



Proceedings  
PRO 78

# Historic Mortars and RILEM TC 203-RHM Final Workshop HMC2010

Proceedings of the  
2<sup>nd</sup> Conference and of the  
Final Workshop of RILEM TC 203-RHM

Edited by J. Válek, C. Groot, J. J. Hughes

RILEM Publications S.A.R.L.



**2<sup>nd</sup> Historic Mortars Conference and  
RILEM TC 203-RHM Final Workshop  
HMC2010**

**22-24 September 2010**

**Prague, Czech Republic**

Published by RILEM Publications s.a.r.l.  
157 rue des Blains F-92220 Bagneux - France  
Tel : + 33 1 45 36 10 20 Fax : + 33 1 45 36 63 20  
http://www.rilem.net E-mail: dg@rilem.net  
© 2009 RILEM – Tous droits réservés. e-ISBN: 978-2-35158-112-4

**Publisher's note:** *this book has been produced from pdf files provided by the individual contributors. In the absence of some of the original source files, limited editorial adjustments and corrections were possible. The publisher makes no representation, express or implied, with regard to the accuracy of the information contained in this book and cannot accept any legal responsibility or liability for any errors or omissions that may be made.*

*All titles published by RILEM Publications are under copyright protection; said copyrights being the property of their respective holders. All Rights reserved.*

*No part of any book may be reproduced or transmitted in any form or by any means, graphic, electronic, or mechanical, including photocopying, recording, taping, or by any information storage or retrieval system, without the permission in writing from the publisher.*

RILEM, The International Union of Laboratories and Experts in Construction Materials, Systems and Structures, is a non profit-making, non-governmental technical association whose vocation is to contribute to progress in the construction sciences, techniques and industries, essentially by means of the communication it fosters between research and practice. RILEM's activity therefore aims at developing the knowledge of properties of materials and performance of structures, at defining the means for their assessment in laboratory and service conditions and at unifying measurement and testing methods used with this objective.

RILEM was founded in 1947, and has a membership of over 900 in some 70 countries. It forms an institutional framework for co-operation by experts to:

- optimise and harmonise test methods for measuring properties and performance of building and civil engineering materials and structures under laboratory and service environments,
- prepare technical recommendations for testing methods,
- prepare state-of-the-art reports to identify further research needs,
- collaborate with national or international associations in realising these objectives.

RILEM members include the leading building research and testing laboratories around the world, industrial research, manufacturing and contracting interests, as well as a significant number of individual members from industry and universities. RILEM's focus is on construction materials and their use in building and civil engineering structures, covering all phases of the building process from manufacture to use and recycling of materials.

RILEM meets these objectives through the work of its technical committees. Symposia, workshops and seminars are organised to facilitate the exchange of information and dissemination of knowledge. RILEM's primary output consists of technical recommendations. RILEM also publishes the journal *Materials and Structures* which provides a further avenue for reporting the work of its committees. Many other publications, in the form of reports, monographs, symposia and workshop proceedings are produced.

**2<sup>nd</sup> Historic Mortars Conference and  
RILEM TC 203-RHM Final Workshop  
HMC2010**

Prague, Czech Republic

22-24 September 2010

**Edited by J. Válek, C. Groot and J. J. Hughes**

RILEM Publications S.A.R.L.

## **RILEM Publications**

RILEM Publications are presented in 6 collections, corresponding to the 5 clusters of active RILEM Technical Committees, sorted by fields of expertise, and a 6th multi-thematic collection dedicated to journals and compendiums:

- A. Mechanical Performance and Fracture
- B. Materials Characterization, Properties Evaluation and Processing
- C. Design and Service Life
- D. Performance and Deterioration Mechanisms
- E. Special Construction Materials and Components
- F. Journals and Compendiums

Each publication is assigned to one of the following series: reports (REP), proceedings (PRO), compendiums (COMP) and journals. The former CD-ROM series is now included in one of these series.

Each publication is available in at least one of the three following editions: print (PR), CD or DVD-ROM (CD), or online (OL).

Online editions are available through our web site, at <http://www.rilem.net>

The RILEM DVD-ROM, gathering several thousands of online articles, is also published and updated each year (internal publication, circulation restricted to RILEM Benefactor Members).

The following list is presenting our global offer, sorted by series.

## **RILEM PROCEEDINGS**

**PRO 1:** Durability of High Performance Concrete (ISBN: 2-912143-03-9); *Ed. H. Sommer*

**PRO 2:** Chloride Penetration into Concrete (ISBN: 2-912143-00-04);  
*Eds. L.-O. Nilsson and J.-P. Ollivier*

**PRO 3:** Evaluation and Strengthening of Existing Masonry Structures (ISBN: 2-912143-02-0);  
*Eds. L. Binda and C. Modena*

**PRO 4:** Concrete: From Material to Structure (ISBN: 2-912143-04-7); *Eds. J.-P. Bournazel and Y. Malier*

**PRO 5:** The Role of Admixtures in High Performance Concrete (ISBN: 2-912143-05-5);  
*Eds. J. G. Cabrera and R. Rivera-Villarreal*

**PRO 6:** High Performance Fiber Reinforced Cement Composites - HPFRCC 3 (ISBN: 2-912143-06-3); *Eds. H. W. Reinhardt and A. E. Naaman*

**PRO 7:** 1st International RILEM Symposium on Self-Compacting Concrete (ISBN: 2-912143-09-8); *Eds. Å. Skarendahl and Ö. Petersson*

- PRO 8:** International RILEM Symposium on Timber Engineering (ISBN: 2-912143-10-1);  
*Ed. L. Boström*
- PRO 9:** 2nd International RILEM Symposium on Adhesion between Polymers and Concrete  
ISAP '99 (ISBN: 2-912143-11-X); *Eds. Y. Ohama and M. Puterman*
- PRO 10:** 3rd International RILEM Symposium on Durability of Building and Construction Sealants (ISBN: 2-912143-13-6); *Eds. A. T. Wolf*
- PRO 11:** 4th International RILEM Conference on Reflective Cracking in Pavements (ISBN: 2-912143-14-4); *Eds. A. O. Abd El Halim, D. A. Taylor and El H. H. Mohamed*
- PRO 12:** International RILEM Workshop on Historic Mortars: Characteristics and Tests (ISBN: 2-912143-15-2); *Eds. P. Bartos, C. Groot and J. J. Hughes*
- PRO 13:** 2nd International RILEM Symposium on Hydration and Setting (ISBN: 2-912143-16-0);  
*Ed. A. Nonat*
- PRO 14:** Integrated Life-Cycle Design of Materials and Structures - ILCDES 2000 (ISBN: 951-758-408-3); (ISSN: 0356-9403); *Ed. S. Sarja*
- PRO 15:** Fifth RILEM Symposium on Fibre-Reinforced Concretes (FRC) - BEFIB'2000 (ISBN: 2-912143-18-7); *Eds. P. Rossi and G. Chanvillard*
- PRO 16:** Life Prediction and Management of Concrete Structures (ISBN: 2-912143-19-5); *Ed. D. Naus*
- PRO 17:** Shrinkage of Concrete – Shrinkage 2000 (ISBN: 2-912143-20-9);  
*Eds. V. Baroghel-Bouny and P.-C. Aïtcin*
- PRO 18:** Measurement and Interpretation of the On-Site Corrosion Rate (ISBN: 2-912143-21-7);  
*Eds. C. Andrade, C. Alonso, J. Fullea, J. Polimon and J. Rodriguez*
- PRO 19:** Testing and Modelling the Chloride Ingress into Concrete (ISBN: 2-912143-22-5);  
*Eds. C. Andrade and J. Kropp*
- PRO 20:** 1st International RILEM Workshop on Microbial Impacts on Building Materials (CD 02) (e-ISBN 978-2-35158-013-4); *Ed. M. Ribas Silva*
- PRO 21:** International RILEM Symposium on Connections between Steel and Concrete (ISBN: 2-912143-25-X); *Ed. R. Eligehausen*
- PRO 22:** International RILEM Symposium on Joints in Timber Structures (ISBN: 2-912143-28-4); *Eds. S. Aicher and H.-W. Reinhardt*
- PRO 23:** International RILEM Conference on Early Age Cracking in Cementitious Systems (ISBN: 2-912143-29-2); *Eds. K. Kovler and A. Bentur*

