



Faculty of Engineering

MODIFIED CEMENT SYSTEM: DURABILITY AND AESTHETIC

Siti Zarini Binti Mohamed Jizi

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(HURUF BESAR)

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Alamat Tetap: 967, Taman Nuri,
Jalan Dato' Kumbang,
05300 Alor Star,
Kedah.

Tarikh: 14 Mei 2009

(TANDATANGAN PENYELIA)

PN. NORSUZAILINA MOHAMED SUTAN
(Nama Penyelia)

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(Puan Norsuzailina Mohamed Sutan)

Project Supervisor

Faculty of Engineering

Universiti Malaysia Sarawak

Date: _____

For my beloved family, special friends and my friends

Thanks for everything.

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ABSTRACT

Efflorescence is a type of discoloration. It is a deposit salt, usually white in color that occasionally develops on the surface of concrete. Although unattractive, efflorescence is usually harmless to the structure such as concrete bridge. In rare cases excessive efflorescence, within the pores of the material, can cause expansion that may disrupt the surface. Efflorescence is caused when soluble salts and other water dispersible materials come to the surface of concrete and mortars. It is induced by low temperatures, moist conditions, condensation, rain, and water added to the surface of concrete. The modified cement system can reduce the efflorescence but cannot avoid it because of the reaction of cement hydration itself. This study proved that by using the modified cement system such as Pulverized Fly Ash (PFA) and Polymers (water based latex grade 29Y46), the efflorescence can be reduced. The mix proportion with and without PFA and Polymers are tested with various properties such as strength test, water absorption and efflorescence in order to understand the effect against the performance of the mortar. The results from this study showed that the modified mortar which is the sample with PFA and Polymers has higher strength, durability, and less efflorescence compared with non-modified cement system.

ABSTRAK

Efflorescence adalah perubahan warna yang berlaku pada konkrit. Ia adalah sejenis garam deposit, biasanya berwarna putih dan terbentuk di permukaan konkrit. Walaupun menjejaskan nilai estetika, *efflorescence* biasanya tidak merbahaya terhadap struktur seperti jambatan konkrit. Untuk sesetengah kes, pengembangan pada liang-liang di dalam konkrit juga mungkin akan mengganggu permukaan konkrit. *Efflorescence* berlaku disebabkan garam-garam larut dan air yang terkandung dalam bahan-bahan binaan akan bertindak balas, (contohnya pasir dan batu baur) dan berlaku di permukaan konkrit. Faktor ini disebabkan oleh suhu yang rendah, kelembapan, pemeluwapan, hujan, dan penambahan air di permukaan konkrit. Cara pencegahan pembentukan *efflorescence* adalah dengan menjalankan beberapa kajian termasuk ujian penyerapan, ujian ketahananlasakan dan ujian terhadap *efflorescence* itu sendiri. Sistem campuran di dalam mortar adalah salah satu cara untuk mengurangkan pembentukan *efflorescence* tetapi tidak dapat dilupuskan secara keseluruhan disebabkan tindak balas yang berlaku di dalam bahan campuran simen. Walau bagaimanapun, kajian ini membuktikan bahawa sistem campuran di dalam mortar contohnya *Pulverized Fly Ash (PFA)* and *Polymers (water based latex grade 29Y46)* dapat mengurangkan pembentukan *efflorescence* ke atas konkrit atau mortar. Sistem campuran di dalam mortar dan tanpa campuran diuji dengan beberapa ujian seperti ujian penyerapan air, ujian ketahananlasakan dan *efflorescence*, bagi memantapkan pemahaman terhadap prestasi kesan-kesan yang berlaku ke atas konkrit. Keputusan dari kajian mendapati sistem campuran di dalam mortar adalah lebih tinggi terhadap kekuatan konkrit, ketahananlasakan serta dapat mengurangkan pembentukan *efflorescence* dibandingkan dengan sistem campuran tanpa PFA and *Polymers*.

