2020

Module guide (Modulhandbuch) NHRE

Bauhaus-Universität Weimar

20.10.2020

Study Regulations - Supplement 1 Master's degree programme "Natural Hazards and Risks in Structural Engineering"				1st semester (winter semester)	2nd semester (summer semester)	3rd semester (winter semester)	4th semester (summer semester)
Modules		Credits		Credits	Credits	Credits	Credits
Applied mathematics and stochastics for risk assessment	**Prof. Gürlebeck,** Prof. Lahmer	6		**6**			
Geographical Information Systems (GIS) and building stock survey	**Prof. Rodehorst,** Dr. Beinersdorf, Dr. Schwarz	6		**6**			
Primary hazards and risks Part I: Seismic Monitoring + Regional Ground Motion Part II: Wind engineering	**Dr. Schwarz,** Prof. Morgenthal, Prof. Höffer	6		**6**			
Finite element methods and structural dynamics	**Prof. Könke,** Dr. Zabel	6		**6**			
Structural engineering Part I: Standard systems (1st semester) Part II: Advanced Systems (2nd semester)	**Prof. Kraus,** Prof. Morgenthal	6		**3**	**3**		
Elective module ** (recommendation: German language)		**6**		**3**	**3**		
Structural parameter survey and evaluation Part I: Systems and data processing Part II: Data evaluation	**Prof. Morgenthal,** Prof. Rodehorst, Prof. Illge	6			**6**		
Earthquake engineering and structural design	**Dr. Schwarz,** Prof. Abrahamczyk	6			**6**		
Geo- and hydrotechnical engineering Part I: Geotechnical Engineering Part II: Flood Hazard and Vulnerability Assessment	**Prof. Morgenthal,** Prof. Wichtmann, Dr. Maiwald	6			**6**		
Elective compulsory module *		6			6		
Disaster management and mitigation strategies	**Prof. Bargstädt,** Prof. Eckardt	6				**6**	
Life-lines engineering	**Prof. Morgenthal**	6				**6**	
Elective compulsory module *		6				6	
Special project		12				12	
Elective module **		6					6
Master's Thesis		24	4 months				24
Total		120		30	30	30	30

* see NHRE module catalogue (updated annually, to be confirmed by the head of the NHRE program and the examination committee)

** see NHRE module catalogue - additionally any master course at the Bauhaus University (German language courses for 6 credits are valid too)

Compulsory modules

Compulsory modules 1st semester (winter semester):

- Applied mathematics and stochastics for risk assessment
- Geographical Information Systems (GIS) and building stock survey
- Finite element methods and structural dynamics
- Structural engineering - Standard systems

Compulsory modules 2nd semester (summer semester):

- Structural engineering - Advanced Systems
- Structural parameter survey and evaluation
- Earthquake engineering and structural design
- Geo- and hydrotechnical engineering

Compulsory modules 3rd semester (winter semester):

- Disaster management and mitigation strategies
- Life-lines engineering

Bauhaus-Universität Weimar / Faculty of Civil Engineering M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]						
Applied mathematics and stochastics for risk assessment						**Module-No.: 2301012**
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 exam** “Applied mathematics and stochastics for risk assessment” / 180 min (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E) Tutorial (T)	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 based on Computer Algebra Systems (MAPLE) for analysis and equation solving.
Provision of basic concepts in probability theory and statistics for the assessment of risks of both single components and complex systems. Emphasis on the theory and application of extreme-value distributions.

Course content

Applied mathematics:
Fundamentals of linear algebra, eigenvalue problems, fixed point principles, solvers; Fourier series, convergence, 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.
Stochastics for risk assessment:
Introduction to probability theory with focus on situations characterized by low probabilities. Random events, discrete and continuous random variables and associated distributions. Descriptive statistics, parameter estimation. Risk Assessment by means of FORM and Monte Carlo Simulations. Introduction to reliability theory: Extreme value distributions; stochastic modelling with software tools e.g. MATLAB, Octave, Excel, R. Reliability Analysis of Systems. Catastrophic events + risk problems, Applications

Course literature

Will be announced.

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Gürlebeck	Applied mathematics (L)	2
Dr. Legatiuk	Applied mathematics (E)	1
Prof. Lahmer	Stochastics for risk assessment (L)	2
Prof. Lahmer	Stochastics for risk assessment (E)	1
--	Tutorial: Computer Algebra Systems (T)	

Bauhaus-Universität Weimar / Faculty of Civil Engineering
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Geographical Information Systems (GIS) and building stock survey

Module-No.: 2904002

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 intermediate evaluation** + **written report** “Geographical Information Systems (GIS) and building stock survey” (100%) / **WiSe**	Lecture (L) Exercise (E) Project (P)	Prof. Dr.-Ing. Volker Rodehorst

Course aim

Students will be trained to reproduce existing natural hazard and risk related data in GIS format using GIS Software Solutions and 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 of three-dimensional positioning, photogrammetry, GIS/cartography, land management / cadastre; 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.

