PROCEEDINGS
OF THE
THIRTY-EIGHTH INTERNATIONAL CONFERENCE ON CEMENT MICROSCOPY

(FINAL PROGRAM AND PAPERS)

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April 17 – April 21, 2016
Novotel Lyon Gerland Hotel, Lyon
Cedex 07, France

Sponsored and Organized by
INTERNATIONAL CEMENT MICROSCOPY ASSOCIATION (ICMA)
Website: www.cemmicro.org
PROGRAM OF THE THIRTY EIGHTH
INTERNATIONAL CONFERENCE ON CEMENT MICROSCOPY
CO-SPONSORED BY ECOLE DES MINES DE DOUAI, FRANCE
Novotel Lyon Gerland Hotel, Lyon, Cedex 07, France

April 17 – April 21, 2016

FINAL PROGRAM OF THE THIRTY EIGHTH

INTERNATIONAL CONFERENCE ON CEMENT MICROSCOPY
SPONSORED & ORGANIZED BY INTERNATIONAL CEMENT MICROSCOPY ASSOCIATION (ICMA)
CO-SPONSORED BY ECOLE DES MINES DE DOUAI, FRANCE
70 AVENUE LECLERC, LYON, CEDEX 07, FRANCE, 69363
April 17 – 21, 2016

SUNDAY, APRIL 17, 2016

6:00 – 8:00 P.M. **Registration – Novotel Lyon Gerland Hotel, Lyon, France**
Welcome Reception
Hosted by ICMA

MONDAY, APRIL 18, 2016

8:00 – 9:00 A.M. **Registration** – Novotel Lyon Gerland Hotel, Lyon, France
Welcome Reception
Hosted by ICMA

9:00 – 9:10 A.M. **Welcome Address**
Vincent Thiery Co-Chairman
ICMA European Organizing Committee

9:10 – 9:20 A.M. **Opening Address**
Arturo G. Nisperos
ICMA General Chairman

9:20 – 9:50 A.M. **Keynote Address**
Dr. Laurent Izoret
Director In-Charge of Products & Qualification
ATILH, Paris, France

9:50 – 10:00 A.M. **Program Introduction**
Herbert Poellmann
Program Committee Chairman

10:00 – 10:25 A.M. **SOME HISTORICAL POINTS ABOUT CEMENT AND MICROSCOPY IN FRANCE**

Vincent Thiery
School of Mines
Dept. of Civil & Environmental Engineering
Douai, Cedex, France

Samuel Meulenyzer
Lafarge-Holcim Research Center
Saint-Quentin-Fallavier, France
Myriam Bouichou
National Research Center of Historical Monuments
Champs-sur-Marne, France

10:25 – 10:40 A.M. **BREAK**

10:40 – 11:05 A.M. **MULTI-SCALE ASSESSMENT OF THE 3D PORE NETWORK OF A HIGH PERFORMANCE CONCRETE**

Yang Song & C. Davy
Ecole Centrale de Lille
Cedex, France

V. Thiery & D. Damidot
Ecole des Mines de Douai
Douai, France

D. Troadec
IEMN, UMR, CNRS, Villenueve d'Ascq, France

X. Bourbon
Andra, Chatenay-Malabry, Cedex, France

11:05 – 11:30 P.M. **EFFECT OF DIFFERENT GRAIN SIZE DISTRIBUTION OF RAW MEAL ON THE BURNABILITY AND THE POLYMORPHISM OF CLINKER PHASES**

Marcus Paul
Wilhelm Dyckerhoff Institut fur Baustofftechnologie
Wiesbaden, Germany

Fulvio Canonico
Buzzi Unicem
Trino, Italy

11:30 – 12:00 Noon **INTRODUCTION OF EXHIBITORS**
Exhibitors Committee Chair & Co-Chair

12:00 – 1:00 P.M. **LUNCH BREAK**

1:00 – 1:25 P.M. **PARTIAL LEAST SQUARES REGRESSION METHOD FOR QUANTITATIVE ANALYSIS OF BLENDED CEMENTS**

Thomas Fuellmann & Thomas Witzke
Panalytical
Almelo, The Netherlands

1:25 – 1:50 P.M. **CONCRETE METASTABLE AFM PHASES: A BARRIER FOR SELENIUM AND MOLYBDENUM TRANSPORT**

B. Ma, A. Fernandez-Martinez, and L. Charlet
University of Grenoble
Grenoble, France

S. Grangeon
BRGM,
Orleans, Cedex, France

1:50 – 2:15 P.M. **NEW CONCRETE WATER PERMEABILITY REDUCING ADMIXTURE (PRAH)**

Giorgio Ferrari, Vincenzo Russo
Mapei S.p.A.
Milano, Italy

Gilberto Artioli, Mariachiara Dalconi, Luca Valentini, Marco Favero.
And Michele Secco
University of Padua, Geoscience Department
Padova, Italy

2:15 – 2:40 P.M. **EXAMINING LARGE SETS OF XRD MEASUREMENTS WITH EXPLORATORY FACTOR ANALYSIS**

Torsten Westphal, Thomas A. Bier, E. Qoku
IKGB, TU Bergakademie Freiberg
Freiberg, Germany

A. Qorllari
Tirana, Albania

2:40 – 3:05 P.M. **COMBINED CHARACTERIZATION OF MSWI BOTTOM ASH**

Katrin Schollbach, Qadeer Alam, Veronica Caprai, Miruna Florea and Jos Brouwers
Eindhoven University of Technology
Dept. of the Built Environment, Unit Bldg. Physics & Services
Eindhoven, The Netherlands

Sieger van der Laan & Corrie van Hoek
Tata Steel Netherlands
Product and Process Materials Characterization
Ijmuiden, Netherlands

3:05 – 3:30 P.M. **PETROGRAPHY, LONG-TERM DURABILITY AND MIX PROPORTIONS OF CONCRETES INB AERIFICIAL ISLAND DAINI KAIHO (SEA FORT NO. 2) AT TOKYO BAY, CONSTRUCTED IN EARLY 20TH CENTURY**

T. Katayama, Y. Ando, T. Sato, S. Hirono, D. Sawaki, and K. Mukai
Taiheiyo Consultant Co., Ltd.
Sakura, Japan

03:30 – 3:45 P.M. **BREAK**

3:45 – 7:00 P.M. **PANEL DISCUSSION: MICROSCOPY AND ITS ROLE IN CEMENT SUSTAINABILITY**

Conducted By: Dr. Karen Luke, Workshop Coordinator, Chairman

Panelists:

- Dr. Maurizio Marchi – C.T.G. S.p.A., Italcementi Group, R&D Dept., Cement & Binder Team, Bergano, Italy: "***New Binders: A Real Alternative to OPC?"***

- Dr. Alexander Pisch – Lafarge-Holcim, France: „**High Temperature Thermo-dynamics as a Tool to Predict Clinker Mineralogy."**
- Dr. Michel Gimenez of Lafarge-Holcim, LCR, France and Dr. Gunther Walentam of Lafarge, Holderbabnk, Switzerland: "**Harnessing CO_2**"
- Prof. Jorgen Skibsted – Instrument Centre for Solid-State NMR Spectroscopy, Interdisciplinary Nanoscience Center (NANO) & Dept. Of Chemistry, Aarhus University, Denmark: "***Application of Solid-State NMR in the Development of Sustainable Portland Cement Blends."***

TUESDAY, APRIL 19, 2016

8:00 – 8:05 A.M. **Registration & Welcome**

8:05 – 8:30 A.M. **CORRELATIONS BETWEEN LIMESTONES PETROGRAPHY AND OPC CLINKER MANUFACTURING PROCESS**

M. Galimberti, N. Marinoni, G. Della Porta
Earth Sciences Department
University of Milan,
Milan, Italy

M. Marchi
CTG – Italcementi Group
Bergamo, Italy

8:30 – 8:55 A.M. **EFFECT OF ACCELERATED CARBONATION ON CALCIUM SULFO-ALUMINATE CEMENTS: A MINERALOGICAL/MICROSTRUCTURAL INVESTIGATION**

D. Gastaldi, F. Canonico, L. Buzzi, S.Irico, F. Bertola
Unicem S.p.A
Monferrato, Italy

S.Mutke
Wilhelm Dyckerhoff Institut fur Baustofftechnologie
Wiesbaden, Germany

8:55 – 9:20 A.M. **HOW DO ADDITIVES INFLUENCE THE MORPHOLOGY OF THE HYDRATION PRODUCT OF CALCIUM SULFATE HEMIHYDRATE?**

C. Pritzel, Y. Sakalli, & R. Trettin
Institute for Building and Materials Chemistry
University of Siegen
Siegen, Germany

9:20 – 9:45 A.M. **CHARACTERIZATION BY EPMA MAPPING OF CEMENTITIOUS COATINGS USED IN SEWER PIPES**

Cedric Patapy, Matthieu Lavigne, Orlane Robin, Etienne Paul, Alexandra Berton, Sopjhie Gouy, and Philippe De Parseval
University of Toulouse
Toulouse, France

9:45 – 10:10 A.M. **BEHAVIOR, PROPERTIES AND SUSTAINABILITY OF CONCRETE CONTAINING PORTLAND LIMESTONE CEMENT**

Moetaz El-Hawary
Kuwait University
Kuwait City, Kuwait

10:10 - 10:25 A.M. **BREAK**

10:25 – 10:50 A.M. **A COMBINED SYNCHOTRON RADIATION MICRO COMPUTED TOMOGRAPHY AND MICRO X-RAY DIFFRACTION STUDY ON DELETERIOUS ALKALI-SILICA REACTION**

N. Marinoni
University of Milan
Milan, Italy

10:50 – 11:15 A.M. **MICROSTRUCTURAL ANALYSIS OF SUPPLEMENTARY CEMENTITIOUS MATERIAL CONTAINING MORTARS**

Funda Inceoglu, Bahar Ayten, Ismail Caglar, Gulden Tombas
Ar-Ge Yoneticisi – Uygulamali Arastirma
R&D Group – Applied Research
Istanbul, Turkey

Kalekim Kimyevi, Maddeler Sanayi ve Ticaret A.S.
Kalekim Chemicals co. Inc. Istanbul, Turkey

11:15 – 11:40 A.M. **GROUND QUARTZ FROM LOCAL KUWAITI SAND USED AS NANO-SILICA FILLER IN CEMENT PASTE MIXTURES**

Saud Al-Otaibi and M. Sherif El-Eskandarany
Energy & Building Research Center
Kuwait Institute for Scientific Research
Kuwait

11:40 – 12:10 A.M. **HISTORIC MORTARS FROM A NATIONAL HISTORIC LANDMARK IN THE NATION'S CAPITAL**

Dipayan Jana
Construction Materials Consultants, Inc.
Greensburg, Pennsylvania, U.S.A.

