Investigation of Flow Distribution along Multi Outlet PVC Pipe Based on Physical Model

Yousef A. Almolhem
College of Agriculture, King Faisal University,
Kingdom of Saudi Arabia

Thamer Ahmad Mohammad
College of Engineering, University of Baghdad, Iraq

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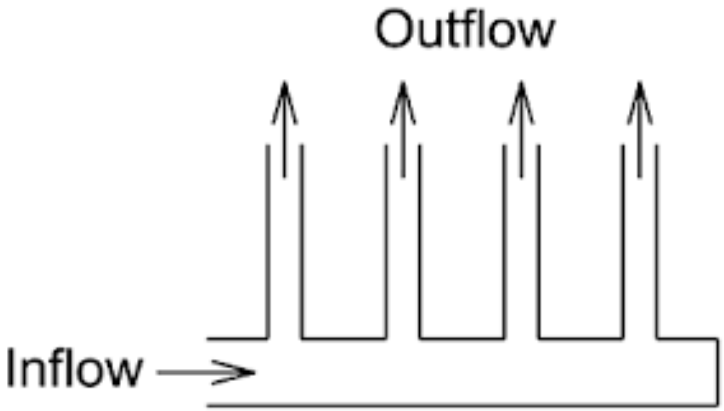
Introduction

Multi outlet pipe is a conduit that either distribute or collect fluids from side outlets with uniform or non-unifrom spacing and it can usually be categorized into dividing or combining type.

Flow in multi outlets pipe has applications in various engineering

In Civil engineering, it is used for distribution of water and wastewater .



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In mechanical engineering, multi outlet pipe is used to distribute fuels to the engine combustion chambers

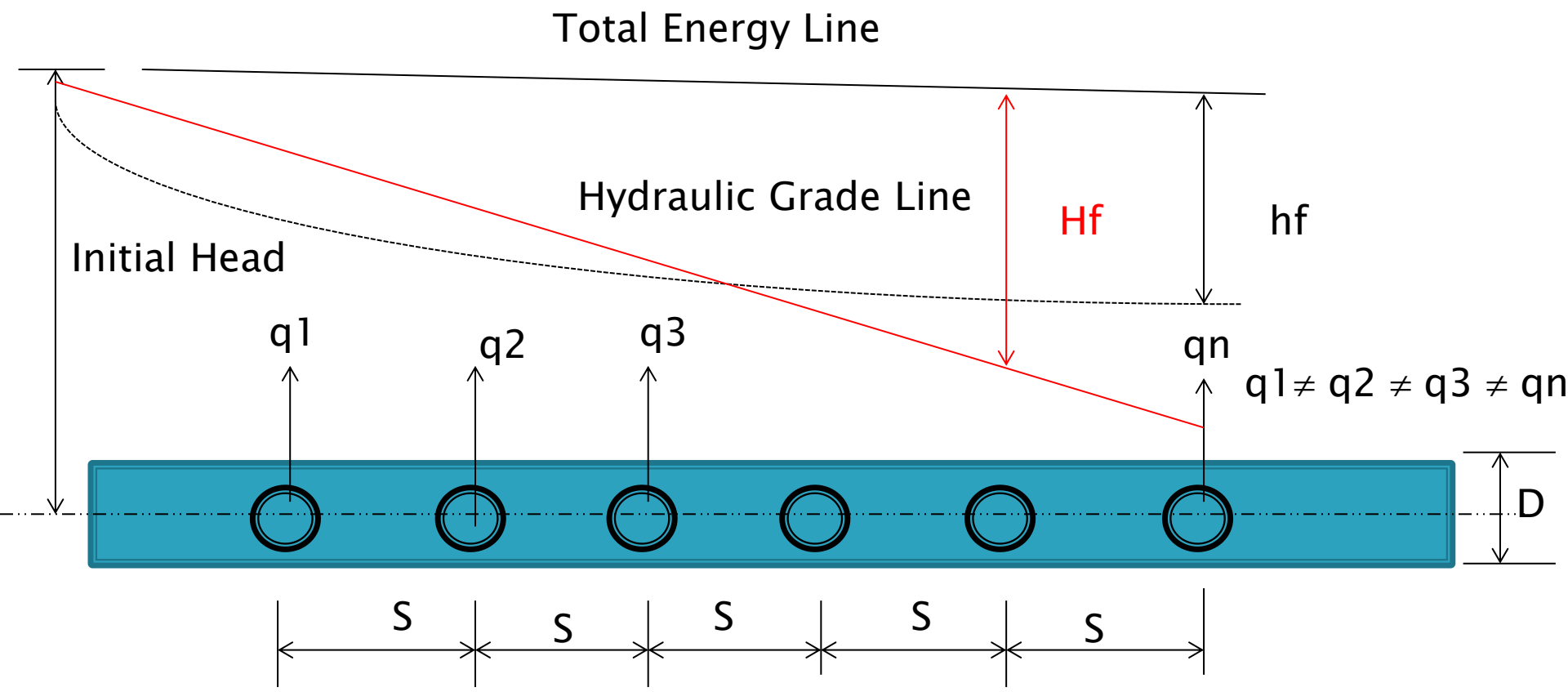
In chemical engineering, it is used to distribute and collect chemicals from industrial units

