

**EVALUATION OF INFLOW/INFILTRATION AND FLOW
CHARACTERISTICS FOR DESIGN OF SANITARY SEWERS IN SKUDAI,
JOHOR BAHRU**

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This study is specially dedicated
to my late Father and late Father in Law who
always persuaded and encouraged me for higher studies,
and also to my Mother, Wife, Brothers, Sister and Children,
for their everlasting love, care and support

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ABSTRACT

The design of the sanitary sewer or a treatment plant needs the assessment of the extent of extraneous water that seeps into the system. The study provides the appropriateness of some of the design parameters used by the local engineers. Particular attention is also given to the variation of inflow / infiltration with respect to rainfall occurrence which is found to be very large. The data used in making the evaluation is obtained using the flow-meters for directly measuring the flow in a running sewer line in two different residential areas in ten phases which include both weekdays and weekends, collecting and measuring the amount of water trapped in an abandoned sewer line (field model) continuously for nearly eight months which include both dry and wet periods and also by performing infiltration tests on a laboratory model under saturated and unsaturated conditions to obtain the results in controlled environment. The rainfall is measured using automatic rain-gauge. The results show that the infiltration into the sewers much higher than allowable under Malaysian Standards and infiltration as high as 275.46 liters/day/km-length/mm-diameter is found during wet period. Laboratory tests show results within allowable limits. Based on site study, the design parameters of per capita flow contribution and peak flow factor are found lower than the Malaysian Standard. The results thus obtained are going to be helpful for the municipal agencies and their consulting engineers quantify and simulate rainfall derived infiltration and inflow that affects the sewer systems they design, operate and manage.

ABSTRAK

Rekabentuk sistem kumbahan atau loji rawatan memerlukan kajian ke atas lebih pengaliran air yang menyusup ke dalam sistem tersebut. Kajian ini akan menentukan parameter rekabentuk yang bersesuaian untuk kegunaan jurutera tempatan. Penumpuan turut diberikan terhadap perubahan corak aliran masuk / penyusupan yang berkait rapat dengan kejadian hujan yang tinggi. Data-data yang digunakan di dalam kajian ini diperolehi dengan menggunakan meter aliran bagi mengukur aliran di dalam pembetung di dua taman perumahan yang berlainan dalam 10 fasa yang mana melibatkan hari biasa dan hujung minggu, menyukat dan mengira jumlah air yang terperangkap di dalam saluran kumbahan yang tidak digunakan (model di tapak) secara berterusan selama 8 bulan bagi mendapatkan maklumat penyusupan semasa musim kering dan musim hujan dan menjalankan ujikaji penyusupan ke atas model di makmal dalam keadaan tepu dan tidak tepu bagi mendapatkan keputusan dalam keadaan terkawal. Tolok hujan automatik digunakan untuk mendapatkan keamatan hujan. Analisis keputusan menunjukkan kadar penyusupan ke dalam saluran pembentungan lebih tinggi daripada nilai piawaian Malaysia iaitu sebanyak 275.46 liters/hari/km-panjang/mm-diameter yang berlaku semasa musim hujan. Hasil ujikaji di makmal pula berada di dalam had yang dibenarkan. Berdasarkan kajian di tapak, nilai parameter rekabentuk untuk per kapita aliran yang disumbangkan serta nilai faktor aliran puncak lebih rendah daripada nilai Piawaian Malaysia. Hasil kajian ini, boleh digunakan oleh pihak berkuasa dan jurutera perunding bagi mengira dan membuat simulasi tentang pengaruh keamatan hujan terhadap kadar penyusupan dan aliran masuk ketika proses merekabentuk, membina dan menyelenggara sistem pembentungan

