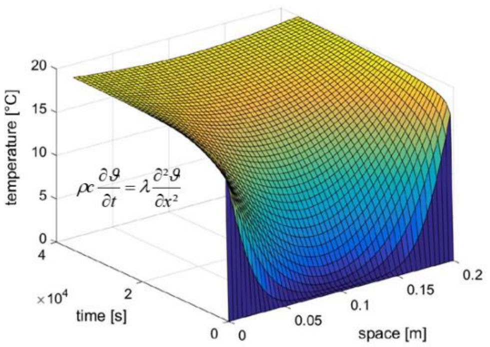
Computational Methods for Building Physics and Construction Materials

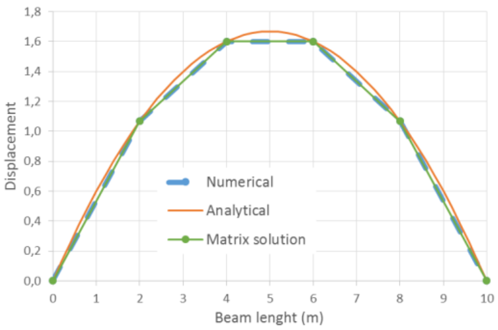
CMBPCM Course 2019
April, 8 – 12

RILEM EAC Evaluation report

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

Venue:
Institute of Construction and Building Materials
Technical University of Darmstadt
Darmstadt, Germany





Computational Methods for Building Physics and Construction Materials

TU Darmstadt
April 23, 2019

INSTITUT FÜR WERKSTOFFE IM BAUWESEN

TECHNISCHE UNIVERSITÄT DARMSTADT

Subject:	Evaluation report CMBPCM course 2019
Purpose:	RILEM EAC feedback
Date report:	23-04-2019
Authors:	Prof. EAB Koenders / Dr. N. Ukrainczyk / MSc. C. Mankel / Dr. A. Caggiano

Venue: Institute for Construction and Building Materials, Technische Universität Darmstadt, Germany.

Figure 1: Institute of Construction and Building Materials of the TU Darmstadt, Germany.

1. Course objective:

This year was the third time that the course "Computational Methods for Building Physics and Construction Materials" was organized under the umbrella of RILEM EAC. The course was organized by the Institute of Construction and Building Materials of the Technische Universität Darmstadt, in Germany (Figure 1). The main objective of the course was 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 the 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 that were addressed in this course were on classical steady-state mechanics problems like bending of a simply supported, and cantilever beam. Modelling transient heat transport and effect of insulation, multi-layer systems, coupled moisture – heat systems, and cement hydration kinetics 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, and to a computational solution. 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, while in the morning 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 M.Sc. Christoph Mankel, all employed at the Technische Universität Darmstadt, and Dr. Antonio Caggiano being a research fellow from the Alexander von Humboldt Foundation. After the course students were asked to fill in a course evaluation form of which the results are attached to this report in Appendix 2. The course ended by handing over a certificate of attendance to each student. As the course is also officially registered as a TU Darmstadt MSc. course, it is valued by 6 ECTS points. With this, PhD students who attended this CMBPCM course could also use it as an official course for their graduate school program.

Figure 2: Lecture room. Discussions with the students.

2. Course program:

The course program (see appendix 1) was designed in such a way that lectures addressing 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 and 3). This concept turned out to be very successful and was appreciated by the participants very much. The used software was a freeware and was provided together with specially designed programming codes prepared by the teachers, and was considered as part of the lecture material. The idea 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 future development.

Figure 3: Lecture room.

The course started on Monday early morning with an introduction of RILEM 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 simple cantilever and supported beam with different types of loading. In the afternoon demonstrations were presented by the teachers and exercises done by the students. In the evening a walking City Tour through the city center of Darmstadt was organized.