12:10 – 1:00 P.M. **LUNCHBREAK**

1:00 – 1:25 P.M. **RESTORATION AND STRENGTHENING OF HISTORICAL HERITAGE WITH COMPOSITE MATERIALS: THE CHIMNEY OF CRESPI d'ADDA VILLAGE**

D. Carbotti & G. Morandini
Mapei S.p.A.
Milan, Italy

1:25 – 1:50 P.M. **DEVELOPMENT OF A NEW CEMENTITIOUS FILLER FOR USE IN FAST CURING COLD BINDER COURSE IN PAVEMENT APPLICATION**

Hassan Al-Nageim & Anmar Dulaimi
Dept. of Civil Engineering
Liverpool John Moores University
Liverpool, United Kingdom

1:50 – 2:15 P.M. **RECYCLING OF WASTE MATERIALS AS LIGHTWEIGHT AGGREGATE BY COLD BONDING PELLETIZING TECHNIQUE**

P. Tang, M.V.A. Florea, and H.J.H. Brouwers
Eindhoven University of Technology
Dept. of the Built Environment, Unit Bldg. Physics & Sciences
Eindhoven, The Netherlands

2:15 – 2:40 P.M. **HYDRATION AND PERFORMANCE OF HIGH BELITE CEMENT CLINKER PRODUCED WITH COPPER SLAG**

Gao Xianshu, Wang Jing, Wang Min, & Wen Zhaijun
China Building Materials Academy
The State Key Laboratory of Green Building Materials
Beijing, China

2:40 - 3:05 P.M. **MICROANALYSIS OF ALKALI-ACTIVATED BINARY BLENDED CEMENTITIOUS FILLER SYSTEM IN A NOVEL COLD BINDER COURSE MIXTURE**

Anmar Dulaimi (PhD Student)
Dept. of Civil Engineering, Liverpool John Moores University, UK
Kerbala University, Kerbala, Iraq

Hassan Al-Nageim & Felicite Ruddock
Liverpool Centre for Materials Technology, School of Built Environment

Liverpool John Moores University
Liverpool, United Kingdom

3:05 – 3:30 P.M. **USE OF RE-CON ZERO FOR CONCRETE CONTAINING ADMIXTURES**

J. Haufe, J. Stindt, A. Vollpracht
Institute of Building Materials Research
RWTH Aachen University
Aachen, Germany

G. Ferrari
Mapei S.p.A.
Milano, Italy

3:30 – 3:45 P.M. **BREAK**

3:45 – 4:10 P.M. **AFM-PHASES – THEIR USE IN BUILDING MATERIALS AND IMMOBILIZATION**

H. Poellmann, R. Kaden, & S. Stober
University of Halle/Saale
Department of Mineralogy & Geochemistry
Halle, Germany

4:10 – 4:35 P.M. **DEVELOPMENT OF NEW CEMENTITIOUS FILLER FOR USE IN MICROASPHALT FOR PAVEMENT MAINTENANCE**

Hassan Al-Nageim & Atif Rasheed (PhD Student)
Dept. of Civil Engineering
Liverpool John Moores University
Liverpool, United Kingdom

4:35 – 5:00 P.M. **SCANNING ELECTRON MICROSCOPY OF AUTOCLAVED AERATED CONCRETE WITH SUPPLEMENTARY RAW MATERIALS**

Chris Straub
Materials Innovation Institute
Delft, The Netherlands

Miruna Florea & Jos Brouwers
Eindhoven University of Technology
Dept. of the Built Environment, Unit Building Physics & Services
Eindhoven, The Netherlands

WEDNESDAY, APRIL 20, 2016

8:00 – 8:05 A.M. **REGISTRATION & WELCOME**

8:05 – 12:30 P.M. **PANEL DISCUSSION: MICROSCOPY AND ITS ROLE IN CONCRETE SUSTAINABILITY**

Conducted by: Dr. Karen Luke, Workshop Coordinator/Chairman

PANELISTS:

- Prof. Harald Justness, SINTEF Building & Infrastructure Research Institute, Trondheim, Norway: ***"Microstructure-Macro Property Relations in Sustainable Cement Blends (Utilization of SEM)"***

- Prof. Kimberly Kurtis, School of Civil & Environmental Engineering & Associate Dean for Faculty Development & Scholarship, College of Engineering, Georgia Institute of Technology, Georgia, U.S.A: ***"Strategies For Evaluation of Non-Portland (or Alternative) Cement."***

- Prof. Gregory Dipple, Dept. of Earth, Ocean & Atmospheric Sciences, University of British Columbia, Vancouver, BC, Canada: ***"Imaging of In-situ Nano-Calcium Carbonate Development in Ready-Mixed Concrete and Implications for Mechanisms of Strength Enhancement."***

- Prof. Dr. Ing Thomas Bier, Technische Universitat Bergakademie, Freiberg, Germany: ***"Characterization of Pore Structure of Various Hardened Cementitious Materials using Indirect Methods."***

12:30 – 1:30 P.M. **LUNCH BREAK**

1:30 – 1:55 P.M. **PHASE DISTRIBUTION ANALYSIS OF CEMENT CLINKERS PRODUCED USING ALTERNATIVE FUELS**

Sorour Semsari Parapari, Pozhhan Mokhtari, Mehmet Ali Gulgun and
Melih Papila
Sabanci University, Faculty of Engineering & Natural Sciences
Istanbul, Turkey

1:55 – 2:20 P.M. **RHEOLOGICAL INVESTIGATION ON CASTING RESUMPTION OF SELF-LEVELLING MORTARS**

E. Carlini, S. Carra, F. Curto, A. Lo Presti
Mapei, S.p.A.,
Milan, Italy

2:20 – 2:45 P.M. **INVESTIGATION OF C_3S HYDRATION BY ENVIRONMENTAL SCANNING ELECTRON MICROSCOPE**

Y. Sakalli, C. Pritzel, R. Trettin
Institute for Building and Materials Chemistry
University of Siegen
Siegen, Germany

2:45 – 3:10 P.M. **PORTLANDITE SAND: FACT OR FICTION?**

Chris Rogers & Karl Peterson
University of Toronto, Dept. of Civil Engineering
Toronto, Ontario, Canada

3:10 - 3:25 P.M. **BREAK**

3:25 – 3:50 P.M. **MODIFICATION OF THE MICROSTRUCTURE OF C_3S PASTES USING AFWILLITE BASED SEEDS**

Matthieu Horgnies, Lingjie Fei, Raquel Arroyo
Lafarge-Holcim R & D
St. Quentin-Fallavier, France

3:50 – 4:15 P.M. **CONTRIBUTION OF RAMAN SPECTROSCOPY TO THE STUDY OF CLINKERS HETEROGENEITY**

F. Gauthier
Universite de Lille
Villenueve d'Ascq, France

F. Amin
Technodes SAS Italcementi Group
Guerville Cedex, France

P. Le Coustumer
Universite de Bordeaux
Pessac, France

4:15 – 4:25 P.M. **CLINKER EXCHANGE**
Hugh Hou, Clinker Sample Exchange Committee Chairman

4:25 – 4:35 P.M. **ANNOUNCEMENT OF 2017 ICMA CONFERENCE**
Tom Dealy, Site Selection & Coordination Committee Chairman

4:35 – 4:45 P.M. **CLOSING REMARKS**
Arturo G. Nisperos
ICMA General Chairman

4:45 P.M. **ADJOURNMENT (**End of Technical Session)

6:00 – 8:00 P.M. **ICMA HOSTED RECEPTION**

THURSDAY, APRIL 21, 2016 - LAFARGE-HOLCIM RESEARCH CENTER, L' ISLE d' ABEAU

9:00 – 12:30 P.M. **Technical presentations**

LafargeHolcim R&D presentation

- Ellis Gartner: ***Overview of Research in Cement and Concrete Over the Last Two Decades.***
- Vincent Meyer: ***Solidia Clinker and Cement Behaviours Analyzed by SEM.***

BREAK

- Frédérique Ferey: ***SEM Point Analyses as Input for the Development of Thermo-dynamic Databases.***
- Matthieu Horgnies, Lingjie Fei, Raquel Arroyo: ***Modification of the Microstructure of C_3S Pastes Using AFWillite- Based Seeds.***
- Pham Ga., Grandclerc A., Meulenyzer S., Lapillonne D., Huet B., Barbarulo R.: ***Hydration of C_3S and CEM 1 52.5N/limestone Filler Blend Pastes at Low relative Humidity.***
- Samuel Meulenyzer, Sébastien Lombard, Didier Lapillonne, Rémi Barbarulo: ***SEM Advanced and Recent Analysis Tools Applied to Cement and Concrete Microstructure: Review of Spectro-Spatial Strategies and Cases of Application.***

12:45 – 2:15 P.M. **BUFFET LUNCH (SHOWROOM)**

2:15 – 4:00 P.M. **Visit of LafargeHolcim Laboratories**

5:00 P.M. **Bus Ride to Novotel Lyon Gerland Hotel**
Or Departure to Airport from LafargeHolcim Research Center
(Note: Possible 20 minutes ride by taxi).

CONTENT

1. PART: REVIEWED PAPERS

EXAMINING LARGE SETS OF XRD MEASUREMENTS WITH EXPLORATORY FACTOR ANALYSIS

Torsten Westphal [1], Thomas A. Bier [1], Elsa Qoku [1], Anxhelina Qorllari [2]

[1] Institut für Keramik, Glas- und Baustofftechnik, TU Bergakademie Freiberg, Leipziger Straße 28, D-09596 Freiberg, Germany
[2] Physics Department, Faculty of Natural Science, University of Tirana, Bulevardi Zogu i Pare, Tirana, Albania
Corresponding author: T. Westphal, e mail: torsten.westphal@ikgb.tu-freiberg.de

ABSTRACT

Modern analytical equipment facilitates collecting huge quantities of diffraction measurements. It becomes increasingly difficult to evaluate each measurement individually. Instead, statistical methods become increasingly important to evaluate such quantities of data. Additional features become detectable by using data mining methods. Such a data mining method is exploratory factor analysis (EFA).

EFA is a method for data reduction and transformation. It separates random from non-random variations in the dataset and it determines a minimum number of variables necessary to describe the non-random variations. The new variables are the so-called factors. For XRD this translates into merging all diffraction angles with similar intensity variations into a single variable.

Each factor contains information about an intensity variation pattern and at which diffraction angles it can be found. The intensity variation patterns can be used to link diffraction data with variations in sample properties. The actual study gives examples on how EFA can be used for quantitative mixture analysis of blended cements and for correlating consecutive in-situ XRD measurements with shrinkage curves of mortars.

A Portland cement (CEM I) has been blended with slag in different proportions. The raw XRD data of these mixtures were used for EFA. Four factors obtained by EFA were then used for regression analyses. Linear and simple non-linear regressions were tested. Values for the coefficient of determination range from 0.985 to 0.998. This means, results from EFA can be used for a calibration and ultimately for a quantitative mixture analysis.

