

ENERGY LOSSES AND PRESSURE HEAD
CHANGES AT STORM DRAIN
JUNCTIONS

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(ii)

STATEMENT

I hereby declare that the content of this thesis does not comprise in the main any work or material which I have previously submitted for a degree or other similar award from any other Institute of Technology or University.

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CONTENTS

ACKNOWLEDGEMENTS	(iii)
CONTENTS	(iv)
LIST OF ILLUSTRATIONS	(vi)
LIST OF TABLES	(ix)
ABSTRACT	(x)
NOMENCLATURE	(xi)
<u>CHAPTER 1</u> Introduction	1
<u>CHAPTER 2</u> Pipe Junction Hydraulics	6
2.1 Introduction	7
2.2 Assumptions	7
2.3 Development of a General Theory	13
2.4 A Check of Theory Against Experimental Data	17
2.5 Hydraulic Performance of Commercially Available Pipe Junctions	17
2.6 Effect of the Reynold's Number	36
2.7 Summary : Pipe Junction Hydraulics	37
<u>CHAPTER 3</u> Junction Pit Hydraulics	38
3.1 Introduction	39
3.2 Literature Review	39
3.3 Flow Across Pit Junction Structures	46
3.4 Effect of Pit Size and Shape	50
3.5 Combining Flow at Three-Pipe Junctions	55
3.6 Effect of Froude Number and Submergence on Pressure Head Change Coefficients	55
3.7 Summary : Pit Junction Hydraulics	57
<u>CHAPTER 4</u> Hydraulic Models of Junction Pits	59
4.1 Use of Hydraulic Models	60
4.2 Model Construction and Apparatus	60

	4.2.1	Scope of the Investigation	60
	4.2.2	Water Supply System	64
	4.2.3	Model System and Pipelines	64
	4.2.4	Model Geometries	81
	4.2.5	Experimental Procedures	88
	4.2.6	Error Analysis	94
.	<u>CHAPTER 5</u>	Experimental Results	98
	5.1	Introduction	99
	5.2	Flow Straight-Through Junction Pits.	102
	5.3	22½° Bends at Pits	104
	5.4	45° Bends at Pits	106
	5.5	67½° Bends at Pits	109
	5.6	90° Bends at Pits	110
.	<u>CHAPTER 6</u>	Conclusions	147
.	<u>CHAPTER 7</u>	Selected Bibliography	154
.	<u>APPENDIX</u>	Test Data	A-1

LIST OF ILLUSTRATIONS

1.1	Effect of Selection of Water Surface Elevation Coefficient, k_w , on Pipe Diameter.	3
2.1	Theoretical Analysis for Pipe Junctions.	8
2.2	Fluid Pressures Acting at a Sudden Expansion.	11
2.3	Commercially Available Pipe Junctions.	16
2.4	Comparison between Equation 2.25 and Experimental Evidence for Sudden Expansions.	19
2.5	Energy Losses and Pressure Head Changes at Sudden Expansions.	20
2.6	Energy Losses and Pressure Head Changes for Reducers (Sudden Contractions)	22
2.7	Comparison between Equation 2.33 and Experimental Evidence for Mitre Bend Pipe Junctions	24
2.8	Performance of Mitre Bends.	25
2.9	Performance of Compound 90° Mitre Bends.	26
2.10	Recommended Equation for Pressure Head Change Coefficients at Intake Junctions.	28
2.11	Pressure Head Change Coefficients in Main Conduit at a 45° Slope Junction.	32
2.12	Pressure Head Change Coefficients in Lateral Conduit at a 45° Slope Junction	33
2.13	Recommended Equations for Pressure Head Change Coefficients at Slope Junctions.	34
3.1	Junction Configurations Tested by Sangster <i>et al</i> (1958)	41
3.2	Junction Configurations Tested by Archer <i>et al</i> (1978)	44
3.3	Positive and Negative Pressure Head Changes.	46
3.4	Typical Junction Pit Operation.	48
3.5	Effect of Box Size and Shape with all Flow Straight Through.	51

