



NATIONAL TECHNICAL UNIVERSITY OF ATHENS
SCHOOL OF CIVIL ENGINEERING

CURRICULUM GUIDE

ATHENS
2008 - 09

SCHOOL OF CIVIL ENGINEERING

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FORWARD

The School of Civil Engineering of the National Technical University of Athens, has undertaken the leadership in the education of civil engineering professionals and researchers in Greece, during its long period of operation.

The role that the School is playing in the social and economic life of the country is based on principles such as high quality standards, enthusiasm of the graduates in performing their duties, smooth communication between persons, valuing of each person's ideas and efforts, and recognition of achievements.

The determination, the specific goals in teaching and research and the hard work of all faculty members is an example to our students from whom we expect not only to be talented, efficient, and successful, but also to work hard towards excellent professional and research achievements in Greece and abroad.

The School is cooperating in scientific and educational programs with Civil Engineering Schools in Greece and abroad, mostly in Europe, but also in Asia, Africa and the Americas. We look forward to continue and extend this cooperation, and we will be very proud to welcome to our lecture halls and laboratories students, professors and researchers for the teaching and joint projects that will contribute and promote mutual understanding, friendship, scientific and engineering achievements.

I have to express my appreciation to all my colleagues for their efforts and their prompt co-operation until now and I look forward to welcoming to the School of Civil Engineering of NTUA distinguished students and faculty members of Higher Education Schools, Universities and Research Institutions.

Professor M. A. Mimikou
Dean of the School

1. A SHORT HISTORY OF NATIONAL TECHNICAL UNIVERSITY OF ATHENS

1.1. Foundation (1837)

Founded in 1837, almost along with the modern Greek State, NTUA is the oldest Technical University in Greece. Initially established by a royal decree “on architectural education” it was a technical school operating on Sundays and holidays which offered instruction to those desiring to master in architecture. Though at a remote location it soon attracted many students. Its popularity led to the extension of courses and by spring 1840 to the operation of a regular day school along with its Sunday counterpart. It was then moved to its own building on Piraeus Street. The joint efforts of students and instructors contributed to a continuous growth and to revising standards.

1.2. Early Performs

The school quickly introduced reforms to make it better able to respond to the domestic needs of reconstruction and industrial development. Studies reached the three years, enriched with new disciplines, and the administration was taken over by the Committee for the Encouragement of National Industry.

1.3. Installation (1871) to the Historical “Polytechnion”

The urgent needs for infrastructure to support ambitious plans of the school led to the 1871 transfer to new building on the Patission Street Complex. Their construction was first supported by Nikolaos Stournaris. In greek, NTUA is called “Ethnicon Metsovion Polytechnion”. It was named “Metsovion” to honor the donors and benefactors Nicolaos Stournaris, Eleni Tositsa, Michail Tositsas and Georgios Averof, all from Metsovo, a small town in the region of Epirus.

1.4. Towards Today's Structure and Organisation

After the introduction of a four-year degree course for civil and mechanical engineering, in 1887, the NTUA, was able to announce that it “educates high level engineers for the public service, industry and construction” as competent as “graduates from the well known engineering schools of Western Europe”. The final major reform of the organization and administration of NTUA took place in 1917. The “Ethnicon Metsovion Polytechnion” acquired five high level engineering schools: Civil, Mechanical and Electrical, Architecture, Chemical, and Surveying. Many subsequent changes since 1917, have led to its current form: a prestigious University of Science and Technology, with eight Engineering Schools and a ninth School of Applied Mathematical and Physical Sciences.

From 1960's NTUA is continuously expanding at the Zografou Campus, where eight of the nine Schools are now located. The School of Architecture remains at Patisision complex. High-specification infrastructure projects completed at NTUA include building of 300.000m² with fully equipped lecture theatres, laboratories and libraries, surrounded by a pleasant natural environment of 100 hectares. To each one of our 13.000 students, correspond 28m² of buildings, 10m² of lecture theatres and 100m² of outdoor green space. NTUA is pioneer in Greece and Eastern Mediterranean area in the cutting-edge field of telematic networks. Advanced capabilities of information society supported by a fully equipped and computerized Central Library are available to the NTUA members via intranet and data network services. To serve the rapid expansion of research needs, NTUA uses a strong Computer centre, equipped with advanced technology computer systems and nine special PC labs for all students in each on school.

The recent struggles against the military dictatorship of 1967 – 74 escalated with the student gathering at the NTUA Patisision Campus

on the 14th of February 1973, followed by an unprecedented brutal attack by the Police inside the campus and the arrest of several students. This was responded by demonstrations, the occupation of the Law School of the University of Athens on 23rd February, and again on the 20th March. Each of these demonstrations was met by force. The protest culminated in the greatest blow against the junta, the Polytechnion (NTUA) Uprising in November, 1973.

Events began on Wednesday, 14th November, and ended on November 17th 1973 with the unprovoked intervention of army tanks and the attack by the army and police against those besieged inside the NTUA Campus and the demonstrating supporters outside in Patisision Str. These few days saw the growth of an impressive popular uprising centered at NTUA. The people of Greece and the country's youth all rallied in support of the students, united around the ideas: Freedom, Democracy, Independence, Education, and Social Progress. The toll of the Polytechnion uprising was tragic. Several demonstrators were killed; many more were arrested by the military police and were tortured for months in military prisons.

The Junta fell a few months later and the Polytechnion is being commemorated every year on November the 17th by the students, high school pupils, the NTUA Senate, the democratic authorities, police parties, the Greek Parliament and the people of Greece.

The Polytechnion Uprising is an outstanding event in recent Greek history. NTUA honored the victims of the Uprising with a monument within its courtyard, opposite the gate which tanks of the dictatorship demolished that night. The monument was placed alongside the column commemorating the National Resistance. The two memorials emphasize the continued struggle of the Greek people and the country's youth over the years.

2. A SHORT HISTORY OF THE SCHOOL OF CIVIL ENGINEERING

The School of Civil Engineering was established in 1887, as one of the three "Schools of Industrial Arts", within the reorganization of the existing school as an Institution of Higher Education, with a four-year curriculum. The first 13 civil engineers graduated in 1890. In 1914 a new reorganization was performed and the institution was renamed as "Ethnikon Metsovion Polytechnion". In 1977 a major reorganization of the courses took place, while three cycles of studies were developed: Structural Engineering, Hydraulic Engineering and Transportation Engineering. Following the 1982 radical reform, by Law 1268/82, NTUA was divided into nine Faculties (Departments). Recently, the Faculty of Civil Engineering was renamed to School, thus retrieving its historical appellation, whereas a fourth cycle of study was established, Geotechnical Engineering.

2.1. Early period (1887-1890)

The Faculty of Civil Engineering was established by Law AFMA of May 27, 1887, as one of the three "Schools of Industrial Arts". The "School of Arts" already existed since in 1873, located at a building on Patision Street, under the name "Metsovion Polytechnion".

The 1887 Law on "the establishment of the School of Industrial Arts in Athens" was the result of many years of effort by the professors of that time, who assisted in the re-organization of the existing school as an Institution of Higher Education with a four-year curriculum.

The organization and operation of the School were specified in the Bylaw of July 3, 1887. The first article of the Bylaw includes the definition: "The School of Industrial Arts, now consisting of three specialized schools, has as its goal the scientific education of civil and mechanical engineers, similar to those graduating from Higher Schools in Europe, as well as the education of surveyors and foremen".

The first 13 civil engineers graduated in 1890. The School operated under this organization until 1914.

2.2. Reorganization of the School (1890-1917)

In 1912, Angelos Ghinis, Head of the School of Civil Engineering, published a history of the Polytechnion, which included a proposal to the State about the development of the school and the prospects of engineering education in the country, in line with the developments of technology and the expectations for the future.

Two years of effort produced Law 388 of November 1914. According to the first article of this Law the Polytechnion was renamed as "Ethnikon Metsovion Polytechnion". The second article of this Law, declared the already operating School of Civil Engineering as a school of university level education.

The efforts of Angelos Ghinis and his colleagues resulted in the reorganization of the courses, the issuing of Working Rules and the autonomy of the School in certain sectors. All these changes were made official by the Bylaw 388 of November 1915.

After 1915, the School of Civil Engineering functioned as a school with a five year curriculum. Further efforts led to Law 980 in 1917.

2.3. Establishment of the Higher School of Civil Engineering (1917-1977)

From the time of its establishment, the School of Civil Engineering had the largest number of professors and students. For a long period, it was the main student body of the Polytechnion. The growth of other departments closed the gap to some extent but the development of the school was still remarkable.

From 1935 onwards the "Ethnikon Metsovion Polytechnion" was known in English as the National Technical University of Athens (NTUA).

2.4. Integrated development (1977-1982)

In 1977 a major reorganization of the courses took place. Three cycles of studies were developed: Structural Engineering, Hydraulic Engineering and Transportation Engineering. The courses were also separated into basic courses, mandatory (for students in all three cycles), elective courses, and non-credit (optional) courses.

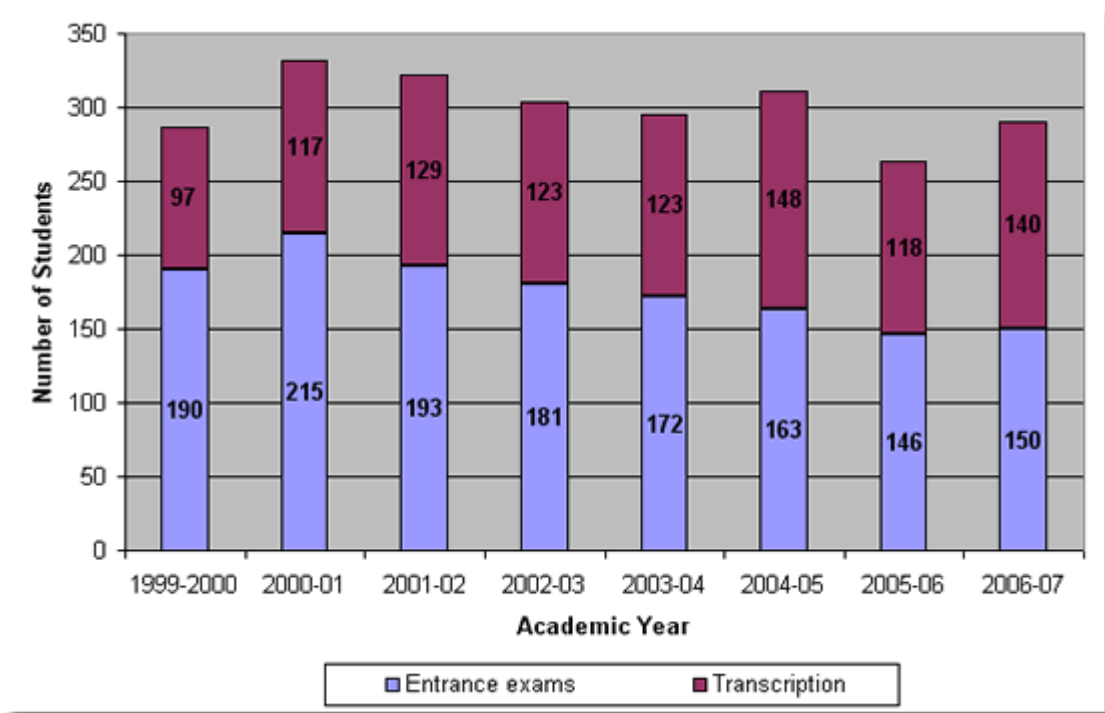
2.5. Recent period (1982 and after)

Following the last radical reform, by Law 1268/1982, NTUA was divided into nine Faculties (Departments). Eight of these award diplomas as follows:

- Civil Engineering
- Mechanical Engineering
- Electrical and Computer Engineering
- Architecture
- Chemical Engineering
- Rural and Surveying Engineering
- Mining and Metallurgical Engineering
- Naval Architecture and Marine Engineering

The ninth one, the Department of General Sciences, provided foundation courses to support the curriculum of the other Departments. From 1999-2000, all Departments were renamed to Schools, whereas the General Department was reformed to independent School with five-year curriculum, the School of applied Mathematics and Physical Sciences. The same year, the School of Civil Engineering established two Interdisciplinary Postgraduate Program Studies, in collaboration with other Schools of NTUA. From

2005-06 a fourth cycle of study was added to the undergraduate program course, Geotechnical Engineering.



Student Body of the School of Civil Engineering

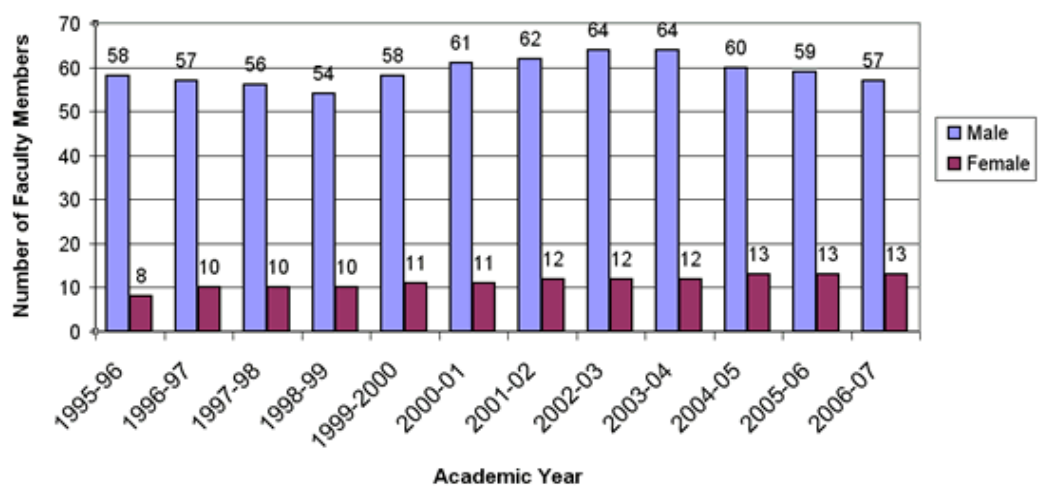
3. SCHOOL STRUCTURE

Dean: **M. A. Mimikou, Professor**

Vice Dean: **I. Ermopoulos, Professor**

Secretary: **V. Kousia**

Emeritus Professors: K. Abakoumkin
A.G. Anagnostopoulos
A. Armenakas
D. Christoulas
H. Efremidis
J.M. Frantzeskakis
J.T. Katsikadelis
A. Kounadis
A. Loizos
T.P. Tassios
T. Xanthopoulos
A. Yiotis



Faculty Members of the School of Civil Engineering

3.1. Department of Structural Engineering

Director:

K. Spyrakos, Professor

Professors:

I. Vagias
 I. Ermopoulos
 G. Ioannidis
 V. Koumousis
 M. Kotsovos
 G. Michaltsos
 M. Papadrakakis
 K. Spyrakos
 K. Syrmakizis

Associate Professors:

E. Vintzilaiou
 C. Gantes

P. Giannopoulos

E. Sapountzakis

K. Spiliopoulos

L. Stavridis

I. Psycharis

Assistant Professors:

C. Zeris

C. Mouzakis

M. Neratzaki

I. Raftoyiannis

I. Tzouvadakis

C. Trezos

Lecturers:

E. Katsaragakis

N. Lagaros

A. Baka

Viss. Papadopoulos

Specific Lab & Teaching Staff:

M. Asimakopoulos

G. Vlachos

E. Vougioukas

X. Lignos

G. Mikelis

G. Tsotras

Scient. Associates:

T. Avraam

S. Glenis

D. Ilias

E. Kanitaki

F. Karydakis

I. Mallis

I. Sigalas

E. Toutoudaki

M. Chronopoulos

Lab Assistants:

S. Vranaki

E. Karavela

E. Manta

P. Papandreou

E. Savvaki

I. Taflampas

3.2. Department of Water Resources and Environmental Engineering

Director: **E. Kalkani, Professor**

Professors: A. Andreadakis
E. Kalkani
D. Koutsoyiannis
C. Memos
M. Mimikou
K. Moutzouris
A. Stamou
G. Christodoulou

Associate Professors: A. Katsiri
I. Papadimitrakis
K. Hadjibiros.

