2016

Module guide (Modulhandbuch) NHRE

Bauhaus-Universität Weimar

18.01.2016

Study Regulations - Supplement 1 Master's degree programme "Natural Hazards and Risks in Structural Engineering" (2013)				1st semester (winter semester)	2nd semester (summer semester)	3rd semester (winter semester)	4th semester (summer semester)
Moduls		Credits		Credits	Credits	Credits	Credits
Stochastics and risk assessment	Prof. Lahmer, Prof. Ilge, Dr. Müller	6		**6**			
Structural dynamics	Dr. Zabel	6		**6**			
Structural engineering	Prof. Morgenthal	6		**6**			
Primary hazards and risks	Dr. Schwarz, Prof. Höffer	6		**6**			
Geographical Information Systems (GIS) and building stock survey	Prof. Rodehorst, Dr. Schwarz, Dr. Beinersdorf	6		**6**			
Earthquake engineering and structural design	Dr. Schwarz, Dr. Abrahamczyk	6			**6**		
Hazard projects and advanced geotechnologies	Prof. Grünthal, Prof. Cotton, Dr. Schwarz	6			**6**		
Geo- and hydrotechnical engineering	Prof. Witt, Dr. Maiwald	6			**6**		
Elective module **		6			6		
Elective compulsory module *		6			6		
Disaster management and mitigation strategies	Prof. Bargstädt, Prof. Eckardt	6				**6**	
Experimental structural evaluation and rehabilitation	Prof. Kraus, Dr. Schwarz, Prof. Lahmer	6				**6**	
Life-lines engineering	Prof. Morgenthal, Prof. Könke	6				**6**	
Elective module **		6				6	
Elective compulsory module *		6				6	
Elective compulsory module *		6					6
Master's Thesis		24	4 month				24
total		120		30	30	30	**30**

* see NHRE module catalogue (updated annually, to be confirmed by the examination committee)
Students must select a project as one of their elective compulsory modules.

** any course at the Bauhaus university is valid (recommendation: "Advanced Training Course" + "German language courses")

Compulsory modules

Compulsory modules 1st semester:

- Stochastics and risk assessment
- Structural dynamics
- Structural engineering
- Primary hazards and risks
- Geographical Information Systems (GIS) and building stock survey

Compulsory modules 2nd semester:

- Earthquake engineering and structural design
- Hazard projects and advanced geotechnologies
- Geo- and hydrotechnical engineering

Compulsory modules 3rd semester:

- Disaster management and mitigation strategies
- Experimental structural evaluation and rehabilitation
- Life-lines engineering

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Stochastics and risk assessment

[Module-No.: NHM10-2010]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
1	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 68hs Attendance time, 82hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**2 written exams** „Mathematical simulation“/ 120 min (67%) / **WiSe** + SuSe „Signal analysis“/ 60 min (33%) / **WiSe** + SuSe	Lecture (L)	Prof. Dr. rer. nat. Tom Lahmer

Course aim

Consideration of Stochastic systems ruled by random influences. Provision of Basic concepts of probability and statistics. Conversance with important issues and elementary methods, Ability to deal with concrete problems.

Course content

Mathematical simulation of natural phenomena and risk problems:
Introduction to probability theory with focus on situations characterized by low probabilities. Random events, discrete and continuous random variables; Descriptive statistics: parameters of one- and two-dimensional samples, graphical representation of samples; Exploratory statistics: statistical tests, parameter estimation; Reliability theory: extreme value distributions; stochastic modelling with software tools eg. MATLAB, Octave, Excel, R.; Characteristics + classification of random functions for risk analysis; catastrophic events + risk problems; hazard/risk/safety/reliability/damage/cost + fuzzy models; life time consideration; analysis by logic trees and charts (fault trees, event trees, cause/ consequence charts, decision trees); risk assessment and risk acceptance.

Signal Analysis:
Real and complex Fourier series; trigonometric polynomials, discrete frequency spectra; real and complex spectra; Continuous and Discrete Fourier Transform; properties of the corresponding discrete and continuous frequency spectra; energy considerations for discrete and continuous signals; discrete and continuous convolution; circular convolution in the DFT; filtering of discrete and continuous signals; cross-correlation and autocorrelation; special applications of the FFT tools: MATLAB

Course literature

Montgomery, Runger: Applied Statistics and Probability for Engineers, 2014 / Taan, Karim: Continuous signals and systems with MATLAB, 2008 / Mallat, S.: A wavelet tour of signal processing, 2009

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Lahmer / Dr. Müller	2500008: Mathematical simulation of natural phenomena and risk problems (L)	4
Prof. Illge	2500009: Signal Analysis (L)	2

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Structural dynamics [Module-No.: 2110002]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
1	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 68hs Attendance time, 82hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 written exams** „Structural dynamics“/ 180 min (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E)	Dr.-Ing. Volkmar Zabel

Course aim

Students will obtain the ability to analyse problems which are related to structural dynamics in a way that they can develop an appropriate solution strategy. They should obtain an understanding about the principal concepts of structural dynamics and methods to apply them to practical engineering tasks. Possible solution methods range from simplified approaches to numerical procedures. The students will also be able to develop small numerical tools for dynamic structural analyses.

Course content

Theory and methods
single and multi-degree of freedom systems, dynamic analyses in time domain, dynamic amplification function, frequency response function, impulse response function, continuous systems, modal analysis, numerical solution methods in time domain.
Applications
human induced vibrations, machine induced vibrations, earthquake excitation, wind excitation, measures to mitigate vibrations.

Course literature

Clough, Penzien: Dynamics of Structures, 2010 / Chopra: Dynamics of Structures, 2015

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Zabel	Structural dynamics (L)	4
Dr. Zabel / et al.	Structural dynamics (E)	2

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M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Structural engineering [Module-No.: 2310012]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
1	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 68hs Attendance time, 82hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 written exams** „Structural engineering "/ 180 min (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E)	Prof. Dr.-Ing. Guido Morgenthal

Course aim

Students will be familiar with the history of structures and structural forms, with building materials and building methods. They will understand the concepts of structural engineering design, including safety concepts, loads and structural design codes. They will be able to convert a structural concept into a mechanical model to determine internal demand and to design and detail the components of the structure, with an emphasis on reinforced concrete and post-tensioned concrete structures.

