INSTITUTE OF ARCHAEOLOGY

BELGRADE, SERBIA

1ST INTERNATIONAL CONFERENCE WITH WORKSHOP

SCIENCE FOR CONSERVATION OF THE DANUBE LIMES

Mortar Design for Conservation – Danube Roman Frontier

2000 Years After

PROGRAMME AND ABSTRACTS

VIMINACIUM, SERBIA

JUNE 27TH - JULY 1ST, 2022

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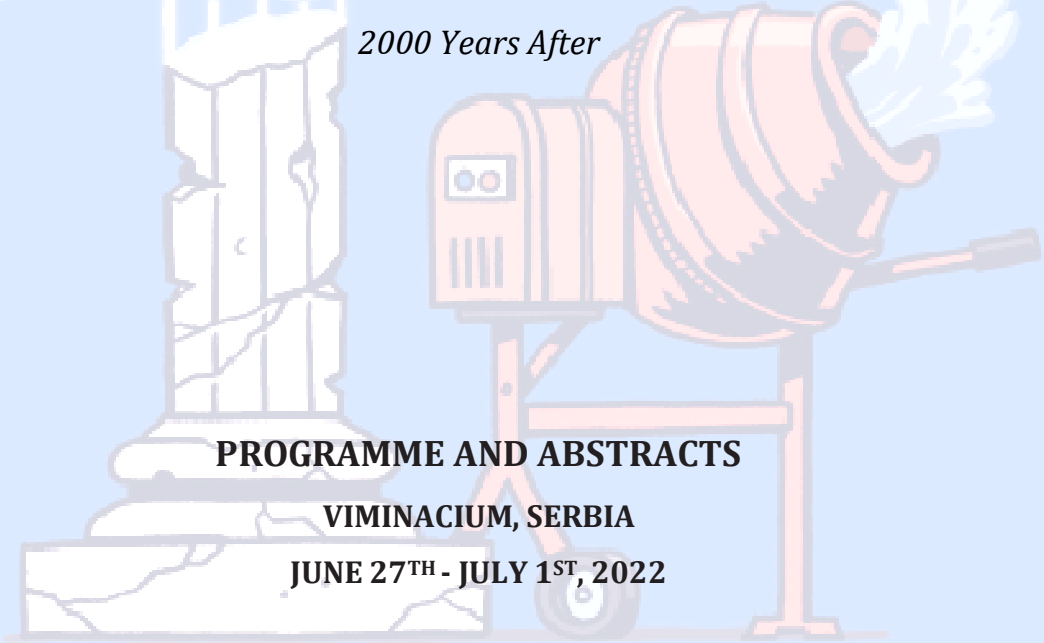

PROGRAMME AND ABSTRACTS

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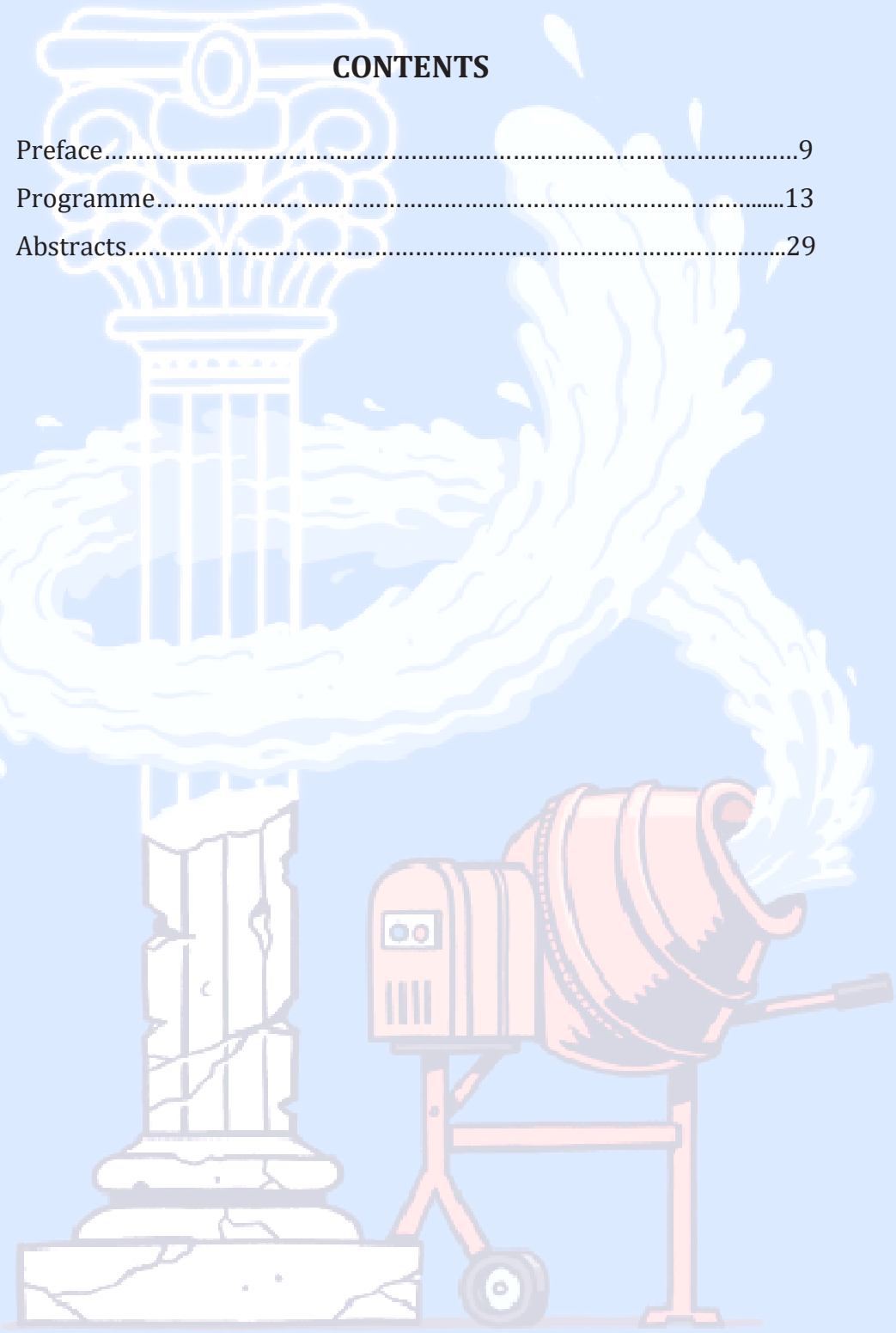

