

625.734

AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
IRRIGATION AND HYDRAULICS DEPARTMENT

DESIGN OF OPEN DRAINS IN EGYPT

By
Eng. Atef Hosny El-Sayed
B.Sc. Civil Eng.
Channel Maintenance Research Institute
National Water Research Center
Ministry of Public Works and Water Resources

Thesis
Submitted In Partial Fulfillment of The Requirements for the
DEGREE OF MASTER OF SCIENCE
IN CIVIL ENGINEERING

625.734
A - H.

68583

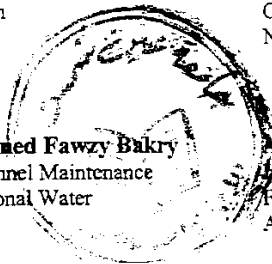
Supervised by

Prof. Dr. Mahmoud Abdel Lateef Mohamed
Prof. of Irrigation design
Faculty of Engineering
Ain Shams University

Prof. Dr. Ahmed Fakhry Khattab
Channel Maintenance Research Institute
National Water Research Center

Assoc. Prof. Mohammed Fawzy Bakry
Deputy Director of Channel Maintenance
Research Institute, National Water
Research Center

Assoc. Prof. Nahla Aboulatta
Irrigation and Hydraulics Dept.,
Faculty of Engineering
Ain Shams University



Cairo, Egypt

1998



**M.Sc. Thesis Submitted by
Eng. Atef Hosny El-Sayed
in Civil Engineering (Irrigation & Hydraulics)**

Examiners Committee

Signature

1. Prof. Dr. Mohamed Hamdi El Kateb
Irrigation and Hydraulics Dept.,
Faculty of Engineering,
Cairo University

M. H. El-Kateb

2. Prof. Dr. Mohamed El Niazi Ali Hammad
Irrigation and Hydraulics Dept.,
Faculty of Engineering,
Ain Shams University

M. A. El-Niazi

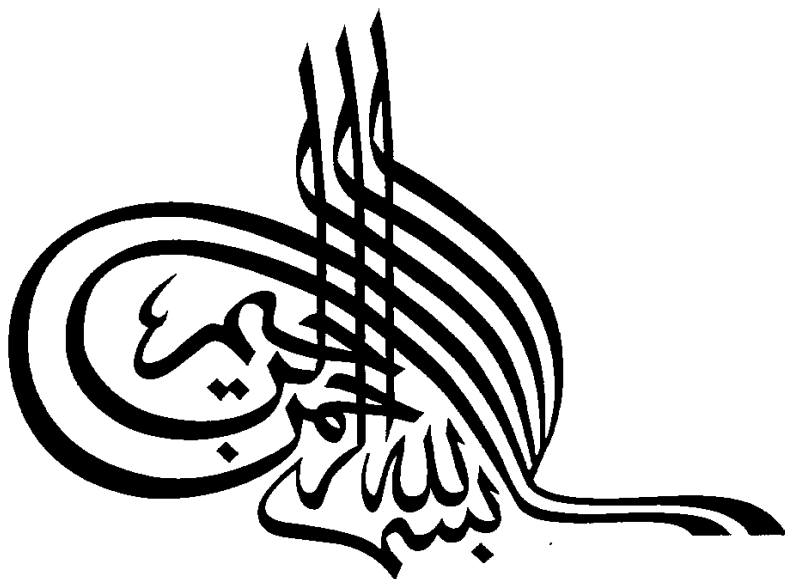
3. Prof. Dr. Mahmoud Abdel Lateef Mohamed
Prof. of Irrigation design
Faculty of Engineering
Ain Shams University

M. Abdel Lateef

4. Prof. Dr. Mohamed Fawzy Bakry
Channel Maintenance Research Center
National Water Research Center

Mohamed Fawzy

Date: /6 /11/ 1998



I would like to express my warmest thanks to my wife and my parents for their sacrifices, blessings and moral support.

STATEMENT

This thesis is submitted to Ain Shams University for the degree of Master of science in civil Engineering.

The work included in this thesis was carried out by the author in the Department of Irrigation and Hydraulics, Faculty of Engineering, Ain Shams University from 1992 to 1998.

No part of this thesis has been submitted for a degree or qualification at any other university or institution.

Date : 16/11/98

Name : Atef Hosny El-Sayed

Signature:



ACKNOWLEDGMENTS

I wish to express my deep gratitude and appreciation to **Prof. Dr. Mahmoud Abdel Lateef**, professor of Civil Engineering, Irrigation and Hydraulics department, Faculty of Engineering Ain Shams University for his guidance, useful suggestions, and encouragement throughout this work.

Special acknowledgment to **Prof. Dr. Ahmed F. Khattab**, Professor of Civil Engineering, Channel Maintenance Research Institute (CMRI), NWRC, for his kind supervision, comments and stimulating discussion which gratefully acknowledge and sincerely appreciated.

Also special word of thanks to **Dr. Mohamed F. Bakry**, Associate professor and Deputy Director of CMRI, and **Dr. Nahla Aboulatta** Associate professor, irrigation and Hydraulics department, Faculty of Eng. Ain Shams Univ. for their kind and parturient guidance, valuable advice and devoted time and effort throughout this work.

The suggestions of the comprehensive examination committee are sincerely appreciated.