Course content

Structural Engineering
History of structures; building materials; structural form and structural behavior; actions on structures; structural reliability and codes of practice; mechanical modelling of structures; reinforced concrete structures and post-tensioned concrete structures design and detailing

Training in:
Structural design project: scheme design, analysis using Finite Element Methods; design of components and detailing; selected drawings

Course literature

Text books (to be announced)

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Morgenthal	Structural engineering (L)	4
Prof. Morgenthal / et al.	Structural engineering (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Primary hazards and risks

[Module-No.: NHM10-2020]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
1	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 68hs Attendance time, 30hs Project work 57hs Self-study time 25hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 Project report** „Regional Ground Motion " (12%) / **WiSe** **2 written exams** „Seismic Monitoring "/ 180 min (50%) / **WiSe** + SuSe „Wind Risk Mitigation"/ 90 min (33%) / **WiSe** + SuSe	Lecture (L) Exercise (E) Project (P)	Dr.-Ing. Jochen Schwarz

Course aim

Students will be able to define the seismic and wind action being related to design concepts and practical applications. They will be familiar to use ground and wind recordings and building response data and they will be trained in practical realization and handling of data, different types of sensors and data acquisition instruments. The students should be able to interpret dynamic building response characteristics and define input parameters for calculations.

Course content

Seismic Monitoring
Measurements for site response evaluation; description of seismic action; recording instruments, input parameters for seismic hazard assessment; EQ-Action for building design; Building Monitoring Systems: tasks and developments, analysis of instrumental data; identification of dynamic and structural response parameters

Regional Ground Motion Prediction and Database
Identification of hazard describing parameters; seismic networks, availability/ elaboration of ground motion data and records; Ground Motion Prediction Equations (GMPEs); application of ground motions models and tools to the study area and target site; re-interpretation of national code background; tool: MATLAB

Wind Risk Mitigation in Structural Engineering
Application of meteorology in wind engineering, extreme value analysis; turbulence effects and aero-elasticity, basics of wind resistant design, risk chain, risk control (control of exposition, shelter projects, risk-based inspection and maintenance), wind tunnel technology, examples and practical applications to support structures of onshore and offshore wind turbines

Course literature

Text books (to be announced); publication from the lecturers

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Schwarz / et al.	2340007/1: Seismic Monitoring (L)	3
Dr. Schwarz / et al.	2340007/2: Regional Ground Motion Prediction and Database (E)	1
Prof. Höffer (Uni Bochum)	2200008: Wind Risk Mitigation in Structural Engineering (L)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Geographical Information Systems (GIS) and building stock survey [Module-No.: 2900003]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
1	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 45hs Attendance time, 75hs Project work 60hs Self-study time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 project presentation** + **written report** „Geographical Information Systems (GIS) and building stock survey " (100%) / **WiSe**	Lecture (L) Exercise (E) Project (P)	Prof. Dr.-Ing. habil. Volker Rodehorst

Course aim

Students will be trained to reproduce existing natural hazard and risk related data in GIS format using MapInfo GIS Tools, will be able to create basic layers for hazard and risk assessment and to establish relevant links and to solve simple example tasks.
Students will be trained in building stock survey, vulnerability assessment, damage interpretation and handling of tools for detailed empirical and instrumental elaboration.
Training in instruments, equipment and technologies for advanced detailed building survey (geodetic, photogrammetric, satellite data).

Course content

Fundamentals, Three-Dimensional Positioning, Fundamentals of Photogrammetry, GIS/Cartography, Land management / Cadastre, Monitoring of Structures; Earthwork Computation; Spatial data in daily life; Instruments, equipment and technologies for advanced detailed building survey (geodetic, photogrammetric, satellite data).

Training in:
Coordinate systems; global maps for the natural hazard phenomena; quality and availability of input data; layers for natural hazard related parameters (topography, geology and subsoil); reproduction of historical events and associated parameters; layers for risk assessment and loss estimation procedures; link between layers and risk mapping procedures;
Tools: MapInfo®, Vertical mapper®

Course literature

Text books (to be announced); publication from the lecturers; results from recent projects

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Rodehorst	Geographical Information Systems (GIS) and building stock survey (L)	2
Dr. Schwarz / Dr. Beinersdorf	Geographical Information Systems (GIS) and building stock survey (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Earthquake engineering and structural design [Module-No.: 2340008]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2	annually in Summer Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 68hs Attendance time, 45hs Project work 47hs Self-study time 20hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
Primary Hazards and Risks	NHRE	**1 Project report + Project presentation** „Structures in Earthquake Regions/Design of RC frames …“ (33%) / **SuSe** **1 written exams** „Earthquake engineering“/ 180 min (67%) / **SuSe** + WiSe	Lecture (L) Exercise (E) Project (P)	Dr.-Ing. Jochen Schwarz

Course aim

Students are trained and qualified in tasks of earthquake engineering, natural hazard and risk determining parameters. Students will be able to process input data, to realize design decision for structures of different building type and risk potential, to apply modern building codes and design concepts and to develop earthquake resistant structures.

Course content

Earthquake engineering
Seismic Code development and generations; simplified analysis methods; design of structures and regularity criteria for earthquake resistance; performance and experience-bases design concepts; rules for engineered buildings (R/C, steel, masonry) and non-engineered buildings; interaction effects between structure and soil, equipment and filling media; special and high risk structures
Structures in Earthquake Regions
Description of National code development; recent code situation; determination of seismic forces for an idealized RC frame system; comparison of different international code levels
Design of RC frames with masonry infill walls in earthquake regions: Application of modern software tools
Training of modelling and calculation with different software tools; interpretation of structural systems in terms of earthquake resistance design (ERD); design and analysis of structural systems for given building layouts; comparison of the results with outcomes of damage surveys; Tools: ETABS, SAP2000

Course literature

Publication and text books from the lecturers

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Schwarz	Earthquake engineering and structural design (L)	4
Dr. Abrahamczyk	Structures in Earthquake Regions (E)	0,5
Dr. Abrahamczyk	Design of RC frames with masonry infill walls in earthquake regions (E)	1,5

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Hazard projects and advanced geotechnologies [Module-No.: 2340006]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2	annually in Summer Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 55hs Self-study time 20hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
Primary Hazards and Risks	NHRE	**1 Project report** „Compilation of EQ hazard-related data" (33%) / **SuSe** **1 written exams** „Hazard projects and advanced geotechnologies "/ 180 min (67%) / **SuSe** + WiSe	Lecture (L) Exercise (E) Project (P)	Dr.-Ing. Jochen Schwarz

Course aim

The students will be familiar with the probability of natural hazard and risk determining parameters. They will be able to recognize procedures of hazard assessment and to process input data and to apply tools to study areas. Students will be introduced in further advanced geotechnologies and existing or on-going global projects conducted by GFZ.