3.6	Effect of Pit Size on Pressure Head Change Coefficients at 90° Junctions.	53
3.7	Effect of Pit Size on Water Surface Elevation Coefficients at 90° Junctions.	54
3.8	Pressure Line Elevations at 0° and 90° Bends.	56
4.1	Schematic Layout for Junction Pit Experiments.	63
4.2	Headtank.	65
4.3	Manometers.	66
4.4	Model Setup for Straight Through Flow.	66
4.5	Flow Through a 45° Pit Junction.	67
4.6	Flow Through a 45° Pit Junction	67
4.7	Typical Inlet Pit.	69
4.8	Tailwater Tank.	71
4.9	70 mm Diameter Model Pipeline.	74
4.10	94 mm Diameter Model Pipeline.	75
4.11	127 mm Diameter Model Pipeline.	76
4.12	Angle Adaptors	78
4.13 - 4.18	Model Geometries Tested.	82-87
4.19	Data and Calculation Sheet	89
4.20	Typical Data Plot (Pressure Head Change Coefficients).	92
4.21	Typical Data Plot (Water Surface Elevation Coefficients).	93
4.22	Friction Slope vs Discharge for 70 mm Diameter Pipe.	96
5.1	Comparison of Experimental Results with those of Investigators and with the Theoretical Analysis for Straight Through Flow	112
5.2	Coefficients for Straight Through Flow ($S/D_o = 2.5$).	113

5.3	Comparison of Theoretical Analysis with Experimental Results for $\theta = 22\frac{1}{2}^{\circ}$.	114
5.4 - 5.8	Coefficients for $22\frac{1}{2}^{\circ}$ Bends at Pit Junctions.	115-119
5.9	Comparison of Theoretical Analysis with Experimental Results for $\theta = 45^{\circ}$.	120
5.10 - 5.19	Coefficients for 45° Bends at Pit Junctions.	121-130
5.20	Comparison of Theoretical Analysis with Experimental Results for $\theta = 67\frac{1}{2}^{\circ}$.	131
5.21 - 5.28	Coefficients for $67\frac{1}{2}^{\circ}$ Bends at Pit Junctions.	132-138
5.29	Hydraulic Improvement of 90° Bends at Pit Junctions.	139
5.30 - 5.31	Comparison of Experimental Results with those of Other Investigators and with the Theoretical Analysis for $\theta = 90^{\circ}$.	141-142
5.32 - 5.35	- Coefficients for 90° Bends at Junction.	143-146
A.1 - A.60	Data Plot.	A3-A62

LIST OF TABLES

2.1	Total Energy Loss Coefficients for Compound Mitre Bends	27
2.2	Comparison of Energy Loss Equations for Sharp-Edged Slope Junctions	31
3.1	Typical Values of k_u for Pit Junctions Tested by Sangster <i>et al</i> (1958)	42
3.2	Magnitude of k_u ($=C_u$) as Determined by Archer <i>et al</i> (1978)	43
3.3	Percentage Conversion of Kinetic to Potential Head Derived from Archer's Experimental Data	50
4.1	Constructed Inlet Pit Size Ratios	68
4.2	Diameter and Area Ratios Used in Model Programme	72
4.3	Pipe Lengths Used in Model Programme	77
4.4	Angle Adaptors	80
5.1	Quick Reference Guide to Geometries Tested	101
5.2	Modification Table for Values of S/D_o Other than 2.5	103
6.1	Typical Values of k_u and k_w (branch point located on downstream face of pit)	149
6.2	Typical Values of k_u and k_w (branch point not located on downstream face of pit)	152

ABSTRACT

An investigation has been made of the magnitude of hydraulic losses produced by storm drain junction structures which connect pipes operating under flow-full conditions.

The study comprised three parts:

- (a) a literature review;
- (b) a study of losses associated with commercially available 'closed' pipe junctions;
- (c) an experimental study, using hydraulic models, to investigate the magnitude of losses at 'open' pit structures.

A theoretical analysis was developed for closed pipe junctions. The theory was found to be adequate when checked against available experimental data. For pit junction structures, the experimental programme comprised thirty models covering an extensive range of geometric and hydraulic variables. The model studies indicated that maximum hydraulic efficiency is attained when the junction branch point is located on the downstream face of the pit. Data have been plotted for bend deflections angles of between 0° and 90° , and for upstream to downstream pipe diameter ratios within the range 0.55 to 1.00. Grate inlet flow and submergence have been identified as parameters affecting losses. Semi-empirical equations have been developed to account for junction losses when the branch point is located on the downstream face of the pit.

