8.7 CE0821 – Plastic Structural Analysis

(1) GENERAL

SCHOOL	ENGINEERING SCHOOL		
ACADEMIC UNIT	CIVIL ENGINEERING DEPARTMENT		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	**CE0821**	**SEMESTER**	**8**
COURSE TITLE	**Plastic Structural Analysis**		

INDEPENDENT TEACHING ACTIVITIES *if credits are awarded for separate components of the course, e.g. lectures, laboratory exercises, etc. If the credits are awarded for the whole of the course, give the weekly teaching hours and the total credits*	**WEEKLY TEACHING HOURS**	**CREDITS**
	4	5
Add rows if necessary. The organisation of teaching and the teaching methods used are described in detail at (d).		

COURSE TYPE *general background, special background, specialised general knowledge, skills development*	Specialisation Course
PREREQUISITE COURSES:	
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	Greek
IS THE COURSE OFFERED TO ERASMUS STUDENTS	
COURSE WEBSITE (URL)	https://eclass.uniwa.gr/modules/auth/opencourses.php?fc=69

(2) LEARNING OUTCOMES

Learning Outcomes

The course learning outcomes, specific knowledge, skills and competences of an appropriate level, which the students will acquire with the successful completion of the course are described.

Consult Appendix A

- *Description of the level of learning outcomes for each qualifications cycle, according to the Qualifications Framework of the European Higher Education Area*
- *Descriptors for Levels 6, 7 & 8 of the European Qualifications Framework for Lifelong Learning and Appendix B*
- *Guidelines for writing Learning Outcomes*

The aim of the course is to give the students fundamental concepts of the plastic bending theory, the plastic analysis of structures and their relation to structural behavior and design. The knowledge and understanding of material nonlinearity, structural member behavior at cross sectional level, limit load and bearing capacity of structural members as well as plastic hinging sequence and formation is of significant importance for the calculation of the global collapse mechanism of a structure.

Upon completion of the course, students will have:

1. Basic knowledge of plastic theory.
2. Basic knowledge of material nonlinearities.
3. In-depth knowledge and critical understanding of the basic theorems of plastic analysis.
4. Knowledge and understanding of plastic mechanisms of simple structures, as well as global mechanism formations of more complex buildings.

5. Knowledge and understanding of the rationale of capacity design concept for the controlled seismic response of structures.

Specifically, students will be able to:

1. Apply the plastic bending theory.
2. Have adequate comprehension skills of nonlinear analysis at cross sectional level.
3. Evaluate the plastic moment of simple structural sections symmetrical or non-symmetrical.
4. Evaluate the plastic mechanism and calculate the corresponding collapse load of simple beams under point or distributed loads.
5. Evaluate all the possible plastic mechanisms of a statically intederminant structure.
6. Evaluate the plastic mechanism, the collapse load and the plastic deformations of simple structures using the step by step method.
7. Build the mathematical model of a structure, evaluate the capacity curve and the collapse mechanism under various combinations of vertical (gravitational) and horizontal (seismic) loads.

General Competences

Taking into consideration the general competences that the degree-holder must acquire (as these appear in the Diploma Supplement and appear below), at which of the following does the course aim?;.

Search for, analysis and synthesis of data and information, with the use of the necessary technology	*Project planning and management*
Adapting to new situations	*Respect for difference and multiculturalism*
Decision-making	*Respect for the natural environment*
Working independently	*Showing social, professional and ethical responsibility and sensitivity to gender issues*
Team work	*Criticism and self-criticism*
Working in an international environment	*Production of free, creative and inductive thinking*
Working in an interdisciplinary environment	*……*
Production of new research ideas	*Others…*

Specifically, students will be able to perform:

- Search for, analysis and synthesis of data and information, with the use of the necessary technology for the plastic analysis of structures.
- Production of new research ideas for the conceptualization and analysis of structures in the post-elastic region.
- Autonomous work. Knowledge of regulations and specifications related to the analysis and the design methods.
- Team work and effective criticism.
- Production of free, creative and inductive thinking.