Course content

Seismic Hazard Assessment and Applications
Primary input and output parameters for EQHAZ; Earthquake statistics and occurrence probability; Methodology of seismic hazard assessment; Seismicity models; Examples of seismic hazard studies
Workshop
"Advanced Geotechnologies (for Engineering Tasks)" Alternative with: "Natural hazards and risks in structural engineering"
Compilation of EQ hazard-related data
Treatment of long term seismicity data files; elaboration of earthquake data to get harmonized input for PSHA; earthquake catalogues (for the countries of the participants and adjacent regions); data preprocessing; Hazard Description for the Project regions
GeoLAB (GeoForschungsZentrum Potsdam)

Optional: Excursion to GeoResearchCenter Potsdam

Course literature

Text books (to be announced); text books from the lecturers

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Grünthal / Prof. Cotton	Seismic Hazard Assessment and Applications (L)	2
Dr. Schwarz / et al.	Workshop (L)	1
Prof. Grünthal / Prof. Cotton.	Compilation of EQ hazard-related data (E)	1

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Geo- and hydrotechnical engineering

[Module-No.: NHM10-2030]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2	annually in Summer Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 68hs Attendance time, 30hs Project work 62hs Self-study time 20hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 Project report** „Flood Management " (33%) / **SuSe** **1 written exams** „Soil mechanics"/ 180 min (67%) / **SuSe** + WiSe	Lecture (L) Project (P)	Prof. Dr.-Ing. Karl Josef Witt

Course aim

The objective of this module is focused on deepening the basics of soils mechanics, the fundamentals of analysis in applications for static and dynamic analysis as well as the basics of soil-structure interaction analysis. The students should be able to apply the strategies and methods to arbitrary engineering problems in the given fields. To fix the theoretical background the student has to apply the methods independently at given tasks during several projects.

Course content

Soil mechanics
Classification and identification of soils, shear strength, stress analysis and settlement analysis / consolidation theory, soil water and permeability. Behavior of problematic soils, fundamentals of unsaturated soils, basics of constitutive modelling and dynamic loads - Pseudo static limit equilibrium analysis, basics of soil dynamics - Wave propagation and dynamic soil-structure-interaction.
Flood Management
Fundamentals of flood defense; Management of low-lying areas; Design of river dikes, channels and dams; Design concepts for the defense of structural objects and buildings; Forecasting, Management and maintenance in flood defense; Risk approach, safety assessment, insurance; Damage analysis and valuation; Hydrology, Hydraulic calculations, flood routing.

Course literature

Lancelotta, R., Geotechnical Engineering, Taylor & Francis, 2nd ed, 2009 / Atkinson, J., The Mechanics of Soils and Foundations, Routledge - Taylor & Francis Group, 2nd ed, 2007 / Muir Wood, D., Geotechnical Modelling, Spon Press - Taylor & Francis Group, 2004 / Chopra, A.K., Dynamics of Structures, Prentice Hall, 2007

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Witt / et al.	2200002: Soil mechanics (L)	4
Prof. Hack / Dr. Maiwald	2420006: Flood Management (L)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Disaster management and mitigation strategies

[Module-No.: NHM10-2040]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 56hs Attendance time, 109hs Self-study time 15hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 written exams** „Project and disaster management "/ 120 min (50%) / **WiSe** + SuSe **1 Presentation + presentation paper** „Urban disaster " (50%) / **WiSe**	Lecture (L)	Prof. Dr.-Ing. Hans-Joachim Bargstädt

Course aim

Training of different aspects of project management; skills in discussion, communication and documentation of project; development of skills to define work breakdown structures, to structurize a complex project into work packages and of time schedules; students learn special demands and procedures in situations of disaster prevention and be able to develop appropriate organizational measures in disaster management; students learn basic assumptions on the social behaviour with main focus on the urban dimension on social actions.

Course content

Project and disaster management
Introduction to Project management; work breakdown structure; time scheduling and network techniques; resource allocation and balancing; cost calculation and cost control measures; special working techniques; types of company and project organization; documentation; risk contract management; communication in projects; leadership in projects; fee structures and fees for construction project management services; Fundamentals in disaster management; examples of methods and procedures in special situations of crisis and catastrophe; introduction into critical incident management systems in Germany and internationally.
Urban disaster
Cities have become the place for the most disastrous catastrophes. Destruction comes from a wide range of phenomena like earthquake, hurricanes, volcanoes, Tsunamis and others. It seems inevitable that these "natural hazards" are hitting cities even more in the future as the climate change develops its consequences. While engineering seeks for technical options for adaptation and mitigation, the main subject will be how people can develop new social practices in their daily life to survive, recapture and prevent damages of their lives..

Course literature

H. Schelle: Project Manager/ RKW: Projektmanagement Fachmann / U. Bauch and H.-J. Bargstädt: Online Course Material and handouts
F. Eckardt Landscapes of Disaster. Symbolic Spaces of Orientation. Topos –the int. review of landscape archit. and urban design, 76 (2011), 51-55.

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Bargstädt / et al.	B01-901005: Project and disaster management (L)	3
Prof. Eckardt	A01-724102: Urban disaster (L)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Experimental structural evaluation and rehabilitation [Module-No.: 2350002]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 56hs Attendance time, 45hs Project work 59hs Self-study time 20hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
Compulsory moduls of 1st and 2nd semester	NHRE	**1 Project report** „Model testing for rehabilitation" (33%) / **WiSe** **1 written exams** „Experimental Structural evaluation "/ 180 min (67%) / **WiSe** + SuSe	Lecture (L) Exercise (E) Project (P)	Dr.-Ing. Jochen Schwarz

Course aim

Students will be familiar with instrumental methods and instrumentation requirements to provide structure related parameters and characteristic force-displacement relationships in support of analytical studies and the outcome of field surveys. Students should be able to decide upon appropriate test configuration for particular problems related to failure cases or on-going projects, and to use the infrastructure for further graduation (master thesis).