Nomenclature

The symbols used in this thesis are listed hereunder. Alphabetical subscripts have been used which conform to a standard format. The subscript 'u' refers to the primary upstream pipe. If more than one upstream pipe converges at a junction, the second such pipe is characterized by the subscript 'b' (branch or lateral pipe). The outfall pipe is identified by the subscript 'o'.

Notation

- a spacer length for compound mitre bend junction.
 A_b mean cross sectional area of the lateral pipe.
 A_m mean cross section area of the model pipeline.
 A_o mean cross sectional area of the outfall pipe.
 A_p mean cross sectional area of the prototype pipeline.
 A_r model-prototype area ratio.
 A_u mean cross sectional area of the upstream pipe.
B pit dimension (square in plan).
 C_b dimensionless total energy loss coefficient as defined by the difference between the lateral total energy line elevation and the downstream total energy line elevation when extrapolated linearly to the branch point of the junction, divided by the average downstream velocity head.
 C_u dimensionless total energy loss coefficient as defined by the difference between the upstream total energy line elevation and the downstream total energy line elevation when extrapolated linearly to the branch point of the junction, divided by the average downstream velocity head.
 D_b mean diameter of the lateral pipe.
 D_m mean diameter of the model pipeline.
 D_o mean diameter of the outfall pipe.
 D_p mean diameter of the prototype pipeline.
 D_r model-prototype diameter ratio.
 F_o Froude number in the outfall pipe.
g acceleration due to gravity (9.81 m/s²).

HGL	Hydraulic Grade Line (or pressure line or piezometric head line).
k_b	dimensionless pressure head change coefficient as defined by the difference between the lateral and downstream pressure line elevations when extrapolated linearly to the branch point of the junction, divided by the average downstream velocity head.
k_u	dimensionless pressure head change coefficient as defined by the difference between the upstream and downstream pressure line elevations when extrapolated linearly to the branch point of the junction, divided by the average downstream velocity head.
k_w	dimensionless pressure head change coefficient as defined by the difference between the water surface elevation in a pit junction and the elevation of the downstream pressure line when extrapolated linearly to the branch point of the junction, divided by the average downstream velocity head.
L_m	characteristic length in a model.
L_p	characteristic length in a prototype.
L_r	scalar ratio of the model equal to the characteristic length of the model divided by the characteristic length of the prototype.
p_b	static pressure in the lateral conduit.
p_o	static pressure in the main conduit.
p_u	static pressure in the upstream conduit.
Q_b	mean discharge in the lateral pipe.
Q_g	mean grate flow discharge through the pit grate inlet
Q_m	mean discharge in the model pipeline.
Q_o	mean discharge in the outfall pipe.
Q_p	mean discharge in the prototype pipeline.
Q_r	model-prototype discharge ratio.
Q_u	mean discharge in the upstream pipe.
R_x	resultant force component acting at the junction used in the impulse-momentum equation.
S	depth of water in a pit junction measured from pit invert elevation to water surface elevation (submergence).
TEL	Total Energy Line.

V_b	mean velocity in the lateral pipe.
V_m	mean velocity in the model pipeline.
V_o	mean velocity in the outfall pipe.
V_p	mean velocity in the prototype pipeline.
V_r	characteristic model-prototype velocity ratio.
V_u	mean velocity in the upstream pipe.
WSE	pressure head change defining the difference between the water surface elevation in a junction pit and the elevation of the downstream pressure line when extrapolated linearly to the branch point of the junction.
γ	specific weight of a fluid.
ΔH	available head.
ΔH_b	total energy loss across a junction as defined by the difference between the lateral total energy line elevation and the downstream total energy line elevation when extrapolated linearly to the branch point of the junction.
ΔH_u	total energy loss across a junction as defined by the difference between the upstream total energy line elevation and the downstream total energy line elevation when extrapolated linearly to the branch point of the junction.
Δk_p	incremental pressure head change coefficient due to presence of a pit structure, over and above a theoretical solution
Δk_s	incremental pressure head change coefficient due to submergence effects, over and above a theoretical solution
$\frac{\Delta P}{\gamma}$	change in pressure head as defined by the difference between an upstream pressure line elevation and the downstream pressure line elevation when extrapolated linearly to the branch point of the junction.
ρ	density of water ($\approx 1000 \text{ kg/m}^3$).
θ_b	angle of lateral pipe deflection.
θ_u	angle of upstream pipe deflection.