AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

Module name: Theory of elasticity and plasticity

Academic year: 2019/2020 Code: GBUD-2-105-GE-s ECTS credits: 2

Faculty of: Mining and Geoengineering

Field of study: Civil Engineering Specialty: Geotechnical Engineering and Underground Construction

Study level: Second-cycle studies Form and type of study: Full-time studies

Lecture language: English Profile of education: Academic (A) Semester: 1

Course homepage: —

Responsible teacher: dr hab. inż. Jakubowski Jacek (Jacek.Jakubowski@agh.edu.pl)

Module summary

Basic concepts, principles and equations of the theory of elasticity and plasticity. Problem solving with the use of numerical and symbolic calculations.

Description of learning outcomes for module

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Connections with FLO	Method of learning outcomes verification (form of completion)
Social competence: is able to			
M_K001	Is aware of the scope of their current knowledge and understands the need for constant self-education and self-development	BUD2A_K01	Oral answer, Test, Activity during classes
Skills: he can			
M_U001	The Student can use the description of the state and field of stress, strain and displacement to solve problems using numerical and symbolic calculations.	BUD2A_U03	Oral answer, Test, Activity during classes
M_U002	The student can use the equations of the theory of elasticity to solve problems using numerical and symbolic calculations.	BUD2A_U03	Oral answer, Test, Activity during classes
Knowledge: he knows and understands			
M_W001	The student knows the basic equations and boundary conditions of the linear theory of elasticity and its relations with energy.	BUD2A_W01	Oral answer, Test, Activity during classes

M_W002	The student knows the basic concepts of the theory of plasticity, models of bodies in the theory of plasticity, yield criteria.	BUD2A_W01	Oral answer, Test, Activity during classes

Number of hours for each form of classes

	Form of classes										
Suma	Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
45	30	0	15	0	0	0	0	0	0	0	0

FLO matrix in relation to forms of classes

MLO code	Student after module completion has the knowledge/ knows how to/is able to	Form of classes										
		Lectures	Auditorium classes	Laboratory classes	Project classes	Conversation seminar	Seminar classes	Practical classes	Fieldwork classes	Workshops	Prace kontrolne i przejściowe	Lektorat
Social competence: is able to												
M_K001	Is aware of the scope of their current knowledge and understands the need for constant self-education and self-development	+	-	+	-	-	-	-	-	-	-	-
Skills: he can												
M_U001	The Student can use the description of the state and field of stress, strain and displacement to solve problems using numerical and symbolic calculations.	+	-	+	-	-	-	-	-	-	-	-
M_U002	The student can use the equations of the theory of elasticity to solve problems using numerical and symbolic calculations.	+	-	+	-	-	-	-	-	-	-	-
Knowledge: he knows and understands												
M_W001	The student knows the basic equations and boundary conditions of the linear theory of elasticity and its relations with energy.	+	-	+	-	-	-	-	-	-	-	-

M_W002	The student knows the basic concepts of the theory of plasticity, models of bodies in the theory of plasticity, yield criteria.	+	-	+	-	-	-	-	-	-	-	-

Student workload (ECTS credits balance)

Student activity form	Student workload
Udział w zajęciach dydaktycznych/praktyka	45 h
Preparation for classes	15 h
Summary student workload	60 h
Module ECTS credits	2 ECTS

Additional information

Module content

Lectures

Elements of tensor calculus, index notation and conventions. Stress vector – tensor formula. Transformation matrix. Transformation of the vector, the coordinate system and the tensor. Dyadics. The problem of principal stresses and principal directions. Stress axiator and deviator. Particular stress conditions. Stress field and differential equations of equilibrium. Displacement field and gradient. Almansi, Green and Cauchy strain tensors. Rotation tensor. Geometric interpretation of the components of strain tensor and rotation tensor. Transformation of the strain tensor, properties of the strain tensor. Strain axiator and deviator. Strain compatibility equations. Shear and purely amorphous deformation. Hooke’s physical equations. Law on form and volume change. Hooke’s equation for anisotropic medium. Basic equations and problems of the linear theory of elasticity with boundary conditions. Synthetic equations: Lame’s and Beltrami-Michell’s equations. Reverse method, static approach and kinematic approach. Airy stress functions. The principle of virtual work. Clapeyron theorem. Elastic energy, axiatoric and deviatoric energy. Stress and strain potential. Betti reciprocal work theorem. The principle of minimum potential energy. The principle of minimum complementary energy. Plasticity and theory of plasticity. Definitions. Material models in the theory of plasticity. Plasticity potential. Reinforcement. Strength criteria for ductile materials and brittle materials.

Laboratory classes

Problems solved with Matlab or another engineering tool for numerical and symbolic calculations: Stress vector – tensor formula. Transformation of the stress tensor. Principal stresses and principal directions. Principal values for deviator. Plane stress. Strain tensor. Displacements, strain and rotation fields. Physical equations. Stress field and differential equations of equilibrium. Airy’s function and boundary loads. Elastic energy. Reduced stress and comparison of strength criteria.