TABLE OF CONTENT

CONTENT	PAGE
TITLE PAGE	i
DEDICATION	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	iv
ABSTRAK	v
TABLE OF CONTENT	vi
LIST OF TABLE	xi
LIST OF FIGURE	xii
CHAPTER 1 INTRODUCTION	1
1.1 Project Overview	1
1.2 Objectives of Study	2
1.3 Scope of Study	2
1.4 Outline of the Project	4
CHAPTER 2 LITERATURE REVIEW	6
2.1 Introduction	6
2.2 Ordinary Portland Cement (OPC)	7
2.2.1 Process of Production	8

2.2.2	Chemical Composition of Portland Cement	8
2.2.3	Hydration Process	9
2.3	Polymers	10
2.3.1	Polymer Modified Concrete	11
2.3.2	Polymer Concrete	13
2.4	Pozzolans (PFA)	15
2.5	Concrete Durability	17
2.5.1	Main Durability Problems and Causes of Deterioration	18
2.5.2	Effect of Chemical Attack	19
2.5.2.3	Effect of Efflorescence	18
2.5.2.1	Effect of Alkali Aggregate Reaction	21
2.5.2.2	Effect of Sulphate Attack	23
2.6	Pore Structure	25
2.6.1	Definition of Porosity	25
2.6.2	Capillary of Pores	25
2.6.3	Gel Pores	25
2.7	Permeability and Water Absorption	26
2.8	Relationship Between Permeability and Porosity	28
2.9	Factors Influencing the Strength and Durability of Concrete	30
2.91	Water Binder Ratio	30
2.92	Curing Process	30
2.10	Conclusions	31

CHAPTER 3	METHODOLOGY	32
3.1	Introduction	32
3.2	Experimental Procedure	33
3.3	Materials Used	34
3.3.1	Ordinary Portland Cement	35
3.3.2	Sand	35
3.3.3	Water	35
3.3.4	Pozzolan (PFA)	36
3.3.5	Polymer (Water Based Polymer Latex)	36
3.4	Specimens Preparation	38
3.4.1	Preparation of Moulds and Casting	38
3.4.2	Mix Design	39
3.4.3	Design Mix Specification	39
3.4.4	Mixing Process	42
3.4.4	Water Cement : Ratio	43
3.4.5	Curing	43
3.5	Test Methods	44
3.5.1	Absorption Test	44
3.5.2	Compression	45
3.5.3	Puddle Test & Electrical Reflectance Photometer	46
3.5.4	Humidity and Temperature	47
CHAPTER 4	RESULTS, ANALYSIS AND DISCUSSIONS	48
4.1	Introduction	48

4.2	Compressive Strength Test	49
4.2.1	PFA Replacement	52
4.2.1.1	10 % and 20% Replacement of PFA	53
4.2.1.2	50% Replacement of PFA	54
4.2.2	Polymers as Additives in Cement System	57
4.2.2.1	1 % Admixtures of Polymers	57
4.2.2.2	2 % and 3 % Admixtures of Polymers	59
4.3	Water Absorption	61
4.3.1	Water Absorption for PFA as Admixtures	63
4.3.1.1	Water Absorption 0% and 10% PFA Replacement	64
4.3.1.2	Water Absorption 0% and 20% PFA Replacement	65
4.3.1.3	Water Absorption 0% and 50% PFA Replacement	66
4.3.2	Water Absorption for Polymer as Admixtures	67
4.3.2.1	Water Absorption 0% and 1% Polymers as Admixtures	67
4.3.2.2	Absorption 0%, 2% and 3% Polymers as Admixtures	68
4.4	Puddle Test & Electrical Reflectance Photometer	70
CHAPTER 5	CONCLUSION & RECOMMENDATION	75
5.1	Conclusion	75

5.2	Recommendation	77
	REFERENCES	78
	APPENDIX	81

LIST OF TABLE

Table		Page No.
2.1	Major Compounds of Portland Cement (Neville,1986)	9
2.2	Typical Properties of Polymer-Containing Concrete Composites And Portland Cement Concrete (Ohama, Y.)	12
2.3	Typical Range of Properties of Common PC Products and Portland Cement Concrete (Ohama, Y.)	14
3.1	Mix Design for PFA (w/c: 0.5)	41
3.2	Mix Design for Polymer (Water Based Latex, w/c: 0.5)	41
4.1	Strength Test Result for PFA Sample	50
4.2	Strength Test Result for Polymer Sample	51
4.3	Water Absorption Result for PFA Sample	61
4.4	Water Absorption Result for Polymer Sample	62
4.5	The puddle test result for PFA sample and Polymer sample	71