Course literature

Textbooks (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)	1
Dr. Schwarz / Dr. Beinersdorf	Geographical Information Systems (GIS) and building stock survey (E, P)	3

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

Primary hazards and risks

Module-No.: NHM-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, 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" (17%) / **WiSe** **2 written exams** "Seismic Monitoring" / 180 min (50%) / **WiSe** + SuSe "Wind Engineering" / 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
Description of seismic action; recording instruments, input parameters for seismic hazard assessment; EQ-Action for building design; Measurements for site response evaluation; Building Monitoring Systems: tasks and developments, analysis of instrumental data; identification of dynamic and structural parameters
Regional Ground Motion
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; site categorization and response studies.
Wind Engineering
Meteorology related wind effects on structures, quantification of wind effects and wind loading after wind loading standards: extreme value analysis and wind maps, aerodynamic and aeroelastic effects on structures, phenomena of wind-induced dynamic response, basics of wind resistant design, wind tunnel technology, numerical simulations of aerodynamic effects, wind risk mitigation; examples

Course literature

Textbooks (to be announced); publication from the lecturers

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Dr. Schwarz / et al.	2902001: Seismic Monitoring (L)	3
Dr. Schwarz / et al.	2902001: Regional Ground Motion (E)	1
Prof. Morgenthal / Prof. Höffer	2204017: Wind Engineering (L, E)	2

Bauhaus-Universität Weimar / Faculty of Civil Engineering M. Sc. Natural Hazards and Risks in Structural Engineering [NHRE]						
Finite element methods and structural dynamics						**Module-No.: NHM-2050**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
1	annually 1st half Winter Semester	1/2 Semester weekly	Compulsory	6	English	180hs, thereof 90hs Attendance time, 60hs 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 exam:** “Fundamentals of finite element methods” / 90 min (50%) / **WiSe** + SuSe **1 written exam:** “Fundamentals of structural dynamics” / 90 min (50%) / **WiSe** + SuSe	Lecture (L) Exercise (E)	Prof. Dr.-Ing. habil. Carsten Könke, Dr.-Ing. Volkmar Zabel

Course aim

CK: Students will obtain the ability to analyse complex structural engineering problems applying numerical simulation techniques, to establish numerical approximation methods for structural engineering problems starting with the PDE and ending in an discretized form of a weak formulation. They will be able to assess the quality of FEM solutions.
VZ: The students will obtain basic knowledge of structural dynamics, become able to understand the concepts of analyses in time and frequency domain for SDOF systems as well as the extension of these analyses to MDOF systems. Further, they will be able to solve simple problems of structural dynamics by means of a numerical tool.

Course content

Finite element methods: (50% of semester course time)
strong and weak form of equilibrium equations in structural mechanics, Ritz and Galerkin principles, shape functions for 1D, 2D, 3D elements, stiffness matrix, numerical integration, Characteristics of stiffness matrices, solution methods for linear equation systems, post-processing and error estimates, defects of displacements based formulation, mixed finite element approaches,
Structural Dynamics: (50% of semester course time)
SDOF systems: free vibrations, harmonic, impulse and general excitation for undamped and damped systems, Impulse response function, frequency response function, base excitation, time step analysis: central difference and Newmark methods; MDOF systems: modal analysis, modal superposition, modal damping, Rayleigh damping, Frequency response functions, state-space models

Course literature

K.J. Bathe: Finite Element Procedures, O.Zienkiewicz: Finite Element Methods
Clough, Penzien: Dynamics of Structures, 2010 / Chopra: Dynamics of Structures, 2015

Courses

Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Könke	2401015: Finite element methods (L)	2
Prof. Könke / et al.	2401015: Finite element methods (E)	1
Dr. Zabel	2401014: Structural dynamics (L)	2
Dr. Zabel / et al.	2401014: Structural dynamics (E)	1

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

Structural engineering						**Module-No.: NHM-2020**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
1	Start annually in Winter Semester	2 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** "Standard systems" / 90 min (50%) / **WiSe** + SuSe "Advanced systems" / 90 min (50%) / **SuSe** + WiSe	Lecture (L) Exercise (E)	Prof. Dr.-Ing. Matthias Kraus

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 as well as steel and steel-concrete composite structures.

