

## SYLLABUS

### 1. Data about the program of study

1.1	Institution	The Technical University of Cluj-Napoca
1.2	Faculty	Faculty of Civil Engineering
1.3	Department	Structures
1.4	Field of study	Civil Engineering
1.5	Cycle of study	Master of Science
1.6	Program of study/Qualification	Artificial Intelligence in Construction Engineering and Management
1.7	Form of education	Full time
1.8	Subject code	15.00

### 2. Data about the subject

2.1	Subject name				Parametric design and Digital fabrication						
2.2	Subject area				Civil engineering						
2.3	Course responsible/lecturer				Conf. dr. ing. PUSKÁS Attila, <a href="mailto:attila.puskas@dst.utcluj.ro">attila.puskas@dst.utcluj.ro</a> Ș.I. dr. ing. TOADER Traian-Nicu, <a href="mailto:traian.toader@dst.utcluj.ro">traian.toader@dst.utcluj.ro</a>						
2.4	Teachers in charge of seminars				Conf. dr. ing. PUSKÁS Attila, <a href="mailto:attila.puskas@dst.utcluj.ro">attila.puskas@dst.utcluj.ro</a>						
2.5	Year of study	II	2.6	Semester	1	2.7	Assessment	E	2.8	Subject category	DS/DI

### 3. Estimated total time

3.1	Number of hours per week	3	3.2	of which, course:	2	3.3	applications:	1
3.4	Total hours in the curriculum	42	3.5	of which, course:	28	3.6	applications:	14
Individual study								hours
Manual, lecture material and notes, bibliography								21
Supplementary study in the library, online and in the field								21
Preparation for seminars/laboratory works, homework, reports, portfolios, essays								31
Tutoring								6
Exams and tests								4
Other activities								-
3.7	Total hours of individual study	83						
3.8	Total hours per semester	125						
3.9	Number of credit points	5						

### 4. Pre-requisites (where appropriate)

4.1	Curriculum	Promoting disciplines Reinforced and prestressed concrete (RFC), as well as Reinforced Concrete Structures (RCS).
4.2	Competence	Advanced knowledge of reinforced concrete design and manufacturing issues. Knowledge of computer programming.

## 5. Requirements (where appropriate)

5.1	For the course	Classroom with blackboard, video-projector. Students will participate to courses and applications without opened mobile phones. Moreover, phone-calls will not be tolerated during courses, nor leaving the class for answering personal phone-calls. Presence minimum 50 %.
5.2	For the applications	Classroom with computers or internet access, software packages (for parametric design). The timeline for delivering the application project is mutually established with the students. For late delivery of the application project, the penalty is 1 point per day of delay. Presence minimum 90 %.

## 6. Specific competences

Professional competences	<ul style="list-style-type: none"> <li>- Identifying suitable problems for using parametric design procedures;</li> <li>- Knowledge of designing for digital production;</li> <li>- Ability to parametrize a reinforced concrete load-bearing component;</li> <li>- Understanding the concept of structure segmentation associated with the stress state for a load-bearing structure;</li> <li>- Single and multi-criteria design of reinforced concrete components through programming.</li> <li>- Understanding the concept BIM and ability to take advantage of it.</li> </ul>
Cross competences	<ul style="list-style-type: none"> <li>- Acquire the skills necessary for the work in a design team;</li> <li>- Acquire the concept of professional ethics;</li> <li>- Taking responsibility for the tasks carried out.</li> </ul>

## 7. Discipline objectives (as results from the *key competences gained*)

7.1	General objective	Formation of competence in the field of parametric design of RCS. Acknowledging the applicability of parametric design methods in construction projects. Developing skills to understand and use parametric design and digital fabrication for specific construction works.
7.2	Specific objectives	Gain general theoretical and applied knowledge for the parametric design of RCS. Ability to do team work, to communicate and manage conflicts.

## 8. Contents

8.1. Lecture (syllabus)	Teaching methods	Notes
1. Introduction to parametric design and digital fabrication.	Exposure. Field trip.	Multimedia equipment
2. Adjustable, adaptable and complex formwork for series and unique products.		
3. Formwork production using Computerized numerical control (CNC). Field trip.		