TABLE OF CONTENTS

STATEMENT	I
ACKNOWLEDGMENTS	ii
TABLE OF CONTENTS	iii
LIST OF FIGURES	vii
LIST OF PHOTOS	viii
LIST OF TABLES	ix
LIST OF SYMBOLS	x
ABSTRACT	xi
CHAPTER I	
INTRODUCTION	1
CHAPTER II	
LITERATURE REVIEW	4
2.1 Background	4
2.2 Agricultural Drainage in Egypt	4
2.2.1 Open Drainage	4
2.2.2 Tile Drainage	6
2.3 Design Practices for Drainage Systems	7
2.3.1 General	7
2.3.2 Field Drainage Requirements	8
2.3.2.1 Characteristics of Topography	8
2.3.2.2 Climate	8
2.3.2.3 Soil	9
2.3.2.4 Surface Irrigation and Land Use	9
2.3.2.4.1 Land Use	10

2.3.2.5 Ground Water and Drainage	10
2.3.2.6 Drainage Models or Drainage Rate	11
2.4 Characteristics of Open Channel Drainage Systems	13
2.4.1 Main Types According to Size	13
2.4.1.1 Field Drains	13
2.4.1.2 Public Drains (Main, Branch, Sub Branch Drains)	13
2.4.2 Classification of Drains by Area Served	13
2.4.3 Alignment of Open Drains	13
2.4.3.1 Irregular Areas	14
2.4.3.2 Sloping Areas	14
2.4.3.3 New Reclaimed Lands	14
2.4.4 Drainage Discharge Rate	15
2.4.5 Permissible Flow Velocities	15
2.4.6 Hydraulic Gradient	16
2.4.7 Depth of Drainage	16
2.4.8 Water Levels of Drains	17
2.4.9 Bed Slopes	17
2.4.10 Side Slopes	18
2.4.11 Freeboard	20
2.4.12 Synoptic Diagram	20
2.4.13 Design of Cross-Section	20
2.5 Empirical Design Regime Theory for Open Drains	25
2.5.1 Empirical Design Regime Formulae for Open Drains in Egypt	28

CHAPTER III

STABILITY OF OPEN CHANNELS	32
3.1 Classification of Open Channels	32
3.1.1 Prismatic and Non-Prismatic Channels	32
3.1.2 Rigid and Mobile Boundary Channels	32
3.2 Channel Stability	33
3.2.1 Discharge Condition	34
3.2.2 Longitudinal Slopes of Open Channels	36
3.2.3 Shape of Open Channels	36

3.2.4 Boundary Material	37
3.2.5 Water Temperature	37
3.2.6 Wash Load and Bed Material Load	38
3.2.7 Effect of Sinuosity or Curvatures	39
3.2.8 Effect of Wind on Stability of Channels	39

CHAPTER IV

DESCRIPTION OF THE SELECTED DRAINS AND THE FIELD

DATA PROCESSING	40
4.1 Desiccation and Characteristics of the Selected Drains	40
4.1.1 Drains of First Order (Main Drains)	45
4.1.2 Branch Drains	45
4.2 Data Measurements	46
4.2.1 The Equipment	56
4.2.2 Velocity and Discharge Measurements	56
4.2.3 Slope Measurements	62
4.3 Laboratory Tests	64
4.3.1 Sediment Transport Sampling	64
4.3.2 Soil Classification and Properties	72

CHAPTER V

ANALYSIS OF FIELD DATA	75
5.1 Presentation of The Results	75
5.1.1 Relationship Between A and Q	75
5.1.2 Relationship Between R and Q	77
5.1.3 Relationship Between P and Q	77
5.1.4 Relationship Between b and Q	80
5.1.5 Relationship Between D and Q	82
5.1.6 Relationship Between T_w and Q	82
5.1.7 Relationship Between V and Q	85
5.1.8 Relationship Between S and V	87
5.1.9 Relationship Between R and D	87
5.1.10 Relationship Between b and P	90
5.1.11 Relationship Between b and T_w	91
5.1.12 Correlation Between Average Velocity V and Drain	

Factor F	91
5.2 State of Aquatic Weed	96
5.3 Comparison Between the Present Study With Other Investigations	96
CHAPTER VI	
DESIGN PROCEDURE AND APPLICATIONS	100
6.1 Design Procedure	100
6.1.1 Area A Based on Discharge Q and Type of Soil underline Main and Branch Drains	100
6.1.2 The Hydraulic Radius R	100
6.1.3 Wetted Perimeter P	101
6.1.4 D and b as a Function of The Discharge Q	101
6.1.5 Top Width T_w as a Function of The Discharge Q ...	101
6.1.6 Determination of The Design Slope S	101
6.2 Additional Useful Relationships	102
6.2.1 Estimation of D, when R is Known or Vice Versa ..	102
6.2.2 Estimating of b when P is Known or Vice Versa ...	102
6.2.3 Estimating of b when T_w is known or Vice Versa ...	102
6.3 Application to the Design Procedure	102
Case (1) Main Drains with Sandy Loam Bed and Silty Clay Banks	102
Case (2) Branch Drain with Silty Loam Bed and Banks ..	104
Case (3) Non - Equilibrium (Unstable) Drain	106
CHAPTER VII	
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	109
7.1 Summary, Conclusions	109
7.2 Recommendations	112
REFERENCES	114
APPENDIX (A)	121
ARABIC SUMMARY	144