BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE, INDIA

PLASTICS PIPES FOR WATER SUPPLY AND DRAINAGE IN BUILDINGS

Plastics in all their variety are an important group of new materials that are being introduced into the building industry. They can be used with great advantage provided their characteristics are properly under-stood.* The pipe is an important building component and a segment of the plastic industry has grown around it. Plastics pipes are now used for cold water supply, waste disposal, chemical pipelines, conduits, etc. The history of the plastics pipe dates back to the development of PVC pipes in Germany in the 1930s. Holland with its corrosive soils, and Italy and Japan, which have little indigenous iron and steel, have used plastics pipes extensively. To-day plastics pipes are used in many countries around the world, some on an experimental basis. From the experience gained so far it is reasonable to conclude that plastics pipes would stand up to long term service under normal conditions of use.

General Characteristics

There are a number of advantages engaged by plastics pipe arising from the basic plastics materials. Plastics pipe is relatively light in weight, which makes for easy handling and installation. It has very smooth inner surface which provides very little resistance to the flow of water. The plastics material does not also corrode or tuberculate significantly Consequently more water will be delivered and the pipe will retain its original flow properties better than conventional metal pipes.

Plastics pipe is more flexible than most other pipes. This property can be used to advantage in handling, and designing for underground installations. The flexibility also allows the pipe to withstand a certain degree of soil movement without failure.

Plastics have a low thermal conductivity which results in less heat loss. Water being transported in plastics pipe therefore remains at a more uniform temperature. Plastics pipe is less liable to freeze-ups in cold weather and even if ice forms, bursts do not occur.

The coefficient of thermal expansion of plastics is much higher than those of other pipe materials. However, the net effect of thermal expansion is not as great because flexibility and elasticity accommodate some of the stresses.

Plastics pipe do not conduct sound as readily as metal pipes. This property can be taken advantage of eliminating noise of sanitary appliances through connecting pipes.

Plastics are combustible. Some will continue to burn once ignited, while others are self-extinguishing. Though organic in nature the basic polymers used in most plastics are not attacked by bacteria and fungi.

Plastics for water supply

There are three types of plastics considered suitable for producing tubing and pipe for potable water supply. They are polyethylene, polyvinyl chloride and acrylonitrite-butadiene-styrene. Only the first two are available in India at present and polyethylene is available in both low and high density grades. This Digest briefly describes the characteristics and application of pipes produced from polyethylene and polyvinyl chloride. Table 1 summarises their properties.

Effect of plastics pipes on water quality

Taste and odour effects of plastics pipes on water are comparable to that of G.I. pipes. No adverse effects have been reported during disinfection of the pipes. Residual chlorine in water has negligible effect on the pipes. However, polyvinyl chloride pipes should not be used for transporting bleaching powder solutions for disinfecting water. Plastics pipes manufactured and tested to Indian Standard Specifications should be free from toxic effects.

*Building Digest No. 51 gives a general introduction to plastics.

Table I

Properties of Plastics Pipes

Property	Unit	Polyethylene		Unplasticized polyvinyl chloride (UPVC)
		Low density (LDPE)	High density (HDPE)	
Specific gravity		0.91-0.93	0.94-0.96	1.35-1.45
Young's Modulus	10^3kg/cm^2	1.3-1.5	8.0-9.1	24.5-31.5
Volume resistivity	Ohm cm	$>17^{14}$	$>10^{16}$	$>10^{14}$
Izod impact strength at 23°C	kg cm/cm	No break	16-27	5-27
Thermal conductivity	kcal/mh°C	0.288	0.434	0.125
Coefficient of thermal expansion	10^{-5} per°C	16-18	12-16	5-6
Softening point	°C	80-100	110-130	75-82
Ultimate tensile strength at 23°C	kg/cm^2	115-170	265-280	445-600
Recommended temperature range for pressure pipes	°C	—40 to+38	—18 to+38	—1 to+49
Recommended temperature range for non-pressure pipes	°C	—40 to+49	—18 to+49	—1 to+60
Flammability		Slow	Slow	Self extinguishing
Weathering characteristics		Fair	Fair	Excellent
Effect of low temperature		Good low temperature properties. Unaffected by large number of freeze-thaw cycles	Same as for low density	Tendency to become brittle at low temperature with possible handling problems. Repeated freezing and thawing reduces working pressure.

Table 1 contd.

