International Union
of Laboratories and Experts
in Construction Materials,
Systems and Structures

# 2023
# 2024

# TECHNICAL REPORT

# About RILEM

**The International Union of Laboratories and Experts in Construction Materials, Systems and Structures** (RILEM, from the name in French – Réunion Internationale des Laboratoires et Experts des Matériaux, systèmes de construction et ouvrages) was founded in June 1947 in Paris, France, with the aim of promoting scientific cooperation and to stimulate new directions for research and applications, thus promoting excellence in construction worldwide.

This mission is achieved through the collaboration of leading experts in construction science and practice, including academics, researchers, industrialists, testing laboratories, and authorities.

## Become a member

If you are interested in joining RILEM, please consult our website www.rilem.net/membership to become a member.

### Individual fees in 2024

| | | | |
|---|---|---|---|
| Young Member | € 27 | Retired Member | € 80 |
| Senior Member | € 395 | | |

### Corporate fees in 2024

| | | | |
|---|---|---|---|
| Associate Member | € 1,340 | Institutional Member | € 2,540 |
| Institutional-Plus Member | € 4,660 | Industrial Member | € 4,660 |

Note that special discounts of 40% up to 90% on the membership fees apply depending on your country of residence. Please consult the website membership.rilem.net for all details.

# Membership categories

**RILEM is composed of:**

- **Corporate members,** including universities, research and testing laboratories, and companies.
- **Individual members,** including scientists, engineers and practitioners.

### Corporate Members

- **Associate Members** are small research, academic or building organisations or companies.
- **Institutional Members** are research and testing organisations of national renown, universities, international or national standards organisations.
- **Industrial Members** are large firms or associations in the materials of construction sectors.

### Individual Members

- **A Senior Member** is an experienced scientist or professional/ practitioner, having reached a position of responsibility and recognised expertise in a public or private organisation or company concerned with testing or research in the field of building materials and structures.
- **A Young Member** is a post-graduate student (including PhD students) or a young research scientist or engineer who is at the early stage of her/his career, and who is under the age of 35 during the membership year.
- **A Retired Member** is a member who has retired.

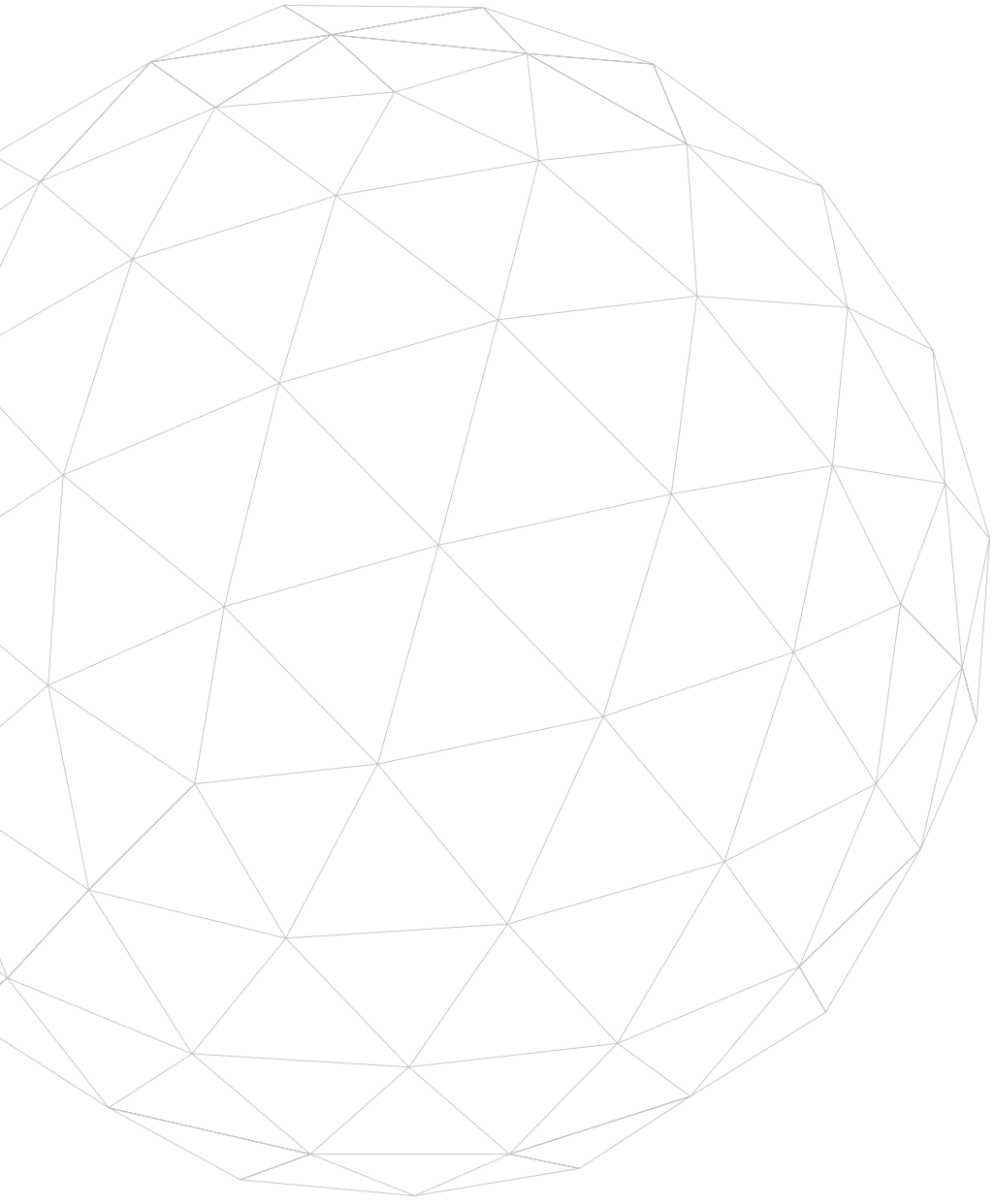
# Benefits

### Benefits for all members (individual and corporate members included):

- **Membership in the RILEM Technical Committees**, allowing *i)* to participate in the Technical Committee meetings, *ii)* to be listed as author of the Technical Committee outputs/publications and as a member on the RILEM website, and *iii)* to have the possibility to directly propose a new Technical Committee to the Secretariat General.
- **Opportunity to publish** selected articles as **free** Open Access papers in *Materials and Structures* and in *RILEM Technical Letters*.
- **Free subscription to the online version of *Materials and Structures* journal** hosted by Springer (access to the current issues and to archives since 1968).
- **Access to online RILEM Proceedings and Reports, and to SPRINGER proceedings,** and benefit of a 20% discount on all SPRINGER e-books.
- **Access to RILEM online Directory of Members.**
- **Reduced fees for RILEM events** (in general 10%, subject to decision of local organisers).

**Corporate members additional benefits:**

- **A certain number of staff members can enjoy the RILEM member benefits.** Please refer to the info reported on this page: https://www.rilem.net/membership.
- **Logo of the company displayed on RILEM presentation and RILEM Annual Report.**
- **Logo and short description of the company** displayed on the RILEM Website, with a link to the corporate member website, for a better visibility.
- Free **advertisement of vacancies** in the RILEM Newsletter BITS&BOBS.



# Editorial

by RILEM TAC Chair Enrico Sassoni

Again this year, I have the immense pleasure to open this issue of the RILEM Technical Report, the document established in 2020 with the aim of informing the scientific community and the wider audience about the updates of the RILEM Technical Committees (TCs).

This issue presents the progress of the current 46 Technical Committees, six of which established over the last 12 months (in Fall 2023 and Spring 2024). These 6 TCs have something in common: the focus on the environment. The proposed TCs' topics share as driving force the interest in promoting, supporting, and/or detailing, best practices for the built environment:

- APD Alternative Paving Materials - Design and Performance and APS Alternative Paving Materials - Sustainability: the use of waste materials as "alternative paving materials" is evaluated with a 360° perspective.
- MCB Mechanical Characterisation of Bamboo: reliable test methods are investigated to promote bamboo as a sustainable building material.
- CUC Carbon dioxide uptake by concrete during and after service life: concrete carbonation is the opportunity to balance carbon emission.
- CTM Testing Methods For Masonry Cores: assessing the mechanical properties of heritage masonry structures will allow to extend their durability.
- SDM Scientific Metadata Management of Construction materials: the FAIR (Findability, Accessibility, Interoperability, and Reusability of data) principles are the tool to share information that will be used to advance research and make better decisions.

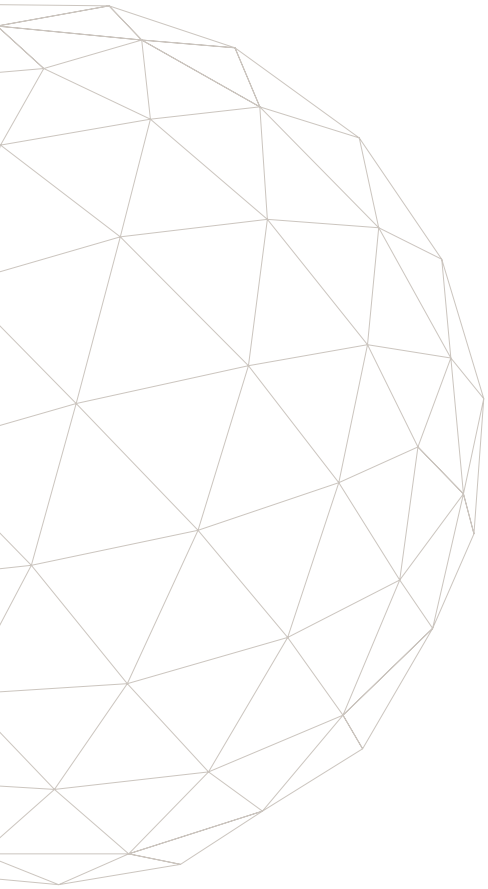
I look forward to seeing the developments of these TCs!

The structure of this year's report remains the same as in the past, except for one new feature: the number of TC members, shown in the summarising table of each Cluster. This piece of information was not given in previous issues. As the reader might know, RILEM is spending a significant effort in advertising that RILEM TCs are open environments, where everyone is welcome to join, no matter age, background, and skills. This campaign has successfully produced its results, as more and more scientists have joined a RILEM TC, thus

testifying the interest of the scientific community in the activities of RILEM TCs. In certain groups, the number of TC members has gone above 200! This is the case for the Technical Committees investigating certain hot-topics like, for instance, *3D printing:* TC 303-PFC Performance requirements and testing of fresh printable cement-based materials, and 304-ADC Assessment of Additively Manufactured Concrete Materials and Structures have respectively 211 and 215 members! There are other examples of extremely populated TCs, and I invite you to read more about them in this report.

As you can imagine, the coordinating work of the TC Chairs and Deputy Chairs might become a very arduous task in these conditions. To find a compromise between the inclusive nature of a RILEM TC and the management viability, RILEM is implementing a new role inside the TC: the observer! More details about this role are given in the chapter *"Technical Committees (TCs): the heart of RILEM"* of this report.

Finally, I would like to take here the opportunity to thank my colleagues, the TAC members, for the amazing job recently accomplished: the review of all the RILEM recommendations published between 1970 and 1994, to identify those that are still relevant today and those that are outdated and superseded by more recent documents! The review continues and you will read more about it in the RILEM Technical Report next year!



# Contents

# An overview of the 2024 RILEM Spring Convention and Conference on advanced construction materials and processes for a carbon neutral society

Milan, Italy, 7-12 April 2024

If you missed the 7th RILEM Spring Convention, organized by Prof. Liberato Ferrara and Prof. Giovanni Muciaccia with their team of the Department of Civil and Environmental Engineering at Politecnico di Milano, this is what happened!
The first three days (7, 8, and 9 April) of the event drifted along through many RILEM Standing Committee and Technical Committee meetings, hosted at Politecnico di Milano

Here, some highlights of the discussions that took place at TAC, DAC, and EAC are presented:

## TAC

- Prof. Giovanni Plizzari replaced Prof. John Provis as *Materials and Structures* Editor-in-Chief.
- Prof. Kei-ichi Imamoto became Cluster C Convener.
- The following new TCs were established:
  - CTM: Testing Methods For Masonry Cores, Cluster E, chaired by Rita Esposito.
  - CUC: Carbon dioxide uptake by concrete during and after service life, Cluster D, chaired by Gregor Gluth.
  - SDM: Scientific Metadata Management of Construction materials, Cluster D, chaired by Tanja Manninger.

## DAC

- Dr Surender Singh replaced Joanitta Nabadda Ndawula as RILEM Youth Council Chair.
- The following regional conveners started their mandate in DAC:
  - For Middle East & North Africa: Prof. Said Kenai, University of Blida, Algeria.
  - For China: Prof. Yamei Zhang, Southeast University, China.

Bureau members at work. Image courtesy of D. Ciancio.

TAC members at work. Image courtesy of D. Ciancio.

## EAC

- Dr Marie Joshua Tapas is a new EAC member.
- Lat-RILEM has a new Presidium planning many webinars and events in Spanish (and English) in the following months.

RILEM officers and TCs' Chairs were treated with an unforgettable dinner with typical Italian food on Monday night, guests of the conference platinum sponsor Penetron Italia. During the event, the President of RILEM, Dr Nicolas Roussel, presented Prof. Marco di Prisco and Prof. Michael Wistuba with the 2023 RILEM fellowship certificates.

From 10 to 12 April, the *Conference on advanced construction materials and processes for a carbon neutral society* was hosted in the prestigious venue of Palazzo Mezzanotte, the seat of the Italian stock exchange (*Borsa Italiana*). The event developed through 5 keynote lectures, 140 technical contributions, 16 parallel sessions, with 200 delegates from 30 different countries.

Prof. Marco di Prisco, on the left, and Prof. Michael Wistuba, on the right, receiving the 2023 RILEM fellowship certificate by Dr Nicolas Roussel, RILEM President. Image courtesy of D. Ciancio.

The RILEM Presidency and the organisers of the 2024 RILEM Spring Convention during the RILEM dinner. From the left: Dr Nicolas Roussel, RILEM President, Prof. Nele De Belie, RILEM President-Elect, Prof. Liberato Ferrara and Prof. Giovanni Muciaccia, respectively Chair and Co-Chair of the organising committee, Prof. Ravindra Gettu, RILEM outgoing President. Image courtesy of D. Ciancio.

The delegates enjoyed the following 5 keynote lectures, all available on the RILEM YouTube channel :

- Prof. José E. Andrade presenting *Enabling the green energy transition through juicier batteries*.
- Dr Agnieszka Bigaj-van Vlijet presenting *Navigating the Challenge: Sustainability in Concrete Structures through Synergy of Material and Structural Engineering.*
- Dr Rob Wolfs, 2024 RILEM Colonnetti medallist, presenting *The status quo of 3D concrete printing: are we there yet?*
- Prof. Zhenming Li, 2024 RILEM Colonnetti medallist, presenting Autogenous shrinkage of alkali-activated materials.
- Prof. Marco di Prisco, Chair of RILEM TC 288-IEC, presenting the outcomes of the work of the RILEM TC 288-IEC Impact and Explosion.

The gala dinner took place at the Museum of Science and Technology "Leonardo da Vinci". Before dinner, the delegates enjoyed a free and personalized tour of the museum, which remained open only to the delegates, followed by an exquisite meal served under the catamaran *Ac72*, with which the Italian team *Luna Rossa* reached the final of the 34th America's cup, in San Francisco, USA, in 2013.

The RILEM Spring Convention (22 – 24 march 2025) & Conference on durability of building materials and systems in the transportation infrastructure (25 – 28 march 2025) will be held at the University of Applied Sciences of Southern Switzerland (SUPSI), in Mendrisio, Switzerland. It will be organised jointly with the *Conference on durability of building materials and systems in the transportation infrastructure*.


From the left: Prof. Giovanni Muciaccia, Dr Agnieszka Bigaj-van Vliet (TNO-Delft) and Prof. José Andrade (Caltech and Energy Vault), keynote speakers of the event, and Prof. Liberato Ferrara. Image courtesy of RILEM.

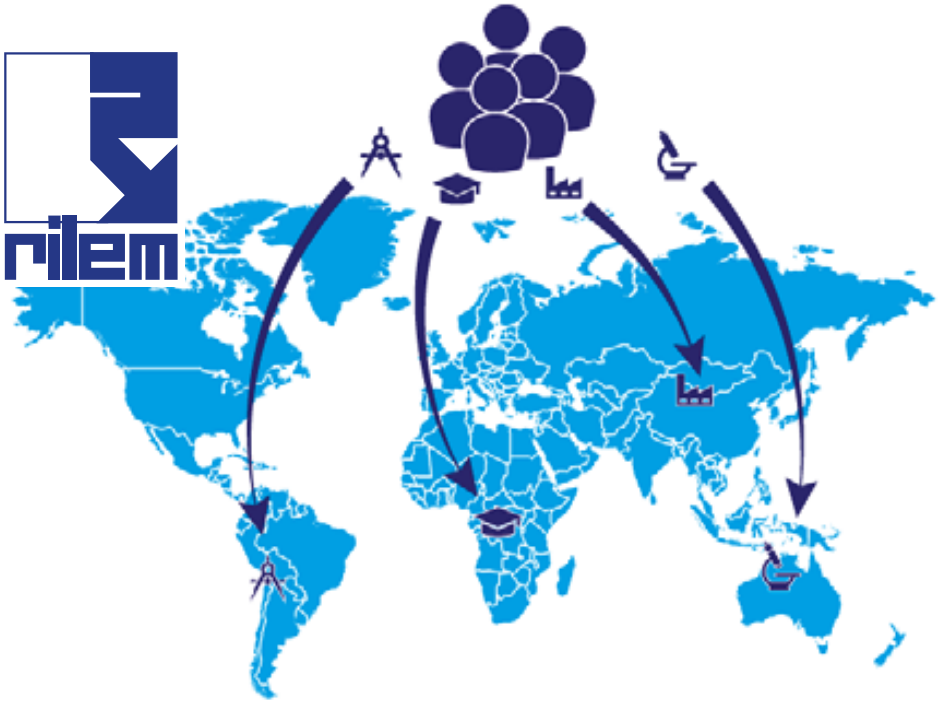

Dr Rob Wolfs (on the left) receiving the 2024 Gustavo Colonnetti medal by Dr Enrico Sassoni (on the right), RILEM TAC Chair. Image courtesy of RILEM.

Prof. Marco di Prisco presenting the outcomes of the work of the RILEM TC 288-IEC Impact and Explosion. Image courtesy of D. Ciancio.

Some moments of the Conference on advanced construction materials and processes for a carbon neutral society. Image courtesy of RILEM.

On the left: the delegates enjoying the pre-dinner visit of the Museum of Science and Technology; on the right: Prof. Liberato Ferrara thanking the delegates and the sponsors of the event. Image courtesy of RILEM.

# Technical Committees (TCs): the heart of RILEM



A Technical Committee is a group of international experts around the world working together in a particular field.

## WHAT IS A RILEM TC?

A group of international experts working together in a particular field in order to:

- Assemble and evaluate research data.
- Harmonise testing methods.
- Suggest new topics for research (also research not to be directly undertaken by RILEM TCs).
- Promote their conclusions.

