Plastic pipes and their application in buildings

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Summary

Plastic pipes are suitable for water supply in buildings provided right type of material is used in a right manner. They are considerably economical than G.I. pipes. Termites and Rodants do not pose any serious threat. Use of plastic pipes can help building industry reduce its dependence on conventional materials and help country save foreign exchange.

Plastic pipes have been used for building applications in a number of countries such as Japan, Holland, France, Italy, Germany, U.K. and U.S.A. Main reasons responsible for the use of plastic pipes in building applications have been corrosive nature of soil and scarcity of steel etc. In India, we often face shortage of Zinc and other non-ferrous metals and even of steel which causes delay in many housing projects. Use of conventional materials such as G.I. pipes is at the cost of foreign exchange component involved in the import of non-ferrous metals. Pilferage of metal parts, having resale value, is another drawback of conventional materials. Use of Plastic pipes will help solve these problems and save country foreign exchange to an appreciable extent.

A beginning in the use of rigid PVC pipe for potable water supply was made in 1962 when a gift of these pipes was received from Holland. The use of indigenously produced PVC pipes started in 1967 and since then plastic pipes have been used at a number of places in the country. But these uses are of small nature and large scale use is yet to take place. The major drawback has been the lack of availability of performance data and fear for using new materials. Presently around 4000 tonnes of PVC are converted into pipes and fittings and this figure is estimated to rise five to seven times in the coming years.

In this paper we want to report our experience on plastic pipes for water supply in building application based on a few installations carried out at this Institute. The discussions include such aspects as availability of plastic pipes and fittings, cost comparison with conventional piping systems, strength of joints and termite and rodant resistance. A brief outline emphasizing future work needed on plastic pipes and use of plastics in other plumbing applications has also been given.

We will first of all review briefly various types of plastic materials which have been used for piping systems in different applications. Plastic pipes are being produced in a large number of different plastic materials offering between them a wide range of characteristics. Although polythlene (PE) and polyvinyl chloride (PVC) account for the bulk of currently produced plastic pipes, the spectrum of available pipes also include polypropylane (PP), acrylonitrile butadiene styrene (ABS), glass reinforced polyester (RP) and epoxides with or without PVC liners and recently acetal. There are also some newer engineering plastics such as polyphenylene oxide, polyvinyldichloride, and poly sulphone which could also offer serious competition to stainless steel pipe. Various applications in which plastic pipes have entered are water supply and irrigation ; drain waste and vent ; sewer and drainage ; chemical processing oil and gas production and distribution and conduits. Plastic mostly used for a particular application have been arranged in descending order of their consumption in table I. Production figures in 1970 in USA is also listed. In India, since at present only PE and PVC pipes are commercially produced, subject matter in this paper is limited to only these two categories.

Field trials

In the present study water distribution system in two types of plastics namely high density polythene (HDPE) and unplasticized PVC were installed in two residential quarters and a few other places in the laboratory. The properties of these pipes compared to conventional piping materials such as GI, CI and AC are shown in table II. The pipes were guaranteed by the supplier to pass relevant IS specifications (1, 2) and were checked for such tests as short term hydraulic characteristics and reversion tests and were found to be satisfactory. We used 10 kg/cm² PVC and HDPE pipes in our installations.

HDPE piping system

These pipes are available in coils and are flexible in nature. The most common types of jointing for use with this system are threaded joint, insert joint and welded joint. Welding requires a special skill, and the threaded jointing can be easily done by an ordinary plumber. In case of insert joint the pipe is slipped over fitting and clamped with the help of iron clamps which generally cut the pipe surface slowly and make the joint weak. Table 3 shows strength of three types of joints of HDPE as prepared by an ordinary plumber in the lab. In our installation work we adopted threaded joints. The major precautions required for installation of HDPE system are :—

1. The threading shall be done with lightweight dye and threads should be as per standard GI pipes.
2. HDPE fittings having proper threading shall be used and be hand tight. Wrench shall not be used.
3. Since HDPE pipe is flexible, proper clamps shall be fixed at closer intervals near bends etc.
4. The projection shall be kept minimum. In this work maximum projection was kept, upto 10 cm. Projection in HDPE pipe should preferably be avoided due to flexible nature of pipe.

