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NEW ZEALAND AGRICULTURAL ENGINEERING INSTITUTE

THE FLOW CHARACTERISTICS OF PLASTIC DRAINAGE PIPE AVAILABLE IN NEW ZEALAND

PROJECT REPORT 10

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1. INTRODUCTION

In recent years different types of plastic drainage pipe, intended primarily for use in agricultural underdrainage systems, have become commercially available in New Zealand. No flow resistance data has been supplied by the manufacturers, and, as all these pipes are perforated, and in some cases corrugated, the flow resistance cannot be predicted using existing data. Designers of drainage systems therefore have had no information on which to base calculations of flow in these pipes when laid on various gradients.

This report presents the results of experiments carried out to determine the flow characteristics of those plastic drainage pipes available in New Zealand. Table 1 gives some details of these pipes which are illustrated at Fig. 1. A full description appears in the Appendix. The results have been incorporated in a Plastic Drain Pipe Design Chart which is based on the Ohio Drainage Guide (5) Tile Drain Design Chart. This chart appears at Fig. 6.

Test procedures developed at the N. Z. A. E. I. for determing the mechanical strength and water intake ability of plastic drainage pipes have already been described by Heiler (1).

2. METHOD OF TESTING

2.1 Pipe Preparation

As all but one of the drainage pipes tested had some wall openings we had to devise a means of preventing leakage from the pipe while under test. For the smooth walled pipes this was successfully achieved by sliding the pipe to be tested inside a length of closely fitting unperforated plastic piping. (See Fig. 2.).

In the case of the corrugated pipes a different approach was necessary. The holes in the walls of the 62 mm diameter pipe were sealed by wrapping the pipe with self adhesive plastic tape. The 100 mm diameter corrugated pipe was obtained from the manufacturers without any holes cut in the walls thus overcoming the problem of sealing.

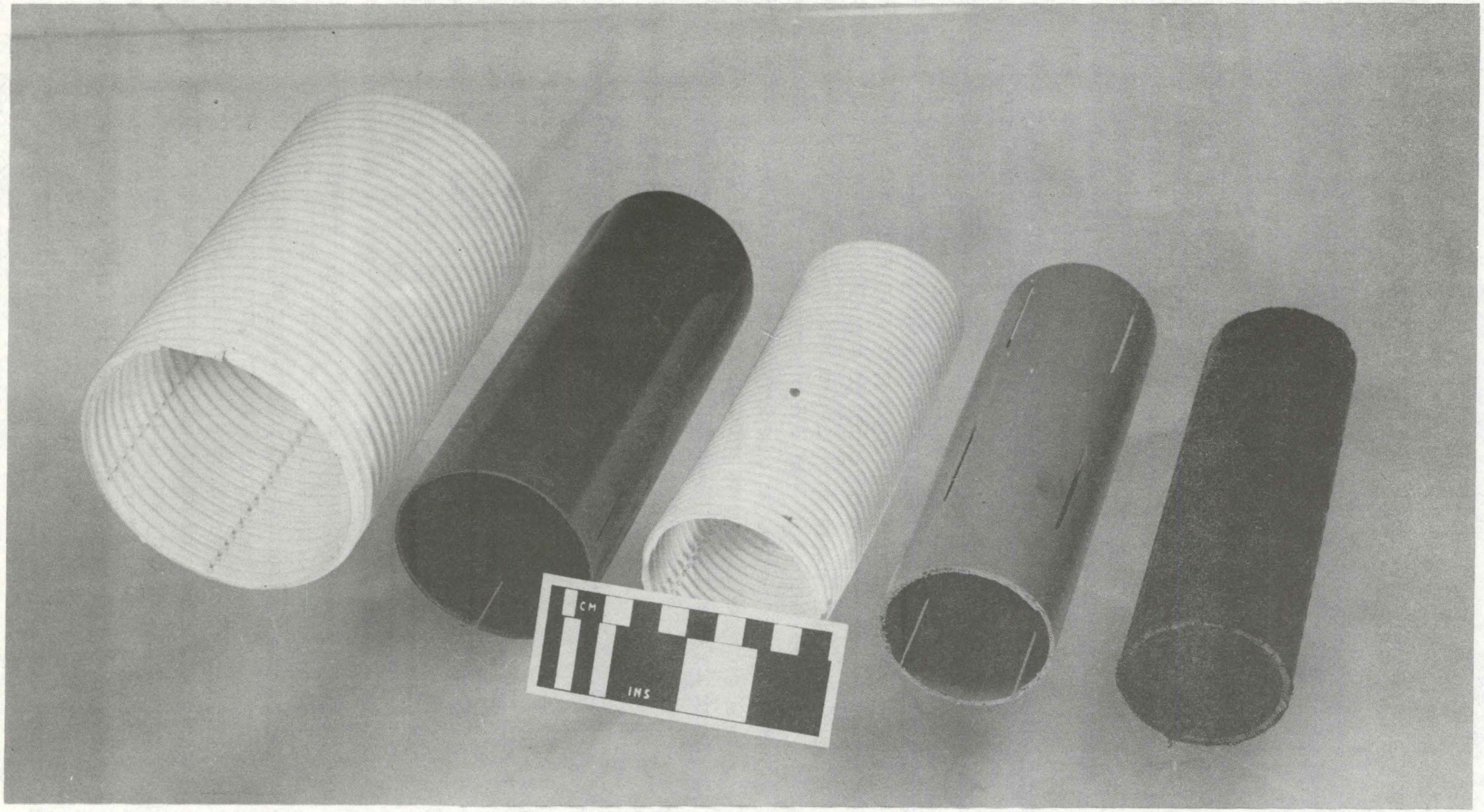
We felt that the results obtained using this unperforated pipe would not have been significantly affected if the pipe had been perforated and the holes then sealed with tape. The ratio of the area of the holes to the total wall area of the pipe was very small and we considered that the losses due to the presence of the corrugations would be considerably greater than any losses that may have been caused by the presence of the holes. This decision was supported by the work of Hermsmeier and Willardson (2) who also used unperforated pipe in their work on friction factors of corrugated plastic drainage pipe.

