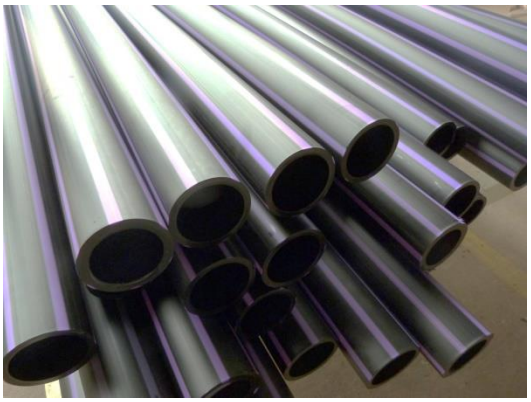
- **Plastic Pipe**

Plastic pipe is made from either thermoplastic or thermoset plastics. Characteristics and constructionvary, but new materials offer high strength and good rigidity. Fluorocarbon plastics are the most resistant to attack from acids, alkalis , and organic compounds, but other plastics also have high chemical resistance. Plastic pipe design must include stiffness, loading , and hydrostatic design stress requirements for pressure piping.

Thermoplastics are plastic materials which change shape when they are heated. Common plastics used in pipe manufacturing include Polyvinyl Chloride (PVC), Polyethylene (PE or HDPE for High- Density PE), Acrylonitrile-butadiene-styrene(ABS), and Polybutylene (PB). HDPE is commonly used with pipe bursting. PVC is strong, lightweight, and somewhat flexible. PVC pipe is the most widely used plastic pipe material. Other plastic pipes or composites with plastics and othermaterials may be more rigid.

Thermoset plastics are rigid after they have been manufactured and are not able to be reformed. Thermoset plastic pipes are composed of epoxy, polyester, and phenolic resins, and are usually reinforced with fiberglass. Resins may contain fillers to extend the resin and to provide specific characteristics to the final material. The glass fibers may be wound around the pipes spirally, in woven configurations, or they may be incorporated into the resin material as short strands. The pipes may be centrifugally cast. Stiffness may also be added in construction as external ribs or windings. Reinforced Plastic Mortar (RPM) and Reinforced Thermosetting Resin (RTR) (or Fiberglass Reinforced Plastic Pipe (FRP)) are the two basic classes of these pipes. Another name is Fiberglass Reinforced Polymer Mortar (FRPM). Thermoset pipes are often manufactured according to the specific buyer requirements and may include liners of different composition for specific chemical uses.

For plastic pipes, resins composed of polymerized molecules are mixed with lubricants, stabilizers, fillers, and pigments, to produce mixtures with different characteristics. Plastic pipes are generally produced by extrusion. Plastic pipe may be used for slip lining or for rehabilitating existing pipes by inserting or pulling them through a smaller diameter pipe. HDPE pipes may also be used for bursting and upgrading. The smaller diameter pipe may be anchored into place with mortar or grout.



Vitrified Clay Pipe

Vitrified clay pipes are composed of crushed and blended clay that are formed into pipes, then dried and fired in a succession of temperatures. The final firing gives the pipes a glassy finish. Vitrified clay pipes have been used for hundreds of years and are strong, resistant to chemical corrosion, internal abrasion, and external chemical attack. They are also heat resistant. These pipes have an increased risk of failure when mortar is used in joints because mortar is more susceptible to chemical attack than the clay. Other types of joints are more chemically stable. It has been shown that the thermal expansion of vitrified clay pipes less than many other types (such as DIP and PVC).

APPLICABILITY

The applicability of different pipe materials varies with each site and the system requirements. The pipe material must be compatible with the soil and groundwater chemistry. The pipe material also must be compatible with the soil structure and topography of the site, which affects the pipe location and depth, the supports necessary for the pipe fill material, and the required strength of the pipe material. The following list shows background information to be used in determining what type of pipe best fits a particular situation:

- Maximum pressure conditions (forcemains).
- Overburden, dynamic, and static loading.
- Lengths of pipe available.
- Soil conditions, soil chemistry, water table,stability.
- Joining materials required.
- Installation equipment required.
- Chemical and physical properties of thewastewater.
- Joint tightness/thrust control.
- Size range requirements.
    - Field and shop fabrication considerations.
    - Compatibility with existing systems.
    - Manholes, pits, sumps, and other requiredstructures to be included.
    - Valves (number, size, and cost).
    - Corrosion/cathodic protection requirements.
    - Maintenance requirements.