Assistant Professors: E. Aftias
D. Mamais
M. Bonazountas

Lecturers:

S. Azorakos
N. Mamasis,
C. Makropoulos
N. Moutafis
A. Nanou
D. Panagoulia
I. Stefanakos
V. Tsoukala

Specific Lab & Teaching Staff: E. Lasithiotakis

Scient. Associates:

E. Andrianis
I. Basilopoulos
T. Katsarelis
T. Papathanasiadis
G. Spathopoulos
S. Xatzikomninou

Lab Assistants:

C. Garini
M. Grigoriou
P. Margaronis

I. Kontogianni

I. Stamataki

3.3. Department of Transportation Planning and Engineering

Director: **A. Loizos, Professor**

Professors: J. Golias,
G. Kanellaidis,
A. Loizos,
A. Stathopoulos,
D. Tsamboulas.

Assistant Professors: G. Yannis,
M. Karlaftis,
A. Ballis.

Lecturers: A. Kaltsounis,
K. Lymperis,
P. Psaraki - Kalouptsidi.

Scient. Associates: G. Glaros,
F. Mertzanis.

Lab Assistants: G. Kardamylakis,
C. Kralli,
A. Stergiou,
T. Stergiou.

3.4.Department of Geotechnical Engineering

Director: G. Boukovalas, Professor

Professors: G. Gazetas
P. Marinos
G. Bouckovalas

Associate Professors: M. Kavvadas
G. Tsiambaos

Assistant Professors: V. Georgiannou
M.Pantazidou,
V. Papadopoulos
I. Protonotarios

Lecturers:

N. Gerolimos

Scient. Associates:

C. Andrikopoulou

A. Kamariotis

M. Karanastasis

I. Kousoulas

S. Maronikolakis

A. Tzirita

V. Tsamis

Lab Assistants:

D. Maurokefalou

G. Pyrgiotis

S. Tsentidis

G. Filippou

3.5. Department of Engineering Construction and Management

Director: V. Koumouisis, Professor

Associate Professors: S. Lampropoulos

Assistant Professors: J.P. Pantouvakis.

Lecturers: K. Rokos

Specific Lab & Teaching Staff: G. Mantas

Scient. Associates: A. Veis
D. Kallianis
N. Kouris
I. Malios
D. Touliatos

Lab Assistants: I. Kampiti

4. SCHOOL CURRICULUM PRINCIPLES

4.1. Organization of courses

The teaching and training of civil engineering students takes place mainly in Zographou Campus, as well as in the Ghini building at 42, Patission Str., Athens.

The Faculty of Civil Engineering operates the following laboratories.

Reinforced Concrete, Steel Structures, Structural Analysis and Aseismic Research, Earthquake Engineering, Earthquake Technology and engineering Seismology, Applied Hydraulics, Harbour Works, Sanitary Engineering, Hydrology and Water Resources, Highway Engineering, Railway Engineering and Transportation, Traffic Engineering, Soil Mechanics, Foundation Engineering, General and Specialized Mechanical Engineering.

Construction of a Civil Engineering Building is under planning on the Zographou Campus. This will provide faculty and students with lecture halls, laboratories and offices. The number of registered students at the Faculty of Civil Engineering for the Academic Year is 1896.

The first and second year courses are taught mainly by staff of the School of Applied Mathematical and Physical Sciences.

Main decisions of the School are taken by board meetings of the School of Civil Engineering. The Secretariat deals with educational and managerial issues.

4.2. Theoretical and experimental courses

The educational procedures of the Faculty of Civil Engineering require attendance of lectures and tutorials in the lecture halls, and experimental work in the laboratories, as well as student – teacher discussions.

Textbooks and/or lecture notes are distributed to the students at the beginning of the semester. Students, along with traditional study, train themselves by solving computer-based problems, by laboratory experiments and measurements, by surveying, and by data processing and evaluation at home. There are also educational visits to engineering projects under construction or in operation in Greece or abroad, and these visits usually last several days.

The educational process also includes video presentations of engineering projects, as well as lectures by invited speakers on engineering aspects of current works.

The extended knowledge required by the profession of the civil engineer means that the curriculum courses constantly need to be updated. Specialization is feasible due to the large number of elective and non-credit courses offered to the students.

4.3. Mandatory, elective and non-credit (optional) courses

Mandatory courses: These are basic courses considered necessary for the students to acquire basic knowledge and in order to prepare themselves adequately for the courses of one of the four specialization cycles. Attendance is mandatory for all students of the School of Civil Engineering.

Elective Courses: These are specialized courses which introduce the students to their chosen field or specialization. The student may

choose from different groups, thus acquiring the knowledge necessary for more specialized courses.

Non-Credit (optional) courses: These include courses in foreign languages. The students register and attend at least one language course.

The four foreign languages taught are English, French, German and Italian. Students who already have an officially recognized certificate of competence in one of these languages, need not register to a language course.

4.4. Teaching hours, courses and examinations

The curriculum provides for a five-year period of studies at the School of Civil Engineering. Each year is divided into two semesters, Winter (September to January) and Spring (February to June). Nine of the ten semesters are allocated to attending courses, while the tenth semester is allocated to preparing and defending the degree thesis.

In the first few semesters, the student attends the theoretical courses on which the engineering courses in the later semesters are based. These courses are indispensable university level courses which enable the students to understand, also, the methodologies, procedures and equipment used in civil engineering research.

During the first six semesters, students are taught all the basic courses required for the civil engineering background. From the seventh semester onwards the students register to courses which belong to one of the four cycles.

At the moment, the four cycles of specialization are Structural Engineering, Hydraulic Engineering, Transportation Engineering and Geotechnical Engineering.

The cycles of specialization comprise about 15% of the courses required for the civil engineering diploma. All the students who have taken the basic courses and the specialization courses of one cycle are awarded the diploma of Civil Engineer. The same diploma is awarded to all four cycles. The professional status of the graduate is the status of civil engineer, no matter which specialization cycle he/she attended as a student.

4.5. Diploma thesis

During the tenth semester, the student has to work on a Diploma thesis under the supervision of one of the faculty staff. The thesis is presented during the examination period, to a committee of three professors competent to judge the thesis.

The thesis is an extended piece of original work, which may be analytic, synthetic or applied to a practical engineering problem or need. The principles are laid down by the National Technical University of Athens. The aim of working on such a thesis is to enable the student to integrate his/her knowledge and display ability to do research or undertake an engineering project.

The basic concept of the thesis, with its aim of giving the engineering student a complete education, is similar to the concept of the Diplomarbeit in Germany, the These de Diploma in France, and the Master's Thesis in the United Kingdom.

4.6. Co-operation with ENPC

The School signed in 2003 an educational agreement with École Nationale des Ponts et Chaussées (ENPC) of Paris, France, whereby students of both establishments can follow a part of the curriculum of

the other and attain a “double diploma”. Thus students from NTUA fulfilling stringent performance criteria can obtain, after attending ENPC during their two last years of studies, a diploma awarded by both NTUA and ENPC. A few students have already exploited this excellent opportunity.

5. COURSE PROGRAM

5.1. 1st Semester

Courses	Hours
I. Mandatory	
• Mathematical Analysis I	4
• Linear Algebra	3
• Descriptive Geometry	5
• Technical Drawing	4
• Geology for Engineers	4
• Engineering Mechanics I (Statics)	4
Total	24
II. Electives (mandatory the choice of one)	
• English Language	2
• French Language and Technical Terminology	2
• German Language	2
• Italian Language	2

5.2. 2nd Semester

Courses	Hours
I. Mandatory	
• Mathematical Analysis II	4
• Engineering Mechanics II (Strength of Materials)	5
• Computer Programming	4
• Materials	4
• General Building Technology	3
• Ecology for Engineers	3
Total	23

II. Electives (mandatory the choice of one)

• Applied Economics	3
• Elements on Philosophy and Cognition Theory	3
Total	26

III. Electives (mandatory the choice of one)

• English Language	2
• French Language and Technical Terminology	2
• German Language	2
• Italian Language	2

IV. Elective

• Computer Aided Design of Civil Engineering Projects	3
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5.3. 3rd Semester

Courses	Hours
I. Mandatory	
• Differential Equations	4
• Numerical Analysis	4
• Engineering Mechanics III (Dynamics)	3
• Topics on Architecture	3
• Geodesy (surveying)	3
• Physics (Vibrations and Waves)	4
Total	21
II. Electives (mandatory the choice of one)	
• Introduction to Energy Technology	3
• Introduction to the Production of Construction Projects	3
• Town and Regional Planning	3
Total	24

III. Electives (mandatory the choice of one)

• English Language	2
• French Language and Technical Terminology	2
• German Language	2
• Italian Language	2

5.4. 4th Semester

Courses	Hours
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I. Mandatory

• Probability-Statistics	4
• Construction Equipment and Methods	4
• Surveying Applications	3
• Statics I	5
• Partial Differential Equations and Functions of a Complex Variable	4
• Fluid Mechanics	5
Total	25

II. Electives (mandatory the choice of one)

• Continuum Mechanics	3
• Experimental Strength of Materials	4
Total	28 or 29

III. Electives (mandatory the choice of one)

• English Language	2
• French Language and Technical Terminology	2
• German Language	2
• Italian Language	2

5.5. 5th Semester

Courses	Hours
I. Mandatory	
• Soil Mechanics I	4
• Structural Analysis II	5
• Engineering Hydrology	5
• Highway Engineering I	4
• Applied Hydraulics	4
• Environmental Engineering	4
Total	26
II. Electives (mandatory the choice of one)	
• Advanced Numerical Analysis	3
• Computer Applications in Civil Engineering	3
• Introduction in Systems Optimization	3
Total	29

5.6. 6th Semester

Courses	Hours
I. Mandatory	
• Engineering Geology	3
• Soil Mechanics II	4
• Introduction to reinforced concrete	4
• Statics III	4
• Highway Engineering II	4
• Urban hydraulic works	4
• Transportation Systems Planning	3
Total	26

5.7. 7th Semester

Courses	Hours
Mandatory	
• Reinforced concrete	5
• Steel Structures I	5
• Maritime Hydraulics and Harbour Engineering	4
• Foundations	5
• Construction Management	4
Total	23
Structural engineering cycle	
I. Mandatory	
• Statics IV	4
II. Electives (mandatory the choice of one)	
• Special Topics on Building Technology	3
• Architectural Special Purpose Building Design	3
Hydraulic engineering cycle	
I. Mandatory	
• Free Surface Flow	4
• Earthquake resistant structures	4
Transportation engineering cycle	
I. Mandatory	
• Earthquake resistant structures	4
• Traffic Flow	4
Geotechnical engineering cycle	
I. Mandatory	
• Experimental Soil Mechanics	4

• Statics IV	4
Total	30-31

5.8. 8th Semester

5.8.1. Structural engineering cycle

Courses	Hours
Mandatory	
• Reinforced Concrete Structures	5
• Steel Structures II	5
• Elements of Law and Technical Legislation	2
• Structural Analysis V	4
• Earthquake Engineering 1	4
Total	20

Group A

Electives (mandatory the choice of one)	
• Introduction to Bridge Construction	4
• Steel Structures III	3
• Selected Topics in Foundation Engineering	4
• Computational Hydraulics	4
• Timber Structures	4
• Soil-Structure Interaction	4
• Composite Materials	3
Total	23-24

Group B

Electives (mandatory the choice of one)	
• Finite Element Analysis of Structures	4
• Advanced Mechanics of Materials	3
Total	26-28

Elective

• Environment and Development	3
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5.8.2. Hydraulic engineering cycle

Courses	Hours
Mandatory	
• Reinforced Concrete Structures	5
• Elements of Law and Technical Legislation	2
• Steel Structures II	5
• Groundwater Flow	4
• Coastal Engineering	3
• Sanitary Engineering	4
Total	23
Group A	
Electives (mandatory the choice of one)	
• Introduction to Bridge Construction	4
• Pavements	4
• Urban Road Networks	4
• Selected Topics in Foundation Engineering	4
• Timber Structures	4
• FINITE ELEMENTS	4
• Hydroelectric Projects	4
• Computational Hydraulics	4
Total	27
Elective	
• Environment and Development	3

5.8.3. Transportation engineering cycle

Courses	Hours
Mandatory	
• Reinforced Concrete Structures	5
• Steel Structures II	5
• Elements of Law and Technical Legislation	2
• Pavements	4
• Railways	4
• Urban Road Networks	4
Total	24
Group A	
Electives (mandatory the choice of one)	
• Introduction to Bridge Construction	4
• Steel Structures III	3
• Special Chapters on Urban Planning	4
• Selected Topics in Foundation Engineering	4
• Timber Structures	4
• Finite Elements	4
• Computational Hydraulics	4
Total	27-28
Elective	
• Environment and Development	3

5.8.4. Geotechnical engineering cycle

Courses	Hours
Mandatory	
• Reinforced Concrete Structures	5
• Earthquake Engineering 1	4
• Steel Structures II	5
• Elements of Law and Technical Legislation	2
Total	16
Group A	
Electives (mandatory the choice of two)	
• Structural Analysis V	4
• Selected Topics in Foundation Engineering	4
• Soil-Structure Interaction	4
Total	24
Group B	
Electives (mandatory the choice of one)	
• Introduction to Bridge Construction	4
• Pavements	4
• Finite Element Analysis of Structures	4
• Timber Structures	4
• Groundwater Flow	4
• Coastal Engineering	3
Total	27-28
Elective	
• Environment and Development	3

5.9. 9th Semester

5.9.1. Structural engineering cycle

Courses	Hours
Mandatory	
• Special Topics on Static and Dynamic Structural Analysis	5
• Prestressed Concrete	4
• Earthquake Engineering 2	4
• Steel Bridges	4
Total	17

Group A

Electives (mandatory the choice of one)

• Rock Mechanics-Tunnels	4
• Soil Dynamics	4
• Geotechnical Topics (Dams, Tunnels, Cuts and excavations)	3
• Quality Control and Quality Assurance	3
• Construction Management – Special Subjects	3
• Environmental Geotechnics	4
• Environmental Impacts	3
• Experimental Soil Mechanics	3
Total	20-21

Group B

Electives (mandatory the choice of three)

• Boundary Elements	4
• Nonlinear Behavior of Steel Structures	4
• Technical Seismology	4
• Special Topics of Finite Element Analysis of Structures	4

• Theory of Disks and Shells	4
• Composite Structures	4
• Modern Design Methods for Reinforced Concrete Structures	4
• Mechanics of Masonry	4
• Theory of Plates	4
• Light Metal Structures	4
• Special Topics on Reinforced Concrete	4
Total	32-33

5.9.2. Hydraulic engineering cycle

Courses	Hours
Mandatory	
• Water Resources Systems Technology	4
Total	4

Group A

Electives (mandatory the choice of three-five)	
• Irrigation Engineering	4
• Unsteady Flows	4
• Experimental Hydraulics	4
• Hydraulic Structures – Dams	4
• Wastewater Treatment and Disposal	4
• Special Topics in Port Engineering	3
• Off-shore Structures	3
• Environmental Fluid Mechanics	4
• Water Resources & Environmental Systems Optimization	4
• Stochastic Methods in Water Resources	4
Total	14-24

Group B

Electives (mandatory the choice of three-one)

• Traffic Flow	4
• Combined Transport - Specialized Systems	4
• Traffic Management And Road Safety	4
• Experimental Soil Mechanics	4
• Rock Mechanics-Tunnels	4
• Environmental Geotechnics	4
• Soil Dynamics	4
• Statics IV	4
• Prestressed Concrete	4
• Quality Control and Quality Assurance	3
• Construction Management – Special Subjects	3
• Environmental Impacts	3
Total	23-28

5.9.3. Transportation engineering cycle

Courses	Hours
Mandatory	
• Combined Transport - Specialized Systems	4
• Airport planning	3
• Special Topics in Highway Engineering	4
• Traffic Management And Road Safety	4
• Mass Transport Network Operations	4
• Road and Airfield Pavements	3
Total	22

Group A

Electives (mandatory the choice of one)

• Rock Mechanics-Tunnels	4
• Soil Dynamics	4
• Geotechnical Topics (Dams, Tunnels, Cuts and excavations)	3

• Quality Control and Quality Assurance	3
• Construction Management – Special Subjects	3
• Environmental Geotechnics	4
• Experimental Soil Mechanics	4
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• Prestressed Concrete	4
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• Environmental Impacts	3
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Total	25-26
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Group B

Electives (mandatory the choice of one)

• Advanced Topics on Highway Design	4
• Special Topics in Traffic Engineering	4
• Pavements - Special Topics	4
• Evaluation and Impacts of Transport Infrastructure Projects	4
• Specific Railway Topics	4
• Quantitative Methods in Transportation	4
• Spatial-Growth Impacts of Transport Systems	4
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Total	29-30
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5.9.4. Geotechnical engineering cycle

Courses	Hours
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Group A	
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Electives (mandatory the choice of five)	
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• Rock Mechanics-Tunnels	4
• Environmental Geotechnics	4
• Soil Dynamics	4
• Geotechnical Topics (Dams, Tunnels, Cuts and excavations)	3
• Computational Geotechnics	4
• Hydraulic Structures – Dams	4
• Prestressed Concrete	4

• Special Topics on Static and Dynamic Structural Analysis	5
Total	19-21
Group B	
Electives (mandatory the choice of two)	
• Special Topics on Reinforced Concrete	4
• Special Topics in Port Engineering	3
• Earthquake Engineering 2	4
• Composite Structures	4
• Mechanics of Masonry	4
• Pavements - Special Topics	4
• Specific Railway Topics	4
• Modern Design Methods for Reinforced Concrete Structures	4
• Experimental Hydraulics	4
• Construction Management – Special Subjects	3
Total	25-29

6. COURSES AVAILABLE AT THE SCHOOL OF CIVIL ENGINEERING

6.1. 1st Semester

6.1.1. MATHEMATICAL ANALYSIS I

Sequences of real numbers, convergence tests. Series of real numbers, convergence tests. Functions of real numbers. Trigonometrical functions. Hyperbolic functions. Continuous functions. Derivatives of functions. Fundamental theorems. Power series. Taylor and Maclaurin series. The Riemann integral of a real-valued function. Applications. Generalized integrals. Applications.