Linear change of mortars made from CAC, anhydrite and fine aggregates were analysed. Also consecutive in-situ XRD measurements were made. EFA was applied to the raw XRD data. The results of EFA were then used for multiple linear regression analyses with the length change data. It was

possible to fit the shrinkage curves by the factors obtained from EFA. This can facilitate new ways to analyse dimensional change of cement based materials.

1 INTRODUCTION

Exploratory factor analysis (EFA) is a data mining method. The actual study attempts to demonstrate potential benefits of applying EFA to raw powder diffraction data of cementitious materials. Powder XRD is increasingly applied for characterising cementitious materials and its reactions. Data mining can open new ways to examine large powder XRD data collections. Perhaps the best known data mining method is cluster analysis. Cluster analysis attempts to sort data according to their degree of similarity or dissimilarity. Cluster analysis can be used for quality assessment as it was shown for example by Paine et al. 2011 [1] and Fuellmann et al. 2012 [2].

Factor analysis is a less known data mining method. It can be used to analyse the nature of non-random variations in a dataset. If several properties vary similarly, it is reasonable to assume an underlying common cause. In data mining such a common cause is called a factor and can be described by a so-called latent variable. This means, such a latent variable can represent several measured variables in a dataset. Using latent variables instead of the measured variables can greatly simplify the mathematical description of a dataset. Factor analysis is therefore used to transform a large and unwieldy set of measured variables into a better usable smaller set of latent variables. These latent variables can be used for further evaluation. Westphal et al. (2015) [3] presented a case of an OPC mortar where non-random X-ray intensity variations at more than 3000 measured diffraction angles can be expressed by just 3 factors.

There are two kinds of factor analysis: Confirmatory and exploratory factor analysis. Confirmatory factor analysis tests if a preconceived factor model fits with the measured data whereas EFA derives a factor model from measured data. Many text books on data mining explain EFA such as Izenman (2013) [4]. Tucker and MacCallum (1997) [5] provide a comprehensive description of EFA. The factors contain two types of information, the so-called scores and loadings. The scores represent magnitudes of all measured variables that have merged into the actual factor. The loadings represent the correlations between the actual factor and the measured variables.

Data can be stationary or non-stationary. Stationary data come from properties that do not change significantly during the experiment such as the composition of dry cement. An example for applying EFA to stationary data is mixture composition analysis of ordinary Portland cement (CEM I) blended with ground granulated blast furnace slag (GGBFS). EFA is used in chemistry for mixture analysis

SOME HISTORICAL POINTS ABOUT CEMENT AND MICROSCOPY IN FRANCE

Vincent THIÉRY[a], Samuel MEULENYZER[b], Myriam BOUICHOU[c], Elisabeth MARIE-VICTOIRE[c]

a- *École des Mines de Douai, LGCgE-GCE, 59508 DOUAI, France, vincent.thiery@mines-douai.fr*
b- *Samuel Meulenyzer, LafargeHolcim R&D center, 95 rue du Montmurier, 38291 Saint Quentin Fallavier – Samuel.Meulenyzer@lafargeholcim.com*
c- *Laboratoire de recherche des Monuments Historiques, Ministère de la culture et de la communication, CRC-LRMH, CNRS-USR 3224, Champs-sur-Marne*

ABSTRACT

France and cement microscopy are intimately linked since the pioneering works of the famous chemist Henry Le Chatelier (1850-1936) who was the first to use the petrographic microscope to describe the phases of Portland clinker and the products of cement hydration. Based on a selection of historical documents and samples, we will give a historical and technical overview of cement and binders, in the broadest sense, in France. We will cover several centuries, from the Roman aqueduct "Pont du Gard" (1st century A.D.) to the first Portland-cement based bridge "Pont de Souillac" built by Louis Vicat from 1812 to 1824, from the natural cements made in Burgundy to the ultrahigh performance decorative concrete used in modern architecture. In Burgundy, we will see the case of the Vassy church, built in 1859 by Gariel, a Vassy natural cement producer. Then, cement mortars from the 19th century, used for the restoration of the Saint-Pierre-et-Saint-Paul Cathedral portal in Troyes, will be presented.

INTRODUCTION: A VARIED GEOLOGY – THUS, VARIOUS CEMENTS

Not to enter into sophisticated considerations about the geology of France, it is worth mentioning its diversity and the abundance of limestone and clays (figure 1). Such a geology easily explains the early and fundamental works carried out on hydraulic binders.

MULTI-SCALE ASSESSMENT OF THE 3D PORE NETWORK OF A HIGH PERFORMANCE CONCRETE

Yang Song [1], C. Davy [1], V. Thiery [2], D. Troadec [3], D. Damidot [2]

1 : Ecole Centrale de Lille, CS20048, 59651 Villeneuve d'Ascq Cedex, France,
2 : Ecole des Mines de Douai and LGCGE, Centre de Recherches, 764 Boulevard Lahure, 59500 Douai, France
3 : IEMN, UMR CNRS 8520, Av. Henri Poincaré, 59491 Villeneuve d'Ascq, France

1- Introduction

Industrial and scientific context. In the context of deep underground radioactive waste storage, an accurate knowledge of the 3D pore network of finely porous media is important to predict coupled and complex phenomena on the long term (e.g. water and gas migration by using chemistry and solid state physics at the nanoscale). For COx (Callovo-Oxfordian) claystone, which is the most probable host rock for the French underground site located in Bure (East of France, Paris Basin), three distinct pore scales have been investigated by consistent imaging (microscopy) techniques [Robinet et al. 2012; Song et al. 2015]. Down to 700 nm voxel size, Computed X-Ray Micro-Tomography (CMT) provides both the distribution of the main mineral phases, and a non connected porosity on the order of 0.5%, whereas the COx claystone total porosity, measured by indirect methods, is on the order of 18% (+/-4%). At the scale of the clay matrix (porous part of the COx claystone, together with the interfaces with non porous minerals), FIB/SEM (Focused Ion Beam/Scanning Electron Microscopy) imaging provides porosities on the order of 1.7-5.9%, for voxel sizes down to 17-20nm. The greatest portion of COx porosity is at the nanoscale, where measured values (in the clay matrix) range between 10.2-25.2%, as observed by TEM (Transmission Electron Microscopy). Additional porosity is expected within the interfaces between the clay matrix and the non porous minerals, but it has not been quantified yet by imaging.

Aims and scopes. High performance concretes are also planned in the underground storage site, as structural engineered parts, and they also possess very fine pores down to the nanometer [Scrivener et al. 2011, Brue et al. 2012]. As a routine experiment, Mercury Intrusion Porosimetry (M.I.P.) is widely used to assess a wide range of pores, down to 4-6nm. However, this method is indirect, and requires highly simplifying assumptions as regards the material pore morphology (assumed to be adequately represented by a set of independent circular cylindrical traversing pores). Similar remarks, as to the necessity to assume a simplified morphology for the pores, are done for other indirect methods, e.g. nitrogen adsorption or CMR (Combined Magnetic Resonance).

By analogy with COx claystone (and Tournemire claystone [Song et al. 2015b]), the purpose of this study is to provide a 3D multi-scale imaging of (1) macro-porosity, (2) meso-porosity and (3) micro-porosity, as defined by IUPAC 1994, for the main high performance concrete used by Andra for the French underground nuclear waste storage [Brue et al. 2012]. This concrete is made of CEMI-based paste, which holds siliceous-calcareous aggregates together. In the following, unless otherwise stated, the aggregates are assumed non porous, whereas the paste and the interface between paste/aggregates are assumed to hold the main pore features.

PARTIAL LEAST SQUARES REGRESSION METHOD FOR QUANTITATIVE ANALYSIS OF BLENDED CEMENTS

Thomas Füllmann , Thomas Witzke

PANalytical B.V., Lelyweg 1, 7602 EA Almelo, The Netherland

ABSTRACT

Partial Least Squares regression, or Projection to Latent Structures, is a popular statistical method. It is used to predict any hidden information (crystallinity, temperature, chemistry) directly from the measured raw data. PLS regression is often called soft modeling too. PLSR can be applied to X-ray diffraction data. No further data processing is required and no knowledge of phases and structures is needed. The simulation of instrument influences is not necessary as long as they are kept constant. It is a perfect tool for cases where the number of variables is high, and where it is likely that the explanatory variables are correlated. Standards to calibrate a model are necessary. After the calibration the model can be used to predict the calibrated property from unknown samples.

PLSR can therefore be used for quantitative analysis of all types of cement and hydrated systems. Quantitative determination of amorphous phases is possible as well as for additives in blended cements. The method can be easily integrated in existing automation systems.

INTRODUCTION

Partial Least Squares regression, or Projection to Latent Structures, is a popular statistical method. It is used to predict any hidden information (crystallinity, temperature, chemistry) directly from the measured raw data. PLSR is often called soft modeling too. PLS regression can be applied to X-ray diffraction data. No further data processing is required and no knowledge of phases and structures is needed. The simulation of instrument influences is not necessary as long as they are kept constant. Standards to calibrate a model are necessary. After the calibration the model can be used to predict the calibrated property from unknown samples.

PLS can therefore be used for quantitative analysis of all types of cement and hydrated systems. Quantitative determination of amorphous phases is possible as well as for additives in blended cements. The method can be easily integrated in existing automation systems.

NEW CONCRETE WATER PERMEABILITY REDUCING ADMIXTURE (PRAH)

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ABSTRACT. This paper describes a new concrete permeability reducing admixture capable of effectively reducing the movement of water under hydrostatic head pressure (PRAH). The new admixture is an aqueous suspension of nano-sized transition metal polymeric silicate hydrates that catalyze the nucleation of C-S-H in the capillary pores of hydrating cement paste. The crystallization of C-S-H in the capillary pores refines the capillary porosity of the cement paste and significantly increases the resistance to water penetration under pressure, as demonstrated by Environmental Scanning Electron Microscope (ESEM) investigations. The effectiveness of the new admixture was tested on concrete specimens by measuring the water permeability according to European Standard EN 12390-8. The results indicated that the new admixture is highly effective in reducing the penetration of water, compared to a reference concrete with the same W/C and to other PRAH admixtures, working with different mechanisms. The new admixture also increases the early strength development of concrete and can be used in conjunction with WR and HRWR to produce concrete with outstanding mechanical performances and durability.

