

7043  
HORMIGON  
C:

Concrete  
SOCIETY

**Technical  
Report  
No.32**

# **Analysis of Hardened Concrete**

**A guide to tests, procedures and  
interpretation of results**

**Report of a Joint Working Party of the  
Concrete Society and Society of Chemical Industry**

7043  
HORNIBOW  
C:

## ANALYSIS OF HARDENED CONCRETE

A guide to uses, procedures and interpretation of results

INTI - CONSTRUCCIONES  
BIBLIOTECA

Report of a joint Concrete Society and Society of Chemical Industry Working Party

## CONTENTS

	Page No
<b>1 INTRODUCTION</b>	<b>9</b>
1.1 Aim - and for whom intended	
1.2 Scope - methods covered	
<b>2 SAMPLING</b>	<b>10</b>
2.1 Introduction	
2.2 Variations in concrete composition	
2.2.1 Mixing	
2.2.2 Handling and compaction	
2.3 Types of sample	
2.3.1 Test cubes, cylinders and prisms	
2.3.2 Cores	
2.3.3 Broken out pieces of concrete	
2.3.4 Drillings	
2.4 Number of samples required	
2.4.1 From a small volume of concrete	
2.4.2 From a large volume of concrete (or a large number of similar units)	
2.4.3 Control samples	
2.5 Sample preparation	
2.6 Sampling of mortars	
References	
<b>3 DETERMINATION OF CEMENT CONTENT</b>	<b>13</b>
3.1 Introduction	
3.2 Sampling and preparation	
3.3 Methods of analysis	
3.3.1 BS 1881: Part 124: 1988	
3.3.2 Non-Standard methods	
3.3.3 Analysis for slag or pfa	
3.4 Calculation and interpretation of results	
3.4.1 Calculation of cement content	
3.4.2 Interpretation of results	
3.5 Possible errors and causes of error	
3.5.1 Aggregate corrections	
3.5.2 Soluble silica determination	
3.5.3 Chalk, shell and other materials containing calcium	
3.5.4 Density of hardened concrete	
3.6 Precision and accuracy	
3.7 Comparison with a specified value	
3.7.1 Calculation of confidence limits	
3.7.2 Check on assumptions and consistency of results	
3.7.3 Procedure if confidence limits do not include specified cement content	
3.7.4 Procedure if confidence limits do include specified cement content	
References	
<b>4 DETERMINATION OF ORIGINAL WATER CONTENT AND WATER/CEMENT RATIO</b>	<b>19</b>
4.1 Introduction	
4.2 Sampling and sample preparation	
4.3 Method of test	
4.3.1 Measurement of capillary porosity	
4.3.2 Aggregate porosity	

	4.3.3	Measurement of combined water	
	4.3.4	Measurement of cement content	
	4.3.5	Calculations	
4.4		Limitations of the method	
	4.4.1	Bleeding and evaporation of water from fresh concrete	
	4.4.2	Damaged concrete	
	4.4.3	Poorly compacted concrete	
	4.4.4	Carbonated concrete	
	4.4.5	Measurement of cement content	
	4.4.6	Aggregate porosity	
	4.4.7	Special aggregates	
	4.4.8	Air-entrained concrete	
	4.4.9	Mortars	
	4.4.10	Concrete containing waterproofing admixtures	
4.5		Precision and accuracy	
		References	
5		<b>DETERMINATION OF ADMIXTURES</b>	23
	5.1	Introduction	
	5.2	Classification and chemical composition of admixtures	
	5.3	Sample requirements and sampling procedures	
	5.4	Extraction procedures	
	5.5	Analysis of extracts	
	5.5.1	Chemical/Colorimetric tests	
	5.5.2	Infra-red spectroscopy	
	5.5.3	Chromatography	
		5.5.3.1 Gas liquid chromatography (GLC)	
		5.5.3.2 Thin layer chromatography (TLC)	
		5.5.3.3 High pressure liquid chromatography (HPLC)	
	5.5.4	Other techniques	
	5.6	Interferences	
	5.7	Analysis for polymer modifiers	
		References	
6		<b>DETERMINATION OF ENTRAINED AIR</b>	30
	6.1	Introduction	
	6.2	Definitions	
	6.3	Sampling	
	6.4	Methods	
	6.4.1	Density method	
	6.4.2	Microscopical methods	
		6.4.2.1 General	
		6.4.2.2 Sample preparation	
		6.4.2.3 Linear traverse (Rosiwal) method	
		6.4.2.4 Modified point count method	
		6.4.2.5 Precision of ASTM C457-82 microscopical methods	
	6.4.3	Automatic image analysis	
	6.4.4	High pressure volumetric method	
	6.5	Interpretation of air void analysis results	
		References	
7		<b>DETERMINATION OF AGGREGATE GRADING</b>	38
	7.1	Introduction	
	7.2	Methods	
		7.2.1 Sampling and sample preparations	
		7.2.2 Mechanical methods	
	7.3	Limitations of the method	
	7.4	Precision and accuracy	
		References	