- PRO 24:** 2nd International RILEM Workshop on Frost Resistance of Concrete (ISBN: 2-912143-30-6); *Eds. M. J. Setzer, R. Auberg and H.-J. Keck*
- PRO 25:** International RILEM Workshop on Frost Damage in Concrete (ISBN: 2-912143-31-4); *Eds. D. J. Janssen, M. J. Setzer and M. B. Snyder*
- PRO 26:** International RILEM Workshop on On-Site Control and Evaluation of Masonry Structures (ISBN: 2-912143-34-9); *Eds. L. Binda and R. C. de Vekey*
- PRO 27:** International RILEM Symposium on Building Joint Sealants (CD03); *Ed. A. T. Wolf*
- PRO 28:** 6th International RILEM Symposium on Performance Testing and Evaluation of Bituminous Materials - PTEBM'03 (ISBN: 2-912143-35-7; e-ISBN: 978-2-912143-77-8); *Ed. M. N. Partl*
- PRO 29:** 2nd International RILEM Workshop on Life Prediction and Ageing Management of Concrete Structures (ISBN: 2-912143-36-5); *Ed. D. J. Naus*
- PRO 30:** 4th International RILEM Workshop on High Performance Fiber Reinforced Cement Composites - HPFRCC 4 (ISBN: 2-912143-37-3); *Eds. A. E. Naaman and H. W. Reinhardt*
- PRO 31:** International RILEM Workshop on Test and Design Methods for Steel Fibre Reinforced Concrete: Background and Experiences (ISBN: 2-912143-38-1); *Eds. B. Schnütgen and L. Vandewalle*
- PRO 32:** International Conference on Advances in Concrete and Structures 2 vol. (ISBN (set): 2-912143-41-1); *Eds. Ying-shu Yuan, Surendra P. Shah and Heng-lin Lü*
- PRO 33:** 3rd International Symposium on Self-Compacting Concrete (ISBN: 2-912143-42-X); *Eds. O. Wallevik and I. Nielsson*
- PRO 34:** International RILEM Conference on Microbial Impact on Building Materials (ISBN: 2-912143-43-8); *Ed. M. Ribas Silva*
- PRO 35:** International RILEM TC 186-ISA on Internal Sulfate Attack and Delayed Ettringite Formation (ISBN: 2-912143-44-6); *Eds. K. Scrivener and J. Skalny*
- PRO 36:** International RILEM Symposium on Concrete Science and Engineering – A Tribute to Arnon Bentur (ISBN: 2-912143-46-2); *Eds. K. Kovler, J. Marchand, S. Mindess and J. Weiss*
- PRO 37:** 5th International RILEM Conference on Cracking in Pavements – Mitigation, Risk Assessment and Prevention (ISBN: 2-912143-47-0); *Eds. C. Petit, I. Al-Qadi and A. Millien*
- PRO 38:** 3rd International RILEM Workshop on Testing and Modelling the Chloride Ingress into Concrete (ISBN: 2-912143-48-9); *Eds. C. Andrade and J. Kropp*
- PRO 39:** 6th International RILEM Symposium on Fibre-Reinforced Concretes - BEFIB 2004 (ISBN: 2-912143-51-9); *Eds. M. Di Prisco, R. Felicetti and G. A. Plizzari*
- PRO 40:** International RILEM Conference on the Use of Recycled Materials in Buildings and Structures (ISBN: 2-912143-52-7); *Eds. E. Vázquez, Ch. F. Hendriks and G. M. T. Janssen*



**PRO 41:** RILEM International Symposium on Environment-Conscious Materials and Systems for Sustainable Development (ISBN: 2-912143-55-1); *Eds. N. Kashino and Y. Ohama*

**PRO 42:** SCC'2005 - China: 1st International Symposium on Design, Performance and Use of Self-Consolidating Concrete (ISBN: 2-912143-61-6); *Eds. Zhiwu Yu, Caijun Shi, Kamal Henri Khayat and Youjun Xie*

**PRO 43:** International RILEM Workshop on Bonded Concrete Overlays (e-ISBN: 2-912143-83-7); *Eds. J. L. Granju and J. Silfwerbrand*

**PRO 44:** 2nd International RILEM Workshop on Microbial Impacts on Building Materials (CD11) (e-ISBN: 2-912143-84-5); *Ed. M. Ribas Silva*

**PRO 45:** 2nd International Symposium on Nanotechnology in Construction, Bilbao (ISBN: 2-912143-87-X); *Eds. Peter J. M. Bartos, Yolanda de Miguel and Antonio Porro*

**PRO 46:** ConcreteLife'06 - International RILEM-JCI Seminar on Concrete Durability and Service Life Planning: Curing, Crack Control, Performance in Harsh Environments (ISBN: 2-912143-89-6); *Ed. K. Kovler*

**PRO 47:** International RILEM Workshop on Performance Based Evaluation and Indicators for Concrete Durability (ISBN: 978-2-912143-95-2); *Eds. V. Baroghel-Bouny, C. Andrade, R. Torrent and K. Scrivener*

**PRO 48:** 1st International RILEM Symposium on Advances in Concrete through Science and Engineering (e-ISBN: 2-912143-92-6); *Eds. J. Weiss, K. Kovler, J. Marchand, and S. Mindess*

**PRO 49:** International RILEM Workshop on High Performance Fiber Reinforced Cementitious Composites in Structural Applications (ISBN: 2-912143-93-4); *Eds. G. Fischer and V.C. Li*

**PRO 50:** 1<sup>st</sup> International RILEM Symposium on Textile Reinforced Concrete (ISBN: 2-912143-97-7); *Eds. Josef Hegger, Wolfgang Brameshuber and Norbert Will*

**PRO 51:** 2<sup>nd</sup> International Symposium on Advances in Concrete through Science and Engineering (ISBN: 2-35158-003-6; e-ISBN: 2-35158-002-8); *Eds. J. Marchand, B. Bissonnette, R. Gagné, M. Jolin and F. Paradis*

**PRO 52:** Volume Changes of Hardening Concrete: Testing and Mitigation (ISBN: 2-35158-004-4; e-ISBN: 2-35158-005-2); *Eds. O. M. Jensen, P. Lura and K. Kovler*

**PRO 53:** High Performance Fiber Reinforced Cement Composites - HPFRCC5 (ISBN: 978-2-35158-046-2); *Eds. H. W. Reinhardt and A. E. Naaman*

**PRO 54:** 5<sup>th</sup> International RILEM Symposium on Self-Compacting Concrete (ISBN: 978-2-35158-047-9); *Eds. G. De Schutter and V. Boel*

**PRO 55:** International RILEM Symposium Photocatalysis, Environment and Construction Materials (ISBN: 978-2-35158-056-1); *Eds. P. Baglioni and L. Cassar*

**PRO56:** International RILEM Workshop on Integral Service Life Modelling of Concrete Structures (ISBN 978-2-35158-058-5); *Eds. R. M. Ferreira, J. Gulikers and C. Andrade*

- PRO57:** RILEM Workshop on Performance of cement-based materials in aggressive aqueous environments (e-ISBN: 978-2-35158-059-2); *Ed. N. De Belie*
- PRO58:** International RILEM Symposium on Concrete Modelling - CONMOD'08 (ISBN: 978-2-35158-060-8); *Eds. E. Schlangen and G. De Schutter*
- PRO 59:** International RILEM Conference on On Site Assessment of Concrete, Masonry and Timber Structures - SACoMaTiS 2008 (ISBN set: 978-2-35158-061-5); *Eds. L. Binda, M. di Prisco and R. Felicetti*
- PRO 60:** Seventh RILEM International Symposium on Fibre Reinforced Concrete: Design and Applications - BEFIB 2008 (ISBN: 978-2-35158-064-6); *Ed. R. Gettu*
- PRO 61:** 1<sup>st</sup> International Conference on Microstructure Related Durability of Cementitious Composites 2 vol., (ISBN: 978-2-35158-065-3); *Eds. W. Sun, K. van Breugel, C. Miao, G. Ye and H. Chen*
- PRO 62:** NSF/ RILEM Workshop: In-situ Evaluation of Historic Wood and Masonry Structures (e-ISBN: 978-2-35158-068-4); *Eds. B. Kasal, R. Anthony and M. Drdácáký*
- PRO 63:** Concrete in Aggressive Aqueous Environments: Performance, Testing and Modelling, 2 vol., (ISBN: 978-2-35158-071-4); *Eds. M. G. Alexander and A. Bertron*
- PRO 64:** Long Term Performance of Cementitious Barriers and Reinforced Concrete in Nuclear Power Plants and Waste Management - NUCPERF 2009 (ISBN: 978-2-35158-072-1); *Eds. V. L'Hostis, R. Gens, C. Gallé*
- PRO 65:** Design Performance and Use of Self-consolidating Concrete - SCC'2009 (ISBN: 978-2-35158-073-8); *Eds. C. Shi, Z. Yu, K. H. Khayat and P. Yan*
- PRO 66:** 2<sup>nd</sup> International RILEM Workshop on Concrete Durability and Service Life Planning - ConcreteLife'09 (ISBN: 978-2-35158-074-5); *Ed. K. Kovler*
- PRO 67:** Repairs Mortars for Historic Masonry (e-ISBN: 978-2-35158-083-7); *Ed. C. Groot*
- PRO 68:** Proceedings of the 3<sup>rd</sup> International RILEM Symposium on 'Rheology of Cement Suspensions such as Fresh Concrete (ISBN 978-2-35158-091-2); *Eds. O. H. Wallevik, S. Kubens and S. Oesterheld*
- PRO 69:** 3<sup>rd</sup> International PhD Student Workshop on 'Modelling the Durability of Reinforced Concrete (ISBN: 978-2-35158-095-0); *Eds. R. M. Ferreira, J. Gulikers and C. Andrade*
- PRO 71:** Advances in Civil Engineering Materials - The 50-year Teaching Anniversary of Prof. Sun Wei' (ISBN: 978-2-35158-098-1; e-ISBN: 978-2-35158-099-8); *Eds. C. Miao, G. Ye, and H. Chen*

