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PLASTIC PIPES IN AGRICULTURE[1]

by

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PLASTIC PIPES IN AGRICULTURE

Introduction

In presenting this paper, it is appreciated that perhaps some of the delegates have detailed knowledge of plastic pipes. This paper will then, be confirmation or contradiction of that knowledge, and in some cases, may well provide a stimulus for further discussion. Many delegates will not be knowledgable or aware of their advantages for agricultural purposes. It is hoped that they will also be stimulated to the point of considering plastic pipes for their future needs.

We no longer speak of plastic pipes as opposed to traditional pipes. Plastic pipes already have a tradition of over a quarter of a century. Plastic pipes are being used in ever increasing quantities at growth rates exceeding those of pipes of other materials. The use of plastic pipes in agriculture is not as advanced as we believe necessary and today it is hoped that this paper will provide the stimuli referred to above. It is presented in answer form for easy reference to the following questions:

1.00 What are Plastic Pipes?
2.00 Where are plastic pipes used in agticulture?
3.00 What are their properties?
4.00 What are their disadvantages?
5.00 Why use plastic pipes?
6.00 How are they made?
7.00 What are the costs of plastic pipe manufacture?

1.00 What are Plastic Pipes?

Plastic pipes are pipes manufactured of polymeric materials, having their origin, these days, mostly in the petrochemical industry. Different polymers are used, conferring varying physical properties on the pipes. Basically, two types of plastic are used - Thermoplastics, i.e. PVC and PE, and Duroplastics, i.e. FRP/GRP. The most common types being rigid poly vinyl chloride (PVC), Polyethylene (PE), Acrylo Nitrile Butadiene Styrene (ABS) and Glass Fibre Reinforced Plastics (FRP or GRP). Other plastics used are flexible PVC, Polypropylene, Polybutylene, Polystyrene. Today we will concern ourselves primarily with rigid PVC, Polyethylene and Glass Fibre Reinforced Plastics.

Plastic pipes are manufactured in lengths and diameters according to National and International Standards. The more rigid plastics like rigid PVC and FRP/GRP are cut off in lengths - usually 6 or 10 metres. The more flexible plastics such as polyethylene, in diameters through 160mm, are coiled. Larger diameters are also cut off in lengths.

Diameters of rigid PVC pressure pipes are 6mm through 630mm. PE pipes are manufactured in diameters up to 1600mm. FRP/GRP pipes are made in a larger range of diameters - the most common size range is 50mm through 3000mm.

2.00 Where are plastic pipes used in Agriculture

The major applications are:

Water supply - bore hole liners, supply and distribution pipelines

Irrigation - supply and distribution lines

Drainage - perforated corrugated thin-walled pipe

Culverting - corrugated thin-walled pipe

Agricultural dwellings - household plumbing, drainage, sewerage

2.01 Bore Hole Liners in GRP or PVC including plastic filter screen, have already proved their value in many countries of the world. Primarily, low cost and durability (corrosion resistance) have been major factors in deciding on plastics.

2.02 Supply and distribution lines for potable water supply and irrigation This is one of the oldest and most justifiable use of plastics. All properties of plastics versus other materials come to advantage. Justification has also been found for replacing open ditch water supply with pumped or gravity mains made of plastics. In hot, dry climates, where there is high evaporation, savings in water alone pay a large proportion of the cost difference. The prevention of salts concentration and contamination in the water makes for better quality water, not only for potable use, but also for agriculture. The flexibility, ease of jointing and installation make the use of plastic pipes almost mandatory for small diameter irrigation distribution lines.

2.03 Drainage Of recent years, plastic pipes have taken over from the once traditional ceramic (clay) or concrete tiles. Plastic pipe has demonstrated clearly, not only lower laid cost, but also lower maintenance costs. Plastic properties plus the design of the drain pipes make them more durable and at the same time, enable alternative methods of installation, such as mole ploughing. This latter method of laying is virtually the only practical way of laying drain pipes in water-logged or boggy soils.

2.04 Culverting Large diameter corrugated PVC tube can replace galvanised steel culverting for culverts under farm roads, railway embankments. It can also be used as a low cost collector main for large drainage schemes.

2.05 Agricultural Dwellings The use of plastic pipes for domestic plumbing and services is well established internationally. It goes without saying, therefore, that agricultural dwellings should be equipped in a similar manner to housing in other sections of the community.

2.06 There have been many large-scale projects involving the use of plastic pipes in agriculture and the following is a more recent example:

Rumania - irrigation The Sadova- Corabia irrigation system in Rumania, completed in 1974, has proven PVC pipes able to play a large part in the development of some 80,000 hectares of land there. 15,000 tonnes of rigid PVC pressure pipe (approximately 1,200 Km) in a range of diameters up to 380mm were supplied from Great Britain for this project in the Danube Valley.

Alternative materials were considered for this piping system, and finally PVC pipes were chosen, not only as a result of their cost advantage, but because their corrosion resistance would combat chemical attack by the fertilisers applied to the sandy soil leaking through to the exterior of the pipework. For this particular project, it is also envisaged that certain fertilisers will be added to the irrigation waters and pumped through the plastic pipes. Naturally, here the corrosion resistance properties of PVC will be advantageous.

