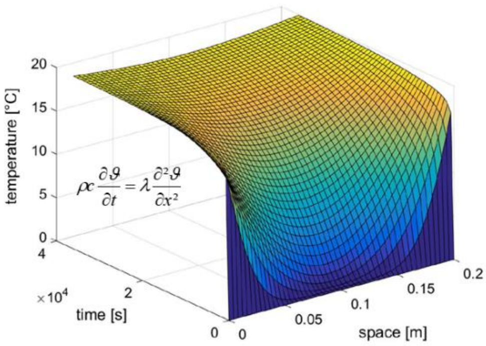
Computational Methods for Building Physics and Construction Materials

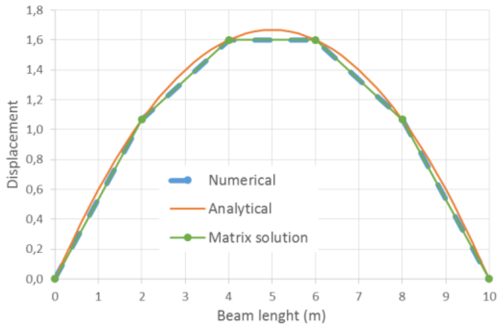
CMBPCM Course 2020
July, 6 – 10

RILEM EAC Evaluation report

Organized by:
Institute of Construction and Building Materials,
Technische Universität Darmstadt, Germany

Venue:
Online course





Computational Methods for Building Physics and Construction Materials

TU Darmstadt
July 24, 2020

INSTITUT FÜR WERKSTOFFE IM BAUWESEN

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TECHNISCHE UNIVERSITÄT DARMSTADT

Subject: Evaluation report CMBPCM course 2020
Purpose: RILEM EAC feedback
Date report: 24-07-2020
Authors: Prof. EAB Koenders / Dr. N. Ukrainczyk / Dr. C. Mankel / Dr. A. Caggiano

Figure 1: Online course organized by the Institute of Construction and Building Materials of the TU Darmstadt, Germany.

1. Course objective:

This year, due to the Corona situation, the RILEM EAC course "Computational Methods for Building Physics and Construction Materials" was organized as an online course (Figure 1) by employing the Zoom-platform. The course was organized by the Institute of Construction and Building Materials of the Technical University of Darmstadt, in Germany. The main objective of the course is to teach MSc, PhD and/or post-doctoral students, solution strategies and computational methods for differential equations in the field of building physics and construction materials. Also this time, emphasis was on numerical solution strategies, explicit and implicit discretization, finite difference method, method of lines, boundary conditions and implementation strategies of physical temperature and moisture processes that frequently occur in construction materials. Typical problems addressed in this course were classical steady-state mechanics problems like a simply supported bending beam and a cantilever beam, followed by modelling transient heat transport problems, multi-layer systems, coupled moisture – heat systems, whereas also the particle structure and kinetics of cement hydration was also addressed. Aim of the course is to provide students a full solution strategy approach, so from a physical problem, to schematization and discretization, to boundary conditions evaluation, a computational implementation strategy. Similar to the last year course, this year a brief introduction to the Finite Element Method was provided as well. The course was structured in a 5 full day (intensive) program, by teaching every day a different aspect of computational modelling. In the morning sessions theoretical lessens were taught and in the afternoons demonstrations and exercises. An overview of the full course program is added in Appendix 1.

Teachers of the course were Prof. Eddie Koenders, Dr. Neven Ukrainczyk, Dr. A. Caggiano and Dr. Christoph Mankel, all employed at the Technical University of Darmstadt. At the endo of the course students were asked to fill in a course evaluation form of which the results are attached to this report in Appendix 2. After the course, a RILEM certificate of attendance was sent to each student individually. The course is also an officially registered TU Darmstadt MSc course with a value of 6 ECTS credit points. With this, all students who attended this CMBPCM course could also opt for these credit points, and use it e.g. for their graduate school program. However, in this case they have to comply with the course requirements, meaning they have to make some homework exercises and write the exam organized by the TU Darmstadt.