## RILEM REPORTS

- Report 19:** Considerations for Use in Managing the Aging of Nuclear Power Plant Concrete Structures (ISBN: 2-912143-07-1); *Ed. D. J. Naus*
- Report 20:** Engineering and Transport Properties of the Interfacial Transition Zone in Cementitious Composites (ISBN: 2-912143-08-X); *Eds. M. G. Alexander, G. Arliguie, G. Ballivy, A. Bentur and J. Marchand*
- Report 21:** Durability of Building Sealants (ISBN: 2-912143-12-8); *Ed. A. T. Wolf*
- Report 22:** Sustainable Raw Materials - Construction and Demolition Waste (ISBN: 2-912143-17-9); *Eds. C. F. Hendriks and H. S. Pietersen*
- Report 23:** Self-Compacting Concrete state-of-the-art report (ISBN: 2-912143-23-3); *Eds. Å. Skarendahl and Ö. Petersson*
- Report 24:** Workability and Rheology of Fresh Concrete: Compendium of Tests (ISBN: 2-912143-32-2); *Eds. P. J. M. Bartos, M. Sonebi and A. K. Tamimi*
- Report 25:** Early Age Cracking in Cementitious Systems (ISBN: 2-912143-33-0); *Ed. A. Bentur*
- Report 26:** Towards Sustainable Roofing (Joint Committee CIB/RILEM) (CD 07) (e-ISBN 978-2-912143-65-5); *Eds. Thomas W. Hutchinson and Keith Roberts*
- Report 27:** Condition Assessment of Roofs (Joint Committee CIB/RILEM) (CD 08) (e-ISBN 978-2-912143-66-2); *Ed. CIB W 83/RILEM TC166-RMS*
- Report 28:** Final report of RILEM TC 167-COM ‘Characterisation of Old Mortars with Respect to Their Repair (ISBN: 978-2-912143-56-3); *Eds. C. Groot, G. Ashall and J. Hughes*
- Report 29:** Pavement Performance Prediction and Evaluation (PPPE): Interlaboratory Tests (e-ISBN: 2-912143-68-3); *Eds. M. Partl and H. Piber*
- Report 30:** Final Report of RILEM TC 198-URM ‘Use of Recycled Materials’ (ISBN: 2-912143-82-9; e-ISBN: 2-912143-69-1); *Eds. Ch. F. Hendriks, G. M. T. Janssen and E. Vázquez*
- Report 31:** Final Report of RILEM TC 185-ATC ‘Advanced testing of cement-based materials during setting and hardening’ (ISBN: 2-912143-81-0; e-ISBN: 2-912143-70-5); *Eds. H. W. Reinhardt and C. U. Grosse*
- Report 32:** Probabilistic Assessment of Existing Structures. A JCSS publication (ISBN 2-912143-24-1); *Ed. D. Diamantidis*
- Report 33:** State-of-the-Art Report of RILEM Technical Committee TC 184-IFE ‘Industrial Floors’ (ISBN 2-35158-006-0); *Ed. P. Seidler*
- Report 34:** Report of RILEM Technical Committee TC 147-FMB ‘Fracture mechanics applications to anchorage and bond’ Tension of Reinforced Concrete Prisms – Round Robin Analysis and Tests on Bond (e-ISBN 2-912143-91-8); *Eds. L. Elfgren and K. Noghabai*
- Report 35:** Final Report of RILEM Technical Committee TC 188-CSC ‘Casting of Self Compacting Concrete’ (ISBN 2-35158-001-X; e-ISBN: 2-912143-98-5); *Eds. Å. Skarendahl and P. Billberg*

**Report 36:** State-of-the-Art Report of RILEM Technical Committee TC 201-TRC ‘Textile Reinforced Concrete’ (ISBN 2-912143-99-3); *Ed. W. Brameshuber*

**Report 37:** State-of-the-Art Report of RILEM Technical Committee TC 192-ECM ‘Environment-conscious construction materials and systems’ (ISBN: 978-2-35158-053-0);

*Eds. N. Kashino, D. Van Gemert and K. Imamoto*

**Report 38:** State-of-the-Art Report of RILEM Technical Committee TC 205-DSC ‘Durability of Self-Compacting Concrete’ (ISBN: 978-2-35158-048-6); *Eds. G. De Schutter and K. Audenaert*

**Report 39:** Final Report of RILEM Technical Committee TC 187-SOC ‘Experimental determination of the stress-crack opening curve for concrete in tension’ (ISBN 978-2-35158-049-3); *Ed. J. Planas*

**Report 40:** State-of-the-Art Report of RILEM Technical Committee TC 189-NEC ‘Non-Destructive Evaluation of the Penetrability and Thickness of the Concrete Cover’ (ISBN 978-2-35158-054-7);

*Eds. R. Torrent and L. Fernández Luco*

**Report 41:** State-of-the-Art Report of RILEM Technical Committee TC 196-ICC ‘Internal Curing of Concrete’ (ISBN 978-2-35158-009-7); *Eds. K. Kovler and O. M. Jensen*

**Report 42:** ‘Acoustic Emission and Related Non-destructive Evaluation Techniques for Crack Detection and Damage Evaluation in Concrete’ - Final Report of RILEM Technical Committee 212-ACD (e-ISBN: 978-2-35158-100-1); *Ed. M. Ohtsu*

## **RILEM COMPENDIUMS**

**COMP 01:** Trilingual Dictionary for Materials and Structures (English-French-German) (CD01) (1970)

**COMP 02:** 1947-1997: 50 years of evolution of Building Materials and Structures (e-ISBN: 2-912143-86-1); *Ed. F. Wittmann*

**COMP 03:** General Conference of RILEM TCs’ Chairmen and RILEM Seminar ‘Advancing the Knowledge in Materials and Structures’ (CD10) (e-ISBN: 2-912143-85-3)

**COMP 06:** Concrete Science and Engineering Journal – Vols. 1, 2, 3, 4 (1999-2002) (CD05)

**COMP 13:** RILEM Technical Day, Moscow (e-ISBN: 2-35158-045-1)

## Contents

<b>Preface</b> .....	XXIII
<b>Scientific Committee</b> .....	XXV
<b>Organising Committee</b> .....	XXVI
<b>RILEM TC 203-RHM Final Workshop Preface</b> .....	XXVII

### **THEME I: CHARACTERISATION OF HISTORIC MORTARS**

Gypsum mortars of the Khoja Zainuddin Mosque in Bukhara (Uzbekistan): a contribution to building archaeological studies <i>J. Badr, Ch. Huck-Stiasny, R. Drewello</i> .....	3
Understanding historic mortars and their variations - a condition for performing restoration with traditional materials <i>K. Balksten</i> .....	11
Irish medieval mortars: implications for the formulation of new replacement mortars <i>J. Bolton</i> .....	19
Ancient mortars under action of marine environment: a physico-chemical characterisation <i>C. Borges, A. Santos Silva, R. Veiga</i> .....	29
Chemical, mineralogical and microstructural characterization of historical mortars from the Roman villa of Pisões, Beja, Portugal <i>G. Borsoi, A. Santos Silva, P. Menezes, A. Candeias, J. Mirão</i> .....	43
Petrographical study of Meroitic mortars from an Amun temple (el-Hassa) <i>M. Bouchar</i> .....	55
Famous men busts decorating a Parisian facade: Characterization and decay process of a cast artificial stone from the XIXth century <i>A. Bourgès, S. Cord, V. Vergès-Belmin</i> .....	65
How did the Romans form concrete underwater? <i>C.J. Brandon</i> .....	73
Mortars from historical buildings in Switzerland: petrographic examination <i>G. Cavallo, A. Jornet, C. Mosca, G. Corredig</i> .....	83
Proteomic identification of milk proteins in historical mortars <i>M. Crhova, S. Kuckova, R. Hynek, M. Kodicek</i> .....	91