Course content

Structural Engineering – Standard systems (winter semester):
History of structures; building materials; structural form and structural behaviour; actions on structures; structural reliability and codes of practice; mechanical modelling of structures; design of reinforced concrete and steel structures

Structural Engineering – Advanced systems (summer semester):
Design of steel and steel-concrete composite structures; Post-tensioned concrete structures – design and detailing; Design of steel connections and detailing

Course literature

Textbooks (to be announced)

Courses

Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Morgenthal	2205012: Structural engineering – Standard systems (L)	2
Prof. Morgenthal / et al.	2205012: Structural engineering – Standard systems (E)	1
Prof. Kraus	2205013: Structural engineering – Advanced systems (L)	2
Prof. Kraus / et al.	2205013: Structural engineering – Advanced systems (E)	1

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

Structural parameter survey and evaluation						**Module-No.: 2204018**
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**
Prim. Hazards and Risks, Appl. Mathem.	NHRE	**1 written exam** “Structural parameter survey and evaluation “/ 180 min (100%) / **SuSe** + WiSe	Lecture (L) Exercise (E) Project (P)	Prof. Dr. Guido Morgenthal

Course aim

The students will be familiar with methods to determine properties of structural systems by means of modern measurement techniques. They will be familiar with the concepts, the application and the limitations of these techniques. They understand the data obtained and the methods to condition, analyse and interpret the data to extract information about structures and structural members and components. They will be able to apply the concepts to develop measurement setups and analysis procedures to problems encountered in structural engineering.

Course content

Signal Analysis
Trigonometric polynomials (TP); amplitude-phase and complex representation; approximation of arbitrary periodic functions by TP using method of least squares, calculation of Fourier coefficients and error estimation; Fourier series. Discussion of spectra and Fourier transform and its basic properties; Convolution and its properties and applications; random variables and central limit theorem; applications of Fourier transforms such as filtering of signals and solving differential equations
Sensor-based Monitoring and System Analysis
Types and principles of sensors; important sensor properties; data acquisition techniques; spectral and stochastic analysis of sensor data; properties of structural systems important in experimental testing and structural health monitoring; relevant limit states; structural analysis, modelling and model calibration; applications to static and dynamic response, load determination, physically nonlinear structural behaviour and optimization of sensor system setups
Geo-spatial Monitoring
Preparation and planning of three-dimensional measurement tasks; application of tacheometry, satellite-based positioning (GNSS), terrestrial laser scanning and photogrammetry for monitoring; image-based sensor orientation and surface reconstruction; spatial transformations, georeferencing, distance measures, pointcloud registration and geometric deformation analyses

Course literature

Baher: Signal Processing and Integrated Circuits, Wiley 2012; Blinder: Guide to Essential Math, Elsevier 2013; Further literature to be announced

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Morgenthal	Sensor-based Monitoring and System Analysis (L,E+P)	1.5
Prof. Rodehorst / et al.	Geo-spatial Monitoring (L+P)	1.5
Prof. Illge	Signal Analysis (L/E)	1.5

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

Earthquake engineering and structural design						**Module-No.: 2202002**
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 written exam** “Earthquake engineering” / 150 min (67%) / **SuSe** + WiSe **1 Project report + Project presentation** “Structures in Earthquake Regions/Design of RC frames” / (33%) / **SuSe**	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, to develop earthquake resistant structures and to evaluate structural design.

Course content
Earthquake engineering Seismic Code development and generations; simplified analysis methods; design of structures and regularity criteria for earthquake resistance; performance and experience-based 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 and modified building layouts; comparison of the results with outcome of damage surveys. Tools: ETABS, SAP2000

Course literature
Publication and Textbooks from the lecturers

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

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Geo- and hydrotechnical engineering						**Module-No.: NHM-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 written exam** “Flood Hazard and Vulnerability Assessment” / 90 min (50%) / **SuSe** + WiSe **1 written exam** “Geotechnical Engineering” / 90 min (50%) / **SuSe** + WiSe	Lecture (L) Project (P)	Prof. Dr. Guido Morgenthal (p.p.), Prof. Dr.-Ing. habil. Torsten Wichtmann

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

Geotechnical Engineering
Classification and identification of soils; Description of soil state; Water in the soil; Hydraulic conductivity and seepage flow; Distribution of vertical stress in the soil; Stress-strain relationships; Settlement analysis; Consolidation theory; Shear strength; Earth pressure; Basics of Soil Dynamics (wave propagation, laboratory and field testing, soil-structure interaction under dynamic loading); Soil Liquefaction (phenomenon, consequences, estimation of liquefaction risk, prevention)
Flood Hazard and Vulnerability Assessment
Flood Management; Fundamentals of flood defence; Management of low-lying areas; Design of river dikes, channels and dams; Design concepts for the defence of structural objects and buildings; Forecasting, management and maintenance in flood defence; Hydrology, hydraulic calculations, flood routing; Characteristics of tsunami action, forces and loads on structures; Structural damage and loss prediction, damage scenarios; Re-interpretation of recent events.