ADVANTAGES AND DISADVANTAGES

The advantages and disadvantages for specific pipematerials are listed in Table 1. The primary advantages and disadvantages to consider for pipes used in sewer applications include those that are related to construction requirements, pressure requirements (force mains), depth of cover, and cost.

TABLE 1 ADVANTAGES & DISADVANTAGES OF DIFFERENT MATERIALS

Advantages	Disadvantages
Ductile Iron	
• Good corrosion resistance when coated	• Heavy
• High strength	
Concrete	
• Good corrosion resistance	• Requires careful installation to avoid cracking
• Widespread availability	• Heavy
• High strength	• Susceptible to attack by H_2S and acids when pipes are not coated
• Good load supporting capacity	
Vitrified Clay	
• Very resistant to acids and most chemicals	• Joints are susceptible to chemical attack
• Strong	• Brittle (may crack); requires careful installation
	• Short length and numerous joints make it prone to infiltration and more costly to install
Thermoplastics (PVC, PE, HDPE, ABS)	
• Very lightweight	• Susceptible to chemical attack, particularly by solvents
• Easy to install	• Strength affected by sunlight unless UV protected
• Economical	• Requires special bedding
• Good corrosion resistance	
• Smooth surface reduces friction losses	
• Long pipe sections reduce infiltration potential	
• Flexible	
Thermosets(FRP)	
• High strength	• High material cost
• Lightweight	• Brittle (may crack); requires careful installation
• Corrosion resistant	• High installation cost

Source: Lamit, 1984, Moser, 1990, Peggs, 1985.

Selection standard of water pipe materials

2.1 Safety

In the selection of pipes, it must be ensured that they are within the relevant national health standards. Otherwise, the pipeline may pollute the internal water, especially the drinking water. Some plastic pipes have additives and soluble metal elements in the production due to the need of processing, which may cause impact on people's health to a certain extent. The pipes can be sold only after the national safety testing and certification.

2.2 Durability & reliability

The priority of water pipe selection is to have a certain mechanical strength under the specified temperature and pressure and not easy to be corroded by the flowing fluid, in order to ensure the normal and long-term use of the pipeline. The corrosion and leakage should be considered specially in the selection of pipes. If water seepage or leakage occurs due to the use of unqualified pipe, the harm will be quite great and it is difficult to carry out effective treatment. It is easy to cause the pollution of drinking water and even cause the group problem of people's water safety.

2.3 Economy

In the selection of pipes, the cost of installation and maintenance should be considered as well as the material price. For example, it needs high cost to install thin-walled copper tube although the price of pipe itself is not expensive. Besides, the selection range of pipe diameter is also different according to the different types of pipe materials. In order to expand interests and meet the needs of various customers, some enterprises increase the diameter type of water pipe, which affects the establishment of pipe standard to a certain extent.

2.4 Convenience

The convenience of pipe use includes the construction convenience and maintenance convenience. For example, when comparing the connection mode, steel pipe performs poorly since it needs a lot of on-site welding. Using the socket joint, cast iron pipe has certain advantages although its weight is greater. The much lighter PVC-U pipe is better which also uses the socket joint. Glass fiber reinforced plastic pipe and PE pipes also have advantages when using bonding. However, for designers and operators, the biggest advantage of steel pipes is that they can be opened on-site at almost anywhere as will.

2.5 Environmental

No matter what kind of pipe, it consumes a certain amount of resources and energy from processing, production, installation to operation. For example, it was found that the energy consumption of metal pipe was much higher than that of plastic pipe, especially when spraying or hot stretching process was selected. In addition, the internal surface roughness of the pipe will also affect the energy consumption.

3 Traditional metal/concrete pipes

3.1 Cast iron pipe

The wall of cast iron pipe is relatively thin, but its strength can fully meet actual demand, while the pressure resistance, impact resistance, earthquake resistance and fire resistance are all good. The cast iron pipe is not easy to produce corrosion in actual use, and the production cost and operation noise are low, so it is very suitable for buried pipeline laying. At present, cast iron pipe has been widely used in water supply and drainage engineering. However, the cast iron material is relatively brittle and itself weight is relatively large, which limits the popularization and application of cast iron pipe.

3.2 Galvanized steel pipe

For galvanized steel pipe, the rigidity is relatively large and the fire resistance is relatively strong, while the cost is relatively low. Therefore, the galvanized steel pipe has been widely used in fire water supply system. However, the weight of galvanized steel pipe is relatively large and it is very easy to corrosion. If used as water supply pipe for several years, a large amount of rust will be produced in the galvanized steel pipe, resulting in yellow water that not only pollutes the sanitary ware, but also be mixed with bacteria growing on the unsmoothed inner wall, which seriously endangers human health.