INTRODUCTION

Water permeability is a measure of the rate at which a liquid under pressure goes through a porous material saturated with the same liquid. In concrete, the permeability is determined by both the cement paste and the aggregate. If the aggregate is scarcely permeable, most of the water penetration in concrete is ascribed to the cement paste. The paste is characterized by a network of pores that can create paths for water to go through, thus reaching the core of the concrete structure and, if present, the steel reinforcement. If aggressive chemicals are dissolved in water, a high degree of permeability may result in rebar corrosion phenomena or chemical attack of the hydration products of cement. To prevent this from happening, a reduction of the permeability of concrete is therefore necessary. The porosity and the resulting permeability are directly proportional to the water/cement ratio, so a good water reduction contributes to minimizing water penetration. If very low water/cement ratios are not achievable, though, the use of chemical admixtures to reduce water penetration becomes a resource. The reduction of water penetration can be obtained either by reducing the extent of the capillary porosity or by water proofing cement and aggregate particles with hydrophobic agents. The latter have the disadvantage of a progressively lower effectiveness as the hydration of cement proceeds over time, due to the formation of new chemical species that are not coated with the hydrophobic molecules. The capillary porosity can be reduced using admixtures containing chemical species that slowly react in the hardened concrete and form hydrated products that fill the pores and also prevent chemical shrinkage. A new and effective way to reduce the capillary porosity, and therefore water penetration, is filling the voids in the microstructure with more cement hydration products by means of nucleation germs. The nucleation and precipitation mechanism promoted by a new admixture based on a nano-

COMBINED CHARACTERISATION OF MSWI BOTTOM ASH

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ABSTRACT

The use of industrial by products such as municipal solid waste incineration (MSWI) bottom ash in concrete aims to incorporate materials with less CO_2 impact, reduce the amount of waste material landfilled and lower the need for natural raw materials in concrete production.

However, the environmental impact of the MSWI bottom ash itself needs to be considered, since both concrete constituents and final concrete products need to comply with the existing European and Dutch legislation. Therefore, the leaching of contaminants needs to be studied, and its effects on the hydration of cement quantified.

XRD analysis can be a powerful tool in this regard, but challenges can arise due to the complex and often varying composition of MSWI bottom ash. For this reason it is necessary to combine other characterisation techniques such as SEM/EDX. Element mapping and PARC phase mapping were employed to identify the phases present in a fine fraction of MSWI bottom ash (0-4mm) which are mainly quartz, calcite, several types of melilites, iron oxides, bottle glas, iron oxides and residues from incinerated rubber.

EFFECTS OF LIMESTONE PETROGRAPHY AND CALCITE MICROSTRUCTURE ON THE BURNABILITY OF ORDINARY PORTLAND CEMENT CLINKER RAW MEALS

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1. Introduction

The ordinary Portland cement (OPC) clinker manufacturing process is energy-intensive mainly because of the calcination and the kiln operating temperature. Calcination is an endothermic reaction requiring a huge heat input to achieve the whole decomposition of calcite into calcium oxide and carbon dioxide. Thus, besides energy consumption, calcination also contributes to the global anthropogenic carbon dioxide emissions, raising the volume of greenhouse gases in the atmosphere [1]. A better comprehension of this process may be an attractive approach for energy preservation, in order to achieve benefits in terms of greenhouse gases abatement and costs reduction, which are the main aims of modern cement industry.

Several authors clarified both the kinetic mechanisms driving calcination [2] [3] and the influence of the limestone features on the carbonate thermal decomposition for clinker and lime production [4] [5] [6] [7], highlighting that a limestone should not be considered as a mere assemblage of carbonate minerals, but attention should be paid to its mineralogy and microfabric.

Starting from here, the present study aims to go a step forward, by combining petrographic observations and XRPD analyses to investigate how the limestone microfabric (texture, grain size, micrite to sparite ratio) and the calcite microstructure (mean crystallite size and root mean square microstrain) affect the progress of the clinkerization.

2. Materials

Four carbonate rock samples were considered as starting materials of this study. To ensure a large variety of carbonate textures and grain composition it was necessary to space widely with respect to carbonate outcrop location, depositional environment and age (Table 1).

EFFECT OF ACCELERATED CARBONATION ON CALCIUM SULFOALUMINATE CEMENTS: A MINERALOGICAL/MICROSTRUCTURAL INVESTIGATION

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ABSTRACT

In the landscape of hydraulic binders alternative to Ordinary Portland Cements, sulfoaluminate cements represent one of the most promising innovative solution: they combine a reduced environmental impact of the production process –thanks to limited CO2 emission and to a lower energy requirement in the production cycle- with high peculiar performance such as rapid hardening and dimensional stability.

Durability of different commercially available sulfoaluminate cements against carbonation has been investigated with the aim to evaluate both mineralogical and microstructural effects of the introduction of CO2 into the structure of hydrated CSA pastes. For this purpose an accelerated carbonation chamber characterized by a CO2 concentration of 4% was designed and realized. Mineralogical features of cement pastes submitted to accelerated carbonation were analysed by means of X-Ray Diffraction and Thermogravimetric/Differential Scanning Calorimetric analysis. For microstructural characterization Mercury Intrusion Porosimetric analyses and Scanning Electron Microscopy investigation were performed on the same materials.

The results showed that CSA cements are able to protect themselves against the CO2 attack thanks to a mechanism involving AFm phases: these phases are able to store CO2 inside their mineral structure preserving the basic environment necessary to protect steel bars from carbonation-induced corrosion.

INTRODUCTION

Calcium Sulfoaluminate Cement (CSA cement), is a non-Portland hydraulic binder produced from limestone, bauxite and gypsum and based on ye'elimite (C_A_S_) as main mineral phase [1, 2]. Differently from OPCs, CSA based systems are high-performance binders characterized by fast setting and rapid hardening as well as high chemical resistance and reduced shrinkage, that they can counteract thanks to an expansive behaviour [3, 4]. These performance arise mostly as the consequence of the rapid formation of stable ettringite crystals during the early hydration [5], according to the following reaction:

HOW DO ADDITIVES INFLUENCE THE MORPHOLOGY OF THE HYDRATION PRODUCT OF CALCIUM SULFATE HEMIHYDRATE

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Key words: Hydration of hemihydrate, gypsum, additives, morphology

1. Summary

Calcium sulfates are used as a retarder for the calcium aluminate hydration in Portland cements, but is also used as a binding material itself. Because the strength of gypsum based binding materials decreases in presence of moisture it could only be used inside of buildings for floor pavement, glue for tiles, stucco or plaster board and reparation mortars. Moreover gypsum based binders are used as a casting material in the ceramic industry because of its porosity, in metal casting or for dental uses. It is also used in plaster bondage or as additive in polymers. For all of these technical uses different technical properties have to be improved and different hydration times are needed.

For plaster bondage, floor pavement and ceramic castes a special porosity is needed and in case of dental gypsum or for metal castes a lower porosity has to be used. For plaster bondage time for hardening of the gypsum based binders should be around 5 minutes, for floor pavements it must be much longer. Porosity and hardening time are only some examples for needed technical properties. Besides, the strength, casting accuracy, stiffness or drying time are also taken into account.

All of these technical properties could be influenced by additives. Citric acid is a well-known retarder for gypsum based binders and gypsum seeds and potassium sulfate are working as an accelerator. The microscopic methods were used to investigate the influence of additives and its mechanism. During these measurements it could be proved that the additives mostly influence the morphology of the created dihydrate crystals and the morphologies influence technical properties. That is one of the main problems because any additive influences the morphology in a special way and normally there are different additives used in a binder system.

For this reason, a technique is needed to check whether a mixture of different additives could work or not. Such methods could be the optical microscopy and the environmental scanning electron microscope (ESEM) technique, because the hydration process and the created gypsum morphology could be investigated beside the solving process of hemihydrate and the seed formation of dihydrate

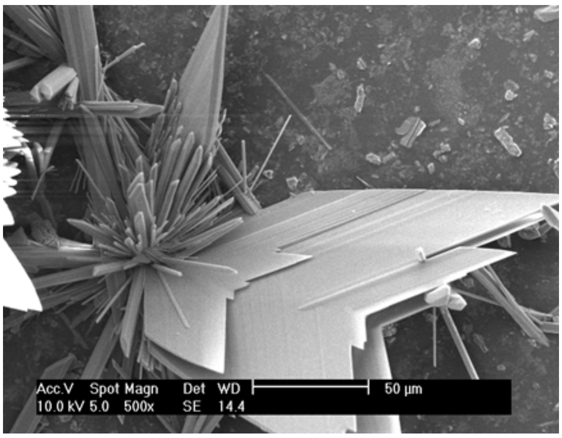
or the reaction time. Especially with the *in situ* optical microscopy much information about the hydration of hemihydrate with and without additives and mixtures of additives could be created.

It could be pointed out, for example, that citric acid creates shorter crystals with less branches due to the poison one of the crystal surfaces caused by citric acid, which was proved by micro-RAMAN-spectroscopy. This phenomenon leads to the porosity of the material and the strengths of the created gypsum normally get lower. Higher temperature or potassium sulfate as an additive is creating longer needles with a smaller diameter. Some polycarboxylate ethers stop the reaction; others change the crystal morphology like citric acid. Optical microscopy could be the good method to check whether a special additive could work for gypsum based binders.

2. Introduction

A variety of morphologies of dehydrate crystals could be observed in calcium sulfate binding materials and in natural gypsum environment. They were described in literature [V.M. Goldschmidt Atlas der Krystallformen 9 Bände 1913-1923] and some examples are given in pictures 1 to 6.

Pic. 1: Dove tailed twined natural gypsum crystal from authors collection



Pic. 2: Dove tailed twined gypsum crystal from hydration of dihydrate

Characterization by EPMA mapping of cementitious coatings used in sewer pipes

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Abstract

Degradation of sewage systems is a major environmental and economic issue worldwide. Rehabilitation of the current network is estimated to about 1 billion dollars per year. One of the technologies available for sewage network is ductile iron pipes coated with special cement based mortar linings intended for offering a good resistance to biogenic corrosion. Indeed, the conversion of sulfur species (present in waste) to sulphate by bacterial biofilm on the surface of pipes is accompanied by the generation of an acidic environment (down to pH 2) causing important microstructure changes (phase transformation, dissolution, etc.). In this context, it has been observed both in laboratory and in ostu conditions that aluminum rich cementitious coatings have increased resistance to biogenic attack compared to calcium-silicate based cements. In this study, microstructure investigations are done to quantify nature (composition of degraded and newly formed phases, presence and quantity of sulfur species) and depth of degradation for samples placed on an accelerated test of biocorrosion developed in Toulouse (BAC test).

Flat polished sections of mortar specimens exposed to the BAC test for 120 days were analyzed with an electron probe microanalyzer (CAMECA SX-Five-WDS detector) fitted with a BSE detector in order to produce quantitative chemical mapping on a profile section between the face in contact with aggressive environment and the core of the sample. This technique provides a visual representation of the various layers of phase transformation and sulfur concentration areas in the samples.

Keywords: *Biodeterioration, sewers, biological test, mortars, microstructural changes*

BEHAVIOR, PROPERTIES AND SUSTAINABILITY OF CONCRETE CONTAINING PORTLAND LIMESTONE CEMENT

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ABSTRACT

Sustainable or green buildings is to design construct and maintain them in a way to use minimum of pollution and cost the minimum while increasing the comfort, health and safety of the people in them. Reducing concrete's embodied energy represents one of the major green features of buildings and an important tool to improve sustainability, save resources for coming generations and reduce greenhouse gas emissions.