PREFACE

The dust that a building is transformed into when it becomes a ruin holds precious traces of the past. The hands of an archaeologist will search through it patiently, and find a necklace bead of a woman that lived in it. The hands of an architect will virtually transform the dust into a mortar, brick, or stone. The first profession sees through the unbuilt. The second one builds from it. However, both perform their work by communicating with the sciences.

Throughout history, various components were chosen, measured, and mixed into one of the most complex building composites ever - mortar, whose re-creation is of invaluable importance for architectural conservation. Geologists and chemists will best tell us about its composition. However, sometimes, while excavating a ruined wall, an archaeologist finds a mortar trowel, accidentally left by the past builder. Is this a more valuable trace for revealing the creation of a wall than the binder/aggregate ratio of the mortar used? Can we pick it up and imagine the hands that combined colourful aggregate grains with the earth, gypsum, lime, or cement?

From the exploitation, transport, and use of raw materials, to the product called mortar, we pass by the people from the past, the quarries, roads, and rivers, we look at the craftsmen working with tools, and observe the investors negotiating with engineers, and the rulers supervising the construction. The four hands from the beginning of the story can combine the chemistry of the red, blue, green, yellow, black, and white mineral grains with the found trowel, and help us revive many

unknown hands from the past. Thus, the research of historic mortars for conservation purposes must not be a purely technical process. Only by understanding the multiple values of a historic building, we can adequately protect it.

The project Mortar Design for Conservation – Danube Roman Frontier 2,000 Years After (MoDeCo2000), funded by the Science Fund of the Republic of Serbia, was created with the sincere intent and great hope that it could help in the future discoveries and preservation of the rich heritage in Serbia from the period of the magnificent Roman Empire, whose Danubian monuments are part of the preliminary list for UNESCO World Heritage. Different researchers and professionals - architects, archaeologists, geologists, chemists, materials scientists, physicists, biologists, restorers, craftsmen, and managers have all made an effort to get closer to the fulfilment of the wish of the project creators.

After sampling and investigating numerous mortars originating from the structures dating to the period from the 1st to the 6th century, many conclusions were made, but challenges for future researchers and conservators also arose, telling us we need to continue our work in the future, in an attempt to gain more knowledge and, thus, preserve our heritage more adequately.

We welcome you to the Viminacium Archaeological Park and the 1st International Conference with Workshop, Science for Conservation of the Danube Limes. With the hope that many new fruitful collaborations between our guest researchers will be developed on this occasion, taking us one step further towards long-term technical

solutions for architectural conservation and civil engineering based on nature, but also to new cognitions about the life of the past people, always for the cause of the preservation of rich world material and immaterial cultural heritage and our planet, we invite you to peruse this publication. All the authors have shown their enormous affection and passionate devotion towards the discoveries of ancient knowledge, advocating its use in the further preservation of the most monumental physical witnesses of the past – buildings, for future generations.