TABLE OF CONTENTS

CHAPTER	DESCRIPTION	PAGE
	TITLE	i
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENT	iv
	ABSTRACT	v
	ABSTRAK	vi
	LIST OF CONTENTS	vii
	LIST OF FIGURES	xiii
	LIST OF TABLES	xv
	LIST OF APPENDICES	xvii
1	INTRODUCTION	
	1.1 Introduction	1
	1.2 Problem Statement	2
	1.3 Study Area	3
	1.3.1 Flow Characteristics	3
	1.3.2 Infiltration Rate	4
	1.4 Objectives Of The Study	4
	1.5 Scope of the Study	4
	1.6 Benefits of the Study	5

2 LITERATURE REVIEW

2.1 Introduction	6
2.2 Sewer Design	6
2.3 Inflow and Infiltration Surveys	8
2.4 Measuring and Sampling of Flow in Sewers	9
2.5 Equipment Used	11
2.6 Malaysian Standard MS1228:1991	11
2.7 Inflow and Infiltration	12
2.7.1 Infiltration	12
2.7.2 Inflow	12
2.7.2.1 Steady Inflow	13
2.7.2.2 Direct Inflow	14
2.7.2.3 Total Inflow	14
2.7.2.4 Delayed Inflow	14
2.7.2.5 Sustained Inflow	14
2.8 Evaluation of Sewer Condition	14
2.8.1 Flow Measurement	14
2.8.1.1 Base Flow	15
2.8.1.2 Infiltration	15
2.8.1.3 Inflow	16
2.8.2 Pre-installation Considerations	16
2.8.2.1 Meter Maintenance	
Monitoring	17
2.8.3 Data Evaluation	17
2.8.4 Rainfall Measurement	17
2.8.5 Groundwater Gauging	18
2.8.6 Rainfall Induced Infiltration/Inflow	18
2.9 Flow Measurement Methodology	18
2.10 Wastewater Flow Rates	20
2.10.1 Components of Wastewater Flow	20
2.11 Types of Sewer Systems	21

2.12	Wastewater Sources and Flow Rates	21
2.12.1	Domestic Wastewater Sources and Flow Rates	21
2.12.2	Residential Areas	22
2.12.3	Commercial Districts	22
2.12.4	Institutional Facilities	22
2.12.5	Recreational Facilities	22
2.12.6	Sources and Rates of Industrial Wastewater	23
2.13	Analysis of Wastewater Flow Rate Data	23
2.13.1	Flow rates for Design	23
2.13.2	Average Daily Flow	23
2.13.3	Maximum daily Flow	24
2.13.4	Peak Hourly Flow	24
2.13.5	Minimum Daily Flow	24
2.13.6	Minimum Hourly Flow	24

3 RESEARCH METHODOLOGY

3.1	Introduction	26
3.2	Project Activities	26
3.3	Infiltration Study	29
3.3.1	Field Test Model	29
3.3.1.1	Test Procedure	30
3.3.2	Rainfall Measurement	30
3.3.3	Laboratory Test Model	30
3.3.4	Leakage Test	32
3.3.4.1	Test Procedure for Leakage Test	33
3.3.5	Infiltration Test	33
3.4	Measuring Modes	34
3.4.1	Measurement Using One Manhole	34
3.4.2	Measurement Using Two Manholes	34

3.5 Data Collection and Analysis	35
3.6 Flow Measurement	35
3.6.1 Average Daily Flow	35
3.6.2 Maximum Daily Flow	36
3.6.3 Minimum Daily Flow	36
3.6.4 Minimum Hourly Flow	36
3.6.5 Peak Hourly Flow	36
3.7 Field Data	37
3.8 Data Collection and Analysis	37
3.9 Selection of the Sewer Line	37
3.10 Population Equivalent	37