Course content

Experimental Structural evaluation
Testing facilities and technical equipment; demands on specimens and scaling requirements; arrangement of sensors, application of equivalent forces and ground motion in pseudostatic and dynamic testing; Load and displacement relationship for full-scale testing of structural elements (RC columns, masonry wall); damping devices, prediction of capacity curves and material properties and parameters; recalculation of model calibration

Signal processing and interpretation
Conditioning of experimental data, error analysis, analog and digital filters; Fast Wavelet-Transform, compression and denoising algorithms; tool: MATLAB

Model testing for rehabilitation
Experimental investigation of design and retrofitting strategies using small scale structural models; testing of elements and interpretation of failure mechanism, derivation of structural layout and simplified models of representative building types, damage prognosis and comparison with observed response; fragility functions; Introduction in data processing for simulation tools 3Muri

Course literature

Text books (to be announced); publication from the lecturers

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Kraus	Experimental Structural evaluation (L)	2
Prof. Lahmer	Signal processing and interpretation (L)	1
Dr. Schwarz / et al.	Model testing for rehabilitation (E)	2

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Life-lines Engineering [Module-No.: 2310013]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Compulsory	6	English	180hs, thereof 68hs Attendance time, 82hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 written exams** „Life-lines Engineering "/ 180 min (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E)	Prof. Dr.-Ing. Guido Morgenthal

Course aim

The students will be familiar with bridges and reservoirs in the context of their functions as critical infrastructure in the event of earthquakes and other natural hazards. They will be familiar with the design objectives and with strategies to limit damage and to ensure operability after a major natural disaster. They will be able to develop structural concepts and to carry out detailed design of such structures, including the application of relevant codes of practice.

Course content

Life-lines Engineering
History of bridge engineering; types of bridges; structural concepts and articulation; planning and design; construction methods; structural modelling and analysis; elastic and plastic design approaches; performance-based design; structural detailing; dynamic characteristics and behaviour under dynamic loading; seismic response and isolation; response to wind loading

Traing in:
Structural modelling and Finite Element Analysis; design of post-tensioning systems in bridges; design and detailing of girders and piers; seismic response; wind response, analysis of cable stayed bridges

Course literature

Text books (to be announced)

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Morgenthal	Life-lines Engineering (L)	4
Prof. Morgenthal / et al.	Life-lines Engineering (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Elective compulsory module						**[Module-No.: NHM10-3000]**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
2 to 4	annually in Winter Semester and Summer semester	1 Semester weekly	Elective Compulsory	18	English	depend on the chosen module Total workload: 540hs

Recommended course requirements	**Course program**	**Form of examination / Duration of examination**	**Teaching and learning methods**	**Responsible for the module**
B.Sc.	NHRE other	depend on the chosen module	depend on the chosen module	depend on the chosen module

Course aim
The students are using the possibility to sharpen their individual profile of free choice of 3 modules from a list with NHRE-elective compulsory modules as well as from all Master's degree programs of the Faculties of Civil Engineering. * see NHRE module catalogue (updated annually, to be confirmed by the examination committee) Students must select a project as one of their elective compulsory modules.

Course content
depend on the chosen module

Course literature
depend on the chosen module

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
	depend on the chosen module	

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Elective module						**[Module-No.: NHM10-4000]**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
1 to 4	annually in Winter Semester or Summer semester	1 Semester weekly	Elective	12	English	depend on the chosen module Total workload: 360hs

Recommended course requirements	**Course program**	**Form of examination / Duration of examination**	**Teaching and learning methods**	**Responsible for the module**
B.Sc.	NHRE other	depend on the chosen module	depend on the chosen module	depend on the chosen module

Course aim
The students are using the possibility to sharpen their individual profile of free choice of 2 modules from a list with NHRE-elective compulsory modules as well as from all degree programs of the Bauhaus-Universität Weimar.. ** any course at the Bauhaus university is valid (recommendation: "Advanced Training Course" + "German language courses")

Course content
depend on the chosen module

Course literature
depend on the chosen module

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
	depend on the chosen module	

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Master's Thesis

[Module-No.: NHM10-8000]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
4	annually in Winter Semester or Summer semester	4 month (continuously in the semester or term-overlapping)	Compulsory	24	English	Total workload: 720hs

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
passed module totalling at least 84 ECTS (including a least one passed project)	NHRE	one digital and two printed copies of the Master's Thesis in English (75%) + Presentation of the thesis (25%)	independent research, consultations	depend on the chosen subject

Course aim

The master's examination should demonstrate that the candidate has the ability to independently assess and solve a problem in his/her discipline using scientific methods.

Course content

depend on the chosen subject

Course literature

depend on the chosen subject

Courses

Lecturer	Title of the course	Semester periods per week (SPW)

Elective compulsory modules/projects & Elective modules

Modules	Lecturers	Elective compulsory module	as project	Elective module	winter semester	summer semester
Elective modules						
Advanced Training Course	Prof. Gürlebeck, Dr. Legatiuk			x	x	
Elective compulsory modules/projects						
Advanced Modelling – Calculation	Prof. Gürlebeck, Dr. Legatiuk	x				x
Finite Element Methods	Prof. Rabczuk	x				x
Modelling of steel structures and numerical simulation	Prof. Kraus	x				x
Numerical Discretisation methods	Prof. Könke	x				x
Stochastic Simulation Techniques and Structural Reliability	Prof. Lahmer, Dr. Most	x				x
Experimental structural dynamics and Building Monitoring	Dr. Zabel	x	x			x
Wind-induced Vibrations of Long-span Bridges (in the frame of “Model validation and simulation”)	Prof. Morgenthal	x	x			x
Introduction to Optimization / Optimization in Applications	Prof. Lahmer	x			x	
Advanced Modelling – CAE	Prof. Gürlebeck, Dr. Legatiuk	x			x	
Nonlinear analysis of structures under extreme Loading	Prof. Morgenthal, Prof.em.Raue, Dr. Timmler	x			x	
Secondary Hazards and Risks (land-use, site studies)	Prof. Witt, Prof. Wuttke	x			x	
Fundamentals of structural health monitoring (SHM) and intelligent structural systems	Prof. Smarsly, Dr. Tauscher	x	x		x	
Risk projects and evaluation of structures	Dr. Schwarz, Dr. Abrahamczyk	x	x		x	
Evaluation of Existing Masonry Structures under Extreme Impacts (in the frame of “Model validation and simulation”)	Dr. Abrahamczyk, Dr. Schwarz	x	x		x	x
Group projects in the frame of “Model validation and simulation”	All NHRE lectures	x	x		x	x
Field Survey/ Laboratory Testing	Dr. Schwarz, Prof. Wuttke	x	x		x	x
Special project	All NHRE lectures	x	x		x	x