Introduction

The most common application of multi outlet pipe is on water supply and irrigation systems (e.g., sprinkler irrigation).

Variation in head loss and discharge when the water transported along the multi outlet pipe.

The discharge downstream from of each outlet will effectively reduce if there is regular spacing between the outlets. Towards downstream, the friction head loss is increasing while the flow rates are decreasing.



Energy Loss for multi outlet pipe

Energy Loss for pipe without outlets

Hf= Energy Loss in pipe without outlets

hf=Energy Loss in multi outlet pipe

Outlet opening

D=Pipe Diameter

S=Spacing between outlets

Schematic diagram for flow in multi outlet pipe

In order to improve and enhance engineering calculations of flow uniformity, the variation in flow along the pipe outlets should be reduced.

Since multi outlets pipe is used in many fields, many researchers were focused their efforts to study its various problems. Some of the researchers studied the mechanics of manifold analytically while others validated some formulae by using experimental data.

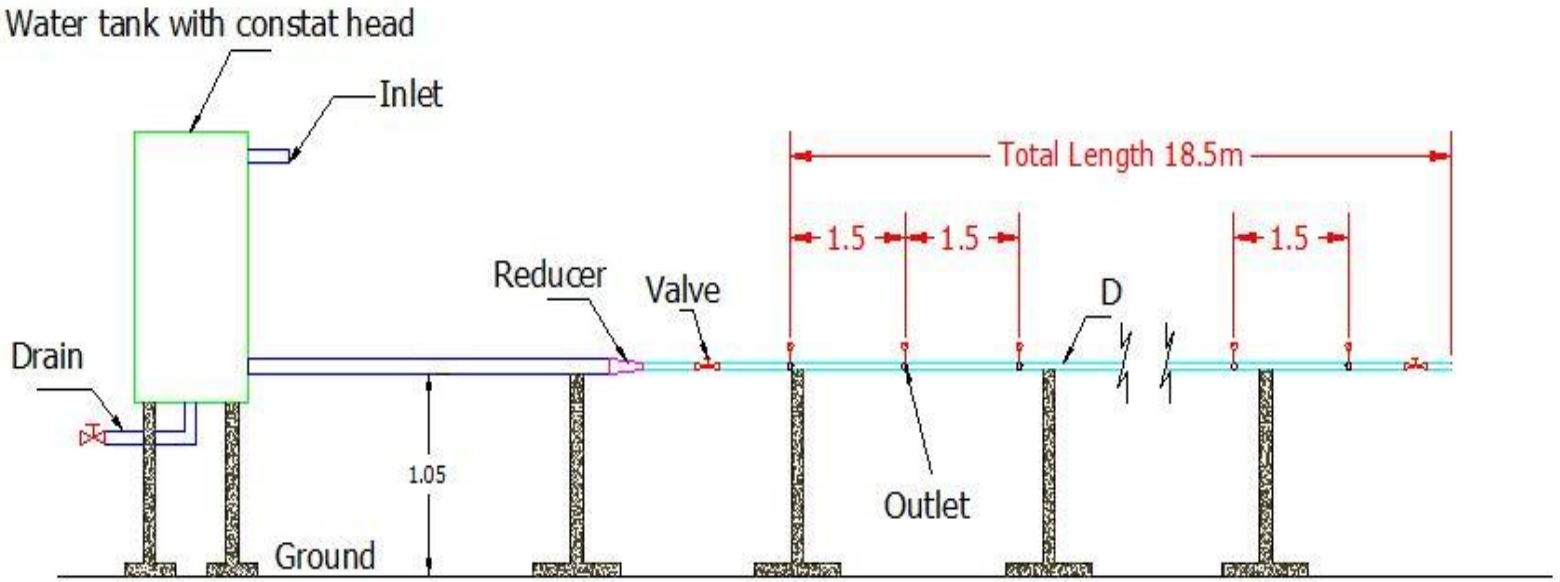
This study aims to experimentally assess the uniformity of multiple outlet pipes by using different pipe diameters, spacing between outlets and different initial heads.

