Biological Forum – An International Journal 14(4): 267-270(2022)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Low Cost Plastic Materials for Construction of Flow Measuring Structures

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(Received 07 August 2022, Accepted 29 September, 2022)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The efficiency of irrigation projects depends on effective flow control and regulation and it require proper measurement and quantification. Low-cost, low-density and environmentally resistant materials with minimal maintenance and long service life are the prerequisite for any flow measurement structures/devices. In this study various properties of the different plastic materials were studied. From the study it is observed that many physical, chemical and other properties are favorable for poly prophelyne plastic materials. It is also mentioned that poly propylene is cost effective in comparison to other plastic materials. Based on this study, it is concluded that, Poly prophelyne can effectively used for construction and fabrication of flow measuring devices.

Keywords: Polymers, Plastic Materials, properties, flow measuring devices.

INTRODUCTION

Any irrigation systems ability to function successfully depends on effective management and precise measurement of the rate and volume of water application. Flow control units are tools for irrigation that gauge and manage the water flow to fields by supplying a determined volume of water flowing at a steady pace upstream or downstream variations in water level within a defined range. Flow measurement and control units can be movable, fixed, or permanent structures. To save the expense of construction several stationary structures, it is desirable to use small discharge, portable control units for a large number of small farm holdings. To get the desired amount of water, the farmer can set the constant discharge control unit at the turnout point for a defined amount of time (Mishra *et al*., 1990).

It can be challenging to choose the right instrument to measure water flow because of a number of issues. This includes cost, durability, ease of working etc. The materials required to build the gadget are frequently less expensive than the cost of installation. The device's flow range must also be taken into consideration. High flow conditions make it difficult for equipment like submerged orifices, small throated flumes, and sharp-crested weirs to function properly. When selecting a water flow monitoring instrument, head loss is another factor to take into account. Compared to broad-crested weirs or acoustic flow metres, sharp-crested weirs typically require higher head loss. Sharp-crested weirs can measure significantly lower flows and are less expensive. These devices frequently need field calibration because of slight variations in installation techniques that lead to misreading. The mild steel and galvanized iron materials are most commonly using for flow measurement and control. However due to rusting and corrosion of GI and MS materials, these structures are damaging within few years after construction. However there is a need for selecting the alternate materials for flow control and regulation systems.

Polymers are the basis for numerous synthetic and organic materials, such as plastics, rubber, thermoplastic elastomers, adhesives, foams, paints, and sealants. In recent years the use of polymers and plastics has been expanded in several applications. Polymers offer a plethora of uses due to their low cost, high specificity, and versatility (Singh, 2020). Products made with plastics are frequently thin, tough, strong, and flexible, low cost and easy to handle and construct. Keeping these considerations in view, the present study was conducted to test the various properties of most commonly available plastic materials for construction of flow measuring devices and structures.

MATERIALS AND METHODS

To construct flow measuring structures with commonly available plastic materials such as fiber reinforced plastics (FRP), Poly Vinyl Chloride (PVC), Poly Prophelyne (PP) and High density poly ethylene (HDPE) (Fig. 1.) in command areas are need to test the physical, mechanical and other properties of these materials. The selection of suitable plastic materials is based on their properties and cost. The ASTM tests were taken **(**Sutar *et al.,* 2019; Wei *et al.,* 2019). The test procedures are mentioned below.

Physical properties of material

Density and Specific Gravity. There are two fundamental test protocols to measure density of materials. They are Method A and Method B. Method A can be applied to moulded, sheet, rod, and tube products. In this study method A was used. For Method A, a sinker and wire were used to hold the sample entirely to weight the sample when it is submerged in distilled water at 23°C and in the air to compute density and specific gravity.

Specific gravity = a/ [(a + w)-b]

a = mass of specimen in air.

b = mass of specimen and sinker (if used) in water.

W = mass of totally immersed sinker if used and partially immersed wire.

Density, kg/m^3 = (specific gravity) × (997.6).

Water Absorption. The water absorption was tested by the established standard procedure. The specimens are dried in an oven at a specific temperature and duration for the water absorption test. Then they are put in a desiccators to cool. The specimens were weighed as soon as they have cooled. The substance is subsequently submerged in water at the predetermined temperature typically at 23°C for 24 hours or until equilibrium. After being taken out specimens are weighed after being dried with a lint-free cloth. Water absorption is expressed as increase in weight percent.

Percent Water Absorption = [(Wet weight - Dry weight)/ Dry weight] × 100

Mechanical properties

Tensile Testing. Tensile tests calculate the amount of stretch or elongation that a plastic sample specimen must undergo to reach its breaking point. At a certain grip separation specimens were loaded into the universal tester's grips and pulled till failure.

