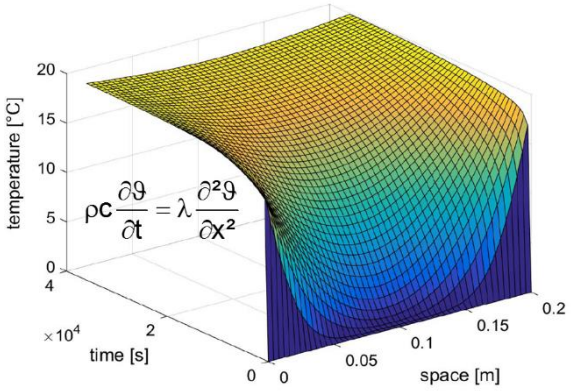
Computational Methods for Building Physics and Construction Materials

CMBPCM Course 2018
April, 16 – 20

RILEM EAC Evaluation report

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

Venue:
Media Center
Technical University of Darmstadt
Darmstadt, Germany



Computational Methods for Building Physics and Construction Materials

TU Darmstadt
May 6, 2018

INSTITUT FÜR WERKSTOFFE IM BAUWESEN

TECHNISCHE UNIVERSITÄT DARMSTADT

Subject:	Evaluation report CMBPCM course 2018
Purpose:	RILEM EAC feedback
Date report:	06-05-2018
Authors:	Prof. EAB Koenders / Dr. N. Ukrainczyk / MSc. C. Mankel / Dr. A. Caggiano

Venue: Media Center, Technische Universität Darmstadt, Germany.

Figure 1: Media Center of the TU Darmstadt, Germany.

1. Course objective:

This year, it was the second 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 in the Media Center 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. Emphasis was on addressing 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. In addition, focus was the meso-scale level and on transport processes that are active in porous construction materials such and/or insulation materials, etc. Typical problems that were addressed in this course were on modelling moisture and/or reactive transport in porous media, heat transport and effect of insulation, multi-layer systems, coupled moisture – heat systems, and cement hydration kinetics. 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. In addition 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 day (intensive) program, by teaching every day a different aspect of computational modelling, while during the morning sessions the theoretical aspects were addressed and in the afternoons the demonstrations and exercise sessions. 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 course and open to M.Sc. students, it is valued with 6CP, which is equal with 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.

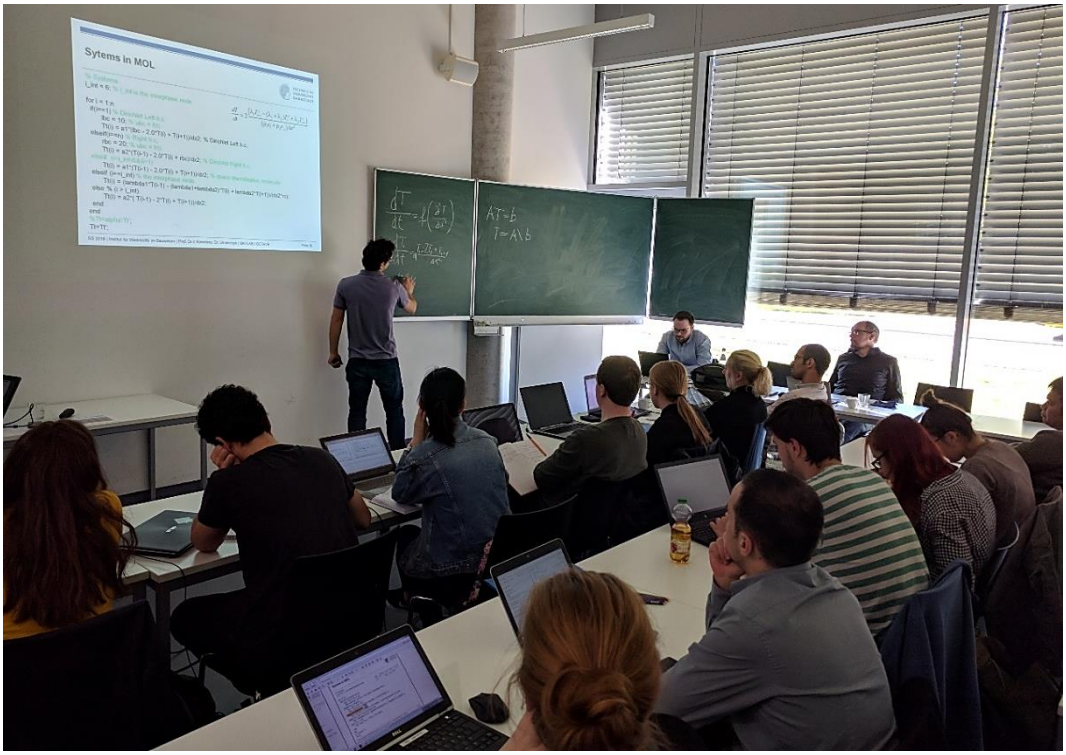


Figure 2: Lecture room. Dr. Ukrainczyk teaching the Method of Lines.