4 RESULTS ANALYSIS AND DISCUSSION

4.1 Infiltration Study	39
4.1.1 Infiltration Study Conducted on Laboratory Model	39
4.1.1.1 Leakage Test	39
4.1.1.2 Infiltration Test	40
4.1.2 Infiltration Study Conducted on Field Test Model	41
4.1.2.1 February 2005	42
4.1.2.2 March 2005	42
4.1.2.3 April 2005	43
4.1.2.4 May 2005	43
4.1.2.5 June 2005	43
4.1.2.6 July 2005	44
4.1.2.7 August 2005	44
4.1.2.8 September 2005	45
4.1.2.9 February to September 2005	45
4.2 Flow Characteristics Study	54
4.2.1 Calibration of ISCO Area-Velocity	

Flow Meter	55
4.2.2 Flow Characteristics using Flow Data Collected From manhole MH11 (PE1705), Taman Sri Pulai area of Johor Bahru	57
4.2.2.1 First Monitoring 11 th to 15 th of June 2005	59
4.2.2.2 Second Monitoring 16 th to 20 th of June 2005	59
4.2.2.3 Third Monitoring 29 th of June to 3 rd of July 2005	60
4.2.2.4 Fourth Monitoring 6 th to 9 th of August 2005	60
4.2.2.5 Fifth Monitoring 23 rd to 25 th of August 2005	61
4.2.2.6 Sixth Monitoring 26 th to 31 st of August 2005	62
4.2.2.7 Seventh Monitoring 4 th to 6 th of September 2005	62
4.2.2.8 Eighth Monitoring 7 th to 10 th of September 2005	63
4.2.3 Flow Characteristics using Flow Data Collected From manhole MH299 (PE3456), Taman Universiti area of Johor Bahru	72
4.2.3.1 First Monitoring 22 nd to 27 th of September 2005	75
4.2.3.2 Second Monitoring 30 th of September to 5 th of October 2005	75

5	CONCLUSIONS AND RECOMENDATIONS	
	5.1 Conclusions	79
	5.1.1 Infiltration	79
	5.1.2 Flow Characteristics	80
	5.2 Recommendations	80
	REFERENCES	82
	APPENDICES	85

LIST OF FIGURES

FIGURE NO	TITLE	PAGE
3.1	Flow Chart Showing Research Methodology	28
3.2	The layout plan of field model and down stream manhole MH74a	29
3.3	The Laboratory Physical Model	31
3.4	and side views of the laboratory test model	32
3.5	Rainfall pumping into the laboratory model for infiltration test	34
3.6	An ISCO Area-Velocity Flow Meter model 4250	35
4.1	Infiltration rate corresponding to leakage rate versus rainfall duration.	42
4.2	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of February, 2005	47
4.3	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of March, 2005	49
4.4	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of April, 2005	51
4.5	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of May, 2005	53
4.6	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of June, 2005	55
4.7	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of July, 2005	57
4.8	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of August, 2005	59
4.9	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the month of September, 2005	61

4.10	Rainfall in mm against Infiltration in liters/day/km-length/mm-diameter for the months of February to September, 2005	54
4.11	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 11 th of June 2005 to 15 th of June 2005	70
4.12	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 16 th of June 2005 to 20 th of June 2005	70
4.13	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 29 th of June 2005 to 3 rd of July 2005	71
4.14	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 6 th of August 2005 to 9 th of August 2005	71
4.15	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 23 rd of August 2005 to 25 th of August 2005	72
4.16	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 26 th August 2005 to 31 st August 2005	72
4.17	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 4 th of September 2005 to 6 th of September 2005	73
4.18	Hydrograph showing flow pattern in Manhole MH11, Taman Sri Pulai dated 7 th of September 2005 to 10 th of September 2005	73
4.19	Hydrograph showing typical flow pattern in Manhole MH11, Taman Sri Pulai on a weekend dated 27 th of August 2005	74
4.20	Hydrograph showing typical flow pattern in Manhole MH11, Taman Sri Pulai on a weekday dated 29 th of August 2005	74
4.21	Hydrograph showing Flow Pattern in MH299, Taman Universiti dated 22 nd of September 2005 to 27 th of September 2005	76
4.22	Hydrograph showing Flow Pattern in MH299, Taman Universiti dated 30 th of September 2005 to 5 th of October 2005	77
4.23	Typical Hydrograph showing Flow Pattern in MH299, Taman Universiti on a weekend dated 25 th of September, 2005	77
4.24	Typical Hydrograph showing Flow Pattern in MH299, Taman Universiti on a weekday dated 26 th of September, 2005	78