EDITORS

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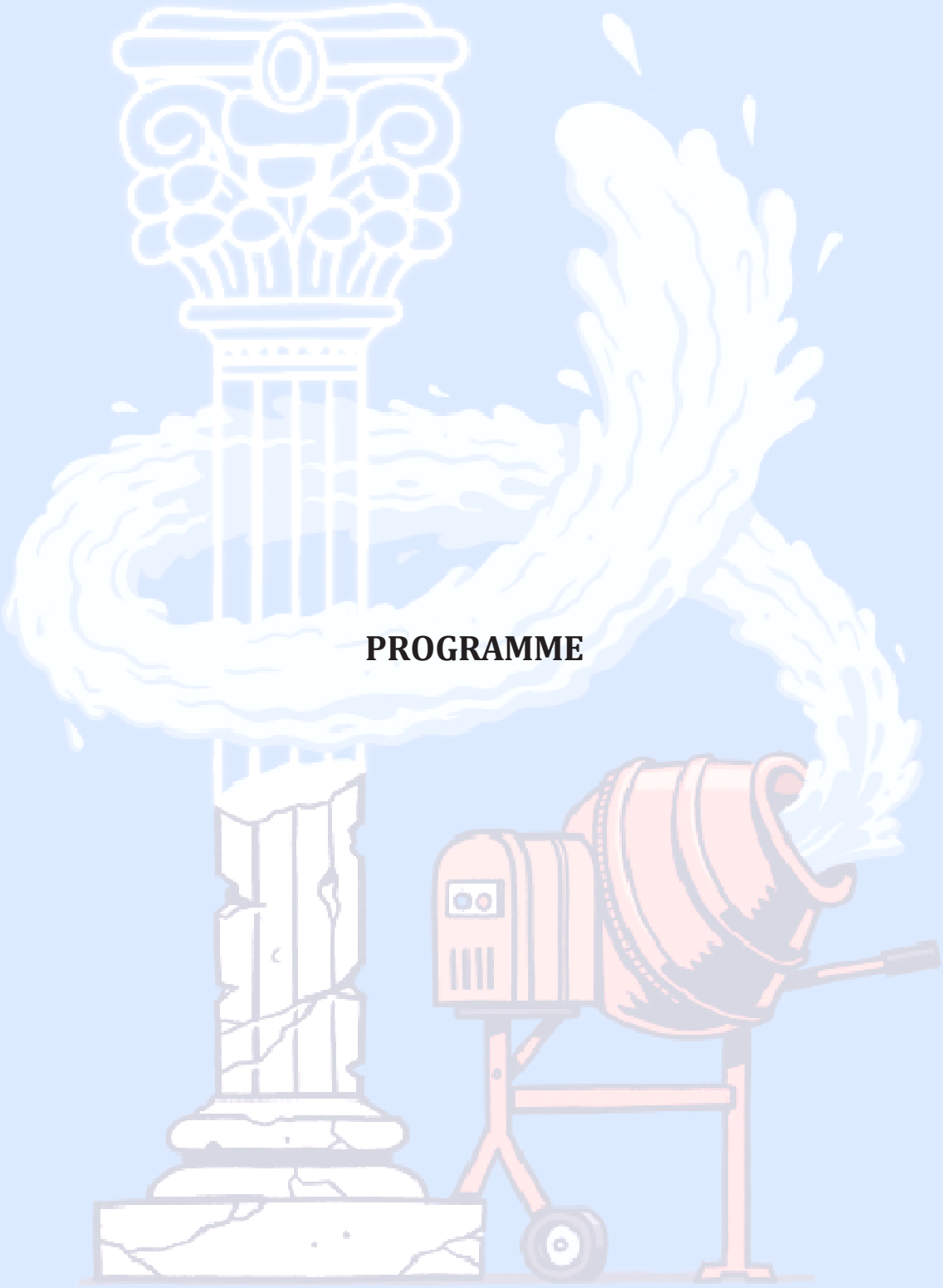


PROGRAMME

MONDAY, JUNE 27TH

08.30 – 10.00 *Breakfast / Coffee and registration*

WELCOME AND INTRODUCTORY SPEECHES

10.00 – 10.40
MIOMIR KORAĆ, Institute of Archaeology, Director
EMILIJA NIKOLIĆ, Institute of Archaeology, PI MoDeCo2000
DUBRAVKA ĐUKANOVIĆ, Institute for the Protection of Cultural Monuments of Serbia Belgrade, Director
JAROSLAV KATONA, Faculty of Technology Novi Sad, University of Novi Sad, Vice Dean for Finances

10.40 – 11.00 NEMANJA MRĐIĆ, IVANA KOSANOVIĆ, MILICA MARJANOVIĆ
Danube Limes in Serbia: On the Way to a UNESCO World Heritage Site – Problems, Challenges and Solutions

11.00 – 11.20 EMILIJA NIKOLIĆ, MLADEN JOVIČIĆ, IVANA DELIĆ-NIKOLIĆ, LJILJANA MILIČIĆ, SNEŽANA VUČETIĆ, JONJAUA RANOGAJEC
Our MoDeCo2000: Results Overview of the Scientific and Research Project

11.20– 11.40 *Coffee break with snack*

LECTURES

11.45 – 12.05 MLADEN JOVIČIĆ

Researching Roman Mortars from the Danube Region - Archaeological Perspective of the MoDeCo2000 Project

12.05 – 12.25 SNEŽANA VUČETIĆ, JONJAUA RANOGAJEC, IVANA DELIĆ-NIKOLIĆ, LJILJANA MILIČIĆ, EMILIJA NIKOLIĆ, MLADEN JOVIČIĆ

Design of Compatible Mortars for Conservation Interventions

12.25 – 12.45 EUGEN VAIDA, VERONICA VAIDA, ALEXANDRA TEODOR

The Ambulance for Monuments - Safeguarding Heritage through Community Engagement

12.45 – 13.30 NIGEL COPSEY

Rediscovering Traditional Mortars, part 1

13.30 – 14.30 *Lunch break*

LECTURES

14.35 – 15.20 NIGEL COPSEY

Rediscovering Traditional Mortars, part 2

15.20– 15.35 *Coffee break*

LECTURES

15.40 – 16.25 NIGEL COPSEY

Rediscovering Traditional Mortars, part 3

17.00 – 18.30 *Viminacium sightseeing*

18.30 – 19.30 *Dinner*

21.00 *Viminacium Fest / Theatre festival*

(Closing night in the Viminacium amphitheatre with a jazz concert)

TUESDAY, JUNE 28TH

07.30 – 09.00 *Breakfast / Coffee*

PRACTICAL WORKSHOP ON LIME MORTARS

09.00 – 13.00 NIGEL COPSEY DEMONSTRATION
Building Experimental Structures of Brick and Stone with Lime Mortar