Development of a methodology for characterization of historical mortars in the Walloon region (Belgium) <i>M. Demelenne, F. Dagrain, J-C. Scaillet</i> .....	99
Lime mortar with natural hydraulic components – characterization of reaction rims with FTIR-imaging in ATR-mode <i>A. Diekamp, R. Stalder, J. Konzett, P.W. Mirwald</i> .....	111
Ancient wall plasters found in archaeological excavations in Marseilles (France): evolution of techniques and materials <i>A-M. D'Ovidio, P. Bromblet</i> .....	119
Hydraulicity in historic lime mortars: a review <i>J. Elsen, K. Van Balen, G. Mertens</i> .....	129
Characteristics of mortars from ancient bridges <i>D. Frankeová, Z. Slížková, M. Drdáký</i> .....	147
Characterization of gypsum-selenite plasters from historic buildings in the Emilia-Romagna region (Italy) <i>E. Franzoni, F. Sandrolini, L. Baldazzi</i> .....	157
Characterization of decorative Portuguese gypsum plasters from the XIX-XX <sup>th</sup> centuries: the case of the Bolsa Palace in Oporto <i>T. Freire, A. Santos Silva, R. Veiga, J. Brito</i> .....	165
Petrographic examination of Gothic mortars of the house of Lords of Kunštát in Brno, Czech Republic <i>M. Gregerová, D. Všianský, R. Procházka, L. Kurdíková</i> .....	175
Case study Nako in Western Himalayas, India. On the relevance of earthen supports material characterisation <i>M. Gruber, G. Krist</i> .....	187
Ancient gypsum mortars from Sta. María Magdalena church (Zaragoza, Spain): advances in technological manufacture <i>J. Igea, P. Lapuente, M.T. Blanco-Varela, S. Martínez-Ramírez</i> .....	197
Micromorphological textures and pozzolanic cements in Imperial Age Roman Mortars <i>M. Jackson, B.E. Scheetz, F. Marra</i> .....	207
Cement compositions and durability in ancient Roman seawater concretes <i>M.D. Jackson, G. Vola, B.E. Scheetz, J.P. Oleson, Ch. Brandon, R.L. Hohlfelder</i> .....	217
Medieval gypsum mortars as a material of architectonic details from the castle of the Teutonic Order in Toruń, Poland <i>M. Jakubek, F. Schlütter, W. Oberta, J. W. Łukaszewicz</i> .....	227
Traditional mortars with burned alum shale as artificial pozzolan <i>S. Johansson, J.E. Lindqvist</i> .....	239

Mineralogical and microstructural analysis of mortars from Kushite archaeological sites <i>J.-P. Letourneux, S. Feneuille</i> .....	<b>247</b>
Identification of mortars in the Ottoman era in Algeria through historical documentation and laboratory analyses <i>N.A. Mahinidad, M. Hamiane</i> .....	<b>257</b>
Historic documents in understanding and evaluation of historic lime mortars <i>C. Marinowitz, C. Neuwald-Burg, M. Pfeifer</i> .....	<b>267</b>
The mortars and plasters under the mosaics and the wall paintings of the Roman villa at Piazza Armerina, Sicily <i>B. Megna, G. Rizzo, L. Ercoli</i> .....	<b>275</b>
How did expertise in maritime hydraulic concrete spread through the Roman empire? <i>J.P. Oleson, M.D. Jackson</i> .....	<b>285</b>
Thermal activation of kaolinite used as hydraulic additive of old lime mixtures: a literature study <i>G.L.A. Pesce</i> .....	<b>293</b>
Radiocarbon dating of lumps of not completely mixed lime contained in old constructions: the sampling problem <i>G.L.A. Pesce</i> .....	<b>301</b>
The earliest use of lime and gypsum mortars in Cyprus <i>M. Philokyprou</i> .....	<b>309</b>
Characterization of Roman mortars and plasters in Tarsus (Cilicia-Turkey) <i>I. Polat-Pekmezci, A. Ersen</i> .....	<b>317</b>
Development of an analytical protocol for characterisation of historical mortars <i>L. Rampazzi, C. Corti, C. Colombo, C. Conti, M. Realini</i> .....	<b>325</b>
Mapping of mortars and ashlar in watchtowers of Reconquest Ages in Cuenca district, Spain <i>J.R. Ruiz Checa, V. Cristini</i> .....	<b>327</b>
Stone-imitating plasters in the Renaissance Ducal Palace in Mantua (Italy): characteristics and decay with relation to microstructure <i>F. Sandrolini, E. Franzoni, E. Sassoni</i> .....	<b>335</b>
Physico-chemical characterization of the plasters from the church of Santissimo Sacramento in Alcântara, Lisbon <i>A. Santos Silva, G. Borsoi, R. Veiga, A. Fragata, M. Tavares, F. Llera</i> .....	<b>345</b>
Air lime-mortars with vegetable fat addition: characteristics and research needs <i>A. Shasavandi, E. Salavessa, F.P. Torgal, S. Jalali</i> .....	<b>359</b>

Characterisation of dolomitic lime mortars from the Benedictine monastery in Riesa, Saxony (Germany) <i>H. Siedel, S. Michalski, B. Ullrich</i> .....	<b>365</b>
Characterisation of ancient gypsum mortars from the archaeological site of Amathus, Cyprus <i>P.E. Tsakiridis, E-E.Toumbakari</i> .....	<b>373</b>
Mineralogical and petrographic characterization of ancient Roman maritime concretes from Mediterranean harbours <i>G. Vola, M.D. Jackson, J.P. Oleson, Ch. Brandon, R.L. Hohlfelder</i> .....	<b>381</b>
Gravel Lime? Research into Danube gravel as the main ingredient of the historic mortars at Castle Prandeggin Upper Austria <i>R. Wacha</i> .....	<b>389</b>
19 <sup>th</sup> century “Novel” building materials: Examples of various historic mortars under the microscope <i>J. Weber, K. Bayer, F. Pintér</i> .....	<b>397</b>
Characterization of mortars in historical modern monuments: a realistic and an analytical approach <i>G. Zacharopoulou</i> .....	<b>405</b>

## **THEME II: ASSESSMENT OF MORTARS AND MASONRY**

Testing the freeze/thaw cycles in lime mortar <i>S. Botas, V.M. Rato, P. Faria</i> .....	<b>417</b>
Assessment of an experimental test setup for glazed tiles by finite element simulations <i>P. Cachim, A. Velosa</i> .....	<b>427</b>
Lime lump development and textural alteration during the production of mortar <i>D. Carran, J. Hughes, A. Leslie, C. Kennedy</i> .....	<b>437</b>
Characterization of mortars using DRMS: Tests on field panels samples <i>D. Costa, A. Magalhães, R. Veiga</i> .....	<b>447</b>
Influence of mechanical properties of lime mortar on the strength of masonry <i>A. Costigan, S. Pavia</i> .....	<b>457</b>
Non-standard testing in characterisation and consolidation assessment of historic mortars <i>M. Drdácký</i> .....	<b>467</b>
In situ techniques for the characterization of rendering mortars <i>A.P. Ferreira Pinto, R. Nogueira, A. Gomes</i> .....	<b>475</b>



The role of mortars in ancient brick masonries' decay: a study in the Pio Palace at Carpi (Italy) <i>E. Franzoni</i> .....	<b>483</b>
Historical busts made of cement mortar – methods of examinations and causes of corrosion <i>A. Gralinska, J.W. Łukaszewicz, W. Topolska</i> .....	<b>491</b>
Deterioration of cement-rendered brick masonry buildings: case study of a World War II airfield in East Lothian, Scotland <i>I. Griffin, A. Hamilton, J. Tate</i> .....	<b>501</b>
The Influence of calcium hydroxide on the plasticity of lime putties <i>D. Klein, S. Hogewoning, S-O. Schmidt, B. Middendorf</i> .....	<b>511</b>
Influence of interfacial material pore structure on the strength of the brick/lime mortar bond <i>M. Lawrence, P. Walker, Z. Zhou</i> .....	<b>519</b>
Analytical diagnosis protocol to assess the impacts of environmental stressors on historical mortars acting as the support of wall paintings <i>M. Maguregui, U. Knuutinen, K. Castro, I. Martinez-Arkarazo, J.M. Madariaga</i>	<b>527</b>
Problems in the assessment of the stress-strain relationship of masonry <i>C. Neuwald-Burg, M. Pfeifer</i> .....	<b>537</b>
Application of <sup>1</sup> H NMR in the hydration monitoring of lime-pozzolan mortars <i>M. Tziotziou, E. Karakosta, I. Karatasios, M. Fardis, P. Maravelaki-Kalaitzaki, G. Papavassiliou, V. Kilikoglou</i> .....	<b>547</b>
Desalination of concrete sculptures on the Battle of the Nations <i>M. Zötl, T. Löther, S. Weise, R. Burkhardt, C. Franzen</i> .....	<b>555</b>