Course literature

Wichtmann, T., Lecture Notes for Geotechnical Engineering, 2018

Courses

Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Wichtmann	2906014: Geotechnical Engineering (L+E)	3
Dr. Maiwald	2202003: Flood Hazard and Vulnerability Assessment (L+E)	3

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

Disaster management and mitigation strategies						**Module-No.: NHM-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 exam** "Project and disaster management "/ 120 min (50%) / **WiSe** + SuSe **1 Presentation + presentation paper** "Urban Sociology" (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 Sociology
The emphasis of sociology of disaster focuses on the precipitating event to the social structure of critical mass within community that leads to the changing routine of social structure. The past decade alone has seen multiple disasters around the world, the historical lesson also shows that after the end of Second World War in Europe, few studies have been available on how to reconstruct the cities. Historical attempts to define and interpret disaster in sociological terms are thus necessary in order to raise questions about the social order and resilience after disaster. Recent research on social networks and organisational forms of association related to disasters from European and International cases are highlighted.

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.
M. Kammerbauer. Planning Urban Disaster Recovery. Spatial, Institutional, and social aspects of urban disaster recovery in the U.S.A. – New Orleans after Hurricane Katrina. (2013) VDG Weimar. ISBN 978-3-89739-745-3
E.L Quarantelli. Urban Vulnerability to disasters in Developing Countries: Managing risks, Book Chapter 15 (2003) 211-231. The World Bank.

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Bargstädt / et al.	2901005: Project- and disaster management (L)	3
Prof. Eckardt, Dr. Podlaszewska	1724415: Urban Sociology (L)	2

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

Life-lines engineering						Module-No.: 2204019
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 exam** "Life-lines Engineering "/ 180 min (100%) / **<u>WiSe</u>** + SuSe	Lecture (L) Exercise (E)	Prof. Dr. Guido Morgenthal

Course aim
The students will be familiar with bridges in the context of their functions as critical infrastructure. They will be familiar with the design objectives with specific emphasis on risks associated with natural hazards 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
<u>Life-lines Engineering</u> 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 **<u>Training in:</u>** 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
Textbooks (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.: NHM-3000
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 and Summer semester	1 Semester weekly	Elective Compulsory	12	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.: NHM-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 or German	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 modules from a list with NHRE-elective compulsory modules as well as from all master's degree programs of the Bauhaus-Universität Weimar. ** any course at the Bauhaus university is valid (recommendation: "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]

Special project						**Module-No.: NHM-5000**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
3	annually in Winter Semester or Summer semester	1 Semester weekly	Compulsory	12	English	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	**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

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

Master's Thesis

Module-No.: NHM-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 months (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 the Special project)	NHRE	one digital and two printed copies of the master's thesis in English (75%) + Presentation of the master's 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

Modules	Lecturers	**winter semester (credits)**	**summer semester (credits)**
Applied finite element methods and structural dynamics	Prof. Könke	6 ECTS	
Advanced modelling – calculation/ CAE	Prof. Gürlebeck, Dr. Legatiuk		6 ECTS
Experimental structural dynamics	Dr. Zabel		6 ECTS
Modelling of steel structures and numerical simulation	Prof. Kraus		6 ECTS
Multi-hazard and risk assessment (incl. Excursion GFZ)	Dr. Schwarz, Prof. Cotton		6 ECTS
~~Model validation and simulation~~ ~~(Group project)~~	~~Prof. Morgenthal,~~ ~~Prof. Abrahamczyk /~~ ~~Dr. Schwarz~~	~~6 ECTS~~	~~6 ECTS~~
Computational and Experimental Wind Engineering for Long-span Bridge Design	Prof. Morgenthal		6 ECTS
Stochastic Simulation and Optimization			
Introduction to optimization / Optimization in applications	Prof. Lahmer		3 ECTS
Stochastic simulation techniques and structural reliability	Prof. Lahmer		6 ECTS
Assessment of structural performance (under extreme loading conditions)	Dr. Schwarz	6 ECTS	
Design and interpretation of experiments (incl. signal processing II)	Prof. Kraus, Prof. Lahmer	6 ECTS	
~~Fundamentals of structural health monitoring (SHM) and intelligent structural systems~~	~~Prof. Smarsly~~	~~6 ECTS~~	
~~Nonlinear analysis of structures under extreme loading~~	~~Prof. Morgenthal,~~ ~~Dr. Timmler~~	~~6 ECTS~~	
Risk projects and evaluation of structures	Prof. Abrahamczyk	6 ECTS	
Secondary hazards and risks (land-use, site studies)	Prof. Wichtmann, Dr. Aselmeyer	6 ECTS	
~~Nonlinear continuum mechanics~~	~~Prof. Rabczuk~~	~~6ECTS~~	
Advanced numerical mathematics	Prof. Gürlebeck		6 ECTS

Additional modules as elective compulsory modules are not allowed!