13.30 – 14.30 *Lunch break*

LECTURES

14.35 – 15.05 VLADICA CVETKOVIĆ, KRISTINA ŠARIĆ
Tuffs of Serbia – What We Need to Know when Characterising Them as Archaeological Raw Material

15.05 – 15.35 KRISTINA ŠARIĆ, SUZANA ERIĆ, VLADICA CVETKOVIĆ, JOSIP ŠARIĆ, DRAGANA ANTONOVIĆ, VESNA BIKIĆ
Geological Knowledge in Service to Archaeological Investigations: Rock and Ceramic Findings as Examples

15.35 – 15.55 YOTAM ASSCHER, MICHELE SECCO, GIULIA RICCI, SERGIO TAMBURINI, GILBERTO ARTIOLI *(virtual)*
Evaluation of Ancient Mortars Hydraulicity through the Characterisation of Long and Short-range Crystallinity

15.55 – 16.15 LJILJANA DAMJANOVIĆ VASILIĆ, VESNA BIKIĆ, SRNA STOJANOVIĆ, IVANA RADOSAVLJEVIĆ EVANS, DANICA BAJUK – BOGDANOVIĆ, IVANKA HOLCLAJTNER – ANTUNOVIĆ
Physicochemical Characterisation of the Medieval Pottery Excavated in Serbia

16.15 – 16.35 *Coffee break with snack*

LECTURES

16.40 – 17.00 MARIA STEFANIDOU
Technological Characteristics of Fired Bricks from Roman and Byzantine Period in Greece

17.00 – 17.20 SIMONE DILARIA, CATERINA PREVIATO, JACOPO BONETTO, MICHELE SECCO, ARTURO ZARA, DOMENICO MIRIELLO, RAFFAELLA DE LUCCA, GILBERTO ARTIOLI
Pyroclastic Rocks in the Structural Mortars of Roman Nora (Sardinia). A Green Material for the Production of Sustainable Concretes in Antiquity

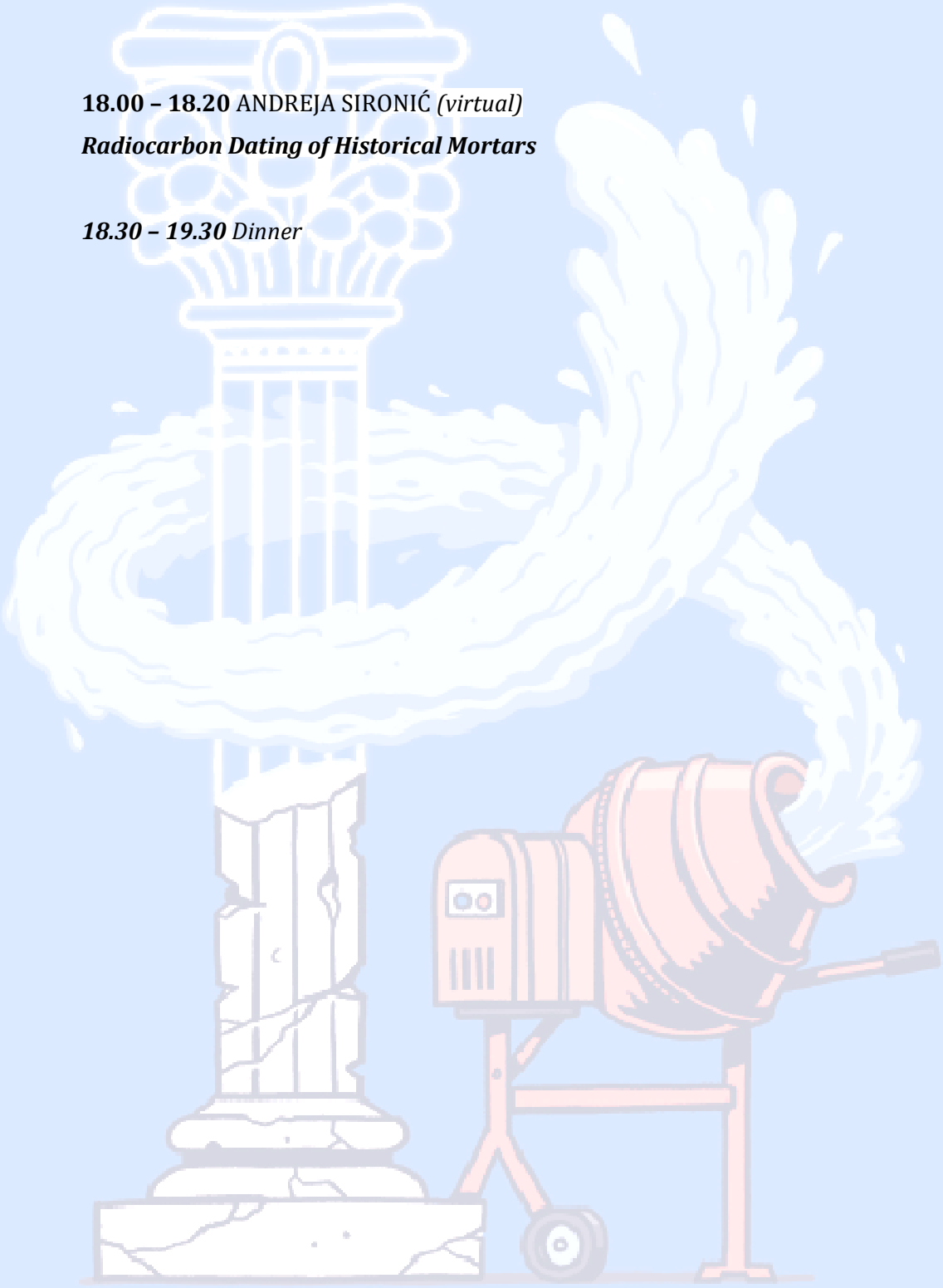
17.20 – 17.40 ANNA ARIZZI
Learning from Historic Mortars: Studies on Lime Manufacturing and Fresco Conservation