*T. Rassias, Professor
A. Benou
N. Giannakakis*

6.1.2. GEOLOGY FOR ENGINEERS

Introduction. Applications of geology in Civil Engineering. The materials of Earth. Minerals. Igneous, sedimentary and metamorphic rocks. Properties, engineering behaviour of rocks for engineering works. Elements of mechanical behaviour of geological materials. Soils, rocks and rock-masses. Industrial minerals and rocks. Building stones and construction materials. Geodynamics. Earthquakes, global tectonism and lithospheric plates, deformations of Earth crust. Geomorphology, weathering and erosion, soil formation. Subsidence and landslides. Underground water, water flow, water-bearing formations and resources. Pollution of water. Principles of geological mapping and evaluation of geological data for the study and construction of engineering works.

*P. Marinos, Professor
G. Tsiambaos, Associate Professor*

6.1.3. LINEAR ALGEBRA

Vector calculus, lines and planes in 3-space. Linear spaces. Row operations and linear independency. Linear systems. Matrices, determinants, linear mappings (inverse matrix, matrix of a linear mapping, change of basis matrix). Eigenvalues and eigenvectors of linear transformations and matrices (characteristic polynomial, Cayley-Hamilton theorem, matrix diagonalization). Orthogonal and symmetric matrices. Quadratic forms and applications.

*S. Lampropoulou, Associate Professor
A. Benou*

6.1.4. DESCRIPTIVE GEOMETRY

Relative positions of lines and planes. Parallel lines and planes. Thales Theorem. Angles between lines, orthogonal lines. Distance of a point from a plane, distance between parallel planes. Dihedral angles, perpendicularity of planes. Perpendicular projection of shapes on a plane. Trihedral angles. Polyhedra: definitions, properties and measurements of prism, pyramid, cylinder, cone and sphere. Exercises.

Projective line, plane, space. Cross ratio. Desargues and Pappos Theorems. Projective transformations. Conic sections, properties, constructions. Applications and exercises.

Introduction to Descriptive Geometry. The system of two planes of projection and the system of horizontal projecting plane with elevations: Point, line and plane depictions, crossing and skew lines. Traces of straight lines and planes, intersection of lines and planes. Problem solving methods. Polyhedra: projections. Pyramid and prism intersection by a straight line and a plane. Development of polyhedra. Intersecting a cone, cylinder and sphere by a straight line and a plane. Development of cylinder and cone. Exercises. Applications.

*S. Markatis, Assistant Professor
N. Palla, Lecturer*

6.1.5. ENGINEERING MECHANICS I (STATICS)

Principles of statics (concurrent forces in a plane and in space). Force and moment equilibrium (analytical and graphical methods). Load bearing structures (free body, constraints, plane rigid structures, reaction forces). Principle of virtual displacements (kinematical determination of reaction forces). Plane, statically determined trusses (realization and methods of analysis). Statically determined beams (shear forces, bending moments and diagrams M,Q). Compound beams and simple isostatic frames (diagrams M,Q,N). Arches (three-hinged arch, parabolic arch). Flexible cables. Stable and unstable equilibrium. Friction (Colomb's friction law).

*I. Vardoulakis, Professor
E. Anastaselou, Assistant Professor
E. N. Theotokoglou, Assistant Professor*

6.1.6. TECHNICAL DRAWING

Line drawing and letter and number drawing. Theory and practice on presentation of elementary floor plans, sections and side views. Drafting of floor plans, sections, side views, of small buildings with detailed reference to architectural drawing-symbols. General reference to structural principles and basic materials of simple structures. Elementary theoretical tuition on the presentation of reinforced concrete structures with drawings. Complete structural drawings including foundation drawing. Topographic survey of small building. Theory of topographic map and construction of contour lines. Introduction to computer aided design. System requirements. Drafting instruments, CAD software. Representation of object and structures in two and three dimensions.

*I. Tzouvardakis, Assistant Professor
A. Vhsilia
G. Vlachos*

6.2. 2nd Semester

6.2.1. MATHEMATICAL ANALYSIS II

The Euclidean space \mathbb{R}^n . Functions between Euclidean spaces, limit and continuity of functions. Differentiation of vector-valued functions of a single variable, applications in mechanics and differential geometry, polar, cylindrical and spherical coordinates. Differentiable functions (partial derivatives, directional derivatives, differential). Vector fields. Gradient-divergence-curl. Fundamental theorems of differentiable functions (mean value theorem, Taylor). Inverse function theorem. Theorems of convoluted functions. Functional dependence. Local and conditional extremes. Double and triple integrals: definitions, integrability criteria, properties. Change of variables, applications. Multiple integrals. Generalised multiple integrals. Contour integrals: Contour integral of the first and second kind, contour integrals independent of path, Green's Theorem, simply and multiply connected domains of \mathbb{R}^2 and \mathbb{R}^3 . Elements of surface theory. Surface integrals of the first and second kind. Fundamental theorems of vector analysis (Stokes and Gauss) applications.

*T. Rassias, Professor
T. Leontiadis, Assistant Professor
N. Giannakakis*

6.2.2. ECOLOGY FOR ENGINEERS

Organization at the organism level: categories, chemical reactions, energy flow. Organization at the population level: temporal changes, interactions, mathematical models. Organization at the ecosystem level: energy flow, bio-geochemical cycles, mathematical models. Introduction to aquatic chemistry, physicochemical properties of water, methods of expressing concentration of chemical compounds in water. Stoichiometry of chemical reactions, acid base reactions,

oxidation reduction reactions. Buffering capacity of water, carbonate system, solubility of solids and gases in water. Human population and environment. Natural environment, deforestation, soil pollution, environmental impact assessment. Urban environment, indoor air pollution, noise pollution. General toxic pollutants, ionizing radiation. Water pollution, oxygen depletion, eutrophication. Atmospheric pollution, acid rain, reduction of stratospheric ozone, the greenhouse effect. Introduction to pollution control technology. Economic development and the environment.

*K. Hadjibiros, Associate Professor
D. Mamais, Assistant Professor
N. Mamasis, Lecturer*

6.2.3. GENERAL BUILDING TECHNOLOGY

Selection of building materials. Load-bearing reinforced concrete structure. Internal and external masonry, openings. Floors and ceilings. General insulation against heat, water and sound. Waterproofing of exposed ceilings and underground structures. Roofing. Internal and external door and window frames. Staircases.

*I. Tzouvadakis, Assistant Professor
A. Sotiropoulou, Assistant Professor
E. Katsaragakis, Lecturer
A. Vhsilia*

6.2.4. APPLIED ECONOMICS

The neoclassical microeconomic theory. Introduction to microeconomic theory. Elements of general theoretical background of the microeconomic - neoclassical theory. Fundamental concepts. Supply and demand: elementary considerations. The demand for goods. The elasticity of demand. The supply of goods. The elasticity of supply. Equilibrium. Shift in demand and supply curves. Demand theories: consumer behaviour. Theory of absolute utility. Theory of cardinal utility. Theory of production and production cost. Market

types: perfect competition, monopoly, monopolistic competition, oligopoly.

I. Tsolas , Lecturer

6.2.5. COMPUTER PROGRAMMING

Introduction to computers and programming. FORTRAN 77/90/95 computer language. Flowcharts and name list. Constants and variables. Input of statements and data into the computer. Simple input and output statements. Input of a complete program into the computer. Files. Arithmetic statements. Transfer instructions. Subscripted variables – matrices. DO loops. Computed GO TO and implied DO LOOP. Subprograms. Library functions. Arithmetic statement functions and function subprograms. More advanced Fortran statements. Practical exercises in the NTUA computer centres. Writing and running computer programs on simple civil engineering applications.

P. Giannopoulos, Associate Professor

6.2.6. ELEMENTS ON PHILOSOPHY AND COGNITION THEORY

This course aims to render basic concepts and problems of contemporary analytic philosophy - theory of knowledge, familiar to the student. The origin of these concepts (truth, meaning, reference, proof, justification) is traced back to the relevant platonic dialogues and the concepts are further compared in terms of their contribution in building a defense against skepticism."

*K. Antonopoulos, Associate Professor
A. Koutougkos, Associate Professor*

6.2.7. COMPUTER AIDED DESIGN OF CIVIL ENGINEERING PROJECTS

Introduction to Computer Aided Design systems. Necessary electronic equipment. Problems which the software is asked to solve. Design algorithms. Programming languages used in the construction of CAD software. Commercial and open source software. Similarities and differences between traditional and electronic means of organization and presentation of studies of technical projects.

Object drafting in two and three dimensions. Generation and printing of drawings of side plans, floor plans, sections, perspective and axonometric projections. Digital scale-models. Use of virtual materials in object presentations. Photorealism. Sun exposure and shading. Virtual reality walk.

Introduction to programming of drawing-objects and to automation of drawing procedures.

*I. Tzouvadakis, Assistant Professor
A. Stamos
A. Vhsilia*

6.2.8. MATERIALS

Introduction. General properties of materials. Measurement techniques. Grouts, cement. Protection against heat and cold: methods and heat insulating materials. Protection against moisture: methods and moisture proof materials. Asphalt materials. Plastic materials. Sealing applications. Surface coating materials. Paints and adhesives. Filling materials: natural stones, marble, artificial stones and plaques. Timber, glass, other materials. Inert materials, gravel, concrete, iron, steel and other metals. Soundproofing: methods and materials. Laboratory and blackboard exercises.

G. Poulakos, Associate Professor

6.2.9. ENGINEERING MECHANICS II (STRENGTH OF MATERIALS)

Simple and compound bars (Hooke's law, theorems elastic behavior, statically indeterminate trusses). Plane stress (Mohr circle of stresses, simple stress states, differential equilibrium equations). Plane strain (strain, rotation, Mohr circle of strains, compatibility relations). Elastic behavior (3D state of stress, simple, plane hyperstatic discs). Engineering elastic beam bending theory (area moment of inertia, pure bending, simple bending). Elastic curve (statically indeterminate beams). Bending, shear and torsion. Skew bending bending with axial force. The principle of energy conservation for ideally elastic and plastic solids. Energy methods (principle of virtual work, Betti-Maxwell- Mohr law. Elastoplastic behavior of solids (yield criteria of Mises and Mohr-Coulomb).

*I. Vardoulakis, Professor
E. Anastaselou, Assistant Professor
E. N. Theotokoglou, Assistant Professor*

6.3. 3rd Semester

6.3.1. NUMERICAL ANALYSIS

Computer numerical errors. Linear systems: Gauss' elimination method, vector and matrix norms. Linear systems stability, general iterative method, Jacobi, Gauss-Seidel and relaxation methods. Computation of eigenvalues and eigenvectors. Least squares method. Interpolation (Lagrange, Hermite and splines cubic functions). Numerical integration methods: trapezoidal, Simpson and three-eighths rules. Non-linear algebraic equations and systems: bisection and secant methods, general iterative method, the Newton-Raphson method and higher order methods. Differential equations: Taylor, Runge-Kutta and predictor-corrector methods.

*E. Tychopoulos, Assistant Professor
I. Chrysovergis, Associate Professor*

6.3.2. GEODESY (SURVEYING)

- Introduction, object and purpose of surveying.
Basic concepts (reference surfaces and coordinate systems, measured quantities, maps and topographic plans).
- Planar Cartesian coordinate reference systems, fundamental problems.
- Observations (mean value, standard deviation, law of error propagation).
- Distance measurements (tapes and EDM, measuring methods, calculations, corrections and reductions).
- Angle measurements (optical and digital theodolites, measuring methods, calculations).
- Levelling (measuring methods, instruments, optical and digital levels, calculations).

- Triangulation (basic concepts, definitions) - Sections (intersection, resection).
- Modern surveying instruments – measuring methods (Total Stations, GPS).

Exercises and problems are given on all the above topics.

D. Stathas, Associate Professor
M. Doufexopoulou, Associate Professor
G. Pantazis, Lecturer
P. Gerontopoulos
G. Georgopoulos, Lecturer

6.3.3. DIFFERENTIAL EQUATIONS

Introduction to differential equations (definitions). First order differential equations (separable variables, total differential and Euler multiplier, linear, Bernoulli, homogeneous Riccati, Clairaut, Lagrange, orthogonal trajectories). Qualitative theory of differential equations (general). Higher order linear differential equations (general theory). Linear differential equations with constant coefficients (solution of linear equations, variation of parameter method, method of undetermined coefficients, Euler's differential equations, applications). Laplace transforms (inverse Laplace transforms, Heaviside step function, δ -Dirac impulse function, convolution, applications). Power series solution of differential equations (regular and irregular points, Bessel functions, Legendre polynomials). Systems of differential equations (linear systems, homogeneous and non-homogeneous systems, elimination method, variation of parameters and Euler's method, applications). Boundary value problems (Sturm-Liouville). Stability (concept, autonomous systems, phase space, stability solution of linear systems, linearization method, Ljapunov's method).

D. Kravvaritis, Professor
K. Xrysafinos, Assistant Professor

6.3.4. INTRODUCTION TO ENERGY TECHNOLOGY

- Energy and Power (energy transformation, mechanical energy, electrical, chemical, nuclear, thermal, heat, entropy).
- Sources of energy and uses (input and output of energy, stored energy, production and consumption of energy, energy management, environmental impact).
- Electricity (basic relations, electricity production, power plants, electricity consumption, generation, co-generation of power and heat, energy savings).
- Coal (composition, reserves, production and consumption, transport, emissions and pollutants, advanced technologies, liquid fuels from coal, environmental concerns).
- Oil (production, reserves of crude oil, synthetic crude oil, environmental problems).
- Natural gas (reserves, production and consumption, methane, environmental effects).
- Geothermal energy (geologic structure, heat flow, geothermal reservoirs, installations, domestic heating, heat pumps, power production, environmental effects).
- Nuclear energy (nuclear fission, radiation, nuclear power plants, nuclear wastes, electricity production, nuclear fusion, environmental concerns).
- Hydraulic energy (hydro power, plant operation, turbine types, conventional plants and pump storage, tidal plants, wave energy and sea currents' energy, environmental concerns).
- Wind energy (available wind energy, theoretical and technical available wind potential, small and large wind turbines, selection of wind farm site, environmental concerns).
- Solar energy thermal (radiation, seasonal variation, heating domestic and industrial water, passive heating of buildings, environmental concerns).

- Solar energy photovoltaic (solar cells and systems, semiconductors, materials of semiconductors, arrays of collectors, environmental concerns).
- Biological and chemical energy (biomass and bio-fuels, photosynthesis, industrial conversion of biomass, burning, pyrolysis, fuel from wood, energy from solid, liquid and gas wastes, environmental concerns).
- Energy future (problems and strategic plans, long term energy solutions with nuclear fission and fusion, solar energy and geothermal energy).