Pressure tappings machined from solid P. V. C. rod were glued to each pipe at 6. 1 m intervals, four such tappings being used for each pipe as shown in Fig. 3.

2.2 Arrangement of Test Equipment

The length of pipe to be tested was laid out on a level concrete floor and the four pressure tappings connected to a bank of water manometers graduated to 3 mm, Fig. 4 illustrates this.

Fig. 1 Plastic drainage pipes tested



From the left: 100 mm Novaflo, 75 mm Cromac, 62 mm Novaflo, 58 mm Polydrain, 50 mm Draincoil

TABLE 1

SIZE, DESCRIPTION AND TRADE NAME OF PLASTIC DRAINAGE PIPES TESTED

Pipe No	Nominal Internal Diameter mm	Actual Internal Diameter mm	Description	Trade Name
1	100	102.50	Corrugated u. PVC* un-perforated	Novaflo
2	75	72.500	Smooth PVC** with longitudinal slits	Cromac
3	62	61.00	Corrugated u. PVC perforated	Novaflo
4	58	57.75	Smooth PVC with longitudinal slits	Polydrain
5	50	50.75	Smooth polyethylene with perforations	Draincoil

* u. PV. C. - unplasticised Polyvinyl Chloride

** P. V. C. - Polyvinyl Chloride

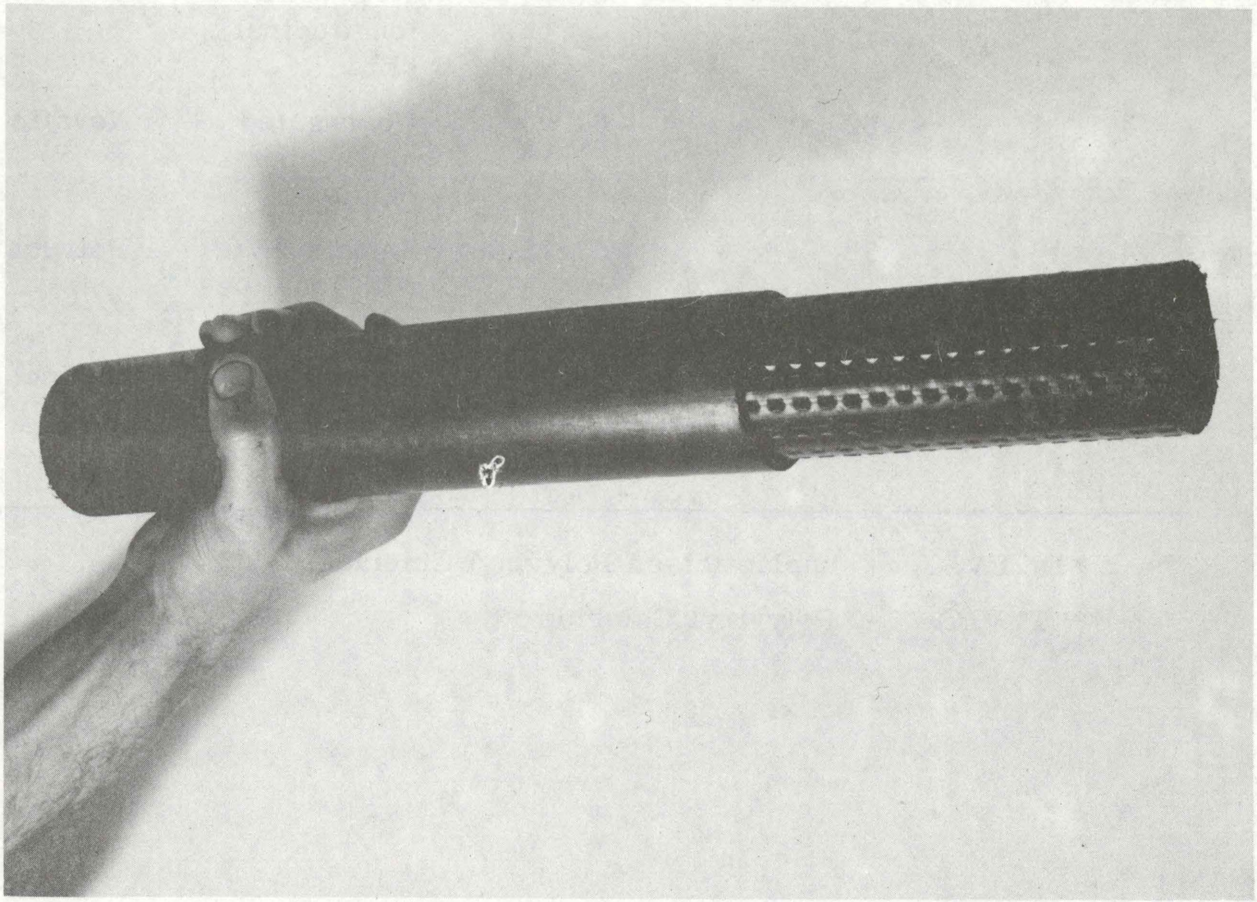


Fig. 2 Sheathing perforated pipe to prevent leakage

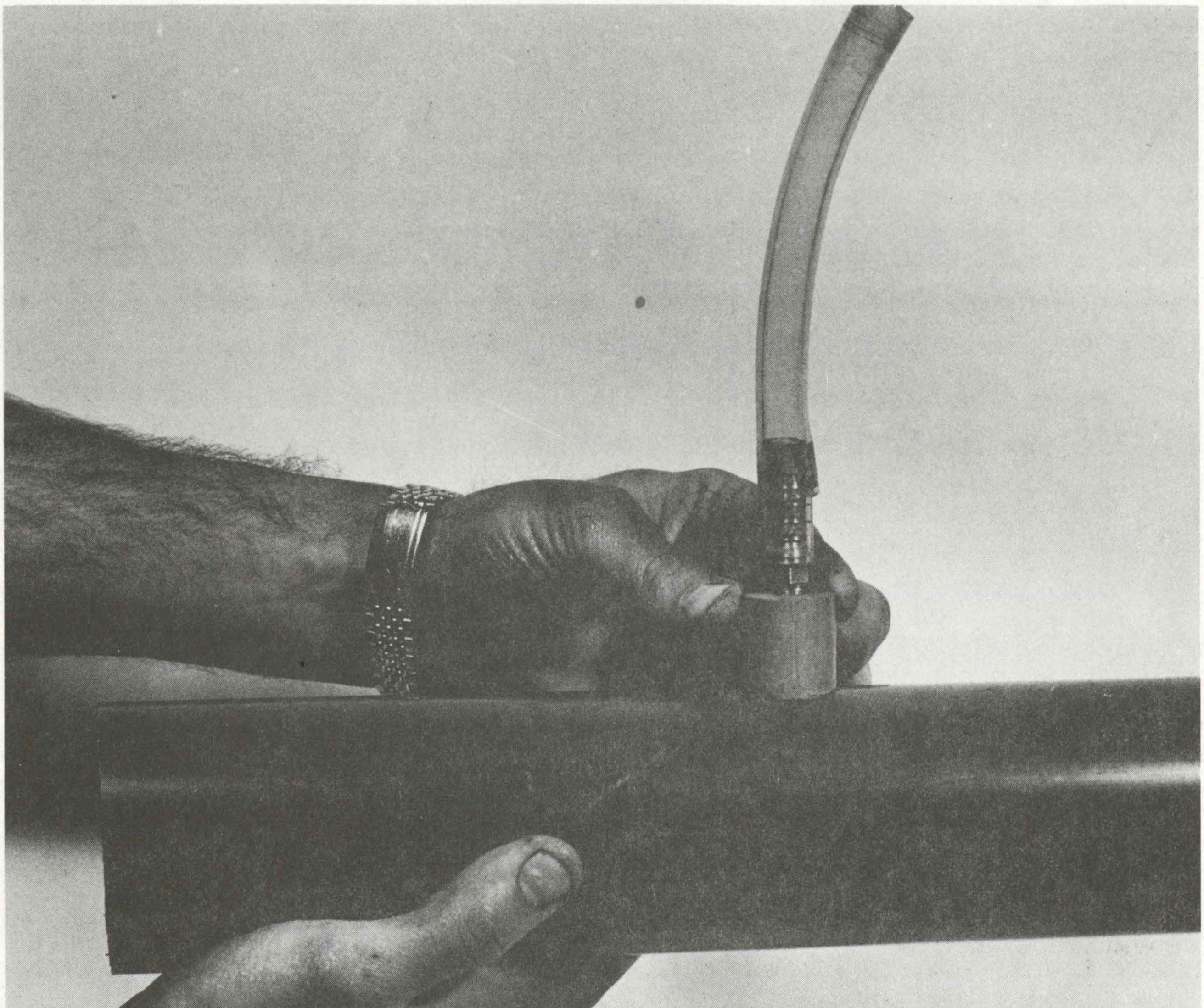


Fig. 3 Pressure tapping

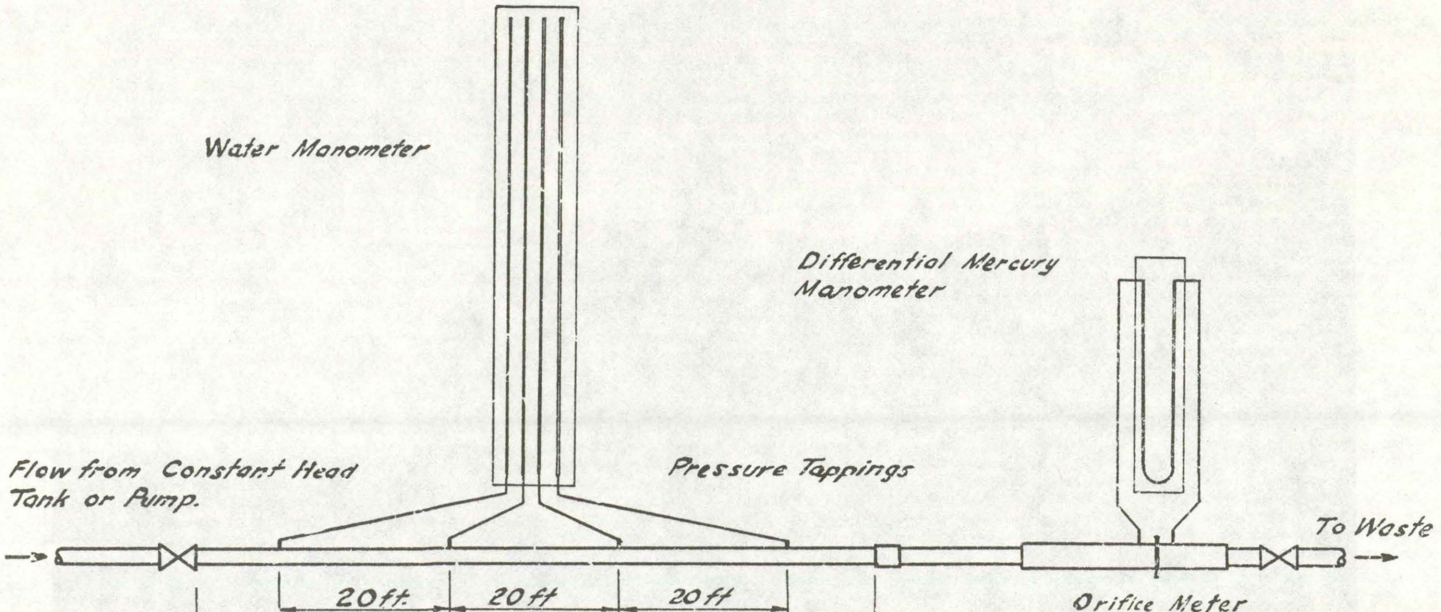


Fig. 4 Diagram of equipment used to determine the head loss in plastic drainage pipe