17.40 – 18.00 MICHELE SECCO SIMONE DILARIA, GIULIA RICCI, ENRICO GARBIN, SERGIO TAMBURINI, YOTAM ASSCHER, GILBERTO ARTIOLI, CATERINA PREVIATO, JACOPO BONETTO
Novel Scientific Perspectives on Ancient Pozzolanicity

18.00 – 18.20 ANDREJA SIRONIĆ *(virtual)*

Radiocarbon Dating of Historical Mortars

18.30 – 19.30 *Dinner*



WEDNESDAY, JUNE 29TH

International Danube Day

07.30 – 09.00 *Breakfast / Coffee*

LECTURES

09.00 – 09.20 IVAN BOGDANOVIĆ

Roman Construction Techniques Used on the Viminacium Amphitheatre

09.20 - 09.40 FLORIAN MATEI-POPESCU

New Archaeological Excavations at the Drobeta Military Amphitheatre

09.40 – 10.00 JASMINA POPOVIĆ RUSIMOVIĆ

Restoration of Ram Fortress

EXCURSION

10.15 – 11.20 Viminacium – Golubac Fortress

11.30 – 12.30 Golubac Fortress Tour

12.40 – 13.45 Golubac Fortress - Golubinje

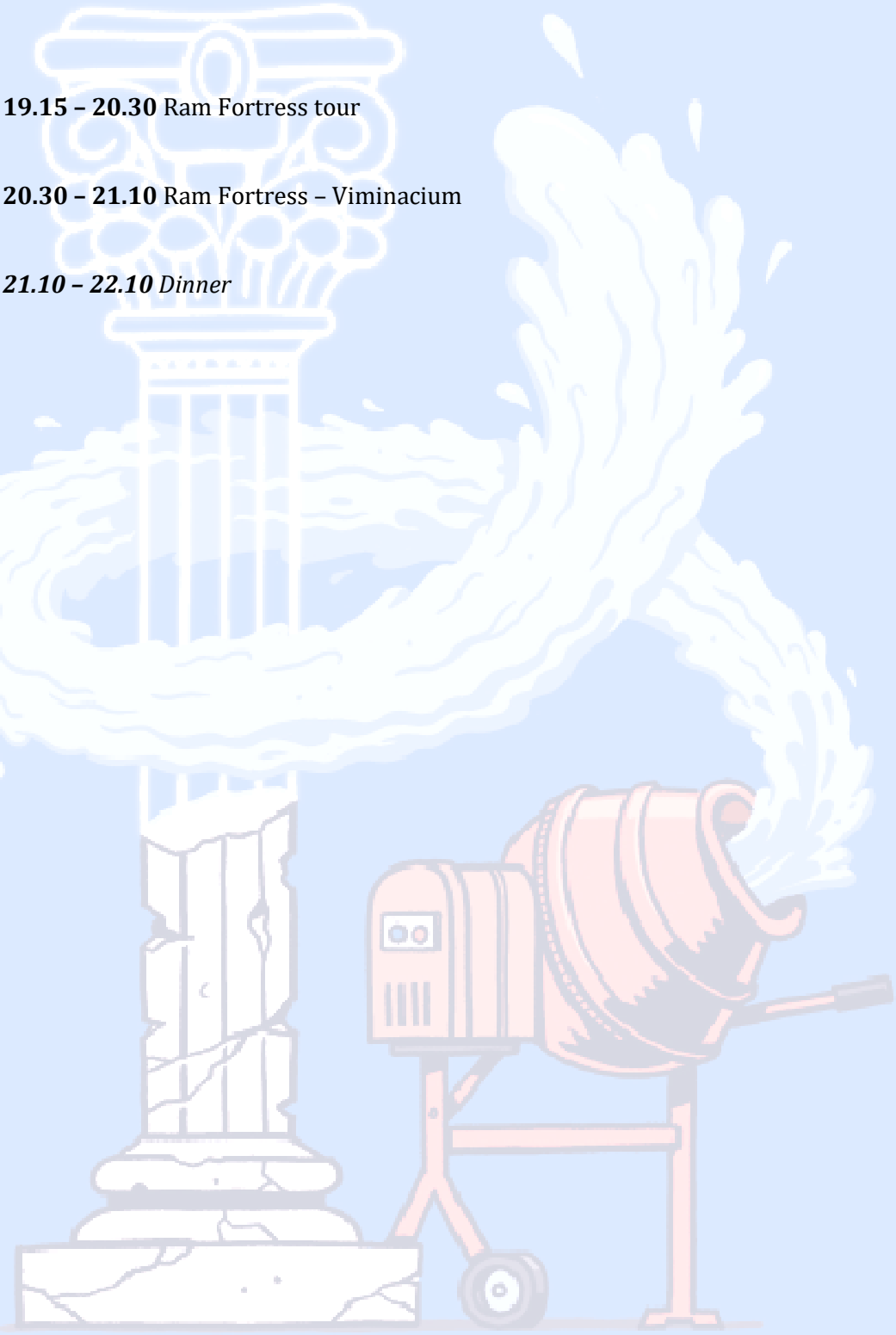
14.00 – 17.00 Hiking to viewpoint Ploče and back (lunch package at the top)

