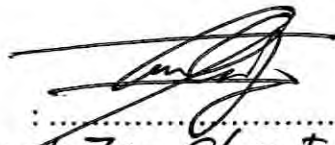


"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of the degree Bachelor of Mechanical Engineering (Structure & Material)"

Signature



Name of Supervisor

Mr. Tan Chee Fai

Date

27.05.2006

**STRUCTURAL DESIGN AND ANALYSIS OF SEWERAGE INSPECTION  
CRAWLER**


**ABD AZIZ BIN KADIR**

**This thesis is submitted to the Faculty of Mechanical Engineering  
In partial fulfillment of requirement for the degree  
Bachelor of Mechanical Engineering (Structure & Material)**

**Faculty of Mechanical Engineering  
Kolej Universiti Teknikal Kebangsaan Malaysia**

**MEI 2006**

I declared that this thesis entitled “Structural Design and Analysis of Sewerage Inspection Crawler” is the result of my own research except as cited in the references.

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Date : 27.05.2006.....

*Dedicated to my beloved parents, family and my special one*

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## ABSTRACT

Structural design and analysis of sewerage inspection crawler is almost like the inspection vehicle that being used to determined the defect that occur in the underground sewerage piping system where human cannot detect in a naked eye. This crawler actually work on a piping system by using a movable robotic camera to detect where the problem in the underground piping system happen. Combining the mechanical, electrical and electronic system, this robotic crawler will be the suitable inspection vehicle to the industrial field in order to detect the problem occurs in the sewerage piping system. This robotic crawler will increase the efficiency of underground piping inspection system by the movement along the piping system inspect by the robotic camera that will detect the area of defect on the underground piping system especially crack and being controlled by the controller at the surface. The development of sewerage inspection crawler will decamp into the narrow piping system follow the pipe specification equipped by the camera, tether cable and the other equipment in internal body of the vehicle. This robotic crawler being design with a basic usage for inspection process in sewerage inspection system and it also giving a good impact in industrial field especially on the underground pipe system inspection.

## ABSTRAK

Rekabentuk struktur dan analisis dalam perayap pembentungan adalah bertujuan melakukan operasi pemeriksaan terhadap sistem perpaipan di bawah tanah dimana manusia tidak dapat melakukannya. Perayap ini biasanya beroperasi di bawah sistem paip dengan menggunakan kamera robotik untuk mengenalpasti masalah yang berlaku pada sistem paip pembentung di bawah tanah. Dengan menggabungkan sistem mekanikal, elektrik dan elektronik perayap robotik ini adalah sangat bersesuaian untuk melakukan pemeriksaan terhadap sistem perpaipan di bawah tanah. Perayap ini dapat meningkatkan kecekapan pengendalian sistem perpaipan di bawah tanah dengan mengenalpasti terlebih dahulu masalah yang terdapat pada sistem tersebut terutamanya rekahan yang berlaku pada paip tersebut dengan dikawal oleh manusia yang berada di atas permukaan tanah. Dengan pembangunan perayap pemeriksaan pembentungan ini masalah untuk mengenalpasti kecacatan pada sistem paip yang sempit dapat diatasi dengan spesifikasi perayap yang dilengkapi dengan kamera dan kelengkapan lain yang terdapat pada perayap ini. Untuk rekabentuk ini perayap robotik ini direka dengan kegunaan asas untuk pemeriksaan selain itu ia juga dapat memberikan impak yang besar terutamanya dalam sistem pemeriksaan paip pembentungan di bawah tanah.