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Advanced Training Course [Module-No.: 2500011]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
1	annually in Winterer Semester	1 Semester weekly	Elective	6	English	180hs, thereof 45hs Attendance time, 30hs Project work 75hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Entry test	NHRE other	**1 Report** „ Advanced Training Course" (0%) / **WiSe** **1 written exam** „ Advanced Training Course "/ 120 min (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E) Project (P)	Prof. Dr. rer. nat. habil. Klaus Gürlebeck

Course aim

Students will be prepared for mathematical requirements in Computer Aided Engineering (CAE), Signal Processing and Engineering lectures. Introduction to Computer Science on the basis of symbolic languages (MAPLE) for analysis and equation solving.

Course content

Fundamentals of linear algebra, eigenvalue problems, solvers, positive definite matrices; Fourier series, Fourier transform, Laplace transform; Solution of initial value problems, boundary value problems and eigenvalue problems for ordinary differential equations;
All topics are discussed from the mathematical point of view and their implementation in MAPLE will be studied.

Course literature

Will be announced

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Gürlebeck	Advanced Training Course (L)	2
Dr. Legatiuk	Advanced Training Course (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Advanced Modelling – Calculation [Module-No.: 2500010]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 or 4	annually in Summer Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 45hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE other	**1 Project report** „Advanced Modelling – Calculation" (0%) / **SuSe** **1 oral exam** „Advanced Modelling – Calculation"/ 30 min (100%) / **SuSe** + WiSe	Lecture (L) Exercise (E) Project (P)	Prof. Dr. rer. nat. habil. Klaus Gürlebeck

Course aim

Scientifically orientated education in mathematics and computer science in view of a complex interdisciplinary and networked field of work and research, modelling and simulation.

Course content

Numerical and analytical solution of partial differential equations, series expansions, integral representations, finite difference methods, description of heat flow, diffusion, wave propagation and elastostatic problems.
All topics are discussed theoretically and then implemented in MAPLE or MATLAB.

Course literature

Will be announced

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Gürlebeck	Advanced Modelling – Calculation (L)	2
Dr. Legatiuk	Advanced Modelling – Calculation (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Finite Element Methods [Module-No.: 2110001]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 or 4	annually in Summer Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 20hs Project work 85hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE other	**1 Project report** „Finite Element Methods" (0%) / **SuSe** **1 written exam** „Finite Element Methods "/ 120 min (100%) / **SuSe** + WiSe	Lecture (L) Project (P)	Prof. Dr.-Ing. Timon Rabczuk

Course aim

Provide students with essential theoretical knowledge and knowledge about Finite Element Methods and computational methods / algorithms in order to enable them to investigate geometrical and physical nonlinear problems.

Course content

Mixed finite element models; non-linear finite element analysis in solid mechanics (geometrically and physical), non-linear methods; solution of equilibrium equations; error estimates and adaptive finite element methods;
Differential equations in strong and weak formulation; Principle of virtual work; Approximate solution techniques; solution errors; Formulation of element stiffness matrices for structural and temperature field problems; Isoparametric finite elements; Global stiffness matrix; Solution techniques for linear static problems; Mixed finite element models; Non-linear finite element analysis in solid mechanics (geometrically and physically non-linear methods); Iterative solution techniques for nonlinear equation systems; Error estimates and adaptive finite element methods; Eigenvalue problems for structural stability problems

Course literature

Will be announced

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Rabczuk	Finite Element Methods (L)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Modelling of steel structures and numerical simulation

[Module-No.: B01-205007]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2	annually in Summer Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 30hs Project work 75hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Mechanics	NHRE other	**1 Project report** "Modelling of steel structures and numerical simulation" (0%) / **SuSe** **1 written exam** „Modelling of steel structures and numerical simulation"/ 120 min (100%) / **SuSe** + WiSe	Lecture (L) Exercise (E) Project (P)	Prof. Dr.-Ing. Matthias Kraus

Course aim

The students will be familiar with skills and expertise in the field of nonlinear structural analyses. Extensive knowledge of theoretical basics and modern modelling methods including numerical representations are the aim of the course. The students will acquire skills in handling advanced tools for the analysis and the design of structures.

Course content

Design of steel structures using finite element methods; basics of the design; modelling of structures and loads; nonlinear material behaviour, numerical analyses of steel-members and structures regarding geometric and physical nonlinearities; stability behaviour of members including flexural and lateral torsional buckling

Course literature

Internal lecture notes

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Kraus	Modelling of steel structures and numerical simulation (L)	2
Prof. Kraus	Modelling of steel structures and numerical simulation (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Numerical discretisation methods [Module-No.: 2110019]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 or 4	annually in Summer Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 105hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Structural dynamics & FEM	NHRE other	**Homework** „Numerical discretisation methods" (0%) / **SuSe** **1 written exam** „Numerical discretisation methods"/ 30 min (100%) / **SuSe** + WiSe	Lecture (L)	Prof. Dr.-Ing. habil. Carsten Könke

Course aim

Students will obtain the ability to develop a numerical solution for an engineering problem, starting with the observation of the physical problem via the mechanical abstraction to a set of partial differential equations and ending with a discretized form, which can be solved approximately. Students will be able to implement this approximate solution into a software environment based on an object oriented approach and verify obtained results with reference examples.

Course content

Finite difference methods for structural mechanics and heat flow problems, strong and weak formulation of stationary and instationary heat flow problem, FEM formulation for stationary heat flow problem, solution techniques of resulting equation system, error control.

Object oriented programming for problems in engineering, data structures and user interaction

Course literature

K.J. Bathe: Finite Lement Procedures / Johnson, Hansbo: Computational Differential Equations

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Könke	Numerical discretisation methods (L)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Stochastic simulation techniques and Structural reliability

[Module-No.: B01-451007]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 or 4	annually in Summer Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 45hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Basics in "Probability Theory" are recommended	NHRE other	**1 Project report** „Stochastic simulation techniques and Structural reliability" (0%) / **SuSe** **1 written or oral exam** (depending on the number of participants) „Stochastic simulation techniques and Structural reliability "/ (100%) / **SuSe** + WiSe	Lecture (L) Exercise (E) Project (P)	Prof. Dr. rer. nat. Tom Lahmer

Course aim

Soils, rocks and materials like concrete are in the natural state among the most variable of all engineering materials. Engineers need to deal with this variability and make decisions in situations of little data, i.e. under high uncertainties. The course aims in providing the students with techniques state of the art in structural reliability assessment and stochastic simulation techniques.