LIST OF FIGURE

Figure		Page No.
1.1	Thesis Organization	5
2.1	The Micrograph of PFA	16
2.2	Efflorescence Occurred at Civil Engineering Laboratory, UNIMAS	19
2.3	The Relation Between The Transport Properties of Cement Paste and The Compressive Strength As A Function of The W/C Ratio and Degree of Hydration.	29
3.1	A Flowchart of Research Methodology	33
3.2	Flow Chart of The Experimental Program	34
3.3	The Pulverized Fly Ash	36
3.4	Polymer (Water Based Polymer Latex)	37
3.5	Two Types of Mould (100 X 100 X 100 Mm And 300 X 300 X 60 Mm)	38
3.6	Concrete Mixing Machine	42
3.7	Curing Processes In Tank	43
3.8	Absorption Testing	44

3.9	Compression Machine	45
3.10	Puddle Testing Processes	46
3.11	Humidity and Temperature Equipment	47
4.1	Comparison Strength Between 0%, 10%, 20% and 50% PFA	52
4.2	Comparison Strength Between 0%, 10% and 20% Replacement of PFA	54
4.3	Comparison Strength Between 0%, and 50% Replacement of PFA	55
4.4	Comparison Strength Between 1%, 2% and 3% Polymer	57
4.5	Comparison Strength Between 0% and 1% Polymer	59
4.6	Comparison Strength Between 2%, 3% and Non-Modified Mortar	60
4.7	Comparison Water Absorption for PFA Replacement	63
4.8	Comparison Water Absorption for 0% and 10% PFA Replacement	64
4.9	Comparison Water Absorption for 0% and 20% PFA Replacement	65
4.10	Comparison Water Absorption for 0% and 50% PFA Replacement	66
4.11	Comparison Water Absorption for Polymer As Admixtures	67
4.12	Comparison Water Absorption for 0% and 1% Polymer as Admixtures	68
4.13	Comparison Water Absorption for 0%, 2% and 3% Polymer as Admixtures	69

4.14	Comparison Color Measurement Between PFA and Polymer	71
4.15	Modified Cement System Versus Days After Demoulding With Fixed Water Content (230 Kg/M ³) and Cement Content (460 Kg/M ³)	74

CHAPTER 1

INTRODUCTION

1.1 PROJECT OVERVIEW

Concrete is a very durable material as exhibited by the number of Roman concrete construction. Durability is achieved by the correct selection of materials, good design and strict quality control when mixing, placing and curing the concrete is essential. The materials and mix proportions used should be such as to maintain its reliability, protect the reinforcement from corrosion and maintain the durability of the concrete. One of the main characteristics influencing the durability of concrete is its permeability. The ingress of water, oxygen, carbon dioxide, chloride and others are the most of the durability problems in the concrete that can be attributed to the changes in the concrete. Volume changes in the concrete can caused by many factors such as hydration process, pozzolonic action, sulphate attack, carbonation, moisture movement, and others. A crack can decrease the durability of the concrete that occurs by interactions involving the materials of concrete and its surroundings environment.

Colours changes of concrete can arise due to a well known yet not well understood phenomenon called efflorescence. Efflorescence occurs when water

percolates through poorly compacted concrete or through cracks when evaporation can take place at the surface of the concrete. It will form white deposits which can decrease the aesthetic values of the concrete.

Efflorescence, which used to be ignored due to its negligible structural effect, is now viewed as a major problem in colored concrete products. To date there are no economical and effective methods to guarantee the prevention of efflorescence. (P.Kresse, 1991)

1.2 OBJECTIVES OF STUDY

The objectives of this study are as follows:

- a. To correlate between compressive strength, water absorption and efflorescence at different ages and different percentage of PFA and Polymers.
- b. To determine the effects of polymer and PFA addition on to efflorescence.