### **THEME III: CONSERVATION AND RESTORATION ISSUES**

Rui Barbosa Museum's architectural surfaces in Rio de Janeiro: reflections and planning issues <i>C.S. Rodrigues de Carvalho, M.I. Kanan</i> .....	<b>565</b>
Practical case study: mortar conservation for the Connaught building, Ottawa, Ontario, Canada <i>J. Cooke, M.I. Subercaseaux, W.Y. Mou</i> .....	<b>573</b>
Mud mortars in masonry construction - Malton, North Yorkshire <i>N. Copsey, B. Gourley, R. Allen</i> .....	<b>581</b>
Conservation of the plaster at the Lavriotike ore washeries <i>Y. Doganis, A. Galanos</i> .....	<b>591</b>

Rosendale natural cement: reintroduction of an authentic North American historic binder <i>M.P. Edison</i> .....	<b>599</b>
Traditional Portuguese techniques for application and maintenance of historic renders <i>P. Faria, M. Tavares, M. Menezes, R. Veiga, G. Margalha</i> .....	<b>609</b>
Drayton Hall: a case study, mortar analysis and replication <i>F. Henderson Ford, K.A. Stojsavljevic</i> .....	<b>619</b>
Santa Ana church – Lagos - Portugal, tender for renovation and restoration <i>P.J.T. Jones</i> .....	<b>629</b>
Comparison between traditional, lime based, and industrial, dry mortars <i>A. Jornet, C. Mosca, G. Cavallo, G. Corredig</i> .....	<b>631</b>
Types of mortars in wall paintings by the “Older Villach’s Workshop” and their followers (15 <sup>th</sup> Century) <i>A. Križnar, A. Ruíz-Conde, P. J. Sánchez-Soto</i> .....	<b>643</b>
The restoration of the cathedral at Kirkjubøur in the Faroe Islands <i>P. Klenz Larsen, T. von Konow, S. Johansson</i> .....	<b>653</b>
Restoration and conservation of the renderings of Santíssimo Sacramento de Alcântara church, Lisbon, Portugal <i>F. Llera, B. Barreiros, M. Tavares, T. Teixeira</i> .....	<b>661</b>
Oscarshall (Oslo, Norway) - case study of a restoration of a natural cement rendered facade from 1849. <i>M. Moe, J. Lukacs, T.S. Hansen</i> .....	<b>673</b>
Causes of decay of the Aveleiras House decorative plasters (in Torre de Moncorvo) <i>M.E. Costa Salavessa, A. Shavsavandi, F.P. Torgal, S. Jalali</i> .....	<b>683</b>
Sgraffito in Portugal: a contribution to its study and preservation <i>S. Salema, J. Aguiar</i> .....	<b>691</b>
Environmental decay of ancient stucco decorations subject to outdoor exposure <i>F. Sandrolini, E. Franzoni, E. Sassoni</i> .....	<b>701</b>
The restoration of the 12 <sup>th</sup> century engraved estrich gypsum floor from the Church in Wiślica <i>M. Stec</i> .....	<b>711</b>
Restoration plaster for the wall paintings presentations in three Pre-Romanesque churches on the Adriatic coast <i>V. Sulic</i> .....	<b>723</b>
Conservation of an Amun Temple in the Sudan <i>T. Sweek, J.R. Anderson, S. Tanimoto</i> .....	<b>733</b>

Grouting mortars for consolidation of historical renders showing loss of adhesion <i>M.L. Tavares, R. Veiga, A. Fragata</i> .....	<b>743</b>
Vitruvius and Antique techniques of plaster work and painting <i>L. Thiemann, S. Gerzer, R. Kilian</i> .....	<b>754</b>
Mortars in the buildings of Pre-Hispanic Peru: structural behavior studies <i>H.E. Torres Peceros</i> .....	<b>761</b>
Strengthening of heritage buildings by means of grout injection-problems and solutions <i>M. Uranjek, R. Žarnić, V. Bosiljkov</i> .....	<b>769</b>
Restoration of the tile cladding of a post-war modernist building complex <i>Y. Vanhellemont</i> .....	<b>779</b>
Repair mortars for the National Congress building, Argentina <i>S. Velázquez, I. Dolmann, M. Domínguez, F. Luna, E. Etchehourry, G. Alonso, S. Acri, M. Mancini</i> .....	<b>791</b>
Ceramic façades in Portugal - conservation issues <i>A.L. Velosa, R. Veiga</i> .....	<b>805</b>
Investigation of 14 <sup>th</sup> century Byzantine and Serbian provenance fresco painting <i>N. Vesić, C. Kyriakou, A. Bakolas, I. Tsamasfyrou, E.T. Delegou, A. Moropoulou</i> <b>813</b>	
Traditional stucco techniques in interior surface coatings: Northern Portugal (XIX-XX <sup>th</sup> centuries) <i>E.S. Vieira</i> .....	<b>823</b>
Overview of the 100 Mortars Project at the archaeological site of Herculaneum <i>A. De Vita, P. Pesaresi, V. Puglisi</i> .....	<b>833</b>
<b>THEME IV: REPAIR MORTARS FOR HISTORIC MASONRY</b>	
Lime - natural pozzolan conservation mortars: parameters that affect reactivity and strength <i>E. Ampatzioglou, I. Karatasios, B. Colston, D. Watt, V. Kililoglou</i> .....	<b>845</b>
Effect of pozzolanic activity of metakaolin on the mechanical properties of air and quicklime mortars <i>S. Andrejkovičová, A.L. Velosa, F. Rocha</i> .....	<b>853</b>
Comparison of different methods to determine the packing density of fresh mortars <i>A. Arizzi, C. Giuseppe</i> .....	<b>863</b>
Characterization of stone masonry panels consolidated by injection of grouts in buildings damaged by the 2009 Abruzzo earthquake <i>G. Artioli, M. Secco, C. Mazzoli, C. Coletti, M.R. Valluzzi, F. da Porto</i> .....	<b>871</b>

The influence of water repellent admixture on lime and lime cement mortars diffusion properties <i>L. Balík, J. Kolísko</i> .....	<b>883</b>
Energy renovation by lime renders <i>M.M. Barbero Barrera, F.J.N. González, L.M. Ramos, A. García Santos, K. Van Balen</i> .....	<b>891</b>
Impact of non-uniform distribution of temperature on the state of stress of masonry <i>P. Beran</i> .....	<b>899</b>
Repair mortars for the sandstones of the cathedral of Berne <i>C. Bläuer, H. Häberli, A. Löffel, B. Rousset</i> .....	<b>909</b>
Lime-metakaolin mortars applied on the Soledade palace, Recife, Brazil <i>T.M.A. Bonilla, A.F. Ferreira, A.F. Nóbrega, E.C.R. Silva, M.L. Souza, A.M.P. Carneiro</i> .....	<b>917</b>
Compatibility of repair mortars with 19 <sup>th</sup> century natural cement cast stone from the French Rhône-Alpes region <i>M. Bouichou, E. Marie-Victoire, E. Cailleux, D. Sommain</i> .....	<b>927</b>
Properties of lime-based restoration mortars modified by the addition of linseed oil <i>E. Čechová, I. Papayianni, M. Stefanidou</i> .....	<b>937</b>
Characterization of repair mortars for the assessment of their compatibility <i>Ö. Cizer, L. Schueremans, E. Janssens, G. Serre, K. Van Balen</i> .....	<b>947</b>
Flexural strength of fiber reinforced lime mortars for historic masonry structures <i>E. Erdogmus, C.K. Armwood, H. Haider, Y. Yang</i> .....	<b>957</b>
Effect of rice husk ash particle size in lime based mortars <i>A.P. Ferreira Pinto, N.G. Almeida, A. Gomes</i> .....	<b>965</b>
Masonry repair options and their philosophical ramifications <i>A.M. Forster</i> .....	<b>973</b>
Salt crystallization in substitution renders for historical constructions <i>A. Fragata, R. Veiga, A.L. Velosa</i> .....	<b>983</b>
Hydration of roman cements used for architectural restoration <i>C. Gosselin, K.L. Scrivener, S.B. Feldman</i> .....	<b>993</b>
Two views to deal with rain penetration problems in historic fired clay brick masonry <i>C. Groot, J. Gunneweg</i> .....	<b>1005</b>
Durability to salt decay of commercial ready-mixed mortars for the conservation of cultural heritage <i>C. Tedeschi, L. Binda, D. Gulotta, L. Toniolo</i> .....	<b>1015</b>