Cement has high embodied energy. About 95% of the embodied energy of concrete is from the cement. Reducing cement consumption is, therefore, essential.

The use of fillers is one of the methods to reduce the utilized cement in construction. With the recent trends to reduce water to cement ratio and improve compaction, there is no enough space or water for complete hydration of cement. This means that actually, a portion of mixed cement acts as expensive filler. Replacing this portion with cheaper filler that requires less energy to produce is, therefore, beneficial.

Crushed limestone is the most promising filler. This work is to investigate the effect of the amount of limestone fillers on the sustainability and the fresh and mechanical properties of the resulting concrete. A rich mix is designed with a low water/cement ratio of 0.4. Lime is introduced as a replacement percentage of cement. Ratios of 0, 10, 20 and 30% were used. Slump, compressive strength, specific gravity and water absorption are evaluated for every mix. Sustainability is evaluated through reduction in the emitted carbon dioxide and reduction in cost. In addition, the effect of the amount of lime on the residual strength of concrete subjected to elevated temperatures is also investigated. Samples are subjected to six different temperature stations of 20, 100, 200, 300, 500 and 700^{o}C for six hours before being cooled and subsequently tested for compressive strength and specific gravity. The paper is concluded with the properties of the concrete containing Portland limestone cement, its behavior at elevated temperatures along

with its sustainability benefits. Microscopic structures of the resulting lime filler concrete along with the distribution of lime in the concrete matrix are illustrated and discussed.

INTRODUCTION

The built environment accounts for approximately 40% of all energy consumption. It was always believed that about 1% of this is consumed during construction, 84% accounted for during the lifetime use and 15% is embedded in construction materials. In a more recent study, however, the embedded energy was found to reach or sometimes exceed 40% of the total lifetime energy[1]. Embodied energy is defined as the energy consumed by all of the processes associated with the production of a building or a material. This includes energies required to extract raw materials, to process raw material, to manufacture the product and to transport of product from source. As can be seen, the energy consumed in materials production decreases as a percentage of total consumed energy with the increase in service life.

The embodied energy of concrete may be reduced by reducing the amount of cement in mix. This may be achieved by proper mix design and by partial replacement of cement with some type of pozzolanic or supplementary cementitious materials such as slag, fly ash or silica fume. The use of fillers is another method to reduce the utilized cement in construction. With the recent trends to reduce water to cement ratio and improve compaction, there is no enough space or water for complete hydration of cement. This means that actually, a portion of mixed cement acts as expensive filler. Replacing this portion with cheaper filler that requires less energy to produce is, therefore, beneficial..

Crushed limestone is the most promising filler. In 2004 ASTM C150 allows for 5% cement replacement. In 1983 Canada allowed for 5% and in 2009 allowed for 15% as per CSA A3001 and CSA A23.1. EN 197-1 allows CEM II to contain up to 35% lime. ASTM is currently discussing increasing the percentage to 15% .

Some research were conducted to investigate the behavior and properties of filler portland cement concrete. This includes the investigation of early age shrinkage [2], equivalent strength [3,4], durability [5], field trials [6] and properties of limestone cement and concrete [7].

In the current research the investigation of the behavior of lime Portland cement concrete under high temperatures was conducted. The effect of high temperature is of high importance in order to fully understand the expected behavior of the material. Research on temperature effect on different types of concrete is numerous [8,9].

GROUND QUARTZ FROM LOCAL KUWAITI SAND USED AS NANO-SILICA FILLER IN CEMENT PASTE MIXTURES

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ABSTRACT

Nanotechnology has gained momentum lately in the field of civil engineering and construction materials. It has been employed for improving the strength and durability of cementitious composites by adding nano-structured ingredients such as silica particles to the Portland cement matrix**.**

This paper presents results of a study at the Energy and Building Research Center in Kuwait Institute for Scientific Research aimed at developing a process to employ a nanotechnology approach for preparing nano-filler materials of SiO_2 using the top-down approach. The starting materials has been obtained from local Kuwaiti sand were subjected to severe mechanical treatment, using room temperature high- energy ball mills to obtain very fine ground quartz particles. Different milling parameters were adjusted in order to obtain homogenous nano-scaled powder particles. The raw material and resulting products were studied by XRF, XRD, and SEM to observe the changes in their crystallography and if any phase changing has occurred as a result of the milling process. Different weight ratio of the selected fabricated nano-structured particles were incorporated as partial replacement of OPC in paste and mortar mixtures**.**

The cementitious paste specimens were prepared, characterized and tested to investigate their mechanical, physical, and chemical properties.

INTRODUCTION

Nanotechnology encompasses a wide range of disciplines in many areas including civil engineering and construction materials. Currently, nanotechnology has been employed for improving the strength and durability of cementitious composites by adding nanostructured ingredients such as silica particles to the Portland cement matrix.

This research project is aimed at developing a process to employ a nanotechnology approach for preparing novel nano-filler materials of SiO_2 using the top-down approach. The starting materials from local Kuwaiti sand were subjected to severe mechanical treatment, using room temperature high- energy ball mills. Different milling parameters were adjusted in order to obtain homogenous nano-scaled powder particles.

"RESTORATION AND STRENGTHENING OF HISTORICAL HERITAGE WITH COMPOSITE MATERIALS: THE CHIMNEY OF CRESPI D'ADDA VILLAGE"

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ABSTRACT

The intervention of restoration and strengthening interested the ultra-centenarian, Southern masonry chimney of the Crespi d'Adda Village, in the district of Capriate San Gervasio (BG). This complex was named after the Crespi family, cotton manufacturers from Lombardy that, at the end of the nineteenth century, realized a modern "ideal workers' Village" nearby their factory, along the Adda River.

The Crespi d'Adda Village is an entire town, built from nothing by the owner of the factory for his workers and their families. The workers were provided with homes, gardens, vegetable gardens and all necessary local services.

Thanks to its shape and environmental characteristics, that have been considered of remarkable value from the historical, urban and social points of view, the UNESCO Committee for the World Heritage entered Crespi d'Adda Village in the World Heritage list on December 5th, 1995.

This ultra-centenarian chimney that is 65 m high and was once used by the thermoelectric power station, remains today the majestic symbol of the Crespi d'Adda Village.

Considering the construction age of the chimney, dated back to 1878, it was identified the need of treating the whole masonry structure, in order to remove the principal structural defects and to obtain a higher safety level of the chimney.

The strengthening project envisaged the use of combined innovative technologies, based on the application of composite materials with inorganic matrix and with polymeric matrix.

The choice of these technologies was linked to their advantages in terms of lightness and reduced thicknesses that allowed a high performance and minimally invasive intervention, making the transport at such substantial heights quite simple.

All in all, the conservatory restoration of the chimney was completed by restoring the cotto-tiles external covering and by protecting it.

DEVELOPMENT OF A NEW CEMENTITIOUS FILLER FOR USE IN FAST-CURING COLD BINDER COURSE IN PAVEMENT APPLICATION

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Abstract

This Paper introduces a laboratory study results on developing fast-curing cold mix asphalt using new cementitious filler generated from waste fly ashes and waste by-product materials to replace the traditional limestone filler normally in use for producing asphalt mixtures. The new products meet the challenges of the increasingly strict traffic and environmental regulations and budgetary restrictions the paving industry faces in the coming years by providing;

1. Fast-curing cold mix asphalt and thus eliminating the restriction imposed by road engineers on the use of cold mix asphalt, namely the needs of such mixes for long curing time. Normally spans from 2 months to 24 months.
2. Environmentally friendly product as the mixing and manufacturing process need no heating and thus no CO_2 emission, further more;
3. Waste fly ashes and waste by-product materials are blended and used for the production of the new LJMU cementitious filler with no heating and or heavy blending process are involved and thus, the production of the new contentious filler has no CO_2 emissions too.

The paper reports analyse and discussion of the SEM laboratory investigations on the cementitious paste making the bonding agent in the mix together with the responses of the new cold mix asphalt binder course to the code of practise testing recommended by road engineers namely; indirect tensile stiffness modulus test. The results proves that the performance of the new products are complying with the European code of practice for the test accomplished and open the gate for further testing recommended by the code of practice which will be reported in another paper to be published in the near future.

Keywords: Binder course, cementitious filler, cold mix asphalt, emulsion, SEM and fly ash.

1. Introduction

Cold emulsion bituminous mixtures (CBEMs) are generally fabricated by mixing cold aggregates with an asphalt emulsion and water (Gómez-Meijide et al., 2015); accordingly, it can be described as bituminous materials produced at ambient temperature (Al-Busaltan et al., 2012). Researchers have made intensive effort to enhance CBEMs properties to achieve their full advantages in improving CBEMs properties (Thanaya, 2003; Al-Busaltan et al., 2012; Dulaimi et al., 2015a). A conventional active filler material such as Ordinary Portland Cement (OPC) was utilized to improve CBEMs characteristics (Head, 1974; Milton and Earland, 1999; Brown and Needham, 2000; Pouliot et al., 2003; Al-Hdabi et al., 2014; Dulaimi et al., 2015b). However, the manufacture of cement is responsible for 5% of global greenhouse gas (GHG) (Sadique et al., 2012). Consequently, it is significant to replace OPC by using cementitious materials from waste products. Accordantly and in order to achieve environmental objectives along with acceptable CBEMs properties, high calcium fly ash (HCFA) were considered in the first phase of this study for improving a new cold asphalt concrete binder course bituminous emulsion mixture (CACBC) with the same gradation as the traditional hot dense bitumen macadam mixtures. The development was achieved by the addition of (HCFA) as a substitution to traditional mineral limestone filler. Whereas, in the second phase a blend of HCFA and a high silica-alumina waste material (HASW) was used. The use of fly ash and waste materials that possess hydraulic and pozzolanic properties in the presence of water will have their advantages of decrease the environmental problems associated with CO_2 emission and by introducing these materials in the pavement construction instead of landfilling. Consequently, these materials offers both economic and environmental benefits in addition to their useful in industry.

SEM imaging technique has been used widely in the cement research area for petrographic analysis of hardened products and to evaluate the hydration' degree (Sarkar et al., 2001; Sánchez de Rojas et al., 2006; Kar et al., 2012).

RECYCLING OF WASTE MATERIALS AS LIGHTWEIGTH AGGREGATE BY COLD BONDING PELLETIZING TECHNIQUE

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ABSTRACT

The pelletizing technique is widely used to produce cold bonded aggregates based on waste powder materials nowadays. In this study, the MSWI bottom ash fines (BAF, 0-2 mm) is utilized together with other waste powders (such as fly ash, paper sludge ash, etc.) to produce lightweight cold bonded aggregates by the pelletizing technique. The properties of the produced aggregate, such as density, particle size distribution, crush resistance, water absorption, etc. are investigated. Additionally, the influencing parameters on the pelletization of the mixed composites are discussed.

