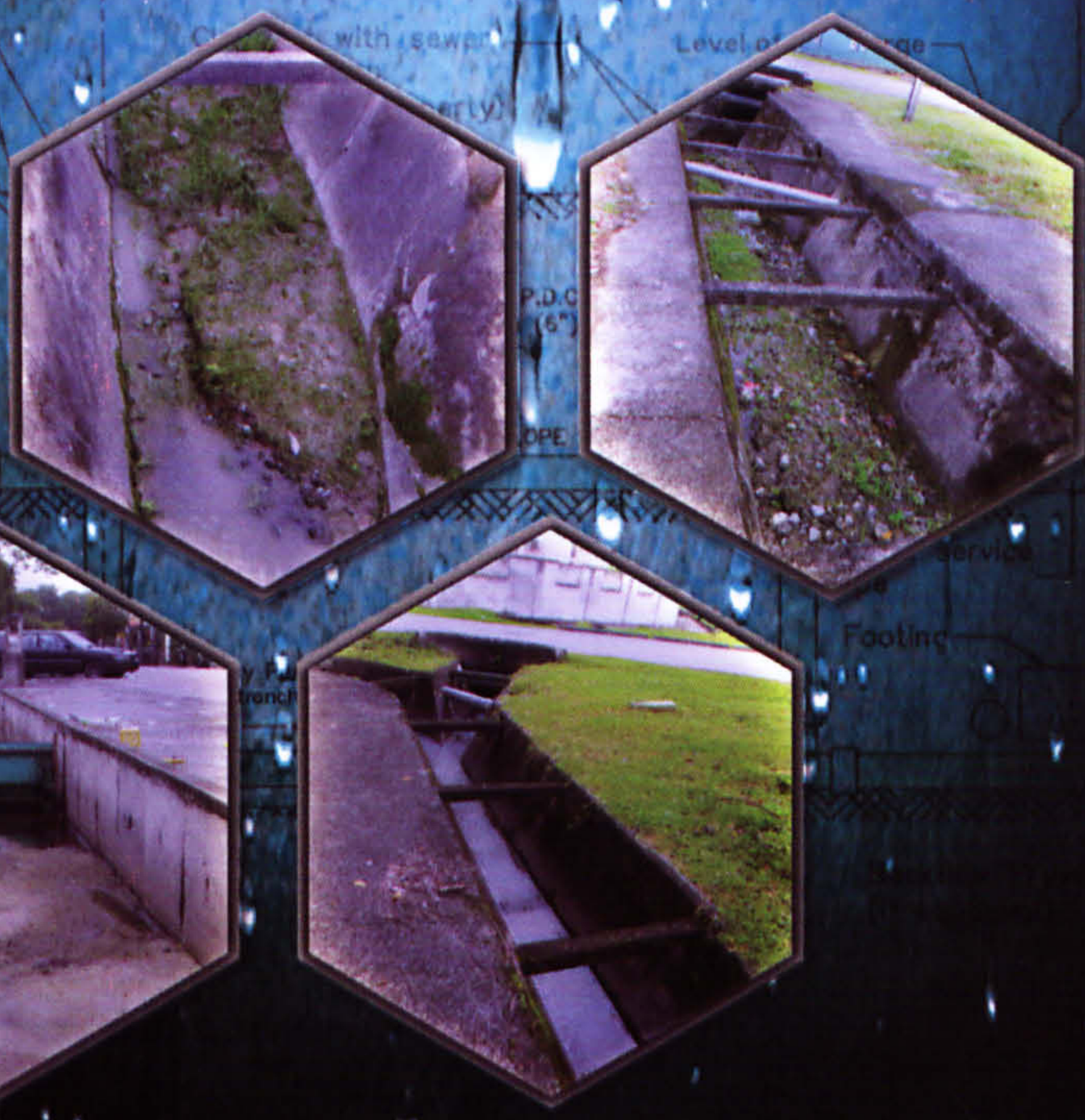
SEDIMENT IN OPEN STORM SEWER AND ITS REMOVAL



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PREFACE

Sedimentation in storm sewer had been known to have adverse effect to the sewer system itself such as reduced flow capacity (one of the cause of flash flood) and environmental pollution. However, it was only within the recent two decades that major research programs have been carried out especially for closed conduit sewer in European countries to understand the origin, nature and behavior as well as the impact of sedimentation entering the sewer systems. As for open storm sewer system which is widely used in developing countries, only limited studies have been reported so far. This book intended to fill this gap in the literature based on the findings from previous works done by the author in sediment sampling from urban concrete open storm sewers in Malaysia; development of self-cleansing design criteria to reduce sedimentation and testing of flushing in open storm sewer to improve sediment removal. It is hope that this book can be used as a vehicle to promote the dissemination of results of recent research in open storm sewer to design engineers, municipal bodies, sewer undertakers, academicians and well as postgraduate students who wish to increase their knowledge in this subject.