E. Kalkani, Professor

6.3.5. INTRODUCTION TO THE PRODUCTION OF CONSTRUCTION PROJECTS

Introduction. Categories of engineering projects. The technical, operational and entrepreneurial dimension of projects. "Life-cycle" of projects. Short historical retrospection. The construction sector in the European Union. The harmonisation of national legislation. The Trans-European Networks and infrastructure programs. National planning and financing of construction projects. Client, Designer, Contractor. Organisational structures. Cost-Benefit Analysis. Categories and stages of designs. Design procurement. Design Management. Cost Estimating & Tendering. Structure, content and administration of construction contracts. Operation, Maintenance and Exploitation of engineering projects. Private Financing of Public Works.

S. Lambropoulos, Associate Professor

6.3.6. TOWN AND REGIONAL PLANNING

Theoretical and practical instruction on the development, operation, organization and planning of towns and districts. Theoretical studies on urban and regional planning and related design procedures.

Regulations and application examples. Basic concepts on regional and town planning. Elements on urban and rural planning operations. References. Elements of technical intervention, urban/rural plans and regulatory framework. Overview of related urban/rural problems. Exercises on urban/rural analysis and simple methods for land registration.

*S. Antonopoulou, Associate Professor
I. Tzouvadakis, Assistant Professor
M. Angelidis, Professor
A. Sotiropoulou, Assistant Professor
A. Stamos*

6.3.7. TOPICS ON ARCHITECTURE

Introduction to architecture. The human scale, analysis of activities and site equipment. Ergonomic design in architecture. Bioclimatic parameters influencing architectural design. Selection of construction materials. Selection and description of the load-bearing structures. Design of utility networks for buildings. Elements for the development of Architectural studies.

*I. Tzouvadakis, Assistant Professor
E. Katsaragakis, Lecturer
A. Vhsilia*

6.3.8. ENGINEERING MECHANICS III (DYNAMICS)

- Kinematics of a particle (curvilinear motion, rectangular, normal-tangential, cylindrical components, coordinate systems).
- Kinematics of a rigid body (translation, rotation about a fixed axis, planar kinematics -mechanisms, rotation about a fixed point, general motion, relative motion).
- Kinetics of a particle (mass, momentum, force, Newton's law of motion, work and energy).
- Kinetics for a system of particles.
- Kinetics of a rigid body (Euler's equations, planar kinetics).
- Principle of virtual work.

- Lagrange's equations, Hamilton's principle.
- Vibrations

*E. Anastaselou, Assistant Professor
V. Kytopoulos, Assistant Professor
K. Thiraios, Lecturer*

6.3.9. PHYSICS (VIBRATIONS AND WAVES)

- Free vibrations. Simple harmonic oscillator. Harmonic motion with damping: decaying vibrations, decay of energy, quality factor. Non-periodic motion of mass-spring systems.
- Forced vibrations. Transient and steady states, resonance, power absorption.
- Coupled vibrations. Two or more coordinate vibrations: normal modes and mode coordinates, inertial and elastic coupling of mechanical oscillators, determination of normal mode frequencies, energy of normal modes. Coupled vibrations with arbitrary initial conditions, beats. Forced vibrations of coupled oscillators, resonance frequencies. Periodic array of many coupled mechanical oscillators in one dimension: normal modes and non-dispersive waves in an ideal string of discrete oscillators.
- Mechanical waves in continuous elastic media in one dimension. Wave equation in an elastic string. Transverse and longitudinal waves. Travelling waves: energy propagation, characteristic impedance of elastic media, reflection and transmission of travelling waves at a boundary. Standing waves: normal modes in a continuous elastic medium, Fourier analysis. Wave packets, phase and group velocity, dispersion.
- Mechanical waves in two and three dimensions. Two dimensions: waves in elastic membranes, surface waves in liquids. Three dimensions: acoustic waves.
- Electromagnetic waves. Propagation of optic waves in dielectric media: speed of light, refractive index, polarization, reflection, refraction, fundamental laws of optics, geometrical optics.

Coherent optical radiation: interference from coherent sources, diffraction, laser radiation.

*K. Raptis, Professor
I. Zouboulis, Associate Professor*

6.4. 4th Semester

6.4.1. SURVEYING APPLICATIONS

- Traversing – Types of traverses – Field observations – Traverse adjustment – Coordinates of traverse stations
- Topographic surveys – Methods - Stadia and electronic surveying
Topographic plans and maps
- Cross sections – Volumes – Volume Computations – Setting out (lines, angles, circular curves)
- Use of Topographic plans and maps.

During the semester students gradually carry out a field survey as a whole.

D. Stathas, Associate Professor
M. Doufexopoulou, Associate Professor
P. Gerontopoulos
G. Georgopoulos, Lecturer
E. Lamprou, Lecturer

6.4.2. CONSTRUCTION EQUIPMENT AND METHODS

Elements of Mechanical Engineering: Construction equipment and methods. Earthmoving, excavators, bulldozers, loaders, trucks, scrapers, compactors, graders., Aggregate production, crushers, mills. Concrete production, batch, mixers, trucks. Asphalt production. Tunnel excavation and lining, fullfacers, jambo. Bridge construction, cranes, travellers. Operation analysis and cost of construction activities.

S. Lambropoulos, Associate Professor

6.4.3. PARTIAL DIFFERENTIAL EQUATIONS AND FUNCTIONS OF A COMPLEX VARIABLE

- Functions of a complex variable: complex numbers and functions. Analytic functions: Cauchy-Riemann conditions. The integral of a

complex variable function. Cauchy theorem. Cauchy integral formulae. Taylor series, Laurent series. Calculus of residues. Applications-conformal mappings. Dirichlet problem solution.

- Partial differential equations: Fourier series, boundary problems. Basic theory of partial differential equations. First order equations. Classification of second order PDE. D' Alembert solution(wave theory), Laplace's heat equation. Wave equation. Three-dimensional problems (Laplace-heat-wave). Spherical harmonic functions. Integral transforms (Fourier, Laplace, Hankel).

*D. Kravvaritis, Professor
V. Papanikolaou, Associate Professor*

6.4.4. CONTINUUM MECHANICS

Lagrangian and Eulerian description (material time derivative; applications from hydrodynamics; Reynolds transport theorem; conservation of mass; continuity equation). Elementary traffic flow theory (the method of characteristics, shock waves; Rankine-Hugoniot condition). Integral form of the conservation of linear and angular momentum (the control volume technique). Waves (surface waves in ideal fluids; tidal waves; non-linear waves; capillary waves). Viscous fluids. (the Navier-Stokes equations; creeping flow of real fluids, flow in porous media, Darcy's law; the laminar boundary layer
Energy conservation (the heat equation; one-dimensional heat flow).

I. Vardoulakis, Professor

6.4.5. FLUID MECHANICS

Introduction. Definitions. Basic properties of fluids. Hydrostatics. Pressure at a point. Hydrostatic pressure. Forces on planar and curved surfaces. Buoyancy. Kinematics. Lagrange and Euler methods. Material derivative. Streamlines, Pathlines. Deformation of a fluid element. Vorticity. Dynamics. Types of forces. Principles of conservation: mass, momentum and energy. Equations of continuity,

momentum and energy for a finite control volume. Piezometric and energy line. General differential equations for continuity and motion (Navier-Stokes). Streamfunction and velocity potential. Ideal fluids. Euler equations. Bernoulli equation. Cavitation. Flow separation. Flow through orifices, over sharp-crested weirs and under sluice gates. Real fluids, Reynolds number. Laminar and turbulent flow. Drag and Lift. Couette and Poiseuille flow. Reynolds equations. Turbulent stresses. Dynamic similitude. Types of similarity. Basic dimensionless numbers. Introduction to boundary layer theory. Laboratory experiments.

*G. Christodoulou, Professor
A. Nanou, Lecturer*

6.4.6. EXPERIMENTAL STRENGTH OF MATERIALS

A. Elements from the Theory of Elasticity: Tensile stress and strain, deformation energy. Material Failure: The theory of torsional energy density of deformations (Mises), the theory of maximum shearing stress (Tresca), the theory of internal friction (Mohr-Coulomb) Material Failure due to Discontinuities: Stress concentration and magnitude, tension field around a discontinuity. Circular opening. Notches. Cracks. Griffith's theory. Energy considerations. Crack opening detours. The plastic zone around cracks. Static Loading: tension, shear, compression, buckling, bending, torsion, hardness. Fluidic behaviour of materials: creeping, relaxation, refolding. Time Influence: failure due to fatigue, Shock loadings.

B. Experiments on the Strength of Materials: Planning and performing an experiment. Collecting, storing and processing experimental data. Writing experiment reports. Experimental study on the mechanical behaviour and failure of materials:

1. Metal tension.
2. Compression and buckling of metals and concrete.
3. Tri-axial stress on concrete.
4. Bending concrete beams on three and four points.

5. Metal hardness measurements.
6. Torsion of metal bars.
7. Creeping, relaxation.
8. Non-destructive testing by ultrasonics.
9. Impact, fatigue.
10. Breakage due to geometric discontinuities (hole, crack).

S. Kourkoulis, Assistant Professor

6.4.7. PROBABILITY-STATISTICS

The meaning of probability. Axioms of probability. Conditional probability. Independent events. Functions of random variables. Density and cumulative density functions. Parameters of distributions. Generating and characteristic functions. Special discrete and continuous distributions. Central limit theorem. Random sample and sampling distributions. Estimation of parameters. Point estimation. Interval estimation. Hypothesis testing. Goodness of fit tests. Contingency tables. Simple and multiple linear regressions.

*V. Papanikolaou, Associate Professor
D. Fouskakis, Lecturer*

6.4.8. STATICS I

Introduction to the static analysis of structures. Concepts of a rigid configuration and of a structure. Supports of a structure. Loads. Equations of equilibrium. Statically determinate and indeterminate structures. Evaluation of the degree of statical indeterminacy. Geometrically unstable structures. Resolution of complex statically determinate structures. Small deformation theory. Cross-sectional stresses. Stress resultants' diagrams of simply supported, cantilever and Gerber-type beams. Three-hinged arches. Cable members. Trusses. System-supported beams. Influence lines of simply supported beams, Gerber-type beams, three-hinged arches, trusses. Maximum and minimum stress resultants under different types of live loads.

Statically and kinematically admissible systems. The principle of virtual work for bar-type structures. Betti-Maxwell theorem. Unit load theorem. Deformation calculations for statically determinate structures.

K. Syrmakizis, Professor
V. Koumousis, Professor
L. Stavridis, Associate Professor
K. Spiliopoulos, Associate Professor
Viss. Papadopoulos, Lecturer
N. Lagaros, Lecturer

6.5. 5th Semester

6.5.1. SOIL MECHANICS I

Introduction, applications of soil mechanics in civil engineering. The nature of soil, types of soil, density, water content, Atterberg limits, subsurface soil investigation. Stresses and strains in soil elements, description of the stress state at a point with the Mohr's circle, total and effective stresses, the "effective stress principle", geostatic stresses and stress changes due to externally applied loads (under plane strain and axisymmetric conditions). Phenomenological and microscopic description of soil deformation mechanisms. The triple role of the fluid phase. Stress-strain relationships under different loading conditions: one-dimensional compression, cylindrical (tri-axial) compression, simple shear, torsion. Shear strength of a soil element, Mohr-Coulomb failure criterion. Undrained loading: excess pore pressure, stress-strain relations under various loading conditions, undrained shear strength of soils.

Laboratory: Demonstration of common soil mechanics tests used to determine physical and mechanical properties.

*G. Bouckovalas, Professor
M. Kavvas, Associate Professor
V. Georgiannou, Assistant Professor
N. Gerolimos, Lecturer*

6.5.2. INTRODUCTION IN SYSTEMS OPTIMIZATION

Basic elements of operation research. Selected optimisation procedures for decision making and design of civil engineering projects.

*M. Karlaftis, Assistant Professor
K. Rokos, Lecturer*

6.5.3. COMPUTER APPLICATIONS IN CIVIL ENGINEERING

The use of electronic computers for the solution of problems related to Civil Engineering. Programming languages with particular emphasis on FORTRAN 90. Geometric and algebraic test problems. Integration, least-squares, Fourier series. Solution of linear algebraic systems and eigenvalue problems. Applications to different Civil Engineering disciplines. The Matlab program and its uses, Matlab toolboxes and mathematical libraries, the Matlab programming language, graphics in Matlab and interaction with other programming languages. Various Matlab commands, such as commands for: Simple calculations, complex numbers, matrices, solution of linear systems, polynomials, polynomial roots, graphics in 2D or 3D, histograms, symbolic mathematics, derivatives, integrals, interpolation polynomials, differential equations, functions, solution of non-linear equations, solution of non-linear systems, Taylor polynomials.

E. Papadrakakis, Professor

6.5.4. APPLIED HYDRAULICS

1. **Introduction.** Properties of the velocity field. Types and basic characteristics of flow. Equations of flow. Boundary layer. Basic flow analysis techniques.
2. **Distribution of flow velocity near walls.**
3. **Theoretical analysis of flow in circular pipes.** Entrance region and uniform flow. Friction losses, friction factor and the Darcy-Weisbach equation. Distribution of flow velocities and shear stresses in laminar and turbulent flow. Effect of rough walls. The Moody chart. Empirical equations. Minor losses.
4. **Practical problems of flow in pipes.** Types of simple problems. Problems with pumps and turbines. Multiple pipe-systems. Complex problems.
5. **Flow in non-circular ducts.** Hydraulic diameter. Friction losses. Flow between parallel plates.

6. **Introduction to open channel flow.** Characteristics and basic equations for steady flow.
7. **Critical flow.** Specific energy and force. Hydraulic jump. Critical depth.
8. **Uniform flow.** The Manning formula. Normal depth.
9. **Efficient uniform flow channels.**
10. **Gradually varied flow.** Basic equation, classification of solutions and composite-flow profiles.

*A. Stamou, Professor
I. Stefanakos, Lecturer*

6.5.5. HIGHWAY ENGINEERING I

Introduction. Planning and design of highways. Basic elements of geometric design. Design speed, operating speed (V85), maximum allowable speed. Horizontal alignment, tangents, spiral curve transitions, circular curves. Types of clothoids. Vertical alignment, profile diagram, grades, sag and crest vertical curves. Fitting alignment to topography. Cross sectional elements and cross slope. Methods of attaining superelevation. Superelevation run-off lengths. Illustrative cross sections. Pavement widening on curves. Stopping sight distance. Passing sight distance. Role of sight distances in planning and design of highways. Sight distance on horizontal and vertical curves. Visibility diagrams.

*G. Kanellaidis, Professor
A. Kaltsounis, Lecturer*

6.5.6. ENVIRONMENTAL ENGINEERING

Transport phenomena in the aquatic environment: advection, molecular and turbulent diffusion, dispersion, related mathematical formulation. Physical, chemical and biochemical processes in the aquatic environment and reactors. Flow and mixing regimes in reactors (batch, continuous flow completely mixed and plug flow).

Disposal of liquid wastes in recipients, study of self purification capacity and quantitative assessment of impacts (oxygen depletion in rivers, eutrophication in lakes, toxicity, microbial pollution of bathing waters). Principles of water and wastewater treatment in compliance with legal requirements and description of related treatment plants. Reuse and utilisation of sewage and sludge with emphasis on agricultural practices. Solid waste management according to the prevention ladder principle: characteristics, valorisation, collection and transportation, recycle, reuse, recovery of materials and energy, landfilling, composting, thermal treatment. Introduction to air and noise pollution due to traffic. Training in experimental methods .

*A. Andreadakis, Professor
A. Stathopoulos, Professor
M. Pantazidou, Assistant Professor
D. Mamais, Assistant Professor*

6.5.7. ADVANCED NUMERICAL ANALYSIS

- Part A: Hermite and Gauss numerical integration. Hermite interpolation. Orthogonal polynomials. Error estimates. Two-dimensional numerical integration. Complex numerical integration (trapezoidal, Simpson). Various types of numerical integration on triangles.
- Part B: Numerical solution of integral equations using trapezoidal and Simpson's formulae. Solutions of partial differential equations by numerical methods. Finite difference method. Finite elements method. Error estimation and stability. Applications: problems on elasticity, liquid flow, heat propagation, infiltration, wave theory problems.