INTRODUCTION

Municipal solid waste incineration (MSWI) bottom ash fine particles (0-2 mm) (BAF) have the potential to be used as sand substitute in mortar or concrete [1–4]. However, it contains relatively high amounts of heavy metals (such as Cu, Sb, Mo, etc.) and salts (such as chlorides, sulphates, etc.), the leaching concentration of which exceed the limit value according to the environmental legislation [4,5]. Specific treatments are applied to improve the properties of the BAF, the efficiency of which on the BAF is limited due to its small particle size. Nowadays, the cold bonded pelletizing technique is widely used to recycle waste powders for producing artificial aggregates, such as iron ore fines, coal fly ash and bottom ash, granulated blast furnace slag, quarry dust, etc. [6-10]. The current widespread research on the production of artificial aggregates using waste powders through cold bonding techniques proposes a positive view on the investigation of producing artificial aggregate using BAF, which is rarely studied.

In this research, the purpose is to use the cold bonded pelletizing technique to produce an artificial aggregate using BAF from a waste-to-energy plant. The properties (such as density, pellet strength, crushing resistance, water absorption, etc.) of the artificial aggregates produced are evaluated.

Microanalysis of Alkali-Activated Binary Blended Cementitious Filler in a Novel Cold Binder Course Mixture

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Abstract

In this study, a new alkali-activated binary blended filler (ABBF) content high calcium fly ash (HCFA) and aluminasilica rich waste material (HASW) was developed for use as a replacement for the limestone filler in a cold asphalt concrete bituminous emulsion in binder course (CACBC) mixtures. Indirect tensile stiffness modulus (ITSM) test was used to assess the enhancement in mechanical properties of the CACBC. Additionally, scanning electron microscopy (SEM) and X-ray diffraction (XRD) were implemented to study the microstructural properties to explain the increase of the ITSM of the new CACBC mixture at different ages.

The experimental results have shown a considerable improvement in the indirect tensile stiffness modulus when using the ABBF as a filler substitution when compared with a conventional hot mix asphalt concrete binder mixture. Furthermore, SEM analysis and XRD proven the formation of hydration products after varying curing ages within the ABBF.

Keywords: Binder course, cold bituminous emulsion mixtures, indirect tensile stiffness modulus, SEM and XRD.

USE OF RE-CON ZERO FOR CONCRETE CONTAINING ADMIXTURES

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ABSTRACT

Recycling of returned fresh concrete using the common treatments such as washing, retarding the hydration reaction for days or even crushing the hardened concrete for reuse is effortful and therefore costly. An innovative alternative procedure has been developed by Mapei S.p.A. A two-component powder is used to granulate the returned fresh concrete in the truck mixer. The granulate can directly be used as recycled concrete aggregate. The two components are a superabsorbent polymer and an accelerating agent. The absorbent reduces viscosity of the fresh concrete while the accelerator gives a high early strength of the resulting granulate.

The aim of this study was to evaluate the effects of different admixtures in the original concrete on the accelerating reaction and the properties of the produced granulate. The use of superplasticisers or retarders may affect the hardening reaction and the granulate properties. A series of tests has been carried out using different types of superplasticisers and retarding agents. The reaction kinetics with and without the addition of the accelerator has been evaluated by means of heat flow calorimetry, ultrasonic speed measurements and x-ray diffraction. Exemplary results are presented in this paper.

The granulate properties and the characteristics of fresh and hardened concrete containing the recycled aggregate were tested. The results show the good performance of the aggregate produced with Re-Con Zero. However water absorption has to be taken into account when using the recycled aggregate at higher substitution levels.

INTRODUCTION

In pre-cast factories as wells as in ready-mix concrete plants a certain amount of residual concrete remains on a daily basis, which has not been used in the production process. This fresh concrete waste has to be recycled. Different methods can be utilised to deal with the recycling of residual concrete.

Waste concrete can be separated into original aggregate and waste water [1]. This method is relatively energy intense and costly. Another way to deal with returned concrete is the addition of set retarders to stop the hydration for a time period of up to three days [2]. After reactivation by adding new fresh concrete the concrete can be used again. However, the set retarder is sensitive to temperature changes and has to be measured out very accurately.

AFm-PHASES – THEIR USE IN BUILDING MATERIALS AND IN IMMOBILIZATION

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ABSTRACT

AFm-phases are important phases in cement hydration and belong to the family of layered double hydroxides which can incorporate many different cat- and anions. Due to this variability these phases can be used for many applications and are formed during many processes. This paper describes their formation and use in cementitious materials and for immobilization purposes. Their overall composition can be given by the layered structure composed of a positive main layer and a negative interlayer :

$$[Me^{2+}_{(1-x)}\, Me^{3+}_{(x)}\, (OH)_2]^{x+}\, [\,(An)^{y}_{(x/y)} \cdot m\, Me_x \cdot zH_2O\,]^{x-}$$

This formula expresses the wide variability of AFm-phases in composition. A SEM image of a typical AFm-phase containing sulfite is shown in image 1.

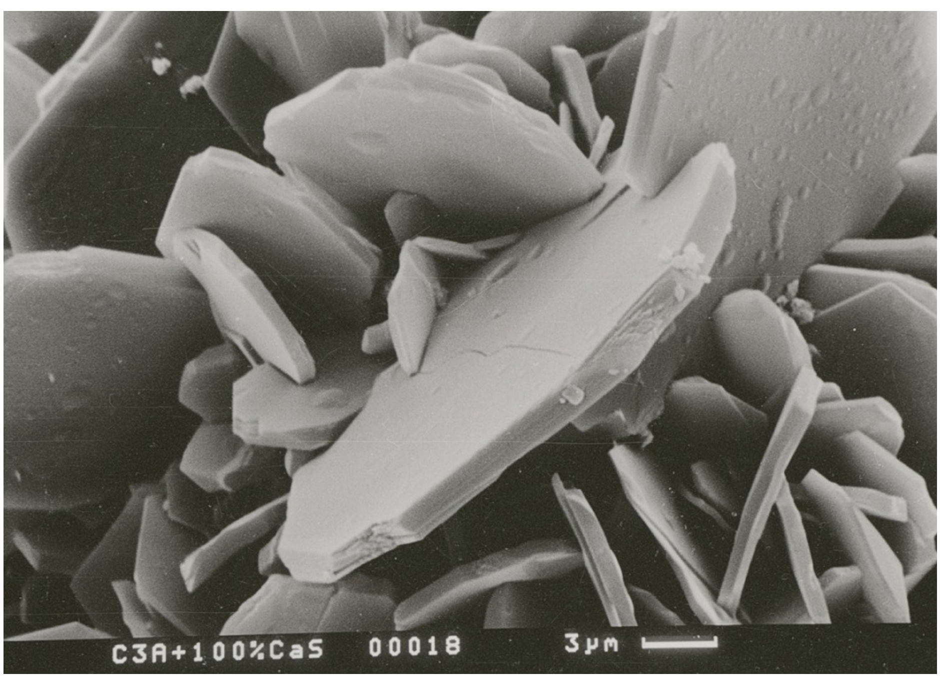

Fig.1 : SEM image of sulfite-containing AFm-phase (PÖLLMANN;H., ICMA 2011)

Assessment the Performance of Cold Bituminous Emulsion Mixtures with Cement and Supplementary Cementitious Material for Binder Course Mixture

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Abstract:

This study aims to develop a fast-curing cold asphalt concrete binder course (CACB) mixture by utilizing cement and waste aluminosilicate material (HASW) as supplementary cementitious material to make a new binary blended cement filler (BBCF) and use this new filler as a substitute for conventional mineral filler. With this purpose, cold asphalt concrete for binder course mixtures (CACB) with cationic emulsions were considered by means of indirect tensile stiffness modulus test while water susceptibility was evaluated by determining the stiffness modulus ratio before and after the samples were conditioned. From the experimental data, it is observed that a significant improvement in the stiffness modulus and rut resistance with a substantial enhancement of water susceptibility resistance is achieved by using cement. Also, the addition of HASW to the CACB as a supplementary cementitious material leads to more improvement in the mechanical properties as well as water sensitivity, which indicates the possibility of the use of CABC in heavy road construction. This will remove the restriction imposed by road engineers on the utilize of CBEMs, namely the needs of such mixes for long curing time (generally spans from 2 months to 24 months). In addition, the new CACB is found to be equivalent with the traditional hot asphalt concrete binder course after short periods of curing.

Keywords: Binder course, cold bituminous emulsion mixtures, indirect tensile stiffness modulus and Industrial wastes.

1. Introduction

One promising, environmentally friendly and economical approach for pavements construction is cold asphalt mixtures which produced and compacted at ambient temperatures. Cold asphalt mixtures are defined as bituminous materials mixed utilizing cold aggregates and binder (Jenkins, 2000). One of the popular types of cold asphalt mixtures is cold bitumen emulsion mixtures (CBEMs). Nevertheless, they have been conventionally considered inferior to hot mix asphalt (HMA) over latest decades due to their weak early life strength, long curing times essential to reach an optimal performance and their high air-void content remaining after compaction (Thanaya et al., 2009). Accordingly, cold mix asphalt utilization is still limited to surface treatment and reinstatement work on low trafficked roads and walkways, nevertheless, it has rarely been used as a structural layer for heavy-duty pavement layers (Read and Whiteoak, 2003; James, 2006; Al Nageim et al., 2012).

Many research is being accomplished currently in order to reduce these mechanical disadvantages. Containing cement in a certain quantity into the cold asphalt mixture has been considered as one of the most significant methods to decrease these drawbacks in the mechanical properties. Cement emulsified asphalt concrete is a composite material formed by Portland cement, emulsified asphalt and graded aggregates (Jun Fu et al., 2015). Many studies have use traditional cement to enhance the mechanical properties of cold mix asphalt (Terrel and Wang, 1971; Schmidt et al., 1973; Head, 1974; Oruc et al., 2006; Oruc et al., 2007; Al Nageim et al., 2012; Fang et al., 2015).

With the continuously increased construction material costs and ecological awareness, the re-using of various types of wastes and by-products materials which have pozzolanic activity in CBEMs is an ongoing research subject that introduces many benefits from economical, technical and environmental perspectives.

SCANNING ELECTRON MICROSCOPY OF AUTOCLAVED AERATED CONCRETE WITH SUPPLEMENTARY RAW MATERIALS

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ABSTRACT

Microscopy is a key analysis technology for the understanding of the achieved properties of building materials. In the case of Autoclaved Aerated Concrete (AAC) it is even more important due to the phase transformation during the hydrothermal hardening. The incorporation of substitution materials in AAC might lead to a change of properties like strength, shrinkage or colour, but the reason for these changes can in most cases be explained by a difference in microstructure. In the current study various AACs were designed, produced and analysed. The influence of the supplementary materials on all manufacturing steps were evaluated and adjusted to keep the workability.