Flexural Properties Testing. The force necessary to bend a beam under three-point loading circumstances was measured by the flexural test. In accordance with ASTM D790 the test is terminated when the specimen deflects by 5% or fractures before 5%. When the specimen breaks the test was terminated according to ISO 178

Compression Properties. When a material is subjected to a compressive load its behavior is described by its compressive properties. The rate of loading is relatively slow and consistent. Two typical results of the test are the compressive strength and modulus. The specimen is positioned between parallel compressive plates. The material is thereafter crushed steadily. Stress-strain information is recorded simultaneously with the maximum load. To calculate modulus an extensometer attached to the fixture's front is employed. Specimens can be either cylinders or blocks. The standard blocks for ASTM are 12.7 × 12.7 × 25.4mm (12 by 12 by 1 in) and cylinders have a diameter of 12.7mm (12 in) and a length of 25.4mm (1 in).

Compressive strength = maximum compressive load/ minimum cross-sectional area

Compressive modulus = change in stress/ change in strain

Other properties. Cost comparison of different available plastic materials like FRP, HDPE, PVC and PP was compared based on market price. The other properties like ease of working, weather resistance and suitable for mechanical joints were observed.

RESULTS AND DISCUSSION

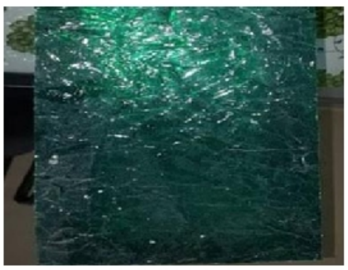
Properties of Plastic materials. In the present study different plastic materials such as FRP, HDPE, PVC and PP were tested for constructing flow measuring structures. The properties of such materials are tensile strength, flexural strength and other properties are presented in Table 1 results are similar to (Bazli *et al.*, 2020; Berardi *et al.,* 2015; Bhat *et al.*, 2019; Gulsoy *et al.*, 2006, Hyie *et al.*, 2017; Khan *et al.*, 2015; Nikmatin *et al.*, 2017; Reddy *et al.*, 2017; Shah *et al.*, 2015).

From the table it is observed that many physical, chemical and other properties are favorable for poly prophelyne plastic materials. Poly prophelyne can effectively used for construction and fabrication of flow measuring devices. Due to its inherent qualities including low density and light weight polypropylene (PP) is used in a variety of applications (Costa *et al*., 2010). Polypropylene's structure lends a good tensile strength around 4,800 psi. It indicated that it can withstand high amounts of pressure or loads, even though the material itself is lightweight, flexibility and less water absorption and similar results were also reported by Anthony *et al*. (2009).

Cost comparison. Comparison of costs of different engineering polymer materials which are available in market are shown in Table 2 from this PP (110) cost was less among PVC (115), HDPE (250) and FRP (375) cost RS/m^2 was highest. For development of flow measuring device, polypropylene is better to use because cost is less compare to FRP, HDPE and PVC.

Table 1: Physical, Mechanical, other properties of plastic materials.

Properties	FRP	HDPE	PVC	PP
Physical				
Average Density (g/cm^3)	1.2	0.85	1.3	0.82
Water Absorption, 24 hrs (%)	0.10	0.01	0.01	0.01
Mechanical				
Tensile Strength (psi) at 72°F	20,000	4,600	7500	4,800
Flexural Strength at Yield (psi)	30,000	4,600	12,800	5400
Compressive Strength (psi)	50,000	**4,600**	**5,200**	**6000**
Other properties				
Weather Resistance	Not Stabilised, poor	Stabilised, good	Stabilised, good	Stabilised, Very good
Suitable of mechanical jointing	Easy	Good	Good	Very Good
Ease of working	Poor	Good	Average	Very Good
Cost (Rs/m$^{2)}$)	375	115	250	110



(a) FRP

(b) HDPE

(C) PVC

(D) PP

Fig. 1. Commonly Available Plastic materials.

CONCLUSION

In the present study most commonly available plastic materials such as FRP, HDPE, PVC and PP were tested for constructing flow measuring structures. From the study it is observed that many physical, mechanical and other properties are favorable for poly prophelyne plastic materials. It is also mentioned that poly propylene is cost effective in comparison to other plastic materials. Based on this study, it is concluded that, Poly prophelyne can effectively used for construction and fabrication of flow measuring devices.

FUTURE SCOPE

There is clear evidence that the PP will continue to be the preferred option for numerous strengthening different flow measuring devices in field channels in the coming years due to the lower cost which farmers offer.

Acknowledgement. I would like to extend my profound regards and deep sense of gratitude to all authors for their prudent guidance, encouragement and constructive suggestions all through the investigation and preparation of this manuscript
Conflict of interest. The authors declare no conflict of interest.

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How to cite this article: Chitte Karishma, B. Krishna Rao, K. Yella Reddy, P.K. Mishra, A. Mani, S. Annapurna, B. Hari Babu and V. Srinivas Rao (2022). Low Cost Plastic Materials for Construction of Flow Measuring Structures. *Biological Forum – An International Journal*, *14*(4): 267-270.