17.15 – 19.05 Golubinje – Ram Fortress

19.15 – 20.30 Ram Fortress tour

20.30 – 21.10 Ram Fortress – Viminacium

21.10 – 22.10 *Dinner*



THURSDAY, JUNE 30TH

07.30 – 09.00 *Breakfast / Coffee*

PRACTICAL WORKSHOP ON LIME MORTARS

09.00 – 13.00 NIGEL COPSEY DEMONSTRATION

Testing Conservation Mortar Mixtures on a Part of an Authentic Structure

13.30 – 14.30 Lunch break

LECTURES

14.35 – 15.05 IOANNA PAPAYIANNI

Analysis of Ancient Mortars from Roman Monuments in Northern Greece. Design and Application of Compatible Repair Mortars

15.05 – 15.25 SLAVICA VUJOVIĆ, RASTKO VLAJKOVIĆ

Holism as a Framework for Understanding and Preserving Heritage – the Example of the Cultural Landscape of Bač

15.25 – 15.45 BURCU TAŞCI ÖZDEMIR, HASAN BÖKE *(virtual)*

Raw Material Characterisation of Roman Mortars in Western Anatolia (Turkey)

15.45 – 16.05 ALEKSA JELIKIĆ

Lime Kiln. The Divine Crucible

16.05 – 16.25 LJUBOMIR JEVTOVIĆ

Ceramic Building Materials of Viminacium

16.25 – 16.45 *Coffee break with snack*

LECTURES

16.50 – 17.10 ANA RADIVOJEVIĆ

The Role of Brick in the Late Antique Architecture of the Central Balkan Roman Provinces

17.10 – 17.30 IGOR BJELIĆ

Construction Methods Applied to the Structures of the Trajan's Bridge over the Danube

17.30 – 17.50 BOJAN POPOVIĆ

Reconsidering the Archaeological Site of Glamija – Rtkovo, Serbia

17.50 – 18.10 TINO LELEKOVIĆ

How to Present the Ancient City of Aelia Mursa

18.10 – 18.30 HELENA HIRŠENBERGER, SNEŽANA VUČETIĆ, JONJAUA RANOGAJEC

Cross-disciplinary Collaboration in Conservation Projects – Managing Key Challenges

18.30 – 19.30 *Dinner*

FRIDAY, JULY 01ST

07.30 – 09.00 *Breakfast / Coffee*

LECTURES

09.00 – 10.30 BRANKO ORBANIĆ

Traditional Lime Production and its Application on the Monuments of Culture – Experience from the Work on Ancient Monuments

10.30 – 10.50 *Coffee break with snack*

LECTURES

10.55 – 11.15 MAJA FRANKOVIĆ, VESNA MATOVIĆ, NEVENKA NOVAKOVIĆ

Intrinsic Properties of the Limestone Used in the Belgrade Fortress and their Influence on Degradation Processes

11.15 – 11.35 DRAGANA GAVRILOVIĆ

Analyses of the Pigments and Plasters on the Examples of Roman Wall Paintings from Sirmium and Viminacium

11.35 – 11.55 MARIA ARGIROVA, GERGANA KABAKCHIEVA, DENITSA YANCHEVA, BISTRA STAMBOLIYSKA, NIKIFOR HARALAMPIEV, DIETER FISCHER, ALBENA LEDERER

Pigment Identification in the Mural Decoration from the Roman City of Ulpia Oescus by Vibrational Spectroscopy and SEM-EDS Analysis

11.55 -12.15 NIKOLA UNKOVIĆ, ŽELJKO SAVKOVIĆ, MILOŠ STUPAR, ALEKSANDAR KNEŽEVIĆ, IVICA DIMKIĆ, MILICA LJALJEVIĆ GRBIĆ
Fungal Proliferation on Fresco Painting: Deterioration of Mortar and Painted Layer

12.15 – 12.35 IVAN VANJA MARTINOVIĆ
Benefits and Limits of DRMS Technology in the Purpose of Designing Repair Mortars by Drilling Resistance Criterion

12.35 – 12.50 *Coffee break with snack*

LECTURES

12.55 – 13.15 MARKO NIKOLIĆ, ENA TAKAČ, JELENA ŠĆEKIĆ
Contemporary Approaches to the Revitalisation, Presentation and Promotion of Cultural and Natural Heritage of the Part of the Roman Limes - Case Study of the Late Antique Tomb in Brestovik

13.15 – 13.35 SILVANA BLAŽEVSKA, ANGELA PENCHEVA *(virtual)*
Master Conservation Plan for the Archaeological Site of Stobi: Goals and Outcomes

13.35 – 13.55 BOJAN MILJEVIĆ, ALENKA MAUKO PRANJIĆ, SERGEY E. KICHANOV, SNEŽANA VUČETIĆ
Computed Tomography as a Tool for Non-destructive Investigation of Cultural Heritage Materials' Inner Structure