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## LIST OF NOTATIONS

<b>SYMBOL</b>	<b>DEFINITION</b>
$b, d$	- Height and width
$A$	- Cross section area
$M_x$	- Moment for the x axis
$W$	- Applied load
$R_a$	- Reaction force
$I$	- Moment of inertia
$L$	- Length
$y$	- Deflection
$E$	- Young's Modulus
$C_1$	- Unknown
<b>GREEK</b>	<b>DEFINITION</b>
$\nu$	- Poisson ratio
<b>SUBSCRIP</b>	<b>DEFINITION</b>
$m_{theory}$	- Theoretical Slope
$m_{exp}$	- Experimental Slope



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## CHAPTER 1

### INTRODUCTION

The Pipe Crawler is a robot controlled from a distance by a human operator (using an ordinary personal computer) as it travels through a plumbing network. It rides on wheels and is composed of multiple sections flexibly connected like the cars of a train. The concept of this inspection crawler is almost like an inspection vehicle and it can move along the piping system and measure the defect on this piping system. Sewerage crawler is a robotic crawler being design measure the problems on the underground sewerage piping system where human cannot detect the specific area of defect occur.

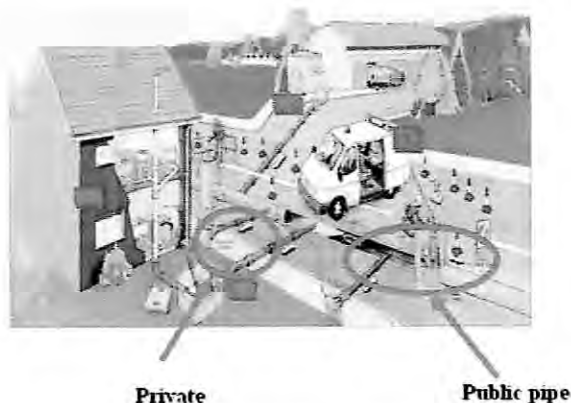
This type of crawler can be use to measure the problem on the underground piping system including breakage, crack and stuck between each connection on the system. Normally, this kind of crawler can be use by Indah Water Konsertium Sdn Bhd (IWK) to make sure the underground pipe system operated without any problem. Sewerage inspection crawler being design to solve the problem on determining the defects occur in the sewerage piping system. Beside all the company that uses the underground piping system can apply the concept of this inspection vehicle on the piping inspection system because the concept is almost same in all condition that occur in operating the system (piping system).

The concept of this crawler is only based on inspection; it will measure the crack and a leakage happen on the underground pipe system. This crawler is portable and it can be applicable in dirty and clear water system that involve on the underground pipe system.

### 1.1 Sewerage System in Malaysia

Sewerage systems are designed to collect, transfer, treat and dispose of domestic waste and wastewater from the toilet. In Malaysia, sewerage systems range from simple toilets providing little or no treatment to modern sewage treatment plants that employ mechanical means to treat large volumes of sewage to acceptable environmental standards. There are mainly two types of sewerage systems/services in Malaysia. The premises' sewerage systems are either connecting to a public sewage treatment plant or have an individual septic tank. IWK is mainly responsible for operating and maintaining the public sewage treatment plants and network of underground sewerage pipelines as well as providing desludging services to individual septic tanks. In order to make sure all the underground pipe systems work without a problem, IWK had made a decision to divide these underground pipes into two sections where:

- a) Public pipe (under IWK)
- b) Private pipe (individual responsibility)

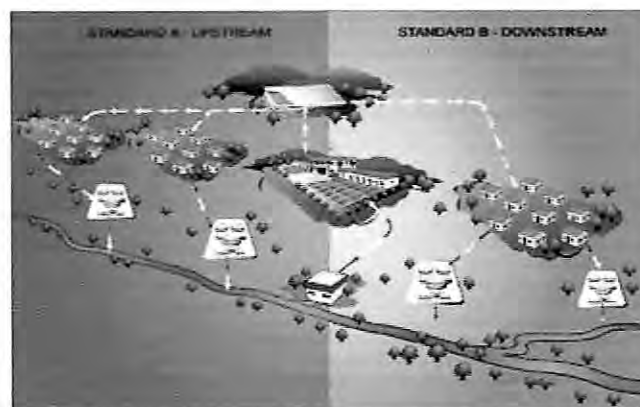


**Figure 1.1** Underground piping systems

Normally, if it has any request from customer about their private pipe, IWK will give services and if it has to pay so, the individual must pay to IWK for their service. The IWK underground pipe is made on Vertical clay pipe (VCP) so it will more expose to the breakage.