1.3 SCOPE OF STUDY

The scopes of this project are to investigate the durability and aesthetic of non- modified cement system and modified cement system. There are three main scope of the project are:

- i. To study the strength development of the modified mortar and non-modified mortar with addition of pozzolans.

- ii. To investigate the absorption factor of mortars that is one of the important properties that determine the durability of mortars.
- iii. To study the relationship between water absorption, strength development and efflorescence

Below are the limitations of this project:

1. Water-cement-ratio of 0.5 was used.
2. The size of samples was 100 x 100 x100mm and 300 x 300 x 60mm,
3. The size of aggregates used is sand aggregates.
4. Cubes and slab were tested at the age 7, 14, 21 and 28 days.
5. For hardened concrete, compressive strength (destructive test), water absorption test, and puddle test were tested.
6. The desired characteristic strength of 30 N/mm² at 28 days was used in this study.

1.4 OUTLINE OF THE PROJECT

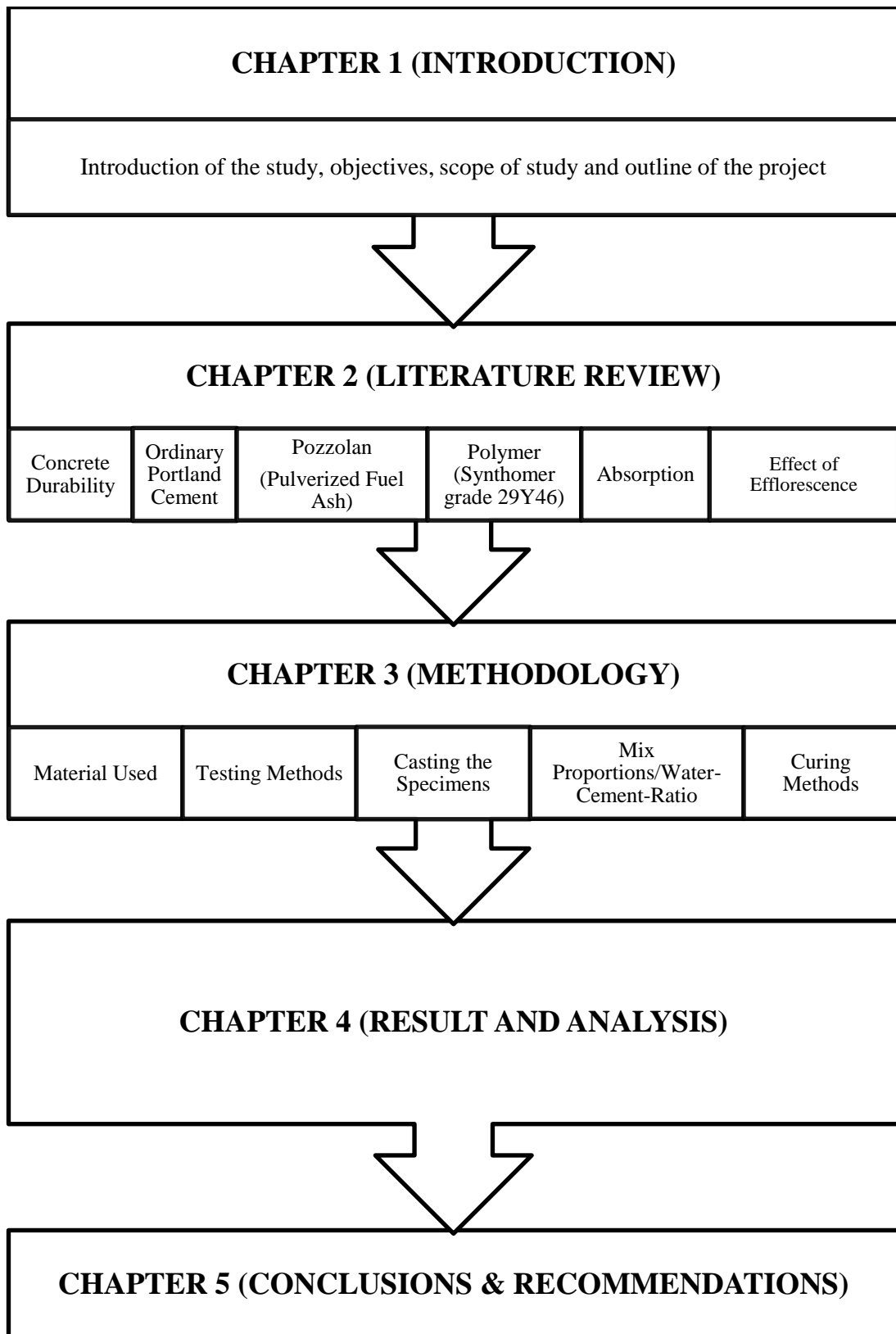
This report is divided into 5 Chapters. The first chapter is the introduction of this project. Chapter 2 is the literature review of OPC, pozzolans (fly ash) and polymer, and detailed explanation of the durability of concrete due to the several effecting factors.