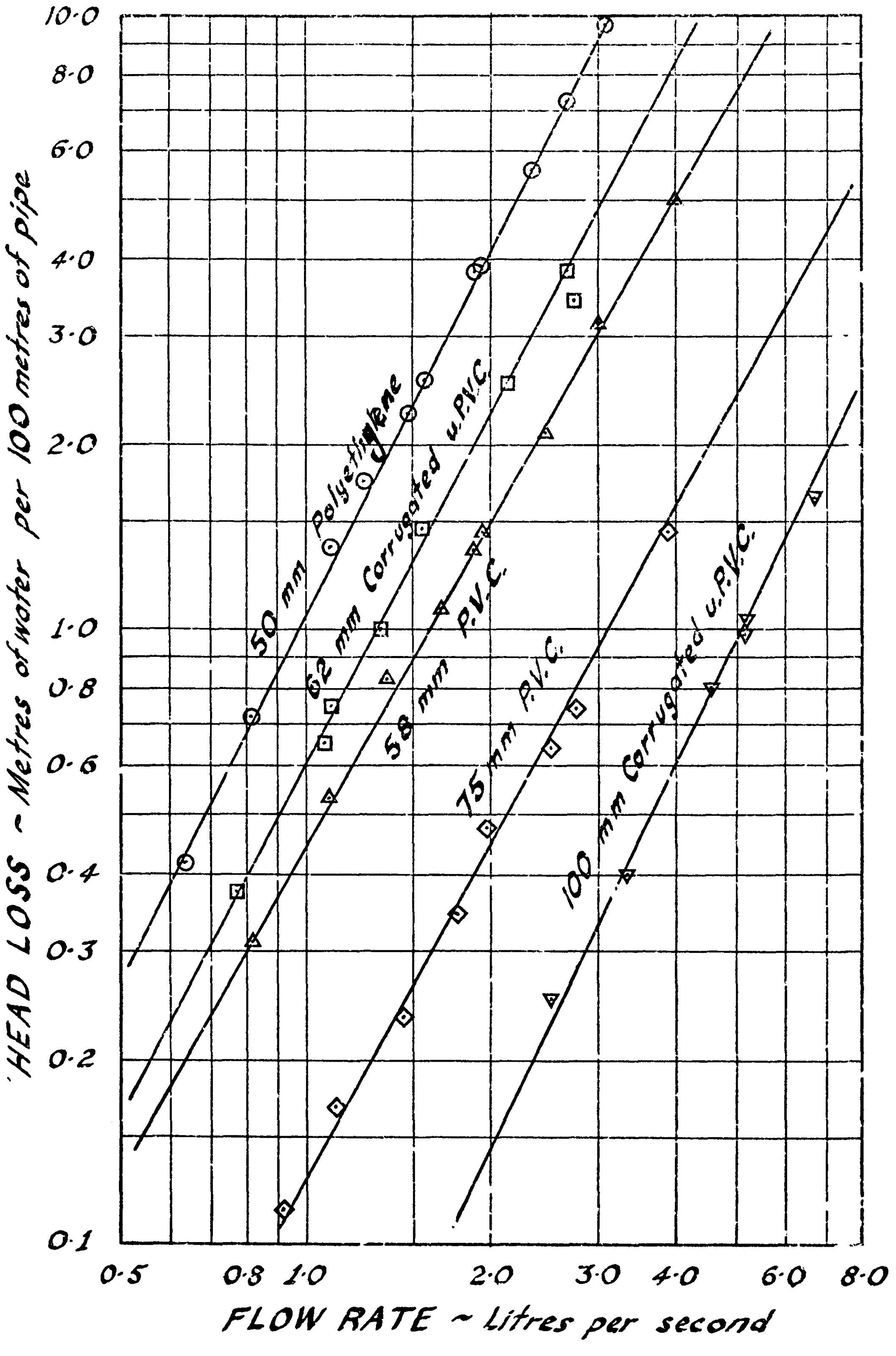


Fig. 5 Experimental results

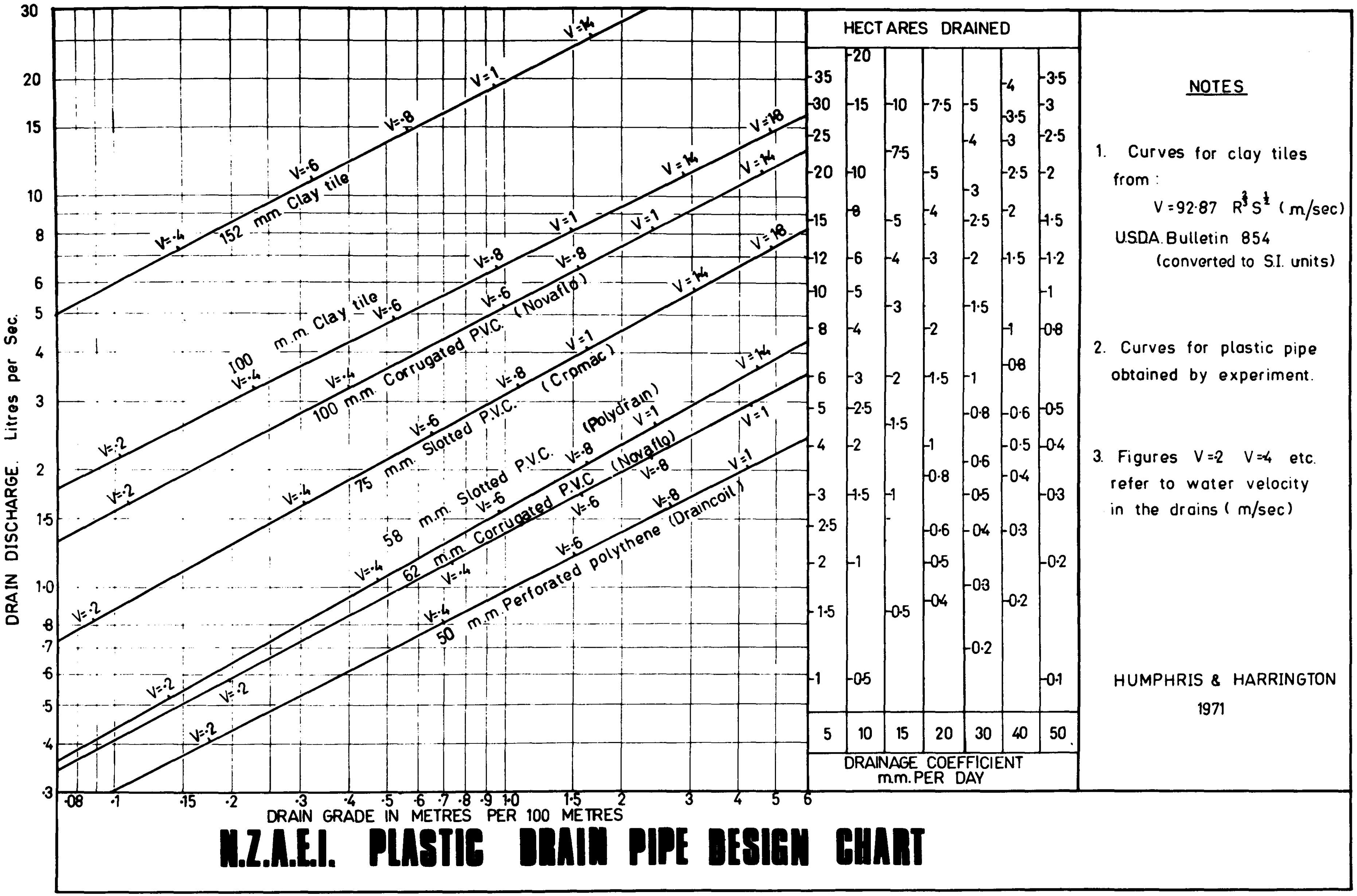


Fig. 6 Plastic drain pipe design chart

Flow was measured using an orifice meter, two sizes of orifice plate, 25.4 mm and 38.1 mm, being used to cover the flow range of 0.53 litres/sec to 7.6 litres/sec.

Water was supplied to the pipe under test from a constant head tank for the smooth walled pipes, and from a centrifugal pumping unit for the two corrugated pipes. This was only because the constant head tank was unavailable for these two tests. In all cases the tests were carried out with the pipes flowing full of water.

2.3 Test Procedure

(i) For each pipe tested flow was initially established at a high rate to flush any trapped air out of the system. We experienced some difficulty in removing all the air from the two corrugated pipes and, probably, small pockets of air were trapped in the top of each corrugation. Because air would be trapped in these positions under normal field operating conditions the effort required to overcome this problem did not seem warranted.

(ii) The flow rate was then adjusted to approximately the highest rate required for the particular size of pipe under test and the system allowed to stabilise over a period of five minutes. The headloss and orifice meter manometer readings were then recorded.

(iii) The flow rate was then reduced in steps until the range of flows required had been covered, the manometers being read at each new flow rate.