MATERIAL AND METHODS

A physical model was fabricated to simulate the flow through PVC closed end multi outlets pipe.

The test rig includes of 4 main components and these components are main pipe with lateral openings, valves, piezometers and water supply tank. The valves are used to control the flow in the multi outlet pipe.

Four different area ratios are used with the aim to determine the relationship between area ratio and manifold uniformity.



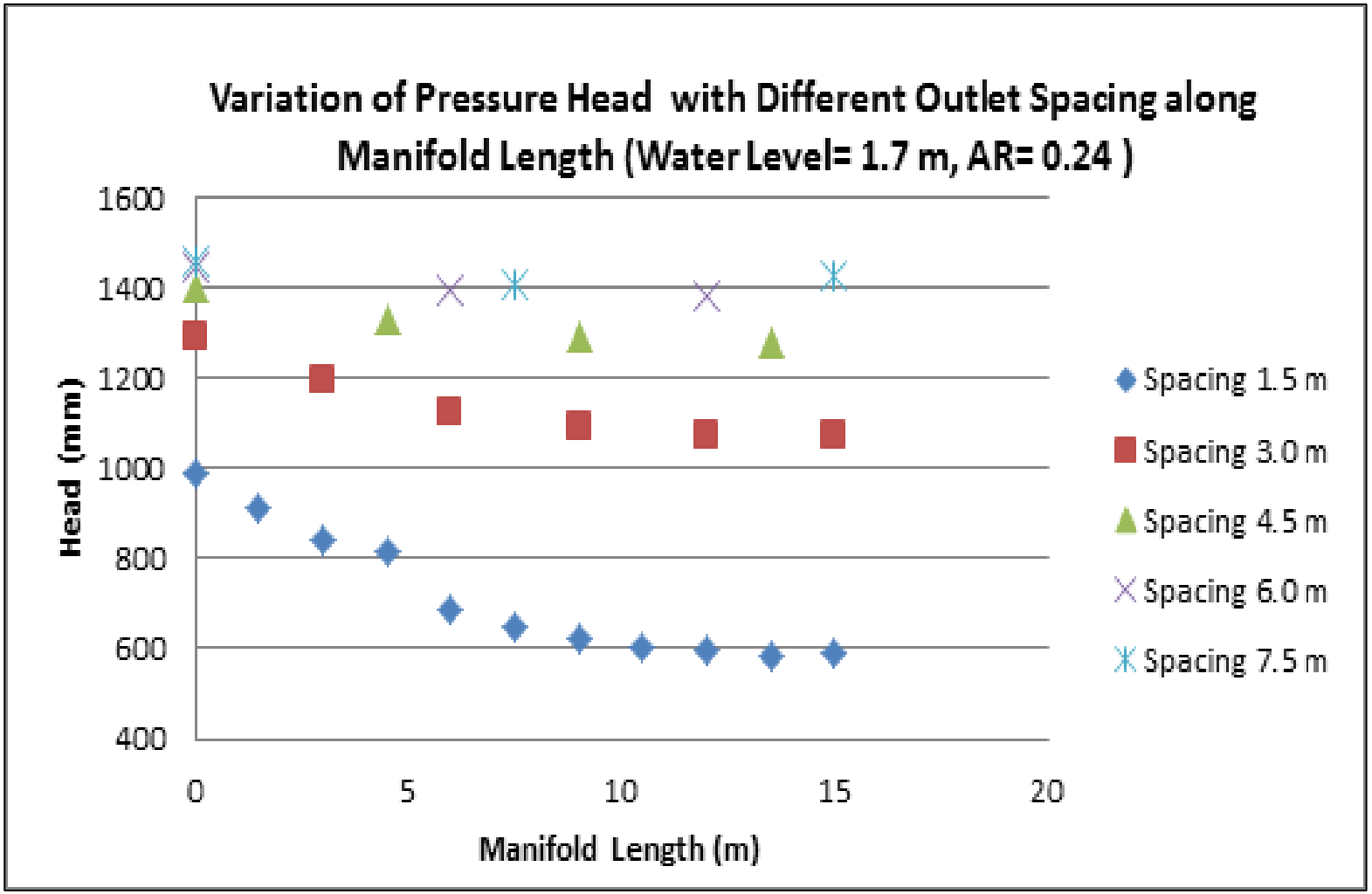
Note:- 1. All Dimensions are in meters.
2. Dimensions of reducers
a. 76.2mm to 50.8mm c. 76.2mm to 25.4mm
b. 76.2mm to 38.1mm
3. D= Diameter of main pipe vares from 25.4mm, 38.1mm, 50.8mm and 76.2mm