Each RILEM TC is of utmost importance to the organisation since the building of scientific and technical expertise, and dissemination of recent results and development form the core of RILEM's mission.

## HOW IS A RILEM TC CREATED?

An application is filled and signed by the proposed TC Chair, who has to be a RILEM Individual Member. This form is sent to the RILEM General Secretariat that forwards it to the members of the RILEM Technical Activities Committee (TAC) for comments and discussion. If needed, a revised proposal might be drafted by the proposed TC Chair to fulfil the TAC recommendations.

After recommendation by TAC and approval by the RILEM General

Council, which verifies that the terms of reference of the proposed TC fit into the technical programme of RILEM, the TC is officially created. Although a TC proposal can be received any time of the year, the final discussion and approval happen twice a year, during the RILEM Spring Convention (around March-April) and the RILEM Annual Week (around August-September), when TAC meetings are held.

## ROLE OF RILEM CLUSTERS

Each RILEM TC is in direct connection with a RILEM Cluster that has the role of coordinating and monitoring the activities of its TCs and advising TAC. Each Cluster is chaired by a Cluster convener. The 6 fields of activities currently treated by active RILEM TCs are:

- **Cluster A.** Material Processing and Characterization (Convener: Daman Panesar)
- **Cluster B.** Transport and Deterioration Mechanisms (Convener: Josée Duchesne)
- **Cluster C.** Structural Performance and Design (Convener: Kei-ichi Imamoto)
- **Cluster D.** Service Life and Environmental Impact Assessment (Convener: Anya Vollpracht)
- **Cluster E.** Masonry, Timber and Cultural Heritage (Convener: Arun Menon)
- **Cluster F.** Bituminous Materials and Polymers (Convener: Eshan Dave)

## LIFESPAN OF A TC

The TC duration is usually limited to 5 years. Under certain circumstances, the lifespan of a TC might be stretched but it cannot be any longer than 7 years.

## CAN I JOIN A TC?

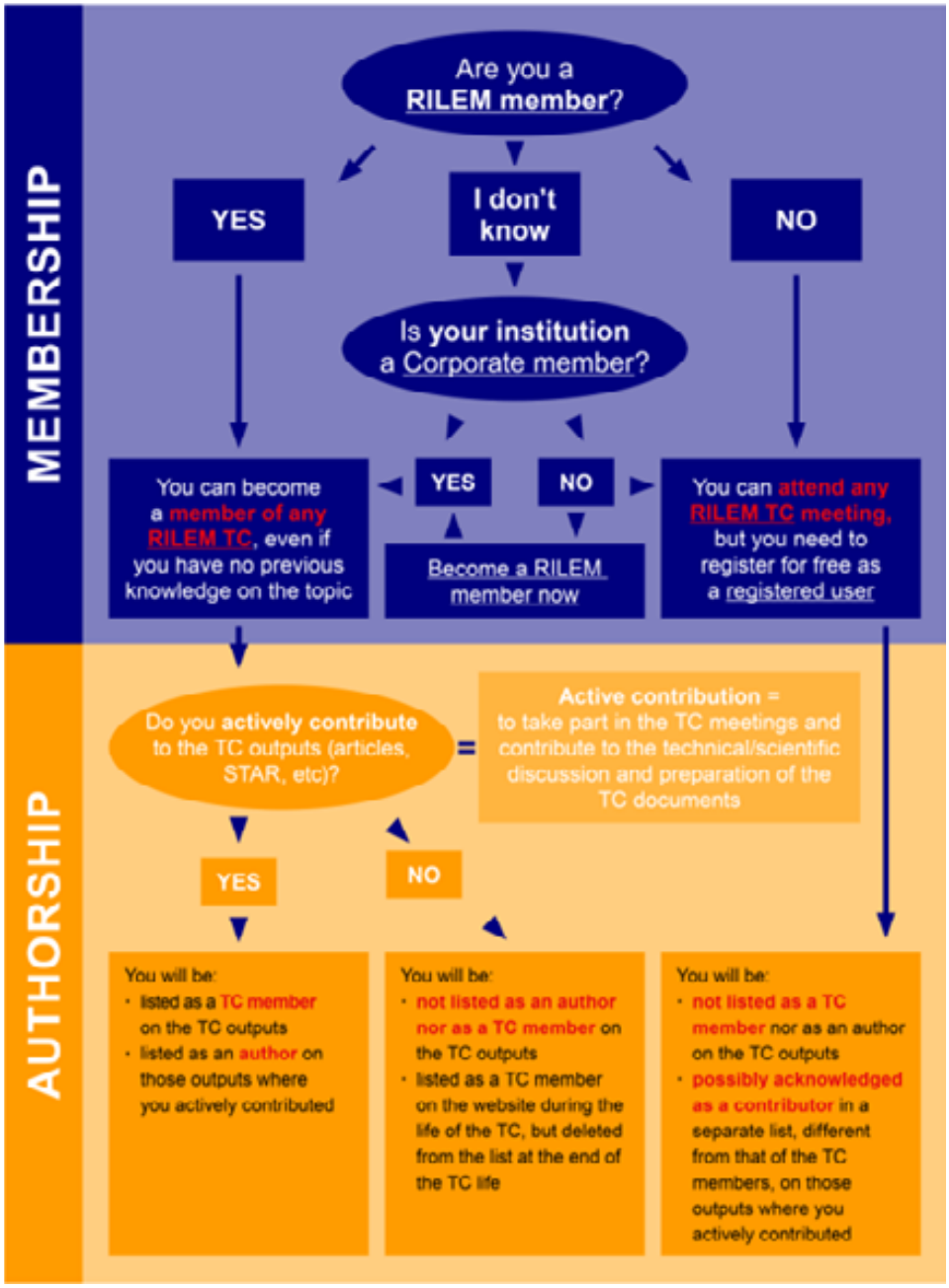
Yes! Anyone is welcome to join a RILEM TC. RILEM values the contribution of everyone, no matter if you are a young PhD student, an experienced researcher, or an industry practitioner. You do not need to be a fee-paying member, as you can join a RILEM TC as a free registered user. Please note that, in this latter circumstance, certain limitations apply for the authorship of the TC outputs.

## New TC MEMBERS AND TC OBSERVERS

In order to cope with the exponentially growing number of TC members (some TCs have more than 200 members), and the consequent effort to manage such a big group of people, a distinction between “active member” and “observer” is on its way to being implemented. When joining a TC, everyone starts as “observer” and then, depending on the actual proactive behaviour, the TC Chair can promote an observer to TC member. The TC Chair has also the

capacity of demoting a person from TC member to observer, if this person is not active. Observers have no say in the TC publications, only active members can comment on the publications produced by the TC.

## Membership & authorship




Scheme of TC membership and TC publications authorship.

1. If you are a RILEM subscribing member who actively contributes to the TC activities and outputs (articles, TC reports, STARs, etc), you are listed as a TC member and as author of the TC publications.

2. If you are not a RILEM subscribing member, you need to become a registered user by clicking on “CREATE YOUR FREE ACCOUNT” here. This step does not involve any cost/payment. As a registered user, you are welcome to join the TC meetings, to receive the produced

documentations[1], and to be part of the activities of the TC. However, you will not be listed as a TC member nor as an author of any TC output. You could possibly be acknowledged as a contributor in a separate list on those outputs where you actively contributed.

The membership fee gives access to many benefits, amongst which the rights to TC membership and authorship. It is not an "entrance fee" for being allowed to contribute to the TC work.

### Background and age

TC chairs should be inclusive and not refuse any request from anyone (RILEM members and not) wishing to become part of their TC; this also applies when the TC could have been running for a few years, unless it is about to close, or if the person interested in joining is considered to have no background on the topic. This spirit aims to encourage as many minds as possible to engage in new topics and contribute to the research. RILEM would like to remind that young researchers, like PhD students, are strongly encouraged to join a TC.

## HOW CAN I JOIN A RILEM TC?

You can submit the registration form available on the RILEM website. Please, remember to login with your credentials before filling in the "Join a TC registration form".

## REWARDS FOR TC MEMBERS AND PARTICIPANTS

Joining a RILEM TC offers many valuable rewards. For young researchers, belonging to a TC means being in touch with the most knowledgeable experts of the areas of research covered by the TC and therefore working in a nourishing and stimulating environment. It also means creating an important network of contacts that can only be advantageous for their career. For senior members, the TC is also an opportunity to work with the best scientists in their field of expertise, to mentor younger people, to put their experience and knowledge at the service of a wider community and to share expertise for the benefit of the society.

1. Confidentiality Clause: None of the working documents of the TC should be circulated, duplicated, or copied by any means, or published on any web page, journal, proceedings of conferences, etc. Any TC member and participant is bounded by this mandatory rule. Any publication of RILEM TC working documents is subjected to the rules defined by RILEM. Until official publication by RILEM, such working documents should remain confidential.

# OTHER BENEFITS WHEN JOINING A TC

Beside the above-mentioned benefits, joining a RILEM TC also means:

**1. For RILEM subscribing members:**

- Access to agendas, minutes, and other committee documents. Those can be accessed through the private directory if uploaded by the TC Chair and/or Deputy Chair.
- Access to any other document produced by the RILEM Technical Committee.
- Access to the Directory of Members.
- Opportunity to publish selected articles as free OA papers in *Materials and Structures* and in *RILEM Technical Letters*.

**2. For non-RILEM members:**

- Access to the documents produced by the RILEM Technical Committee, sent by email.

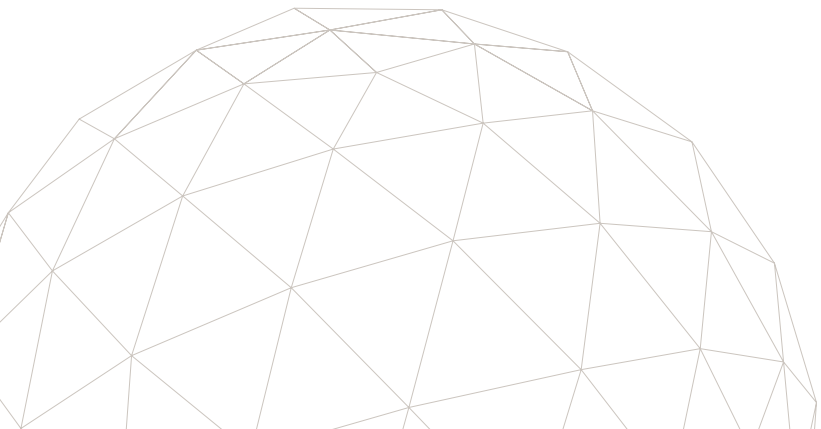
# EXPECTED ACHIEVEMENTS (DELIVERABLES) OF A TC

Each TC might produce at the end of its lifespan one or some of the following:

- A state-of-the-art report (STAR).
- One or more recommendations for test methods or construction practice.
- Conference or workshop proceedings, if organised by the TC.
- Technical reports and other educational material.
- A Topical Collection containing TC reports and TC recommendations.
- TC papers outside of a topical collection.

For more details, see the chapter “RILEM Publications” in the following pages of this report.

TC outputs are the result of the collective effort of the TC members. To make sure that the publication reflects the view of the TC, the approval from all TC members must be obtained. This and other regulations are explained in the scheme “Guidelines for submission of TC papers”.



## Publications in *Materials and Structures* (M&S) and *RILEM Technical Letters* (RTL) by RILEM Technical Committees (TCs)

Check **definitions** and **guidelines** for the various types of publications (Link A)

| State-of-the-art-report (STAR) | TC recommendation | TC paper | |
|---|---|---|---|
| | | Original research | TC overview: TC Opening (rationale) and/or Closure (review and prospects) |
| STAR can be a **book** or **journal papers** in M&S | Check **guidelines** (Link B) | | |
| Papers (e.g. TC research reports, TC recommendations or STAR) can be grouped in a **Topical Collection** in M&S (cf. point 4) | | Papers published in RTL (max 4500 words) | |

**1** **Obtain approval by all TC members** (in the form of minutes of TC meeting or e-mail chain)

- ☑ All authors of the paper must be **RILEM members**
- ☑ All TC members (also non-authors) **must approve**
- ☑ The paper should report in a dedicated section: (1) the **approval by all TC members** (2) the **list of all TC members**
- ☑ Exemptions from **standard formatting rules** are available upon request (max 15'000 words and max 25 figures+tables for M&S, max 6000 words for RTL)

Check **examples** of **TC recommendation** (Link C) and **TC paper** (Links D)

**2** **Send the manuscript and the proof of approval** by all the TC members to:

- ☑ **M&S** (materstruct@rilem.org) or **RTL** (RTL@rilem.org)
- ☑ **Anne Griffoin** (a.griffoin@rilem.org)
- ☑ **RILEM Assistant** (assistant@rilem.org)
- ☑ **Cluster Convener**
- ☑ **TAC Chair**

**3** **Obtain approval by** the General Secretariat about the TC membership reported in the manuscript

**4** *For M&S submission only:* Decide whether to create a **Topical Collection** in M&S (at least 4 papers submitted in 2-3 years maximum)

Check **guidelines for** (Link E) **and examples of** (Link F) **Topical Collections**

- ☑ Propose a **Guest Editor** (= the Cluster Convener)
- ☑ Propose a **title** (most likely, same title as the TC) that should be approved by the Cluster Convener
- ☑ Notify **M&S** (materstruct@rilem.org), the **General Secretariat** (Anne Griffoin, a.griffoin@rilem.org) and the **TAC Chair**

**5** **Submit the paper** → Paper handled by the **TAC Chair** as **Deputy Editor-in-Chief of M&S** or by the **Editor-in-Chief of RILEM Technical Letters**

**LINKS**

**A) Types of publications and respective guidelines**: https://www.rilem.net/global/gene/link.php?doc_id=6347&fg=1

**B) Guidelines for RILEM Recommendation (TAC-N183):** https://www.rilem.net/global/gene/link.php?doc_id=6351&fg=1

**C) Example of TC recommendation**: https://link.springer.com/article/10.1617/s11527-017-1000-3

**D) Example of TC paper in M&S**: https://link.springer.com/article/10.1617/s11527-022-01927-7 **RTL**: https://letters.rilem.net/index.php/rilem/issue/view/7

**E) Guidelines for Topical Collection:** https://www.rilem.net/global/gene/link.php?doc_id=6348&fg=1

**F) Examples of Topical Collection**: https://link.springer.com/journal/volumesAndIssues/11527?tabName=topicalCollections

TAC194REV2 - Guidelines for submission of TC papers.

# RILEM TCs in the pipeline

© Mike Benna, unsplash.

RILEM TCs are extremely open environment, where everyone is welcome to join. However, it might happen that a potential member finds out about the TC when it has already set up its work and schedule, and for the potential member it is hard to find a role in the TC activities.

Establishing a contact in the early stage, i.e. expressing the interest in being part of a future TC during its development process or at the TC kick-off meeting, could be an opportunity to find one's own role inside a TC; furthermore, the interested person could take part in the process of writing the TC proposal, get acquainted with the TC Chair and Deputy-Chair, contribute with her/his own knowledge, and promote the TCs within her/his network. For these reasons, and also to attract the interest of the scientific community in general, RILEM collects topics for which the creation of a new TC is being discussed. These potential TCs are called "Future TCs" and they are listed on the RILEM website.

Currently the following topics are proposed:

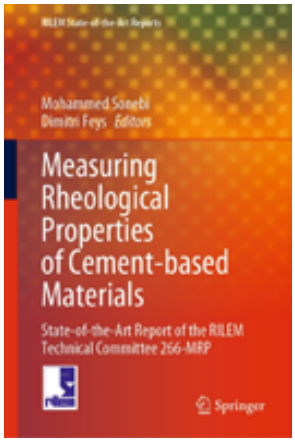
- Indoor Air Quality
- Non-destructive testing of bituminous materials
- World catalogue of masonry types, mechanical characterisation through on-field and laboratory testing and numerical modelling
- Damage evaluation of initial quality and performance of additively manufactured materials by cutting-edge NDT
- Mechanical behaviour of bio-aggregates based buildings materials
- Long-term performance and durability of masonry under a changing climate.

Any additional input to these topics or expression-of-interests by scientists and researchers are highly welcome! To receive more information about the work in progress on a specific topic, to propose any addition to the topic description and to express your interest in participating in a new TC, please get in contact with RILEM.

# RILEM PUBLICATIONS


RILEM Publications showcased at the 7th RILEM Spring Convention and Conference on advanced construction materials and processes for a carbon neutral society in Milan, Italy, in 2024. Image courtesy of D. Ciancio.

The mission of RILEM is "to advance scientific knowledge related to construction materials, systems and structures and to encourage transfer and application of this knowledge world-wide". This mission is achieved through the outstanding work of the RILEM Technical Committees and the dissemination of their outcomes in the form of RILEM publications.




Cover of STAR of RILEM TC 266-MRP. Courtesy of Springer.

## State-of-the-Art reports (STAR)

These reports constitute a critical appraisal of current knowledge on a specific research subject. They often identify gaps in knowledge, thereby contributing to the development of strategies and scenarios for future research. Since 2009, RILEM State-of-the-Art reports are published by Springer and they are indexed by SCOPUS, Google Scholar and SpringerLink.

Anyone can download for free from the RILEM web page the unedited version of each RILEM STAR, as PDF «unedited version».

RILEM has initiated the series of "STARs in a Nutshell". These documents should not be considered as a summary of the exhaustive work of the RILEM Technical Committees, but more like a brief overview of the contents available in the STAR. The purposes of these "STARs in a Nutshell" are: 1) to provide some initial guidance to a non-expert reader, 2) to inspire more comprehensive reading of the STAR and 3) to clarify the relevance of the contents before downloading or purchasing the full document for further details.

# Recommendations


Recommendation of RILEM TC 289-DCM. Courtesy of Springer.

More than 200 RILEM Technical Recommendations have been produced by the RILEM Technical Committees. Many of these recommendations have been adopted in research and practice, and are used by international standardisation bodies, as a basis for their work. In the last few years, RILEM recommendations have been published in the form of journal papers in *Materials and Structures*. They are free to be downloaded for all.

Recently, the members of RILEM TAC have accomplished the review of all the RILEM recommendations published between 1970 and 1994. 93 were withdrawn (in most cases with indication of more recent standards) and 91 were kept active. The next review process will deal with the recommendations between 1996 and 2005!

# Proceedings

RILEM has been organising symposia and workshops since its foundation, with more than 100 proceedings published by RILEM Publications S.A.R.L. A quick glance at the RILEM website shows the diversity, importance and international scope of the topics. All proceedings published by RILEM Publications S.A.R.L. can be downloaded for free (even by non-RILEM members) from the RILEM website.

Non-RILEM members need to create a “registered user” account (free of charge). The proceedings that are not published by RILEM Publications S.A.R.L. are published by Springer and can be downloaded for free by RILEM members through their private RILEM profile; non-RILEM members can purchase them online. There are currently 52 volumes in this RILEM Bookseries, available here.


Cover page of the 7 RILEM Proceedings released in the last 12 months. Images courtesy of RILEM Publications and Springer.


