# Contents

## Part I Full Papers

**Sulphate and ASR Resistance of Concrete Made with Calcined Clay Blended Cements**

André Trümer and Horst-Michael Ludwig

---

**The Influence of Metakaolin on Limestone Reactivity in Cementitious Materials**

Guillermo Puerta-Falla, Magdalena Balonis, Gwenn Le Saout, Narayanan Neithalath and Gaurav Sant

---

**Sustainable Secondary Resources from Brazilian Kaolin Deposits for the Production of Calcined Clays**

H. Pöllmann, M.L. Da Costa and R. Angelica

---

**Carbonation of Blended Binders Containing Metakaolin**

R. Bucher, M. Cyr and G. Escadeillas

---

**Service Life and Environmental Impact Due to Repairs by Metakaolin Concrete After Chloride Attack**

Aruz Petcherdchoo

---

**Properties of Calcined Lias Delta Clay—Technological Effects, Physical Characteristics and Reactivity in Cement**

N. Beuntner and K.Ch. Thienel

---

**Alternative Binders Based on Lime and Calcined Clay**

Harald Justnes and Tone A. Østnor
Optimization of Cements with Calcined Clays as Supplementary Cementitious Materials .................................................. 59
Roland Pierkes, Simone E. Schulze and Joerg Rickert

Feasibility of Calcined Marl as an Alternative Pozzolanic Material .................................................. 67
Tobias Danner, Harald Justnes, Geir Norden and Tone Østnor

From Ancient to Modern Sustainable Concrete .................. 75
A. Tagnit-Hamou, M.T. Tognonvi, T. Davidenko and D.Z. Belkacemi

Pozzolanicity of Calcined Clay ........................................... 83
Anjan K Chatterjee

Research on Properties of MK–CFBCA Mineral Admixtures ........ 91
Guiming Wang, Ming Bao, Tao Sun, Shuxuan Xing and Kun Li

Optimization of Alkali Activated Portland Cement—Calcined Clay Blends Based on Phase Assemblage in the Na₂O–CaO–Al₂O₃–SiO₂–H₂O System .................... 101
Erika Vigna and Jørgen Skibsted

Phase Assemblages in Hydrated Portland Cement, Calcined Clay and Limestone Blends From Solid-State ²⁷Al and ²⁹Si MAS NMR, XRD, and Thermodynamic Modeling .................... 109
Zhuo Dai, Wolfgang Kunther, Sergio Ferreiro, Duncan Herfort and Jørgen Skibsted

Heated Montmorillonite: Structure, Reactivity, and Dissolution .................................................. 117
Nishant Garg and Jørgen Skibsted

Reactivity of Heated Kaolinite from a Combination of Solid State NMR and Chemical Methods .................... 125
Cristina Ruiz-Santaquiteria and Jørgen Skibsted
Durability of Portland Cement Blends Including Calcined Clay and Limestone: Interactions with Sulfate, Chloride and Carbonate Ions ........................................ 133
Zhenguo Shi, Mette R. Geiker, Klaartje De Weerdt, Barbara Lothenbach, Josef Kaufmann, Wolfgang Kunther, Sergio Ferreiro, Duncan Herfort and Jørgen Skibsted

Thermodynamic Modeling of Portland Cement—Metakaolin—Limestone Blends ................................... 143
Wolfgang Kunther, Zhuo Dai and Jørgen Skibsted

Comparison of the Pozzolanic Reactivity for Flash and Soak Calcined Clays in Portland Cement Blends .................. 151
Kasper E. Rasmussen, Mette Moesgaard, Lea L. Køhler, Thuan T. Tran and Jørgen Skibsted

The Impact of VMA on the Rheology, Thixotropy and Robustness of Self-compacting Mortars ...................... 159
Farid Van Der Vurst, Steffen Grünewald and Geert De Schutter

Calcined Coal Gangue and Clay Shale for Cementitious Materials Without Clinker ........................................ 169
Huiwen Wan and Zhifei Gao

Red Ceramic Wastes: A Calcined Clay Pozzolan ...................... 179
Viviana Rahhal, Zbyšek Pavlík, Monica Trezza, Cristina Castellano, Alejandra Tironi, Tereza Kulovaná, Jaroslav Pokorný, Robert Černý and Edgardo F. Irassar

Assessment of Sustainability of Low Carbon Cement in Cuba. Cement Pilot Production and Prospective Case .... 189
Sofía Sánchez Berriel, Yudiesky Cancio Díaz, José Fernando Martirena Hernández and Guillaume Habert

Ternary Blended Cement with Limestone Filler and Kaolinitic Calcined Clay ............................................. 195
Alejandra Tironi, Alberto N. Scian and Edgardo F. Irassar