Design of jointing mortar compatible with the masonry of the Villa Maheddine of the “Ottoman era” <i>M. Hamiane, S. Aitouakli, L. Boumghar, W. Zekagh, M. Saidi</i> .....	<b>1023</b>
Water transport between mortar and brick: the influence of material parameters <i>R. Hendrickx, S. Roels, K. Van Balen</i> .....	<b>1035</b>
Roman cement for the production of conservation mortars <i>D.C. Hughes, J. Weber, R. Kozłowski</i> .....	<b>1043</b>
Design and production of repair mortars for historic masonry taking into account the characteristics of old mortars <i>I. Ioannou, M. Philokyprou, A. Ilia</i> .....	<b>1051</b>
Stress rate sensitivity of masonry units bound with hydraulic lime mortar <i>Md.T. Islam, R. Chan, V. Bindiganavile</i> .....	<b>1059</b>
The design and use of repair mortars for historical masonry in Australia <i>B. Jordan</i> .....	<b>1069</b>
The effect of relative humidity on the performance of lime-pozzolan mortars <i>I. Karatasios, M. Amenta, M. Tziotziou, V. Kilikoglou</i> .....	<b>1079</b>
The new groups of Formulated Limes (FL) of lime standard EN 459 – bane or boon? <i>B. Middendorf, D. Klein, S. Hogewoning, S-O. Schmidt</i> .....	<b>1087</b>
Impact of historically inspired processes of lime mortar preparation on its properties <i>D. Michoinová</i> .....	<b>1097</b>
Mortars for conservation-restoration of wall painting support in rupestrial churches <i>I. Mohanu, I. Gomoiu, D. Mohanu, D. Nastac</i> .....	<b>1105</b>
Strengthening of pure lime mortars with nanoparticles of calcium hydroxide <i>C. Moreau, Z. Sližková, M. Drdácý</i> .....	<b>1113</b>
Grouts for injection of historical masonries: influence of the binding system and other additions on the properties of the matrix <i>I. Papayianni, M. Stefanidou, V. Pachta</i> .....	<b>1123</b>
Influence of sand fines on the mechanical and physical properties of lime-based renders and plasters <i>I. Papayianni, M. Stefanidou, S. Christodoulou</i> .....	<b>1135</b>
The long-term effectiveness of renovation plasters from Jevíčko castle <i>M. Peřínková</i> .....	<b>1145</b>
Mortars from Roman cement and their properties <i>A. Peterová, K. Doubravová, V. Machovič, J. Jiroušek</i> .....	<b>1151</b>
Nano-lime as a binder for injection grouts and repair mortars <i>E. Maryniak-Piaszczyński, G. Ziegenbalg</i> .....	<b>1159</b>

High fired gypsum mortar for screeds, terrazzo and masonry repair on historic monuments. Production, properties and sample applications <i>F. Schlütter, W. Kaiser, H. Juling</i> .....	<b>1169</b>
Design of conservation mortars for the restoration of the Piraeus stones at the monuments of the Acropolis of Athens <i>N-A. Stefanis, P. Theoulakis</i> .....	<b>1181</b>
Repair mortars studied for the conservation of temple G1 in Mỹ Sơn, Vietnam <i>C. Tedeschi, L. Binda, P. Condoleo</i> .....	<b>1189</b>
Two siliceous grouts for the preservation of stone. <i>A. Thorn</i> .....	<b>1199</b>
Cement-stabilized earth mortars for application in archaeological sites and prehistoric monuments <i>E-E. Toumbakari, A. Ntziouni, V. Kasselouri-Rigopoulou</i> .....	<b>1209</b>
Strengthening of heritage buildings by means of grout injection - problems and solution <i>M. Uranjek, R. Žarnić, V. Bokan-Bosiljkov</i> .....	<b>1219</b>
Experimental study of hot mixed mortars in comparison with lime putty and hydrate mortars <i>J. Válek, T. Matas</i> .....	<b>1229</b>
Conservation of historic renders and plasters: from lab to site <i>R. Veiga</i> .....	<b>1241</b>
High-temperature gypsum plaster: investigations into conservation and restoration of historic gypsum objects <i>U. Wende, P. Kozub, T. Arnold, J. Meinhardt</i> .....	<b>1257</b>
Reducing shrinkage cracks in Roman cement renders <i>D. Wilk, Ł. Bratasz, R. Kozłowski</i> .....	<b>1265</b>
Correlation of initial and final available lime, and free water in lime putties to carbonation rate and mechanical characteristics of lime mortars <i>G. Zacharopoulou</i> .....	<b>1273</b>
The effect of wet slaked lime putty and putty prepared from dry hydrate on the strength of lime mortars <i>G. Zacharopoulou</i> .....	<b>1283</b>
Historic and modern injection grouts used in Poland for wall painting conservation <i>K. Zajadacz, J. Nykiel, S. Simon</i> .....	<b>1283</b>
Nano-lime - a new material for the consolidation and conservation of historic mortars <i>G. Ziegenbalg, K. Brümmer, J. Pianski</i> .....	<b>1301</b>

Analysis and testing methodology of mortars: a case study of the Báthory castle in  
Șimleu Silvaniei, Romania  
*A.B. Magó, A. Cosma, M Guttman, B. Szabó* ..... 1311

**RILEM TC 203-RHM ‘REPAIR MORTARS FOR HISTORIC MASONRY’  
FINAL WORKSHOP**

The role of mortar in masonry: an introduction to requirements for the design of  
repair mortars  
*J. Hughes, RILEM TC 203-RHM members* ..... 1323

Influence of masonry typology and mortar joints on the mechanical behaviour of  
masonry walls  
*L. Binda, RILEM TC 203-RHM members* ..... 1331

Repair mortars for historic masonry. From problem to intervention: a decision  
process  
*R. van Hees, RILEM TC 203-RHM members* ..... 1337

Testing of repair mortars for historic masonry  
*B. Bicer-Simsir, RILEM TC 203-RHM members* ..... 1343

Performance and repair requirements for repointing mortars  
*M. Subercaseaux, RILEM TC 203-RHM members* ..... 1349

Performance and repair requirements for bedding mortars  
*B. Middendorf, RILEM TC 203-RHM members* ..... 1353

Performance and repair requirements for renders and plasters  
*C. Groot, RILEM TC 203-RHM members* ..... 1359

Performance and repair requirements for flooring mortars  
*I. Papayianni, RILEM TC 203-RHM members* ..... 1365

Performance and repair requirements for surface repairs  
*J. Válek, RILEM TC 203-RHM members* ..... 1377

**Authors’ index** ..... 1385





## Preface

The 1st Historical Mortars Conference which took place in Lisbon, 2008, chaired by Dr. Rosario Veiga from LNEC was a very successful meeting and it gave rise to an idea that such a specialised event on historic mortars should be repeated. During the conference it became clear that sharing knowledge, creating new contacts and interdisciplinary collaborations are very much required in this topic. Mortars are not seen as a single discipline, but attract attention from a wide range of professions. This was confirmed by the number and variety of research projects on mortars which were presented.

Research has been focusing on historic mortars for some time. Demand for an improved scientific and technical guidance for conservation field led to the formation of the RILEM Technical Committee TC 167-COM on 'Characterisation of old mortars with respect to their repair' and its follow-up TC 203-RHM 'Repair mortars for historic masonry'. The later committee is now in its final stage. The final workshop of the TC 203-RHM will be incorporated as part of the conference and the resulting documents promise interesting material for discussions during the conference.

An objective of the 2nd Historic Mortars Conference is to bring together scientists, technicians and professionals involved in research and studies of historic mortars to present and discuss advances in this topic. The main theme of the conference is the conservation of historic buildings and works of art, i.e. studying mortars with respect to repair. This is a unifying field where a truly interdisciplinary collaboration is needed and where contributions of archaeologist, architects, civil and structural engineers, geologists, material scientists, chemists, conservation scientists and art restorers interested in mortars should have their place. The special focus of the conference will be on the application of research and technical knowledge to conservation practice and vice versa in its reflection on such recommendations.

A number of contributions, representing the whole world have been collected under the following four main conference themes:

- I Characterisation of historic mortars*  
(architectural, material, archaeological, construction and technological aspects)
- II Assessment of mortars and masonry*  
(diagnostics and testing methods, complex evaluation of masonry and mortars, structural issues, damage and deterioration)
- III Conservation and restoration issues*

(case studies, values, authenticity and compatibility of mortars, restoration and conservation techniques)

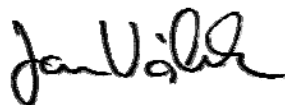
*IV Repair mortars for historic masonry*

(design and requirements for repair mortars, testing and evaluation of repair mortars, emerging materials and technologies).