A network of public sewer pipes is being constructed in areas currently being served by individual septic tanks to link homes to sewage treatment plants. The responsibility for laying the public sewer pipes rests with Indah Water while house owners are required to lay the private connection pipe that will connect their sewage outlet to the public sewer pipe. Connected sewerage systems comprise a network of underground sewer pipes, pump stations, sewage treatment plants and sludge treatment facilities. They generally operate by gravity. If pipe near the logistic so it will be deeper. As a result, sewage treatment plants are usually located at drainage catchments outlets so that they can capture all the sewage easily without the high cost required for pumping. Normally the pipe will divide into two standards:

- a) Standard A (Upstream)
- b) Standard B (Downstream)



**Figure 1.2** Piping standard

### 1.1.1 Connected Sewerage System

Areas with connected service will have manholes along the public road and is covered with a round metal cover with IWK logo on top. In the manhole, which is about 10ft - 20ft deep, are sewerage pipes connecting the premises to the sewage treatment plant. Whenever there is any blockage, the checking and clearing of the blockage using a high powered vacuum and high pressured water hose will be done via the manhole.

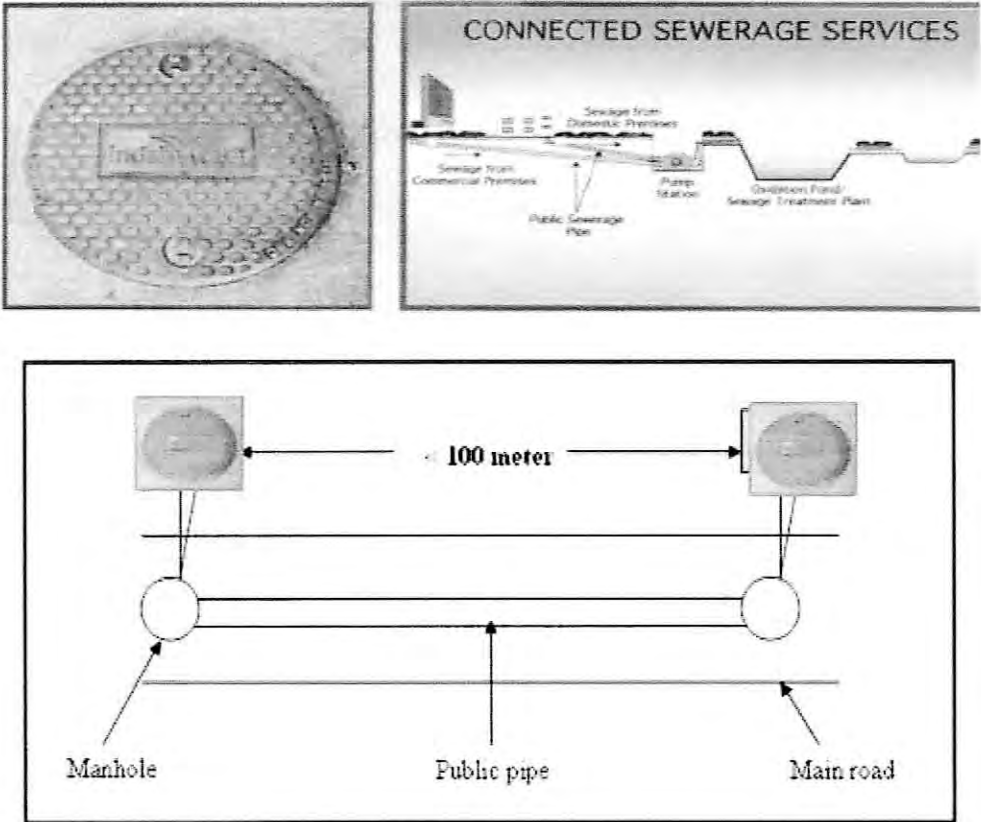


Figure 1.3 Distance between manholes

### **1.1.2 Sewerage Services**

Refurbishment, upgrading and constructing of public sewerage systems.