Blended Cements with Kaolinitic Calcined Clays: Study of the Immobilization of Cr(VI) .......................... 203
Mónica A. Trezza, Alejandra Tironi, Edgardo F. Irassar and Alberto N. Scian
The Efficacy of Calcined Clays on Mitigating Alakli-Silica Reaction (ASR) in Mortar and Its Influence on Microstructure  
Chang Li, Jason H. Ideker and Thanos Drimalas  

Influence of MK-Based Admixtures on the Early Hydration, Pore Structure and Compressive Strength of Steam Curing Mortars  
Jinlong Han, Zhonghe Shui, Guiming Wang, Jiancong Shao and Yun Huang  

Design and Preparation of Metakaolin-Based Mineral Admixture and its Effects on the Durability of Concrete  
Zhonghe Shui, Kai Yuan, Tao Sun, Qiu Li and Weineng Zeng  

Reactivity and Microstructure of Calcined Marl as Supplementary Cementitious Material  
Tone Østnor, Harald Justnes and Tobias Danner  

Assessing the Synergistic Effect of Limestone and Metakaolin  
D. Nied, C. Stabler and M. Zajac  

Study on Influence of Limestone Powder on the Fresh and Hardened Properties of Early Age Metakaolin Based Geopolymer  
Jiang Qian and Mu Song  

Evaluation of the Permeation Properties of Concrete Added with a Petrochemical Industry Waste  
Nancy Torres Castellanos, Janneth Torres Agredo and Ruby Mejía de Gutiérrez  

Calcined Illitic Clays as Portland Cement Replacements  
Roxana Lemma, Edgardo F. Irassar and Viviana Rahhal  

Low Carbon Cement: Durability Performance Assessment with Laboratory and Site Tests  
Ernesto Díaz, Fernando Martirena, Adrian Alujas and Roberto Torrent  

Influence of the Manufacturing Process on the Performance of Low Clinker, Calcined Clay-Limestone Portland Cement  
A. Perez, A. Favier, F. Martirena and K. Scrivener
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of Room Temperature Curing Geopolymer from Calcined Water-Treatment-Sludge and Rice Husk Ash</td>
<td>291</td>
</tr>
<tr>
<td>Anurat Poowancum, Ekkasit Nimwinya and Suksun Horpibulsuk</td>
<td></td>
</tr>
<tr>
<td>Characterising the Reaction of Metakaolin in an Alkaline Environment by XPS, and Time- and Spatially-Resolved FTIR Spectroscopy</td>
<td>299</td>
</tr>
<tr>
<td>John L. Provis, Syet Li Yong and Jannie S.J. van Deventer</td>
<td></td>
</tr>
<tr>
<td>From a View of Alkali Solution: Alkali Concentration to Determine Hydration Process of Alkali Activating Metakaolin</td>
<td>305</td>
</tr>
<tr>
<td>Mu Song, Jiang Qian, Liu J. Zhong and Shi Liang</td>
<td></td>
</tr>
<tr>
<td>What Happens to 5 Year Old Metakaolin Geopolymers’ the Effect of Alkali Cation</td>
<td>315</td>
</tr>
<tr>
<td>Susan A. Bernal, Jannie S.J. van Deventer and John L. Provis</td>
<td></td>
</tr>
<tr>
<td>Development and Introduction of a Low Clinker, Low Carbon, Ternary Blend Cement in Cuba</td>
<td>323</td>
</tr>
<tr>
<td>Jose Fernando Martirena Hernandez and Karen Scrivener</td>
<td></td>
</tr>
<tr>
<td>Influence of Calcination Temperature in the Pozzolanic Reactivity of a Low Grade Kaolinitic Clay</td>
<td>331</td>
</tr>
<tr>
<td>Adrián Alujas and J. Fernando Martirena</td>
<td></td>
</tr>
<tr>
<td>Pozzolanic Reactivity of Low Grade Kaolinitic Clays: Influence of Mineralogical Composition</td>
<td>339</td>
</tr>
<tr>
<td>Adrián Alujas, Roger S. Almenares, Sergio Betancourt and Carlos Leyva</td>
<td></td>
</tr>
<tr>
<td>Industrial Manufacture of a Low-Clinker Blended Cement Using Low-Grade Calcined Clays and Limestone as SCM: The Cuban Experience</td>
<td>347</td>
</tr>
<tr>
<td>L. Vizcaíno, M. Antoni, A. Alujas, F. Martirena and K. Scrivener</td>
<td></td>
</tr>
<tr>
<td>Development of Low Cost Geopolymer from Calcined Sedimentary Clay</td>
<td>359</td>
</tr>
<tr>
<td>Anurat Poowancum and Suksun Horpibulsuk</td>
<td></td>
</tr>
<tr>
<td>Hydrothermochal Synthesis Products of CaO Metakaolin H₂O System at 90 °C</td>
<td>365</td>
</tr>
<tr>
<td>Mian Sun, Tao Sun, Weiwei Han, Guiming Wang and Mingjun Mei</td>
<td></td>
</tr>
</tbody>
</table>
Reactivity of Calcined Clay in Alite-Calcium Sulfoaluminate
Cement Hydration .................................................. 373
Natechanok Chitvoranund, Barbara Lothenbach,
Sakprayut Sinthupinyo and Frank Winnefeld