Figure 2: Lecture room used for online teaching.

2. Course program:

The course program (see appendix 1) was designed in such a way that the core lectures addressing the theoretical backgrounds on computational modelling were scheduled during the morning sessions and hands-on demonstrations and practical sessions with the use of software in the afternoon (Figure 2). This concept turned out to be very successful and was appreciated by the students very much. However, it has turned out that for this online course

the scheduled exercises could not be done in the planned way where teachers help students to solve exercises individually, but rather resulted in an extension of the demonstration session. This part of the program will be restructured for the next online course.
The used software was mostly Excel, and the freeware program called Octave. Along with this specially designed programming codes, prepared by the teachers, were provided as part of the lecture material. The basic idea of the course is that after successful attendance of the course, students learned how to use the software and understand/ may use the provided codes for their personal research interests and/or future modelling developments.

The course started on Monday early morning with an introduction of RILEM by Prof Koenders (Figure 3) and a presentation of the course program and teachers. After that the official part of the course started. First, the basics of schematization and discretization was explained followed by the explicit discretization method for steady state problems and how to implement this in Excel. Main focus was on a simply supported bending beam and a cantilever beam with different types of loading. In the afternoon demonstrations and extended examples were presented by the teachers along with the students.

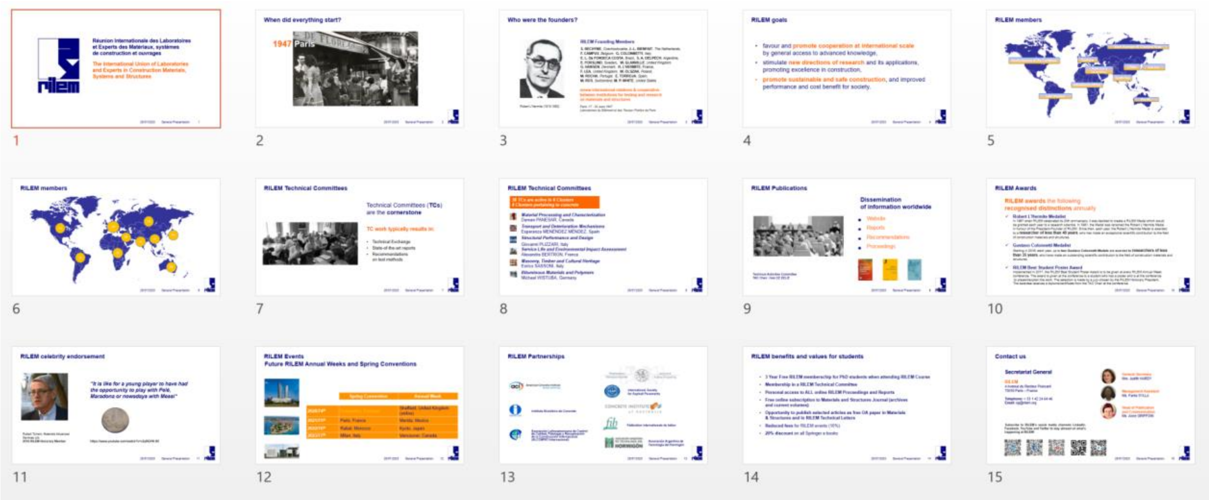


Figure 3: PPTs presented to introduce RILEM.

On Tuesday morning, the course continued with the explicit method for transient problems, representing a transient heat flow problem, implemented in Excel, and followed by an implementation in Octave. An introductory lecture on programming in Octave and applying matrix-vector instructions was lectured by Dr. Neven Ukrainczyk (Figure 4). In the afternoon, again demonstration on transient problems and exercises were done by the teachers and students. After the course, all students and teachers went for a tour through the laboratory facilities of the Institute of Construction and Building Materials.