E. Tychoopoulos, Assistant Professor

6.5.8. STRUCTURAL ANALYSIS II

Statically determinate and indeterminate structures - degree of indeterminacy. Compatibility of deformations. Formulation of the

force method. Calculation of flexibility coefficients. Temperature variation effects. Settlement of supports. Elastic supports. Applications. Calculation of deformations of statically indeterminate structures. Checking of solutions. Simple space structures. Symmetric structures. Symmetric and anti-symmetric loading. Degree of kinematic indeterminacy of structures, nodal displacements, examining the kinematic indeterminacy. Formulation of the nodal displacement method. Comparison with the force method. Fundamental solutions for fixed-fixed and fixed-simply supported beams. Stiffness coefficients. Applications. Symmetric structures. Structures having skew members. Applications. Cross method with non-translated and translated nodes. Influence lines of statically indeterminate structures. Muller-Breslau principle. Applications on continuous beams and frames.

*V. Koumouisis, Professor
L. Stavridis, Associate Professor
K. Spiliopoulos, Associate Professor
Viss. Papadopoulos, Lecturer
N. Lagaros. Lecturer*

6.5.9. ENGINEERING HYDROLOGY

Introductory concepts (definitions, historical review, hydrological cycle, hydrological information, drainage basin). Description, analysis and measurement of hydrological processes (atmospheric precipitation, water losses, surface runoff, groundwater, aquifers exploitation). Probabilistic and statistical methods in technical hydrology (probabilistic description of hydrological processes, risk analysis, standard statistical analysis and forecast of hydrological variables, statistical investigation of the correlation between hydrological variables, improvement of hydrological information). Calculation methods (flood hydrograph, linear basins, unit

hydrograph, flood routing, introduction to catchment scale simulation models).

*M. Mimikou, Professor
N. Mamasis, Lecturer
C. Makropoulos, Lecturer*

6.6. 6th Semester

6.6.1. URBAN HYDRAULIC WORKS

Introduction to water supply. Quality of drinking water. Water demand. Water collection and intake. Case study: the water supply system of major Athens. Aqueducts: general layout, design flows, water transfer by open channels and conduits, special constructions, pumping stations, water tanks. Water distribution networks: design flows, general layout, pressure zones, pressure reducing valves, minimum pressure control. Mathematical modelling of water supply networks: schematisation, computational procedures. Sewer systems: storm, sanitary and combined sewers, general layout, design flows, hydraulic modelling, technology of sewers, wastewater quality issues.

*D. Koutsogiannis, Professor
E. Aftias, Assistant Professor*

6.6.2. SOIL MECHANICS II

Application of elastic continuum theory: stresses and strains of soil masses under external loading. Plane strain and axis-symmetric loading. The St. Venant principle. Horizontal earth pressures under different loading conditions. Rankine and Coulomb methods. Gravity retaining walls. The role of elastic deformations. Retaining structures at the Athens metro stations. Undrained soil deformation and undrained shear strength. Limit equilibrium methods in soil mechanics. Slope stability under drained and undrained conditions. Calculation of limit load under foundation (bearing capacity). Ground water flow. Evolution in time of excess pore water pressures and consolidation of a clay layer. Seismic Liquefaction.

*G. Gazetas, Professor
I. Protonotarios, Assistant Professor
N. Gerolimos, Lecturer
I. Anastasopoulos*

6.6.3. INTRODUCTION TO REINFORCED CONCRETE

- Concrete (Introduction, constituent materials, production, quality control and applications. Concrete behaviour: cracking, uni-, bi- and tri-axial behaviour; Stress-strain relationships; statistical variability; creep, shrinkage, etc.). Steel (mechanical characteristics and technical information). Concrete-steel interaction.
Laboratory work: concreting, workability tests, compression and direct and indirect tension tests; tensile testing of steel bars. Bond tests
- Reinforced concrete (RC) (linear structural elements): linear elastic beam; RC beam; serviceability and ultimate limit states; behaviour in bending and shear; effect of axial load.
Laboratory work: testing of beams with and without stirrups under transverse load with and without the combined action of axial load.
- Introduction to prestressed concrete

*M. Kotsovos, Professor
C. Zeris, Assistant Professor*

6.6.4. HIGHWAY ENGINEERING II

Highway earthworks. Area of cross sections. Determination of volume of earthworks by appropriate methods. The mass diagram. Calculation of average haul distance and corresponding cost. Freehaul, overhaul and economic haul. Balancing lines. Principles of pavement design and pavement types. Soil classification for highway construction purposes. Traffic loads. Elements of flexible pavements and traffic engineering. Elements and types of intersections and interchanges. Highway drainage. Basic elements of three dimensional highway design. Combinations of horizontal and vertical alignment.

*G. Kanellaidis, Professor
A. Kaltsounis, Lecturer*

6.6.5. STATICS III

The Direct Stiffness Method and its application in the analysis of framed structures. Vectors of nodal forces and nodal displacements of an element. Transformation matrices. Stiffness matrix of a truss element (in two and three-dimensions), of a frame element (in two and three-dimensions), of a grid element in local and global system of axes. Equivalent nodal forces. Formulation of nodal load, nodal displacement and global stiffness matrices of the structure. Structure support. Inclined supports. Internal releases. Calculation of structure's nodal displacements and elements' nodal forces. Elements of variable cross-section. Rigid offsets. Static condensation. Substructures. Computer implementation of the Direct Stiffness Method.

*E. Papadrakakis, Professor
E. Sapountzakis, Associate Professor
M. Neratzaki, Assistant Professor*

6.6.6. TRANSPORTATION SYSTEMS PLANNING

Introduction to transportation- activity systems. Land use. Accessibility. Systems characteristics, the 4-step planning process. Transportation demand analysis: aggregate and disaggregate demand, economic aspects. Transportation infrastructure supply analysis: cost models and economic planning. Demand-supply equilibration and network equilibria. Transportation models and simulation methods: regression, choice models and traffic assignment. Travel data collection and analysis methods.

*A. Stathopoulos, professor
P. Psaraki – Kalouptsidi, Lecturer
D. Tsamboulas, Professor
M. Karlaftis, Assistant Professor
A. Ballis, Assistant Professor*

6.6.7. ENGINEERING GEOLOGY

Introduction. Engineering Geology and Geotechnics. Properties of geological materials. Rocks as discontinuous media: Rock mass.

Geotechnical classification of rocks and rockmasses. Site investigation. Geology and foundation of buildings and engineering works. Geology and underground openings and tunnels. Geology and dams-reservoirs. Rock slope stability. Geology and construction materials. Geology of Greece and geological conditions in relation to the study and construction of engineering works. Geology and waste disposal.

P. Marinos, Professor
G. Tsiambaos, Associate Professor

6.7. 7th Semester

6.7.1. EARTHQUAKE RESISTANT STRUCTURES

- Fundamental concepts of engineering seismology: Cause of earthquakes - Recording of earthquakes – Seismometry – Seismic waves – Accelerograms – Principles of seismic hazard analysis.
- Elastic seismic response of single degree-of-freedom systems: Equation of motion - Response spectrum – Effects of foundation conditions on the seismic response – Torsional response of elastic SDOF systems.
- Inelastic response of single-degree-of-freedom systems: Ductility – Behaviour factor - Design spectrum – Seismic design (force method).
- Seismic response of multi degree-of-freedom systems: Modal spectrum analysis – Simplified lateral force method of analysis – Seismic response of continuous systems.
- Basic concepts of the Greek Seismic Code and Eurocode 8: Seismic loads – Capacity design – Principles for a rational seismic design.
- Demonstration of the dynamic response of model structures.

*K. Spyrakos, Professor
I. Psycharis, Associate Professor*

6.7.2. CONSTRUCTION MANAGEMENT

Introduction to Construction Management and to the relevant legislative & regulative framework. Books of Knowledge (BOKs) and Project Management Standards. Project Organisation. Planning, Scheduling and Controlling methods. Gantt Charts, S-curves, Matrix Schedules, Horse Blankets, Lines of Balance. Critical Path Analysis (GERT, CPM, MPM, PERT). Project Cost and Financial Planning (Actual vs Contractual Cost, cost estimating, unit rates and operational

estimating, cost reporting, invoicing and cost protocols according to the Greek Law), Cost / Time Trade Offs. The use of Floats, Scheduling of Resources with resource / time constraints. Project Control - Schedule control / Financial Control. Product Breakdown Structures (PBS), Work Breakdown Structure (WBS) and Organisational Breakdown Structures (OBS). Construction management software & IT applications, Quality in Construction, Application of ISO 9000 in construction, Health and Safety of Construction Works.

J.P. Pantouvakis, Assistant Professor

6.7.3. SPECIAL TOPICS ON BUILDING TECHNOLOGY

Timber and metal structures, forming methods. Restoration, maintenance and reinforcement of traditional structures. Modern construction methods (prefabrication, space trusses).

A. Sotiropoulou, Assistant Professor

I. Tzouvadakis, Assistant Professor

E. Katsaragakis, Lecturer

6.7.4. MARITIME HYDRAULICS AND HARBOUR ENGINEERING

Introduction to sea hydraulics. Waves: generation of wind-waves, wave measurements, real waves and their mathematical representation. Theories of small and finite amplitude waves. Analysis of wave records: description parameters, distribution of wave heights. Seabed influence: shoaling, breaking, refraction. Wall influence: reflection, diffraction. Pressures of standing and breaking wave on vertical wall. Types and roles of ports. Design criteria for harbour works. Vessel characteristics. General layout of harbours. Navigation channels, port entrance, manoeuvring area. Wharves and piers. Design of rubble-mound breakwaters. Walls with vertical face: calculations under standing and breaking wave conditions. Design of quaywalls.

Berth outfits. Planning of back – up area of general cargo area. Sheds and other facilities.

*K. Moutzouris, Professor
S. Azorakos, Lecturer
V. Tsoukala, Lecturer*

6.7.5.FOUNDATIONS

Factors affecting foundation design. Bearing capacity of shallow foundations. Principles of settlement design. Settlement of shallow foundations on cohesive and non-cohesive soils. Allowable settlements of structures. In situ tests for the design of shallow foundations. Contact pressures. Design of shallow foundations, spread footings, combined footings, beams on elastic foundations, raft foundations. Piled foundations, construction methods. Bearing capacity of piles into cohesive and non-cohesive soils. Settlement of piles. Design of piles with the help of in situ tests. Groups of piles. Piles under horizontal loads. Selection of foundation type.

*M. Kavvadas, Associate Professor
V. Papadopoulos, Assistant Professor*

6.7.6. ARCHITECTURAL SPECIAL PURPOSE BUILDING DESIGN

Design of special purpose buildings and environments (office buildings, transport terminals for mass transport carriers, research installations, industrial buildings, warehouses, etc). Analysis of operations, determination of equipment and installations, analysis and development of space design criteria (anthropometric, structural, environmental, financial, etc). Structures and construction respecting the existing environment. Computer assisted analysis of the criteria, in order to achieve optimum design.

*I. Tzouvadakis, Assistant Professor
A. Sotiropoulou, Assistant Professor
A. Vhsilia*

6.7.7. TRAFFIC FLOW

- Traffic flow theory. Basic traffic flow parameters. Use of statistical distributions for the description of traffic flow parameters. Relations between traffic flow, speed and traffic density.
- Traffic capacity and level of service. Principles. Variables affecting traffic capacity. Calculations for the estimation of traffic capacity and level of service on interurban roads of two and three lanes per direction and of two lanes in total.
- Principles of traffic investigations and counts. Principles of sampling. Counts of traffic flows, delays and speeds. The moving observer method.

*J. Golias, Professor
G. Yannis, Assistant Professor*

6.7.8. EXPERIMENTAL SOIL MECHANICS

The course covers laboratory methods commonly used to determine the soil parameters that govern its engineering behaviour. As part of the course the students have the opportunity of performing standard laboratory tests. Tests include: soil classification tests based on the measurement of the grading of a soil sample, its water content, unit weight and Atterberg limits (e , $w\%$, γ_s , γ_d , LL, PL). Measurement of hydraulic conductivity using constant head and falling head permeameters. Measurement of the parameters needed for consolidation settlement calculations (E_s , c_c , c_s , c_v) using the consolidation test. Determination of shear strength parameters of non-cohesive soils using the direct shear strength apparatus. Drained and undrained triaxial tests. Comparison between laboratory and field measurements. Use of a single unifying framework based on critical state theories to describe and interpret the observed soil behaviour.

V. Georgiannou, Assistant Professor

6.7.9. STEEL STRUCTURES I

Introduction, production of steel products, mechanical properties of steel, limit state design, ultimate and serviceability limit states, cross section classification, verification for strength (normal force, bending, shear), elastic and plastic analysis and design, bolts in shear, verification for flexural buckling, elements of single storey buildings (sheeting, purlins, beams, trusses, columns), loads on buildings, conceptual planning, analysis and design of single storey industrial buildings, laboratory exercises:

1. Bolting – erection of beam-to-column joints, preloading of bolts, loading tests
2. Lateral buckling load of beams
3. Corrosion protection of steel structures

*I. Vagias, Professor
G. Ioannidis, Professor
C. Gantes, Associate Professor*

6.7.10. REINFORCED CONCRETE

Introduction. Design limit states. Ultimate and serviceability limit states. Design against direct actions: Assumptions, properties of materials. Rectangular sections. Axial tension. Prevalent bending, diagrams and CEB design tables. Prevalent compression. Columns, interaction diagrams. Biaxial bending. T-beams, analytical design and design tables. Anchorage of steel bars, bond, anchorage types, basic development length. Lap splices. Design for shear. Cyclic shear. Torsion. Cracking. Modelling of RC structures. Construction detailing, minimum covers, distance of bars, allowed curvatures. Minimum requirements per structural element (sectional dimensions, minimum reinforcement). Laboratory tests (production-reinforcing-casting of concrete, anchorages).

*E. Vintzilaiou, Associate Professor
P. Giannopoulos, Associate Professor
K. Trezos, Assistant Professor*

6.7.11. STATICS IV

Dynamic loads. Free and forced vibrations of single-degree-of-freedom systems. Damping. Generalised single-degree-of-freedom systems. Simulation and analysis of Civil Engineering structures of a single degree of freedom. Free and forced vibrations of multi-degree-of-freedom systems. The finite element method for the dynamic analysis of framed structures. Eigenmode analysis. Numerical integration of the equations of motion and computer implementation. Approximate dynamic analysis (Rayleigh's method). Numerical methods for the computation of natural frequencies and modes of vibration. Damping of multi-degree-of-freedom systems. Response of multi-degree-of-freedom systems with moving supports. Applications on Civil Engineering structures. Dynamic analysis of multi-story buildings.

*K. Syrmakezis, Professor
M. Neratzaki, Assistant Professor
E. Sapountzakis, Associate Professor*

6.7.12. FREE SURFACE FLOW

Introduction. The equations of continuity, momentum and energy. Critical flow theory. Applications. Examples. Uniform flow. Design of lined and unlined channels for uniform flow.

The optimal cross section. Non-uniform, gradually varying flow. Classification of flow profiles. Qualitative analysis, control sections. Quantitative analysis. Profile calculation for free surface flow in natural and artificial conduits.

Complex problems. The hydraulic jump. Types and characteristics of jump. Locating and controlling the jump. Energy dissipation. Stilling basins. Rapidly varying flow. Broad and sharp crested weirs. Lateral spillways. Dam spillways.

Sluice gates. Free overfall. Design of transitions for sub-critical flow. Curves and transitions in super-critical flow. Oblique hydraulic jumps.

Bridge abutments. Culverts. Junctions. Spatially variable flow. Unsteady flow. Gradually varying flow, St. Venant equations. Stage – discharge relationship in unsteady flow. Introduction to flood routing methods (e.g. Muskingum and others). Elements of sediment transport.

G. Christodoulou, Professor

6.8. 8th Semester

6.8.1. COASTAL ENGINEERING

Introduction. Field of application. Coastal wave mechanisms. Wave breaking. Theory of radiation stress. Wave - generated currents. Coastal sediments, sample collection, statistical parameters. Sediment motion. Sea bed shear stress. Sea bed roughness. Wave friction coefficient. Initiation of sediment movement. Sediment suspension. Sediment transport. Neutral line. Sediment motion. Monitoring techniques. Sediment transportation along - and cross - shore. Sediment transport rate. CERC method. Sediment accumulations Influence of coastal obstacles and works. Mathematical study of coastal line evolution. Introduction to coastal protection works. Structures parallel to the coastline. Structures perpendicular to the coastline. Beach nourishment.