Cover page of RILEM flagship publication "*Materials and Structures / Matériaux et Constructions*" (MAAS). Courtesy of Springer.

# Materials and Structures

*Materials and Structures*, the flagship publication of RILEM, provides a unique international and interdisciplinary forum for new research findings on the performance of construction materials. A leader in cutting-edge research, the journal is dedicated to the publication of high-quality, original papers examining the fundamental properties of building materials, their characterization and processing techniques, modeling, standardization of test methods, and the application of research results in building and civil engineering. *Materials and Structures* also publishes comprehensive reports and recommendations prepared by the RILEM Technical Committees. This journal publishes the articles of the RILEM L'Hermite Medallists.

## Topical collections in *Materials and Structures*

Recently, TC members have been given the choice of publishing the outcomes of their TCs in the form of a minimum of 4 papers grouped in a Topical Collection. The papers must be submitted in a short time frame of 2-3 years maximum. *Materials and Structures* presents at the moment 7 Topical Collections for the following TCs:

- RILEM TC 258-AAA: Recommendations for Avoiding Alkali Aggregate Reactions in Concrete – Performance Based Concept (7 articles)
- RILEM TC 265-TDK: Development and assessment of a RILEM Recommendation: Testing methods for determination of the double-K criterion for crack propagation in concrete (4 articles)
- RILEM TC 281-CCC: Carbonation of concrete with supplementary cementitious materials (5 articles)
- RILEM TC 282-CCL: Calcined Clays as Supplementary Cementitious Materials (8 articles)
- RILEM TC 299-TES: Thermal energy storage in cementitious composites (1 article)
- RILEM TC 266-MRP: Round-Robin Rheological Tests on high performance mortar and concrete with adapted rheology (Bethune, France, 2018) (3 articles)
- RILEM TC 267-TRM: Development and Validation of Tests for Measuring the Reactivity of Supplementary Cementitious Materials (3 articles).

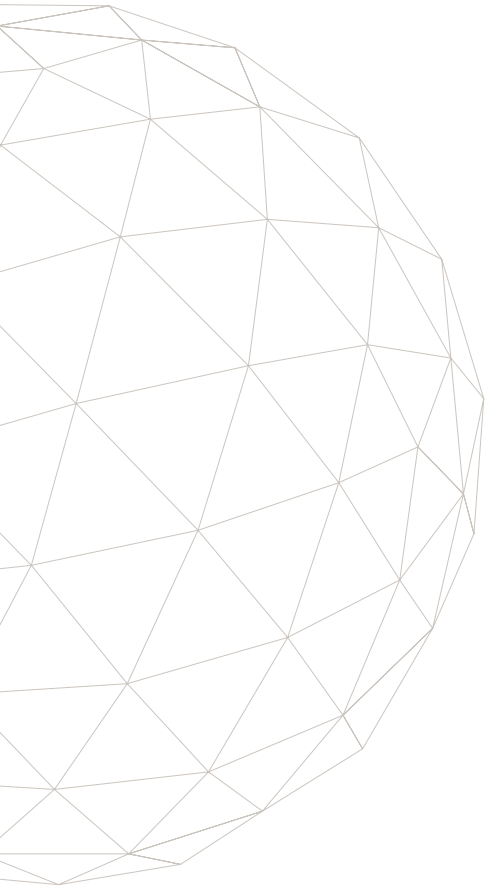
# RILEM Technical Letters

*RILEM Technical Letters* Journal was launched in March 2016 as a sister journal of RILEM's flagship, *Materials & Structures* journal, published by Springer/Nature. *RILEM Technical Letters* journal is published as a *Diamond Open Access* journal available online free of charge. The articles are submitted on invitation by the Editorial Board but the journal has recently also opened the possibility of submitting spontaneous contributions. Many articles are technical reports of the activities of the RILEM TCs.

Logo of *RILEM Technical Letters*. Courtesy of RILEM Publications S.A.R.L.

*RILEM Technical Letters* is indexed in Scopus, Scimago, Sherpa Romeo, and in the Directory of Open Access Journals. This journal publishes the articles of the RILEM Colonnetti Medallists. It also features some special regional papers, describing and detailing the state of the art of a topic in a certain geographical area. More recently, the Journal also publishes short letters when a RILEM TC is established or terminates its activities; so far, the following papers have been released:

- Harries, K.; Molari, L. Mechanical Characterisation of Bamboo for Construction: The State-of-Practice and Future Prospects. RILEM Tech Lett 2024, 8, 150-157, for TC MCB Mechanical Characterisation of Bamboo
- Keita, E.; Perrot, A. Processing of Earth-Based Materials: Current Situation and Challenges Ahead. RILEM Tech Lett 2024, 8, 141-149, for TC PEM Processing of earth-based materials.



# RILEM International Partners

Photo by fauxels.

Partners are mostly associations or organisations similar to RILEM. They sign an International Partnership Agreement (IPA) and agree on various collaborations with RILEM. The purpose of the relationship with Partners is to create information exchange between RILEM and industry partners who share similar values and interests, and to increase both partners' opportunities to network in academia and practice. Staff members of Partners do not get the RILEM membership benefits, but are strongly invited to take advantage of the free RILEM benefits, like being directly involved in RILEM technical activities such as Technical Committees, and eventually becoming members.

With some of the existing partners the collaboration goes beyond the information exchange of mutual events and publications, as it is extremely active and productive, like, for instance:

- FICEM: the *Inter-American Cement Federation* represents the majority of the cement manufacturers, institutes and associations in Latin America, the Caribbean, Spain and Portugal. FICEM has co-organised with RILEM a ROC&TOK webinar in January 2023 (available on YouTube in English and in Spanish), and coordinated the writing of a regional paper in *RILEM Technical Letters*. FICEM has recently launched the e-learning platform "Academia FICEM", where some relevant videos of past ROC&TOK webinars will be made available, together with new contents generated with the collaboration of the Lat-RILEM presidium.
- ICT: the *Institute of Concrete Technology* was formed in 1972. The Institute's mission is to preserve and promote concrete technology as a recognized engineering discipline and to consolidate the professional status of practicing concrete technologists worldwide. Upon request, ICT provides Continuous Professional Development (CPD) credits to the attendants of the ROC&TOK webinars and of some EAC doctoral courses.
- *fib*: the *International Federation for Structural Concrete* is a not-for-profit association. The *fib*'s mission is to develop at an international level the study of scientific and practical matters capable of

advancing the technical, economic, aesthetic and environmental performance of concrete construction. Together with RILEM, *fib* is actively engaged with the Global Consensus on Sustainability in the Built Environment (GLOBE), which is to direct the attention of the global community, politicians, industry leaders, and societal decision-makers to the critical importance of the built environment for sustainable development at global and local scales.

- ACI: the American Concrete Institute is an historical RILEM's partner. The partnership was signed in 2009, 15 years ago! Since then, RILEM and ACI has worked together co-organising events and publications. The most recent joint activity other the last 12 months is the RILEM participation into the "24 hours concrete knowledge" event, where RILEM was in charge of the time slots on Wednesday, July 10, 2024, from 7:00 to 8:00 PM Paris time, (1:00 to 2:00 AM, Detroit Time).


Logos of the current RILEM International Partners

# Material Processing and Characterization

## Foreword

### ▶ from Cluster A Convener,
### Daman K. PANESAR

There are currently 12 RILEM Technical Committees that fall in Cluster A: *Material Processing and Characterization*. The Technical Committees in Cluster A advance knowledge and applications in the fields of emerging material processing technologies, characterization of composites, cement-based materials, aggregates, polymers and expansive agents. In the last 12 months, TC 275-HDB : Hygrothermal behaviour and Durability of Bio-aggregate based building materials completed its activities, and no new TCs were established.

The specific focus areas of the technical committees in Cluster A include: properties of calcined clay (TC 282-CCL); reactive MgO-based expansive agents to reduce the risk of crack formation (TC 284-CEC); use of agro-based materials as cementitious additions in concrete and cement-based materials (TC 291-AMC); assessment of electrical materials to study corrosion of steel in concrete (TC 296-ECS); carbon based nanomaterials for multifunctional cementitious matrices (TC 302-CNC); performance requirements and testing of fresh printable cement-based materials (TC 303-PFC); assessment of additively manufactured concrete materials and structures (TC 304-ADC); pumping of concrete (TC 305-PCC); mineral carbonation of construction materials (TC 309-MCP); assessment of magnesia-based binders in concrete (TC 311-MBC); performance testing of hydraulics cements (TC 312-PHC); and investigation of active control of properties of fresh and hardening cementitious materials (TC APC).

A couple of TCs have attracted a significant interest from the scientific community, having more than 200 members each! The leadership and membership of these committees reflects an international representation. Meetings, workshops, and doctoral courses organized by the Technical Committees have been held around the world online, in person and hybrid mode, and have enabled engagement, knowledge transfer, and networking opportunities for design engineers, industry professionals, research scientists, students and is also a starting point to attract new RILEM members.

Research outcomes are disseminated to the broader community through the publication of: state-of-the-art reports (STAR), RILEM recommendations, topical collections in Materials and Structures journal, results of round-robin tests, proceedings from international RILEM conferences, RILEM PhD course materials, and dissemination in journals including *RILEM Technical Letters*. Outcomes of the Technical Committee work is also used by standardization bodies to facilitate the development of codes and standards in the field of material processing and characterization.

I have had the honour to serve on the RILEM Technical Activities Committee (TAC) since 2018 and have been the Convenor of Cluster A since 2019, previously held by Professor Barzin Mobasher.

# Current TCs in Cluster A

| CODE<br>TITLE | CHAIR<br>DEPUTY CHAIR | OPENED IN | NO. OF MEMBERS |
|---|---|---|---|
| **282-CCL**<br>Calcined Clays as Supplementary Cementitious Materials | Fernando MARTIRENA-HERNANDEZ<br>Manu SANTHANAM | 2018 | 73 |
| **284-CEC**<br>Controlled expansion of concrete by adding MgO-based expansive agents taking the combined influence of composition and size of concrete elements into consideration | Jiaping LIU<br>Ole Mejlhede JENSEN | 2018 | 33 |
| **291-AMC**<br>Use of Agro-Based Materials as Cementitious Additions in Concrete and Cement-Based Materials | Said KENAI<br>Mike B. OTIENO | 2018 | 37 |
| **296-ECS**<br>Assessment of electrochemical methods to study corrosion of steel in concrete | Sylvia KESSLER<br>Ueli ANGST | 2020 | 66 |
| **302-CNC**<br>Carbon-based nanomaterials for multifunctional cementitious matrices | Florence SANCHEZ<br>Marco LIEBSCHER | 2021 | 88 |
| **303-PFC**<br>Performance requirements and testing of fresh printable cement-based materials | Nicolas ROUSSEL<br>Dirk LOWKE | 2021 | 211 |
| **304-ADC**<br>Assessment of Additively Manufactured Concrete Materials and Structures | Viktor MECHTCHERINE<br>Freek BOS | 2021 | 215 |
| **305-PCC**<br>Pumping of concrete | Dimitri FEYS<br>Geert DE SCHUTTER | 2021 | 60 |
| **309-MCP**<br>Accelerated Mineral Carbonation for the production of construction materials | Ruben SNELLINGS<br>Thomas MATSCHEI | 2022 | 192 |
| **311-MBC**<br>Magnesia-based binders in concrete | Paivo KINNUNEN<br>Ellina BERNARD | 2022 | 77 |
| **312-PHC**<br>Performance testing of hydraulic cements | Karen SCRIVENER<br>Laurent IZORET | 2022 | 81 |
| **ACP**<br>Active Control of Properties of Fresh and Hardening Cementitious Materials | Geert DE SCHUTTER<br>Jay SANJAYAN | 2023 | 99 |

# **282-CCL** Calcined clays as supplementary cementitious Materials

**Chair Fernando MARTIRENA-HERNANDEZ**
**Deputy Chair Manu SANTHANAM**
**Activity started in 2018**

### Significance

The scarcity of common Supplementary Cementitious Materials (SCMs) like fly ash and slag and the great pressure that the cement industry is receiving on reducing GHG emissions, has prompted the use of calcined clays as an alternative to traditional SCMs. However, practical implementation demands for further information for companies and government bodies to adapt existing standards to the new product and tackle the yet remaining gaps in the knowledge.

### Progress

- A new paper added to the Topical Collection: Kanavaris, F., Vieira, M., Bishnoi, S. et al. Standardisation of low clinker cements containing calcined clay and limestone: a review by RILEM TC-282 CCL. Mater Struct 56, 169 (2023).
- TC outcomes to be presented at the 2024 RILEM Annual Week.
- Organization of the 4th International Conference on Calcined Clays for Sustainable Concrete, 15-18 May 2024, Nanjing, China.
- Organization of the LC3 doctoral school in February 2024, in Lausanne, Switzerland, to be offered again in September 2024.


Some 282-CCL members presenting at the 4th International Conference on Calcined Clays for Sustainable Concrete. Image courtesy of F. Martirena.

# **284-CEC** Controlled expansion of concrete by adding MgO-based expansive agents taking the combined influence of composition and size of concrete elements into consideration

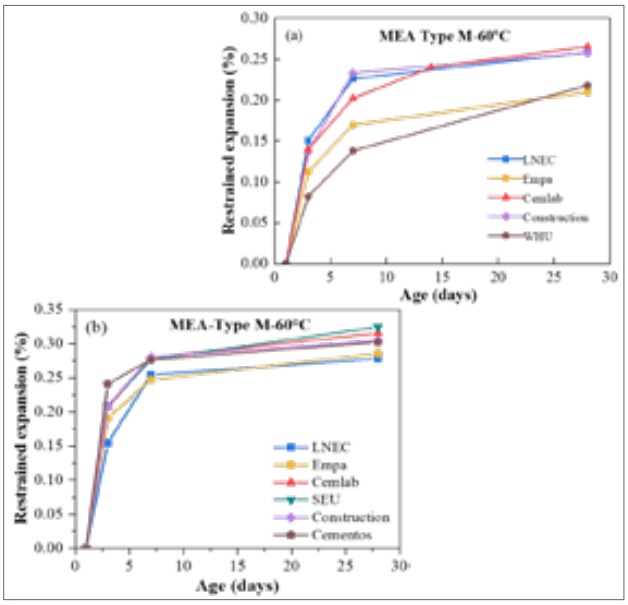
**Chair Jiaping LIU**
**Deputy Chair Ole Mejlhede JENSEN**
**Activity started in 2018**

### Significance

MgO-based expansive agents have proven to be effective in compensating shrinkage and mitigating cracking of concrete. In addition to the characteristics of MgO itself, the composition and size of concrete element also have strong influence on expansion of concrete with MgO-based additives, which is still not fully understood.

### Progress

- TC meeting (hybrid-mode) in September 2023 during the RILEM Annual Week in Vancouver, Canada.
- Next TC meeting planned for RILEM Annual Week in August 2024 in Toulouse, France.
- TC outcomes expected to be presented at the 2026 RILEM Annual Week.
- Draft STAR to be submitted to RILEM this year.
- Guidelines for the quality control of MgO expansive agent planned to be completed in 2024.




Comparison of the reproducibility of multi-laboratory test results on restrained expansion of MEA mortars: (a) first multi-laboratory test; (b) second multi-laboratory test (Courtesy of TC 284-CEC).

# **291-AMC** Use of agro-based materials as cementitious additions in concrete and cement-based materials

**Chair Said KENAI**
**Deputy Chair Mike OTIENO**
**Activity started in 2018**

### Significance

Agro-based materials are renewable materials that can reduce the construction industry greenhouse emissions and negative impact on the environment. However, there is currently a shortage of industrial applications.

### Progress

- TC meetings over the last 12 months: online in March 2024, and in-person in Accra, Ghana, in April 2024.
- STAR expected to be finalized by August 2024.
- TC meeting held in person in Dec 2022 in Dakar, Senegal.
- Presentation of TC outcomes scheduled during the 2024 RILEM Annual Week.


Some moments of the 291-ACM meeting in Ghana in April 2024. Image courtesy of W. Schmidt.

# **296- ECS** Assessment of electrochemical methods to study corrosion of steel in concrete

**Chair Sylvia KESSLER**
**Deputy Chair Ueli ANGST**
**Activity started in 2020**

### Significance

Corrosion of steel in concrete is major reason for deterioration of concrete structures. The corrosion process of the reinforcement itself is of electrochemical nature. Therefore, electrochemical measurements are an essential tool in order to be able to assess and scientifically study the corrosion behaviour of metal-concrete-systems. Besides the assessment of the corrosion behaviour, electrochemical measurements form the basis to predict/model the time of corrosion initiation and the propagation period.

### Progress

- Two papers in preparation:
  - > Recommendations on the design of lab test setups for electrochemical measurements of steel in concrete.
  - > Recommendations on electrochemical impedance spectroscopy of steel in concrete
- TC meetings over the last 12 months:
  - > Online Editorial Board meeting for the future publications, in March 2024.
  - > Online, in April 2024
  - > Hybrid, during the 2024 RILEM Week in August in Toulouse, France.
- TC outcomes to be presented during the 2025 RILEM Spring Convention, in Switzerland.

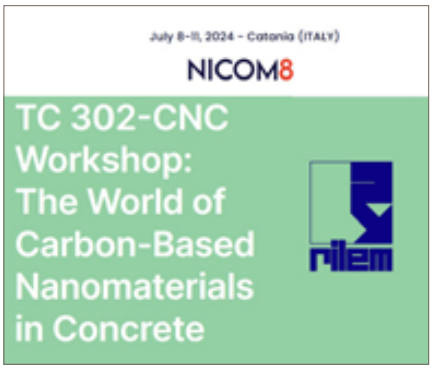
Advanced corrosion of steel in concrete. Image courtesy of S. Kessler.

# **302-CNC** Carbon-based nanomaterials for multifunctional cementitious matrices

**Chair Prof. Florence SANCHEZ**
**Deputy Chair Marco LIEBSCHER**
**Activity started in 2021**

### Significance

Carbon-based nanomaterials - such as graphene, carbon nanotubes or carbon black - have gained recently a significant interest in research and development for civil engineering applications. When successfully dispersed in cementitious matrices, they have shown to improve strength, ductility, and fracture resistance; reduce cracking; decrease permeability; and increase durability, while providing innovative properties such as electrical and thermal conductivity. However, despite a large number of research activities, the application of nanocarbon modified cementitious matrices in concrete construction remains to date limited in part due to challenges related with scale-up implementations and a lack of a clear understanding of usually multiple, overlapping mechanisms.




Logo of the Workshop organised by TC 302-CNC in Italy in July 2024.

### Progress

- Organization of the TC 302-CNC Workshop: The World of Carbon-Based Nanomaterials in Concrete, on 11 July 2024, in Catania, Italy, following the Nanotechnology in Construction Materials, NICOM-8, Symposium.
- Ongoing discussion about developing papers that could be grouped into a Topical Collection in *Materials and Structures*.