Course content

The course topics comprise
- (a very brief review) of probability theory
- Discrete and continuous random processes and fields
- Estimation of statistical parameters
- Stochastic simulation techniques (Monte Carlo Simulations)
- Sensitivity Analysis
- Structural Safety

The lecture consists of weekly lectures and computer classes by Prof. Tom Lahmer (Bauhaus University Weimar) throughout the semester and an intensive practical training ("Blockkurs")

Course literature

Fenton and Griffith ,,Risk Assessment in Geotechnical Engineering", Bucher: ,,Computational Analysis of Randomness in Structural Mechanics"

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Lahmer	Stochastic simulation techniques and Structural reliability (L)	2
Dr. Most	Stochastic simulation techniques and Structural reliability (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Experimental structural dynamics and Structural monitoring [Module-No.: 2100001]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 or 4	annually in Summer Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 75hs Self-study time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Structural dynamics	NHRE other	**1 Project report + Presentation** „ Experimental structural dynamics and Structural monitoring" (100%) / **SuSe**	Project (P)	Dr.-Ing. Volkmar Zabel

Course aim

The students obtain deepened knowledge in structural dynamics, structural dynamic analysis, dynamic test equipment and its handling, data processing. They learn to analyse the dynamic behaviour of structure utilizing both numerical and experimental state-of-the-art methods. Furthermore the students have to develop strategies and concepts of investigation. The work in small groups enhances the social competence of the students.

Course content

Operational modal analysis, sensor types, sensor positioning, data analysis and assessment, assessment of structural changes, structural modelling, model updating

Course literature

Ewins, D.J.: Modal Testing: Theory, Practice and Application, 2nd edition, 2000 / Maia, N.M.M., Silva, J.M.M. (eds.): Theoretical and Experimental Modal Analysis, 1997 / Clough, R.W., Penzien, J.: Dynamics of Structures, 1993

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Zabel	Experimental structural dynamics and Structural monitoring (P)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Wind-induced Vibrations of Long-span Bridges (in the frame of "Model validation and simulation")

[Module-No.: B01-204014]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 or 4	annually in Summer Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 135hs Project work

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Structural dynamics / Structural Engineering	NHRE other	**1 Project report + Presentation** „ Wind-induced Vibrations of Long-span Bridges" (100%) / **SuSe**	Project (P)	Prof. Dr.-Ing. Guido Morgenthal

Course aim

Methods of modelling the structural behaviour of Long-span bridges, specifically cable-stayed and suspension bridges, i.e. the dynamic properties, like natural frequencies and corresponding mode shapes. Additionally various phenomena of dynamic wind excitation will be introduced. These include turbulence-induced buffeting, vortex-induced vibrations and instabilities like flutter.
A Computational Fluid Dynamics (CFD) software will be introduced and applied to determine the aerodynamic properties of bridge decks. These results will be used to assess the wind excitation phenomena using various analytical and numerical methods. Also fully coupled numerical fluid-structure interaction analyses are performed.
Finally, optimizing the structural response through aerodynamic optimization as well as additional structural damping measures.

Course content

Wind-induced Vibrations

- Numerical modelling techniques for long-span cable-supported bridges and their dynamic behaviour.
- Numerical (CFD) analysis of bridge aerodynamics and dynamic response to wind.
- Models for Predicting Wind-induced Vibrations of Long-span Bridges.
- Optimizing aerodynamic performance

Course literature

Emil Simiu, Robert H. Scanlan: Wind Effects on Structures, 1996 / You-Lin Xu: Wind Effects on Cable-Supported Bridges, 2013 / Clough, R.W., Penzien, J.: Dynamics of Structures, 1993

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Morgenthal / et al.	Wind-induced Vibrations of Long-span Bridges (P)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Introduction to Optimization / Optimization in Applications

[Module-No.: NHM10-3200]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
1 + 2 or 3 + 4	annually in Winter Semester + Summer Semester	2 Semester weekly	Elective compulsory	6	English (German)	180hs, thereof 45hs Attendance time, 105hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE other	**1 written or oral exam** (depending on the number of participants) „Introduction to Optimization“/ (50%) / **WiSe** + SuSe **1 written or oral exam** (depending on the number of participants) „Optimization in Applications“/ (50%) / **SuSe** + WiSe	Lecture (L)	Prof. Dr. rer. nat. Tom Lahmer

Course aim

We will discuss classical optimization tasks in the field of linear and nonlinear optimization, e.g. optimization of the use of resources, routing problems and calibration.

In engineering science we are often faced with problems having potential for optimization. We learn how to formulate this in mathematical terms and we will study techniques how to improve the situations, generally by involving numerical models.

Course content

Introduction to Optimization:
Linear Problems, Simplex Method, Duality
Nonlinear Problems: Constrained and unconstrained continuous problems, descent methods and variants
Optimization using Graph Theory
Optimization in Applications:
This course treats topics concerned with the combination of optimization methods and (numerical) models. Typical problems, where such combinations arise are Calibration of Models, Inverse Problems; (Robust) Structural Optimization (including Shape and Topologyoptimization); Design of Experiments

Course literature

I. M. Bomze, W. Grossmann - Optimierung - Theorie und Algorithmen - Eine Einführung in Operations Research für Wirtschaftsinformatiker / C.T. Kelley- Iterative methods for Optimization / L. Harzheim – Strukturoptimierung - Grundlagen und Anwendungen /
R. E. Burkard, U. Zimmermann - Einführung in die mathematische Optimierung / L. Harzheim, Strukturoptimierung / R. Kelley, Iterative Methods for Nonlinear Optimization

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Lahmer	B01-451002: Introduction to Optimization (L)	2
Prof. Lahmer	B01-451006: Optimization in Applications (L)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Advanced Modelling – CAE [Module-No.: 2650004]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 75hs Self-study time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Struct.dynamics Adv.modell.-Calculation Programming in MAPLE and MATLAB	NHRE other	**1 Project report + Presentation** „Advanced Modelling – CAE" (100%) / **WiSe**	Lecture (L) Exercise (E) Project (P)	Prof. Dr. rer. nat. habil. Klaus Gürlebeck

Course aim

Students will have experience in Computer Aided Engineering (CAE) by establishing a problem specific model on the basis of a mathematical formulation, an applicable solution technique, design of efficient data structures and software implementation.