Property	Unit	Polyethylene		Unplasticized polyvinyl chloride (UPVC)
		Low density (LDPE)	High density (HDPE)	
Chemical resistance		Good all round chemical resistance. Cannot be solvent welded.	Same as for low density	Good chemical resistance. Easily jointed by solvent welding.
Safe working stress at 20°C	kg/cm²	32	50	100
Rate of fall of recommended working stress per degree rise in temperature above 20°C	per cent of stress at 20°C	3	3	2.0 upto 40°C 3.5 from 40-49°C
Pressure ratings	kg/cm²	2.5,4,6,10	2.5,4,6,10	2.5,4,6,10
Abrasion resistance		Low	Fair	Good
Flexibility		Highly flexible. Pipes can be coiled.	Same as for low density	Relatively rigid. Only small bore pipe may be coiled.
Common jointing methods		Heat welding & by compression fittings	—do—	Solvent welding and by rubber gaskets
Available sizes	mm	6-100	10-500	10-150
Economic advantages		Pipes are available in long lengths of 25 to 200 m requiring few joints in long installations.		Easily solvent welded. Low installed cost.
Applications		Long lengths of unbranched underground water supply lines. Flexible water supply connectors in place of lead connectors in houses and laboratories. Waste pipes for appliances like wash basins and sinks.		Substitute for G. I. pipes in water supply and drainage. In distribution networks of water supply.

Hydraulic characteristics

Extrusion and injection moulding process of manufacturing plastics pipes and fittings respectively ensure smooth bores. For calculation of flow rates according to Hazen-Williams equation, a value of 150 should be used for the constant 'C' against 100 for metal pipes. Approximate values for frictional losses caused by injection moulded fittings are given by the equation:

$$E = F \times D$$

where E is the equivalent pipe length in cm, D is the pipe bore in cm and F is a constant which has the values given in Table 2.

Table 2

Fitting	Value of constant F
90° elbow	21.6
90° sweep bend	10.8
Straight through Tee	10.8
Branch Tee	42.0
Angle value	180.0
Globe value	360.0

These values will be higher when insert type fittings which have a smaller bore than the pipe are used.

Polyethylene pipes.

Polyethylene (PE) is a very stable thermoplastic material, soft enough to be used without any plasticizer. The high density variety is relatively more strong, and rigid and has higher temperature and chemical resistance. Since exposure to sunlight causes degradation in this material, for pipe manufacture, it is compounded with 2-3 per cent carbon black pigment which incidentally also prevents organic growths inside the pipes. Small amounts of a stabilizer is also added to high density polyethylene for processing.

Polyethylene is corrosion resistant to a high degree. The only cold water service application for which polyethylene pipes are not recommended is in soils liable to contamination by coal gas. The precaution is necessary because aromatic constituents of the gas can permeate the pipe and taint the water.

Flexibility combined with high impacts resistance produces a high degree of toughness in PE pipes. The low density variety is somewhat superior in this respect. Both varieties do not become brittle even at temperatures as low as-40°C.

Though PE pipes have a coefficient of linear expansion about twenty times that of metal, normal changes in direction will provide adequate accommodation for thermal movements. But in continuous straight runs suitable expansion loops or joints should be used. The thermoplasticity of PE, while permitting easy bending and heat welding. causes loss of rigidity with rise in temperature. High working temperatures also reduce safe working pressures, necessitate greater support and may even cause deformation of pipe under external load.

Jointing polyethylene pipes

Polyethylene pipe is easily cut with a sharp knife or saw. It is generally jointed by insert type joints or fusion welding. It cannot be solvent welded. Insert type fittings, both of plastics and metals, may be used for jointing PE pipes. In corrosive locations plastics fittings are preferred. In less corrosive conditions gun metal fittings, and in normal or slightly corrosive environments brass fittings can be employed. The outer serrations of these fittings lock into the PE pipe. Hose clips of worm drive type secure the fittings and ensure leak-proof joints.

Fusion or butt welding gives a permanent joint. The ends of the pipe are cut square, champfered on the bore, and heated. Heating may be done by holding the pipe ends about 2-3 cm from a red hot surface, preferably an electrically heated element or sheet metal. Naked flames should be avoided as far as possible. When the pipe ends begin to melt visibly, they are brought together with a slight twisting motion.

For cutting threads on PE pipe ordinary metal cutting die of adjustable and guided variety can be used. As far as possible a full thread must be cut in one operation and it is advisable to plug the end of the pipe during threading. Only the required number of threads for the joint should be cut. When PE pipe is threaded the permissible safe working pressure is reduced and in such cases pipe of the next higher pressure rating should be used.

Flanged joints, joints of aluminium compound fittings with male and female coupling parts and rod welded joints are also feasible with PE pipes.

Polyvinyl chloride pipes

Polyvinyl chloride (PVC) is a hard, rigid thermoplastic material which is compounded with a minimum amount of stabilizers, pigments including about 3 per cent carbon black or titanium dioxide to prevent deterioration by sunlight, and mould lubricants. It is important that the PVC and additives should be of good quality. No plasticizer is used for pipe manufacture. Unplasticized PVC (UPVC) is difficult to extrude and the quality of the pipe is dependent on the quality of the extrusion operation.