# **303-PFC** Performance requirements and testing of fresh printable cement-based materials

**Chair Nicolas ROUSSEL**
**Deputy Chair Dirk LOWKE**
**Activity started in 2021**

### Significance

3DCP (3D Concrete Printing) is an Additive Manufacturing process. The geometric quality of manufactured parts is not only affected by the precision of the printing but also by the deformation under self-weight during manufacture. Fresh material must initially remain fluid enough to facilitate deposition and inter-layer bonding, but materials that are too fluid can lead to buckling and collapse of structures. The importance of these mechanisms has driven significant efforts in: determining the rheological requirements of the fresh material; quantifying buildability; and predicting structural failure. Being able to measure, assess and benchmark process and material performance using standardised and internationally accepted approaches is therefore essential for the industrial future of the technology.


Logo of the Digital Concrete Conference, in September 2024 in Germany.

### Progress

- Organization of *4th RILEM International Conference on Digital Fabrication with Concrete* in September 2024 in Germany.
- TC outcomes to be presented during the 2026 RILEM Annual Week.
- Currently running an interlaboratory study of various quality control testing protocols.

# **304-ADC** Assessment of Additively Manufactured concrete materials and structures

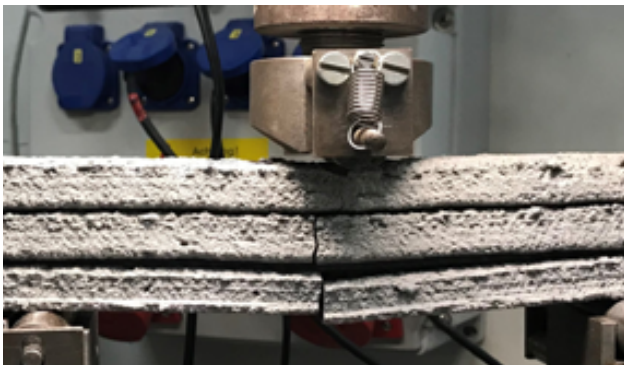
**Chair Viktor MECHTCHERINE**
**Deputy Chair Freek BOS**
**Activity started in 2021**

### Significance

Additive manufacturing (AM) of concrete structures is revolutionizing the construction sector with its efficient material use, architectural freedom, and high automation and productivity. Products created through AM often exhibit considerable anisotropy, attributable to their layer-by-layer manufacturing process. These unique characteristics of AM necessitate a critical reassessment of all relevant material characterization test methods to establish new, universally accepted standards.

### Progress

- Two extensive inter-laboratory studies involving 30 labs worldwide have been successfully completed, focusing on: (i) mechanical properties, and (ii) durability and early-age shrinkage.



3-point bending testing of a 3D printed concrete specimen. Image courtesy of T. Neef.

- Based on these studies, six journal papers for a Topical Collection in Materials and Structures are currently in preparation
- Organizing the 4th RILEM Conference on Digital Concrete - DC 2024 in Munich in collaboration with RILEM TC 303-PFC.

# **305-PCC** Pumping of concrete

**Chair Dimitri FEYS**
**Deputy Chair Geert DE SCHUTTER**
**Activity started in 2021**

### Significance

- Current international documents on pumping of concrete are substantially aged and need modifications to incorporate the results on modern concrete mixtures.
- With the further development of specialty, flowable and high-performance concrete, this knowledge is crucial to be spread to the industry to maintain the competitive advantage of concrete in the construction industry.
- The need exists to create a State-of-the-art report on pumping of concrete, incorporating the developments made in the last 20 years.
- To the knowledge of the proposers, there is no such document available which includes the latest developments.

### Progress

- TC meetings over the last 12 months: hybrid in Vancouver, Canada, in September 2023 during the 77th RILEM Annual Week, and hybrid in Toulouse, France, in August 2024, during the 78th RILEM Annual Week.
- TC outcomes might be presented at the 81st RILEM Annual Week in 2027.
- Plans to publish a State-of-the-art Report in 2025.
- A paper titled "Practical Insights and Advances in Concrete Pumping" has been submitted to *RILEM Technical Letters*.

On the left: concrete pumping on a small construction site. On the right: large-scale concrete pump test on a major construction site. Image courtesy of G. De Schutter.

# **309-MCP** Accelerated Mineral Carbonation for the production of construction materials

**Chair** Ruben SNELLINGS
**Deputy Chair** Thomas MATSCHEI
**Activity started in** 2022

### Significance

- The conversion and use of $CO_2$ into solid, stable mineral carbonates (mineral carbonation) as a means to produce construction materials is an innovative and rapidly developing field that is expanding in various application domains.
- As an emerging field there is a lack of common terminology, material characterisation test methods and reliable process impact data and assessments. Therefore, there is a need for sharing experiences and understanding and for developing best practices and test method recommendations to build a common knowledge base.

### Progress

- TC meetings over the last 12 months: hybrid, at the 16th International Congress on the Chemistry of Cement (ICCC), in September 2023, in Bangkok, Thailand; in person at the 1st International Conference on Mineral Carbonation for Cement and Concrete in Germany in April 2024.
- Organization of the 1st International Conference on Mineral Carbonation for Cement and Concrete in Germany in April 2024, at RWTH Aachen University, Germany, in April 2024.
- TC outcomes to be presented at the 80th RILEM Week in 2026 or the 81st in 2027.
- 6 review papers in progress, to be part of a Topical Collection in *Materials and Structures*. Round robin tests and 4 additional papers in preparation.


Delegates of the 1st RILEM International Conference on Mineral Carbonation for Cement and Concrete. Image courtesy of T. Matschei/RWTH.

# **311-MBC** Magnesia-based binders in concrete

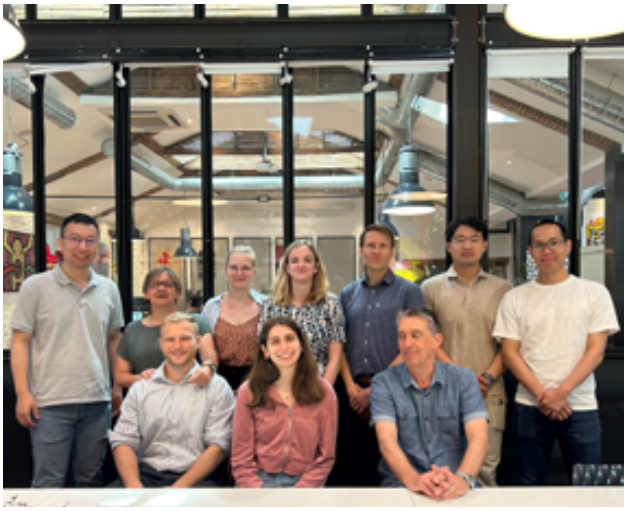
**Chair** Paivo KINNUNEN
**Deputy Chair** Ellina BERNARD
**Activity started in** 2022

### Significance

Magnesia-based cements are relatively unstudied systems. MgO is found as magnesium silicates in Earth's crust, and therefore constitutes a potentially zero-$CO_2$ raw material for its uncarbonated form. The scientific as well as technological viability and scalability related to the MgO-based binders' utilization are still open questions to a large degree. The understanding of the potential of these binders is still in its infancy and the research is scattered and relatively uncoordinated.

### Progress

- TC meetings over the last 12 months: online in Jan 2024, and hybrid in June 2024 Toulouse, France, during the 12th ACI/RILEM International Conference on Cementitious Materials and Alternative Binders for Sustainable Concrete (ICCM 2024).



Members of TC 311-MBC during the TC meeting in Toulouse, France, in June 2024. Image courtesy of E. Bernard.

- TC outcomes might be presented during the 79th RILEM Annual Week in 2025.

# **312-PHC** Performance testing of hydraulic cements

**Chair Karen SCRIVENER**
**Deputy Chair Laurent IZORET**
**Activity started in 2022**

### Significance

To accommodate new "blended" or "composite" cements, the current "prescriptive" cement standards are getting more and more complex. In view of the diversifying range of cementitious constituents and their expanding levels of incorporations, the number of combinations as cements is bound to exponentially increase if current prescriptive approaches are maintained. Moving away from specifications based on cement composition to a performance-based approach could rigorously resolve the issue, align with policy expectations and enable a more rapid introduction of new sustainable cements. The aim of this committee will be to prepare the way for performance approaches to defining cements suitable for application and look at existing and new test methods of performance.

Members of TC 312-PHC at the TC meeting in June 2024. Image courtesy of F. Boscaro.

### Progress

- TC meetings over the last 12 months: in October 2023, in January and June 2024.
- TC outcomes might be presented during the 79th RILEM Annual Week in 2025 or 80th RILEM Annual Week in 2026.
- Several round robins are underway.
- The topic is receiving much interest, and it is very much in line with debate elsewhere. This TC focuses on providing hard data.

# **ACP** Active Control of Properties of Fresh and Hardening Cementitious Materials

**Chair Geert DE SCHUTTER**
**Deputy Chair Jay SANJAYAN**
**Activity started in 2023**

### Significance

Active Control of Concrete Properties is a recently identified subfield within concrete technology. The new concept of Active Control of concrete properties is based on the application of external signals to trigger an intended response in the material. Several challenges remain, like the stability and functioning of the responsive material in a cementitious environment, the applicability of the control signal in a cementitious material, and the cost, logistics and safety of a control system on a construction site or in precast industry. Finding solutions to these challenges will lead to marvellous opportunities in general, and for concrete 3D printing more particularly.

TC members attending the hybrid meeting in Milan, in April 2024, during the RILEM Spring Convention. Image courtesy of D. Ciancio.

### Progress

- TC meetings over the last 12 months: in hybrid mode in April 2024 in Milan, Italy, and in physical mode in August 2024 in Toulouse, France, during the 78th RILEM Annual Week.
- Presentation of TC outcomes expected at the 80th RILEM Week in 2026.
- Planning for publication in 2024 in RILEM Technical Letters.
- Aiming to publish a State-of-art Report in conjunction with the RILEM Spring Convention in 2026, in Ghent, Belgium.

# Transport and Deterioration Mechanisms

## Foreword

### ▶ from Cluster B Convener,
### Josee Duchesne

Cluster B coordinates the activities of the Technical Committees dealing with Transport and Deterioration Mechanisms. This topic is related to the properties of the construction materials and their chemical, physical, mechanical and durability behaviour. The use of traditional and novel construction materials is conditioned by their properties. The service life of the structures is conditioned by these properties as well as by environmental and exposure conditions. The development of test methods, modelling and validation are among the topic addressed by this cluster.

Currently, Cluster B has five active TCs dealing with different aspects of traditional and novel construction materials, their properties, and the durability behaviour and combination of actions. The active technical committees include: Test method for concrete durability under combined role of sulphate and chloride ions (285-TMS); Test Methods for Gas Diffusion in Porous Media (286-GDP); Degradation of organic coating materials and its relation to concrete durability (297-DOC); Test methods to evaluate durability of blended cement pastes against deleterious ions (EBD-298); and Modelling and experimental validation of moisture state in bulk cementitious materials and at the steel-concrete interface (313-MMS). Over the last 12 months, the 281-CCC : Carbonation of concrete with supplementary cementitious materials and 283-CAM : Chloride transport in alkali-activated materials have completed their activities. Over 250 RILEM members currently participate in Technical Committees coordinated under Cluster B.

Between 2005 and 2024, 25 Technical Committees have been created under Cluster B. Cluster B's technical committees have published numerous recommendations, state-of-the-art reports, journal articles, and conference papers to disseminate information and contribute to RILEM visibility.

Since September 2020, it has been a privilege to coordinate the activities of Cluster B. I took over the role previously filled by Dr Esperenza Menendez Mendez.

# Current TCs in Cluster B

| CODE<br>TITLE | CHAIR<br>DEPUTY CHAIR | OPENED<br>IN | NO. OF<br>MEMBERS |
|---|---|---|---|
| **285-TMS**<br>Test method for concrete durability under combined role of sulphate and chloride ions | Changwen MIAO<br>Geert DE SCHUTTER | 2018 | 36 |
| **286-GDP**<br>Test Methods for Gas Diffusion in Porous Media | Bruno HUET<br>Philippe TURCRY | 2019 | 34 |
| **297-DOC**<br>Degradation of organic coating materials and its relation to concrete durability | Takafumi NOGUCHI<br>Kei-Ichi IMAMOTO | 2020 | 35 |
| **298-EBD**<br>Test methods to evaluate durability of blended cement pastes against deleterious ions | William WILSON<br>Prannoy SURANENI | 2020 | 92 |
| **313-MMS**<br>Modelling and experimental validation of moisture state in bulk cementitious materials and at the steel-concrete interface | Zhidong ZHANG<br>Chunsheng ZHOU | 2022 | 60 |

# **285-TMS** Test method for concrete durability under combined role of sulphate and chloride ions

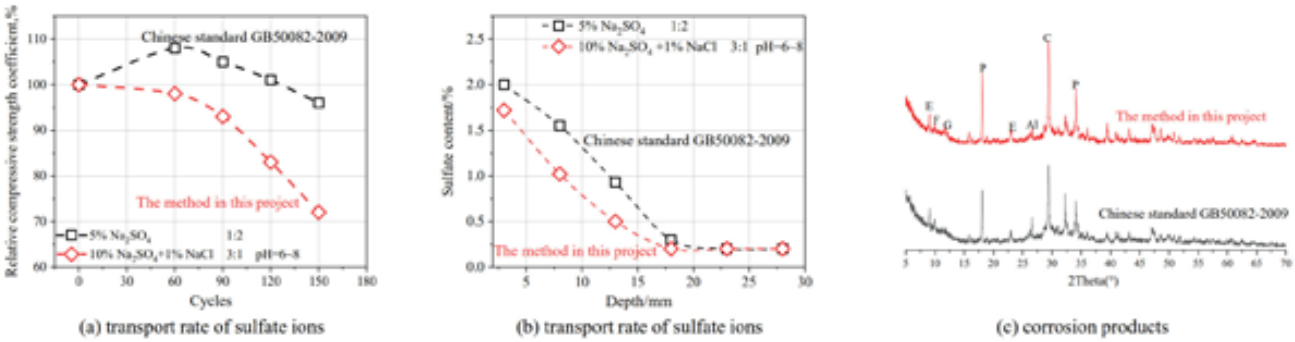
**Chair** Changwen MIAO
**Deputy Chair** Geert DE SCHUTTER
**Activity started in** 2018

### Significance

Deterioration processes of combined sulphate and chloride attack are rather complex for reinforced concrete. Under the combined role of sulphate and chloride ions, service life of reinforced concrete structures can be shortened considerably.

### Progress

- The paper titled 'State of the art report on test methods for sulfate attack and chloride transport' was circulated amongst TC members in April and is going to be submitted to Materials and Structures.
- A study on the impact of pH levels and wet-dry ratios was conducted and compared with the acceleration methodology specified in the Chinese standard GB50082-2019. Subsequently, a series of round-robin tests will be conducted by other laboratories to validate these findings.
- Results of the inter-laboratory tests presented at the 2nd International Conference on Innovation in Low Carbon Cement and Concrete Technology-ILCCC2024, in July 2024, in London, UK. During this conference, a TC meeting was also scheduled.




Results showing that the acceleration regimes suggested in the TC study facilitated the intrusion of sulfate ions and the degradation of concrete's compressive strength. Image courtesy of TC 285-TMS.

# **286-GDP** Test methods for gas diffusion in porous media

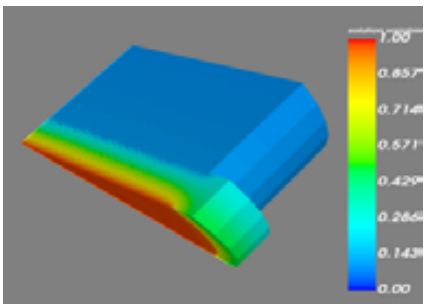
**Chair** Bruno HUET
**Deputy Chair** Philippe TURCRY
**Activity started in** 2019

### Significance

Rebar corrosion and other detrimental phenomena for concrete are linked to oxygen, carbon dioxide and water vapor mass transfer. The gas diffusion coefficient is a general indicator of the resistance to gas transfer. Different methods for measuring gas diffusion coefficient of cementitious materials have been developed but no technical consensus exists on those methods.

### Progress

- State of the art report will be published through a Topical Collection in *Materials and Structures* (MAAS).
- Nine papers are under writing or under review by the active members of the TC.
- Test campaigns are finished for all involved laboratories.



3D - Oxygen concentration map during a diffusion test to illustrate transient effect in sample and in downstream volume as well as side effects because of sealing joints. This work contributes to defining the right analytical solution for interpreting gas diffusion test results. Image courtesy of B. Huet.

Analysis of the obtained results are ongoing and recommendations for test methods are planned.

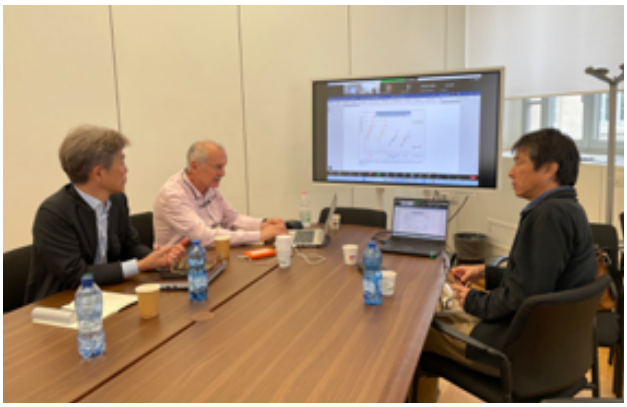
- Parametric studies (effects of geometry, boundary conditions, etc.) with numerical simulations are still ongoing.

# **297-DOC** Degradation of organic coating materials and its relation to concrete durability

**Chair Takafumi NOGUCHI**
**Deputy Chair Kei-Ichi IMAMOTO**
**Activity started in 2020**

### Significance

Coating materials contributes to extend the lifetime of concrete structures by acting not only as texture of a building but also as protection of reinforced concrete structures from harmful substances. Organic coating material such as multi-layer coating material will degrade by ultraviolet light and/or heat and its barrier effect might be reduced. The effect of coating materials to prevent the ingress of $CO_2$ have been extensively verified throughout accelerated tests in laboratory conditions. However, the degradation of coating materials under real environmental conditions and its relation to concrete durability still need further investigation.



A moment of the TC 297-DOC meeting held in hybrid mode in Milano, Italy, in April, during the 2024 RILEM Spring Convention. Image courtesy of D. Ciancio.

### Progress

- TC meetings in the last 12 months held in Milano, Italy, in April, during the 2024 RILEM Spring Convention, and in Toulouse, France, in August, during the 78th RILEM Annual Week.
- TC STAR contents: 60% progress
- Estimated time of TC's closure: 2026.

# **298-EBD** Test methods to evaluate durability of blended cement pastes against deleterious ions

**Chair William WILSON**
**Deputy Chair Prannoy SURANENI**
**Activity started in 2020**

### Significance

The $CO_2$ reduction targets of the cement industry necessitate the development of alternative supplementary cementitious materials (SCMs) to reduce the global clinker factor of cements. The adoption of novel SCMs requires efficient and reliable test methods to investigate the effect of SCMs on long-term concrete durability. As long-term concrete durability tests are laborious and time consuming, this TC focusses on paste-level durability tests for chloride and sulfate.

