<table>
<tr><td>Course code</td><td></td></tr>
<tr><td>Type and description</td><td>EC– Elective Course in Discipline: Civil engineering and transport</td></tr>
<tr><td>ECTS credit</td><td>1</td></tr>
<tr><td>Course name</td><td>Innovative Systems for Structural Reinforcement and Strengthening</td></tr>
<tr><td>Course name in Polish</td><td>Innowacyjne systemy zbrojenia i wzmacniania konstrukcji</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>dr hab. inż. Renata Kotynia, profesor uczelni</td></tr>
<tr><td>Course instructors</td><td></td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td>0</td><td>0</td><td>5</td><td>0</td><td>0</td><td>5</td></tr>
<tr><td>E-learning</td><td>no</td><td>no</td><td>no</td><td>yes</td><td>no</td><td>no</td><td>yes</td></tr>
<tr><td>Assessment criteria (weightage)</td><td>0</td><td>0</td><td>0</td><td>100%</td><td>0</td><td>0</td><td>100%</td></tr>
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<tr><td>Course objective</td><td>1. The aim of the course is to provide knowledge on:
1a) new types and technologies of structural reinforcement from traditional steel reinforcement to modern various types of Fiber Reinforced Polymer (FRP).
1b) new techniques of structural strengthening using the FRP Externally Bonded (EB) and Near Surface Mounted (NSM) materials.

2. Presentation of structural design methods using different types of structural reinforcement in new concrete structures and existing concrete structures strengthened with FRP materials.

3. Effectiveness analysis of the FRP reinforcement type according to qualitative, quantitative and economic parameters.</td></tr>
<tr><td>Learning outcomes</td><td>A PhD student can do it after completing the course:

1. Characterise the material from the point of view of strength and its physical properties; properly select the reinforcement type with regard to the exposure of the external environment - effects W1, U2, K3

2. Describe the conditions for selection of the reinforcement type to the type of structure and external actions - effects W2, U1, K1-K3

3. Structural design based on the design codes, external actions and the type of the structure - W2, U1, K2

4. Make a comparative analysis of the proposed solutions in the context of different types of reinforcement - W2, U2, K3</td></tr>
<tr><td>Assessment methods</td><td>Methods of verifying learning outcomes

The verified effect - presentation of the project on the basis of a specific project task

The final evaluation consists of: Project score - 100%</td></tr>
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Prerequisites	
Course content with delivery methods	**A FRP RC MEMBER DESIGN** 1. Flexural design of continues beams 2. Flexural design of one-way slabs 3. Flexural design of two-way slabs 4. Shear design of beams 5. Long-term & durability evaluation 6. Fire design **B FRP PC MEMBER DESIGN** 7. Flexural design 8. Fire design **C. STRENGTHENING OF RC MEMBERS** 9. EBR - Flexural and shear strengthening 10. NSM - Flexural and shear strengthening 11. Confinement of columns 12. Beam-column joint **D. STRENGTHENING OF PC MEMBERS** 13. EBR - Flexural and shear strengthening 14. NSM - Flexural and shear strengthening
Basic reference materials	1. Materials by lecturer 2. R. Kotynia; "Wymiarowanie i kształtowanie wybranych konstrukcji betonowych ze zbrojeniem niemetalicznym". Wykład zamawiany. XXXIII Ogólnopolskie, Warsztaty Pracy Projektanta Konstrukcji, Szczyrk, 6-9.03.2018. s. 295-408 (113 stron) ISBN 978-83-930482-9-8 (in Polish) 3. ACI 440.1R-15 Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars, 2015 4. CSA S806-12: Design and construction of building structures with fibre reinforced polymers. Canadian Standards Association (CSA), 2012. 5. ISIS-M03-07 Reinforcing concrete structures with fiber reinforced polymers. Canadian network of centers of excellence on intelligent sensing for innovative structures. Univ. of Winnipeg, Winnipeg, 2007. 6. Japan Society of Civil Engineers Recommendation for design and construction of concrete structures using continuums fiber reinforcing materials. Concrete Engineering Series JSCE, no.23, 325, 1997. 7. ACI 440.2R-08, 2008. Guide for the design and construction of externally bonded FRP systems for strengthening concrete structures. MI, USA.24. 8. Fib Bulletin 14, 2001. Externally Bonded FRP Reinforcement for RC Structures. Technical Report, Lusanne, Switzerland. 9. Fib Bulletin 90, 2019. Externally applied FRP reinforcement for concrete structures. Technical report prepared by a working party of the T5.1 FRP reinforcement for concrete structures. 10. JSCE, 2001. Recommendations for the upgrading of concrete structures with use of continuous fiber sheets. Journal of Concrete Engineering, Series 41, Japanese Society of Civil Engineers, Tokyo. 11. Technical Report no 55, 2000. Design guidance for strengthening concrete structures using fiber composite materials. Concrete Society, London. 12. [CNR-DT 200, 2004. Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Existing Structure. National Research Council, Advisory Committee on Technical Recommendations for Construction, Roma. 13. CNR DT200/2013, 2013. Istruzioni per la Progettazione, l'Esecuzione ed il Controllo di Interventi di Consolidamento Statico mediante l'utilizzo di Compositi Fibrorinforzati, Roma. 14. SIA166, 2004. Klebebewehrungen (Externally bonded reinforcement). Zurich, Switzerland, Schweizerischer Ingenieur- und Architektenverein, SIA. 15. [DAfStb-Guideline, 2014. Strengthening of concrete members with adhesively bonded reinforcement. Deutscher Ausschuss für Stahlbeton, Beuth, Berlin. pp. 148.

	16. Mazzotti, C., Bilotta, A., Carloni, C., Ceroni, F., D'Antino, T., Nigro, E., Pellegrino C. 2016. "Bond between EBR FRP and concrete, in: Design procedures for the use of composites in strengthen.ng of reinforced concrete structures", Springer. DOI:10.1007/978-94-017-7336-2. 17. Kotynia R. 2019. "FRP Composites for flexural strengthening of concrete structures theory, testing, design". Publisher Lodz University of Technology, pp. 240. DOI:org/10.34658/9788372839961.
Other reference materials	
Average student workload outside classroom	15 h
Comments	
Last update	July 2020