2. Course program:

The course program (see appendix 2) 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 software was mostly 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 the course, students learned how to use the software and understand/use the provided codes for their personal research interests and further developments.

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 simply 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.

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 using 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 an implicit discretization system. The afternoon was again for demonstrations and exercises on implementations in Octave. During the lunch break also a group photo was made (see appendix 2).

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 coupled temperature-moisture problem was lectured and it was shown how to solve these systems using a predictor-corrector method. In the afternoon, as a special “gift”, Dr. Antonio Caggiano prepared a brief lecture on the Finite Element Method, addressing a glance of the theoretical backgrounds, the implementation and he prepared a demonstration in Octave, of which he also gave the code files to the students. After this, a demonstration was done on a thermal – moisture problem using the freeware version of the software WUFI, which is a volume element model for coupled temperature-moisture problems. WUFI could also be used for the exercises where students could simulate different coupled problems themselves. After the exercise session a dinner was organized at City Braustüb´l restaurant in the city center of Darmstadt (see Figure 4). The dinner was very much enjoyed by all course participants.

Figure 4: CMBPCM course dinner in Darmstadt.

Friday started with the schematization of a 3D particle structure followed by a lecture on the reaction kinetics of such systems. In the afternoon both Octave codes as well as the Hymostruc model was used for the demonstration session and also students used those software’s for

their exercises. In the afternoon, students filled out the evaluation form and the certificate of attendance were handover.

3. Number of persons:

The official number of registered participants for the CMBPCM course was 23 (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:

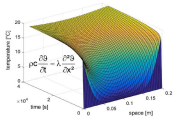
The attendees of the CMBPCM course came from 13 different countries. From these, 11 were M.Sc. students that registered via the TU-Darmstadt and 12 were PhD or Postdocs from Germany or other countries. In total 4 students came from Germany, 1 from Croatia, 1 from Portugal, 2 from Sweden, 1 from Switzerland, 2 from Ireland, 1 from France, 1 from Taiwan, 1 from Iran, 1 from Argentina, 2 from Italy, 2 from Brazil, and 1 from India. Many of the students from TU-Darmstadt were DAAD or Erasmus exchange students. A group photo of the course participants is shown in Appendix 2.

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 experiences of the teachers is considered very important to achieve a divers and comprehensive program of lectures, examples and exercises, and provides 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 second time. Next year (2019) the CMBPCM course will be organized again by the Institute of Construction and Building Materials at the TU Darmstadt.



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 2019.

9. RILEM support:

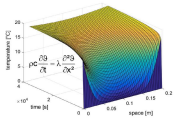
RILEM guidelines are followed and a presentation about RILEM is given during the introduction session of the course. The RILEM presentation was given by Prof. Eddie Koenders. Students are informed about the RILEM activities and about the three year free membership for PhDs.

10. Flyer:

Every year a new flyer is designed (Appendix 3) showing the program and details of the CMBPCM course including the logos of the organizing institute and the RILEM logo. Furthermore, since the event is an official RILEM course, CMBPCM course information will also be available via the RILEM website as well as via the website of the Institute of Construction and Building Materials.

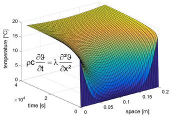
11. Evaluation:

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 4



APPENDIX 1

Course program 2018



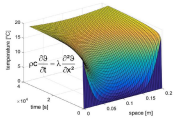
Program of the CMBPCM 2018 course

CMBPCM	Time	Monday	Tuesday	Wednesday	Thursday	Friday
	8.00 - 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 discretization**
	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**	**Kinetics modelling 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/FEM/WUFI**	**Demo on hydration and kinetics 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

Group photo CMBPCM 2018

Group photo CMBPCM 2018 @ TU-Darmstadt, Darmstadt, Germany.



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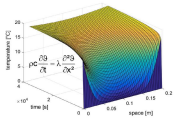
APPENDIX 3

Flyer CMBPCM 2018



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Objective:

Objective of the course is to train MSc, PhD and Postdoc students on how to solve common differential equations and what solution strategies can be applied to simulate physical problems in construction materials. After finishing this course, students will be able to use computational methods skills for their own research.

CP/ECTS: 6/6
Language: English

Contact information:

TU Darmstadt MSc students can register via the TU Darmstadt TUCaN system.