A moment during the in-person TC meeting held during the conference Synercrete'23. Image courtesy of Synercrete'23.

### Progress

- Around 10 subgroup meetings were held in the last 12 months.
- An in-person TC meeting was held at SynerCrete'23 – 14-16 June 2023, Milos, Greece.
- A special session was organized by TC 298-EBD at the RILEM SynerCrete'23 Conference with the title "Durability of pastes against ions".
- Drafts of 3 journal publications are in progress and will be submitted in the next months.
- Analysis and synthesis of data from literature is ongoing.
- Pre-round robin testing for bulk resistivity on cement pastes have been completed and the first results of the round robin phase 1 have been collected.

# **313-MMS** Modelling and experimental validation of moisture state in bulk cementitious materials and at the steel-concrete interface

**Chair Zhidong ZHANG**
**Deputy Chair Chunsheng ZHOU**
**Activity started in 2023**

## Significance

Various scientific studies found that the key parameter controlling the corrosion rate of steel in carbonated concrete is the water content at the steel surface; other showed that only when water front reached the steel surface, the measured corrosion rate became significant. This implies that, by controlling the "right" water condition at the steel surface, the risk of steel corrosion can be kept low.

The consequence of this is that the moisture ingress through the (carbonated) concrete cover becomes a highly important mechanism to ensure corrosion resistant structures. Methods to measure and model this process at the engineering level are thus needed. A prevailing key question is the identification of moisture transport models that can capture the key features of moisture transport and moisture state that are directly related to steel corrosion, while keeping the degree of complexity such that needed input parameters can be measured or otherwise made available in engineering practice.

Members of TC 313-MMS during the TC meeting in October 2023 at the 16th Int Conf on Durability of Building Materials, China. Image courtesy of Cheng Liu.

## Progress

- Last TCs meetings held in:
  - > October, 2023, at *the 16th International Conference on Durability of Building Materials,* China.
  - > November 2023, online, to prepare the TC opening letter.
  - > May 2024, online
  - > August 2024, in Toulouse, France, during the 78th RILEM Annual Week.
- Workshop on Moisture-Related Durability Issues For Low-Carbon Binder - TC 313-MMS, during the 2024 RILEM Annual Week.
- Preparation of the TC opening letter to be submitted to *RILEM Technical Letters* before the end of 2024.

# Structural Performance and Design

## Foreword

### ▶ from Cluster C Convener,
### Kei-ichi IMAMOTO

Material and structural behaviour are closely connected since the optimization starts from structural performance which significantly depends on material behaviour. Indeed, structural behaviour should carefully look at material performance as well as material behaviour to be oriented to a better structural response.

For this reason, RILEM activated Cluster C, which coordinates the activities of the Technical Committees (TCs) dealing with "Structural Performance Design". A close collaboration with *fib* and their impressive work on drafting the *fib*-model code is also materialised through the cluster.

Currently, in the Cluster C seven TCs are active in: early age and long-term crack width analysis in RC Structures (287-CCS), impact and explosion (288-IEC), mechanical characterization and structural design of textile reinforced concrete (292-MCC), Mechanical properties of alkali-activated concrete (294-MPA), Concrete during Fire - Reassessment of the framework (306-CFR), On-site Corrosion Condition Assessment, Monitoring and Prediction (314-OCM), and the recently (Spring 2023) approved TC RCC Rolled compacted concrete for pavement applications.

Structural behaviour should be supported by reliable numerical models that are particularly useful for better understanding structural performance as well as structural design. Therefore, TCs active in "numerical modelling" of materials and structures are an important component of Cluster C as it may use experimental data to better predict structural performance.

The first TC belonging to Cluster C was established in 1996 and it was *"175-SLM: Computer bases on service life methodology"*. Since then, 24 TCs have worked under the coordination of the convener of Cluster C, service that I have the honour to have held since late 2023, after Professor Giovanni Plizzari.

# Current TCs in Cluster C

| CODE<br>TITLE | CHAIR<br>DEPUTY CHAIR | OPENED IN | NO. OF MEMBERS |
|---|---|---|---|
| **287-CCS**<br>Early age and long-term crack width analysis in RC Structures | Miguel AZENHA<br>Fragkoulis KANAVARIS | 2019 | 88 |
| **288-IEC**<br>Impact and Explosion | Marco DI PRISCO<br>Ezio CADONI | 2018 | 29 |
| **292-MCC**<br>Mechanical Characterization and Structural design of Textile Reinforced Concrete | Barzin MOBASHER<br>Flávio DE ANDRADE SILVA | 2019 | 79 |
| **294-MPA**<br>Mechanical properties of alkali-activated concrete | Guang YE<br>Frank DEHN | 2019 | 142 |
| **306-CFR**<br>Concrete during Fire - Reassessment of the framework | Pierre PIMIENTA<br>Robert MCNAMEE | 2022 | 64 |
| **314-OCM**<br>On-site Corrosion Condition Assessment, Monitoring and Prediction | Carmen ANDRADE<br>Pedro CASTRO BORGES | 2022 | 82 |
| **RCC**<br>Rolled compacted concrete for pavement applications | Christian PAGLIA<br>Corey ZOLLINGER | 2023 | 30 |

# **287-CCS** Early age and long-term crack width analysis in RC structures

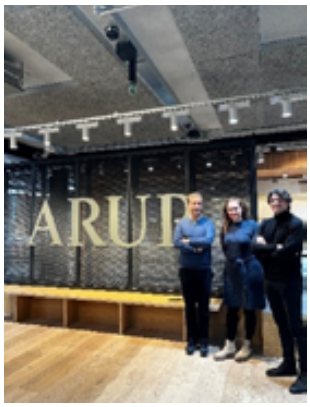
**Chair** Miguel AZENHA
**Deputy Chair** Fragkoulis KANAVARIS
**Activity started in** 2019

### Significance

Cracking due to restrained shrinkage and thermal effects is still an ongoing serviceability issue in concrete structures. Understanding and improving current approaches require a strong element of interdisciplinarity, focusing on the interplay between materials science and structural engineering. This entails the need to adequately combine the fundamental material behaviour of concrete since casting with experimental substantiation and advanced numerical and analytical modelling of cracking in structures.

### Progress

- Multi-scale Cracking of Concrete Materials course, at the University of Leeds, UK, in October 2023.
- Two full member meetings in the last 12 months, and several separate WP related meetings.




On the left: a severely cracked section investigated by TC 287-CCS; on the right: gathering of certain core TC 287-CCS members in Arup headquarters in London. Images courtesy of F. Kanavaris.

- RILEM TC 287-CCS book on cracking being finalised.
- Closing event for the TC: the International RILEM Conference on Early-Age and Long-Term Cracking in RC Structures - CRC 2025 - to be held in Katowice, Poland, in September 2025.

# **288-IEC** Impact and explosion

**Chair** Marco DI PRISCO
**Deputy Chair** Ezio CADONI
**Activity started in** 2018

### Significance

In the framework of impact and explosion, there are many specific experimental devices all over the world, which have never been thoroughly compared and connected. There is the need to develop a stronger link between the worldwide existing experimental laboratories that have specific devices, often not fully used. A joint committee RILEM-fib working on the chapter “Impact and Explosion” of the fib Model Code 2020 can contribute to revitalize the RILEM association as “Labs link” and not only as “Experts link”, fully rediscovering its original mission. In the two following years, the Committee will achieve the last three main objectives.

### Progress

- TC 288-IEC report paper submitted to *Materials and Structures* in April 2024.
- Two TC meetings held in the last 12 months, in January and April 2024.
- TC completed its research activities; TC Chair, Marco Di Prisco, presented the TC outcomes during a plenary lecture at the 2024 RILEM Spring Convention, in Milan, in April. The video of this presentation is available on the RILEM YouTube Channel.


Two moments during the last RILEM Spring Convention in Milan, Italy, in April 2024. On the left: TC 288-IEC meeting; on the right: TC Chair, Prof. Marco Di Prisco, presenting the TC outcomes in a plenary lecture. Image courtesy of D. Ciancio.

# **292-MCC** Mechanical characterization and structural design of textile reinforced concrete

**Chair** Barzin MOBASHER
**Deputy Chair** Flávio DE ANDRADE SILVA
**Activity started in** 2019

### Significance

Textile reinforced concrete (TRC) materials have the potential to be used as structural components taking tensile, flexural, cyclic and impact loads. The advancements in the textile technology specifically directed at their use in cement-based materials has led to composites with an order of magnitude higher in strength and two orders of magnitude higher in ductility than fiber reinforced concrete (FRC). The common areas of application of TRC, such as ultra-high performance concrete, UHPC, 3D printing, FRCM and repair of infrastructure to mention a few, are in urgent need to develop and implement design tools and applications for strain hardening cement composites.

### Progress

- Preinstorfer, P., El Kadi, M., Dittel, G. et al. Article of RILEM TC 292-MCC: bond behaviour of textile-reinforced concrete—a review. *Mater Struct* 57, 97 (2024).
- 2 TC meetings held in the last 12 months.

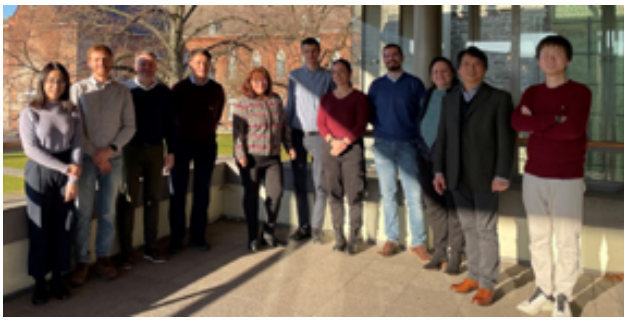

Mapping of the complex interconnections of the bond behaviour of TRC on the base of grouped keywords. Image courtesy of Springer.

# **294-MPA** Mechanical properties of alkali-activated materials

**Chair** Guang YE
**Deputy Chair** Frank DEHN
**Activity started in** 2019

### Significance

Alkali-activated concrete is considered as an environment-friendly construction material with a great potential for construction. However, at this moment it is not fully clear whether existing design codes for structural concrete can be fully applied in case of alkali-activated concrete. Although short term behaviour (28 days) might be similar, this might not be the case for the long-term behaviour and simply applying existing codes for conventional concrete to design alkali-activated concrete structures could be problematic. Another key point of focus is creep and shrinkage of alkali-activated concrete as the application of traditional creep and shrinkage laws has not still been defined suitable.



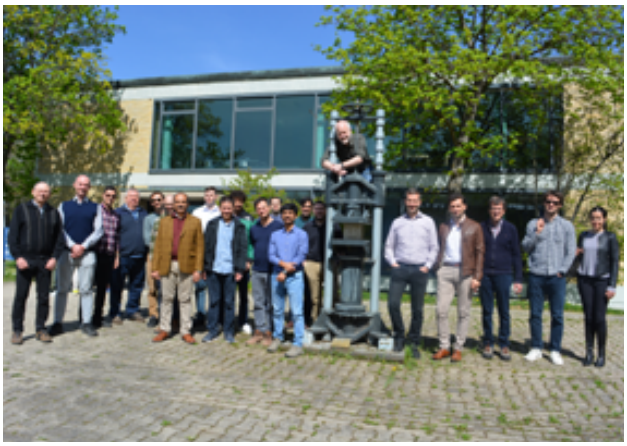
Some members of TC 294-MPA. Image courtesy of G. Ye.

### Progress

- 1 TC meeting in the last 12 months.
- The state-of-the-art report is 80% already completed.
- *Materials and Structures* Topical Collection publication is 30% completed, aiming to submit it before the end of 2024.

# **306-CFR** Concrete during Fire - Reassessment of the framework

**Chair** Pierre PIMIENTA
**Deputy Chair** Robert MCNAMEE
**Activity started in** 2022



Members of TC 306-CFR at the TC meeting in April 2024, held at the University of Stuttgart (Vaihingen Campus). Image courtesy of TC 306-CFR.

### Significance

No real assessment of the whole framework "concrete at high temperature" has been done in the last decades. This new committee will:

- review the existing framework based on the Eurocode regarding prediction of real behaviour of concrete elements and structures during fire exposure,
- make a detailed study of one or two reference mixes from material characterization and modelling to real behaviour during fire exposure,
- create a database with fire spalling of concrete test results.

### Progress

- 2 physical TC meetings held in the last 12 months, and several online meetings in small groups.
- TC aims to produce some reports; however, the work of the TC has not yet reached this stage.
- TC member population is made of senior and young researchers, from the academia and the industry (the latter includes 3 manufacturing private companies), from 24 countries and 5 continents.

# **314-OCM** On-site Corrosion Condition Assessment, Monitoring and Prediction

**Chair** Carmen ANDRADE
**Deputy Chair** Pedro CASTRO BORGES
**Activity started in** 2022

Inspection of a concrete structure to identify corrosion conditions. Image courtesy of C. Andrade.

### Significance

- Reinforcement corrosion is one of the major causes of the deterioration of structural concrete. Nevertheless, its assessment in real structures still lacks standardized procedures.
- A comprehensive approach for the corrosion condition assessment has not been found yet. A procedure of the implementation of this approach into the actual trend is also missing.
- The prediction of evolution of the corrosion in different environments and the calculation of the remaining life until the ad-hoc structural limit state are not contained in present Codes. A gap exists which needs pre-normative documents which could be used to gain experience with the aim to have rules incorporated into the future structural codes.

### Progress

- Two TC meetings held in 2023.
- Three recommendations are being updated and three new recommendations are being developed.

# **RCC** Rolled compacted concrete for pavement applications

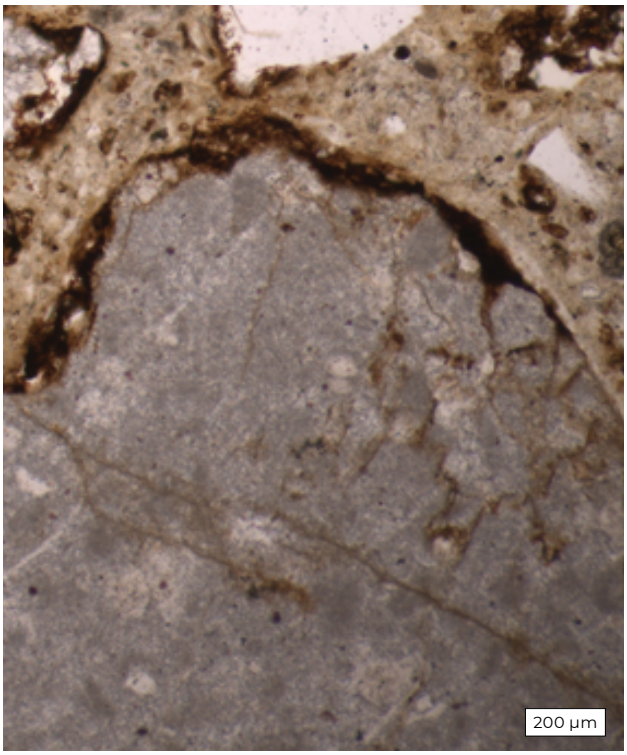
**Chair** Christian PAGLIA
**Deputy Chair** Corey ZOLLINGER
**Activity started in** 2023

### Significance

in the last decade, roller compacted concrete has been increasingly applied for heavy duty pavements, rather than for exclusively gravity dams. Despite the existing application guides, most of the knowledge is still strongly based on field experience without a systematic scientific approach. Moreover, a wide, constant and well-structured sharing of the knowledge in the topic is missing.

### Progress

- One online meeting in the last 12 months. Next TC meeting in October 2024 (online) to:
  > Present working group tasks
  > Discuss preliminary literature research on RCC topics.
- Working groups to complete the literature review:
  > WG 1 fresh state / compaction
  > WG 2 mechanical properties and design
  > WG 3 durability
  > WG 4 application techniques
  > WG 5 sustainability and technology
  > WG 6 structural planning
  > WG 7 LCA / case studies.




Optical microscope image of Rap aggregate mechanically cleaned from most of the bituminous binder and adhesion with the concrete matrix. Image courtesy of C. Paglia.

# Service Life and Environmental Impact Assessment

## Foreword

► **from Cluster D Convener,**
**Anya VOLLPRACHT**

Cluster D coordinates the activities of the Technical Committees (TCs) dealing with “Service life” and “environmental impact” of structures, mainly reinforced concrete structures. Currently, Cluster D comprises eight TCs. The most recent ones are CUC : Carbon dioxide uptake by concrete during and after service life and SDM : Scientific Metadata Management of Construction materials , established in spring 2024.

One major topic in Cluster D is alkali-silica reaction (ASR), which is explored in two committees from different perspectives (TC 300-ARM and TC 301-ASR). Another service life aspect is the durability of marine structures (TC 289-DCM). With respect to the environmental issues, TC 299-TES investigates different methods to store thermal energy in order to improve the energy efficiency of buildings and TC UMW focuses on the use of mineral wastes in cement matrices, including the recycling of these new concretes. TC 315-DCS aims to gather, analyze and present the state-of-the-art on the use of AI algorithms (machine learning and deep learning) in concrete structures.

The first TC belonging to Cluster D was established in 1998 and it was *“183-MIB Microbial impacts on building materials – weathering and conservation”*. Since then, 29 TCs have worked under the coordination of the convener of Cluster D, a title that I have the honour to hold since September 2021.

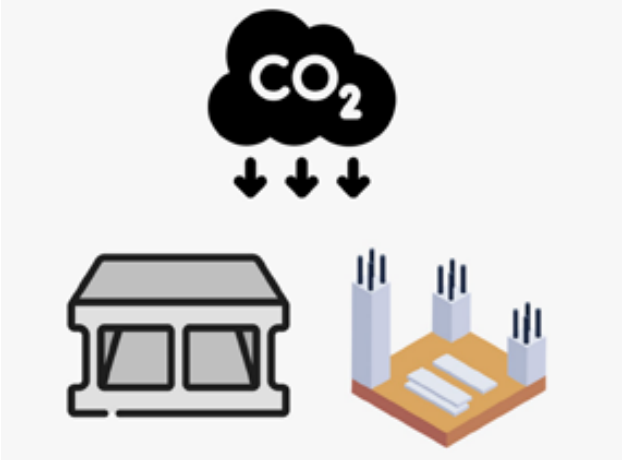
# Current TCs in Cluster D

| CODE<br>TITLE | CHAIR<br>DEPUTY CHAIR | OPENED<br>IN | NO. OF<br>MEMBERS |
|---|---|---|---|
| **CUC**<br>Carbon dioxide uptake by concrete during and after service life | Gregor GLUTH<br>Susan BERNAL LOPEZ | **NEW**<br>Spring 2024 | 48 |
| **SDM**<br>Scientific Metadata Management of Construction materials | Tanja MANNINGER<br>Fabien GEORGET | **NEW**<br>Spring 2024 | 14 |
| **289-DCM**<br>Long-term durability of structural concretes in marine exposure conditions | Kefei LI<br>Junjie ZENG | 2019 | 80 |
| **299-TES**<br>Thermal energy storage in cementitious composites | Jorge SÁNCHEZ DOLADO<br>Antonio CAGGIANO | 2020 | 65 |
| **300-ARM**<br>Alkali-aggregate reaction mitigation | Esperanza MENENDEZ MENDEZ<br>Leandro SANCHEZ | 2020 | 69 |
| **301-ASR**<br>Risk assessment of concrete mixture designs with alkali-silica reactive (ASR) aggregates | Jason H. IDEKER<br>Maxime RANGER | 2020 | 94 |
| **315-DCS**<br>Data-driven concrete science | Sandra NUNES<br>Moncef NEHDI | 2022 | 109 |
| **UMW**<br>Upcycling Powder Mineral “Wastes” into Cement Matrices | Antonios KANELLOPOULOS<br>Theodore HANEIN | 2022 | 169 |

New

# **CUC** Carbon dioxide uptake by concrete during and after service life

**Chair** Gregor GLUTH
**Deputy Chair** Susan BERNAL LOPEZ
**Activity started in** 2024




Schematics of carbon dioxide uptake by concrete.