*K. Moutzouris, Professor
V. Tsoukala, Lecturer*

6.8.2. SOIL-STRUCTURE INTERACTION

The concept of soil--foundation--structure interaction, examples of applications to foundations, retaining systems, above-ground and underground structures. The rigid foundation on elastic continuum. Seismic soil--structure interaction. Beams and plates on soil under external loading. Foundations subjected to concentrated soil deformation. Piles under lateral and axial loading. Tunnel--soil interaction.

*G. Gazetas, Professor
M. Kavvadas, Associate Professor
I. Anastasopoulos*

6.8.3. FINITE ELEMENT ANALYSIS OF STRUCTURES

Energy theorems. Principle of virtual work. Stationary principle of total potential energy. Rayleigh-Ritz and Galerkin methods. General stiffness matrix derivation of a finite element in two and three dimensions. Shape functions and stiffness matrix derivation of one-dimensional elements. Stiffness matrix derivation of a finite element in plane stress and plane strain elasticity problems. Triangular and orthogonal elements. Isoparametric formulation. Isoparametric shape functions, coordinate transformation, numerical integration. Quadrilateral elements in plane stress, plane strain and axisymmetric conditions. Three dimensional solid elements of tetrahedral and hexahedral type. Selection rules for the shape functions, equilibrium and compatibility conditions, convergence requirements and the patch test. Numerical errors and convergence. Modelling, discretization, manipulation of errors. Applications to the analysis of shear walls, dams and buildings according to the seismic design codes. Numerical implementation and computer programming of the method.

*E. Papadrakakis, Professor
V. Koumouisis, Professor*

6.8.4. EARTHQUAKE ENGINEERING 1

- Elastic seismic response of single degree-of-freedom systems: Equation of motion – Free vibrations – Damping – Earthquake response - Response spectrum – Alternative ways of displaying spectra - Effects of foundation conditions on the seismic.
- Inelastic response of single-degree-of-freedom systems: Ductility – Behaviour factor – Overstrength – Relations q_d - μ – Inelastic response spectrum - Design spectrum – Seismic design (force method).
- Seismic response of multi degree-of-freedom systems: Modal spectrum analysis – Simplified lateral force method of analysis – Seismic response of continuous systems.

- Basic concepts of the Greek Seismic Code and Eurocode 8: Seismic loads – Capacity design.
- Demonstration of the dynamic response of model structures.

*K. Spyrakos, Professor
I. Psycharis, Associate Professor
C. Mouzakis, Assistant Professor*

6.8.5. URBAN ROAD NETWORKS

Introduction to urban transportation systems. Hierarchy, standards, configuration and spacing of urban road networks. Traffic capacity of intersections. U.S.A. and U.K. methods. Signalization. Signalization warrants. Optimization of an isolated intersection. Delays. Queuing. Coordinated signalization of an artery. Road Signs and markings. Parking. Characteristics. Estimation of parking needs. Design, construction and operation of parking garages. Parking surveys and studies. Financial evaluation of parking garages construction and operations.

*J. Golias, Professor
D. Tsamboulas, Professor*

6.8.6. SELECTED TOPICS IN FOUNDATION ENGINEERING

- **Flexible retaining walls and anchors:** General overview. Computation of earth pressures for cohesive and non-cohesive soils, under various drainage and flow conditions. Design of self supported flexible walls (without anchors). Design of flexible walls with single or multiple anchors. Construction and design methods for anchors. Evaluation of the overall stability of the wall-anchor-soil system.
- **Soil improvement and reinforcement:** General review of available methods. Soil improvement by pre-loading. Strength and compressibility of the improved ground for different cases of applied preloading. Use of drains to accelerate excess pore pressure dissipation and reduce pre-loading time-design methodology. Soil

reinforcement using gravel piles. Construction methods. Bearing capacity and settlements of single gravel piles. Equivalent shear strength and settlement of a group of gravel piles.

- **Field exercises:** Two visits of relevant construction sites within the Greater Athens area and one 3-day visit to major construction sites all over Greece.

G. Boukovalas, Professor

6.8.7. SPECIAL CHAPTERS ON URBAN PLANNING

Contemporary urban areas: Socio-economic and spatial restructuring. Social cohesion. European dynamics. City and region: New relationships, new geography. Analytical methods and tools for spatial planning analysis. Planning and sustainable urban development. Impact on gentrification of state-led renewal and infrastructure projects as well as of cultural industry. City transportation planning, environmental aspects. The challenges for cities in Greece. Case studies on relevant topics

E. Panagiotatou, Professor

A. Stathopoulos, Professor

I. Tzouvadakis, Assistant Professor

K. Rokos, Lecturer

A. Stamos

6.8.8. INTRODUCTION TO BRIDGE CONSTRUCTION

Introduction. Background knowledge. Preparatory actions, acquisition of input information and data. General characteristics of bridges. Terminology of bridges. Superstructure details. Structural systems of bridges. General arrangement. Forms of bridge supports and wingwalls. Assessment of bridge total length- Bridge hydraulics. Standards of bridge design loading - Design guidelines. Types of deck structures - General features and methods of analysis. Slab - T beam and box girder bridges. Design of piers and abutments. Bridge foundations. Seismic design of bridges. Durability of bridges. Modern

construction methods. Design topics pertaining to particular construction methods.

*M. Kotsovos, Professor
G. Gazetas, Professor
I. Anastasopoulos*

6.8.9. REINFORCED CONCRETE STRUCTURES

Slabs. Two way slabs. Flat slabs. Non rectangular slabs. Frames. Footings. Corbels. Deep beams. Walls. Buckling, Seismic design. Repair and strengthening of reinforced concrete structures. Surveillance and certification of production control.

*P. Giannopoulos, Associate Professor
K. Trezos, Assistant Professor
E. Katsaragakis, Lecturer*

6.8.10. TIMBER STRUCTURES

Introduction, areas of applications, comparison of structures made with various materials. Composition, properties, dampness of timber. Basic mechanical characteristics. Structural timber. Calculation principles, strength, forces, combination of forces. Calculation of timber structures. Joints, fabrication and design, riveting, bolting, bonding. Roofs. Calculation of timber frame. Scaffoldings. Formwork. Bridges. Foundations. Durability. Earthquake resistant design of timber structures. The effects of fire on timber. Assessment of earthquake damage. Restoration after damage

E. Katsaragakis, Lecturer

6.8.11. PAVEMENTS

General concepts. Definitions. Pavement types and categories. Damaging effects on pavements caused by various factors. Road traffic. Climate. Analytical/theoretical pavement design. Empirical pavement design methods. Mechanical properties of materials. Asphalt-bituminous mixes. Unbound pavement materials and soils.

Bound materials and stabilized soils. Semi-rigid pavements. General principles of pavement maintenance -management.

A. Loizos, Professor

6.8.12. FINITE ELEMENTS

Introduction to the Finite Element Method (FEM). General description of the method. Displacement Method. Plane elements. Three dimensional and axisymmetric elements. General families of elements and isoparametric elements. Generalization of the Finite Element Method. Weighed residual Method (Variational method, Rayleigh-Ritz method). Fluid and Heat conduction field problems. Elastodynamic field problems (static and dynamic behaviour). Incompressible and non-Newtonian materials (application in the simulation of structural problems). Methods for the solution of large systems in the FEM. Pre-processing and post-processing of data and other techniques in the FEM. The error in the FEM.

E. E. Theotokoglou, Professor

6.8.13. ENVIRONMENT AND DEVELOPMENT

Part 1: Theoretical background and tools: environment and development, sustainable development and other approaches, policies for environment and development, different tools.

Part 2: Case-studies: global warming, Waste management-saving-recycling-valorisation. Air conditioning friendly to the environment. Lignite, natural gas and alternative energy resources, technological and environmental approach. Water resources and environment. Environment as an economic activity: a second life for former industrial zones (Lavrio). The role of law in the conflict between environment and development.

Part 3: the role of engineer in the conflict between environment and development.

K. Hadjibiros, Associate Professor

V. Tsoukala, Lecturer

6.8.14. ADVANCED MECHANICS OF MATERIALS

Plane problems in Cartesian and polar coordinates. Airy's stress function. Stress concentration problems. The problems of Kirsch, Kelvin and Flamant Boussinesq. Contact problems. Fracture mechanics for concrete and rock. Quasi brittle materials. Introduction to Linear Elastic Fracture Mechanics. Stress concentration effect of flaws. Griffith's energy balance. The energy release rate.

D. Eftaxiopoulos, Assistant Professor

6.8.15. STEEL STRUCTURES II

Mechanical fasteners, normal bolts, high strength friction bolts, eye-bars, bolted connections and joints, column bases, welding technology, welded connections, beam-to-column connections and joints, St Venant torsion, warping torsion, lateral torsional buckling, design of beams and beam columns, seismic design of single and multi story buildings, fire design of steel structures, fatigue, laboratory exercises:

1. Weldability of steel, welding methods, welding parameters and welding consumables
2. Quality control of welds with destructive methods
3. Quality control of welds with non-destructive methods

I. Vagias, Professor

G. Ioannidis, Professor

C. Gantes, Associate Professor

6.8.16. STEEL STRUCTURES III

Introduction. Historical review. Metallurgy of iron. Steel and structures. Advantages/disadvantages. Classification of structures. Structural form of structures. Design criteria. Optimum design. Structural components (roofs, floors, main and secondary beams, columns, bracing systems, foundations). Actions on structures due to wind, snow, etc. Models of analysis. Construction details. Bracing systems. Fabrication, erection, maintenance. Special structures (hollow sections, space trusses, cranes, cable supported roofs, fuel tanks, etc). Description of modern steel structures.

I. Ermopoulos, Professor

6.8.17. RAILWAYS

Introduction- the role of railways. Permissible axle loads. Permanent way, track materials, rails, sleeper, fastenings, ballast. Static and dynamic calculations of the permanent way. Turnouts and crossings. Substructure: embankments, cuttings, draining. Special structures. Track geometry, vehicles,. Clearances, tractions, train configuration, railway stations.

K. Lympiris, Lecturer

6.8.18. STRUCTURAL ANALYSIS V: PLASTIC ANALYSIS OF FRAMED STRUCTURES

Engineering theory of elastoplastic bending. Fully plastic bending moment, elastoplastic boundaries, influence of shear and axial forces. Loading-unloading, remaining stresses. Classical methods of plastic analysis. Theorems of plastic collapse. Method of combined mechanisms. Foulkes graphical method of plastic design with minimum weight. Matrix methods of plastic analysis and design with linear programming. Linear programming equations based on kinematic and plastic collapse theorems. Automatic evaluation of plastic collapse mechanisms. The matrix step-by-step elastoplastic

analysis for the determination of load-displacement curves and critical loads. Modification of computer codes for elastic analysis to account for the elastoplastic analysis of framed structures. Elastoplastic stiffness matrix of beams based on a layered approach with distributed plasticity. Pushover analysis of structures. Performance-base design, reduction factor q , capacity curves, effectivity index. Structural design methodologies under earthquake loading.

*E. Papadrakakis, Professor
K. Spiliopoulos, Associate Professor*

6.8.19. ELEMENTS OF LAW AND TECHNICAL LEGISLATION

Elements of Law: Introduction. Fundamental concepts and legal aspects on the following branches of the law: Public Law (Constitutional, Administrative, Protection of Environment, Environmental Impact Studies). Civil Law (General Principles, Property Law, Obligations Law, Copyright Law) Commercial Law (Mercantile Law, Commercial Transaction Law, Company Law, Security Law, Industrial Property Law, Assurance Law, Merchant Marine and Bankruptcy Law) Labour Law (Personal and Collective, Workers' Safety and Health, Labour Accidents, Liability of Engineers) European Law (Sources, Institutions, Directives, Internal Market Legislation on Regional Development of Infrastructure).

Technical Legislation: National and E.U. Legislation on Public Works (Tendering, Authorities, Construction Companies, Contracts, Contract Misconduct, etc.) Urban Law (Object and Purpose of the Law, the Relationships with Rural Law, Protection of the Environment, Architectural Heritage, Development Sustainance). General Building Regulation.

*V. Karasmanis, Associate Professor
S. Gerasimou*

6.8.20. COMPOSITE MATERIALS

Technical background and development of composite materials. Production procedures. Mechanical behavior of composite materials. Hooke's law for orthotropic and anisotropic materials. Rule of mixtures. Micromechanical and macromechanical properties. Membrane, bending and combined loading of laminates. Failure criteria for plies and laminates. Experimental procedures for determining the properties of constituent materials, plies and laminates. Fracture mechanics of composite materials. Viscoelastic behavior. Analysis of damping. Aging and fatigue. Interlaminar stresses and delamination criteria. Hygrothermal behavior. Analysis of structures made from composites. Applications using the finite element method.

I. Raftoyiannis, Assistant Professor

6.8.21. SANITARY ENGINEERING

Part A. Required qualitative characteristics of potable water and related legislation. Groundwaters and surface waters intended for abstraction of potable water (classification, protection). Water treatment plants: process design of conventional units (pre-chlorination/ozonation, coagulation, flocculation, sedimentation, filtration, disinfection). Advanced treatment through activated carbon, ion exchange, hardness removal, membranes. Design project.

Part B. Quantitative and qualitative characteristics of domestic liquid wastes. Required treatment and relevant legislation. Wastewater treatment plants: process design of units (preliminary and primary treatment, secondary treatment using suspended and fixed-film biomass). Mathematical model for the design of the activated sludge process, aiming at carbon and nitrogen removal. Sludge treatment (thickening, digestion, dewatering). Tertiary effluent treatment

through filtration and additional sludge processing for subsequent reuse and utilisation (sludge sanitation). Design project.

*A. Andreadakis, Professor
D. Mamais, Assistant Professor*

6.8.22. HYDROELECTRIC PROJECTS

Hydroelectric energy and Hydro-potential. Reservoir design. Lay-out of conventional hydroelectric projects, small hydroelectric installations and pump-storage projects. Phases of preliminary design, final design, construction and operation. Environmental design of hydroelectric projects. Auxiliary and investigation works (topographical, geological, geotechnical, hydrological, climatological, electric loads at peak and base). Design of the energy production system and the associated works, intakes, tunnels, surge tanks, penstocks, power plant, tailrace channels and tunnels. Design of power water ways, loading assumptions, conduit lining. Design of power plants. Action turbines (Pelton). reaction turbines (Francis Kaplan). Reversible units. Pumps. Flow in turbine rotor and pump impeller. Cavitation and water hammer. Gates, valves. Turbines of small hydropower plants (bulbs, S-type). Basic principles, design criteria and operation of small hydroelectric projects, environmental considerations. The economics of hydroelectric projects. bill of quantities, cost estimates, investments, capital amortization, construction management, energy production and operation. Hydrothermal cooperation.

I. Stefanakos, Lecturer

6.8.23. GROUNDWATER FLOW

Introduction, definitions, continuum approach to flow through porous media. Aquifers and classification of aquifers, groundwater balance. Darcy's law in three dimensions, hydraulic conductivity, anisotropy, continuity equation. Mathematical statement of the flow through

porous media, boundary conditions, seepage face, methods for solving groundwater problems, flow nets. Hydraulic approach to flow in aquifers, Dupuit assumption for phreatic aquifers. Analytical solutions for 1-D aquifers. Leaky confined or unconfined aquifers. Seepage through earth dams. The complex variable method, introduction to conformal mapping. Flow underneath engineering structures, method of fragments. Hydraulics of pumping and recharging wells, multiple well systems, method of image, wells near boundaries. Aquifer storativity, unsteady flow. Sea water intrusion in coastal aquifers. Introduction to mathematical modeling of groundwater aquifers.

A. Nanou, Lecturer

6.8.24. COMPUTATIONAL HYDRAULICS

Introduction. Methods for solving linear and non-linear systems, algebraic equations and ordinary differential equations. Classification of second order partial differential equations. Finite differences method. Discretisation methods and boundary conditions. Applications: Flow of ideal and real fluids, unsteady flow in closed conduits (water hammer) and open channels (St. Venant equations, flood routing), groundwater flow, diffusion and dispersion in one and two dimensions. Introduction to turbulence models. Mathematical models of hydrodynamic behaviour and pollution in rivers, coastal areas and lakes.