Elevation view of the designed test rig

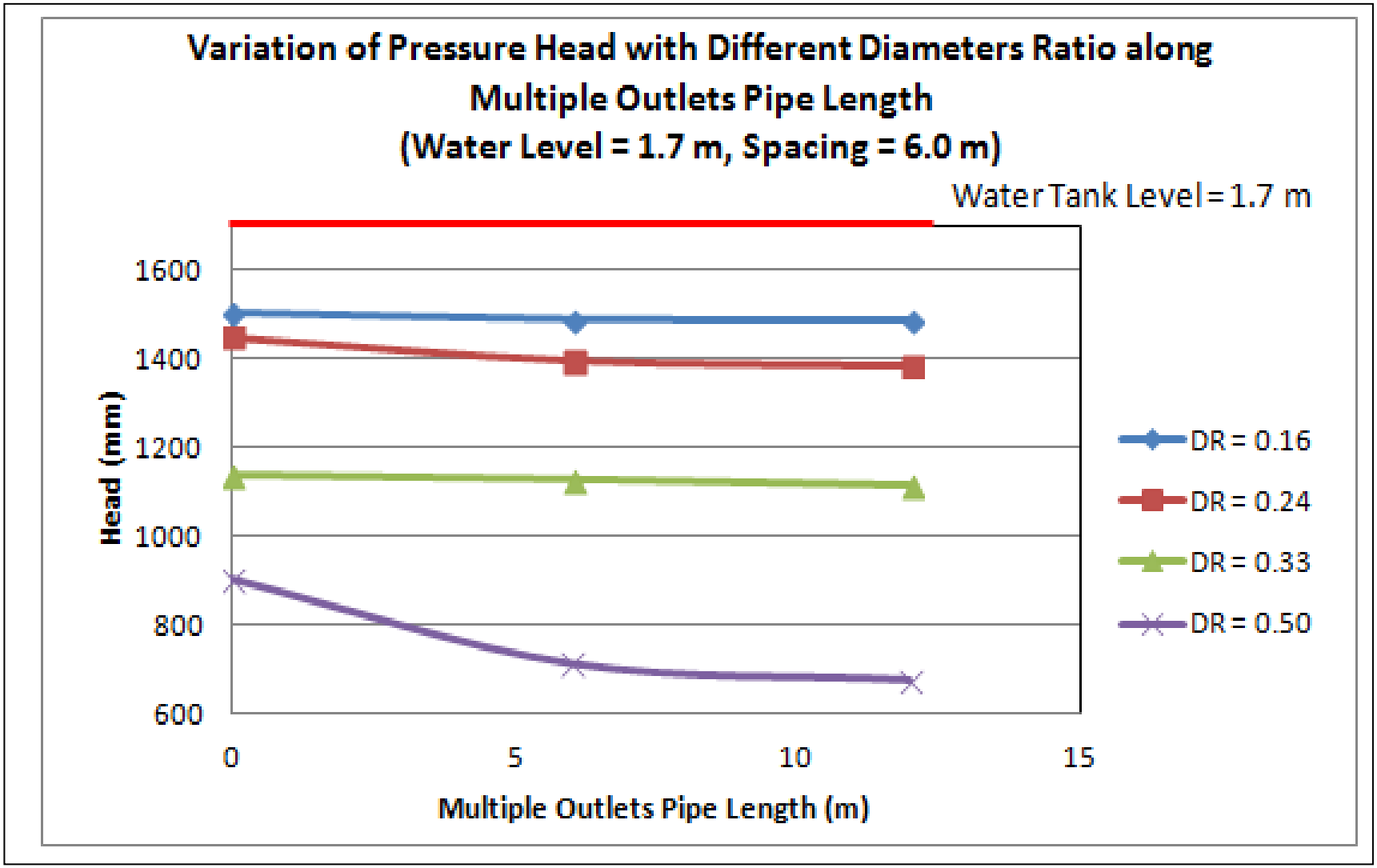
Table 1. Manifolds combination used in the experiments

Manifold Dia, mm	Lateral Dia, mm	Diameters Ratio
25.400	6.000	0.240
38.100	6.000	0.160
50.800	25.400	0.500
76.200	25.400	0.330