## Significance

The carbonation of cementitious materials is not only important in the context of their durability and lifetime predictions but also because carbonation means incorporation of atmospheric $CO_2$ in solid reaction products, which partly compensates for the $CO_2$ released during cement production (recarbonation). Estimates of recarbonation rely on the carbonation rate (or the coefficient of carbonation, kc) and other material parameters of concretes or mortars, which are, however, difficult to predict. The values originally proposed two decades ago for such estimates, with the suggestion to be verified or adjusted, have propagated into the most recent assessments of global $CO_2$ uptake by cement carbonation, while the values themselves have seldom been scrutinized. Thus, there is an urgent need to review and, if necessary, revise and extend available compilations of those values.

## Relevance

The results of the TC work:

- Can be assumed to be of high relevance for the construction industry and beyond, as they relate directly to service lifetime and $CO^2$ uptake predictions/estimates for cementitious materials.
- Will be particularly relevant for academics and practitioners dealing with service life prediction models accounting for durability performance (particularly carbonation) of cementitious materials.
- Are expected to be of interest for policy makers and the general public as well.
- Are expected to have a significant impact on the scientific community, policy, and industrial practice, as they support the further deve¬lop¬ment of environmental product declarations (EPD) for cementitious materials-based construction products, and can help to create a consensus about best practices for calculating the recarbonation of concrete which is often used for issuing EPDs.

## Goals

- Conducting a comparison of the coefficients of carbonation kc and the fraction of carbonated CaO employed in previous and present assessments of $CO_2$ uptake by hardened cement carbonation.
- Determining the influence of the $CO_2$ concentration on the carbonation rate of concretes as a function of cement/binder types and the mechanical performance of concretes.
- Elucidating the influence of the relative humidity on the carbonation rate of concretes or mortars
- Identify the type and abundance of the reaction products in the carbonated layer of cementitious materials.
- Producing reviews and, if a consensus can be reached, recommendations regarding the influence of the $CO_2$ concentration on the carbonation rate of concretes and mortars, including quantitative relationships to describe this influence.

## Methodology

The TC will mainly conduct bibliographical research. Optionally, experiments will be performed to obtain additional data. During the lifetime of the TC, the progress will be presented at conferences.

## Progress

RILEM TC CUC has been approved by the RILEM Technical Activities Committee (TAC) in Spring 2024. Its kick-off meeting took place in Toulouse, France, during the 78th RILEM Annual Week.

New

# **SDM** Scientific Metadata Management of Construction materials

**Chair** Tanja MANNINGER
**Deputy Chair** Fabien GEORGET
**Activity started in** 2024

Metaphor of metadata: the map represents the Metadata as the World represents the Data. To navigate the World properly a Map is very helpful. Image courtesy of K. Beyzanur.

## Significance

Digitalization of the concrete industry is constantly progressing, this is also the case for academic research in the field. The findability, accessibility and reusability of data especially for simulation and modelling is currently insufficient. RILEM TCs usually include the measurement and publication of high-quality data; it is essential to make these data reusable. We want to improve the situation by helping the researchers to create metadata information and giving them a tool to do so. Additionally, the use of repositories should be encouraged. Open data sharing and adherence to the FAIR (Findability, Accessibility, Interoperability, and Reusability of data) principle is still in its infancy among many research communities. To ensure that this becomes a widespread practice to benefit the scientific community, and by extension the entire society, actions at various levels are required.

## Relevance

The targeted users ("data providers") are researchers, Ph.D. students, practitioners, and industry experts in the field of construction materials and structures. A second target group ("data users") are researchers in simulation, machine learning and AI training.

## Goals

- The primary objective of this new TC is to provide a guideline for all RILEM TCs and associated researchers for data handling and metadata creation.
- Another objective of the TC is to develop (a) tool(s) for metadata collection. The first version will be a sophisticated excel document that enables the user to export a metadata document in a machine-readable format without any previous knowledge.
- This TC will produce a State-of-the-art report which will contain the work and project parts collected during the committee's tenure.

## Methodology

- Experimental work will be implemented in the form of case studies utilizing the developed tool to support metadata collection in ongoing experiments and presenting the work process.
- The work will be carried out in collaboration with diverse groups from various countries, including practitioners, and people working in modelling and simulation.
- Online tools, or guidelines to develop online tools will be created depending on the interest in the TC, and the progress of applications for funding.

## Progress

RILEM TC SDM has been approved by the RILEM Technical Activities Committee (TAC) in Spring 2024. Its kick-off meeting took place in June 2024.

# **289-DCM** Long-term durability of structural concretes in marine exposure conditions

**Chair Kefei LI**
**Deputy Chair Junjie ZENG**
**Activity started in 2019**

### Significance

Data collection from exposure stations is rather intuitive, and a systematic format for data collection/presentation is missed. The standardized of data presentation will greatly increase the added value of exposure data. The interpretation of exposure data through apparent chloride diffusivity is not enough, and the research community is ready to investigate more practical indicators through advanced modelling.

Large-sized concrete specimens (0.2 m × 1 m × 2 m) from marine exposure site at Rødbyhavn, Denmark. Image courtesy of Springer.

### Progress

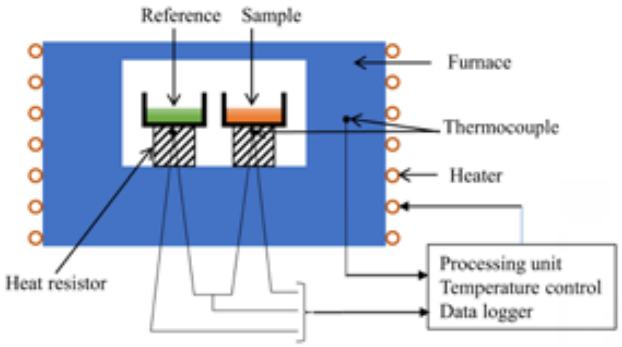
- TC meetings in November 2023 and April 2024.
- Li, K., Zeng, J., Tang, L. et al. RILEM recommendation from TC 289-DCM: guideline for designing and operating long-term marine exposure sites. *Mater Struct* 57, 44 (2024).
- State-of-the-Art report:
  - > Outline and contributors are fixed.
  - > Time plan: initial drafting till March 2024, elaboration till July 2024, finishing in Sept. 2024.
- Presentation of TC outcomes during the 2024 RILEM Annual Week.

# **299-TES** Thermal energy storage in cementitious composites

**Chair Jorge SANCHEZ DOLADO**
**Deputy Chair Antonio CAGGIANO**
**Activity started in 2020**

### Significance

Energy supply is a vital issue, with special concerns of the public regarding the emission of greenhouse gases and the need to reduce the use of fossil fuels. Energy consumption in EU buildings counts with almost 40 percent of the total demand. Energy efficiency and novel technologies are considered the key pillars for limiting the high consumption for the new and existing building stock. The main challenge of most renewable energies (wind, solar, etc.) is to find appropriate energy storage devices to correct the mismatch between the supply and demand of energy. Concrete and cement-based materials present themselves as good solid material for Thermal Energy Storage (TES) applications, as they are abundant, cheap and have relatively good thermal capacities for such a purpose.




Scheme of Differential Scanning Calorimetry technique: heat-flux method. Image courtesy of Springer.

### Progress

- Gaitero, J.J., Prabhu, A., Hochstein, D. et al. Reviewing experimental studies on sensible thermal energy storage in cementitious composites: report of the RILEM TC 299-TES. *Mater Struct* 57, 100 (2024).
- Paper titled "Reviewing of Experimental techniques on Latent TES in cementitious composites" submitted to *Mater Struct*.
- Last meeting held in January 2024 in hybrid mode at the 2nd international workshop on net zero carbon buildings, in Bath (UK).
- Special session on Materials for energy storage (Sensible-Heat, Latent-Heat, and Thermochemical), organised during the 2024 RILEM Annual Week.

# **300-ARM** Alkali-aggregate reaction mitigation

**Chair** Esperanza MENENDEZ MENDEZ
**Deputy Chair** Leandro SANCHEZ
**Activity started in** 2020

### Significance

Alkali-aggregate reaction (AAR) is one of the most harmful distress mechanisms affecting the durability and serviceability of aging structures worldwide. Several approaches, recommendations, and test procedures have been developed to assess the potential alkali-reactivity of concrete aggregates and the efficiency of preventive measures prior to AAR development in the field. There is currently no consensus about the most efficient method(s) that should be implemented, and when, for the mitigation of AAR-induced damage. This situation is extremely critical for some structures whose AAR-associated risks are extremely high since they cannot be easily rehabilitated nor replaced such as dams, nuclear power plants, tunnels, bridges, etc.

### Progress

- TC meetings in the last 12 months: online in Nov 2023, and hybrid in May 2024 during the International Conference on Alkali-Aggregate Reaction (ICAAR) in Concrete, Canada.

TC meeting during the International Conference on Alkali-Aggregate Reaction (ICAAR) in Concrete, Canada, in May 2024. Image courtesy of TC 300-ARM.

- Drafting STAR on "Techniques and alternative products enabling the mitigation of AAR-induced development in the field".
- Round-robin test results shall be finished by the middle of 2025 and published in *Materials and Structures*.

# **301-ASR** Risk assessment of concrete mixture designs with alkali-silica reactive (ASR) aggregates

**Chair** Jason H. IDEKER
**Deputy Chair** Maxime RANGER
**Activity started in** 2020

### Significance

Alkali-silica reaction (ASR) is a well-known concrete durability problem. However, the industry needs clear guidance on how to design and specify concrete mixtures that are resistant to ASR. The TC will develop a framework for risk assessment of mixture designs for concrete prone to ASR. This framework would allow the user to determine a pathway for mixture designs with reduced risk for deleterious ASR.

### Progress

- TC meetings in the last 12 months: online in Sept. 2023, hybrid in Nov 2023 in Düsseldorf, Germany, and hybrid in May 2024 during the International Conference on Alkali-Aggregate Reaction (ICAAR) in Concrete, Canada.
- Seven contributions to the ICAAR proceedings.
- Planning a Topical Collection in *Materials and Structures* with 15 papers from the three working groups; 4 papers to be submitted by the end of 2024.
- Planning one STAR that presents the outcomes of the three work packages of this TC.

TC members at the TC meeting during the International Conference on Alkali-Aggregate Reaction (ICAAR) in Concrete, Canada, in May 2024. Image courtesy of M. Ranger.

# **315-DCS** Data-driven concrete science

**Chair** Sandra NUNES
**Deputy Chair** Moncef NEHDI
**Activity started in** 2022

### Significance

The concrete industry is increasingly in need of intelligent tools to further develop and use concrete in important structures. It also needs more advanced simulation tools for concrete performance validation and uncertainty quantification. Such requirements are well aligned with recent developments in data-driven models based on artificial intelligence (AI). A better use of existing data, as well as the availability of more structured and validated information of the materials and components, are essential for the ability to reliably simulate options and make sound decisions. Open data sharing among the concrete research community is still in its infancy and actions at various levels are required.

### Progress

- TC meetings in the last 12 months: online in October 2023 and hybrid in April 2024 during the 2024 RILEM Spring Convention in Milan, Italy.

TC 315-DCS online meeting. Image courtesy of TC 315-DCS.

- TC is planning:
  - > A Topical Collection with at least 5 papers to be published by *Materials and Structures*.
  - > The organization of the 1st International RILEM Symposium on "Data-Driven Concrete Science" in 2027.
- Special session on Data-driven concrete science (AI for concrete material and civil infrastructures), organised during the 2024 RILEM Annual Week.

# **UMW** Upcycling Powder Mineral "Wastes" into Cement Matrices

**Chair** Antonios KANELLOPOULOS
**Deputy Chair** Theodore HANEIN
**Activity started in** 2022

### Significance

Mineral wastes are typically rich in $SiO_2$, $Al_2O_3$, CaO, MgO, and $Fe_2O_3$, making them very attractive candidates to be used in the production of cementitious materials. In the last several years there is a growing interest in utilising such wastes in the manufacture of cement-based composites, particularly alkali-activated binders. Mineral wastes can offer a natural solution to the need to switch to alternative raw materials and at the same time be diverted from landfill while their own environmental impact is mitigated. Upcycling such wastes in the production of cements is the most promising way to improve resource efficiency and material circularisation while maintaining our natural reserves of raw materials.

### Progress

- TC meetings over the last 12 month: in Oct 2023, and in May 2024 during the 2024 RILEM Spring Convention in Milan, Italy.

Members of TC UMW at the hybrid TC meeting of during the 2024 RILEM Spring Convention in Milan, Italy. Image courtesy of A. Kanellopoulos.

- TC plans to produce:
  - > A paper about strategic needs and importance, to be submitted to *RILEM Technical Letters*.
  - > A Topical Collection, including technical guidelines and recommendations, to be published by Materials and Structures.

# Masonry, Timber and Cultural Heritage

## Foreword

► **from Cluster E Convener,**
**Arun MENON**

Cluster E coordinates the activities of the Technical Committees (TCs) dealing with “Masonry, Timber and Cultural Heritage”. At the moment, it comprises seven TCs, working on masonry reinforcement (290-IMC) and masonry tests (CTM), bamboo (MCB), timber joints (310-TPT), and on earthen-materials (BEC, MAE and PEM).

Several of these topics have been addressed by RILEM TCs since a long time, but only recently was a dedicated Cluster established. In fact, the first recommendations on masonry date back to 1988, on timber to 1990, on rammed earth to 1997 and on historic mortars to 2000.

As a general trend, the aim of the TCs has moved from the characterization of the historic substrates (e.g., mortar, masonry, timber) to the development of testing methods to assess the performance of conservation and reinforcement strategies for these substrates (e.g., repair mortars, composite materials applied to masonry and timber). To evaluate the suitability of the new conservation strategies, not only their effectiveness is addressed, but also their compatibility with the historic substrates, their durability over time and their environmental sustainability are gaining increasing attention by the TCs. The recent decision to establish a Cluster specifically dedicated to the building materials constituting our Cultural Heritage has a twofold meaning. On the one hand, it is an important recognition of the value that RILEM attributes to research on these historic materials and to the urgency to develop successful strategies for their conservation. On the other hand, it highlights the importance that the research and the practice of cultural heritage conservation be carried out with the same rigorous scientific approach that RILEM applies to all the other fields of building materials and structures.

I have been Convener of Cluster E since September 2021, when I took over the role previously filled by Dr Enrico Sassoni.

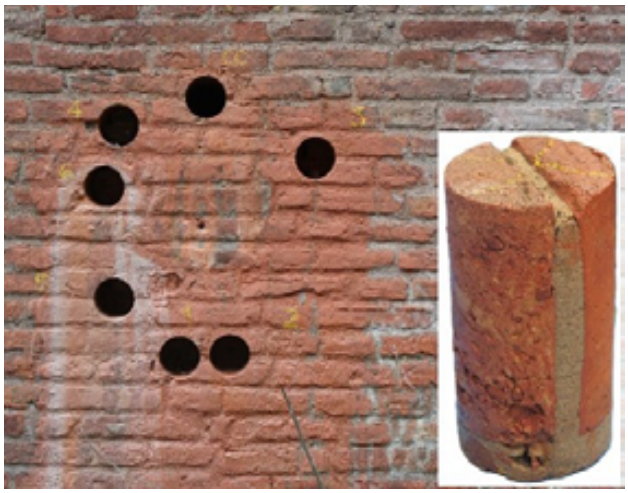
# Current TCs in Cluster E

| CODE<br>TITLE | CHAIR<br>DEPUTY CHAIR | OPENED<br>IN | NO. OF<br>MEMBERS |
|---|---|---|---|
| **CTM**<br>Testing Methods for Masonry Cores | Rita ESPOSITO<br>Francesca FERRETTI | **NEW**<br>Spring 2024 | 5 |
| **MCB**<br>Mechanical Characterisation of Bamboo | Kent HARRIES<br>Luisa MOLARI | **NEW**<br>Fall 2023 | 25 |
| **290-IMC**<br>Durability of Inorganic Matrix Composites used for Strengthening of Masonry Constructions | Antonietta AIELLO<br>Catherine PAPANICOLAOU | 2019 | 88 |
| **310-TPT**<br>Tests methods for a reliable characterization of resistance, stiffness and deformation properties of timber joints | Jorge BRANCO<br>Andreas RINGHOFER | 2021 | 20 |
| **BEC**<br>Bio-stabilised earth-based construction: performance-approach for better resilience | Ana BRAS<br>Céline PERLOT | 2022 | 112 |
| **MAE**<br>Mechanical performance and durability assessment of earthen elements and structures | Antonin FABBRI<br>Christopher BECKETT | 2022 | 123 |
| **PEM**<br>Processing of earth-based materials | Emmanuel KEITA<br>Arnaud PERROT | 2022 | 124 |

New

# **CTM** Testing Methods For Masonry Cores

**Chair** Rita ESPOSITO
**Deputy Chair** Francesca FERRETTI
**Activity started in** 2024



Core extraction from a brick masonry wall. Image courtesy of F. Ferretti.

## Significance

For an accurate assessment of unreinforced brick masonry structures and infrastructure, the estimation of mechanical performance of masonry material is of importance. The core testing represents a promising methodology, used over the last 80 years, but it shows some inconsistencies for the reliable estimation of compression and shear properties of unreinforced brick masonry. The harmonization of the testing procedures and the development of standard guidelines are needed to improve the reliability of structural assessment and thus the sustainable maintenance of the existing assets.

## Relevance

- The foreseen outcomes will be of interest to academics, testing laboratories and practitioners working within the field of assessment and rehabilitation of existing masonry structures and infrastructure.
- By providing testing guidelines, the core testing methods will be consistently and more often used by practitioners.

## Goals

- To develop a comprehensive state-of-the-art to set up of an inventory of current testing procedures.
- To identify influencing factors on the results of core testing method.
- To carry out an experimental testing campaign to define optimal testing procedures.
- To define guidelines for core testing to evaluate: i) compression properties (elastic modulus, compressive strength), and ii) shear properties (cohesion, friction coefficient).