Primary Kaolin Waste as Pozzolanic Material in Dry Concrete:
Mechanical Properties and Resistance to Attack by Sulphates .......... 381
M.L.S. Rezende, J.W.B. Nascimento, G.A. Neves
and H.C. Ferreira

The Influence of Cavitation Treatment on Amorphization
of Kaolinite in the Dispersion of the “Kaolin—
Na$_2$O · nSiO$_2$ · mH$_2$O—NaOH—H$_2$O” Composition ..................... 387
P. Krivenko, S. Guziy and J. Abdullah Al Musa

Role of Metakaolin on Lowering pH of the Alkali Activated
Cement Concrete in Barrier Application ................................. 395
P. Krivenko, O. Petropavlovsky and E. Kavalerova

Protocol for Prediction of Durability of New Cements:
Application to LC$^3$ .................................................. 403
Aneeta Mary Joseph, Vineet Shah and Shashank Bishnoi

The Role of Calcined Clay Cement vis a vis Construction
Practices in India and Their Effects on Sustainability ...................... 411
Arun C. Emmanuel, Anuj Parashar and Shashank Bishnoi

Testing of Suitability of Supplementary Materials Mixed
in Ternary Cements .................................................... 419
Anuj Parashar, Sreejith Krishnan and Shashank Bishnoi

Compatibility of Superplasticizers with Limestone-Metakaolin
Blended Cementitious System ........................................... 427
Behnaz H. Zaribaf, Burak Uzal and Kimberley Kurtis

Field Application of Limestone-Calcined Clay Cement
in India ................................................................. 435
Soumen Maity, Shashank Bishnoi and Arun Kumar

Raw Material Mapping in Selected Areas of Rajasthan
and West Bengal and Their Suitability for Use in Low
Carbon Cement Production ........................................... 443
Soumen Maity and Shashank Bishnoi
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitability of Raw Materials in Gujarat for Production of Low Carbon Cement</td>
<td>451</td>
</tr>
<tr>
<td>Palas K. Haldar and Soumen Maity</td>
<td></td>
</tr>
<tr>
<td>Effects of Metakaolin on Nanomechanical Properties of Cement Paste</td>
<td>459</td>
</tr>
<tr>
<td>Salim Barbhuiya and PengLoy Chow</td>
<td></td>
</tr>
<tr>
<td>Meta-Kaolin for High Performance Concrete</td>
<td>467</td>
</tr>
<tr>
<td>Sui Tongbo, Wang Bin, Zhang Lijun and Cheng Zhifeng</td>
<td></td>
</tr>
<tr>
<td>Clay Activation and Color Modification in Reducing Calcination Process: Development in Lab and Industrial Scale</td>
<td>479</td>
</tr>
<tr>
<td>Fabiano F. Chotoli, Valdeciro A. Quarcioni, Sérgio S. Lima, Joaquim C. Ferreira and Guilherme M. Ferreira</td>
<td></td>
</tr>
<tr>
<td>Experimental Study on Evolution of Pore Structure of Cementitious Pastes Using Different Techniques</td>
<td>487</td>
</tr>
<tr>
<td>D. Yuvaraj and Manu Santhanam</td>
<td></td>
</tr>
<tr>
<td>Various Durability Aspects of Calcined Kaolin-Blended Portland Cement Pastes and Concretes</td>
<td>491</td>
</tr>
<tr>
<td>M. Saillio, V. Baroghel-Bouny and S. Pradelle</td>
<td></td>
</tr>
<tr>
<td>Economic Implications of Limestone Clinker Calcined Clay Cement (LC³) in India</td>
<td>501</td>
</tr>
<tr>
<td>Shiju Joseph, Aneeta Mary Joseph and Shashank Bishnoi</td>
<td></td>
</tr>
<tr>
<td>Fresh and Mechanical Properties of High Strength Self Compacting Concrete Using Metakaolin</td>
<td>509</td>
</tr>
<tr>
<td>S.N. Manu and P. Dinakar</td>
<td></td>
</tr>
<tr>
<td>Effective Clinker Replacement Using SCM in Low Clinker Cements</td>
<td>517</td>
</tr>
<tr>
<td>Sreejith Krishnan, Arun C. Emmanuel and Shashank Bishnoi</td>
<td></td>
</tr>
<tr>
<td>Durability Characteristics of Sustainable Low Clinker Cements: A Review</td>
<td>523</td>
</tr>
<tr>
<td>Vineet Shah, Aneeta Mary Joseph and Shashank Bishnoi</td>
<td></td>
</tr>
</tbody>
</table>
Calcined Shale as Low Cost Supplementary Cementitious Material
Saamiya Seraj, Rachel Cano, Raissa P. Ferron and Maria C.G. Juenger