3. RESULTS

The difference in head between adjacent pressure tappings along the pipe was calculated from the manometer readings. These three figures were then averaged to give the average head loss over a 6.1 m length of pipe. From this figure the head loss as a percentage was calculated for each flow rate for all the pipes tested. These results are presented graphically in Fig. 5.

4. USING THE EXPERIMENTAL RESULTS IN DRAINAGE DESIGN

A rational approach to the design of subsurface drainage systems is to choose a desirable rate at which water is to be removed from an area and, knowing the grade on which it is possible to lay the drain, select an appropriate size of drain to give this flow.

The general philosophy of designing subsurface drainage systems accepts that under severe conditions, and for short durations, piped drainage systems may be taxed to such an extent that water in the soil profile is not able to flow into the pipe because the drain is operating at a pressure in excess of soil pore pressure.

In a drainage system, however, the design rate of removal of water should not impede its removal from the soil along the entire length of the pipeline.

This condition is met when the grade of the drain is equal to or greater than the pressure drop along the pipeline when it is carrying the design flow.

The experimental results therefore indicate the minimum grade on which a drain may be laid to pass the design flow.

These results are more conveniently used for design purposes when presented in the form of the Plastic Drain Pipe Design Chart as shown in Fig. 6.

This chart is used in exactly the same manner as the Tile Drain Design Chart and readers who are unfamiliar with the use of this chart and drainage design in general are referred to Hudson et al (3) or Luthin (4) for a detailed description of this topic.

5. FLOW RANKING OF DRAINAGE PIPES

On the basis of pipe flow within the range of grades shown on the Plastic Drain Pipe Design Chart the plastic pipes have the following ranking at any one grade.

TABLE 2

FLOW RANKING OF PLASTIC DRAINAGE TUBES TESTED

Ranking		Description
1	Highest Flow	4 inch (100 mm) Novaflo
2		3 inch (75 mm) Cromac
3		2.25 inch (58 mm) Polydrain
4		2.5 inch (62 mm) Novaflo
5	Lowest Flow	2 inch (50 mm) Draincoil