## Methodology

- A literature review will be carried out to make an inventory of all available experimental data and related testing procedure used; as an outcome, two open-access databases will be created.
- Influencing factors in the testing procedures will be identified.
- A round-robin testing campaign across different institutes is foreseen.
- Eventually, guidelines for testing will be drafted and published as RILEM recommendations.

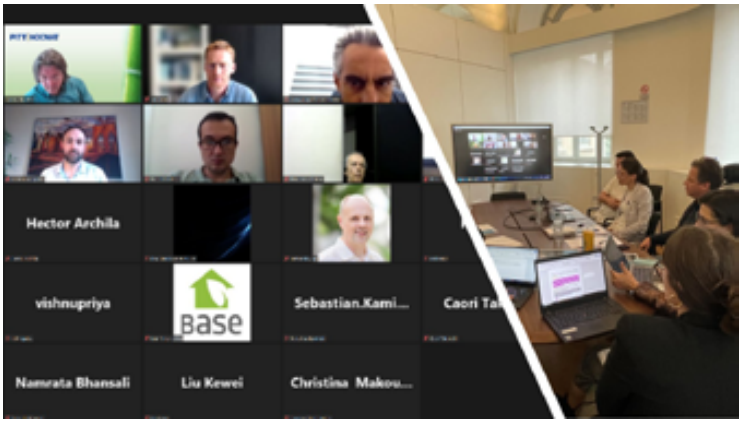
## Progress

RILEM TC CTM has been approved by the RILEM Technical Activities Committee (TAC) in Spring 2024. The kick-off meeting took place at the University of Birmingham on July 22nd 2024, during the IB²MAC Conference.

New

# **MCB** Mechanical Characterisation of Bamboo

**Chair** Kent HARRIES
**Deputy Chair** Luisa MOLARI
**Activity started in** 2023




On the left: Bamboo column-beam-truss connection (photo: K. Harries). On the rights: partecipants of the TC kick-off meeting, in hybrid mode, in Milan in April 2024 (photo: D. Ciancio).

## Significance

Bamboo is receiving considerable interest as a material for construction. Bamboo has remarkable potential to reduce the environmental impact of the construction sector and has the demonstrated potential for promoting social and economic equity. Nonetheless, bamboo construction remains largely a marginal material, viewed as being of lower quality and suited only to temporary applications. This could not be further from the truth. Although important advances have been made to standardise the use of bamboo, it is still necessary to provide builders, engineers, and architects with tools to allow them to select bamboo in construction design.

## Relevance

- The target audience of TC MCB is engineers, architects, practitioners, researchers, technicians and experts from the industry. Emphasis on participation from, and dissemination to, the Global South is a priority.
- The proposed TC activities and recommendations will be disseminated to national and multi-national groups – with an emphasis on standards writing bodies – to promote the use of bamboo structural design.

## Goals

- This TC proposes to analyse the state-of-the-art and the state-of-practice associated with bamboo materials characterisation. The focus will be on constituent bamboo material intended for either full-culm (round pole) construction or for engineered bamboo products and composites for structural components and buildings.
- One of the goals of this TC is to provide an excellent opportunity for synthesis and harmonization in the context of international standardisation.

## Methodology

The following work will be carried out as a RILEM committee in an independent and neutral environment:

- Task 1: Review, Gap Analysis and Prioritisation
- Task 2: International Database (initiate with Task 1 and ongoing throughout the life of the committee)
- Task 3: Oversight of Round-Robin Testing (need determined from Task 1 gap analysis)
- Task 4: Development of Classification and Grading Syntheses (Year 4+)
- Task 5: Quantification of Sustainability Credentials
- Task 6: Recommendations for Standard Test Methods (Year 5)

## Progress

- RILEM TC CTM was approved by the RILEM Technical Activities Committee (TAC) in Fall 2023. Its kick-off meeting took place in hybrid mode during the 2024 RILEM Spring Convention in Milan, Italy, in April 2024.
- Harries, K.; Molari, L. Mechanical Characterisation of Bamboo for Construction: The State-of-Practice and Future Prospects. *RILEM Tech Lett* 2024, 8, 150-157.

# **290-IMC** Durability of inorganic matrix composites used for strengthening of masonry constructions

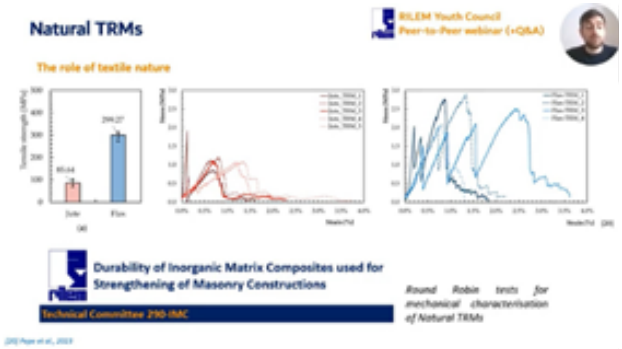
**Chair** Antonietta AIELLO
**Deputy Chair** Catherine PAPANICOLAOU
**Activity started in** 2019

### Significance

- Fiber Reinforced Polymer (FRP) materials do not always provide an efficient strengthening solution for masonry structures. Inorganic Matrix Composites (IMC) have been studied as an affordable solution, especially for historical masonry. The study of the long-term behaviour, currently missing, is necessary in order to provide complete design guidelines for practitioners.

### Progress

- TC meetings over the last 12 months: Jan 2024, April 2024, and July 2024 during the 18th International Brick and Block Masonry Conference (IB2MaC), in Birmingham, UK.
- Some TC outcomes presented at the RILEM Peer-to-peer webinar "Bio-composites in structural applications for new and existing buildings: potential, challenges and perspectives".
- The TC is wrapping its activities, focusing on publication of the produced results:




Round Robin Test results of TC 290-IMC presented at the RILEM Peer-to-peer webinar in March 2024. Image courtesy of TC 290-IMC..

> STAR "Strengthening of masonry structures with IMC: Durability aspects/structural implications": 10 Chapter leaders; final Springer-formatted drafts to be sent to RILEM General Secretariat for validation.

> 5 papers have been discussed for drafting on: "Experimental methodology", "Natural fibre-based FRCM systems", "Glass FRCM systems with cement-or lime-based matrices", "CRM systems", "Basalt or Carbon FRCM lime-based matrices".

# **310-TPT** Tests methods for a reliable characterization of resistance, stiffness and deformation properties of timber joints

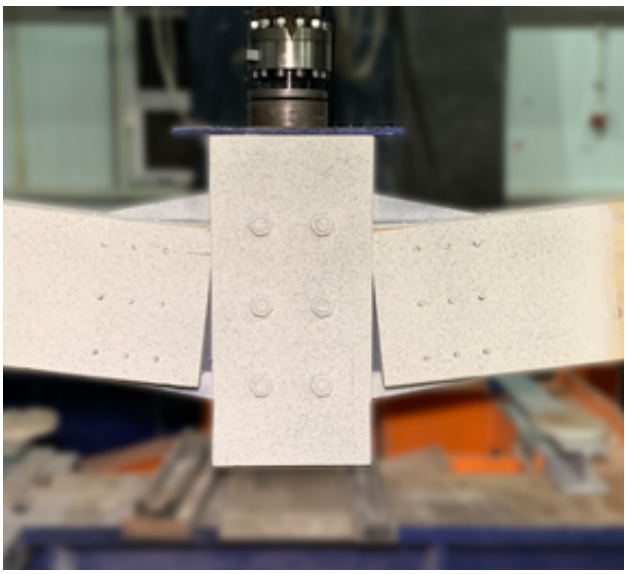
**Chair** Jorge BRANCO
**Deputy Chair** Andreas RINGHOFER
**Activity started in** 2021

### Significance

- Existing test standards and protocols on timber joints are limited to the very simplistic nature of traditional connections.
- Although experimental campaigns provide important information on the mechanical behaviour of modern connections, the non-standardization of the test procedures often precludes the comparison between the obtained results.
- In order to allow for a better future evaluation and reusability of experimental data, existing testing protocols for timber joints should be discussed and reviewed.
- Reliable and well-established assessment methods are required, to support the safe and economic design of timber joints.

### Progress

- TC meetings over the last 12 months: in late 2023, early 2024, and in August 2024 at the 10th INTER – International Network on Timber Engineering Research, in Biel/Bienne, Switzerland.
- Workplan of the round-robin tests delivered in mid 2024.



Laboratory testing of a timber joint. Image courtesy of J. Branco.

# **BEC** Bio-stabilised earth-based construction: performance-approach for better resilience

**Chair** Ana BRAS
**Deputy Chair** Céline PERLOT
**Activity started in** 2022

### Significance

- The main weakness of Earth-based construction materials is their sensitivity to liquid water. To overcome this, the materials could be reinforced through stabilisation methods.
- The most frequent hydraulic binders (lime or cement) are used as chemical stabilisers, but they have the disadvantage of increasing the carbon footprint of the earthen materials.
- Alternative bio-sourced methods with low environmental impact are increasingly used.
- There is no fully established classification of bio-additives and bio-stabilisation methods.

### Progress

- General meeting with TC MAE and TC PEM held in Paris, on 30 November –1 December 2023.
- Organization of 2nd International Conference on Earthen materials (ICEC24) in Edinburgh, in July 2024. Full papers and invited lectures to expose TC BEC activities. Article written by the deputy chair and the WP's leaders in Springer book of proceedings.


Doctoral pre-course on "earthen constructions" during the RILEM Annual Week 2024 in Toulouse, France, in August 2024.

- General meeting held on the 10th of July in Edinburg.
- Involvement of Deputy-Chair in doctoral pre-course on "earthen constructions" during RILEM Annual Week 2024 in Toulouse.
- STAR: regular WP meeting to draft the STAR. development of an article database. Chapters 1, 3 are almost completed; Chapters 2, 4 and 5: are to be finished in July 2024. Objective: presentation of a first draft in Toulouse, for the 2024 RILEM Annual Week. General meeting on the 26th of August in Toulouse.
- WG3: Reflecting on the possibility of making round-robin tests.
- Application of an ERC-COST Action project in line with TC objectives to support studies and strengthen links between the community.

# **MAE** Mechanical performance and durability assessment of earthen elements and structures

**Chair** Antonin FABBRI
**Deputy Chair** Christopher BECKETT
**Activity started in** 2022

### Significance

The relevance of building with earth in the 21st century has already been shown in showcase examples built in Switzerland (by Martin Rauch), France (by Nicolas Meunier) and China (by Lu Wenyu and Wang Shu - 2012 Pritzker Prize). However, the prospects of earthen and bio-based materials of entering mainstream construction, and a fortiori as the main structural materials, are limited notably due to the lack of knowledge on the assessment of their performance and durability. A good understanding of the behaviour of crude earth is also crucial to develop proper methodologies for the rehabilitation and maintenance of buildings constructed more than 50 years ago.

### Progress

- General meeting with TC BEC and TC PEM held in Paris, France, in December 2023, and in Edinburgh, UK, in July 2024.
- Organization of 2nd International Conference on Earthen materials (ICEC24) in Edinburgh, in July 2024, with presentation of TC activities.


The Second RILEM International Conference on Earthen Construction ICEC2024, hosted by the University of Edinburgh, UK, in July 2024.

- Involvement of TC Chair in doctoral pre-course on "earthen constructions" during RILEM Annual Week 2024 in Toulouse.
- Organisation by TC Chair of a special session on "Earth-based materials and construction" at the 2024 RILEM Week in Toulouse, France.
- Round-robin testing on methods to measure durability based on the ASTM and French abrasion tests have commenced, using earth bricks manufactured in Burkina Faso. Guidelines for abrasion testing for earth materials are forthcoming.

# **PEM** Processing of earth-based materials

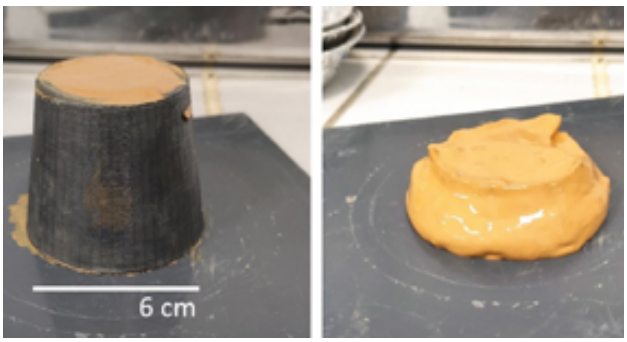
**Chair Emmanuel KEITA**
**Deputy Chair Arnaud PERROT**
**Activity started in 2022**

## Significance

- The building sector contributes by a significant share to the entropic carbon emissions. In this context, earth appears as a promising solution for low carbon emission, recycling, and reuse in the construction field.
- In recent years, various rheometric and characterisation tests have been developed for earth-based building materials. However, some large scope aspects are often lacking.
- There is a need to understand the underlying physics behind the additives effect in order to have mix-design strategies not only based on trials and errors or empirical methods.
- This TC will deal with the behaviour of earth-based material in its fresh state and during hardening.

## Progress

- General meeting with TC BEC and TC MAE held in Paris, on 30 November –1 December 2023.
- Keita, E.; Perrot, A. Processing of Earth-Based Materials: Current Situation and Challenges Ahead. *RILEM Tech Lett* 2024, 8, 141-149.




Slump flow (inspired by concrete technology) characterization method used for earthen construction. Image courtesy of *RILEM Tech Lett.*

- Involvement of TC Chair and Deputy-Chair in doctoral pre-course on "earthen constructions" during RILEM Annual Week 2024 in Toulouse.
- Organization of 2nd International Conference on Earthen materials (ICEC24) in Edinburgh, in July 2024.
- TC meetings over the last 12 months: September 2023, online (discussion of detailed Table of Content for STAR), and November 2023, hybrid in Paris (identification of authors of STAR), May 2024, online (STAR writing advancement).
- Plan to submit STAR in early 2025

Cluster F

# Bituminous Materials and Polymers

## Foreword
### ▸ from Cluster F Convener,
## Eshan DAVE

Since the late 1960s RILEM activities in the field of Bituminous Materials and Polymers have been focusing on design and technical development of bituminous (asphalt) pavement infrastructures, that are mainly built from natural aggregate and asphalt binders derived from crude oils. Use of non-petroleum-based binders and additives as well as recycled asphalt materials in bituminous pavement infrastructures is also on a steady rise. The use of environmental product declarations to support decarbonization of transportation infrastructure is a significant interest area for pavement professionals.

Facing the need for increased sustainability and resilience for road infrastructure, around 26 Technical Committees have been treating the challenging objectives to characterize and steadily develop the complex performance of these materials as well as to optimize design, construction, rehabilitation and recycling technologies to achieve most sustainable life cycles and to adapt to climate change. Currently, Cluster F, chaired by Eshan V. Dave, University of New Hampshire, USA, engages approximately 150 experts from 25 countries, and is composed of 7 Technical Committees (TCs).

These committees are and have always been most efficient research and development platforms for connecting professionals from all over the world in the field of bituminous materials research to share their expertise, to develop recommendations on testing and evaluation approaches and to publish state-of-the-art reports and papers in the RILEM Journals of *Materials and Structures* and *RILEM Technical Letters*. Activities under the umbrella of RILEM have contributed a lot to strengthen the asphalt research community, and to steadily remind all members of being united people, researching together for a prosperous and sustainable future.

The next Cluster F Annual Meeting 2024 will be hosted on 2-4 October 2024 in Delft, the Netherlands. The meeting is organized by the Pavement Engineering section at TU Delft, and the Structural Reliability of Construction, Infrastructure and Maritime group at TNO. Two workshops are scheduled before and after the Cluster F meeting on the Characterization and Evaluation of Asphalt Binder Properties (1 October 2024) and Alternative Binders - Current Status and Future Perspectives (4 October 2024).

RILEM and ISAP - International Society for Asphalt Pavements have been partners for a long time. To strengthen the collaboration between these institutions, RILEM have co-sponsored the ISAP annual conferences during which some meetings of Cluster F TCs take place, further, there have been co-sponsored workshops and other knowledge dissemination and technology transfer activities.

# Current TCs in Cluster F

| CODE<br>TITLE | CHAIR<br>DEPUTY CHAIR | OPENED<br>IN | NO. OF<br>MEMBERS |
|---|---|---|---|
| **APD**<br>Alternative Paving Materials - Design and Performance | Augusto CANNONE FALCHETTO<br>Fan YIN | **NEW**<br>Fall 2023 | 59 |
| **APS**<br>Alternative Paving Materials - Sustainability | Davide LO PRESTI<br>Emmanuel CHAILLEUX | **NEW**<br>Fall 2023 | 58 |
| **280-CBE**<br>Multiphase characterisation of cold bitumen emulsion materials | Andrea GRAZIANI<br>Alan CARTER | 2017 | 27 |
| **295-FBB**<br>Fingerprinting bituminous binders using physico-chemical analysis | Bernhard HOFKO<br>Katerina VARVERI | 2020 | 80 |
| **307-PPB**<br>Physicochemical effects of polymers in bitumen | Hinrich GROTHE<br>Sayeda NAHAR | 2021 | 51 |
| **308-PAR**<br>Performance-based Asphalt Recycling | Gabriele TEBALDI<br>Eshan V. DAVE | 2022 | 80 |
| **316-FEE**<br>Fume Emissions Evaluation for Asphalt Materials | Johan BLOM<br>Laurent POROT | 2021 | 30 |

New

# **APD** Alternative Paving Materials - Design and Performance

**Chair** Augusto CANNONE FALCHETTO
**Deputy Chair** Fan YIN
**Activity started in** 2023


Graphical Concept of TC APD.

## Significance

As the awareness and focus on the sustainability of road infrastructure have grown over time, exploring the potential for utilizing recycled, marginal, and secondary materials in pavement has emerged as a crucial challenge in road engineering. Identifying an urgent imperative to advance and extensively demonstrate solutions that transcend conventional bituminous materials, along with the promotion of their widespread adoption, is of paramount importance.

## Relevance

The coordinated work of the proposed new TCs APD and APS offers a unique opportunity to maximize research and practical, valuable outputs for engineers, practitioners, and authorities in this unfamiliar area of investigation. Therefore, TC APD represents an optimal international collaborative arena that can take a substantial and recognizable stride toward addressing critical aspects associated with an advanced performance-engineered design of paving composites natively conceived with alternative paving materials.

## Goals

TC APD will work to advance research in design and performance aspects that were only initially explored in the former TC 279-WMR's effort while shifting toward a more inclusive vision of waste and secondary materials to a broader concept of alternative paving materials (APMs) as originally part of the native design of road composites.

## Methodology

TC APD will identify a limited number of targeted APMs with particular attention to bio-binders, recycled tire rubber, and recycled plastic as replacements for conventional petroleum-based binders, natural aggregates, and polymeric additives.
TC APD will concentrate on three key areas: 1) Prepare a Literature Review; 2) Address the Design and Performance of paving composites containing alternative paving materials (APMs); 3) Evaluate the Field Performance of paving composites containing APMs.

## Progress

The RILEM Technical Activities Committee (TAC) approved the TC APD in Fall 2023, and its virtual kick-off meeting took place on May 23, 2024.