LIST OF TABLES

TABLE NO	TITLE	PAGE
2.1	Minimum slope for various sized sewers at a flowing full velocity of ft/sec and corresponding discharge based on Manning's 'n' = 0.013	7
2.2	Types of Flow Parameters	19
2.3	Components of Wastewater Flow	20
2.4	Comparative Statement of Design Parameters of Past Studies	25
3.1	Characteristics of Laboratory Test Model	31
3.2	PE (Malaysian Standards)	38
4.1	Results summary for the laboratory leakage tests	40
4.2	Result summary for the laboratory infiltration test	41
4.3	Calibration of sensor number 1 with area velocity flow meter	56
4.4	Calibration of sensor number 2 with area velocity flow meter	56
4.5	Calibration of area velocity flow meter at very low water level	57
4.6	Details of data collection for flow characteristics from Manhole MH11, Taman Sri Pulai area of Johor Bahru	58
4.7	Details of flow characteristics from MH11, Taman Sri Pulai area of Johor Bahru	64
4.8	Details of Per Capita Flow Contribution for weekend and weekdays based on data collected from Manhole MH11, Taman Sri Pulai area of Johor Bahru	65
4.9	Details of Peak Flow Factor K based on data collected from Manhole MH11, Taman Sri Pulai area of Johor Bahru	66

4.10	Details of data collection for flow characteristics from Manhole MH299, Taman Universiti area of Johor Bahru	73
4.11	Details of flow characteristics from MH299, Taman Universiti area of Johor Bahru	73
4.12	Details of Per Capita Flow Contribution for weekend and weekdays based on data collected from Manhole MH299, Taman Universiti area of Johor Bahru	74
4.13	Details of Peak Flow Factor K based on data collected from Manhole MH299, Taman Universiti area of Johor Bahru	74

LIST OF APPENDICES

APPENDICES	TITLE	PAGE
A	Infiltration data collected from manhole MH74a, Taman Sri Pulai, field test model (abandoned sewer section MH74 – MH74a) from 10 th of February, 2005 to 30 th of September, 2005	85
B1	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	91
B2	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	92
B3	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	93
B4	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	94
B5	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	95
B6	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	96
B7	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	97
B8	Daily rainfall volume in mm and Infiltration in liters/day/ km-length/mm-diameter for the month of February, 2005	98
C	List of Project Inflow & Infiltration in Sewerage System	99
D	Some Pictures Taken During the Project	101

CHAPTER 1

INTRODUCTION

1.1 Introduction

Sewerage system plays an important role in ensuring public health, environmental protection and enhancing the standard of living of the general population. Sanitary sewers are constructed primarily to transport the wastewater of a community to a point of treatment or ultimate disposal. Inflow, infiltration and leakage are common problems in waste water collection system. Infiltration is water (groundwater and/or subsurface flow) that leaks into a sewer through defective joints and cracked or broken sewer pipes or manholes. Inflow is mainly water from surface runoff that enters the sewer via manholes. Leakage is water seepage through cracks and improperly joints of piping. Both I & I and leakage affect flow in the sewer.

The rate at which infiltration water enters a sewer depends on pipe condition, joints, groundwater levels, and soil permeability. For a new sewer, this is controlled by proper design, pipe selection, closely supervised construction, and limiting infiltration allowances. For an existing I & I problem sewer, a relief sewer may be constructed so that flow may bypass a treatment facility and flow straight to a receiving watercourse.