Chapter 3 is the methodologies which consist of method are used in experimental program.

Chapter 4 is an analysis of result. Analyses that were done are being reported in this chapter.

In the last chapter, Chapter 5 is the discussion and conclusion for this project. This chapter wraps up this project with some suggestions for improving the production of good quality concrete. **Figure 1.1** shows the thesis organization for this project.

Figure 1.1: Thesis Organization



CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Cement is a well known building material and has occupied in construction works. There are a variety of cements available in market. A mixture of cement and sand when mixed with water to form a paste is known as cement mortar. The cement commonly used is ordinary Portland cement (OPC). In order to obtain a strong, durable and economical concrete mix, it is necessary to understand the characteristics and the effect of durability of concrete.

In order to understand the durability of concrete which consist the ordinary Portland cement, a review on the properties of concrete will be covered in this section. These include the factors affecting the durability of concrete. The influence of OPC on permeability and porosity to the concrete also will be discussed in this chapter.

2.2 ORDINARY PORTLAND CEMENT (OPC)

Portland cement is most often used in concrete and mortar. Concrete is made by combining water, sand, gravel, and cement, whereas mortars are made by combining cement with water and sand only. Concrete is much stronger than mortar, and is used in most modern buildings as a durable and strong construction material capable of bearing great loads. Mortar is used to bind other substances together, such as the bricks in a house.

Portland cement usually takes several hours to set, and will harden in a matter of weeks. Cement is a somewhat curious material in that it continues to harden over time as long as there is water available for the components of the cement to form bonds with. One week old Portland cement has strength of around 23 MPa, whereas three month old cement has strength of 41 MPa. These numbers apply to standard Portland cement which has not had any additives added to it. Various treatments and additives can make cement set and harden at different rates, and various types of Portland cement also possess different properties which affect the rate of setting and hardening. (Neville, 1996)

The term cement in the construction can be defined as a material with adhesive and cohesive properties that make it possible to bond together mineral fragments into a compact mass. For structure that carry loads, hydraulic cement is used which exhibits the character of setting and hardening under water from the results of a chemical reaction. (Neville, 1996)

2.2.1 Process of Production

Cement is produced by pulverizing raw materials, which consists of calcareous material and argillaceous materials like limestone or chalk, alumina and silica found as clay or shale. It is then mixed in certain proportions and followed by the burning process is crushed into fine powder named cement. The mixing and grinding process takes place.

There are two methods of producing cement. It is categorized by the condition where the mixing and grinding process takes place. If the process is done in water, it is named the wet process. Normally, wet process is meant for softer raw materials like clay and lime. Harder raw materials like shale and limestone is process by the dry process where the raw materials are mixed without the presence of water (Neville, 1996)

2.2.2 Chemical Composition of Portland Cement

Constituents of Portland cement vary and result in several numbers of compounds that may develop in the clinker. However, there are four major compounds obtained from appropriate combinations of the raw constituents as listed below. A slight change in the proportions will result in different properties of concrete (Neville, 1996).

It should also note that in the clinking process, impurities such as Mn_2O_3 , P_2O_5 , and TiO_2 would also be formed (G.D. Taylor, 2002). These