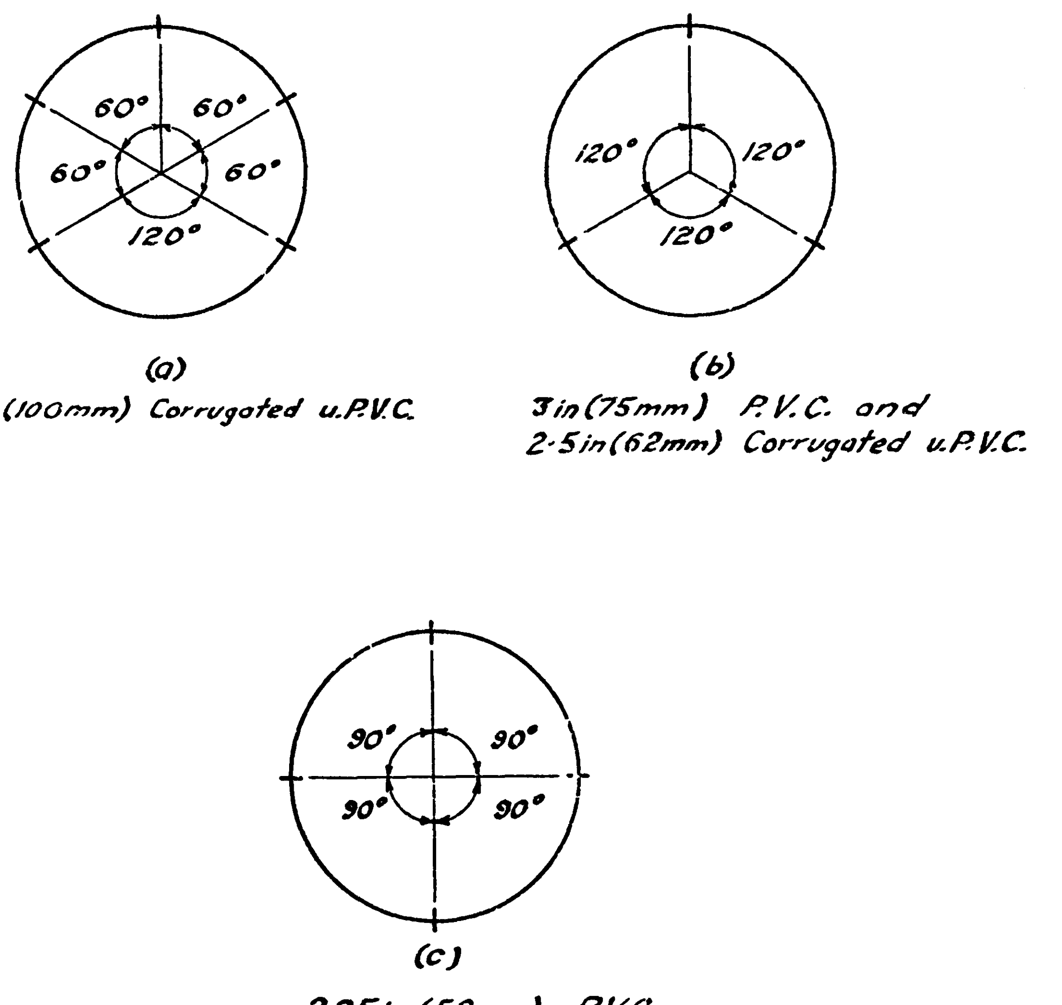


Fig. 7 Spacing of perforations around the circumference of plastic drainage pipes

APPENDIX

DETAILED DESCRIPTION OF PIPES TESTED

1. 100 mm corrugated u. P. V. C.

Internal Diameter:	102. 50 mm - minimum diameter
Corrugations:	Depth 3. 69 mm Pitch 6. 86 mm
Perforations:	(NOTE: This pipe was tested in an unperforated condition but the following details have been included for the sake of completeness.) The perforations consisted of small rectangular holes cut in the valley of the corrugations (as viewed from outside the pipe). These holes were arranged in five rows spaced around the circumference of the pipe as shown in Fig. 7 (a). Each hole was approximately 2. 10 mm long and 1. 63 mm wide. The holes have been formed from the inside of the pipe and very often a large burr of material is left attached to one side of the hole.
Colour:	White
Manufacturer:	Novaplast Ltd, Porirua.
Supplier for Test:	Novaplast Ltd, Porirua.
Trade Name:	"Novaflo"

2. 75 mm smooth P. V. C.

Internal Diameter:	72. 50 mm
Wall Thickness:	1. 50 mm
Perforations:	The perforations inthis pipe were in the form of slits 101. 50 mm long and 1. 25 mm wide cut through the wall of the pipe. The slits were spaced at 101. 50 mm centres longitudinally and in three rows around the circumference as shown in Fig. 7 (b) The slits were neatly cut with little material resulting from this process remaining inside the pipe.

Colour:	Blue
Manufacturer:	Modern Plastics, Lower Hutt.
Supplier for Test:	A. S. Paterson Ltd, Christchurch.
Trade Name:	"Cromac"

3. 62 mm Corrugated u. P. V. C.

Internal Diameter:	61.00 mm - minimum diameter
Corrugations:	Depth 3.43 mm Pitch 4.96 mm
Perforations:	Similar to 1 above except that the holes are arranged in three rows around the circumference as shown in Fig. 7 (b). Each hole was approximately 1.33 mm long and 1.79 mm wide. (The "long" dimension is taken along the length of the pipe). Often burrs of material were left attached to one side of each hole.
Colour:	White
Manufacturer:	Novaplast Ltd, Porirua.
Supplier for Test:	Novaplast Ltd, Porirua.
Trade Name:	"Novaflo"

4. 58 mm Smooth P. V. C.

Internal Diameter:	57.75 mm
Wall Thickness:	1.50 mm
Perforations:	The perforations in this pipe were in the form of slits cut through the wall of the pipe. The slits were spaced at 101.50 mm centres longitudinally and were arranged in 4 rows around the circumference as shown in Fig. 7 (c).
Colour:	Grey
Manufacturer:	Modern Plastics, Lower Hutt.
Supplier for Test:	National Mortgage and Agency Co. of N. Z., Christchurch.
Trade Name:	"Polydrain"

5. 50 mm Smooth Polyethylene

Internal Diameter:	50. 75 mm
Wall Thickness:	2. 75 mm
Perforations:	The perforations consisted of punched slits spaced over the surface of the pipe on a grid pattern of 10. 25 mm centre to centre both ways. The slits were approximately 3. 86 mm long and 0. 18 mm wide. These slits had been formed by displacing the pipe wall material rather than removing it and there tended to be a considerable variation in the width of the slit. The inside of the pipe wall was deformed along each slit.
Colour:	Black
Manufacturer:	Neil Cropper Ltd, Auckland.
Supplier for Test:	Garnite Plastic Sales Ltd, Christchurch.
Trade Name:	"Draincoil"

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