Legend: ~~crossed out~~ - not offered currently

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

Applied finite element methods and structural dynamics						**Module-No.: NHM-3000**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
1 or 3	annually 2nd half Winter Semester	1/2 Semester weekly	Elective compulsory	6	English	180hs, thereof 90hs Attendance time, 60hs 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	**1 written exam:** “Fundamentals of finite element methods” / 90 min (50%) / **WiSe** + SuSe **1 written exam:** “Fundamentals of structural dynamics” / 90 min (50%) / **WiSe** + SuSe	Lecture (L) Exercise (E)	Prof. Dr.-Ing. habil. Carsten Könke, Dr.-Ing. Volkmar Zabel

Course aim

CK: Students will obtain the ability to analyse geometrical and nonlinear structural engineering problems and to establish numerical models for static and dynamic problems in structural engineering. They will be able to assess the quality of numerical solutions by error estimation concepts and will understand how to solve large equation systems by efficient solution techniques.
VZ: The students will become able to apply the concepts of SDOF and MDOF system analysis to practical problems, understand the principles of action of different kinds of dynamic loading on structures, obtain knowledge about the design of remedial measures. Further they will be able to solve more complex problems by means of a numerical tool.

Course content

CK: Finite element formulation for geometrical and physical nonlinear problems in structural engineering, incremental-iterative concepts, quality assessment of numerical results via error estimates, efficient solver techniques for large linear and nonlinear equation systems resulting from the FE concepts, application of FE-methods for typical engineering problems (50 % of course time)
VZ: Continuous systems: free and forced vibrations, travelling loads; machinery induced vibrations, earthquake excitation wind induced vibrations human induced vibrations (50 % of course time)

Course literature

K.J. Bathe: Finite Lement Procedures / Johnson, Hansbo: Computational Differential Equations
Clough, Penzien: Dynamics of Structures, 2010 / Chopra: Dynamics of Structures, 2015

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Könke	2401012: Applied Finite element methods (L)	2
Prof. Könke / et al.	2401012: Applied Finite element methods (E)	1
Dr. Zabel	2401011: Applied Structural dynamics (L)	2
Dr. Zabel / et al.	2401011: Applied Structural dynamics (E)	1

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

Advanced modelling – calculation/CAE	**Module-No.: 2301013**

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, 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 + Presentation** “Advanced Modelling – Calculation/CAE” (100%) / **SuSe** (50%) **1 written exam: 6**0 min (50%) / **SuSe** + WiSe	Lecture (L) Exercise (E) Project (P)	Prof. Dr. rer. nat. habil. Klaus Gürlebeck

Course aim

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

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.
The topics are discussed theoretically and then implemented.
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 3D. After 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 solution methods will be implemented by help of MAPLE or MATLAB.

Course literature

Will be announced

Courses

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

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

Experimental structural dynamics						Module-No.: B01-401009
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 60hs Attendance time, 80hs Project work 40hs Self-study time

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

Course aim

The students obtain deepened knowledge in structural dynamics, structural dynamic analysis, data processing, dynamic test equipment and its handling. They learn to analyse the dynamic behaviour of a 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 / Rainieri, C. & Fabbrocino, G.: Operational Modal Analysis of Civil Engineering Structures, 2014 / Clough, R.W., Penzien, J.: Dynamics of Structures, 2010

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]

Modelling of steel structures and numerical simulation						Module-No.: 2205007
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. 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)	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 / et al.	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]						
Multi-hazard and risk assessment						**Module-No.: 2202004**
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 (Compulsory for DAAD scholarship-holders)	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** (100% each) / **SuSe**	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 single and multi-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 research as well as global projects conducted by GFZ.

Course content
Hazard Assessment and Applications Primary input and output parameters for EQ (and other natural) hazard; Earthquake statistics and occurrence probability; Methodology of seismic hazard assessment; Seismicity models; Examples of seismic hazard and risk studies; Synopses of natural hazards; procedures and developments in multi-hazard assessment; Case studies of multi-hazard, vulnerability and risk considerations. **Workshop** “Natural Hazards and Advanced Geotechnologies“ **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 pre-processing; Hazard Description for the Project regions Excursion to GeoResearchCenter Potsdam

Course literature
Textbooks (to be announced); Textbooks from the lecturers

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Cotton et al. / Dr. Schwarz / Dr. Beinersdorf	Hazard Assessment and Applications (L)	2
Prof. Cotton / Dr. Schwarz et al.	Workshop (L)	1
Prof. Cotton et al. / Dr. Schwarz et al.	“Compilation of hazard related data” and „Synopsis of Multi-Hazard Assessment Normatives” (E)	3

