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| **Course code** | CC4 |
| **Type and description** | CC 4 – program basis for Civil Engineering and Transportation  |
| **ECTS credit** | 1 |
| **Course name** | **Reliability and Optimization in Civil Engineering II**  |
| **Course name in Polish** | **Niezawodność i Optymalizacja w Budownictwie II**  |
| **Language of instruction** | English |
| **Course level** | 8 PRK |
| **Course coordinator**  | **Prof. dr hab. inż. Marcin Kamiński**  |
| **Course instructors** | **Prof. dr hab. inż. Marcin Kamiński**  |
| **Delivery methods and course duration** |

|  | **Lecture** | **Tutorials** | **Laboratory** | **Project** | **Seminar** | **Other** | **Total of teaching hours during semester** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Contact hours | 15 |  |  | 15 |  | 0 | 30 |
| E-learning | No | No | No | No | No | No |  |
| Assessment criteria (weightage) | 0,50 |  |  | 0,50 |  | 0,00 | 1,00 |

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| **Course objective** | 1. The first objective of the course is presentation of the fundamental definitions, theorems and methods in reliability analysis of civil engineering structures according to various order theories and its application and importance in engineering. 2. The second objective is presentation of structural sensitivity problem and an overview of different theories and methods in this area. 3. The next objective is presentation of the basic definitions and theorems concerning structural optimization in both linear and nonlinear ranges including cost function, constraints as well as non-gradient and gradient approaches. Various numerical methods enabling for determination of an optimal solution in linear, quadratic and nonlinear programming problems are to be presented. 4. Finally, computational implementation for all the aforementioned methods and structural state functions in computer algebra program MAPLE will be presented including numerical visualization and parametric discussion of the results achieved.  |
| **Learning outcomes** | PhD student will be able after this course: 1. to define the reliability index, to list its admissible numerical values and also to demonstrate the basic analytical formulas for simple civil engineering applications (W1); 2. to determine the reliability indices according to the first and the second order theories using Monte-Carlo simulation, semi-analytical method as well as due to higher order stochastic perturbation technique (W1); 3. to define sensitivity coefficient and to propose various methods of its determination in different engineering problems (W1); 4. to determine sensitivity coefficients with the use of analytical methods, central finite difference method, semi-analytical method as well as direct differentiation method (W1); 5. to list and to describe various optimization methods applied in civil engineering problems (W1); 6. to determine solutions of the optimization problems without and with constraints for engineeirng problems with deterministic design parameters (U1); 7. to solve stochastic optimization problems with reliability indices constraints (U2); 8. to propose efficient numerical methods for a solution of the given engineering problem including reliability, sensitivity and optimization and to discuss the differences resulting from various numerical methods in this context (K1); 9. to optimize structural mass of the steel structure accounting for stochastic corrosion process (U1). |
| **Assessment methods** | Double assessment method is foreseen for the learning outcomes from this course – using a project, and separately, by the oral exam. The main aim of the project is to solve some stochastic optimization problem based on reliability of some civil engineering structure and it will include assessment of (a) analytical symbolic calculus, (b) determination of the key design parameter for the given case study, (c) its randomization using Monte-Carlo, semi-analytical and stochastic perturbation methods, (d) optimization of the structure mass using the constraints defined using reliability indices in the selected limit functions. A verification of this part is completed in an electronic way, using on-line consultations. The second part consists of the oral exam verifying fundamental information presented during the lecture and contained in the project and can be completed after successful presentation of the project. Assessment methods for the particular learning outcomes: the outcomes no 1, 3, 5, 8, 9 will be verified during oral exam, while the outcomes no 2, 4, 6, 8, 9 will be verified during presentation and discussion of the project. A final grade from this course consists from oral exam grade (50%) as well as presentation and defence of the project (50%). |
| **Prerequisites** | PhD candidate for this course should have the knowledge concerning mathematical analysis (linear algebra, probability theory) as well as computer science (visualization techniques) necessary for computer algebra programing or higher level programming language as well as all fundamental information delivered at the first part of this course. |
| **Course content with delivery methods** | LECTURE discusses the following topics: 1. basic definitions, theorems and properties in reliability assessment – catastrophe probability, safety index, reliability index and discussion of the engineering codes selected statements also; 2. fatigue loads and effects in civil engineering structures, fundamental theories concerning material and structural fatigue failure; 3. presentation of the definition as well as various methods of structural sensitivity approximation, and also of numerical analysis of sensitivity coefficients of civil engineering structures in linear elastic range, in large irreversible deformations and for heat transfer and thermo-elastic processes; 4. basic definitions and theorems in single and multicriterial optimization, linear, quadratic and nonlinear optimization problems with examples programmed in computer algebra system MAPLE; 5. presentation of the basic non-gradient (deterministic and stochastic) as well as gradient methods including especially Newton, Newton-Raphson as well as Broyden-Fletcher-Goldfarb-Shanno (BFGS) techniques; 6. application of the Finite Element Method and its stochastic extension as well as computer algebra programs for reliability, sensitivity and optimization problems; 7. application of the optimization apparatus supported with reliability analysis for statistical prognosis of civil engineering materials and structures. OTHER FORMS The lectures are supported with the presentations and exemplary computer programs coded in MAPLE as well as with lecturer webpage {http://www.kmk.p.lodz.pl/pracownicy/kaminski/index.htm} including online consultation of the project progress and of other issues concerning this course.  |
| **Basic reference materials** | [1] J. Murzewski, Niezawodność konstrukcji inżynierskich. Arkady, Warszawa, 1989. [2] W. Pogorzelski, Teoria systemów i metody optymalizacji. OWPW, Warszawa, 1996. [3] R.T. Haftka, Z. Guerdal, Elements of Structural Optimization. Springer, Amsterdam, 1992.  |
| **Other reference materials** | [1] M. Sysło, N. Deo, J.S. Kowalik, Algorytmy optymalizacji dyskretnej z programami w języku PASCAL. PWN, Warszawa, 1999. [2] M. Kleiber, Handbook of Computational Solid Mechanics. Springer Verlag, Berlin-Heidelberg, 1998. |
| **Average student workload outside classroom** | 20 h  |
| **Comments** | Not applicable  |
| **Last update** | 04.04.2019  |