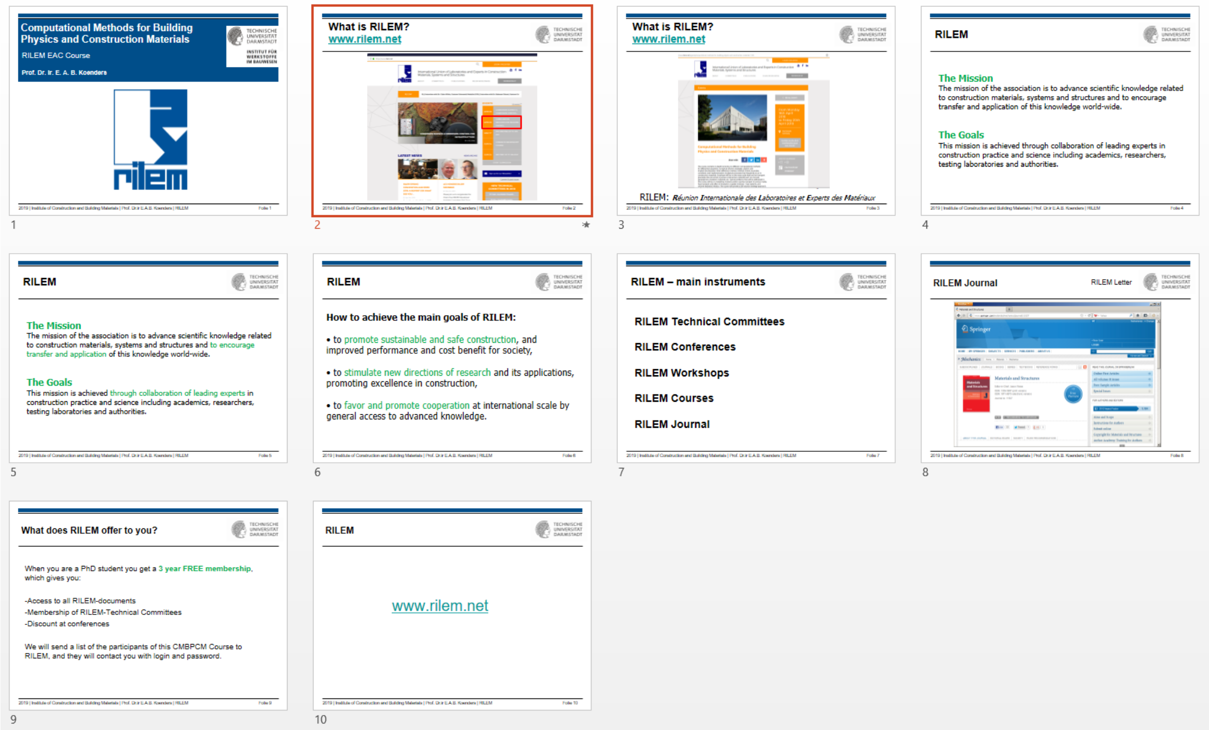


Figure 4: PPT slides presented to introduce RILEM.

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 manipulations was lectured by Dr. Neven Ukrainczyk. 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.

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/Matlab 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 guidance which method should one use optimally, 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 for demonstrations and exercises on implementations in Octave.

Thursday started with lecturing the multi-layer systems, which represents a kind of geometrical coupling of various layers. 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 problems, on a heat-moisture example. After that, students did exercises themselves where they were able to apply the theory learnt. After the exercise session, a dinner was organized at Ratskeller restaurant in the city center of Darmstadt. The dinner was very much enjoyed by all course participants.

Friday started with the schematization of a 3D particle structure followed by a lecture on the reaction kinetics of such systems and coding implementations in Octave. After that, Dr. Antonio Caggiano prepared a brief lecture on the Finite Element Method, addressing at a glance the theoretical backgrounds, the implementation and a solution strategy for the common transport 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 and also students used those software's for their exercises. Finally, the students filled in the evaluation form (Appendix 2) and the certificates of attendance were handover.

3. Number of persons:

The official number of registered participants for the CMBPCM course was 11 (excluding teachers).

4. Target group:

The target group was as expected, i.e. MSc students from TU Darmstadt, as well as PhD students and Postdocs, which complied with the objective of the course. As all levels were present, they could also exchange experiences and learn from each other.

5. Country of participants:

The attendees of the CMBPCM course came from 4 different countries. From these, 5 were M.Sc. students that registered via the TU-Darmstadt, 1 MSc student from Karlsruhe, and 5 were PhD or Postdocs from Germany or other countries. In total 7 students came from Germany, 2 from Iran, 1 from Brazil, 1 from China.

6. Teachers:

The teachers; Prof. Dr. E.A.B. Koenders (TU Darmstadt, course responsible) / Dr. Ukrainczyk (senior researcher at the TU Darmstadt), Dr. Antonio Caggiano (Von Humboldt fellow), and MSc Christoph Mankel (PhD student 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.

7. Frequency and co-organization:

The CMBPCM course is an official TU-Darmstadt course as well as an annual EAC supported RILEM Educational Course, which was this year organized for the third time. Next year (2020) the CMBPCM course will be organized by the Institute of Construction and Building Materials at the TU Darmstadt again for the fourth consecutive time.

8. Date:

The basic idea is to organize the course 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. A preliminary date for the next year CMBPCM course has already been set for April 2020. In addition, the possibility of an on-line course will be explored as well.

9. RILEM support:

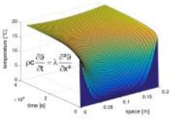
RILEM guidelines are followed and a presentation about RILEM is provided during the introduction session of the course. The RILEM presentation was given by Prof. Eddie Koenders. Students are informed about the general RILEM activities and also about the three year free membership.

10. Flyer:

This year, due to time constrains no flyer has been made. Next year a more efficient flyer will be designed and arranged.

11. Evaluation:

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



APPENDIX 1

Course program 2019

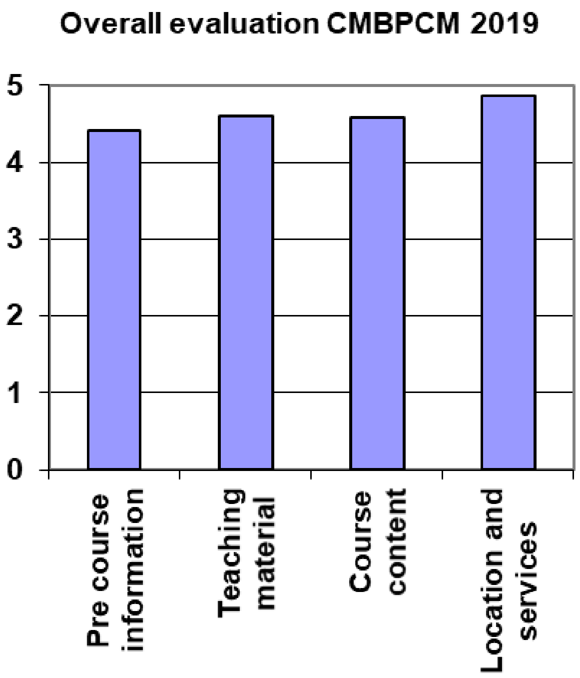
Program of the CMBPCM 2019 course

CMBPCM	Time	Monday	Tuesday	Wednesday	Thursday	Friday
	8.30 - 9.00	Welcome, introduction and presenting RILEM				
Lectures	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**
	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	Lunch	Lunch	Lunch	Lunch
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**
	18.00	City walk	Free	Free	Dinner	Free

APPENDIX 2

Evaluation results CMBPCM 2019

Evaluation results CMBPCM 2019



(Average results of 11 students)