Teaching methods and techniques:

Lectures: Treści prezentowane na wykładzie są przekazywane w formie prezentacji multimedialnej w połączeniu z klasycznym wykładem tablicowym wzbogaconymi o pokazy odnoszące się do prezentowanych zagadnień.
Laboratory classes: W trakcie zajęć laboratoryjnych studenci samodzielnie rozwiązują zadany problem praktyczny, dobierając odpowiednie narzędzia. Prowadzący stymuluje grupę do refleksji nad problemem, tak by otrzymane wyniki miały wysoką wartość merytoryczną.

Warunki i sposób zaliczenia poszczególnych form zajęć, w tym zasady zaliczeń poprawkowych, a także warunki dopuszczenia do egzaminu:

Credit is obtained within the primary deadline and one retake. The final test covers the scope of both classes and lectures. Attendance in classes is mandatory. Attendance in lectures is recommended. Detailed assessment for classes is agreed by the lecturers at the beginning of the semester. Exceptions and temporary rules applicable in a given academic year will be presented at the first lecture.

Zasady udziału w poszczególnych zajęciach, ze wskazaniem, czy obecność studenta na zajęciach jest obowiązkowa:

Lectures:
– Attendance is mandatory: No
– Participation rules in classes: Studenci uczestniczą w zajęciach poznając kolejne treści nauczania zgodnie z syllabusem przedmiotu. Studenci winni na bieżąco zadawać pytania i wyjaśniać wątpliwości. Rejestracja audiowizualna wykładu wymaga zgody prowadzącego.
Laboratory classes:
– Attendance is mandatory: Yes
– Participation rules in classes: Studenci wykonują ćwiczenia laboratoryjne zgodnie z materiałami udostępnionymi przez prowadzącego. Student jest zobowiązany do przygotowania się w przedmiocie wykonywanego ćwiczenia, co może zostać zweryfikowane kolokwium w formie ustnej lub pisemnej. Zaliczenie zajęć odbywa się na podstawie zaprezentowania rozwiązania postawionego problemu. Zaliczenie modułu jest możliwe po zaliczeniu wszystkich zajęć laboratoryjnych.

Method of calculating the final grade

The final grade is the same as the score for passing classes. Attendance and activity at lectures may be rewarded by raising the grade.

Sposób i tryb wyrównywania zaległości powstałych wskutek nieobecności studenta na zajęciach:

Excused absence from classes can be made up for with another group, with the consent of both lecturers and provided that the class covers the same topic.

Prerequisites and additional requirements

Prerequisites and additional requirements not specified

Recommended literature and teaching resources

1. Timoshenko S.P., Goodier J.N. / Theory of Elasticity / McGraw-Hill Books Company
2. Starovoitov E., Bakhman F. Naghiyev O. / Foundations of the Theory of Elasticity, Plasticity, and Viscoelasticity / CRC Press
3. Westergaard, H. M. / Theory of Elasticity and Plasticity / Harward University Press
4. Matlab User Manual

Scientific publications of module course instructors related to the topic of the module

1. Local buckling of highly corroded hot-rolled box-section beams / Przemysław FIOŁEK, Jacek JAKUBOWSKI // Journal of Constructional Steel Research ; ISSN 0143-974X. — 2019 vol. 157, s. 359–370.

2. Code calculations for local stability of shaft guides / Przemysław FIOŁEK, Jacek JAKUBOWSKI, Kamil TOMCZAK // Studia Geotechnica et Mechanica ; ISSN 0137-6365. — 2017 vol. 39 nr 3, s. [1–9].
3. The effects of age, cement content, and healing time on the self-healing ability of high-strength concrete / Kamil TOMCZAK, Jacek JAKUBOWSKI // Construction and Building Materials ; ISSN 0950-0618. — 2018 vol. 187, s. 149–159.
4. Uogólnienia metody elementów skończonych w inżynierskich symulacjach numerycznych ośrodka nieciągłego i dyskretnego / Jacek JAKUBOWSKI // Górnictwo i Geoinżynieria / Akademia Górniczo-Hutnicza im. Stanisława Staszica, Kraków ; ISSN 1732-6702. — 2010 R. 34 z. 2, s. 325–340.

Additional information

Credit is obtained within the primary deadline and one retake. The final test covers the scope of classes and lectures. Attendance in classes is mandatory. If a student had skipped more than 20% of the classes, he or she cannot get credit and shall not be allowed to pass the retake. Excused absence from classes can be made up for with another group, but only with the consent of both lecturers and provided that the class covers the same topic. Detailed assessment for classes is agreed by the lecturers at the beginning of the semester. Attendance at lectures is mandatory. Exceptions and temporary rules applicable in a given academic year will be presented at the first lecture.