PVC piping system

The common types of joints employed in PVC piping system are cement solvent joint, threaded joints and welded joints. The threaded joints can be used with standard GI and PVC fittings. Laboratory tests show that threaded joints of PVC and GI made by cutting threads at pipe end with a die are weak and fail at low pressure (table 3). This is mainly because of less wall thickness of pipe which does not permit proper threading depth. Threaded joints were therefore discarded in the present installation. The cement solvent joint is easy to make. One end of pipe is heated and a socket is formed by inserting pipe. After cooling, the two joining ends are separated and cement solvent applied uniformly over pipe surface and inner surface of socket. Then pipe is pushed inside the socket. Extra solvent over pipe surface is wiped off. This joint is very strong and attains its maximum strength almost instantaneously (table 3). The welded joint requires skilled workmanship and is done with hot air torch. The pipe ends are cut at an angle and hot air is blown over welding rod which are available in different diameters for different size of pipes. Since these joints require controlled supervision are suited for factory use only. However, in the present supply of piping and fittings a few factory made welded joints were found to be very weak and some were broken even during transport.

The major precautions required for PVC installation are :

1. Standard PVC fittings should only be used and material before use should thoroughly be checked for any pin holes, grooves or any other manufacturing defects.

2. All joints should be made very carefully and with cement solvent only by a plumber who has some experience of working with these materials.

3. Special care should be taken while connecting PVC with G.I. Either araldite (table 3) joint or standard injection moulded fittings should be used.

4. Plastic pipes (PVC & HDPE) should not preferably be used in exposed conditions open to sun rays etc. till their performance and life in these conditions become known.

5. It should be borne in mind that plastic pipes are not as rigid as steel and they should be handled carefully i.e. minimum load during the use should be transferred to them.

Cost comparison with GI pipes

Material costs of HDPE and PVC pipes and fittings compared to GI used in the installation carried out in this work are reported in table 4. It can be seen that there is a saving in material cost of well over 50 per cent in both the cases compared to GI pipes and fittings. Others (3, 4) have also found savings of the same order in use of pl. pipes over that of GI systems. Labour cost for PVC HDPE systems was found to be comparable with GI systems in the present installation. However, some economy may be achieved in larger installations.

Table I

Application of Plastic pipes

Applications	Materials (In descending order of consumption)	Consumption in USA in 1970 (Thousand tonnes)
Water supply and irrigation ...	PVC, PE, *other RP*	126
Drain, waste & Vent	ABS, PVC	34
Sewer & Drainage	PVC, ABS	33
Chemical Processing	PVC, RP, *PE, other*	8
Oil and gas production	PVC, RP, *PE, other*	7
Gas distribution	PE, PVC	12
Electrical and telephone conduit ...	PVC, ABS, PE	33
Miscellaneous*	PVC, PE, *ABS, other RP*	64

Other — includes PP, Nylon, acetal, butyrate etc.
* — Mostly fittings.
Note — Under-lining means that their consumption is much less than 50% of the maximum used.

Table II

S.No.	Characteristics	Plastics pipes			Conventional Pipes	
		LDPE	HDPE	PVC	CI/GI	AC
1.	Specific gravity	0.91—0.93	0.94-0.96	1.35—1.45	7.2—7.8	2—2.8
2.	Tensile strength Kg/cm²	115—170	265—280	445—600	1400—4000	100—400
3.	Young's Modulus X 10³ Kg/cm²	1.3—1.5	8.0—9.1	24—31	2100	—
4.	Thermal conductivity K Cal/m hr. C.	0.288	0.434	0.125	70	0.24
5.	Coefficient of Thermal expansion 10^{-2} per C	16—18	12—16	5—6	1.0 to 1.2	—
6.	Flexibility	Highly flexible, pipe can be coiled	Less flexible than low density	Relatively rigid	rigid	rigid
7.	Available sizes (mm)	12 to 140	10 to 400	16 to 315	50—315 CI 16—100 GI	50—315
8.	Common jointing methods	Insert type Joints and Compression fittings	Compression fittings fusion welding threaded joint	Solvent welded joints, welded joints, threaded joints	Threaded for GI Lead joint and cement joint for CI	Cement joint
9.	Applications	Irrigation, water distribution etc.	Water distribution etc.	Water distribution sewerage. Rain water pipes etc.	Water distribution CI for sewerage etc.	Water main, rain water pipes, sewerage etc.
10.	Effect of low temperature	Good low temp. properties unaffected by large No. of freeze thaw cycle	Same as for low density	Tendency to become brittle at low temp. with possible handling problem. Repeated freezing & thawing reduces working pressure	Likely to burst at freezing temp.	Likely to burst at freezing temp.
11.	Dependence of working stress at temp.	Yes	Yes	Yes	Negligible	Negligible