- 8.1 Introduction
- 8.2 Sampling
  - 8.2.1 Cores
  - 8.2.2 Drillings
  - 8.2.3 Variations of concentration
  - 8.2.4 Depth of penetration
  - 8.2.5 Number of samples
- 8.3 Analytical methods
  - 8.3.1 Chloride
  - 8.3.2 Sulphate
- 8.4 Interpretation of results
  - 8.4.1 Chloride
  - 8.4.2 Sulphate
- References

- 9.1 Introduction
- 9.2 Applications
- 9.3 Techniques
  - 9.3.1 Stereoscopic microscope
  - 9.3.2 Thin section examination
  - 9.3.3 Polished specimen examination
  - 9.3.4 Electron microscopy
  - 9.3.5 Electron probe microanalysis
  - 9.3.6 Quantitative microscopical methods
- 9.4 Sampling
- 9.5 Personnel
- 9.6 Qualitative identification of concrete components
  - 9.6.1 Aggregates
  - 9.6.2 Cement
    - 9.6.2.1 General
    - 9.6.2.2 Ordinary Portland cement (OPC) and sulphate- resisting Portland cement (SRPC)
    - 9.6.2.3 Rapid hardening Portland cement (RHPC)
    - 9.6.2.4 White Portland cement (WPC)
    - 9.6.2.5 Old Portland cements
    - 9.6.2.6 High alumina cement (HAC)
  - 9.6.3 Cement replacement materials
    - 9.6.3.1 General
    - 9.6.3.2 Ground granulated blastfurnace slag
    - 9.6.3.3 Pulverized fuel ash
    - 9.6.3.4 Natural pozzolans
    - 9.6.3.5 Silica fume
- 9.7 Determination of concrete mix proportions
  - 9.7.1 Introduction
  - 9.7.2 Preparation of samples
  - 9.7.3 Coarse aggregate/fine aggregate ratio
  - 9.7.4 Aggregate grading
  - 9.7.5 Cement content
  - 9.7.6 Water/cement ratio
- 9.8 Precision of microscopical methods
- 9.9 Deterioration studies
  - 9.9.1 Introduction
  - 9.9.2 Secondary deposits and reaction features
  - 9.9.3 Crack patterns
  - 9.9.4 Interpretation
- References

10	OTHER MATERIALS IN CONCRETE	58
10.1	Portland cement replacement materials	
10.1.1	Introduction	
10.1.2	Blended cements of known composition	
10.1.3	Cements of unknown composition and replacement materials added separately	
10.1.3.1	Qualitative examination	
10.1.3.2	Quantitative examination for pfa	
10.1.3.3	Quantitative examination for slag	
10.1.4	Accuracy and precision	
10.2	Sodium and potassium in concrete	
10.2.1	Introduction	
10.2.2	Method	
10.2.3	Interpretation	
	References	
11	BIBLIOGRAPHY	62
APPENDICES		
A	PRECISION EXPERIMENT - PORTLAND CEMENT CONTENT	69
A1	Introduction	
A2	Details of the precision experiment	
A3	Precision estimates R and r	
A4	Accuracy	
A5	Influence of primary determinations on reproducibility	
A6	Conclusions	
B	PARTICIPANTS IN THE PRECISION EXPERIMENT, REPORTED IN APPENDIX A	90
C	CALCULATION AND ADJUSTMENT OF CEMENT CONTENT	91
C1	Concrete less than 5 years old	
C1.1	Cement contents in agreement	
C1.2	Cement content from SiO <sub>2</sub> determination lower	
C1.3	Cement content from CaO determination lower	
C2	Concrete more than 5 years old	
C2.1	Aggregate containing no calcium	
C2.2	Aggregate containing calcium	
C2.2.1	Assumptions	
C2.2.2	Procedure	
C2.2.3	Example of calculation	
D	MICROSCOPIC ANALYSIS OF AIR ENTRAINED CONCRETE - A PRECISION EXPERIMENT	97
E	SELECTION OF PETROGRAPHIC METHODS FOR CONCRETE ANALYSIS	104
F	MICROMETRIC DETERMINATION OF MIX PROPORTIONS	105
G	AN EXAMPLE OF THE COMPARISON OF MEASURED CEMENT CONTENTS WITH A SPECIFIED VALUE	109
H	ADVERTISEMENTS	111