4. Robotic manufacturing of formwork: Algorithms for trajectories.		
5. Structural optimization principles, single and multi-objective optimizations.		
6. Robotic manufacturing of reinforcement cages. Parameters and constraints.		
7. Parametrization of reinforcement cages. Algorithms.		
8. Fabrication of welded cages. Field trip.		
9. Parametric formulation in the design of reinforced and prestressed concrete elements.		
10. Segmentation of structures using artificial intelligence.		
11. Design of concrete implants using stress fields.		
12. Workflow in the design of structures using Building Information Modelling (BIM). Field trip.		
13. Design of graded concrete structures.		
14. Connection between digital design software - digital manufacturing. File formats.		
<p><b>Bibliography</b></p> <ol style="list-style-type: none"> <li>1. L. Blandini, R. Bechmann, M. Brunetti, „Die Digitalisierung des Planens und Bauens – Ansätze und Ziele“, Beton-Kalender 2022: Nachhaltigkeit, Digitalisierung, Instandhaltung. (eds. K. Bergmeister, F. Fingerloos, J.-D. Wörner). Chapter XI, 2022</li> <li>2. L. Blandini, R. Bechmann, und T. Winterstetter, „Planen und Bauen in Zeiten der Digitalisierung“, in Realität – Modellierung – Tragwerksplanung, 24. Dresdner Baustatik-Seminar, 16.10.2020, Dresden, 2020, S. 87-103.</li> <li>3. O. Gericke, D. Kovaleva, W. Sobek, „Fabrication of Concrete Parts using a Frozen Sand Formwork“, Conference: IASS Annual Symposium 2016 at: Tokyo, Japan, 2016</li> <li>4. O. Gericke, W. Haase, W. Sobek, „Production of Curved Concrete Sandwich Panels Using a Frozen Sand Formwork“, Proceedings of the IASS Annual Symposium 2017 “Interfaces: architecture . engineering . science” September 25 - 28th, 2017, Hamburg, Germany (eds. A. Bögle, M. Grohmann)</li> <li>5. L. Blandini, G. Nieri und W. Sobek, „Das Schalentragwerk des Kuwait International Airport Terminal 2 – Bemessung und Ausführung einer komplexen Megastruktur in Zeiten der Digitalisierung“, Stahlbau, Bd. 88, Nr. 3, S. 194-202, 2019, doi: 10.1002/stab.201900017.</li> <li>6. G. Nieri, L. Blandini, and W. Sobek, „Kuwait International Airport Terminal 2: detailed design and fabrication of a large-span composite shell“, in Form and Force, IASS Symposium, October 7-10, 2019, Barcelona, 2019, pp. 2544-2553.</li> <li>7. M. Brunetti und L. Blandini, „Komplexität berechenbar machen: das parametrische Engineering des Kuwait International Airport“, in 14. Fachtagung Baustatik – Baupraxis, 23.-24. März 2020, Stuttgart, 2020, S. 367-374.</li> <li>8. A. Schuster, L. Blandini, and T. Spiegelhalter, „Parametric-algorithmic automated modeling and fabrication: the railway station Stuttgart 21“, in Post-parametric automation in design and construction, A. Andia and T. Spiegelhalter, eds. Boston: Artech House, 2015, pp. 89-98.</li> <li>9. L. Blandini, T. Schmidt, and W. Sobek, „Customized algorithmic engineering of a curved cable-stayed façade: the Enzo Ferrari Museum, Modena, Italy“, in Post-parametric automation in design and construction, A. Andia and T. Spiegelhalter, eds. Boston: Artech House, 2015, pp. 131-139.</li> </ol>		