Tremite resistance

Susceptibility to termite attack is a serious problem to be considered. There are many instances of plastics being destroyed by termite (5, 6). Polyethylene and PVC have been reported in the literature to be liable to attack by termites. However, it may be argued that rigid PVC pipe containing no plasticizer should be termite resistance. But this alone does not satisfy the user and some experimental data is required. In the present study, low density and high density polyethylene and PVC pipes were subjected to termite exposure in the field as well as in the laboratory. Pipe samples were buried in soil in heavily termite infested area and termite mounds in the field (fig. 1). After three years of exposure the samples were found to be completely unaffected by termites.

Pipe samples were also exposed to termite colonies in the laboratory. The termite chosen for the study was micro cerotermes beesoni, a virulent type of termite and widely found in India. A feeder strip was tied with the sample and termite colonies were maintained (7). When feeder strip was finished termites would starve and attack the sample. It was found that termites had made a number of nibbling marks on LDPE (Fig. 2) (low density polythylene pipe) and also a hole at one place (fig. 3) in one of the samples. In HDPE nibbling marks were few and there was no puncture (fig. 4). Whereas in case of PVC no damage of any kind was seen (fig. 5). If termites were able to consume plastic material, perhaps no pipe sample could have been left at the end of test. It could therefore be concluded that plastic pipes (HDPE and PVC) under study offered no nutrition value to termites and extent of attack is dependent on the hardness of material.

Table III

Material		Type of Joints	Details of Preparation	Pressure at which fails Kg/cm^2
HDPE	1	*Threaded joints* HDPE/HDPE	HDPE threaded socket factory made, pipe threaded with light weight die	29
		HDPE/GI	GI Socket, HDPE pipe threaded with die	10
	2	*Fusion Welding* HDPE/HDPE	Fusion welding with the help of a flame	21
	3	*Insert type joint* HDPE/HDPE	HDPE fitting inserting in pipe end and clamping	8
PVC	1	*Solvent cement joints* PVC/PVC	Joint made by preparing socket and spigot by heat application at pipe ends to be joined by solvent cement. Tested after 24 hrs.	66
			—do— tested after 2 hrs.	62
			—do— tested after fifteen minutes	50
			—do— tested immediately	55
			Injection moulded socket and pipe end tested after 24 hrs.	62
	2	*Threaded Joints* PVC/GI	PVC pipe end threaded on lathe machine, metal socket	8
		PVC/GI	Araldite Joint	62
	2	*Fusion welded joints* PVC/PVC	Factory made fitting	29

Rodant resistance

Doubts are often expressed regarding stability of these pipes against rodants. National Sanitation Foundation of USA found plastic pipes to be susceptible to rodant attack in a report published by them. In the present work samples were exposed to three species of rodants viz. R. rattus, R. norvegicus and B. bengalensis. It was found that none of these species of rodants was observed to eat plastic pipes in any form either crushed pieces or powdered form (table V).

These pipes could be damaged to some extent by gnawing habits of these rodants particularly the field rat. However, there is no danger of serious damage due to R. rattus or R. norvegicus as can be seen from table VI and VII.

Table IV

*Material cost comparison of PVC & HDPE pipes and fittings with GI**

Sl. No.	Material	PVC Quantity	PVC Rate	PVC Amount	GI Rate	GI Amount	HDPE Quantity	HDPE Rate	HDPE Amount	Amount
1.	20 mm pipe	10 M	2.10	21.0	5.50	55.00	14 M	1.60	22.40	77.00
	—do— Tee	5 Nos.	0.55	2.75	1.05	5.25	1 No	1.00	1.00	1.05
	—do— Elbow	5 Nos.	0.55	2.75	1.05	5.25	5 Nos.	0.75	3.75	5.25
	—do— Bends	2 Nos.	0.55	1.10	0.85	1.70	—	—	—	—
	—do— Sockets	5 Nos.	0.35	1.75	0.67	3.35	3 Nos.	0.60	1.80	2.01
2.	25 mm pipe	14 M	2.75	38.50	5.75	80.50	14 M	2.50	35.00	80.50
	—do— Bends	1 No.	0.75	0.75	1.10	1.10	—	—	—	—
	—do— Elbow	1 No.	0.75	0.75	1.35	1.35	7 Nos.	1.10	7.70	9.45
	—do— Tee	—	—	—	—	—	2 Nos.	1.40	2.80	2.70
3.	32 mm pipe	6 M	4.00	24.00	9.00	54.00	2 M	4.25	8.50	18.00
	—do— Tee	3 Nos.	1.88	5.64	2.50	7.50	1 No.	2.50	2.50	2.50
	—do— Elbow	3 Nos.	1.25	3.75	2.50	7.50	—	—	—	—
4.	Polythene taps	5 Nos.	3.00	15.00	5.50	27.50	5 Nos.	3.00	15.00	27.50
	—do— Stopcocks	1 No.	4.00	4.00	7.00	7.00	2 Nos.	4.00	8.00	14.00
	Total ...			121.74		257.00			108.45	239.96