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LIST OF SYMBOLS

A	flow area [m^2]
A_{os}	total cross sectional area of the open sewer [m^2]
A_s	cross sectional area occupied by sediment deposit [m^2]
B	channel bed width [m]
B^*	bimodality parameter
C_p	Mallows' goodness-of-prediction
C_v	volumetric sediment concentration [ppm]
D_{gr}	dimensionless grain diameter
$D.R.$	discrepancy ratio
d	particle size [m]
d_{50}	particle median diameter size [m]
d_m	particle mean diameter size [m]
d_{md}	particle mode diameter size [m]
F_d	particle Froude number
g	acceleration due to gravity [m^2/s]
M_O	overturning moment [Nm]
M_R	resisting moment [Nm]
n	number of observation
Q	discharge [m^3/s]
R	hydraulic radius

Re	Reynolds number
Re_*	grain Reynolds number
R_p^2	coefficient of determination for regression model
R_{adj}^2	adjusted coefficient of determination for regression model
r	correlation coefficient
S_0	channel slope
S_s	sediment specific gravity
t_s	sediment deposition thickness [m]
V	average velocity [m]
V_c	critical velocity [m/s]
W	width [m]
y	flow depth [m]
y_0	normal flow depth [m]
γ_g	specific weight of gate [N/m2]
γ_w	specific weight of water [N/m2]
λ_0	Darcy-Weisbach friction factor
μ	mean value
θ	angle of gate opening from the horizontal axis [°]
θ_c	dimensionless critical shear stress
ρ	density of fluid [kg/m^3]
ρ_s	density of particle [kg/m^3]
σ	standard deviation
σ_g	geometric standard deviation

τ_c	critical shear stress [N/m^2]
υ	kinematic viscosity of fluid [m^2/s]

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ARI	Annual Recurrence Interval
ASTM	American Society for Testing and Materials
BC	Bau Commercial
BDCC	BDC Commercial
BDCR	BDC Residential
BLC	Bayan Lepas Commercial
BLI	Bayan Lepas Industrial
BLR	Bayan Lepas Residential
BoC	Bormill Commercial
BR	Bau Residential
BS	British Standard
CCTV	Closed-Circuit Television
CIRIA	Construction Industry Research and Information Association, UK
CPC	Central Park Commercial
DID	Department of Drainage and Irrigation, Malaysia

GHR	Green Height Residential
HSGR	Hui Sing Garden Residential
IDF	Intensity – Duration – Frequency
JSR	Jalan Song Residential
KSC	Kota Samarahan Commercial
KSR	Kota Samarahan Residential
LHS	Left Hand Side
MMC	Mak Mandin Commercial
MMI	Mak Mandin Industrial
MMR	Mak Mandin Residential
MPM	Meyer-Peter and Muller
MPSP	Majlis Perbandaran Seberang Perai
MSE	Mean Square Error
NTC	Nibong Tebal Commercial
NTR	Nibong Tebal Residential
PerI	Perai Industrial
PI	Pending Industrial
RHC	RH Plaza Commercial
RHS	Right Hand Side
SC	Serian Commercial
SR	Serian Residential
SSE	Sum of Square Error
SST	Sum of Square Total

TJC	Tabuan Jaya Commercial
TVD	Total Variation Diminishing
UK	United Kingdom

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INTRODUCTION

1.1 Background

Open sewer system are frequently used in developing (Geiger, 1990) and less developed countries to convey storm water runoff. Though closed conduit sewer is more hygienic and aesthetics; the construction and maintenance of closed conduit sewer are more costly than open sewer and need special equipment or trained staff. Due to this, open sewer system is still preferred in spite of the benefits of closed conduit sewer system. Open storm sewer system could be quite efficient in rapid removal of surface runoff; however, sediment deposition tends to build up in the drain after a period of time (see Figure 1.1). Sediment deposition in urban open storm sewer had caused many adverse effect to the sewer system itself such as reduction in hydraulic capacity (which had been identified as one of the cause of flash flood) and environmental pollution due to the high pollutant concentrations that might be released during the erosion of these depositions (Ashley, Wotherspoon, Coghlan *et al.*, 1992; Schellart *et al.*, 2010; Rodríguez *et al.*, 2012).

Generally, only limited data and works were available in the literature for sediment in storm sewer for developing and less developed countries as compared to European countries (Ashley

et al., 2004). Though some data on sediment for developing countries exist in unpublished literature such as consulting reports; these data are difficult to obtain, the measurement procedures are not always known and the variability from one study to another is great (Ashley *et al.*, 2004). Hence, there is still a lack of understanding of the sediment properties commonly found in urban open storm sewer especially in developing and less developed countries.

Figure 1.1 Sediment deposit in open storm sewer (Bong, 2013)

To reduce sediment deposition, open storm sewer has been designed to have self-cleansing properties. Many designers prefer to adopt a single minimum constant value of velocity or shear stress since these criteria are easier to use, especially for a simple or small sewer network. In Malaysia, to prevent