(3) SYLLABUS

- Introduction to plastic theory. Basic hypotheses of plastic behavior. Plastic hinge assumption. Nonlinearity types. Basic force-deformation relations of structures.
- Elastoplastic behavior. Stress-strain relation for ductile materials and steels. Moment-curvature relationship. Ductile behavior.
- Elastic and plastic design. Ultimate limit state design. Plastic design and structural codes. Limitations of plastic design.
- Introduction to plastic bending. Plastic hinge. Plastic hinge length.
- Elastic-plastic bending. Evaluation of plastic moment. Elasto-plastic analysis of rectangular cross section. Section with a single axis of symmetry. Effect of upper yield stress. Shape factor.
- Biaxial bending. Idealized steel sections. Effect of shear force on plastic moment. Effect of normal axial force on plastic moment. Combined axial force – bending moment. Normal force and bending moment interaction diagrams. Residual stresses.
- Introduction to elastic-plastic analysis. Simple cases of plastic collapse. Simply supported beam. Load-deflection relation for simply supported beam. Plastic collapse load of simply supported beam.
- Fixed-ended beam. Direct evaluation of the plastic collapse load. Unloading behavior. Continuous beams. Elastic-plastic analysis of simple rectangular portal frame.
- Basic theorems of plastic analysis. Equation of virtual work. Static theorem. Kinematic theorem. Uniqueness theorem.

- Combination of plastic mechanisms. Distributed loads. Work method. Multi-story and multi-bay frames.
- Estimates of deflections at point of collapse. Assumptions and basic equations. Minimum weight plastic design. Linear programming.
- Stiffness matrix for elastic beam element. Stiffness matrix for a beam with plastic hinges at one or both ends. Numerical procedure for first-order plastic analysis.
- Nonlinear static analysis. Step by step solution. Influense of gravitational loads. Capacity curve. Global and local mechanism. Limit load. Plastic rotation limit states. Displacement based evaluation of structural capacity.

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY *Face-to-face, Distance learning, etc.*	Face-to-face
USE OF INFORMATION AND COMMUNICATIONS TECHNOLOGY *Use of ICT in teaching, laboratory education, communication with students*	PowerPoint presentations. Online educational material, digitized bibliography, interactive stuff. Communication with students via announcements, email, Skype or MSTeams.
TEACHING METHODS *The manner and methods of teaching are described in detail.* *Lectures, seminars, laboratory practice, fieldwork, study and analysis of bibliography, tutorials, placements, clinical practice, art workshop, interactive teaching, educational visits, project, essay writing, artistic creativity, etc.* *The student's study hours for each learning activity are given as well as the hours of non- directed study according to the principles of the ECTS*	(see table below)
STUDENT PERFORMANCE EVALUATION *Description of the evaluation procedure* *Language of evaluation, methods of evaluation, summative or conclusive, multiple choice questionnaires, short-answer questions, open- ended questions, problem solving, written work, essay/report, oral examination, public presentation, laboratory work, clinical examination of patient, art interpretation, other* *Specifically-defined evaluation criteria are given, and if and where they are accessible to students.*	Language of Evaluation: Greek. Final written examination (60%) with problem solving (formative, concluding). Preparation of mid term assignments (40%) which will be delivered at the end of each thematic session. Explanations are given for the evaluation criteria at the beginning and during the courses and the relative weight of the topics and the criteria of the final written examination are pointed out. The implementation of these criteria is easily accessible and can be checked by each student, as there is a short commentary on the written intermediate assignments/problems and on the exam, which can be seen and discussed by the student with the teacher.

Activity	*Semester Workload*
Lectures	52
Personal Study & Analysis of Literature	52
Assignements	21
Course Total	**125**

(5) ATTACHED BIBLIOGRAPHY

Greek Bibliography:

1. Papadrakakis M. (2013), Structural Analysis V, Plastic analysis of framed structures, Modern Methods, Tsotras An. Athanasios Publications, ISBN: 978-618-5066-02-4, Athens (in Greek).
2. Gantes Ch.I. (2015), Non-linear behavior of structures, Hellenic Academic EBooks, ISBN: 978-960-603-388-9, Athens (in Greek).
3. Kirtas E., Panagopoulos G. (2015), Computer modelling of structures – Applications using SAP 2000 structural analysis software, Hellenic Academic EBooks, ISBN 978-960-603-227-1, Athens (in Greek).