In addition, the Rumanian Authorities saw great advantage in the integral pipe jointing used, which simplified the installation, enabling the use of semi-skilled workmen.

3.00 What are their properties?

3.01 Plastic pipes are corrosion-resistant - a high degree of chemical resistance is obtained with most plastic materials used for pipes - some plastics are more resistant than others. The pipes discussed today, such as PVC, PE and FRP/GRP, are resistant to all chemical conditions normally found in soils.

3.02 The low specific gravity of polymeric materials makes plastic pipes light in weight - approximately one-quarter the weight of cast iron.

3.03 Plastic pipes are easy to joint. Small diameter PVC pipes (below 50mm) are usually cemented together. Larger sizes are mechanically jointed by means of an integral rubber ring joint, a rubber ring coupler or metallic (sometimes plastic) mechanical fittings. PE pipes are jointed by welding or mechanical fittings. FRP/GRP are either cemented together (generally small diameters) or connected by a rubber ring joint integral with the pipe, or as a separate coupler.

3.04 Plastic pipes have varying degrees of flexibility. Certainly they are more flexible than their counterparts in iron, steel, asbestos cement or concrete. Some plastic pipes, such as polyethylene, can be coiled into coils in varying lengths according to diameter and practicability of handling.

3.05 Plastic pipes are relatively low cost, dependent upon the dimaeter and comparative competitive material. Cost savings are obtained not only in the basic pipe price, but also in the finished pipe installation. Installation costs of pipelines in general are often as high as 75% of the total cost of contract. Savings of up to 10% of these costs have been obtained by using plastic pipes rather than pipes of other materials. In larger diameter pipelines, these savings can offset the higher initial cost of plastic pipe (viz. Table 1).

TABLE 1

Costs of various pipes - Europe - Mid-1974 (US $ per metre)

	PVC	PE	GRP	A/C	Grey C1.1 CI	Ductile Iron	Steel
25mm	0.3	0.58	-	-	-	-	1.25?
80mm	1.63	3.98	15.19	2.66	3.55	4.13	4.22
160mm	5.04	12.50	19.22	5.04	6.24	6.72	11.50
315mm	16.10	35.01	45.65	13.82	14.93	17.88	18.26
600mm	56.83	102.35	102.60	43.20	-	46.84	114.86 (9.0mm wall thickness)

Note

The following factors have been used in the above cost table:

1. Nearest equivalent metric size
2. Nearest equivalent pipe with working pressure rating of 10 atmospheres
3. Asbestos cement cost includes bitumen dipping
4. All pipe prices include joints, except 600mm steel

4.00 What are their possible disadvantages?

There aren't any that cannot be overcome by the application of correct procedures and common sense!

4.01 UV Degradation

Some plastic materials suffer a deterioration in their properties as a result of continuous exposure to bright sunlight. The deterioration is very slow and in thick walled plastic pipe has very small effect. However, pipes are mainly used buried in the ground, and this is where they should be laid as soon as is possible. For open air storage, a light cover of opaque material is all that is required to protect the pipes from any UV degradation at all. Pipes like black polyethylene are even guaranteed by the manufacturers for use in above-soil installations for two years and even white coloured PVC pipes have been used in above-ground European conditions for many years without problems.

4.02 Impact Resistance

Some plastic pipes, such as rigid PVC or even FRP/GRP, will suffer damage if subjected to heavy blows with sharp appliances. A pane of glass will also break if subjected to a sharp blow, but many millions of these have been installed througnout the world without breakage, and of course, the same is true about plastic pipes. Just a little more care is needed in handling a plastic pipe than, say, a galvanised steel pipe. Pipes made of other materials than plastics are in some cases fragile when compared to plastic, but these pipes have also been laid successfully for years.

4.03 Temperature Resistance

The properties of plastic materials, particularly thermoplastics are influenced by temperature. Due care must be paid to manufacturers' instructions in respect of operating temperature range. For normal agricultural purposes all plastic pipes have sufficient temperature resistance to carry out their normal function of transporting liquids.

It must be remembered, however, that if plastic pipes are left on the surface, not in service but filled with water, high ambient temperatures will eventually cause the liquid in the pipes to reach temperatures which could soften the pipe and cause damage.

Equally, the storage of plastic pipes out of doors must be carried out in such a manner so that, in conditions of high ambient temperature, pipes are not stacked in a manner to cause high loads on individual pipes, other wise deformation will take place.

4.04 Deformation

The rigidity of plastic materials is generally not as high as for other pipe materials such as cast iron or concrete. Plastic pipes when laid in the gorund do sometimes deform due to static or transient loads. Such flexibility is designed in the pipe, and as long as manufacturer's installation recommendations are taken into account, then this will present no difficulty and, in fact, is an advantage in that such flexibility can take up excess stresses which occur from time to time. It has been reported that in areas subject to earthquake or ground movement, quite often the only pipes left intact after being subjected to stresses, are plastic pipes, because of their flexible nature, other more brittle pipes have broken and become unserviceable.

