شبكة المعلومات الجامعية

بسم الله الرحمن الرحيم

شبكة المعلومـــات الجامعية

التوثيق الالكتروني والميكروفيلم

شبكة المعلومات الجامعية

جامعة عين شمس

التوثيق الالكتروني والميكروفيلم

﴿ قـسـم ﴾

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
علي هذه الأفلام قد اعدت دون آية تغيرات

يجب أن

تحفظ هذه الأفلام بعيداً عن الغبار

في درجة حرارة من 15 – 20 مئوية ورطوبة نسبية من 20-40 %

To be kept away from dust in dry cool place of
15 – 25c and relative humidity 20-40 %

بعض الوثائق الأصلية تالفة

بالرسالة صفحات

لم ترد بالأصـــل

APPLICATION OF WATER HYACINTH ASH AS A PARTIAL REPLACEMENT FOR CEMENT

by

Aly Ahmed Aly Hassan Makhlouf

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
CIVIL ENGINEERING (STRUCTURAL ENGINEERING)

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
June, 2002

APPLICATION OF WATER HYACINTH ASH AS A PARTIAL REPLACEMENT FOR CEMENT

by

Aly Ahmed Aly Hassan Makhlouf

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
CIVIL ENGINEERING (STRUCTURAL ENGINEERING)

Under the Supervision of

Assoc. Prof. Dr.
Hossam Abdel-Ghafour Hodhod
Structural Engineering Dept.
Cairo University

Assoc. Prof. Dr.
Mohamed Anwar El-Sayed
Construction Research Institute
National Water Research Center

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
June, 2002

APPLICATION OF WATER HYACINTH ASH AS A PARTIAL REPLACEMENT FOR CEMENT

by

Aly Ahmed Aly Hassan Makhlouf

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY
in
CIVIL ENGINEERING (STRUCTURAL ENGINEERING)

Approved by the
Examining Committee

Assoc. Prof. Dr. Hossam Abdel-Ghafour Hodhod, Thesis Main Advisor

Assoc. Prof. Dr. Mohamed Anwar El-Sayed, Thesis Advisor

Prof. Dr. Mahmoud Aly Reda Youssef, Member

Prof. Dr. Assem Abdel-Alim, Member

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
GIZA, EGYPT
June, 2002

TABLE OF CONTENTS

	Page
TABLE OF CONTENTS	iv
LIST OF TABLES	ix
LIST OF FIGURES	xi
LIST OF SYMBOLS	xx
ACKNOWLEDGEMENT	xxii
ABSTRACT	xxiii
1. INTRODUCTION	1
2. LITERATURE REVIEW	4
2.1 Introduction	4
2.2 Production and Utilization Rates	5
2.3 Classification of Mineral Admixture	7
2.4 Production and Availability of Pozzolanic Material	10
2.4.1 Rice husk ash	10
2.4.1.1 World rice production	10
2.4.1.2 Methods of production of rice husk ash	10
2.4.1.3 Rice husk incineration	12
2.4.1.4 Grinding of rice husk ash and fineness	14
2.4.1.5 Silica in rice husk ash	15
2.4.1.6 Pozzolanic activity of rice husk ash	17
2.4.2 Condensed silica fume	19
2.4.2.1 Historical background of silica fume	19
2.4.2.2 Production of different types of silica fume	20
2.4.2.3 Chemical composition of silica fume	21
2.4.2.4 Physical characteristics of silica fume	21
2.4.2.5 Water requirement and pozzolanic activity of silica fume	24

2.5 Effect of Mineral Admixture on Fresh Concrete 24

2.6 Effect of Mineral Admixture on Properties of Hardened Concrete 28

2.6.1 Effect of Mineral Admixture on Mortar and Concrete Strength 30

2.6.2 Effect of Mineral Admixture on Volume Change 40

2.7 A Recent Development 42

3. PRODUCTION AND PROPERTIES OF WATER HYACINTH ASH 45

3.1 Introduction 45

3.2 Historical Background on Water Hyacinth 45

3.3 Production of Water Hyacinth Ash (WHA) 47

3.4 Pozzolanic Activity of WHA 51

3.5 Chemical Composition 52

3.6 Specific Gravity 53

3.7 X-Ray Diffraction 53

3.8 Morphological studies of WHA 53

3.9 Water Hyacinth Ash as Cement Additive 58

3.9.1 Setting time 58

3.9.2 Compressive strength of mortar cubes 60

3.9.3 Tensile strength 64

3.10 Correlation parameters of setting time of WHA paste 65

3.11 Relationship between the Mechanical Properties of WHA and OPC Mortar 66

4. EXPEREMENTAL PROGRAM 68

4.1 Introduction 68

4.2 Effect of WHA on Fresh Concrete 68

4.3 Effect of WHA on Mechanical Properties of Concrete 68

4.3.1 Materials and mix proportions 68
4.3.2 Procedure for mixing and casting concrete 70
4.3.3 Measurement of compressive strength 71
4.3.4 Measurement of flexural and splitting strength 71
4.3.5 Measurement of Modulus of elasticity 71
4.3.6 Measurement of drying shrinkage 72
4.3.7 Creep test 72
4.4 Morphology and Microstructure 78
4.4.1 Electron Microscope Scanning sample preparation 73
4.5 Durability Testing program 74
4.5.1 Chloride ion concentration analysis 75
4.5.1.1 Soluble chloride test 75
4.5.1.2 Total chloride test 76
4.5.2 Accelerated carbonation test 76
4.5.2.1 Test procedure and apparatus 76
4.5.3 Pore structure 79
4.5.3.1 General 79
4.5.3.2 Procedure of sample preparation 79
4.5.3.3 Mercury porosimetry technique 80
5. MECHANICAL AND DEFORMATIONAL PROPERTIES OF WHA CONCRETE 87
5.1 Introduction 82
5.2 Properties of WHA Fresh Concrete 82
5.3 Compressive Strength of Concrete 83
5.4 Splitting Strength of Concrete 89
5.5 Flexural Strength of Concrete 89
5.6 Elastic Modulus of Concrete 90

5.7 Rebound Number 92
5.8 Shrinkage Behaviour 94
5.9 Creep Behaviour 95
5.10 Relationships between the Mechanical Properties of Concrete 96
6. INSPECTION OF WHA MORTAR AND CONCRETE USING SCANNING ELECTRON MICRSCOPE (SEM) 99
6.1 Introduction 99
6.2 Inspection of WHA Mortar using SEM 99
6.2.1 Inspection of interface (near surface) with sand 101
6.2.2 Inspection of paste 101
6.3 Inspection of Concrete using SEM 108
6.3.1 Inspection of interface (near surface) with gravel 111
6.3.2 Inspection of interface (near surface) with sand 117
6.3.3 Inspection of paste 118
7. PORE STRUCTURE Of WHA MORTAR AND CONCRETE 131
7.1 Introduction 131
7.2 Measurement of Pore Structure 132
7.3 Results and Discussion of Pore Structure of Mortar 133
7.4 Results and Discussion of Pore Structure of Concrete 141
7.5 Relationship between Porosity and Compressive Strength 145
8. CHLORIDE AND CARBONATION PERMEABILITY IN WHA CONCRETE 155
8.1 Introduction 155
8.2 Chlorides in Concrete 156
8.3 Results and Discussion of Chloride Ion contents 157
8.3.1 Total chloride ion content 157
8.3.2 Soluble chloride ion content 163