PVC is light in weight, unaffected by moisture and does not support combustion (self-extinguishing). Unlike polyethylene it is impermeable to coal gas.

PVC pipe is much less flexible than polyethylene pipes but it can accommodate gradual bends in a pipeline. It is generally supplied in straight factory-cut lengths. The smaller diameter pipes can be coiled.

PVC has relatively low impact strength compared to traditional pipe materials. It also has high notch sensitivity. A high impact grade having better low tempera-

ture properties and greater tensile strength is expected to be manufactured in India in the near future.

PVC has a coefficient of linear expansion considerably less than that of polyethylene but high enough to warrant special precautions. It tends to become brittle at low temperatures and extra care is necessary when it is used in freezing temperatures. UPVC pipe should be protected by burying below frost level, or by any other suitable measure.

Jointing

Solvent welded joints are most commonly used. This technique is used for both spigot and socket type joints as well as for injection moulded fittings. Rubber gaskets are gradually replacing solvent welding and would find wider use in future because of their simplicity and ease of working. Welded joints and screwed joints have only limited application.

Solvent cement for UPVC pipes consists essentially of a vinyl polymer dissolved in a suitable mixture of volatile organic solvents. The solvents soften the mating surfaces which diffuse into one another to form a 'cold weld'.

UPVC pipes can be cut readily with a finetoothed hand-saw. The formation of socket and jointing may be carried out in one step or in two. In the one step method the cold male end is coated with the solvent and forced into the heat-softened female end. Bevelling of the male and female ends on the outer periphery and on the bore respectively is essential. In the two step method a socket is formed at the female end in the first stage by withdrawing the dry male end after cooling. Solvent cement is then applied on the inner surface of the female end and the outer surface of the male end and the joint is made as in the one step method. The remaining cement solvent on the pipe should be wiped off immediately, as continued action of the solvent will weaken the wall of the pipe. The length of the joint should be 1 to 1.5 times the outer diameter of the pipe.

Injection moulded fittings with built in sockets are available for jointing UPVC pipes. Fabricated fittings should be avoided as far as possible.

In rubber gasket joints, generally the gasket is placed in injection moulded couplers. The gasket gets compressed when the pipe is inserted and makes a water tight joint. For water supply and sewage, natural or styrene-butadiene rubber gaskets may be used. Natural rubber is, however, inferior owing to its non-uniform density and susceptibility to bacterial and chemical degradation. Synthetic rubber gaskets perform better in aggressive soils. Gaskets of circular cross section are the simplest but other shapes are possible for specific additional advantages. Joints made with gaskets are however, weak in longitudinal pull.

Bending plastics pipes

Small diameter PE pipes can be bent to a radius 12 times the outer diameter of the pipe without heating and without causing residual stress. UPVC pipes cannot accommodate bends to the same degree. Smaller radius bends may be formed after softening by heating in a hot air oven, or water or glycerol bath. The forming temperature for PE is 100°-110°C and for UPVC 125°-140°C. A soft low pressure gas flame may be used for UPVC, but this operation should be carried out by experienced technicians only. While bending after heat softening plastics pipe should be filled with fine, dry, warm sand to prevent the collapse of the bore and the pipe should be restrained in its new shape until cool. The radius of bend for pipes up to 50 mm size should not be less than three times the nominal bore diameter for low density PE and UPVC pipes and five times for high density PE. Pipes of larger diameter require a larger radius of bend.

Installing plastics pipes

It should always be borne in mind that plastics pipes are less robust than metal pipes. Adequate allowances should be made for expansion and contraction due to fluctuating temperature, and correctly designed and positioned supports should be provided. Continuous support is necessary for PE pipes above 40°C and it must be protected against localised overheating.

In underground installations it is necessary to avoid contact with sharp edges. Underbedding and back-filling should be of uniform, relatively soft, fine grained soils.

Storage and handling

Plastics pipes should be stored in a cool place shaded from direct sunlight. They should be adequately supported during prolonged storage to prevent distortion at high atmospheric temperatures. Contact with burrs or sharp edges should be avoided. The ends of the pipes should be protected from damage to ensure satisfactory jointing.

Precautions

Plastics pipes are not conductors of electricity and should not be used for earthing electrical equipment. The pipes do not take paint well and should not be painted. They should also not be exposed to any heat source. Plastics in general and polyethylene in particular are liable to be damaged by sharp instruments. They should therefore not be exposed in areas where mischief can be expected.

Standards on plastics pipes

Indian Standard Specification 3076-1965 covers low density polyethylene pipes for potable water supplies. Standards for HDPF and UPVC as well as Codes of Practice for plastics pipe work for water supply are under preparation.