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.: NHM19-3010
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]

Computational and Experimental Wind Engineering for Long-span Bridge Design	Module-No.: 2204025

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	depend on the chosen module Total workload: 180hs

Recommended course requirements	Course program	Form of examination / Duration of examination	Teaching and learning methods	Responsible for the module
B.Sc.	NHRE	**1 Intermediate presentation** “Theoretical background and work update (20%)“ / **SuSe** **1 Final presentation** “Presentation of final outcome (30%)“ / **SuSe** **1 Final report** “Computational and Experimental Wind Engineering for Long-span Bridge Design” (50%) / **SuSe**	Lecture (L) Exercise (E) Project (P)	Prof. Dr. Guido Morgenthal

Course aim

The course aims to introduce the students to the fundamentals and state-of-the-art methods of wind engineering and different aerodynamic phenomena that are relevant to the design of long-span cable-supported bridges. To characterize and quantify aerodynamic and aeroelastic effects, students will understand the concepts of computational fluid dynamics (CFD) simulations and experimental wind tunnel tests, along with their advantages and limitations. Students will be able to model complex bridge structures using Finite Element Analysis methods and simulate dynamic response due to wind. Different combinations of analytical, numerical and experimental analysis approaches are employed to investigate dynamic wind excitations with a focus on identifying serviceability issues and ultimate limit scenarios of the structure.

Participating students are tasked with practical bridge design-oriented challenges and work in groups to address them. Group organization and goal-oriented work are an important aspect to the project work. Results are reported periodically in presentations. Results are to be summarized in a report following scientific writing standards and presented orally.

Course content

Literature review on aerodynamic phenomena in long-span bridges; Fundamentals of computational wind engineering; Aerodynamic loads; Self-excited or motion-induced forces; Aerodynamic instabilities; Finite Element modelling and dynamic simulation of long-span bridges (arches, cable-stayed bridges, suspension bridges); Model Validation; Analytical and semi-analytical aerodynamic models; 2D and pseudo-3D CFD simulations; Developing experimental scaled models; Experimental wind tunnel testing; Comparison of results from different methods; Strategies for vibration mitigation; Aerodynamic optimization; Scientific writing and design-focused reporting.

Course literature

Textbooks and relevant articles (to be announced)

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Morgenthal	Computational and Experimental Wind Engineering for Long-span Bridge Design (L)	2
Prof. Morgenthal / et al.	Computational and Experimental Wind Engineering for Long-span Bridge Design (E, 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.: NHM-3020**

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	3	English (German)	90hs, thereof 22hs Attendance time, 53hs 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 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

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

Course content

Introduction to Optimization (winter semester):
Definitions, Classification of Optimization Problems,
Linear Problems, Simplex Method, Duality, Optimization on Graphs
Nonlinear Problems: Constrained and unconstrained continuous problems, descent methods and variants
Optimization in Applications (summer semester):
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

This course can be combined with Stochastic Simulation Techniques and Structural Reliability (L) to form a 6 CP module named Stochastic Simulation and Optimization.

Course literature

C.T. Kelley- Iterative methods for Optimization
Forst, Wilhelm, Hoffmann, Dieter: Optimization—Theory and Practice
I. M. Bomze, W. Grossmann: Optimierung - Theorie und Algorithmen - Eine Einführung in Operations Research für Wirtschaftsinformatiker

Courses

Lecturer	Title of the course	Semester periods per week (SPW)
Prof. Lahmer	2451002: Introduction to Optimization (L+E)	1.5
Prof. Lahmer	2451006: Optimization in Applications (L+E)	1.5

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.: 2451007**
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 (German)	90hs, thereof 30hs Attendance time, 40hs Project work 20hs Self-study 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	NHRE other	**1 written or oral exam** (depending on the number of participants) "Stochastic Simulation Techniques and Structural Reliability" / (50%) / **SuSe** + WiSe	Lecture (L)	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 risk assessment (structural reliability) and stochastic simulation.