4. Papadrakakis M. (1996), Plastic analysis of framed structures – Modern methods, Publications N.T.U.A (in Greek).
5. Demetrios M. (1993), Plastic analysis and design of steel structures, Technical Chamber of Greece, Western Greece (in Greek).
6. Varkarakis K. (1985), Analysis and design of framed structures using plasticity theory, Publications N.T.U.A (in Greek).
7. Bairaktaris D. (1978), Static calculations in the post elastic region, Technical Chamber of Greece, Athens (in Greek).
8. Bairaktaris D. (1978), Introduction to plasticity theory (short notes), Technical Chamber of Greece, Athens (in Greek).
9. Bairaktaris D. (1978), Elasto-plastic analysis of structures (short notes), Technical Chamber of Greece, Athens (in Greek).
10. Kalevras B. (1978), Limit state analysis of framed reinforced concrete structures, Technical Chamber of Greece, Athens (in Greek).
11. Surmakezis P. (1978), Calculation of deformations of plane framed structures using the plastic hinge methods, Technical Chamber of Greece, Athens (in Greek).
12. Palasopoulos G. (1978), Examples of plastic analysis of framed structures with the use of computer, Technical Chamber of Greece, Athens (in Greek).

Foreign Bibliography:

1. Wong M.B. (2009), Plastic analysis and design of steel structures, Butterworth Heinemann, London, ISBN: 9780750682985.
2. Neal B.G. (1985), The plastic methods of structural analysis 3rd Edn., Chapman & Hall. London, ISBN: 978-0412214509.
3. Horne, M.R. and Morris, L.J. (1982), Plastic design of low-rise frames (structural mechanics) (1st Edition), The MIT Press, ISBN: 978-0262081238.
4. Rees D.W.A. (2000), Mechanics of solids and structures, Imperial College Press, London, ISBN: 978-1860942181.
5. Baker J.F., Horne M.R. and Heyman J. (1956), The steel skeleton, volume II, Plastic behaviour and design, Cambridge University Press, ISBN: 978-0521040884.
6. McKenzie W.M.C. (2006), Examples in structural analysis (1st Edition), CRC Press, ISBN: 978-0415370547.
7. Nethercot D. (2001), Limit states design of structural steelwork (3rd Edition), CRC Press, ISBN: 978-0419260905.
8. Heyman J. (1957), Plastic design of portal frames, Cambridge University Press, London, ISBN: 9781001282435.
9. Baker J.F. and Heyman J. (1969), Plastic design of frames, Vol. 1: Fundamentals, Cambridge University Press, London, ISBN: 9780511586514.
10. Heyman J. (1971), Plastic design of frames, Vol. 2: Applications, Cambridge University Press, London, ISBN: 978-0521079846.
11. Bruneau M., Uang C.M. and Sabelli S.E.R. (2011), Ductile design of steel structures, McGraw-Hill Education, New York, ISBN: 978-0071623957.
12. Hodge P.G. (1959), Plastic analysis of structures, McGraw-Hill, New York, ISBN: 978-0070291294.
13. Davies J.M. and Brown B.A. (1996), Plastic design to BS5950, Willey-Blackwell Science, Oxford, ISBN: 9780632040889.
14. Heyman J. (1974), Beams and framed structures (2nd Edition), Pergamon Press, ISBN: 9781483160580.
15. Heyman J. (1996), Elements of the theory of structures, Cambridge University Press, ISBN:978-0521550659.
16. Neal B.G. (1964), Structural theorems and their applications, Pergamon Press, ISBN: 9781483139029.
17. Thompson F. and Haywood G.G. (1986), Structural analysis using virtual work, Chapman and Hall, ISBN: 978-0412222801.
18. Tichy, M. (1977), Plastic analysis of concrete frames: (with particular reference to limit states design), Scholium International, ISBN: 978-0569081993.

Related academic journals:

1. Journal of Structural Engineering.
2. Journal of Applied Mechanics.
3. Engineering Structures.
4. Earthquake Engineering and Structural Dynamics.