The rehabilitation work on existing plants with same capacity and/or treatment process will enhance the effectiveness and efficiency of such plants. The process entails fairly complex work ranging from civil engineering aspects of safety, security, cleanliness and aesthetics, to highly complex skilled mechanical and electrical serviceability of the plants.

The refurbishment works involve:

- a) Tidying up the treatment plant area and improving aesthetics and security
- b) Repairing or replacing pumps, electrical wiring and control panel
- c) Providing lightning protection
- d) Removing sludge from plants and holding tanks
- e) Testing and repairing processing equipment
- f) Ensure the plant meet applicable environmental standard
- g) Inspect and repairing or replacing sewage network pipes underground, which are connected to the plant.

### 1.1.3 Underground Pipe Summary

Example on Taman Melaka Perdana (AGH 139)

\*All the specification is same on each country.

\*Reference Indah Water Konsertium Sdn. Bhd Melaka

#### **For Public pipe (near neighbourhood)**

Max diameter = 225mm (9 inch)

Min diameter = 150mm (6 inch)

Max length < 100m

Min length = 15.666m

#### **For Logistic pipe (near logy)**

Max diameter = 375 mm

Min diameter = 300mm

Max length < 100m

Min length = 24.105m

From this data, estimation being made in specification of this crawler design to make sure that it can be use in this pipe system. According to this data, it have some major problem to design this crawler follow the specification of this pipe especially on how to fit this crawler on the underground pipe system and a conceptual design on this crawler according to the pipe type.

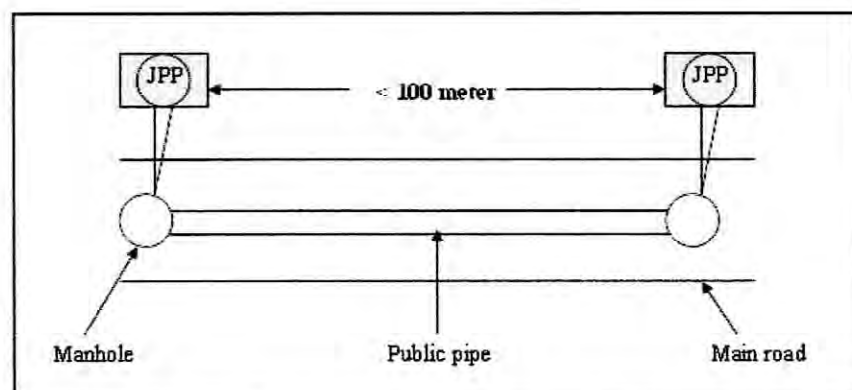
## 1.2 Problem Statement

To make sure this design is useful the major problem being determine. The problem on this designing inspection crawler is about the specification of the underground pipe system. It will be the most important thing because if the specification does not be measure this crawler probably cannot move into the underground pipe system. According to this problem, the research being made on Indah Water Konsertium Sdn. Bhd. (IWK) about the underground pipe specification and system. IWK staff Mr. Ishafudin B. Idris show the detail information about the specification that being use by IWK not only in Malacca but the whole state in Malaysia.

The specification of the underground pipe system for IWK is dividing into three groups where:

- a) Standard pipe (Diameter 225mm)
- b) Public pipe (Diameter 150mm)
- c) Building pipe (Diameter 100mm)

The specification between two manholes is less those a hundred meters. Manhole is the main entrance for every public pipe and it is located under the main road for every places.



**Figure 1.4** Manhole specification