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 Samplings)
- reliability-based design
- sensitivity analysis
- structural safety
- Risk assessment and stochastic modelling in practice

Course literature

Gordon A. Fenton, D. V. Griffiths, Risk Assessment in Geotechnical Engineering
Ch. Bucher, Computational Analysis in Structural Mechanics,

Courses

Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Lahmer	Stochastic Simulation Techniques and Structural Reliability (L+E)	4

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

Assessment of structural performance (under extreme loading conditions)						Module-No.: 2202011
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 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
B.Sc. Seismic Monitoring/ Earthquake Engineering	NHRE other	**1 Project report** „Elaboration of structural models for performance assessment of existing buildings and their small-scale testing" (33%) / <u>**WiSe**</u> **1 written exam** „Assessment of structural performance (under extreme loading conditions)"/ 180 min (67%) / <u>**WiSe**</u> + SuSe	Lecture (L) Exercise (E) Project (P)	Dr.-Ing. Jochen Schwarz

Course aim

Students will be familiar with the existing building typologies, the methods of structural performance assessment and design rules for traditional and engineered building types. Examples of different small to large scale testing and the instrumentation requirements are elaborated to provide structure related parameters and characteristic force-displacement relationships in support of analytical studies and the re-interpretation of damage patterns. Students should be able to evaluate the quality of structural systems, to interpret the performance of masonry and steel structures under horizontal action, to derive appropriate models and to decide upon the applicability of equivalent or simplified ones. Students will be informed about on-going research projects and recent code developments which are linked to the course topics and options for further graduation (master thesis).

Course content

<u>**Structural performance of traditional and engineered building types (L)**</u>
Examples of small and larger scale testing; facilities and technical equipment; demands on specimens and scaling requirements; application of equivalent forces and ground motion in pseudo-static and dynamic testing; load and displacement relationship for full-scale testing of structural elements and building configurations; prediction of capacity curves and material properties and parameters; design principles and structural solutions for traditional (masonry) and engineered (steel) type structures, basic rules for non-engineered buildings (with locally available materials).
<u>**Elaboration of structural models for performance assessment of existing buildings (P)**</u>
Search for typical building representatives of the target regions (home countries of the participants); experimental investigation of design and retrofitting strategies using small scale structural models; testing of elements and interpretation of failure mechanisms, 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, a.o.3MURI
<u>**Small Scale testing (E)**</u>
For the target masonry building of the project, a representative small-scale model has to be developed following the scaling requirements as well the demands and limitations on specimens and size of testing platform. A real model for testing has to prepared using a set of small stone units and wooden elements. The model will be shaken using existing facilities. [Note: The realization and final testing depend on the pandemic situation.]

Course literature

Publication from the lecturers:

Grünthal, G. (ed.), Musson, R., Schwarz, J., Stucchi, M. (1998): European Macroseismic Scale 1998. Cahiers du Centre Européen de Geodynamique et de Seismologie, Volume 15, Luxembourg

Maiwald, H., Schwarz, J. (2019): Unified damage description and risk assessment of buildings under extreme natural hazards, European Journal of Masonry 23, 2, 95-111.

Schwarz, J., Maiwald, H., Kaufmann, C., Langhammer, T., Beinersdorf, S. (2019): Conceptual basics and tools to assess the multi hazard vulnerability of existing buildings. European Journal of Masonry 23, 4, 246-264.

Schwarz, J., Abrahamczyk, L., Leipold, M., Wenk, T. (2015): Vulnerability assessment and damage description for R.C. frame structures following the EMS-98 principles. Bulletin of Earthquake Engineering Vol. 13 (4), 1141-1159.

Schwarz, J., Beinersdorf, S., Kaufmann, C., Golbs, C. (2017): Simulation of Earthquake Libraries for Risk-Targeted and Performance-Based Design Concepts. Proceedings16th World Conference on Earthquake Engineering, Santiago Chile, Jan. 9-13, 2017. (Paper-No. 4734).

Thesis and other Publications relevant for the exercises will be available on MOODLE.

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Dr. Schwarz / et al.	Structural performance of traditional and engineered building types (L)	3
Dr. Schwarz / et al.	Elaboration of structural models for performance assessment of existing buildings (P)	2
Dr. Schwarz / et al.	Small Scale testing (E)	1

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

Design and interpretation of experiments						**Module-No.: 2205014**
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 56hs Attendance time, 94hs 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 exam / 120 min** / **<u>WiSe</u>** + SuSe including “Experiments in Structural Engineering” and “Signal Processing, Design of Experiments and System Identification”	Lecture (L) Exercise (E)	Prof. Dr.-Ing. Matthias Kraus

Course aim

Students will be familiar with following: Design and setup as well as evaluation and interpretation of experimental testing in structural engineering. Provision of techniques linking experimental and mathematical / numerical modelling. Parallel assessment of steps being part of any verification and validation procedure. Discussion of common techniques of optimal experimental designs

Course content

The course gives an overview on experiments and their evaluation regarding different tasks and scopes of structural engineering. Next to different testing techniques applied for diverse aims, the equipment and measuring devices employed for testing are treated as well. Besides the experiment itself, it is an important question, how we can use the experimental data for the calibration and validation of models in engineering. In this course, we give insights to techniques called parameter and system identification.
As often signals are not useable directly, transforms are necessary, like filtering, Fourier Transform, Wavelet Transform and, in particular for signals with noise, averaging techniques. Having models at hand, the experiment can be designed virtually by means of nonlinear optimization.