New

# APS Alternative Paving Materials - Sustainability

**Chair** Davide LO PRESTI
**Deputy Chair** Emmanuel CHAILLEUX
**Activity started in** 2023


The kick-off meeting of TC APS will take place in October 2024, during the Cluster F Annual Meeting, in Delft, the Netherlands.

## Significance

Material scientists and road pavement technologists are fully aware that end-of-life products can be engineered and re-used and/or recycled. However, the road pavement industry, society and governing bodies are still considering these end-of-life products as waste and secondary materials. The proposed TC offers a clear shift in terminology. Rather than focusing on waste and/or secondary materials, the terminology will consider paving material 'alternatives' to the conventional components of bituminous mixtures: Alternative Paving Materials (APMs). TC APS is structured to fill some of the research gaps highlighted from the former TC 279-WMR and ensures that a structure is in place that allows for continuity and follow ups.

## Relevance

- The group of users of the outcomes of this TC are: academics, road authorities and standardization committees, testing laboratories and test equipment producers, material producers and construction equipment manufacturers, professionals and practitioners, and researchers.
- Results will be used as a basis to improve national and international standards as well as exchange of data and experience among members.

## Goals

- This TC will aim at investigating the sustainability of using APMs as full and/or significant partial replacement of conventional components of bituminous mixtures, such as aggregates, bitumen, synthetic polymers and any other fossil-fuel derived additive/admixture.
- In more pragmatic terms, this TC will aim at providing an answer to one fundamental question: "Is maximising the content of APMs within the bituminous mixtures a sustainable practice?"

## Methodology

- This TC wants to focus the investigation on three specific most-promising materials: 1) recycled tyre rubber, 2) recycled plastic 3) binders from biological sources (biobinders).
- The following three Task Groups are defined:
  - > TG1: Life Cycle Sustainability Assessment
  - > TG2: Recyclability
  - > TG3: Ecotoxicity and potential release of pollutants and microplastics.

## Progress

RILEM TC CTM has been approved by the RILEM Technical Activities Committee (TAC) in Fall 2023. Its kick-off meeting will take place during the Cluster F Annual Meeting 2024, hosted on 2-4 October 2024 in Delft, the Netherlands.

# **280-CBE** Multiphase characterisation of cold bitumen emulsion materials

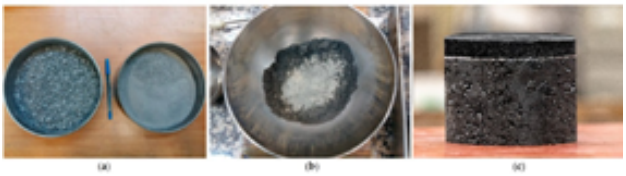
**Chair** Andrea GRAZIANI
**Deputy Chair** Alan CARTER
**Activity starting in** 2017

### Significance

Cold bitumen emulsion technologies are proven sustainable solutions for pavement construction and rehabilitation. A lack in fundamental knowledge on the long-term behaviour of structural and non-structural cold bitumen emulsion materials limits their usage. TC 280-CBE will develop a consistent experimental framework for characterizing the mix design and performance properties of cold microsurfacings.

### Progress

- TC has successfully arrived at the end of its term. Majority of planned objectives and work are finished.
- Disseminations have occurred over TC life, however still needs to get the planned *Materials and Structures* Topical Collection completed:
  > Recommendation of RILEM TC 280-CBE: test method to assess the bonding of microsurfacing mixtures using the direct shear testing apparatus: submission before end of 2024.
  > Recommendation of RILEM TC 280-CBE: Volumetric Characterization of Cold Bitumen Emulsion Mortars: submission before end of 2024.
  > Rheological Behavior of Cold Bitumen Emulsion Composites: from Mastics to Mortars: submission before end of 2024.
  > Evolutive Behavior of Cold Bitumen Emulsion Mortars: Results of a RILEM Interlaboratory Test (summarize results of TG1 on CBE mortars): submission by April 2025.



Microsurfacing production and specimen preparation: (a) aggregate fraction separation, (b) mixing phase (addition of cement), (c) double-layered specimen ready for testing. Image courtesy of C. Sangiorgi.

# **295-FBB** Fingerprinting bituminous binders using physico-chemical analysis

**Chair** Bernhard HOFKO
**Deputy Chair** Aikaterini VARVERI
**Activity started in** 2020

### Significance

Bitumen is an organic material and as such it is prone to aging. Oxidative aging causes an increase of brittleness and stiffness, resulting in higher risk for cracking. We need to track bitumen oxidation to ensure long-lasting and sustainable road infrastructure. Enhanced long-term performance can also be achieved by modifying bitumen with various polymers, rejuvenators or other additives. However, simple and standardized analysis methods to detect these additives in bitumen are missing.

### Progress

- TC meetings over the last 12 months: in November 2023 in-person, Vaulx-en-Velin, France, for the RILEM Cluster F annual meeting, and in June 2024 during ISAP 2024 in Montreal, Canada.
- TG1 - FTIR pre-standardization: Round robin testing concluded, data evaluation ongoing for the first manuscript “Evaluating the Repeatability of ATR-FTIR from the RILEM 295-FBB TG1 Round Robin Test”, to be submitted before the end of 2024.
- TC workshop held on June 6th 2024 in Montreal, Canada, in conjunction with the ISAP 2024 conference.

A moment of the RILEM Association TC 295-FBB workshop on "Fingerprinting of Bituminous Materials - Emerging Data Exploration Methods", which took place right after the end of ISAP2024 conference. Image courtesy of A. Carter.

# **307-PPB** Physicochemical effects of polymers in bitumen

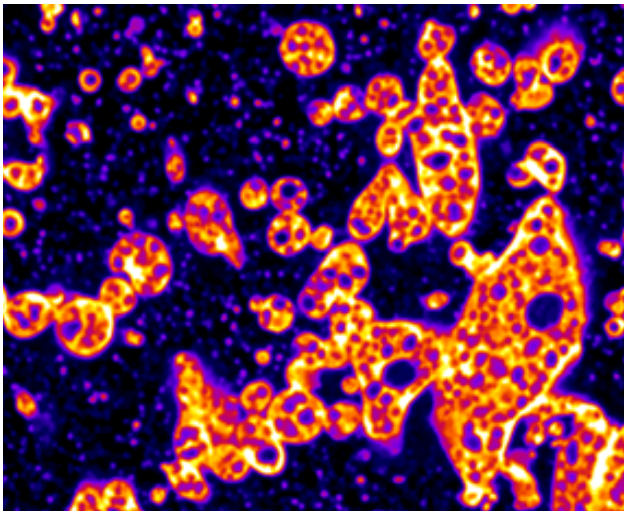
**Chair** Hinrich GROTHE
**Deputy Chair** Sayeda NAHAR
**Activity starting in** 2021

### Significance

The spectroscopic and microscopic techniques (like infrared and fluorescence spectroscopy and microscopy, atomic force microscopy, and scanning electron microscopy) are increasingly getting into the focus of scientists because they are able to characterise the chemical and microstructural changes of bitumen from a more intrinsic aspect. The goal of this TC is to identify and compare available methods for fingerprinting and quantification of certain additives and judge their benefits.

### Progress

- TC meetings over the last 12 months: in November 2023 in-person, Vaulx-en-Velin, France, for the RILEM Cluster F annual meeting, and in March 2024 (online).
- TG 1 has finalized the outline of the interlaboratory test program, the samples are sent to the participating lab and made progress in drafting the literature review.



Fluorescence micrograph of phase separation in highly polymer-modified. Image courtesy of M. Miljković.

- TG 2 made progress on collecting and preparing the PmB samples, drafting the interlaboratory experimental procedure, sample dissemination to 10 labs, and structuring a literature review on aging susceptibility.

# **308-PAR** Performance-based Asphalt Recycling

**Chair** Gabriele TEBALDI
**Deputy Chair** Eshan V. DAVE
**Activity started in** 2022

### Significance

Although the significant efforts underway to develop and implement balanced mix design tools for bituminous mixtures that adopt performance related laboratory tests to support proportioning of mixture, there is a lack of consensus on the selection of laboratory tests as well as their thresholds. The outcomes of this TC will have balance between fundamental developments and knowledge disseminations to aid in improved mixture design methods and use of life-cycle analysis tools.

### Progress

- TC meetings over the last 12 months: in November 2023 in hybrid mode, in Vaulx-en-Velin, France, for the RILEM Cluster F annual meeting.


2nd TC workshop held in June 2024 in Montreal, Canada, in conjunction with the ISAP 2024 conference.

- Results of inter-laboratory studies from all TGs will be published as RILEM recommendations.
- 2nd TC workshop held on June 7th 2024 in Montreal, Canada, in conjunction with the ISAP 2024 conference.
- Upcoming TC meeting: on 30th September 2024 in Delft, the Netherlands, and on 9th June 2025 in Ancona, Italy.

# **316-FEE** Fume emission evaluation for asphalt materials

**Chair** Johan BLOM
**Deputy Chair** Laurent POROT
**Activity starting in** 2021

### Significance

Bituminous materials are widely used for paving and roofing applications. During the manufacturing elevated temperatures are required. As organic-based material, the bituminous binder emits fumes and emissions, including Volatile Organic Components (VOC). Proper qualification and quantification of fume emissions from asphalt materials are gaining more and more interest today. However, there are various ways to define and quantify fume emissions from asphalt materials, but no standardised methodology has been established so far.

### Progress

- TC meetings over the last 12 months: in September 2023, in-person during the RILEM Annual Week in Vancouver, Canada; in November 2023 in-person, in Vaulx-en-Velin, France, for the RILEM Cluster F annual meeting; in May 2024 online.
- Blom, J. (2024). Paving Zero Emissions?. In: Banthia, N., Soleimani-Dashtaki, S., Mindess, S. (eds) Smart & Sustainable Infrastructure: Building a Greener Tomorrow. ISSSI 2023. RILEM Bookseries, vol 48. Springer, Cham.
- Inter-laboratory studies underway for TG 1 (Binder Scale) and 2 (Asphalt mix scale).

Ion Tiger VOC gas detector using photoionisation (pid). Image courtesy of J. Blom.

# Recently closed TCs

In the last 12 months, the TCs presented in the table below have been officially closed as they completed their work or reached the end of their lifespan.

| CODE<br>TITLE | CHAIR<br>DEPUTY CHAIR | TC OPENED IN<br>TC CLOSED IN |
|---|---|---|
| **275-HDB**<br>Hygrothermal behaviour and Durability of Bio-aggregate based building materials | Sofiane AMZIANE<br>Florence COLLET | 2016<br>Fall 2023 |
| **281-CCC**<br>Carbonation of concrete with supplementary cementitious materials | Nele DE BELIE<br>Susan BERNAL LOPEZ | 2017<br>Spring 2024 |
| **283-CAM**<br>Chloride transport in alkali-activated materials | Arnaud CASTEL<br>Shishir MUNDRA | 2018<br>Spring 2024 |
| **269-IAM**<br>Damage Assessment in Consideration of Repair/ Retrofit-Recovery in Concrete and Masonry Structures by Means of Innovative NDT | Tomoki SHIOTANI<br>Dimitrios AGGELIS | 2016<br>Fall 2023 |
| **293-CCH**<br>Stress Corrosion Cracking and Hydrogen Embrittlement of Concrete-Reinforcing Steels | Javier SANCHEZ MONTERO<br>Alvaro RIDRUEJO | 2016<br>Fall 2023 |
| **277-LHS**<br>Specifications for testing and evaluation of lime-based repair materials for historic Structures | Ioanna PAPAYIANNI<br>Jan VALEK | 2017<br>Spring 2024 |

More details of these recently closed TCs can be found in the previous editions of the RILEM Technical Report or by visiting the page "Index of past TCs" on our website. The activities in the last 12 months of some of these TCs is presented in the following lines:

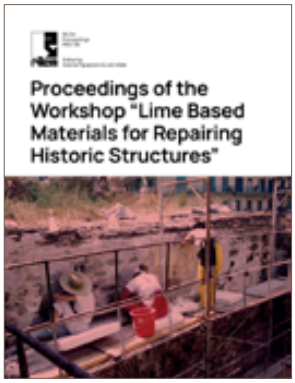
**281-CCC** Carbonation of concrete with supplementary cementitious materials

- TC outcomes presented at the 77th RILEM Annual Week. Video of the presentation available on the RILEM YouTube channel.

**283-CAM** Chloride transport in alkali-activated materials

- Gluth, G.J.G., Mundra, S. & Henning, R. Chloride binding by layered double hydroxides (LDH/AFm phases) and alkali-activated slag pastes: an experimental study by RILEM TC 283-CAM. *Mater Struct* **57**, 72 (2024).

- Presentation of TC outcomes scheduled during the 2024 RILEM Annual Week.




Cover of the Proceedings of the Workshop "Lime-based materials for repairing historic structures". Image courtesy of RILEM Publications.

**277-LHS** Specifications for testing and evaluation of lime-based repair materials for historic Structures

- Proceedings of the Workshop "Lime-based materials for repairing historic structures" that took place on 3-4 February 2022 in Thessaloniki, Greece, Edited by Ioanna Papayianni & Jan Válek.
- Presentation of TC outcomes scheduled during the 2024 RILEM Annual Week.

**293-CCH** Stress Corrosion Cracking and Hydrogen Embrittlement of Concrete-Reinforcing Steels

- Presentation of TC outcomes scheduled during the 2024 RILEM Annual Week.

Here also come the latest publications and videos of some past TCs, released after their closure date:

**279-WMR** Valorisation of Waste and Secondary Materials for Roads

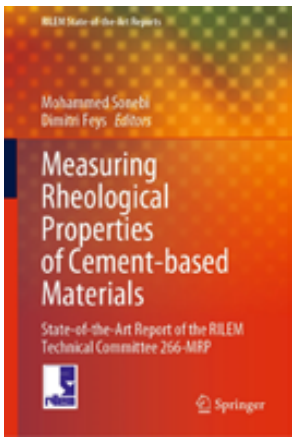
- TC outcomes presented at the 77th RILEM Annual Week. Video of the presentation available on the RILEM YouTube channel.

**256-SPF** Spalling of concrete due to fire: testing and modelling

- Pimienta, P., McNamee, R., Robert, F. et *al.* Recommendation of RILEM TC 256-SPF on fire spalling assessment during standardised fire resistance tests: complementary guidance and requirements. *Mater Struct* 57, 3 (2024).
- Pimienta, P., McNamee, R., Hager, I. et *al.* Recommendation of RILEM TC 256-SPF on the method of testing concrete spalling due to fire: material screening test. *Mater Struct* **56**, 164 (2023).

**260-RSC** Recommendations for use of superabsorbent polymers in concrete construction

- Wyrzykowski, M., Schroefl, C., Toropovs, N. et *al.* Verification of the presence of superabsorbent polymers (SAP) in fresh concrete: results of an interlaboratory study of RILEM TC 260-RSC. *Mater Struct* **57**, 69 (2024).




Cover of STAR of RILEM TC 266-MRP.

**266-MRP** Measuring Rheological Properties of Cement-based Materials

- Amziane, S., Khayat, K., Sonebi, M. et *al.* RILEM TC 266-MRP: Round-Robin rheological tests on high performance mortar and concrete with adapted rheology—evaluating structural build-up at rest of mortar and concrete. *Mater Struct* **56**, 150 (2023).
- Measuring Rheological Properties of Cement-based Materials, State-of-the-Art Report of the RILEM Technical Committee 266-MRP, Editors: Mohammed Sonebi, Dimitri Feys.

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# Concluding remarks

By the time this report is circulated, the "Workshop Imagine - RILEM and Climate change" would have taken place. For the time being, the report is still a couple of months away, but this does not prevent me from talking about this initiative in this issue of the RILEM Technical Report.


**Workshop Imagine - RILEM and Climate change**

The workshop is a strategic event for RILEM, an association that never rests, always evolves. The lockdown period imposed by the COVID-19 pandemic, and the shocking effects everyday of climate change, forced us to think about the impact of our travels to attend a RILEM event. Does a RILEM event with limited carbon footprint exist? If yes, how does it look like? Can you imagine RILEM with a reduced transportation footprint? At the moment, RILEM organises two major events every year: the Annual Week and the Spring Convention. In these occasions, the meetings of the RILEM standing committees and of some Technical Committees are held, and a conference comprising all RILEM topics is organised. It is a very pleasant experience in which we can chat to our colleagues, exchange ideas, shake hands with old friends... but at what cost for the environment? I am afraid that I still do not have the answers to this and the previously mentioned difficult questions, but I acknowledge the importance of this issue and I understand that the answers to these questions will have the power to change the way RILEM members interact.

Another topic to be debated during the "Workshop Imagine - RILEM and Climate change" is the RILEM contribution to the society. RILEM TCs work very hard to produce recommendations and best practice documents in the form of journal papers and, more generally, scientific publications. But are we sure this knowledge reaches the broader scientific community and the society? Many of these documents contain useful information to reduce the carbon footprint of the built environment, but it is up to us, RILEM members,

to make sure that these results are well communicated and that they reach the government bodies capable of making a real difference. So, the question becomes: “how do we communicate these TCs’ outcomes”? RILEM is turning its existing partnerships into active collaborations, and it is also creating new connections with similar associations. The ongoing joint activities, in terms of dissemination of reciprocal documents and informative webinars, are strategic actions to disseminate knowledge, but can we do more? Within this frame, I am putting a lot of hope in the Globe initiative. By gathering the main active associations in the field, it allows us to be part of something with a louder voice.

We will collect the answers to all these questions during the workshop, and they will be probably shared in the next RILEM Technical Report, released in 2025. Then, I will no longer be the RILEM President, as my mandate terminates in September 2024. I leave the association in the competent hands of Prof. Nele de Belie, but I will continue to stay involved as RILEM outgoing President over the next 3 years. My primary focus as RILEM President has been to enhance inclusivity and bolster the involvement of young researchers in RILEM activities. This has included opening RILEM Technical Committees to anyone willing to join, doubling the financial resources dedicated to supporting young members travel to major RILEM events, and welcoming the creation of the RILEM Youth Council (RYC) to attract more young members.

I think my input to the association as RILEM President has not been different from the one I brought as TAC Chair, TC Chair, or as any RILEM member: RILEM is a bottom-up association where each member is invited to improve the association up to the amount of time and energy any one of us is able to commit and offer to the association. This upcoming strategic workshop is another occasion to do so. I had the pleasure to join RILEM many years ago, to contribute to its development, and I have enjoyed every bit of it since then.

Nicolas Roussel,
RILEM President
Nele De Belie,
RILEM President-Elect,
Ravindra Gettu,
RILEM Past-President.
Image courtesy of D. Ciancio.

September will be the end of the 9-year long mandate of Prof. Ravindra Gettu, 3 years as Vice-President, 3 as President, and 3 as Outgoing President. I would like to take the opportunity here to thank Ravindra for his devotion and commitment to the association. He will probably be remembered as the “COVID-President”, but for those who know him well, he is a real pillar upon which we stand: Ravindra’s care, smile, and kindness has been for me and is for so many of us the quintessence of the RILEM family spirit.

*Nicolas Roussel, RILEM President, on behalf of the RILEM Presidency*

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