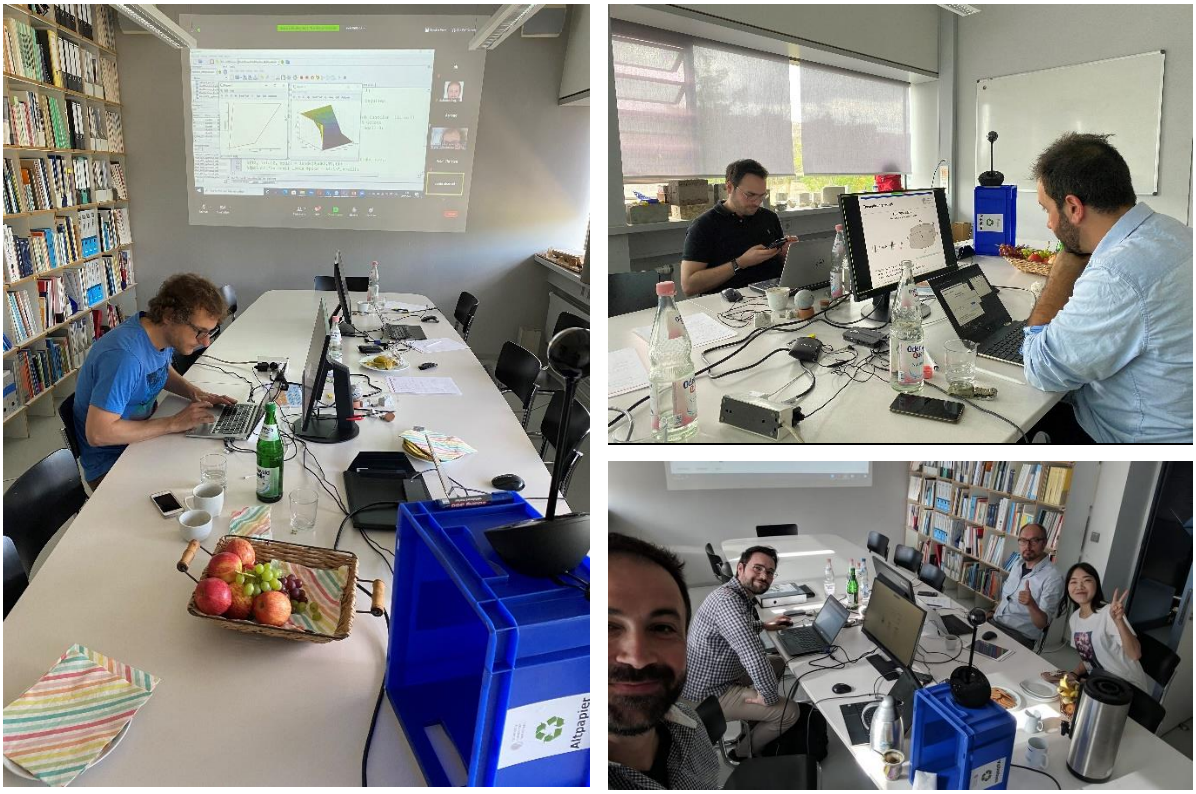


Figure 4: Teachers during preparation and lecturing of the course.

On Wednesday the implicit discretization was introduced as well as different boundary conditions, namely the Dirichlet, the Von Neumann and the Robin boundary conditions, how to discretize and how to implement them in various (implicit and explicit) discretization systems. Method of lines was taught as well, demonstrating the powerful and easy to use time integrator tools readily available in the Octave toolbox. Dr Ukrainczyk concluded the theoretical part by a critical overview of all different methods learnt, systematically comparing theirs's pros and cons, and concluding with a clear recommendation on which method one could use best, depending on the modeling case and its specific characteristics, such as: discretization size, desired accuracy, flexibility to adapt the code, computational cost/speed and ease of implementation. The afternoon was again used for demonstrations and exercises on various examples and implementations in Octave.