*Rates as per CBRI stores, Jan., 1973.

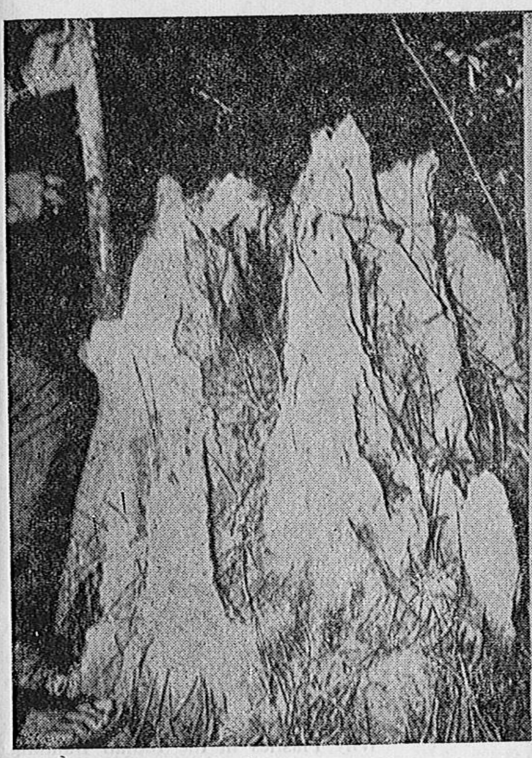

Fig. 1.

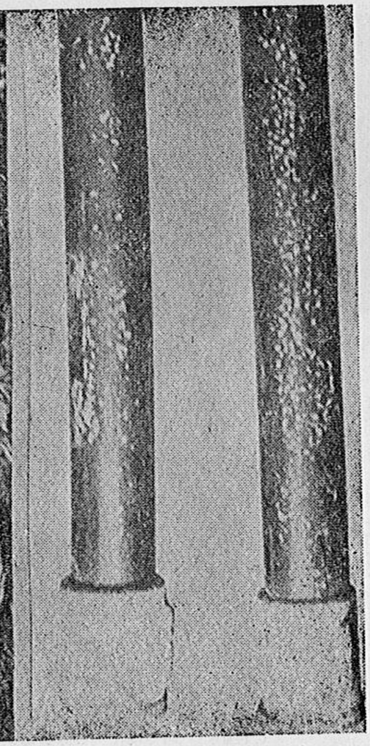

Fig. 2.

Table V

Evaluation of Nutritive value of Pl. pipes for rodants

Sp. of rats offered	No. of rats	Period of exposure	Amount eaten	Remarks
R. rattus ...	5	3 days	Nil	60% mortality due to starvation.
R. norvegicus ...	5	—do—	Nil	40% mortality due to starvation.
B. bengalensis ...	5	—do—	Nil	40% mortality due to starvation.

Table VI

Evaluation of damage by Rodants (Group of 5 rats)

Sp. or rats	Period of exposure	Extent of Gnawing in cms (Average)	Damage eaten/ destroyed	Remarks
R. Rattus	30 days	3.5 cm	Nil	No damage
R. Norvegicus	30 days	3.5 cm	Nil	No damage
B. Bengalensis	30 days	7.5 cm	destroyed	Can damage

Two types of experiments were conducted. In one case (table VI) pipes were erected in an experimental room and a batch of 5 rodants with freely littered food for one week were released to observe the damage. In the second type of experiment (table VII), 6" of pipe pieces were offered to individual rats and the damage caused is measured quantitatively.

B. bengalensis species of rodant is known as field rat and is distributed all over India but this forms only about 1% of the total rodant infestation in majority of towns and rural areas. Species R. rattus can climb up the pipe and smoothness of the plastic material apparently has no effect on the climbing capacity of this species.