3.3 Concrete & Reinforced concrete pipes

The production cost of concrete pipe or reinforced concrete pipe is relatively low. Thus, it has been widely used in urban water supply and drainage system. However, the weight of (reinforced) concrete pipe is relatively large, which leads to the difficulty in installation process. Moreover, the sealing performance of the joint position is poor, and leakage often occurs.

4 New-type plastic pipes

4.1 Polypropylene-random (PPR) pipe

PPR pipes are widely used in cold and hot water system inside buildings, mainly due to the following advantages. PPR pipe has excellent sanitary performance with no scale in using process. It has good pressure resistance performance and overall quality can be effectively guaranteed, resulting in a long service life. PPR pipe has excellent heat resistance, the maximum working temperature is 95℃ and it can be used for a long time at 70℃. PPR pipe has light weight and excellent welding performance, which makes easy installation and maintenance, leading to the energy saving and environmental protection.

4.2 Polyethylene (PE) pipe

According to the density, PE material can be divided into three types: low density, medium density and high density. In water supply and drainage engineering, high density PE pipe is used mostly. The single solid-wall PE pipe can be used for urban water supply, while double-wall corrugated/wound PE pipe can be used for drainage system. PE pipe is light in weight, good in flexibility and reliable in connection with each other, making it easy to be installed. PE pipe has good stress resistance, aging resistance and corrosion resistance, and good low temperature performance, leading to a long service life.

4.3 Polybutene (PB) pipe

PB pipe has good anti-aging, high temperature resistance and environmental protection performance. Therefore, it is widely used in water supply pipeline and heating pipe laying.

4.4 Un plasticized Polyvinyl Chloride (UPVC) pipe

UPVC pipe has beautiful appearance, light weight, low price, and good corrosion resistance. It is easy to cut off, convenient for installation and maintenance. The smooth inner surface makes good water tightness, good drainage performance and noise prevention performance. Therefore, UPVC pipe is mostly used for building drainage pipe. However, it is not good in temperature resistance performance. It has poor compressive strength and cannot be used in high-rise buildings. Besides, glue and other additives with high toxicity that used in processing and installing may cause potential safety risk.

4.5 Acrylonitrile-Butadiene-Styrene plastic (ABS) pipe

ABS pipe has good pressure resistance and acid/alkali resistance, at the same time has a strong impact resistance. ABS pipe has strong stability and is not easy to be affected by the changes of humidity and temperature. The applicable temperature range of ABS pipe is -30℃ to 70℃, so it is suitable for low temperature environment, it did not add toxic additives in the production process, leading to high healthy and environmental protection performance. However, the price of ABS pipe is relatively high and it cannot be widely used now.

5 Composite materials pipes

5.1 Aluminum-plastic composite (PAP) pipe

Discovered in the 1970s, polyethylene and welded aluminum pipe are compounded into PAP pipe by extrusion, presenting a three-layer structure from outside to inside. PAP pipe has the advantages of light weight, high mechanical strength, stable chemical properties, good corrosion resistance and non-toxic, so it can be used continuously for a long time. The polyethylene material used in the inner layer of PAP pipe makes it have very good smoothness, corresponding small friction coefficient and little noise in the process of water flow. In addition, there will be no scale and will not pollute the inside fluid.

5.2 Steel-plastic composite (PSP) pipe

As a new kind of composite pipe material, PSP pipe retains the rigidity and strength of traditional metal pipe, which is far better than plastic pipes and PAP pipe. PSP pipe has the characteristics of high mechanical strength, stable pressure bearing performance, well protection of water quality and long service life. PSP pipe can be connected by twisted wire, socket, flange, groove, welding, etc., showing fast and easy to install. As safer, more reliable, more economic and more environmental, PSP pipe can completely replace cast iron pipe and galvanized steel pipe in water supply field.

6 Conclusions

In order to ensure the safety and stability of water supply and drainage system and protect the health of users, the selection of pipe materials is very important. Reasonable selection of pipe material can also effectively save money and energy. Using traditional mental pipes, corrosion and water leakage are easy to occur, while new-type plastic pipes and composite materials pipes can solve the problems well. With the progress of science and technology, more pipes with strong comprehensive performance and good environmental protection performance will appear, which will bring great improvement to people's life.

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