Development of a New Rapid, Relevant and Reliable (R³) Testing Method to Evaluate the Pozzolanic Reactivity of Calcined Clays
F. Avet, R. Snellings, A. Alujas and K. Scrivener

Investigation of Ternary Mixes Made of Clinker Limestone and Slag or Metakaolin: Importance of Reactive Alumina and Silica Content
M. Antoni, L. Baquerizo and T. Matschei

Using of Libyan Calcined Clay in Concrete
Abdelsalam M. Akasha

Part II Abstracts

Physical, Mineralogical and Chemical Characterization of Venezuelan Kaolins for Use as Calcined Clays in Cement and Concrete
Fuentes Irania, Martinez Francis, Reátegui Katya and Bastos Vannesa

Pozzolanic Potential of the Calcined Clay-Lime System
Sofie Hollanders, Özlem Cizer and Jan Elsen

Effect of Metakaolin on the Drying Shrinkage Behaviour of Portland Cement Pastes
Duyou Lu, Jingwang Luo and Zhongzi Xu

BIND-AMOR: Reuse of Dredged Sediments as Supplementary Cementitious Materials
 Liesbeth Horckmans, Ruben Snellings, Peter Nielsen, Philippe Dierckx, Joris Dockx, Jos Vandewalle, Koen Van Balen and Lea Lindequist Kohler

Influence of Mineral Impurities on the Pozzolanic Reactivity of Metakaolin
Sofie Hollanders, Özlem Cizer and Jan Elsen
Fresh Properties of Limestone Calcined Clay Cement (LC³) Pastes ................................................ 575
Sendhil Vigneshwar and Prakash Nanthagopalan

Alkali Silica Reaction Mitigating Properties of Ternary Blended Cement with Calcined Clay and Limestone. ..................... 577
Aurélie R. Favier, Cyrille F. Dunant and Karen L. Scrivener

Autogenous Shrinkage of Limestone and Calcined Clay Cements ........................................ 579
J. Ston and K. Scrivener

Sustainable Benefits of a Low Carbon Cement Based Building .............................. 581
Kriti Nagrath and Soumen Maity

CO₂ Abatement During Production of Low Carbon Cement ........ 583
Bhaskar Dutta and Soumen Maity

Role of Blended Cement in Reducing Energy Consumption ........ 585
Bhaskar Dutta and Soumen Maity

Investigation of Sulphate Attack on Limestone-Calcined Clay Cement Mortars .................................... 587
Fathima Suma and Manu Santhanam

Experimental Study of the Flow Behaviour of Superplasticized Pastes with Cement-Calcined Clay-Limestone Blends ............. 589
B. Karmugil and Ravindra Gettu

Hydration Properties of Cement Pastes with Recycled Demolition Waste from Clay Bricks and Concrete ................. 591
Thiago Melo Grabois, Guilherme Chagas Cordeiro and Romildo Dias Toledo Filho

Calcined Natural Clays: Performance Evaluation as Cementitious Material ........................................... 593
Nikola Mikanovic, Michael Hoffeins, Diego Rosani and Inga Hauschildt
Rheology of Limestone Calcined Clays Cement Pastes.  
A Comparative Approach with Pure Portland Cement Pastes  . . . . . . . .  595
Lukas Gebbard, Blandine Feneuil, Marta Palacios
and Nicolas Roussel

Chloride-Induced Corrosion Rates of Steel Embedded  
in Mortar with Ordinary Portland and Limestone  
Calcined Clay Cements (OPC and LC3)  . . . . . . . . . . . . . . . . . . . . . . . . . .  597
Sripriya Rengaraju and Radhakrishna G. Pillai
Calcined Clays for Sustainable Concrete
Proceedings of the 1st International Conference on Calcined Clays for Sustainable Concrete
Scrivener, K.; Favier, A. (Eds.)
2015, XVI, 597 p. 268 illus., 141 illus. in color., Hardcover
ISBN: 978-94-017-9938-6