It may be concluded from this study that Plastic pipes are suitable for use in buildings as the extent of danger from rat is negligible. However, effect of long term use on resistance of pipes to rodants needs further assessment in the use conditions.

Conclusions

Based on the experience gained in this work it could be recommended that plastic pipes are suitable for use in building applications. They are considerably economical and possess certain other advantages compared to conventional metal pipes. It is high time to use more and more plastic pipes to save metals and precious foreign exchange for some more useful purpose. However, only standard material such as passing IS Specifications should be used. Plumber employed for the installation work should have some preknowledge of working with plastic pipes. Termites and Rodants do not pose any serious danger to plastic pipes.

There is a need to publish actual use performance data to create confidence in the user. Manufacturers should produce and market only good quality materials otherwise it will not harm their interest

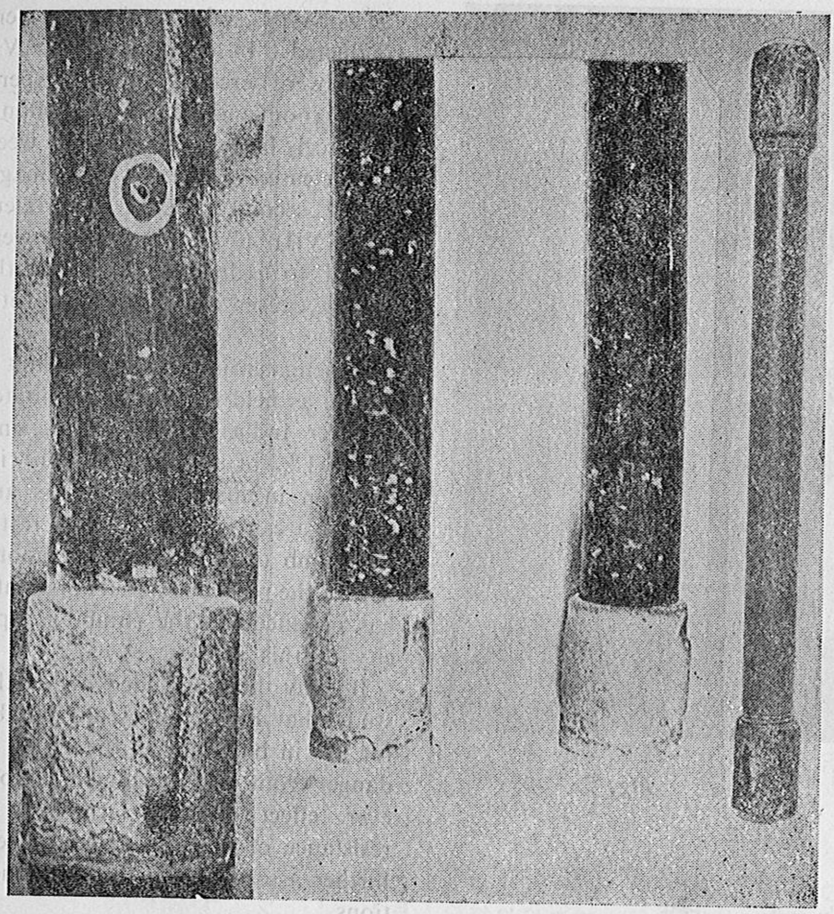

Fig. 3. *Fig. 4.* *Fig. 5.*

but also bring bad name to plastics. Injection moulded fittings of standard sizes should be readily available to the user which is, however, not the case at present. The systems installed in the present case are working satisfactorily for more than a year.

Future outlook

Performance of plastic pipes in the exposed condition should be evaluated as a considerable portion of plastic pipe is used exposed in many Indian houses.

Plastics could also be used in other plumbing applications such as overhead water storage tanks in HDPE, drainage and sewerage pipes etc. Some beginning has already been made in these directions. Compared to stonewave pipes, PVC pipes could be used economically and with added advantage in sewerage applications. This Institute is evaluating some of these applications in detail.

Acknowledgement

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Table VII

Evaluation of damage by Rodants (Individual rat)

Sp. of rats	Period of exposure	Extent of Gnawing in cms. (average)	Damage eaten/ destroyed	Remarks
R. Rattus	30 days	2.5	Nil	No damage
R. Norvegicus	30 days	3.0	Nil	No damage
B. Bengalensis	30 days	6.0	destroyed	Can damage