I. Papadimitrakis, Associate Professor

6.9. 9th Semester

6.9.1. WATER RESOURCES & ENVIRONMENTAL SYSTEMS OPTIMIZATION

PART-I: Introduction to systems analysis for civil engineers, investment & capital return, environmental sustainability & management. Elements of water resources & environmental systems analysis. Mathematical techniques: linear programming, dynamic programming, non-linear programming, hierarchical analysis, multi-objective optimization, stochastic programming, input-output analysis, risk analysis, statistical methods, and basic econometrics. Database design, use of webGIS and of internet technologies.

PART-II: Application of systems methods in: environmental decision making, environmental quality (pollutants, air, water, soil, biota), ecosystems, inland & coastal waters, solid & toxic wastes, EIA & sustainability plans. Optimal design of water & environment works: dam, energy systems, water supply, sewerage, treatment plant, outfall, agricultural & drainage system, regional actions & decision making. Scheduling of works, project management via systems techniques, optimal works performance. Hands-on systems applications and site visit.

M. Bonazountas, Assistant Professor

6.9.2. EARTHQUAKE ENGINEERING 2

- Modal analysis of seismic response – Numerical calculation of eigenmodes.
- Effect of torsion on the seismic response – Torsionally flexible systems - Torsional response of elastic SDOF systems.
- Performance based seismic design.
- Static nonlinear (Pushover) analysis – Nonlinear time-history analysis.

- Seismic isolation – Principles of design of seismically isolated structures.
- Fundamental concepts of engineering seismology: Cause of earthquakes - Recording of earthquakes – Seismometry – Seismic waves –Accelerograms – Principles of seismic hazard analysis.

*I. Psycharis , Associate Professor
C. Mouzakis, Assistant Professor*

6.9.3. EVALUATION AND IMPACTS OF TRANSPORT INFRASTRUCTURE PROJECTS

Type of transport infrastructure projects (road, railway, airport, port terminals, freight villages, etc) and their impacts (positive/negative). Identification of impacts occurring during construction and operation phases of a project. Impacts on the natural environment (landscape, nearby lakes, coastlines, rivers; air pollution; underground water pollution, etc), on human environment (human settlements, agriculture, noise, visual intrusion, accidents and safety, historical heritage, etc) and on resources (energy, materials, etc). environmental impact assessment studies for transport infrastructure projects. The scope and objectives of evaluation for the construction and operation of transport infrastructure projects. The evaluation process. Evaluation criteria: economic, financial, etc. Cost categories and their measurement. Determination of user benefits. Socioeconomic evaluation of impacts to the natural and human environment. Time dimension of costs and benefits (and revenues). Methods of evaluations and applications. Uncertainty and risk analysis. Process of decision making. Examples.

D. Tsamboulas, Professor

6.9.4. ROCK MECHANICS-TUNNELS

Discontinuity properties and their effect on rock mass behaviour. Rock mass classification systems (Deere, Bieniawski, NGI, GSI). In

situ stresses, models of mechanical behaviour, physical properties and mechanical parameters. Strength criteria, laboratory and in situ tests, stability of rock slopes. Elastic stress distribution of deep and shallow openings. Elastoplastic redistribution of stresses and estimation of tunnels deformations deformations. Principles of the NATM method of tunneling. Zone of influence of excavations, loosening pressures, vertical and lateral pressures on linings. Rock mass reinforcement and support during excavation. Design of rigid and flexible linings.

V. Papadopoulos, Assistant Professor

6.9.5. TRAFFIC MANAGEMENT AND ROAD SAFETY

- Planning, programming and design of projects and measures for traffic management. Improvement of traffic flow. Policies for parking management, preferential treatment of high occupancy vehicles, vehicles' traffic restrictions. Design of exclusive bus lanes. Bicycles. Pedestrians.
- Road safety. Collection and analysis of accident data. Data bases. Identification of hazardous locations. Numerical and Statistical Methods. Identification and evaluation of improvements. Traffic conflict technique. Correlation of accidents with driver and vehicle characteristics as well as with road, traffic and environment.

*J. Golias, Professor
G. Yannis, Assistant Professor*

6.9.6. IRRIGATION ENGINEERING

Introduction. Modern irrigation works in Greece. Water requirements of plants: evapotranspiration-ground humidity-ground salinity. Irrigation networks: Small scale irrigation: non-permanent network, relevant calculations and technology. Transportation and storing: springs, pumps, reservoirs, control reservoirs, canals, closed conduits (gravitational flow) pressurized conduits, flow meters. Large scale irrigation: area irrigation, artificial rain, drip irrigation. General layout

and hydraulic calculations. Source and irrigation water quality. Legislation issues relating to irrigating water. Optimization of irrigation networks under pressure. Control of the hydraulic jump. Introduction to drainage methods and flood protection. Introduction to irrigation works management. Irrigation works consequences and environmental protection.

D. Panagoulia, Lecturer

6.9.7. WASTEWATER TREATMENT AND DISPOSAL

Review of treatment, disposal and reuse processes with reference to legislative requirements. Wastewater characterisation. Detailed design of wastewater treatment plants: layout, process calculations, hydraulic computations, technical considerations, equipment selection. Preliminary treatment (pumping, screening, reception of septage, grit and oil removal, odour control), primary treatment, activated sludge for carbon, nitrogen and phosphorous removal with selectors and appropriate flow configurations for bulking control. Selection and design of aeration systems. Rectangular and circular settling tanks. Tertiary treatment units. Sludge treatment processes and biogas utilisation. Operational problems and automation. Environmental impact considerations. Laboratory work and design project.

*A. Andreadakis, Professor
D. Mamais, Assistant Professor
K. Noutsopoulos*

6.9.8. SOIL DYNAMICS

Introduction : problems and significance of soil dynamics. Dynamics of simple elastic structures. Concept and applications of response spectrum. Seismic sliding of rigid block supported on frictional surface. Seismic Overturning of rigid body. Soil behaviour under dynamic and cyclic loading. Liquefaction of saturated granular soils. Measurements of soil parameters in the laboratory and in situ. One-

dimensional wave propagation, reflection and refraction, propagating and stationary waves. The viscous-damping analogue. Resonance. Seismic wave propagation through soil deposits (soil amplification of seismic motion). Analysis of case studies on the role of soil conditions (Mexico, Kalamata, Pyrgos, Northridge, Kobe, Aegion). Two-dimensional wave propagation, surface waves. Vibrations of surface and embedded foundations. Seismic response of piles. Applications of soil dynamics in recent projects in Greece.

*G. Gazetas, Professor
G. Bouckovalas, Professor
I. Protonotarios, Assistant Professor
V. Georgiannou, Assistant Professor
N. Gerolimos, Lecturer*

6.9.9. GEOTECHNICAL TOPICS (DAMS, TUNNELS, CUTS AND EXCAVATIONS)

- Geotechnics of Gravity and Earth dams : Engineering geological issues, design and construction considerations.
- Tunnels : Wall convergence in weak rockmasses, principles of the NATM method, principles of the convergence – confinement method, principles of tunnel excavation and primary support methods.
- Excavations and cuts in rockmasses : mechanics of failure, stability improvement methods, design and construction considerations
- Use of explosives in engineering projects

*P. Marinos, Professor
M. Kavvadas, Associate Professor
V. Papadopoulos, Assistant Professor
G. Panagiotou, Professor*

6.9.10. SPECIAL TOPICS ON STATIC AND DYNAMIC STRUCTURAL ANALYSIS

Special topics on second order static analysis. Determination of the critical loads on reference planar members under elastic and inelastic buckling using the method of limit strength state.

Dynamic response of bridges. Infinite state elastic systems. Free and forced flexural vibrations of beams. Solution using Fourier series. Special cases of dynamic loading. Bridges and gantry cranes under impact loading. The influence of the velocity of moving loads on the dynamic behavior of bridges and gantry cranes. Dynamic influence lines. Dirac and Heavicide functions. Free and forced longitudinal vibrations. Torsional vibrations. The viscous-elastic beam. Timoshenko's beam. Damping of vibrations. Dynamic loads of elastic instability. Problems of aero elasticity. Active and passive control device.

*G. Michaltsos, Professor
I. Raftoyiannis, Assistant Professor*

6.9.11. CONSTRUCTION MANAGEMENT – SPECIAL SUBJECTS

Scheduling of Linear Projects – critical sequence & critical path. Statistics for Construction Management (concepts, distributions, assumptions & tests). Fuzzy project scheduling. Project orientation as a management strategy – the IPMA system for project management (Methods for project start, coordination, discontinuities management, project control and project close-down) & the ELOT 1429 standard. Review of Construction Management Information Systems (Web technologies, classification systems, ERP, e-construction, document control). Applications of Computer Packages (Primavera, MS-Project).

J.P. Pantouvakis, Assistant Professor

6.9.12. SPECIAL TOPICS IN TRAFFIC ENGINEERING

Traffic control systems using computers and telematics. Traffic analysis software for junctions, corridors and networks. Traffic simulation software. Traffic software applications. Queuing theory. Main characteristics of a queuing system. Types of queues. Single and multiple channel queuing systems. Queuing theory applications in

traffic applications. Use of specialized software for queue and delay computations. Traffic capacity in areas of traffic streams merging. General principles. Main variables. Queue and delay calculations. Weaving areas: length, layout, operational types, parameters and traffic capacity. Traffic flow analysis. Short-term traffic flow prediction.

*J. Golias, Professor
M. Karlaftis, Assistant Professor*

6.9.13. SPECIAL TOPICS IN PORT ENGINEERING

Port operation: mooring, berthing of vessels along quayside. Return period. Tranquility of harbour basins: calculation of disturbances due to wind waves, overtopping of structures, port down-time, seiches. Probabilistic design of port structures: introductory concepts, stochastic analysis of surface waves, failure mechanisms, reliability assessment of structures, sub-systems, stability of mounds, partial coefficients of safety. Quaywalls of sheetpiles: types of walls, design of sheetpiling, superstructure and anchorage. Ramps: geometry. Scour protection. Fenders and outfits. Dredging mechanical equipment. Port container terminal: design guidelines, cargo handling, stacking yards, berths, mechanical equipment, operations. RoRo terminal.

*S. Azorakos, Lecturer
V. Tsoukala, Lecturer*

6.9.14. PAVEMENTS - SPECIAL TOPICS

Types of asphalt mixes (Hot, cold asphalt mixes). Asphalt mix design and tender documents. Asphalt production units. Anti-skid wearing courses. Modified asphalt/asphalt mixes. Other pavement material mixtures and pavement strengthening and reinforcement technologies. Asphalt mix laying and compaction. Environmental impacts and low noise pavements. Pavement recycling, technologies and implementation. Laboratory testing and asphalt mix design.

Mechanical characteristics. Laboratory exercise. Field measurement and technical visits. Accuracy, repeatability, reproducibility.

A. Loizos, Professor

6.9.15. SPECIFIC RAILWAY TOPICS

Wheel/rail contact. Derailment conditions. Train control systems. High-speed trains, rail wear control and maintenance of railway tracks. Introduction of the queuing theory in railway operation. Line capacity. Capacity of railway stations. Special terminals.

*A. Ballis, Assistant Professor
K. Lymperis, Lecturer*

6.9.16. ADVANCED TOPICS ON HIGHWAY DESIGN

Introduction to Digital Terrain Modeling (DTM). Highway design software: horizontal and vertical alignment, superelevation diagram, cross-sections, earthworks, three dimensional design. Topics in research and guidelines for highway design. Strategic planning for road safety improvement. Road Safety Audits.

G. Kanellaidis, Professor

6.9.17. SPECIAL TOPICS OF FINITE ELEMENT ANALYSIS OF STRUCTURES

Mesh generation methods. Isoparametric Timoshenko beam elements in two and three dimensions. Natural mode triangular elements under plane and bending stresses. Isoparametric quadrilateral elements for plates and shells. Mixed type finite elements of displacement-stress and displacement-stress-strain formulations. Derivation of equilibrium equations Adaptive finite elements, error estimation, h, p and hp adaptivity. Simulation methods of structures with finite elements. Simulation of shear walls, plates, beam-plate, diaphragm-column systems Direct and iterative solution methods of equilibrium equations. Storage techniques for the stiffness matrix. Programming

the finite element method. Data handling, memory management, stiffness matrix formation, stress computation. Applications with open and commercial finite element codes.

E. Papadrakakis, Professor

6.9.18. SPECIAL TOPICS IN HIGHWAY ENGINEERING

Types of intersections. Basic principles in highway intersection design. Vehicle movement at intersections. Elements of intersection design. Types and design of intersection islands. Speed - change lanes at intersections. Horizontal and vertical alignment, visibility and grading design at intersections. Interchanges. Three-leg designs. Four leg-designs. Determination of interchange configuration. Interchange spacing. Uniformity of interchange patterns. Route continuity. Coordination of lane balance and basic number of lanes. General ramp design considerations. Entrance and exit ramps. Acceleration and deceleration lengths. Illustrative design examples. Designing highways in mountainous terrain. Horizontal and vertical alignment. Superelevation diagram. Traffic noise characteristics and measurements. Noise control. Noise reduction designs.

*G. Kanellaidis, Professor
A. Ballis, Assistant Professor*

6.9.19. SPECIAL TOPICS ON REINFORCED CONCRETE

The seismic behaviour and the earthquake-resistant design of reinforced concrete structures. (The concepts of: Ductility, confinement of concrete, the behaviour of reinforced concrete materials under cyclic actions, the logic of earthquake-resistant design, design models and structural detailing for beams, columns, joints, coupling beams and shear walls). Fire resistant design for reinforced concrete structures (the nature of fire, the behaviour of reinforced concrete constituent materials under high temperatures, practical fire resistant design). Design for damage rehabilitation or

strengthening of reinforced concrete structures under earthquake or fire. The concept of inelastic design. Application to a typical reinforced concrete building with an appropriate analysis and design computer software.

Design of concrete structures for durability. Exposure classes and design for environmental loading. Design regulations and Standards.

*E. Vintzilaïou, Associate Professor
C. Zeris, Assistant Professor*

6.9.20. LIGHT METAL STRUCTURES

The theory of straight bars with open thin-walled cross-sections. Moments and warping resistance. Simple bending. Double bending. Simple torsion. Flexural-torsional distress. The bimoment and its physical meaning. The theory of straight bars with closed thin-walled cross-sections. Bending, torsion, shearing of single and multiple cell cross-sections. Flexural, torsional, flexural-torsional buckling. Bulging. Diaphragms, longitudinal stiffeners. The in plane curved beam. Design and calculation of planar joints. Surface elements. Basic theory of discs, plates, shells. Stability of surface elements. Corrugated members. Secondary warping resistance. Deformation of a cross-section in its plane. Beams with initial curvature. Codes for thin-walled structures.

*G. Michaltsos, Professor
I. Raftoyiannis, Assistant Professor*

6.9.21. QUALITY CONTROL AND QUALITY ASSURANCE

Basic statistical methods. Statistical methods for quality assurance. Random sampling procedures. Producers' and consumers' risk. Compliance criteria. Operation characteristic curves. Quality control charts, Shewhart charts, running mean charts, cusum charts. Classical v. Bayesian methods. Adjusted and non-adjusted payments. Quality control and assurance programs for construction works and services

(EN 29000). Incorporating quality control and assurance procedures in contract documents.

*A. Stathopoulos, Professor
K. Trezos, Assistant Professor*

6.9.22. OFF-SHORE STRUCTURES

Introduction to hydro-dynamics affecting off-shore structures. Formulation of the interaction problem on sea waves and solid objects. Solution for specific cases. Loads on thin cylindrical elements due to wave action. Morrison's formula for vertical and inclined elements. Large volume compact objects. The MacCammy and Fychs cylinder. Vertical axis cylindrical elements through the sea surface or the sea bed. The catenaries. Solution of the equations. Mooring buoys. Floating moorings. Rigid moorings. Mooring systems and loadings due to wave action and operational loads. Design of crash barriers. The hydrostatic stability of floating structures. Underwater pipes. Estimation of hydro-dynamic loads. The stability of underwater pipe. Recommendations on the design and lying of undersea pipes.

S. Azorakos, Lecturer

6.9.23. THEORY OF DISKS AND SHELLS

Historical review. Elasticity theory and analysis of real structures. The general equations of elasticity. Fundamental elasticity problems. Application on real structures. Boundary conditions. Strain compatibility conditions. Applications. Compatibility of deformations conditions. Applications. Calculation of deformations. The planar stress-strain problems. Approximate methods of solution (finite differences, Fourier series and integrals, energy methods). Problem solution in polar and skew coordinates. Orthotropic and variable thickness disks. Problems on pre-stressed disks. Orthogonal-triangular elements on point supports (finite elements). Computer aided problem solution of plane elasticity. Examples of application on real structures.