Course content

Convergence, stability and error analysis of finite difference methods (FDM), Modelling of steady and unsteady heat conduction problems, wave propagation and vibrations and problems from linear thermo-elasticity in 2D and 3DAfter considering the mathematical basis the students will work on individual projects passing all levels of work (engineering model, mathematical model, numerical model, computer model, simulation, evaluation).
The computer models will be developed using MATLAB. Concepts of modern programming techniques, interfaces, data structures and visualization of the results will be discussed.

Course literature

Will be announced

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Gürlebeck	Advanced Modelling – CAE (L)	2
Dr. Legatiuk	Advanced Modelling – CAE (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Nonlinear analysis of structures under extreme loading [Module-No.: 2350007]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 45hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Mechanics, Structural Engineering	NHRE other	**1 Project report** "Nonlinear analysis of structures under extreme loading" (0%) / **WiSe** **1 written exam** „ Nonlinear analysis of structures under extreme loading "/ 120 min (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E) Project (P)	Prof. em. Erich Raue

Course aim

The students will be familiar with basics of the nonlinear analyses, especially of reinforced concrete structures. The course focuses on the application of the mathematical optimisation for nonlinear analyses of structural elements.

Course content

- physically and geometrically nonlinearity, rheological models
- elastic, plastic and adaptive bearing behavior
- Plasticity in structural design of r/c members
- static and kinematic formulation of energy methods
- Energy Method with Integral Description of Material Behavior (EIM)
- capacity design and advanced capacity of seismic loaded r/c structures

Course literature

Will be announced

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Raue	Nonlinear analysis of structures under extreme loading (L)	2
Dr. Timmler / Dr. Schröter	Nonlinear analysis of structures under extreme loading (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Secondary Hazards and Risks (land-use, site studies) [Module-No.: 2210012]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 45hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Geo- and hydrotechnical Engineering	NHRE other	**1 Project report** "Secondary Hazards and Risks" (0%) / **WiSe** **1 written exam** „Secondary Hazards and Risks"/ 120 min (100%) / **WiSe** + SuSe	Lecture (L) Project (P)	Prof. Dr.-Ing. Karl Josef Witt

Course aim

The objective of this module is focused in advanced methods of Landslides, Geotechnical Earthquake Engineering and Problematic Soils in Statics and Dynamics. The students should be able to apply the strategies and methods at realistic problems in the given fields. To fix the theoretical background the student has to apply the methods independently at given tasks during several practical and theoretical projects

Course content

Secondary Hazards and Risks (land-use, site studies)
Mass Movements: Classification, Landslides in Soil & Rock, Landslide hazards, Slope-Stability-Analysis, Slope Monitoring & Investigation, Slope Control, Stabilization; Problem Soils: Quick clays, Expansive and Collapsible soils
Geotechnical Earthquake Engineering: Assessment of Liquefaction potential, Amplification studies and site effects & topography, Seismic bearing capacity, Seismic design of retaining walls & Seismic earth pressure

Course literature

Kramer, S.L., Geotechnical Earthquake Engineering, Prentice-Hall, 1996 / Sassa, K., Landslides: Risk Analysis and Sustainable Desaster Management, Springer, 2005 / Dungar, R., Studer, J.A., Geomechanical Modelling in Engineering Practice, Balkema, 1986 / Cornforth, D., Landslindes in Practice: Investigation, Analysis and Remedial / Preventail Options in Soils, Wiley, 2005

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Witt / Prof. Wuttke	Secondary Hazards and Risks (L)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Fundamentals of structural health monitoring (SHM) and intelligent structural systems

[Module-No.: B01-907004]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 60hs Project work 45hs Self-study time 30hs Exam-preparation time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Object-oriented modelling and Java programming language	NHRE other	**1 Project report (written paper)** "Fundamentals of structural health monitoring" (0%) / **WiSe** **1 oral exam** „Fundamentals of structural health monitoring " (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E) Project (P)	Prof. Dr.-Ing. Kay Smarsly

Course aim

The students learn the theoretical and practical foundations of structural health monitoring and smart structural systems. Also, the students will learn to design decentralized, intelligent sensor systems using embedded computing, state-of-the-art data analysis techniques, and modern software design concepts.

Course content

Structural health monitoring (SHM) and smart structural systems, also referred to as "smart structures" or "intelligent infrastructure", are primary subjects of this course: Basic principles of modern SHM are taught; also, concepts of smart structural systems, which are capable of self-assessing their structural condition with a certain degree of intelligence, are eluci¬dated in more detail. Measuring techniques, data acquisition systems, data management and processing as well as data analysis algorithms will be discussed. Furthermore, approaches towards autonomous and embed¬ded computing, to be used for continuous (remote) monitoring of civil infrastructure, are presented. Throughout the course, a number of illus¬trative examples is shown, demonstrating how state-of-the-art SHM sys¬tems and smart structural systems are implemented. In small groups, the students design structural health monitoring systems that are validated in the field. The outcome of every group is to be documented in a paper, which is graded, together with an oral examination, at the end of the course. No previous experience in the above fields is required by the students; limited enrolment.

Course literature

Will be announced

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Smarsly	Fundamentals of structural health monitoring (L)	2
Dr. Tauscher	Fundamentals of structural health monitoring (E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Risk projects and evaluation of structures [Module-No.: 2340010]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
3	annually in Winter Semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 68hs Attendance time, 60hs Project work 52hs Self-study time

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE other	**1 Project report (written paper)** "Risk projects" (33%) / **WiSe** **1 Project report (written paper)** "Evaluation and Re-Design of structures/ Evaluation of a Seismic Instrumented Building" (67%) / **WiSe**	Lecture (L) Exercise (E) Project (P)	Dr.-Ing. Jochen Schwarz

Course aim

Training of student's ability to apply methods and current state in natural hazard and risk assessment integrating research and practical applications to site- or structure-specific risk analysis and planning decision.
Students will be able to apply modern EQ software to transfer buildings into dynamic models and to evaluate the seismic response characteristics in dependence on design decisions; they will be trained to identify failure mechanism and design defects, and to evaluate appropriateness of strengthening measures. Students will be familiar with different analysis methods, techniques and tools of vulnerability assessment.