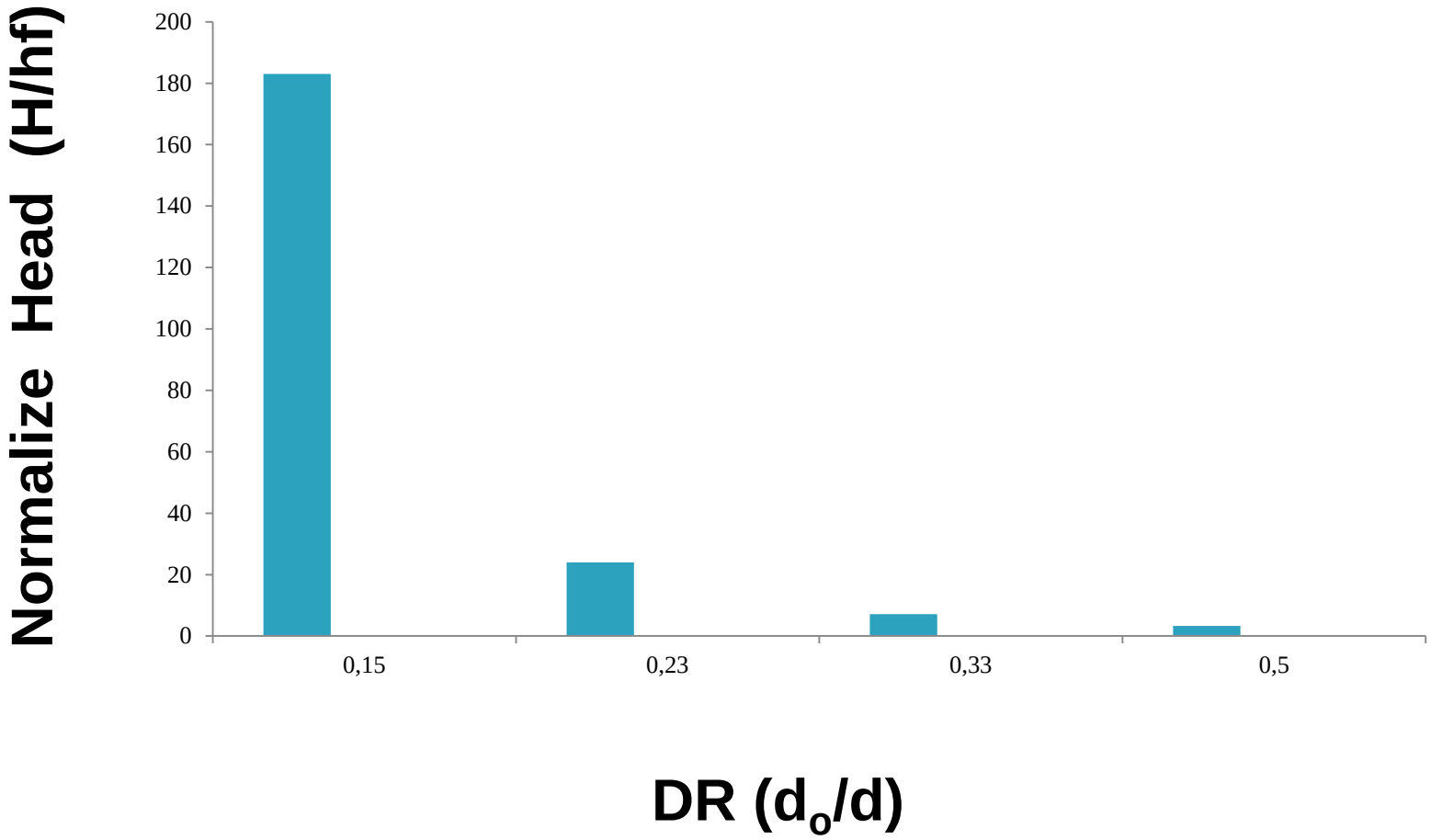
Results and Discussion



Variation of pressure head with different outlet spacing



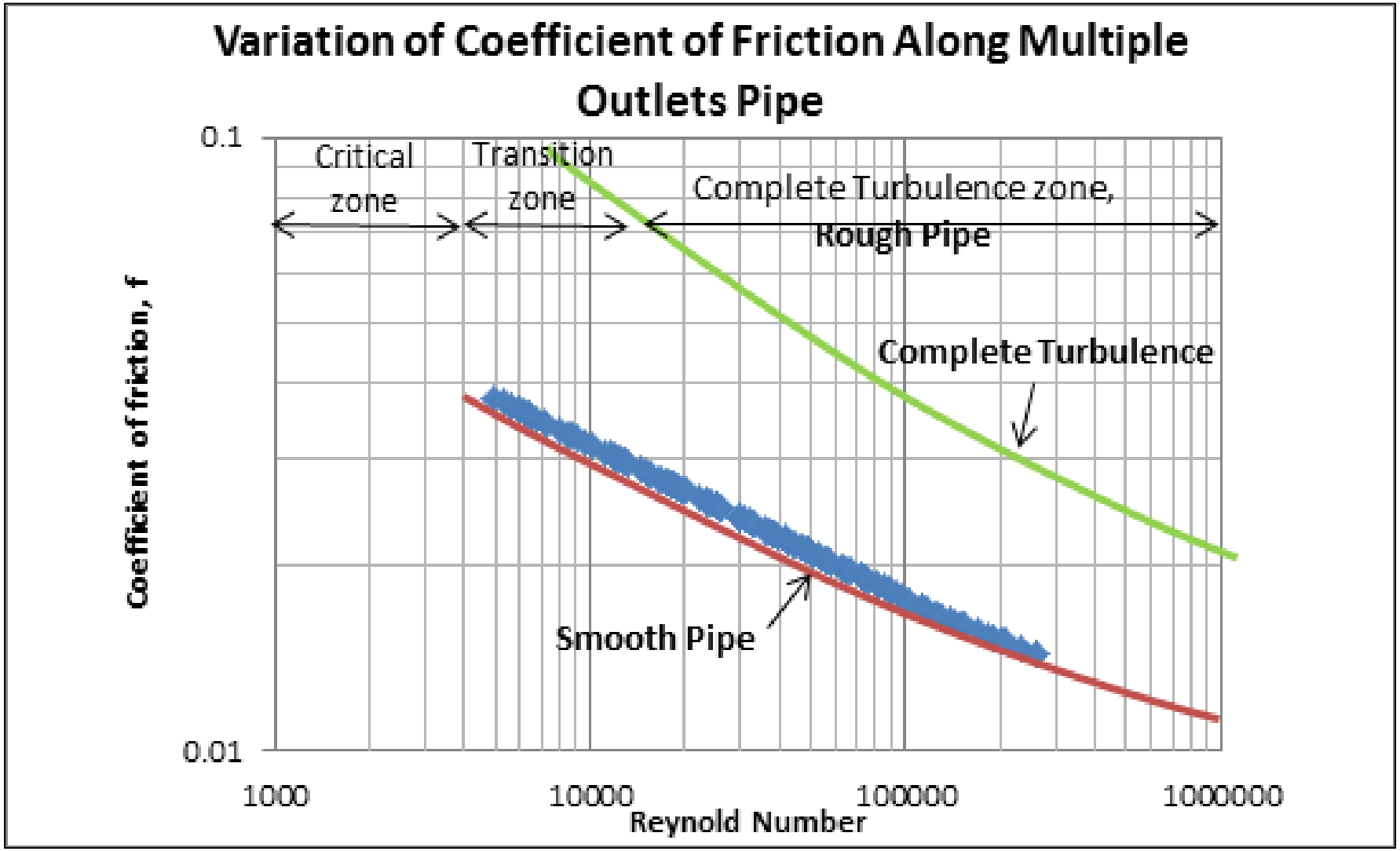
Variation of pressure head with different area ratios


Normalize Head (H/hf)
200
180
160
140
120
100
80
60
40
20
0
0,15
0,23
0,33
0,5
DR (d_o/d)