Thursday started with lecturing the multi-layer systems, representing a geometrical coupling of various layers of a wall. It was shown how to discretize and how to implement these multi-layer systems in Octave. Next, the discretization of a fully coupled heat-moisture problem was lectured by Dr. Ukrainczyk and it was shown how to solve these systems using a predictor-corrector explicit method.

In the afternoon, teachers demonstrated using of the models implemented in Octave and explaining the implementations for fully coupled heat-moisture example. After that, various exercises were lectured as a step by step procedure.

Friday started with the schematization and modelling of a 3D particle structure followed by a lecture on the reaction kinetics of such systems and how to do the coding in Octave. After that, Dr. Antonio Caggiano gave a brief lecture on the Finite Element Method, addressing at a glance the theoretical backgrounds, implementation and a solution strategy for the heat diffusion differential equation. After lunch, a demonstration session was prepared showing implementations in Octave, where the code files were also provided to the students. In the afternoon both Octave codes as well as the Hymostruc model were used for the demonstration session. Finally, the students filled in the online evaluation form (Appendix 2) and a “group photo” was made (Figure 1).

3. Number of persons:

The official number of registered participants for the full online CMBPCM course was 76 (excluding teachers). In addition, two students signed in for attending one day.

4. Target group:

The target group was as expected, i.e. MSc students predominantly from TU Darmstadt and China, as well as PhD students, Postdocs, Professors, and a few researchers from the Industry. The course structure enables all educational levels to learn from the provided content.

5. Country of participants:

The attendees of the CMBPCM course were from 30 different countries. From these, Argentina 1x, Australia 1x, Austria 1x, Belgium 1x, Brazil 3x, China 23x, Colombia 1x, Croatia 1x, Cyprus 1x, Czech 1x, Estonia 1x, France 4x, Germany 6x, India 2x, Iran 1x, Italy 1x, Japan 1x, Korea 1x, Netherlands 1x, Portugal 2x, Russia 1x, Saudi Arabia 2x, Serbia 1x, Slovenia 1x, South Africa 1x, Spain 1x, Sweden 2x, Switzerland 1x, Turkey 1x, UK 3x, and USA 7x.

6. Teachers:

The teachers; Prof. Dr. E.A.B. Koenders (TU Darmstadt, course responsible) / Dr. Ukrainczyk and Dr. Antonio Caggiano (senior researcher at the TU Darmstadt), and Dr. Christoph Mankel (Postdoc researcher at the TU Darmstadt). All teachers showed professional skills and all were very much able to present inspiring lectures to the students during the theoretical morning sessions as well as during the practical afternoon sessions. The different backgrounds (Koenders and Mankel are Civil Engineer and Ukrainczyk a Chemical Engineer and Caggiano

Computational Mechanics Engineer) and wide research and educational experiences of the teachers is considered very important to achieve a divers and comprehensive program of lectures, examples and exercises, and to provide a broad vision on the various aspects of computational modelling and implementation.

7. Frequency and co-organization:

The CMBPCM course is an annual EAC supported RILEM Educational Course and an official TU Darmstadt course, which was this year organized for the fourth time, and because of the Corona situation, as an online course. Next year the CMBPCM course will be organized again by the Institute of Construction and Building Materials as a Post-Course to the RILEM Spring Convention, with a slightly rescheduled program, more suitable for online education, and with more practical examples.

8. Date:

The course will be organized every year in the spring. In this way, the course is expected to be complementary to the MMC course (also RILEM EAC course), which is always organized in the fall. The date for the next year CMBPCM course has already been fixed on April 12-16 2021. The course will be offered as an on-line course again.

9. RILEM support:

RILEM guidelines are followed and a presentation about RILEM is provided during the introduction session of the course. The RILEM presentation was given by Prof. Eddie Koenders. Students are informed about the general RILEM activities and also about the three year free membership.