13.55 – 14.15 ROMAN BALVANOVIĆ, PERICA ŠPEHAR, DRAGANA SPASIĆ-ĐURIĆ, OLIVERA MILOVIĆ, MIHAILO MILINKOVIĆ

Roman, Late Antique and Byzantine Window Glass from 3rd – 6th Century in Serbia: Chemical Characteristics, Compositional Groups and Provenance

14.15 – 14.30 *Closing of the event*

14.30 – 15.30 *Lunch*

SPECIAL GUEST OF THE WORKSHOP

NIGEL COPSEY, Stonemason and Building Conservator

Starting out as a dry-stone waller in Cornwall, Nigel trained after 1989 as a stonemason and carver at Weymouth College, working largely thereafter in the conservation industry across the south and south-west of England, as well as travelling widely in the USA, working and advising upon building conservation projects in Vermont, New York City and Nebraska as well as in Granada, Andalusia, and, more recently, in British Columbia and Alberta, Canada.

Nigel was consultant stonemason for the Irish Hunger Memorial project in Battery Park City, New York, 2001. Since 2001, Nigel has worked extensively as a consultant and practitioner in the field of building conservation and repair in North Yorkshire on a wide range of vernacular and high status buildings, as a building conservation consultant for the Fitzwilliam Estate in Malton, 2003-2010, designing, specifying and executing major repair projects on a wide range of historic buildings within the town, as well as researching, designing and specifying a number of building repair and conservation projects on behalf of Natural England, most recently at Scampston Hall.

A committed SPAB-member, Nigel is also a professionally accredited conservator-restorer and determined advocate for the thoroughgoing use of traditional materials in the care and repair of old buildings, and a leading advocate for the routine use of traditional

earth-lime and hot mixed lime mortars for most applications, working with Historic England, Historic Environment Scotland and CADW and international partners in the delivery of practical training and education regarding the informed use of traditional quicklime mortars for the like for like and compatible repair of historic buildings. In recent years, Nigel has worked closely with the North York Moors National Park, educating and upskilling builders and professionals regionally in the use of like-for-like traditional mortars.

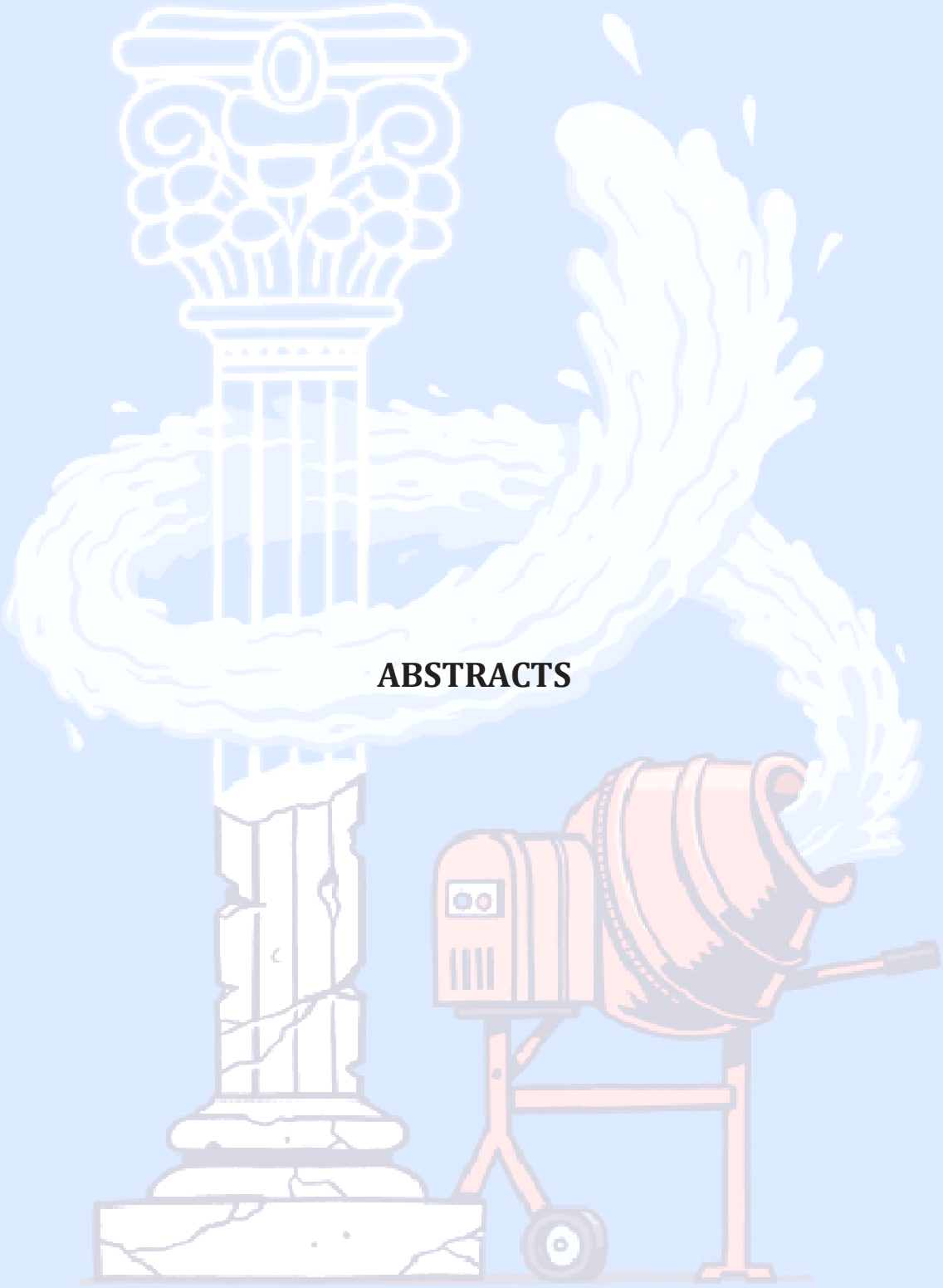
A Research Associate of the Department of Archaeology, University of York, Nigel regularly delivers hot mixed earth and lime mortars and traditional skills training and led the Practical Skills module for the MA Conservation Studies 2012-2018. Nigel has a BA (Hons) in Political Science from the University of York, a PGDip in Building Conservation from Bournemouth University, and an MA (by research) awarded by the University of York in 2019, for his critical review of historic texts, thinking and craft practice in the preparation and use of lime (and earth-lime) mortars.