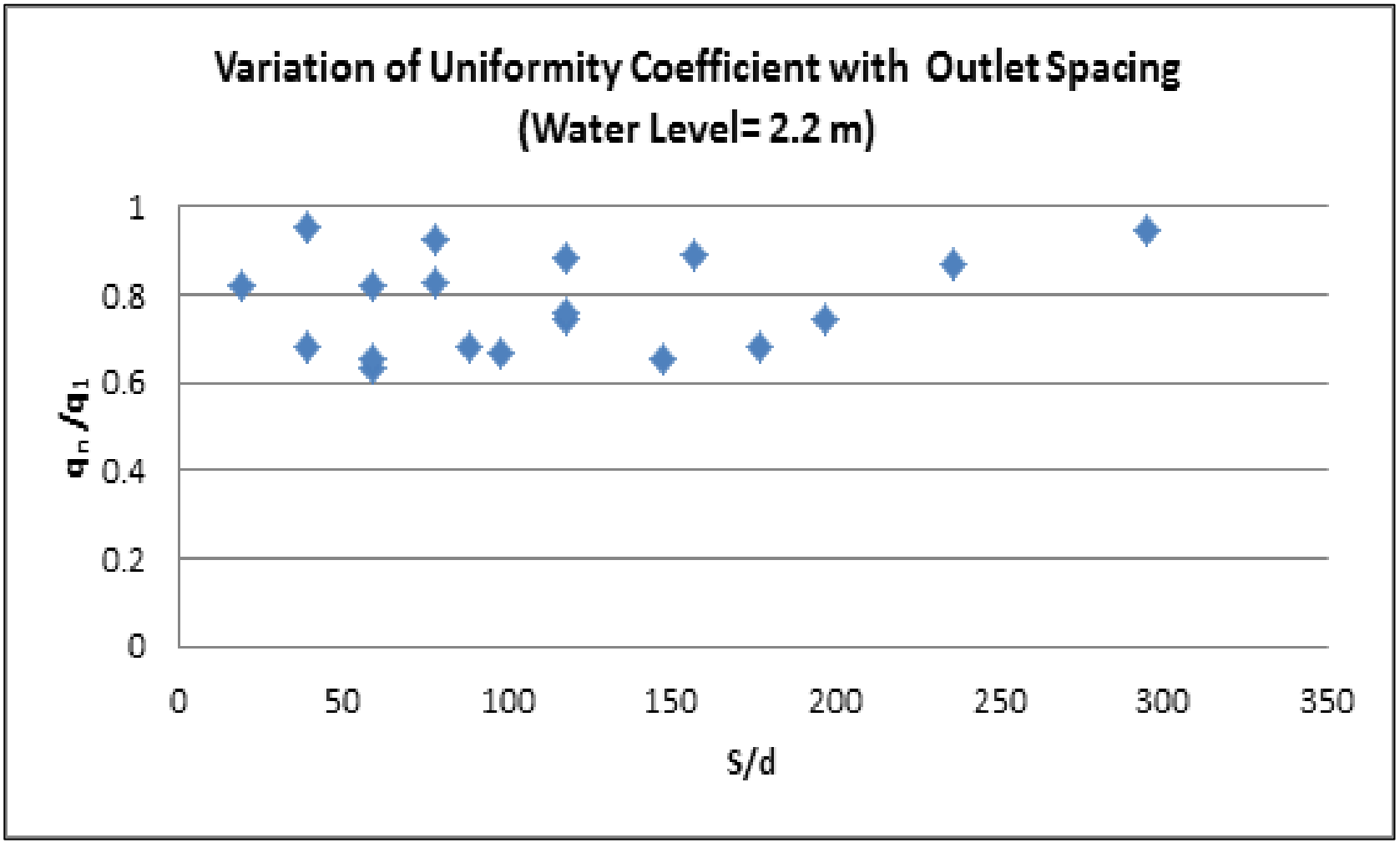
Computed head loss for pipe with and without outlets and experimental G factor

Pipe Dia.	Water Level (m)	Spacing (m)	h_f (pipe with outlets) (mm)	h_f (pipe without outlets) (mm)	Exp. G factor
25.400 mm	1.700	1.500	403.500	974.000	0.410
		3.000	216.000	660.000	0.330
		4.500	120.000	485.000	0.250
		6.000	65.000	235.000	0.280
	2.200	1.500	479.000	1314.000	0.360
		3.000	271.000	512.000	0.530
		4.500	125.000	412.000	0.300
		6.000	92.000	339.000	0.270
		7.500	57.500	308.000	0.190
38.100mm	1.700	1.500	165.500	1010.000	0.160
		3.000	50.000	254.000	0.200
		6.000	14.500	196.000	0.070
		7.500	12.000	145.000	0.080
	2.200	1.500	121.000	1180.000	0.100
		3.000	57.500	195.000	0.290
		6.000	12.000	145.000	0.080
		7.500	5.000	100.000	0.050