Other MSc, PhD or PostDoc students can register via the following contact information:

Institute of Construction and Building Materials

Ms. A. Cevik

E-Mail: cevik@wib.tu-darmstadt.de

Tel: +49-6151-16-22210

TECHNISCHE UNIVERSITÄT DARMSTADT
INSTITUT FÜR WERKSTOFFE IM BAUWESEN

Summary Course Informations:

Venue: Technische Universität Darmstadt
Campus Lichtwiese
Building L4|02 (HMZ)

Address: Franziska-Braun-Straße 10, 64287 Darmstadt

Monday:	Room 333
Tuesday:	Room 333
Wednesday:	Room 333
Thursday:	Room 301
Friday:	Room 6

CP/ECTS: 6/6

Language: English

Technische Universität Darmstadt
Faculty of Civil and Environmental Engineering
Institute of Construction and Building Materials

Franziska-Braun-Straße 3
64287 Darmstadt/Germany
www.wib.tu-darmstadt.de

Official RILEM EAC Course

Computational Methods for Building Physics and Construction Materials

Date: April 16 – 20, 2018

Teachers:
Prof. Dr. ir. E.A.B Koenders
Dr. chem. Ing. N. Ukrainczyk
Dr. Antonio Caggiano
M.Sc. Ch. Mankel

TECHNISCHE UNIVERSITÄT DARMSTADT
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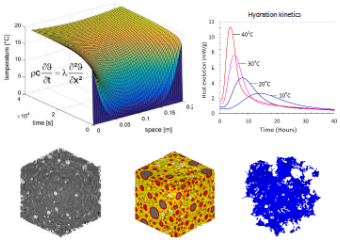

Course description:

The course contains in-depth lecturing on different computational methods for differential equations, numerical solution strategies, explicit and implicit discretization, finite difference method, method of lines, finite element method, boundary conditions and implementation of physical processes that frequently occur in construction materials. Emphasis will be on the meso-scale level and on transport processes that are active in porous construction materials such as concrete, geopolymers, insulation materials, etc. Typical problems that will be addressed in this course will be on modelling moisture and/or reactive transport in porous media, heat transport and effect of insulation, coupled moisture - heat systems, and cement hydration kinetics. The course will provide a full solution strategy approach, so from a physical problem, to schematization and discretization, to boundary conditions evaluation, and to a computational solution.

Key topics:

- Steady state problems – discretization and implementation in Excel
- Transient problems – explicit & implicit heat and moisture flow – implementation in Octave/Matlab/FEM
- Coupled layer systems – coupled heat and moisture flow, discretization and implementation in Octave/Matlab
- Particle structure formation and hydration kinetics of cementitious systems

Course programme:

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Exercises	16.00 - 17.30	Exercises 1	Exercises 2	Exercises 3	Exercises 4	Exercises 5	
	18.00	City walk	Free	Dinner	Free	Free	

Venue:

The course venue will be the *Hörsaal – und Medienzentrum* (HMZ) of the Technische Universität Darmstadt, Franziska-Braun-Straße 10, 64287 Darmstadt. The HMZ was built in 2013 and accommodates many modern lecture and presentation rooms. It is a place where students and teachers meet to transfer knowledge in an academic atmosphere. Darmstadt is a "City of Science" which is situated in state of Hessen, near to Frankfurt. The University is one of Germany's leading TUs.

Costs:

- PhDs and Postdocs **500 €**
- MSc students from the TU Darmstadt: **Free**
- MSc students from other German Universities: **150 €**

This includes the course attendance, basic course materials (PDF copy of PPTs, etc), a course dinner, and coffee breaks and lunches during the whole course week. Accommodation is not included.

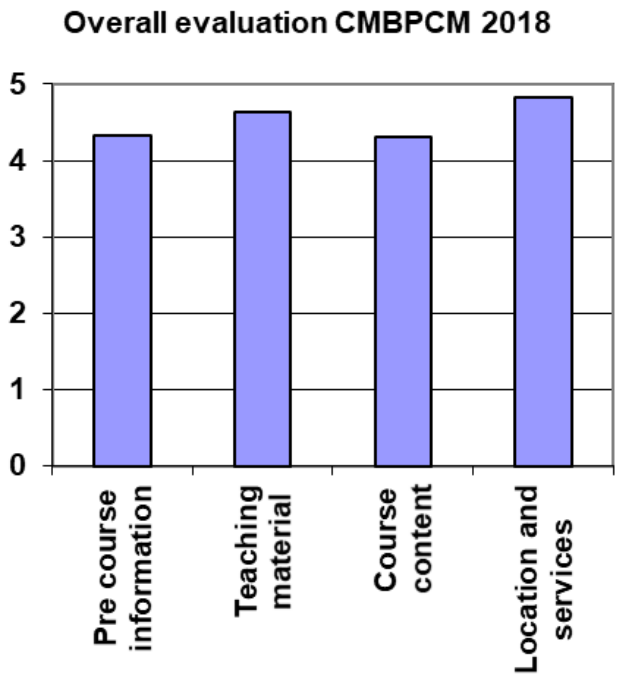
Accommodation:

For this course accommodation will not be arranged by the organizers. Hotels or Bed and Breakfast options can be found from regular websites.

APPENDIX 4

Evaluation results CMBPCM 2018

Evaluation results CMBPCM 2018



(Average results of 21 students)