The conference was organised by the Institute of Theoretical and Applied Mechanics of the Academy of Sciences of the Czech Republic (ITAM AV ČR) in cooperation with the International Union of Laboratories and Experts in Construction Materials (RILEM). The conference administration was managed by Congress Business Travel, Ltd. The Organising Committee greatly appreciate the financial support of Vicat from France and VAS v.o.s. building restoration and property management company from the Czech Republic. The prize for the best student presentation was supported and awarded by Lafarge, France. The conference was organised under the auspice of Mr. Ondřej Pecha, Member of the Committee of Prague City Council for Monument Care and Tourism.

The organisation was a team effort of the staff of the Institute of Theoretical and Applied Mechanics of the Academy of Sciences of the Czech Republic, with special thanks going to Dr. Claire Moreau who made the key contribution to the efficient organisation of the event and all the members of the Organising Committee. The papers were reviewed and edited by the members of the Scientific Committee and their great effort was greatly appreciated and in particular I wish to thank Dr. John Hughes of University of the West of Scotland and Dr. Caspar Groot of TU Delft. The full papers were proof read and edited by Jennifer Wehby, Dorn Carran and Dr. John Hughes. I also wish to thank Mr. Martin Pavala, Dr. Eva Čechová, Mr. Jiří Novotný, Mr. Josef Jiroušek for leading the excursions following the conference.

In Prague, September 2010



## International Scientific Committee

Dr. Karol Bayer	University of Pardubice, Czech Republic
Prof. Luigia Binda	Politecnico di Milano, Italy
Dr. Philippe Bromblet	Interregional Centre for Heritage Conservation and Restoration, France
Dr. Anjan Chatterjee	Institute of Structural Protection and Rehabilitation, India
Prof. Jan Elsen	Katholieke Universiteit Leuven, Belgium
Dr. Caspar Groot	Delft University of Technology, Netherlands
Prof. Rob van Hees	Delft University of Technology, TNO, Netherlands
Dr. John Hughes	University of the West of Scotland, Scotland
Dr. Jan Erik Lindqvist	Swedish Cement and Concrete Research Institute, Sweden
Dr. Paul Maurenbrecher	National Research Council of Canada, Canada
Prof. Bernhard Middendorf	Technische Universität Dortmund, Germany
Prof. Ioanna Papayianni	Aristotle University of Thessaloniki, Greece
Prof. Pavla Rovnaníková	Brno University of Technology, Czech Republic
Dr. Stefan Simon	The Rathgen Research Laboratory in Berlin, Germany
Ms. Maria Subercaseaux	Public Works and Government Services Canada, Canada
Dr. Margaret Thomson	Chemical Lime Company, USA
Dr. Eleni Eva Toumbakari	Hellenic Ministry of Culture, Greece
Dr. Jan Válek	ITAM, Academy of Sciences of the Czech Republic, Czech Republic
Dr. Rosario Veiga	National Laboratory for Civil Engineering, Portugal
Mr. David Young	Heritage consultant, Australia

## Organising Committee

Mr. Pavel Beran	(ITAM AV ČR, Czech Republic)
Mr. Tomáš Brůna	(ITAM AV ČR, Czech Republic)
Dr. Eva Čechová	(ITAM AV ČR, Czech Republic)
Ms. Dita Frankeová	(ITAM AV ČR, Czech Republic)
Dr. Jiří Frankl	(ITAM AV ČR, Czech Republic)
Ms. Vladislava Kostkanová	(ITAM AV ČR, Czech Republic)
Dr. Michal Kloiber	(ITAM AV ČR, Czech Republic)
Mr. Tomáš Matas	(ITAM AV ČR, Czech Republic)
Dr. Claire Moreau	(ITAM AV ČR, Czech Republic)
Dr. Jan Válek	(ITAM AV ČR, Czech Republic)

## **RILEM TC 203-RHM Final Workshop Preface**

At the successful first Historic Mortars Conference at Lisbon in 2008 (HMC08) it was concluded that there is a clear need for continuity in the exchange of experience and knowledge in this specialized field of restoration.

To this end the second Historic Mortar Conference (HMC 2010) was organized by the Institute of Theoretical and Applied Mechanics of the Academy of Sciences of the Czech Republic, chaired by Dr Jan Valek, in cooperation with the RILEM TC 203 RHM: Repair Mortars for Historic Masonry.

As part of the conference members of RILEM TC 203 presented in a workshop the final deliverables of the TC on performance requirements of repair mortars for historic masonry.

More than 140 papers were submitted after the call in which the conference themes are covered in a wide range of topics and views: fundamental aspects of mortar characterization with a view to repair, property development of binders and repair choices are discussed in the contributions as well as how to realize performance and repair requirements in restoration practice.

From this it may be expected that an interesting and useful interdisciplinary exchange of knowledge and experience will take place at HMC10.

It may as well be hoped that the findings of these conference proceedings will find their way to the field and that they may contribute to an improved restoration and conservation practice.

Caspar Groot  
Chair RILEM TC 203-RHM  
Delft, 29 Aug 10



## Authors' Index

Acri S.	791	Bromblet P.	119
Aguiar J.	691	Brümmer K.	1301
Aitouakli S.	1023	Burkhardt R.	555
Allen R.	581	Cachim P.	<b>427</b>
Almeida N.G.	965	Cailleux E.	927
Alonso G.	791	Candeias A.	43
Amenta M. I	079	Carneiro A.M.P.	917
Ampatzioglou E.	<b>845</b>	Carran D.	<b>437</b>
Anderson J.R.	733	Castro K.	527
Andrejkovičová S.	<b>853</b>	Cavallo G.	<b>83, 631</b>
Arizzi A.	<b>863</b>	Chan R.	1059
Armwood C.K.	957	Christodoulou S.	1135
Arnold T.	1257	Cizer Ö.	<b>947</b>
Artioli G.	<b>871</b>	Coletti C.	871
Badr J.	<b>3</b>	Colombo C.	325
Bakolas A.	813	Colston B.	845
Baldazzi L.	157	Condoleo P.	1189
Balík L.	<b>883</b>	Conti C.	325
Balksten K.	<b>11</b>	Cooke J.	<b>573</b>
Barbero Barrera M.M.	<b>891</b>	Copsey N.	<b>581</b>
Barreiros B.	661	Cord S.	65
Bayer K.	397	Corredig G.	<b>83, 631</b>
Beran P.	<b>899</b>	Corti C.	325
Binda L.	1015, 1189	Cosma A.	1311
Bindiganavile V.	1059	Costa D.	<b>447</b>
Blanco-Varela M.T.	197	Costa Salavessa M.E.	<b>683</b>
Bläuer C.	<b>909</b>	Costigan A.	<b>457</b>
Bokan-Bosiljkov V.	1219	Crhova M.	<b>91</b>
Bolton J.	<b>19</b>	Cristini V.	327
Bonilla T.M.A.	<b>917</b>	Čechová E.	<b>937</b>
Borges C.	<b>29</b>	Dagrain F.	99
Borsoi G.	<b>43, 345</b>	De Vita A.	<b>833</b>
Bosiljkov V.	769	Delegou E.T.	813
Botas S.	<b>417</b>	Demellenne M.	<b>99</b>
Bouchar M.	<b>55</b>	Diekamp A.	<b>111</b>
Bouichou M.	<b>927</b>	Doganis Y.	<b>591</b>
Boumghar L.	1023	Dolmann I.	791
Bourgès A.	<b>65</b>	Domínguez M.	791
Brandon C.J.	<b>73, 217, 381</b>	Doubravová K.	1151
Bratasz Ł.	1265	D'Ovidio A-M.	<b>119</b>
Brito J.	165	Drdacky M.	147, <b>467, 1113</b>