Course content

Risk projects
Assessment of hazard phenomena; multi-hazard and risk mapping; lessons from recent events and field missions; reinterpretation of observed response for different building types; recent developments in design and construction; regional seismic risk assessment projects; damage scenarios and loss prediction; results from global earthquake models

Evaluation and Re-Design of structures/ Evaluation of a Seismic Instrumented Building
Identification of building type representatives; empirical and analytical vulnerability assessment; evaluation of damaged structures, rehabilitation strategies and reconstruction techniques; performance- and scenario-based risk assessments; comparison of instrumentally or experimentally gained results with outcomes of numerical simulations; damage prognosis; elaboration of instrumental data and model calibration.
Tools: Perform3D / 3Muri

Course literature

Text books (to be announced); publication from the lecturers; results from recent projects

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Schwarz	Risk projects (L)	2
Dr. Abrahamczyk	Evaluation and Re-Design of structures/ Evaluation of a Seismic Instrumented Building (E)	2
Dr. Abrahamczyk	Evaluation and Re-Design of structures/ Evaluation of a Seismic Instrumented Building (P)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Evaluation of Existing Masonry Structures under Extreme loading Impacts (in the frame of "Model validation and simulation")

[Module-No.: B01-205008]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 to 4	annually in Winter Semester and Summer semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 135hs Project work

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE other	**1 Project report (written paper) + oral presentation** "Evaluation of Existing Masonry Structures" (100%) / **WiSe** and **SuSe**	Project (P)	Dr.-Ing. Lars Abrahamczyk

Course aim

The aim of the project is to introduce the participants into advanced requests in the field of earthquake engineering. The studies will be concentrated on a real masonry building, for which all necessary information could be collected in the frame of the SERAMAR project. Further the building response could be measured by the temporary installation of a building monitoring system.

Course content

Evaluation of Existing Masonry Structures
The participants of the project will analyze the measured data, assess the performance of the structure and evaluate the earthquake resistant design. Further they will carry out an analogy consideration for the collapse analysis of masonry structures under extreme horizontal action by using modern software tools (3Muri, SAP2000).
Training in methods of modelling and damage prognosis using advanced commercial software; assessment of the performance and safety margin of the target structure; discussion of different strengthening techniques/ strategies; re-check of the vulnerability of the structure before and after the design modifications.
Groups of 3 students are working on all topics, but different buildings (ambient vibration measurements).

Course literature

Will be announced

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Abrahamczyk Dr. Schwarz	Evaluation of Existing Masonry Structures (P)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Frame for Group projects – "Model validation and simulation"						**[Module-No.: B01-xxxxxx]**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
2 to 4	annually in Winter Semester and Summer semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 135hs Project work

Recommended course requirements	**Course program**	**Form of examination / Duration of examination**	**Teaching and learning methods**	**Responsible for the module**
B.Sc.	NHRE other	**1 Project report (written paper) + optional oral presentation** "Title of project" (100%) / **WiSe** and **SuSe**	Project (P)	all NHRE lectures depend on the chosen project

Course aim
depend on the chosen project

Course content
Group projects in the frame of "Model validation and simulation" Task given by the lectures

Course literature
depend on the chosen project

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
	"Title of project" (P)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Field Survey / Laboratory Testing [Module-No.: 2350014]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 to 4	annually in Winter Semester and Summer semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 135hs Project work

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc. Primary Hazards and Risks Geo- and hydrotechnical Engineering	NHRE other	**1 Project report (written paper)** "Field Survey / Laboratory Testing " (100%) / **WiSe** and **SuSe**	Project (P)	Dr.-Ing. Jochen Schwarz

Course aim

The objective of this module is focused on the experimental assessment of soil material in hazard regions, like Earthquake sites, landslides and problematic soils. To determine and estimate the parameter for hazard regions, field and laboratory investigations are to interpret in a common way. The course will present fundamentals and advances in soil testing. The students have to apply several investigation methods during experimental projects.

Course content

I) Experimental Soil Dynamics & Geotechnical Earthquake Engineering:
- a) Introduction into measurements of dynamic soil parameter,
- b) Instrumentation and Applied Signal Processing for Laboratory and Field measurements,
- c) Design and Realization of Field investigation and Laboratory Measurements,
- d) Validation of numerical simulations,
- e) Field Survey and Laboratory testing for assessment of liquefaction potential

II) Experimental Soil Mechanics & Geotechnics:
- a) Soil Laboratory and field testing for landslide risk assessment,
- b) Soil laboratory and field testing for problematic, expansive soils and soil erosion,
- c) Validation of numerical simulations

Course literature

Ishihara, K., Soil Behaviour in Earthquake Geotechnics, Clarendon Press, 1996 / Robertson, P.K., Mayne, P.W., Geotechnical Site Characterization, Balkema 1998

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Schwarz / et al.	Field Survey / Laboratory Testing (P)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]

Frame for "Special projects" [Module-No.: 2340012]

Semester No.	Frequency of the module offering	Duration	Type of module	Credit points (ECTS)	Language(s)	Student workload
2 to 4	annually in Winter Semester and Summer semester	1 Semester weekly	Elective compulsory	6	English	180hs, thereof 45hs Attendance time, 135hs Project work

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE other	**1 Project report (written paper) + optional oral presentation** Title of "Special project" (100%) / **WiSe** and **SuSe**	Project (P)	all NHRE lectures depend on the chosen project

Course aim

Demonstration of student's ability to apply methods commonly used in their professional field to recognize a problem, evaluate it in a reflective, analytical-critical manner, and come up with ways of solving it within a limited period of time

Course content

Special problems derived from demanding engineering tasks in the areas of planning, construction and realization of structures under specific conditions, integrating research and practical applications; site- or structure-specific risk analysis using modern tools to estimate the threat of natural hazards; contributions to modelling, simulation and application of performance-based design, including field work and laboratory investigation, engineering-related topics with focus on the support by natural sciences, social sciences and economics; derived from on-going planned projects at both regional and global level, sub-tasks reflect the reached progress in training of the general course content.

Course literature

depend on the chosen project

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
	Title of "Special project" (P)	4