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

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A project report submitted in partial fulfilment of the requirements for the award of the degree of Master of Engineering (Civil – Hydrology and Water Resources)

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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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Deepest thanks to my wife and children especially for their encouragement and support in life. Without them I would not have been able to complete this project.
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 lebihan 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 berkaitrapat 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.
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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 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, whereas 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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