Drewello R.	3	Hughes D.C.	<b>1043</b>
Edison M.P.	<b>599</b>	Hughes J.	437
Elsen J.	<b>129</b>	Hynek R.	91
Ercoli L.	275	Igea J.	<b>197</b>
Erdogmus E.	<b>957</b>	Ilia A.	1051
Ersen A.	317	Ioannou I.	1051
Etchehourry E.	791	Islam Md.T.	<b>1059</b>
Fardis M.	547	Jackson M.D.	<b>207, 217, 285, 381</b>
Faria P.	<b>609, 417</b>	Jakubek M.	<b>227</b>
Feldman S.B.	993	Jalali S.	359, 683
Feneuille S.	247	Janssens E.	947
Ferreira A.F.	917	Jiroušek J.	1151
Ferreira Pinto A.P.	<b>475, 965</b>	Johansson S.	<b>239, 653</b>
Forster A.M.	<b>973</b>	Jones P.	<b>629</b>
Fragata A.	345, 743, <b>983</b>	Jordan B.	<b>1069</b>
Frankeová D.	<b>147</b>	Jornet A.	83, <b>631</b>
Franzen C.	555	Juling H.	1169
Franzoni E.	<b>157, 335, 483, 701</b>	Kaiser W.	1169
Freire T.	<b>165</b>	Kanan M.I.	565
Galanos A.	591	Karakosta E.	547
García Santos A.	891	Karatasios I.	547, 845, <b>1079</b>
Gerzer S.	754	Kasselouri-Rigopoulou V.	1209
Giuseppe C.	863	Kennedy C.	437
Gomes A.	475, 965	Kilian R.	754
Gomoiu I.	1105	Kilikoglou V.	547, 845, 1079
González F.J.N.	891	Klein D.	<b>511, 1087</b>
Gosselin C.	<b>993</b>	Klenz Larsen P.	<b>653</b>
Gourley B.	581	Knuutinen U.	527
Gralinska A.	<b>491</b>	Kodicek M.	91
Gregerová M.	<b>175</b>	Kolíško J.	883
Griffin I.	<b>501</b>	Konzett J.	111
Groot C.	<b>1005</b>	Kozłowski R.	1043, 1265
Gruber M.	<b>187</b>	Kozub P.	1257
Gulotta D.	1015	Krist G.	187
Gunneweg J.	<b>1005</b>	Križnar A.	<b>643</b>
Guttman M.	1311	Kuckova S.	91
Häberli H.	909	Kurdíková L.	175
Haider H.	957	Kyriakou C.	813
Hamiane M.	257, <b>1023</b>	Lapuente P.	197
Hamilton A.	501	Lawrence M.	<b>519</b>
Hansen T.S.	673	Leslie A.	437
Henderson Ford F.	<b>619</b>	Letourneux J-P.	<b>247</b>
Hendrickx R.	<b>1035</b>	Lindqvist J.E.	239
Hogewoning S.	511, 1087	Llera F.	345, <b>661</b>
Hohlfelder R.L.	217, 381	Löffel A.	909
Huck-Stiasny C.	3	Löther T.	555



Lukacs J.	673	Papavassiliou G.	547
Łukaszewicz J.W.	227, 491	Papayianni I.	937, <b>1123</b> , <b>1135</b>
Luna F.	791	Pavía S.	457
Madariaga J.M.	527	Peřinková M.	<b>1145</b>
Magalhães A.	447	Pesaresi P.	833
Magó A.	<b>1311</b>	Pesce G.L.A.	<b>293</b> , <b>301</b>
Maguregui M.	<b>527</b>	Peterová A.	<b>1151</b>
Mahindad N.A.	<b>257</b>	Pfeifer M.	267, 537
Machovič V.	1151	Philokyprou M.	<b>309</b> , 1051
Mancini M.	791	Pianski J.	1301
Maravelaki-Kalaitzaki P.	547	Pintér F.	397
Margalha G.	609	Polat-Pekmezci I.	<b>317</b>
Marie-Victoire E.	927	da Porto F.	871
Marinowitz C.	<b>267</b>	Procházka R.	175
Marra F.	207	Puglisi V.	833
Martinez-Arkarazo I.	527	Ramos L.M.	891
Martínez-Ramírez S.	197	Rampazzi L.	<b>325</b>
Maryniak-Piaszczyński E.	<b>1159</b>	Rato V.M.	417
Matas T.	1229	Realini M.	325
Mazzoli C.	871	Rizzo G.	275
Megna B.	<b>275</b>	Rodrigues de Carvalho C.S.	<b>565</b>
Meinhardt J.	1257	Roels S.	1035
Menezes M.	609	Rocha F.	853
Menezes P.	43	Rousset B.	909
Mertens G.	129	Ruiz Checa J.R.	<b>327</b>
Middendorf B.	511, <b>1087</b>	Ruiz-Conde A.	643
Michalski S.	365	Saidi M.	1023
Michoinová D.	<b>1097</b>	Salavessa E.	359
Mirão J.	43	Salema S.	<b>691</b>
Mirwald P.W.	111	Sandrolini F.	157, 335, <b>701</b>
Moe M.	<b>673</b>	Sánchez-Soto P.	643
Mohanu D.	1105	Santos Silva A.	29, 43, 165, <b>345</b>
Mohanu I.	<b>1105</b>	Sassoni E.	335, 701
Moreau C.	<b>1113</b>	Scaillet J-C.	99
Moropoulou A.	813	Scheetz B.E.	207, 217
Mosca C.	83, 631	Schlütter F.	227, <b>1169</b>
Mou W.Y.	573	Schmidt S-O.	511, 1087
Nastac D.	1105	Schueremans L.	947
Neuwald-Burg C.	267, <b>537</b>	Scrivener K.L.	993
Nóbrega A.F.	917	Secco M.	871
Nogueira R.	475	Serre G.	947
Ntziouni A.	1209	Shahsavandi A.	683, <b>359</b>
Nykiel J.	1293	Siedel H.	<b>365</b>
Oberta W.	227	Silva E.C.R.	917
Oleson J.P.	217, <b>285</b> , 381	Simon S.	1293
Pachta V.	1123	Slizkova Z.	147, 1113

Sommain D.	927	Weber J.	<b>397, 1043</b>
Souza M.L.	917	Weise S.	555
Stalder R.	111	Wende U.	<b>1257</b>
Stec M.	<b>711</b>	Wilk D.	<b>1265</b>
Stefanidou M.	937, 1123, 1135	Yang Y.	957
Stefanis N-A.	<b>1181</b>	Zacharopoulou G.	<b>405, 1273,</b>
Stojsavljevic K.A.	619		<b>1283</b>
Subercaseaux M.I.	573	Zajadacz K.	<b>1293</b>
Sulic V.	<b>723</b>	Zekagh W.	1023
Sweek T.	<b>733</b>	Zhou Z.	519
Szabó B.	1311	Ziegenbalg G.	1159, <b>1301</b>
Tanimoto S.	733	Zötzl M.	<b>555</b>
Tate J.	501	Žarnić R.	769, 1219
Tavares M.L.	345, 609, 661, <b>743</b>		
Tedeschi C.	<b>1015, 1189</b>		
Teixeira T.	661		
Theoulakis P.	1181		
Thiemann L.	<b>754</b>		
Thorn A.	<b>1199</b>		
Toniolo L.	1015		
Topolska W.	491		
Torgal F.P.	359, 683		
Torres Peceros H.E.	<b>761</b>		
Toumbakari E-E.	373, <b>1209</b>		
Tsakiridis P.E.	<b>373</b>		
Tsamasfyrou I.	813		
Tziotziou M.	<b>547, 1079</b>		
Ullrich B.	365		
Uranjek M.	<b>769, 1219</b>		
Valek J.	<b>1229</b>		
Valluzzi M.R.	871		
Van Balen K.	129, 891, 947, 1035		
Vanhellemont Y.	<b>779</b>		
Veiga R.	29, 165, 345, 447, 609, 743, 805, 983, <b>1241</b>		
Velázquez S.	<b>791</b>		
Velosa A.L.	427, <b>805, 853, 983</b>		
Vergès-Belmin V.	65		
Vesic N.	<b>813</b>		
Vieira E.S.	<b>823</b>		
Vola G.	217, <b>381</b>		
von Konow T.	653		
Všianský D.	175		
Wacha R.	<b>389</b>		
Walker P.	519		
Watt D.	845		

2<sup>nd</sup> Historic Mortars Conference HMC2010 and RILEM TC 203-RHM Final Workshop  
22-24 September 2010, Prague, Czech Republic

**2nd Conference on Historic Mortars and  
RILEM TC 203-RHM Final Workshop  
HMC2010**

Proceedings of the 2nd RILEM Conference

Edited by J. Válek, C. Groot, J. J. Hughes

RILEM Proceedings PRO 78

e-ISBN: 978-2-35158-112-4

2010 Edition

An objective of the 2nd Historic Mortars Conference is to bring together scientists, technicians and professionals involved in research and studies of historic mortars to present and discuss advances in this topic. The main theme of the conference is the conservation of historic buildings and works of art, i.e. studying mortars with respect to repair. This is a unifying field where a truly interdisciplinary collaboration is needed and where contributions of archaeologist, architects, civil and structural engineers, geologists, material scientists, chemists, conservation scientists and art restorers interested in mortars should have their place. The special focus of the conference will be on the application of research and technical knowledge to conservation practice and vice versa in its reflection on such recommendations.

RILEM Publications S.a.r.l.

157 rue des Blains

F-92220 Bagneux - FRANCE

Tel: + 33 1 45 36 10 20 Fax: + 33 1 45 36 63 20

E-mail : [dg@rilem.net](mailto:dg@rilem.net)