10. Flyer:

A flyer has been made in paper and PDF form and was distributed actively among potential participants via the RILEM website, the TU Darmstadt website and other online platforms.

11. Evaluation:

After the course, students were asked to fill in an evaluation form. The results of this evaluation will be used to improve the course for the forthcoming year. An overview of the results is provided in Appendix 2.

APPENDIX 1

Course program 2020

Program of the CMBPCM 2020 course

CMBPCM	Time	6 July 2020 Monday	7 July 2020 Tuesday	8 July 2020 Wednesday	9 July 2020 Thursday	10 July 2020 Friday
	8.45 - 9.00	Welcome, introduction and presenting RILEM				
	9.00 - 10.15	**Introduction schematization and discretization**	**Transient discretization problem, explicit method in Excel**	**Transient discretization problems, boundary conditions evaluation**	**Transient multi-layer systems, implicit implementation in Octave/Matlab**	**Particle structure schematization and Kinetics and implementation**
Lectures	10.15 - 10.45	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
	10.45 - 12.30	**Steady state problem, explicit implementation in Excel**	**Transient discretization problem explicit method in Octave/Matlab**	**Transient discretization, implicit implementation in Octave/Matlab**	**Transient heat-moisture systems, implementation in Octave/Matlab**	**FEM - Discretisation and Implementation in Octave/Matlab**
	12.30 - 13.30	Lunch break	Lunch break	Lunch break	Lunch break	Lunch break
Demos	13.30 - 15.30	**Demo on steady state Excel implementation**	**Demo on explicit transient implementations**	**Demo on implicit transient implementations Octave/Matlab**	**Demo on coupled heat - moisture systems Octave/WUFI**	**Demo on hydration and FEM implementations**
	15.30 - 16.00	Coffee break	Coffee break	Coffee break	Coffee break	Coffee break
Exercises	16.00 - 17.30	**Exercises 1**	**Exercises 2**	**Exercises 3**	**Exercises 4**	**Exercises 5**

APPENDIX 2

Evaluation results CMBPCM 2020

Evaluation Questions and Results CMBPCM 2020

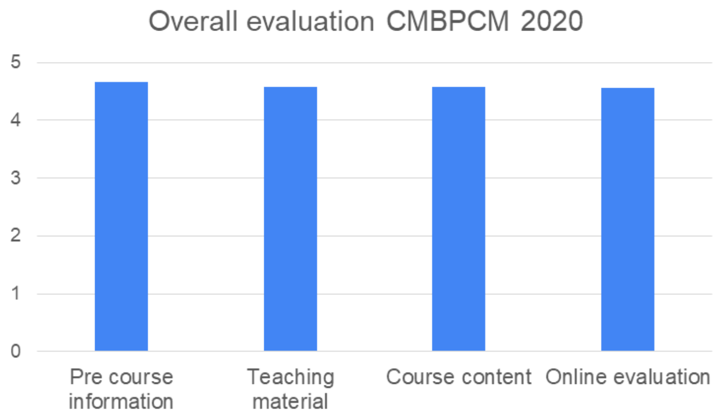
Questions asked:

Pre-course information:
Was the available information before the course started enough?
Was the E-mail contact appropriate?
Was the written contact appropriate?
Was the (RILEM) Website information appropriate?

Teaching material:
Providing PDFs of PPTs as lecture notes was appropriate?
Quality of the lecture notes?
Quality of the exercises?
Quality of the demonstrations?

Course content:
What is your opinion about the quality of the lectures in general?
What is your impression about the quality of the whole course?
Was the teaching level appropriate?

Online evaluation:
Was the quality of the online platform sufficient?
The possibility for asking questions was enough?
Were the questions satisfactory answered?
Were the hand-notations by tablet clear enough?



(Average results of 48 students)