An industrial by-product (municipal recycling waste glass) and micro-silica are investigated as supplementary materials. The glass addition leads to a less crystalline appearance of tobermorite, the main binding phase. The higher solubility of glass compared to quartz causes a relatively dense layer of hydration products around the glass grains, which is enriched in sodium (and magnesium) as well. Due to the enhanced dissolution of the glass the grain does not have contact with the surrounding phases. The quartz grains show a decreasing reactivity with the increasing glass amount. Micro-silica serves as thickener in AAC during the mixing, which needs to be compensated. However, the increased strength by a rather small addition of micro-silica is reflected by the shape change of the tobermorite crystals, which increase in width.

RHEOLOGICAL INVESTIGATION OF HEALING PROPERTIES OF SELF-LEVELLING MORTARS

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ABSTRACT

Self levellers are cement based dry mix compounds that, when homogenized with water, take on a consistency that allows them to be spread in a thickness that can go from few millimeters to 4 or 5 centimeters on an existing substrate to supply, when hardened, a subfloor for the final covering, that can be made by ceramic tiles, natural stones, resilient material or wood. Self levellers usually require fast workability and the possibility of installing the final floor in one or few days at worst, so the binder phase is usually made by a system that allows fast set. Furthermore its rheological properties need to provide a good equilibrium between flow and resistance to segregation. Another important properties is the ability to "heal": i.e. two products pours, applied in subsequent times, when product is still fresh, must be able to join so that the final surface is flat and the two pours do not have a "valley" between them. The ability of healing of different self-levelling formulations will be discriminated by evaluating their rheological characteristics: in particular the evolution of the elastic modulus over time as the product approaches set will be monitored by using an appropriate measurement protocol in a rotational rheometer. For every formulation we will be able to determine a critical time after the product has been mixed with water, within which healing properties are maintained. This phenomenon will be also described by optical and electronic microscopy.

Introduction

Self-levelling compound represents probably one of the most complex applications for a dry-mix mortar in building applications. These products are designed to provide smooth and solid substrates suitable for applying all kinds of flooring materials (carpets, wooden parquet, PVC, tiles, etc…) but also as a final wear surface. Mechanical performances are fundamental for this kind of products as much as shrinkage movement control, but they also need to have a rheological behavior that has to be sufficiently fluid to be easily applied even in big areas.
The choice of an appropriate binder is fundamental to obtain a proper setting time, usually not longer than 90 minutes, with a fast development of mechanical strengths, and to provide low movements of expansion and shrinkage to avoid detachments. This is the reason why self-levelling binders are based on ettringite forming systems that means a mix of Ordinary Portland Cement (OPC), Calcium aluminate cement (CAC) and a source of sulphate ions (Gypsum, anhydrite etc.) rather than only OPC. Fluidity and workability are fundamental properties of self levellers and represent the core of a good product allowing a very easy application in every jobsite. Workability is obtained by using a high amount of mixing water, usually in excess with respect to the

STUDY OF C3S EARLY HYDRATION BY ENVIRONMENTAL SCANNING ELECTRON MICROSCOPE (ESEM™)

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Key words: Electron microcopy, ESEM, C3S Hydration, CSH-Phases, Hydration, Cement chemistry

1. Summary

Scanning Electron Microscope (SEM) is a powerful research tool, but it requires high vacuum conditions. The moist and biological samples must undergo a complex preparation that limits the application of SEM on these specimens and often causes the introduction of artifacts. The Environmental Scanning Electron Microscopy (ESEM) working in gaseous atmosphere enables high resolution dynamic observations of structure of materials, from micrometer to nanometer scale. This provides a new perspective in material research. ESEM significantly allows imaging of specimen in their natural state without the need for special preparation (coating, drying etc.) that can alter the physical properties. This article presents the results of our experimental studies of hydration of tricalciumsilicate (C3S, Alite) using ESEM. The ESEM turned out to be an important extension of the conventional scanning microscopy. The purpose of these investigations is to gain insight of hydration mechanism to determine which hydration products are formed and to analyses if there are any differences in the composition of the hydration products.

2. Introduction

Alite is the major component of the Portland cement clinker which consists of calcium, silicon, oxygen [Ca3SiO5 = 3CaO·SiO2] and 3% foreign oxides whose mounting volumes mainly by the composition of output materials of the firing temperature and the cooling process depend on built-in foreign oxides (MgO, Al2O3, TiO2, Fe2O3, etc.). The extraneous oxides influence the properties of hydrated clinker. The proportion of foreign oxides incorporated into Alite increases the strength of the cement (Woerman, Hahn, & Eysel, 1963).

PORTLANDITE IN CONCRETE SAND FROM HAWAII: FACT OR FICTION?

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Abstract

A sample of concrete from a concrete floor in a commercial building was studied to investigate claims of alkali silica reactivity. A small fraction of the fine aggregate was found to consist of white particles with a darkened rim - features compatible with manifestations of alkali silica reactivity. However, there was no evidence of any alkali silica reaction product associated with these particles. Further investigation by optical and scanning electron microscope along with quantitative x-ray energy dispersive spectrometry and x-ray diffraction show the particles are composed of portlandite surrounded by a thin iron and calcium rich carbonate shell. A proposed origin for these unusual portlandite sand particles is the creation of free lime by calcination of carbonate sand covered by a basalt lava flow. The lime subsequently hydrated to portlandite but because of the inability of CO_2 to reach the particle because of the dense outer shell it did not carbonate to calcium carbonate.

Introduction

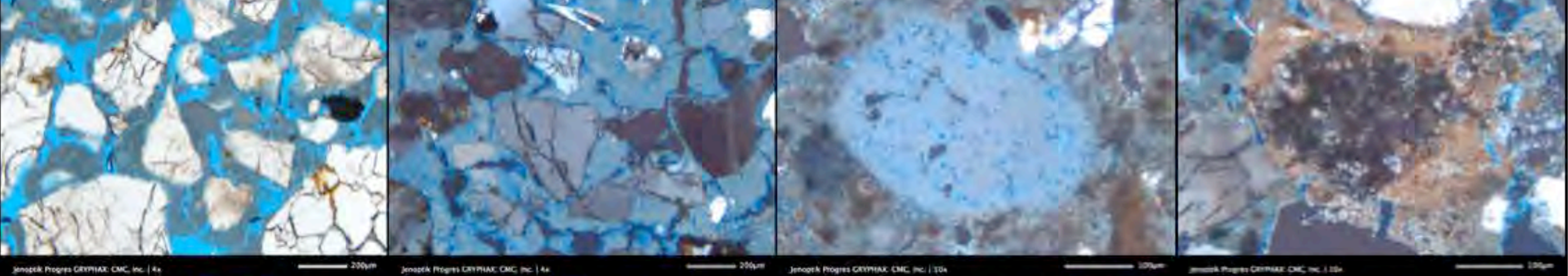
The concrete second and third floors of a commercial building in the city of Honolulu on the island of O'ahu were reported to be distorted and not level. A number of thin overlays had been applied apparently without success and prior to a further restoration a petrographic examination was done. The investigation reported alkali silica reaction (ASR). The results of the initial investigation were questioned, and the thin sections and core remnants were sent to the authors for a second opinion on the ASR diagnosis.

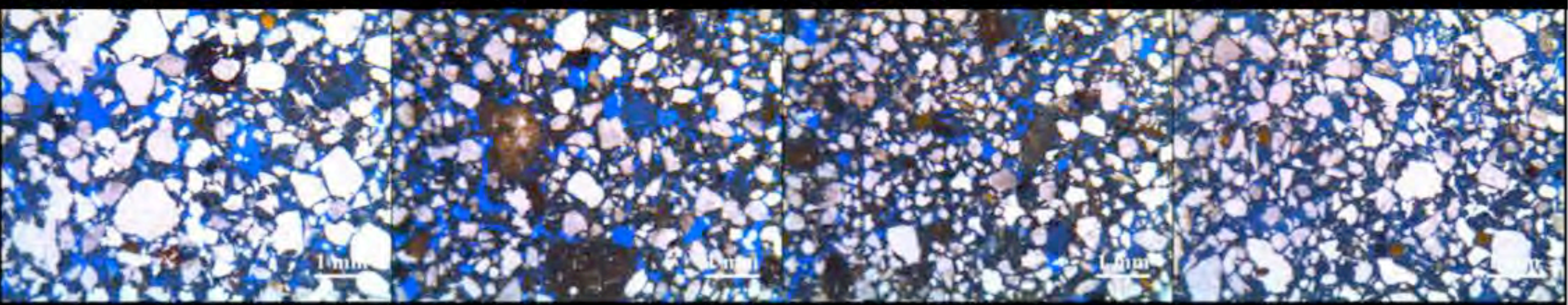
The concrete was well proportioned and well consolidated with a maximum aggregate size of about 15 mm and of moderate strength. The concrete was judged to have a relatively high water to cement ratio greater than 0.5 and was uncarbonated except near the surface. After an extensive study, no signs of ASR or alkali-silica gel , or secondary ettringite within air voids, were found which was hardly surprising given the location within a building and the relatively young age of the concrete (about 6 years).

The coarse aggregate was a crushed unweathered basalt with a trachytic texture, uncommon olivine crystals and about 10% opaque minerals. Some varieties had a vesicular texture with trace amounts of chalcedony in some voids. There were also small amounts of zeolite minerals coating some particles.

The fine aggregate was composed of a mixture of natural sand mainly composed of carbonate fragments and manufactured sand composed of crushed basalt fragments. The carbonate grains were composed of fragments of coral, echinoderms, mollusk shells and foraminifera with a maximum size of about 0.6 mm and an average size of about 0.2 mm and well rounded. There were also trace amounts of rounded sand size grains of altered olivine and pyroxene. These grains were yellow brown in color and often altered to chlorite. The manufactured sand grains were of angular and sometimes flakey crushed basalt and generally greater than about 0.5 mm.