4.05 Termite Attack

The question of termite attack on plastic pipe is often raised and, as due to the relatively soft nature of plastics materials, it could well be believed that these would not be resistant to termites. In 1972 the Building & Road Research Institute of Ghana carried out a test and exposed plastic pipes to a concentrated termite attack for a period of approximately 28 months. At the end of this period, only minutely small areas of nibbling had occurred to a maximum depth of 0.2mm. It is believed that this can be regarded as negligible attack.

5.00 Why use plastic pipes?

Cost

At the outset, it is only fair to state that the technical/economic competitiveness of plastic pipes against pipes made of other materials has lost ground lately, as a result of the world plastics raw material shortages and resultant price increases. The effect of the higher raw materials costs has been to reduce the size range over which plastic pipes are cheaper than their competitors (not counting the lower installation costs). However, cost comparisons of PVC or PE pipe, say against galvanised steel, still show strongly in favour of PVC and PE.

The costs of plastic pipe always need to be considered in the context of the installation, where, as well as comparing the relative installation costs, the freight and duties applicable to the pipe are taken into account.

5.01 Properties

Corrosion resistance, flexibility, ease of jointing and installation and lightness in weight, for obvious reasons, all strongly favour plastic rather than pipes of other materials.

5.02 Availability

Notwithstanding the world plastics raw material shortage, plastic pipes are freely available and delivery times are nowhere near those of iron and steel, for instance.

5.03 Ease of manufacture

The technology for manufacture of plastic pipes, whilst highly sophisticated, is relatively easy to acquire via technology transfer, and the overall capital costs for the manufacture of a standard range of pipes is lower than that for other pipe materials. It is possible to have very small manufacturing units which are transpotable, leaving only the raw materials for bulk transportation. Any country wanting to establish a plastic pipes manufacturing operation would, therefore, find this much easier than, say, a steel rolling mill or an asbestos cement pipe factory.

6.00 How are they made?

6.01 Thermoplastic pipes are made by a continuous process of extrusion wherein the compounded plastic raw materials containing the basic polymers, colourants and processing additives are fed into a heated metal barrel in which a metal screw (or several screws) rotates. The design of this screw/barrel combination plus heat converts the plastic compound into a fused molten (and plastic) mass which is pressurised by the screw and forced through a tubular forming die.

As the molten extrudate exits the die, it is immediately cooled in a sizing die and further cooled in a water bath until its cylindrical form is stable. The plastic pipe is then cut off to the desired length and the pipe is ready for immediate use. It requires no curing or additional processes.

6.02 Duroplastic pipes, FRP/GRP, are made by either the batch process or continuously.

The continuous process necessitates the use of a continuously moving mandrel on which the fibre glass reinforcements impregnated with duroplastic resin are wound. The mandrel is designed in such a manner that it withdraws from the FRP tube and re-assembles itself at the front of the new line - all automatically. The other continuous process utilises a stationary solid mandrel or a support pipe (usually of thermoplastic) on which the fibre glass reinforcements and resins are applied. The resultant pipe exits the machine continuously.

The batch method of manufacture is more common and has a longer history. A steel mandrel of either a slightly tapered form or of one which can be collapsed and withdrawn from the manufactured tube, is used on which to wind the fibre reinforcements and the appropriate resin. After curing, the mandrel is extracted from the pipe. Such pipes are generally manufactured is maximum lengths of 10 metres.

Using either method, FRP/GRP pipes can be manufactured to different design of pressure resistance or stiffness by modification of the winding angle of the filaments and the number of layers of reinforcement.

7.00 What are the costs of plastic pipe manufacture?

The comparative costs for setting up and operating representative plants of 1,000 tonnes or 10,000 tonnes annual output of PVC pipe would be in the region of:

7.01

CAPITAL COSTS ($ x 1000)	1,000 tonne	10,000 tonne
Buildings & services (1250/3500m^2)	30	178
Process machinery	200	1624
Laboratory & test equipment	54	81
Other equipment	81	135
	365	2018
Preliminary expenses	54	225
Initial working capital	313	2759
TOTAL INVESTMENT	732	5002

7.02

OPERATING COSTS ($ x 1000)	1,000 tonne	10,000 tonne
Materials	924	9240
Wages & salaries (16/32 persons)	82	163
Energy	72	576
Manufacturing overheads	90	609
Depreciation	84	449
MANUFACTURING COSTS	1252	11037
Distribution expenses	78	552
Interest on investment	110	421
TOTAL ANNUAL COST	1440	12010

NOTES:

Raw material costs have been taken at (even for present day conditions) an optimum and to include freight, etc. Present US price for PVC pipe compound is approximately $537 per tonne, whereas two years ago, they were only $200-300 per tonne.

As well as variation in raw materials costs, figures for individual countries might differ considerably, due to local variations in wage rates, price levels and in delivery costs on imported plant and equipment.

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