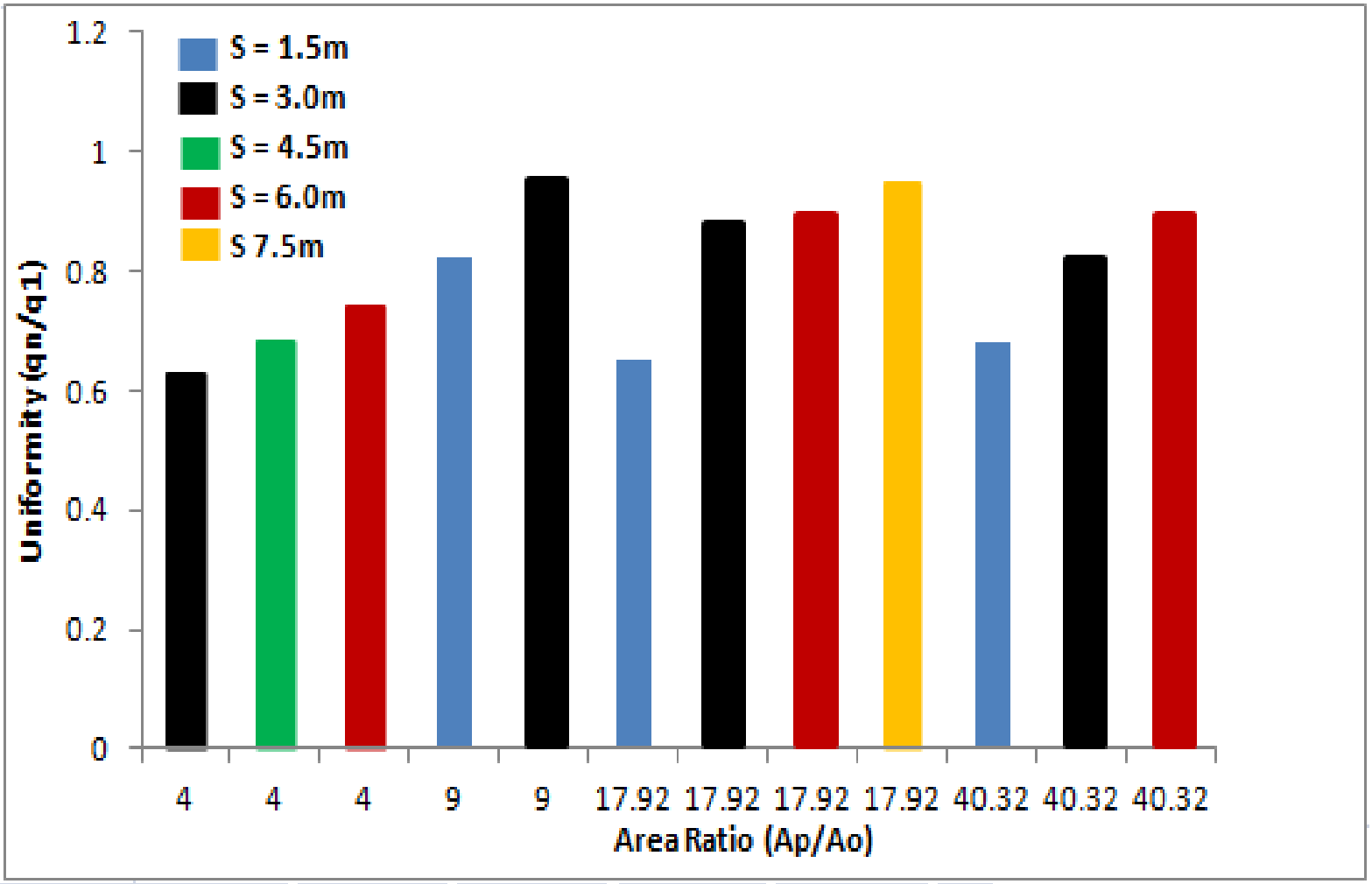
Pipe Dia.	Water Level (m)	Spacing (m)	h_f (pipe with outlets) (mm)	h_f (pipe without outlets) (mm)	Exp. G factor
50.800mm	1.700	1.500	15.600	765.000	0.020
		3.000	408.000	747.000	0.550
		4.500	313.000	682.000	0.460
		6.000	224.000	655.000	0.340
		7.500	301.000	667.000	0.450
	2.200	1.500	25.500	1127.000	0.022
		3.000	590.000	1091.000	0.540
		6.000	675.000	1050.000	0.640
		7.500	364.000	940.000	0.390
76.200 mm	1.700	3.000	19.000	488.000	0.040
		4.500	85.500	481.500	0.180
	2.200	1.500	16.400	665.000	0.020
		3.000	30.500	644.000	0.050
		6.000	31.000	553.000	0.060



Variation of coefficient of friction along the pipe with multiple outlets highlighted on Moody's diagram



Variation of uniformity coefficient with outlet spacing



Variation of uniformity coefficient with area ratios

Conclusions

A test rig to simulate the uniformity of multiple outlets PVC pipe is designed, fabricated and operated. From this study, it is found that the inlet head, spacing between outlets and diameter ratio, S/d and diameter ratio, d_o/d are the governing factors affecting friction head loss and uniformity of the flow along the multiple outlet of the PVC pipe. For the same inlet head and area ratio, results indicated increasing the uniformity with the increase in the outlet spacing. For fixed

spacing, S/d and fixed inlet head, the smaller the diameters ratio, the smaller the total head loss. The relationship between head ratio with the diameter ratio, was found to be non linear (in general head loss increases with the increase in DR). The coefficient of friction in the pipe and for different discharges is found to follow the smooth pipe curve in Moody diagram. For the same length, material, diameter and discharge, the measured friction head losses in two pipes one with outlets and the other without outlets did not showed any clear relationship between them. This can be attributed to variation in outlet diameter, main pipe length and diameter, spacing between the outlets, inlet head as well as the errors in recording the data. So, the experiment G factor is fluctuated with inlet head, pipe diameters, and outlet spacing.

Thank You