1.2 Problem Statement

There are several reasons why extraneous waters entering sewer systems are of concern. A serious problem results from excessive infiltration into sewers from groundwater sources, and high inflow rates into sewer systems directly from sources other than those that sewer conduits are intended to serve. The hydraulic and sanitary effects of these extraneous flows are particularly important because urban growth creates the need for all available sewer system capacity. Infiltration and inflow seriously affect the operation of sewer systems and pumping, treatment, and overflow regulator facilities. It also adversely affects the urban environment and the quality of water resources. Some examples of its detrimental effects are as follows:

1. Illegal taking of some of the capacity of the sewer facility that should be reserved for present sanitary wastewater flows and future urban growth.
2. Need for construction of relief sewer facilities before originally scheduled dates.
3. Surcharging and back flooding of sewers into streets and private properties.
4. Bypassing of raw wastewater at various points of spill or diversion into storm drains or nearby water courses.
5. Surcharging of pumping stations, resulting in excessive wear on equipment, higher power costs, or bypassing of flows to adjacent water sources.
6. Surcharging of wastewater treatment plants, with adverse consequences to treatment efficiency.
7. Diversion of flow from secondary-tertiary treatment stages, or bypassing of volumes of untreated wastewater into receiving waters.
8. Increases in the incidence and duration of storm water overflows at combined sewer regulators.

1.3 Study Area

The study consists of two main parts; the determination of flow characteristics and the evaluation of infiltration rate which are determined separately as discussed below:

1.3.1 Flow Characteristics

A total of two (2) major housing estates in Skudai area of Johor Bahru in the State of Johor are selected for the flow characteristics study, one in Taman Sri Pulai and the other in Taman Universiti. The areas selected are in the vicinity of Universiti Teknologi Malaysia. Both the sites are in fact located in fast growing areas, while Johor State itself is only third behind Kuala Lumpur and Selangor as far as development is concerned.

The sites are conducive to the overall study requirements. The generally undulating and hilly terrains must have posed specific problems to sewer construction when the first sewers were constructed 20 years ago in Skudai Township while newer developments in the study areas have newer sewers. The Skudai area in particular virtually receives varying rainfall intensity influenced by Gunung Pulai (mountains) where some of the state's valuable non-intake catchments areas are situated. In the circumstances, the area has various soil characteristics, water table conditions that influence infiltration and inflow, various types of premises contributing to wastewater flow (PE sources), and biological treatment systems employing oxidation ponds only. Furthermore, the area has mixed racial communities with different water-use habits, wastewater treatment facilities and industrial activities. Although the present study excludes study on industrial wastewater, a future study can be expected as follow-up to the present study that will inevitably include industrial wastewaters. It would then be a matter of extending the study to include the industrial premises.

1.3.2 Infiltration Rate

For the purpose of infiltration study two physical models; one a field test model which is an abandoned sewer between two manholes MH74 and MH74a, situated in the Taman Sri Pulai area of Skudai, Johor Bahru, where as the other is a real size laboratory test model installed in the hydraulics and hydrology laboratory of the Faculty of Civil Engineering, Universiti Teknologi Malaysia, Skudai campus.

1.4 Objectives of the study

The objectives of the study are:

- To evaluate design criteria (infiltration rate, peak flow factor & per capita flow contribution) for the sewerage system.
- To study the flow characteristics in the sewerage system.

1.5 Scope of the study

The scope of the study includes the data collection for the infiltration study and also for the flow characteristics study. Data collection is also done for daily rainfall measurement with the help of automatic rain gauge.

Water table measurement is also done to verify the condition of the soil surrounding the sewer, whether it is in saturated condition or unsaturated condition.

Data collection and analysis is also to be done on the two physical models one in the laboratory and other in the field.

1.6 Benefits of the study

The following benefits are realized from the study:

1. The benefits include a basis for corrective measures to be carried out in problem areas.
2. After improvement works reduction in infiltration will decrease cost of treatment.
3. True infiltration rate of peak flow factor will be more suitable for sewer design.
4. The results will also provide basis for future studies.

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