

DURABILITY OF REINFORCED CONCRETE

by

Christos Hadjiyiannis

Project Report

Submitted to

the Department of Civil Engineering  
of the Higher Technical Institute

Nicosia Cyprus

in partial fulfillment of the requirements  
for the diploma of  
TECHNICIAN ENGINEER

in

CIVIL ENGINEERING

June 1993



## ACKNOWLEDGMENTS

I wish to express my appreciation for the valuable assistance offered to me during the course of the execution of this project to Mr. K. Anastasiades project supervisor and lecturer in civil engineering at Higher Technical Institute.

I would like to acknowledge TSIRKON Company for their great help and specially to Mr. A. Tsirides and Miss Emily Christou.

Finally through this occasion thanks are expressed to those who have given us all the necessary guidance and help and specially Mrs. Maria Joannou for typing this project.

# CHAPTER 1

## INTRODUCTION

The word concrete comes from the Latin "concretus" meaning compounded. Today concrete is understood to consist of a graded range of stone aggregate particles bound together by a hardened cement paste.

Concrete is required to be strong free from excessive volume changes and resistant to penetration by water. It may also need to resist chemical attack or possess a low thermal conductivity.

Concrete is a material which although relatively in compression is weak in tension and for structural members subject to tensile stress may be reinforced by steel bars. The effectiveness of reinforced concrete as a structural material depends on the following:

1. The interfacial bonding between steel and concrete which allows it to act as a composite material.
2. The passivating effect of the concrete environment to inhibit steel corrosion.
3. The similar coefficients of thermal movement of concrete and steel.

The requirement of good quality concrete and the provision of adequate reinforcement cover is a fundamental importance to the specification of durable concrete. Low permeability is identified as being the key to durable concrete and is governed by W/C ratio, cement content curing and the degree of compaction obtained.

Concrete will not deteriorate if the specifications covering its production are correct and are followed. It follows, therefore, that when concrete does deteriorate either the specifications were improper or they were violated.

## CONTENTS

	<u>Page</u>
<u>CHAPTER 1</u> <u>Introduction</u>	1-2
<u>CHAPTER 2</u> <u>Factors Affecting Durability</u>	3-6
(a) Design	
(b) Construction Practices	
(c) Material Characteristics	
(d) Exposure Conditions	
<u>CHAPTER 3</u> <u>The causes of cracks in Reinforced</u>	
<u>Concrete</u>	7-17
(a) Structural Cracks	
(b) Non Structural Cracks	
<u>CHAPTER 4</u> <u>Chemical Attack of concrete</u>	18-31
(1) Biological Attack	
(2) Attack of soft water	
(3) Use of Unsound Cement	
(4) Salt Weathering	
(5) Alkali-Aggregate Attack	
(6) Acid Attack	
(7) Sea Water Damage	
(8) Sulphate Attack	
(9) Carbonation	
<u>CHAPTER 5</u> <u>Physical and Electrochemical Causes</u>	
<u>of Degredation</u>	32-41
(1) Abrasion	
(2) Shock Waves	
(3) Thermal Stress	
(4) Drying Shrinkage	
(5) Creep	
(6) Erosion and Cavitation	
(7) Damage due to fire	
(8) Freezing and Thawing	

(9) Corrosion of reinforcement

CHAPTER 6

Repair Techniques

42-56

- (1) Removal of defective concrete
- (2) Cleaning the steel reinforcement
- (3) Protecting the steel reinforcement
- (4) Using a bond coat
- (5) Mixing mortars and concretes
- (6) Placing
- (7) Crack Resin Injection
- (8) Sprayed Concrete

CHAPTER 7

Prevention, Protection and  
Maintenance

57-62