10. Kovaleva D, Gericke O, Wulle F, Mindermann P, Sobek W, Verl A, Gresser G. Rosenstein Pavilion: a lightweight concrete shell based on principles of biological structures. In: Knippers J, Schmid U, Speck T (ed.) Biomimetics for Architecture: Learning from Nature. Berlin, Boston: Birkhäuser; 2019. p.92-101. <https://doi.org/10.1515/9783035617917-012>
11. D. Kovaleva, O. Gericke, J. Kappes, I. Tomovic, W. Sobek. „Rosenstein Pavilion: Design and structural analysis of a functionally graded concrete shell”, Structures, 2019, pp.91-101
12. Wörner, M., Schmeer, D., Schuler, B., Pfinder, J., Garrecht, H., Sawodny, O. and Sobek, W. (2016), Gradientenbetontechnologie: Von der Mischungsentwicklung über den Bauteilentwurf bis zur automatisierten Herstellung. Beton- und Stahlbetonbau, 111: 794-805. <https://doi.org/10.1002/best.201600056>
13. B. Kromoser, O. Gericke, W. Sobek (2018). Implants for load introduction into thin-walled CFRP-reinforced UHPC beams. Composite Structures. 194. 10.1016/j.compstruct.2018.03.044.
14. B. Kromoser, O. Gericke, M. Hammerl, W. Sobek (2019). Second-Generation Implants for Load Introduction into Thin-Walled CFRP-Reinforced UHPC Beams: Implant Optimisation and Investigations of Production Technologies. Materials 2019, 12, 3973; doi:10.3390/ma12233973
15. L. Blandini, A. Braun und E. Wolgast, „BIM bei komplexen Megaprojekten: BIM-Projekt Kuwait International Airport“, Build-Ing, Bd. 2, Nr. 4, S. 20-31, 2019.
16. L. Blandini, „Paradigmenwechsel – was bedeutet die digitale Revolution für die Ausbildung der Studierenden im Bauwesen?“, in Building Information Modeling 2019, Berlin: Ernst & Sohn, 2019, S. 36
17. B. Blagojevic, B. Schönemann, D. Nigl, L. Blandini, and O. Sawodny, „Trajectory Planning for Concrete Element Fabrication with Optimal Control“, in IECON 2021 – 47th Annual Conference of the IEEE Industrial Electronics Society, October 13-16, 2021, Toronto, Canada, 2021, doi: 10.1109/IECON48115.2021.9589695.
18. L. Blandini, T. Noack, A. Schuster, and W. Sobek, „Structural modelling of the railway station Stuttgart 21“, in 23. SOFiSTiK-Seminar, 20.-21. April 2012, Köln, 2012, paper V14.
19. S. Kalmbach, W. Haase, W. Sobek. Anwendung von Methoden des maschinellen Lernens zur ganzheitlichen Raumregelung, Gebäudetechnik, 2020

8.2. Applications/Seminars	Teaching methods	Notes
1. Parametric design of a reinforced concrete element for digital fabrication. (12 hours)	Exposure, workshop, applications	Eurocode 1 Eurocode 2
2. Presentation of the project by teams. (2 hours)		

#### Bibliography

1. P. Debney, „Computational Engineering“, The Institution of Structural Engineers, 2020.
2. M. Juhász, J.Szalai, Á.Kis, „Hungexpo Arrival Hall Project – A real case study on advanced parametric BIM workflow“, 2020
3. O. Gericke et al., „Holistic Quality Model and Assessment—Supporting Decision-Making towards Sustainable Construction Using the Design and Production of Graded Concrete Components as an Example“, Sustainability, 2022
4. L. Blandini and G. Nieri, „Kuwait International Airport Terminal 2: engineering and fabrication of a complex parametric megastructure“, in Fabricate 2020, September 9-12, 2020, London, 2020, pp. 84-91.

5. L. Blandini, A. Schuster, and W. Sobek, „The railway station Stuttgart 21 : structural modelling and fabrication of double curved concrete surfaces“, in Computational Design Modelling, 3rd Design Modelling Symposium, October 7-12, 2011, Berlin, Berlin, Heidelberg, 2011, pp. 217-224.

**9. Bridging course contents with the expectations of the representatives of the community, professional associations, and employers in the field**

The acquired competences will serve the employees who are working in design offices or manufacturing companies in constructions.

**10. Evaluation**

Activity type	10.1 Assessment criteria	10.2 Assessment methods	10.3 Weight in the final grade
10.4 Course	Solving two subjects of theory and a case study.	Written test (theory): 1,0 hour	25 %
		Written test (Case Study): 0,5 hour	25 %
10.5 Applications	Presentation and arguing the project. Project evaluation.	Verification and discussion	50 %
10.6 Minimum standard of performance			
Project evaluation: Evaluation of the project must be minimum 6.			
Solving two subjects of theory for minimum 5; solving the case study for minimum 6.			
Attendance to minimum 7 lectures and minimum 6 applications.			

Date of filling in:		Title Surname Name	Signature
25.06.2024	Lecturer	Conf. dr. ing. PUSKÁS Attila	
		Ș.l. dr. ing. TOADER Traian-Nicu	
	Teachers in charge of application	Conf. dr. ing. PUSKÁS Attila	

Date of approval in the Department Structures	Head of department
<u>27.06.2024</u>	Conf. dr. ing. PUSKÁS Attila
Date of approval in the Faculty of Civil Engineering	Dean
<u>12.07.2024</u>	Prof. dr. ing. MANEA Daniela-Lucia