Method comparison. Membrane theory of shells. Shell generation by surface rotation. Introduction to the bending theory of shells. Applications.

*K. Syrmakizis, Professor
V. Koumousis, Professor*

6.9.24. THEORY OF PLATES

Basic assumptions of the theory of thin plates. Deflection surface and its geometrical relations. Stress resultants. Differential equation of equilibrium of a plate element in cartesian and polar coordinates. Boundary conditions for rectilinear and curvilinear boundaries. Classical analytical solutions of plates (Navier, Levy), circular and annular plates. Plates with other geometrical shapes (skew, triangular, elliptic). Practical solutions of plates in Civil Engineering applications. Approximate and numerical solutions (Galerkin, Ritz, finite difference and finite element methods). Plates under in-plane forces, stability. Plates of variable thickness. Plates on elastic foundation. Large deflections of plates. Dynamic analysis of plates.

*E. Sapountzakis, Associate Professor
M. Neratzaki, Assistant Professor*

6.9.25. MASS TRANSPORT NETWORK OPERATIONS

Characteristics of transport modes (metro, tram, buses, electric buses). Transport capacity determination. Determination of network operation characteristics, planning and design principles, load factors, routing, frequency and crew scheduling. Traction: calculation of traction forces, train configuration, speed and time diagrams. Introduction to signaling systems and safety installations. Railway station signaling. Block sections. Interlocking diagrams and tables. Track occupation diagrams. Train schedules. Capacity. Examples and exercises.

*M. Karlaftis, Assistant Professor
K. Lympetis, Lecturer*

6.9.26. **NONLINEAR BEHAVIOR OF STEEL STRUCTURES**

Fundamental concepts of nonlinear behavior: material nonlinearity, geometric nonlinearity, interaction of nonlinearities, equilibrium path (primary & secondary), bifurcation point (stable, unstable, unsymmetric), influence of initial imperfections, limit point, critical buckling loads and buckling modes, postbuckling strength, snap-through buckling, load vs displacement controlled tests, linear and nonlinear stability theory, elastoplastic behavior of cross-sections, members and structures subjected to simple and combined actions, failure criteria, structures prone to nonlinear behavior, examples.

Analysis methods for nonlinear problems: equilibrium (Euler) method, energy method and energy criteria, dynamic method, linear and nonlinear theory, perfect and imperfect systems, single and multiple degree-of-freedom systems, continuous systems, interaction of buckling modes, recommended analysis methods, examples.

Numerical algorithms for solving nonlinear problems: nonlinear finite element method, application of loading in steps, Newton-Raphson and modified Newton-Raphson methods, convergence criteria, criteria for the selection of analysis method, number of steps, number of iterations and convergence limits, load vs displacement controlled analyses, arc-length methods, examples with application of finite element software.

Comparison of analytical and numerical methods and code provisions for nonlinear problems: members subjected to simple and combined actions, influence of boundary conditions and slenderness, frames, moment-rotation equations, calculation of equivalent buckling lengths, plates, local buckling, flexural-torsional buckling, built-up members, arches, shells, bracing systems (x-bracing, eccentric and concentric lamda-bracing), connections.

*C. Gantes, Associate Professor
I. Raftoyiannis, Assistant Professor*

6.9.27. UNSTEADY FLOWS

Unsteady flow in closed conduits - Water hammer. Theory of incompressible water column. Elasticity theory. Equations of one-dimensional analysis. General solution of water hammer equations. Wave propagation velocity. Boundary conditions. Water hammer for sudden and slow downstream control valve closure. Unsteady flow in open channels. Gradual and rapidly varying flow. General flow equations (St. Venant). Kinematic wave. Flood waves. Characteristics. Formation and types of surges. Positive and negative surges. Solution methods for closed conduit problems (finite differences, characteristics, numerical integration, Allievi) and open channel problems (finite differences, characteristics, diffusion analogue, hydrological flood routing methods). Dam break waves.

I. Papadimitrakis, Associate Professor

6.9.28. MECHANICS OF MASONRY

Masonry materials, construction types of masonry, mechanics of arches, mechanical and deformation characteristics of unreinforced masonry, the mechanics of unreinforced masonry under compression, tension and tension due to bending. Masonry under heterosemous biaxial stresses. Buckling of masonry (under eccentric compression). Unreinforced masonry subjected to shear. The mechanics of reinforced masonry. Pathology of unreinforced masonry buildings, methods of in-situ and in-Laboratory investigation. Design of masonry against normal and accidental actions.

E. Vintzilaiou, Associate Professor

6.9.29. ROAD AND AIRFIELD PAVEMENTS

Airfield pavement types and their implementation. Pavement loading due to aircraft loads. Airfield pavement design principles. FAA pavement design methods. Pavement Management Systems (PMS)

and structural classification of airfield pavements (LCN method, ACN-PCN method). General components of concrete pavements. Rigid pavement analysis, design and technology. Structural evaluation principles and their implementation. Bearing capacity determination. Structural evaluation indexes. Pavement functional condition evaluation. Functional characteristics and pavement distresses. Long life pavements and PPP, BOT in Concession Systems.

A. Loizos, Professor

6.9.30. EXPERIMENTAL HYDRAULICS

Introduction. Measurements and experimental research. Dimensional analysis. Rayleigh's method and the Π theorem Experimental errors. Processing of experimental data. Hydraulic similitude. Elementary laws. Complete and partial similarity. Model construction. Scale effects. Applications. Overview of techniques and instruments for measuring hydraulic parameters. Laboratory experiments in the areas of flow in open and closed conduits, jet diffusion, maritime hydraulics and coastal engineering.

*G. Christodoulou, Professor
V. Tsoukala, Lecturer*

6.9.31. ENVIRONMENTAL GEOTECHNICS

The overarching goal of the course is to develop environmental thinking related to

- (1) assessing the severity of a subsurface contaminant release,
 - (2) recognizing the physical-chemical-biological mechanisms that affect the fate and transport of the released contaminant and,
 - (3) selecting appropriate remedial measures and/or technologies.
- Course objectives are met if at the end of the semester students
- (a) can locate reliable data on the effects of contaminants on human health,

- (b) are confident in applying principles of mass transfer, groundwater flow and contaminant transport to problems of contamination and restoration of the subsurface,
- (c) are able to address the geoenvironmental aspects of landfill and clay barrier design,
- (d) are familiar with a wide range of remediation technologies,
- (e) are able to take initiatives related to modeling (i.e., related to the formulation of a simplified problem that admits solution) and,
- (f) are aware of some social or public policy dimensions of subsurface contamination and restoration problems.

M. Pantazidou, Assistant Professor

6.9.32. ENVIRONMENTAL IMPACTS

- Theoretical introduction: Sustainable development and environmental policy. Dimensions of environmental policy. Environmental impact assessment: study, public hearing, monitoring, implementation. Environmental impact study: objective, technical content. Strategic environmental assessment.
- Environmental impact statement for a real technical project.

*K. Hadjibiros, Associate Professor
I. Stefanakos, Lecturer
V. Tsoukala, Lecturer*

6.9.33. ENVIRONMENTAL FLUID MECHANICS

1. Introduction: concepts and definitions. Molecular diffusion. The diffusion equation: derivation using Fick's Law and solution.
2. The advection-diffusion equation: derivation and solutions.
3. Mixing in rivers: turbulent diffusion and dispersion. The turbulent advection-diffusion equation. Longitudinal dispersion. The advection-dispersion equation.

4. Chemical, physical and biological transformation processes: concepts and definitions, reaction kinetics and their incorporation in the advection-dispersion equation.
5. Processes at interfaces: the air-water interface (aeration models) and the sediment- water interface (sediment models).
6. Atmospheric mixing: turbulence in the atmospheric boundary layer and related transport models.
7. Water quality modeling. Methodology. Simple models. Numerical models and stability criteria.
8. Integrated examples and applications.

A. Stamou, Professor

6.9.34. QUANTITATIVE METHODS IN TRANSPORTATION

Planning and organization of public transport. Routing and scheduling. Public transport preferential treatment in networks. Network optimization. Optimization methods. Real-time systems management and transport telematics. Central and distributed control. Decision support methods in transportation. Knowledge- and rule-based methods; fuzzy set theory applications. The role and responsibility of the transportation engineer. Theory and applications of logistics; fleet management.

*A. Stathopoulos, professor
M. Karlaftis, Assistant Professor*

6.9.35. PRESTRESSED CONCRETE

Introduction. Basic concepts. Materials, prestressing systems and anchorages. Partial losses due to friction, anchorage slip, creep, shrinkage and relaxation, Serviceability limit state design: flexural and shear design. Final design of prestressed concrete structures. Ultimate limit state design. Prestressed concrete technology and detailing. Design of anchorage systems. Statically indeterminate prestressed concrete structures.

A. Baka, Lecturer

6.9.36. STEEL BRIDGES

Introduction. Historical review. Damages of steel bridges. Advantages/disadvantages. Categories of steel bridges. Members and parts of highway and railway bridges (decks, lattice or plate girders, main and secondary bracings, bearings, abutments). Basic design principles. Materials. Actions on bridges. Loading combinations. Loading due to traffic. Other loading. Analysis of bridges. Truss and plate girder (open or closed type) bridges. Main and secondary girders. Strength of cross sections. Stability of members (flexural and shear buckling). Composite steel and concrete bridges (sizing of cross sections, shear connection). Serviceability. Fatigue. Bearings. Steel abutments. Fabrication, erection and maintenance. Other types of bridges (cable, etc).

*I. Ermopoulos, Professor
I. Raftoyiannis, Assistant Professor*

6.9.37. STOCHASTIC METHODS IN WATER RESOURCES

Introduction: general concepts, utility, types of problems. Simulation: general concepts, categories of simulation, uses of stochastic simulation, simulation models, random numbers. Random variables, statistical parameters, stochastic processes, stationarity, ergodicity, auto-correlation, cross-correlation. Spectral analysis of time series. Univariate stationary stochastic models: Markov models and their physical basis, AR(1), AR(2), ARMA(1,1), ARMA(p, q), MA(q) and SMA(q) models. Long-term persistence (Hurst phenomenon) and simple scaling processes. Seasonal models. Multivariate models. Introduction to disaggregation models. Introduction to point processes. Applications to water resource problems.

D. Koutsogiannis, Professor

6.9.38. MODERN DESIGN METHODS FOR REINFORCED CONCRETE STRUCTURES

- Theoretical background: The behaviour of concrete at material and structure levels.
- Design: Physical models of reinforced concrete structural elements. Implementation in ultimate limit-state design. Design procedure. Applications.
- Analysis: Constitutive modeling of concrete behaviour. Implementation in analysis. Examples.

M. Kotsovos, Professor

6.9.39. COMPOSITE STRUCTURES

Introduction, materials, cross section classification, cracked and uncracked analysis, elastic and inelastic analysis, composite slabs, composite beams, composite columns, shear connection, conceptual design of multi storey buildings, fire resistant design, seismic design of buildings, composite bridges, construction phases, creep and shrinkage.

*I. Vagias, Professor
I. Ermopoulos, Professor*

6.9.40. COMBINED TRANSPORT - SPECIALIZED SYSTEMS

Combination of Transport systems. Systematic analysis of maritime, rail, road and air systems. Development trends. Intermodal/Combined Transport: unitized units, transport modes, equipment, planning and operation of intermodal terminals. Combined passenger transport - Public transport systems. Transportation projects: operating cost, marginal cost and demand management. Environmental and energy considerations.

A. Ballis, Assistant Professor

6.9.41. BOUNDARY ELEMENTS

Introduction. Mathematical prerequisites. Basic concepts. Boundary element method for problems governed by the Laplace and Poisson equation. Direct and indirect method of boundary elements. Arithmetic solution procedure. Computer programming of the method. Application in problem solving: torsional bending of elastic membranes, elastostatics, plates and shells. Dynamic problems: elastodynamics and plate vibrations. The domain-boundary element method. Applications combining the boundary element and finite elements methods.

M. Neratzaki, Assistant Professor

6.9.42. AIRPORT PLANNING

Air industry, privatization, deregulation. Forecasts. Dynamic strategic planning, Master Plan, strategic plans. Airfield design. Airport classification and design standards. Runway, taxiway, aprons layouts and geometry. Approach surfaces. Airfield capacity and delays. Demand management, slots. Air traffic management. Configuration of passenger buildings, design requirements. Ground access, parking facilities, on the airport access, baggage system distribution. Marking. Cargo terminal and other airport facilities. Multi-airport systems. Environmental impacts. Organization and financing. User charges.

P. Psaraki – Kalouptsidi, Lecturer

6.9.43. TECHNICAL SEISMOLOGY

Introduction. Earthquake generation. The seismic rift. Propagation of seismic waves. Seismometry. Accelerographs. Analysis of accelerograms. The influence of local parameters in disturbing strong seismic shocks. Earthquake and geology. Geological and geophysical imprint of a geodynamic system. Measurements of distortion of Earth's crust. Seismic hazard analysis. Criteria and parameters of

earthquake resistant design. Seismic-tectonic properties of Greek territories and the seismic prerequisites of the National Building Code. Interdisciplinary technical seismology projects.

*K. Spyrakos, Professor
C. Mouzakis, Assistant Professor*

6.9.44. WATER RESOURCES SYSTEMS TECHNOLOGY

Introduction. Hydrological planning – reservoir design. Conventional method of reservoir design. Non-conventional stochastic reservoir design methods. Reservoir design in rivers with basins ungauged. Hydrological planning of safety structures. Spillway Design flood. Flood planning of river flow diversion works. Hydrological design of other related works. Hydro-power production planning. Risk analysis of hydro-power production.

Optimization of water resources management works. Methodology of aquatic systems analysis. Methods of systems analysis. Application of the systems analysis theory to water resources issues. Optimization methods. Dynamic programming. Applications. Tasks.

*M. Mimikou, Professor
C. Makropoulos, Lecturer*

6.9.45. HYDRAULIC STRUCTURES – DAMS

- Characteristic and hydraulic design of reservoirs. Environmental aspects of reservoir formation. Types of dams and technical-economical selection criteria. Environmental aspects of dam construction. Dam design specifications.
- Design of embankment dams (earth fill and rock fill). Exploitation of earth materials. Environmental aspects of borrow areas and quarries. Construction of embankment dams, jobsite development, areas for stockpiling and dumping.

- Engineering of gravity dams. Design and construction of a) conventional concrete, b) roller compacted concrete and c) face symmetrical hard fill gravity dams.
- Engineering, design and construction of concrete faced rock fill dams.
- Basic engineering of arch dams
- Types of spillways, hydraulic and structural design and environmental aspects of spillway design and construction. Engineering of flood control structures and energy dissipation works.
- Engineering of river diversion works, i.e canals, surface pipes, tunnels and cofferdams. Hydraulic and structural design of river diversion systems
- Flow control in spillways and water conveying systems, using gates and valves. Instruments for monitoring the behaviour of embankment and gravity dams. Dam failures and incidents. Risk and dam safety.

N. Moutafis, Lecturer

6.9.46. COMPUTATIONAL GEOTECHNICS

Continuum Mechanics in Computational Geotechnics (theory of elasticity, failure criteria). Common constitutive models for non-linear soil behaviour. Simple numerical methods: slope stability analysis with the method of slices. Introduction to the Finite Difference and the Finite Element methods for the solution of boundary value problems in geotechnics. Application of the Finite Element method in engineering practice: simulation of laboratory tests, bearing capacity and settlement of foundations, groundwater flow, deep excavations and retaining structures, static soil-structure interaction. Case studies.

*G. Gazetas, Professor
G. Bouckovalas, Professor
N. Gerolimos, Lecturer*

6.9.47. SPATIAL-GROWTH IMPACTS OF TRANSPORT SYSTEMS

Introduction: the relationship between growth and transport. The impact of the transport system on growth and total factor productivity: and vice-versa. Models of long-run and short-run growth. Production functions and cost functions. The theory of spatial multipliers. The sectoral and distributional effect of transport. Simple spatial interactions models: simulation and calibration. Integrated spatial interaction models. The Garin-Lowry model. Recent modeling efforts (TRANUS, POLIS, EMPAL).

K. Rokos, Lecturer

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