Nigel has contributed to several volumes of the recently published Historic England Practical Conservation series. He has published a book on the subject of Traditional Mortars (2019) as well as a review of Historic Literature on Lime and Lime Mortars (HES Technical Paper 30 (2019).

www.nigelcopsey.com

www.maltonbuildingsgroup.com

www.hotmixedmortars.com



ABSTRACTS

COMPATIBLE MORTARS FOR THE ARCHITECTURAL CONSERVATION OF THE DANUBE LIMES IN SERBIA – IMPORTANCE OF THE RAW COMPONENT CHARACTERISATION

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Recipes for compatible mortars for conservation must be based on raw materials whose presence was determined during the characterisation of historical mortars used on buildings on which we perform renewal or repairs. Additional materials are often used that improve the resistance of conservation mortars to various influences,

while all the time ensuring that they do not have any negative effects on any part of the structure.

Within the MoDeCo2000 project, lime mortars for the conservation of monuments that belonged to the former Roman frontier in today's Serbia were prepared. The process was preceded by research into the materials used to make Roman mortars in the area. The selection of component materials, primarily binders, for the creation of conservation mortars included tests, in accordance with the methods prescribed by the relevant standards, of parameters that could adversely affect the properties of fresh or hardened mortar. In slaked lime, the content of free water required for the calculation of the optimal amount of water that will be used for the preparation of the mixture, in order to obtain a mortar of good consistency and workability, was tested. Examination of unextinguished lime particles and the stability of the volume was carried out in order to avoid the use of lime, which can lead to the appearance of microcracks in the mortar after hardening. When it came to choosing the quality of quicklime, it needed to have high reactivity, low content of inextinguishable particles, and high yield.

In accordance with the results of laboratory tests of historical mortars, many mixtures for conservation were prepared with the exclusive use of lime and river aggregate, in different interrelationships and different granulations of aggregates. In addition to river aggregate, crushed stone aggregate was added to some mixtures. In the historical mortars used for plastering and

flooring, a larger amount of brick was mostly used as an artificial material with pozzolanic properties and, thus, used for the compatible mixtures as well. Mineralogical testing of certain samples allowed consideration of the possible use of natural materials with pozzolanic properties for their preparation, so the use of zeolitised tuffs and kaolin clays in new mixtures was also tested, but carefully, in parallel with additional testing of historical samples.

The characteristics of mortars made exclusively of lime and river aggregate are lower mechanical properties, low resistance to atmospheric influences, primarily freezing and defrosting, as well as high water absorption. Although their good degree of compatibility with old mortars recommends their use in conservation, their application, depending on the climatic conditions of the environment, is generally suitable in structures protected from external influences. In accordance with the climate that is present in our territory, it was necessary to formulate preparations for conservation mortar with improved mechanical properties and greater resistance to external influences, which entailed the use of various additives. Natural and artificial materials with pozzolanic properties were added to a number of mortar mixtures prepared as compatible with pure lime mortars, including local clays, bricks, zeolitized tuffs, and kaolin clays, which were mechanically activated in the laboratory and whose use was expanded by using an industrial product created by their thermal activation, i.e., metakaolin. By applying these additives, in addition to a significant improvement in mechanical properties and durability, an

attempt was made to achieve the desired appearance of the mortar, which included the colour of the mixture. In the phase of testing the suitability of applied recipes, in laboratory conditions, the appearance of cracks, fissures, flaking, discoloration due to drying or wetting, water absorption, volumetric mass, and mechanical properties, as well as their contact with samples of historical mortars were monitored.

Tests of the use of various components for the preservation of conservation mortars through the preparation of mixtures within the MoDeCo2000 project showed the possibility of using pure lime mortars for the conservation of Danube Limes monuments, but also the need to use different additives with pozzolanic properties in many cases. A large number of possibilities of combining these additives, in order to obtain more durable mortars for building conservation, while constantly adhering to the need to ensure the compatibility of old and new mortars and of existing built structures and new materials, raises the need for new research, which needs to be directed to acquiring additional knowledge related to the composition of historical mortars, especially when it comes to the use of natural additives with pozzolanic properties.

Keywords – historical mortars, mortars for conservation, compatibility, Roman mortars, Danube Limes

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