Within the sand fraction small amounts (< 5%) of bright white, oval and subangular sand particles typically from about 0.1 to 0.8 mm in diameter were observed. These usually, but not always, had a thin rim (typically about 20 µm thick) that was black to dark red in color and had a soft white colored interior in reflected light with a Mohs hardness of about 2. In thin section the interior was colorless and clear and of very fine crystal size. In cross polarized light faint birefringence was noted with grey/white colours. Grain mounts of the material taken from broken concrete with a needle were made and the refractive index determined to be in the range about 1.54 to 1.57. It was suspected, but could not be conclusively proven, that these particles were

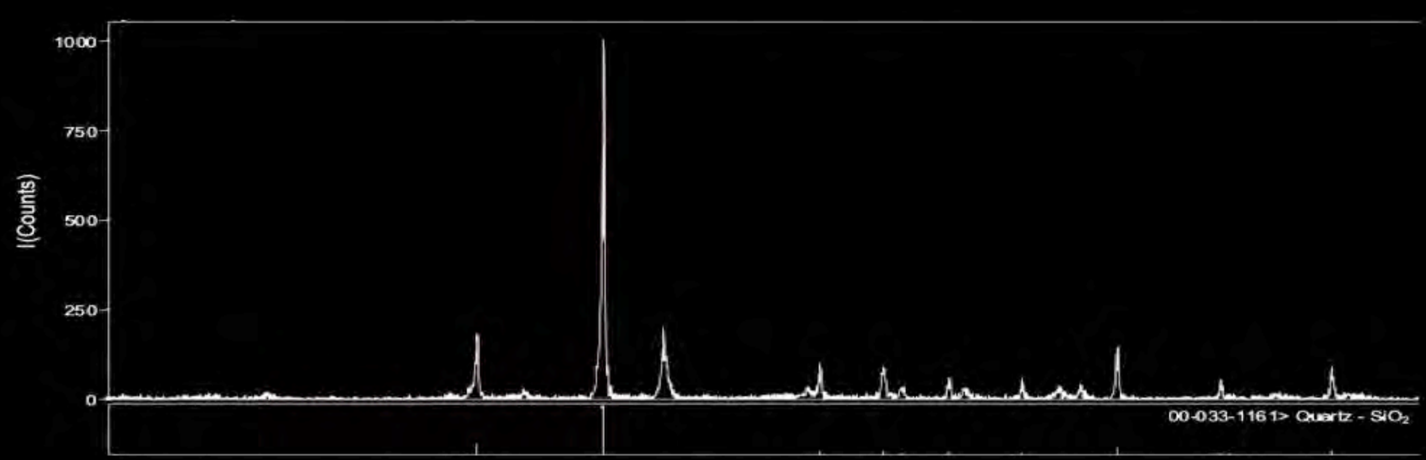


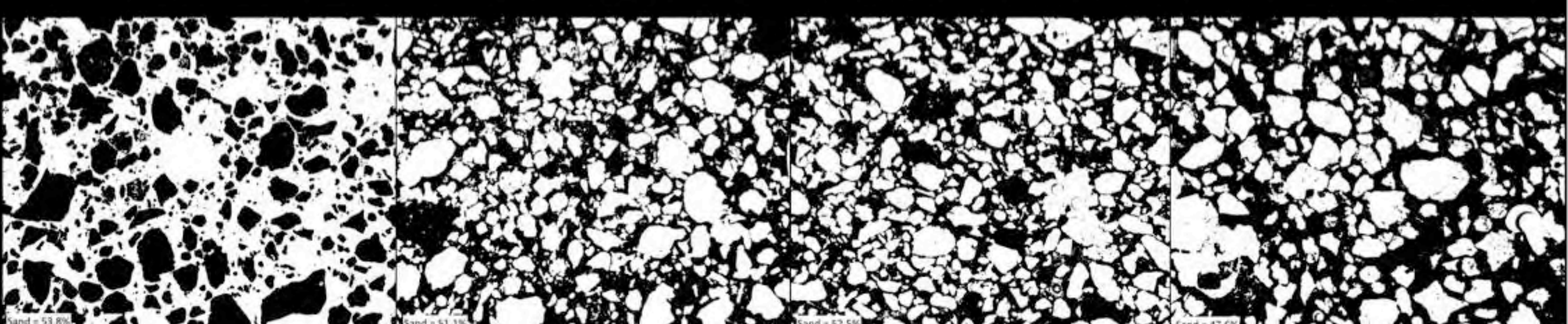


Historic Mortars From A National Historic Landmark In The Nation's Capital

Dipayan Jana

Construction Materials Consultants, Inc. and Applied Petrographic Services, Inc.





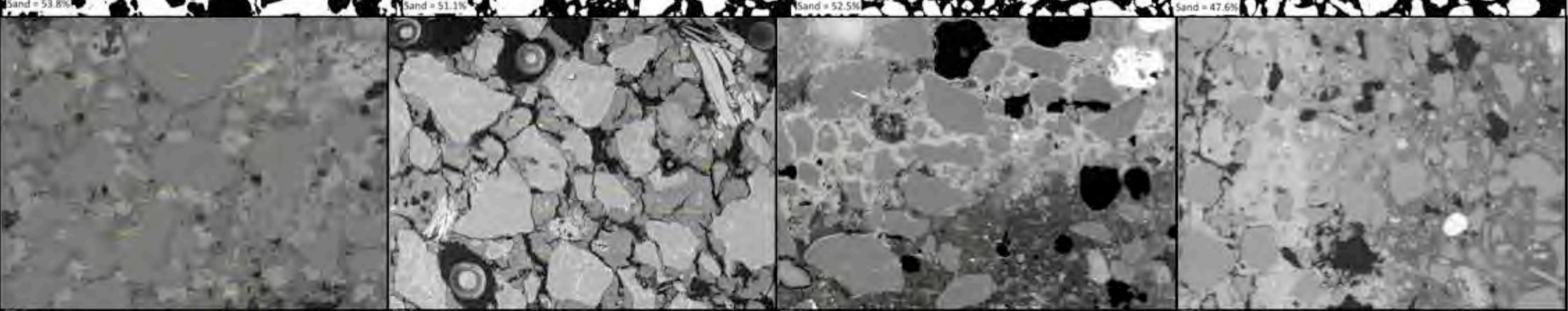


TABLE OF CONTENTS

Abbreviations:
PPL: Observations in plane polarized light mode in a petrographic microscope; XPL: Observations in crossed polarized light mode in a petrographic microscope; FW: Field width of a photomicrograph measured in millimeters
XRD: X-ray diffraction
SEM-EDS: Scanning electron microscopy and Energy-dispersive X-ray fluorescence spectroscopy
BSE: Backscatter electron image; SED: Image from a secondary electron detector
CI: Cementation Index
THIS ARTICLE CAN BE BEST VIEWED IN A PC OR TABLET WITH ZOOMING OPTIONS TO SEE THE PHOTOMICROGRAPHS BETTER.

ABSTRACT

One of the oldest known types of mortars, dating back to the 6th millennium BC and widely used in Ancient Rome and Greece, lime mortars have been used extensively as the material of choice for many masonry constructions. Lime is produced from calcination of high calcium limestone, magnesian limestone, or dolomite (dolostone) having various degrees of silica, alumina, and iron impurities as interstitial clay or silica minerals. Slaking of the calcination product i.e. quicklime with a controlled amount of water, or, with excess water produces a range of binders from dry hydrate powder (hydrated lime), to a liquid, paste, or slurry suspension of lime in water, of high-calcium, magnesian, or dolomitic lime varieties depending on their respective raw feeds. The final slaked lime could either be a high-purity non-hydraulic lime (if their feeds had negligible impurities), or, a hydraulic lime containing 'hydraulic' component(s) i.e. if the feeds contained appreciable silica from interstitial quartz/chert and/or dehydroxylated clay impurities to react with lime and form hydraulic components that set under water. Despite its widespread use in many other countries, in the United States especially during the pre-1950s constructions, use of hydraulic lime was far more limited compared to its non-hydraulic cousins i.e. limes manufactured from high purity forms of high-calcium, magnesian limestones, or dolomitic stones.

Natural cements were used extensively in the US during many 19th century constructions from structural to masonry applications, especially prior to the acceptance of Portland cement from late 19th century. In this regard, the present case study stands as a good example where a range of historic (mid-19th century) mortars of varying compositions and hydraulicity, e.g., from non-hydraulic lime mortars to blended lime-natural cement mortars of varying lime-cement proportions have been used during various phases of constructions of a national historic landmark in the nation's capital.

Brick and stone masonry mortars from eight interconnected buildings at the St. Elizabeths West Campus Center Building, a mid-19th century national historic landmark in Washington D.C. were studied by petrographic and chemical techniques. Twelve brick mortars (MA1 through MA12) contained: (i) non-hydraulic lime mortars (MA11 and MA12), and (ii) blended lime-natural cement mortars having estimated more lime than cement in most (except MA3 and MA7) mortars. The non-hydraulic lime mortars show the hallmark microstructures of many historic lime mortars, e.g., porous, fine-grained, severely carbonated lime matrix having occasional lumps of unmixed lime with sharp boundaries from the rest of the lime matrix, carbonation shrinkage microcracks in lime matrix as well as within the unmixed lumps, etc. The lime-natural cement mortars show (i) remnants of ground, variably calcined raw feed particles of natural cement, and (ii) patchy-textured paste having areas denser and richer in silica along with calcium (representing pastes from hydration and carbonation of the original hydraulic components of natural cement) adjacent to more porous, fine-grained, carbonated paste areas (representing areas contributed from carbonation of the original slaked lime component of binder). All hydraulic brick masonry mortars share both these end member compositions and microstructures at varying degrees, indicating a range of hydraulicity of the original lime-natural cement binders from varying proportions used, all mixed with compositionally similar, well-graded, well-distributed, sound, siliceous (quartz-quartzite) sand aggregates. Mix proportions are calculated to be in the range of 1-part natural cement to slightly less than 1 (in MA3 and MA7) to 5-part lime to 2 to 8-part sand for MA1 through MA10 hydraulic mortars, and 1-part lime to 3-part sand (sand volume is over-estimated for included clay) for non-hydraulic mortars MA11 and MA12. Calculation proportions, however, are dependent on the assumed composition (20% SiO_2, 40% CaO) of natural cement, which, unlike Portland cement, vary considerably. Proportions of sand relative to sums of separate volumes of cement and lime are less than the commonly recommended minimum of 2½ times sand for modern masonry mortars *a la* ASTM C 270.

Stone masonry mortars from the same set of buildings show similar compositional variations of mortars from non-hydraulic lime in one mortar to blended lime-natural cement mortars in the rest, all containing sands of similar types as those found in the brick mortars. Noticeable amongst the stone mortars (especially in the hydraulic types), however, are various degrees of weathering, alterations, and leaching of lime from the carbonated lime matrix of mortars, leaving patches of silica gel-type optically isotropic pastes, often contaminated with coarse secondary calcite crystallization, all indicating extensive moisture percolations, loss of lime from the mortars (probably provided seeds for efflorescence and secondary calcite deposits in voids), microcracking from freezing at moist conditions, or salt crystallization, and overall more altered and distressed conditions of mortars from the service environment than the relatively 'fresher' and better overall conditions of brick masonry mortars.

Suitable tuckpointing mortars for both brick and stone masonries could be similar lime-natural cement-quartz sand mortars having variable proportions of components adjusted within the acceptable limits to generate mortars giving closest match in appearances and properties to the existing mortars, along with the needed breathability of the walls and ability to withstand any wall movements.