Course literature

Internal lecture notes
Farrar, Worden: Structural Health Monitoring: A Machine Learning Perspective, WILEY
Darius Ucinsky: Optimal Measurement Methods for Distributed Parameter System Identification, Taylor and Francis
Further Textbooks (to be announced)

Courses

Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Kraus	Experiments in Structural Engineering	2
Prof. Lahmer	Signal Processing, Design of Experiments and System Identification	2/1

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.: 2907004**

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**	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 elucidated 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 embedded computing, to be used for continuous (remote) monitoring of civil infrastructure, are presented. Throughout the course, a number of illustrative examples is shown, demonstrating how state-of-the-art SHM systems 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
N.N.	Fundamentals of structural health monitoring (E)	2

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

Nonlinear analysis of structures under extreme loading						**Module-No.: 2204010**
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, 45hs Project work 60hs 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 written exam** “Nonlinear analysis of structures under extreme loading” / 120 min (100%) / **WiSe** + SuSe	Lecture (L) Exercise (E) Project (P)	Dr.-Ing. Hans-Georg Timmler

Course aim
The students will be familiar with basics of the nonlinear analyses of reinforced concrete structures and other composite constructions. The course focuses on energy methods and the application of the mathematical optimisation for nonlinear analyses of structural elements.

Course content

- physically and geometrically nonlinearity, rheological models
- nonlinear determination of internal forces
- elastic, plastic and adaptive bearing behaviour
- plasticity in structural design of r/c members – plastic hinge and yield line theory
- static and kinematic formulation of energy methods in cross-section analysis
- static and kinematic formulation of energy methods in element analysis
- energy method with integral description of material behaviour (EIM)
- capacity design and advanced capacity design of seismic loaded r/c structures

Course literature
comprehensive script of the course (revised in 2016/2017)

Courses

Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Dr.-Ing. Hans-Georg Timmler	Nonlinear analysis of structures under extreme loading (L,E,P)	2
Dipl.-Ing. Christopher Taube	Nonlinear analysis of structures under extreme loading (L,E,P)	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.: 2202005**
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 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**
B.Sc. Seismic Monitoring / Earthquake Engineering	NHRE other	**1 written exam** “Risk projects and evaluation of structures” 90 min (50%) / **WiSe** + SuSe **1 Project presentation (oral)** “Risk projects” (25%) / **WiSe** **Project reports (written short paper)** “Evaluation of structures” (25%) / **WiSe**	Lecture (L) Exercise (E) Project (P)	Jun.-Prof. Dr.-Ing. Lars Abrahamczyk

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 decisions.
Students will be able to apply modern software tools to transfer buildings into dynamic models and to evaluate the seismic response characteristics in dependence on design situation and performance directed concepts; 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 empirical and analytical vulnerability assessment. Students are encouraged to contribute reports of regionally particular building types to World Housing Encyclopedia and NHRE database.

Course content

Lessons from recent events and field missions; assessment of hazard phenomena; reinterpretation of observed response for different building types; recent developments in design and construction; performance assessment of masonry, steel and wooden structures as well as interaction effects between structure and soil, equipment and filling media; damage classification and fragility functions; building assessment criteria for strengthening; evaluation of applied strengthening and rehabilitation measures.

Training in:
Modelling and assessment of masonry structures applying equivalent frame approach; determination of characteristic building response parameters; determination of fragility function.

Course literature

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

WHE (2004): World Housing Encyclopedia [Internet]. http://www.world-housing.net/

Federal Emergency Management Agency. FEMA 440. Improvement of Nonlinear Static Seismic Analysis Procedures, Applied Technology Council (ATC-55 Project), Washington D.C., USA, June, 2005.

Ghiassi B., Milani G. (editors) (2019): Numerical Modeling of Masonry and Historical Structures. In Woodhead Publishing Series in Civil and Structural Engineering, Woodhead Publishing, ISBN 9780081024393

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Abrahamczyk / Dr. Schwarz	Risk projects (L, E)	2
Prof. Abrahamczyk	Evaluation of structures (L, E)	2
Prof. Abrahamczyk	Studies on Recent Natural Hazard Events (P)	1

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Secondary Hazards and Risks (land-use, site studies)						**Module-No.: B01-906016**
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**
Geo- and hydrotechnical Engineering	NHRE other	**1 Project report** “Secondary Hazards and Risks” (33%) / **WiSe** **1 written exam** „Secondary Hazards and Risks“/ 120 min (67%) / **WiSe** + SuSe	Lecture (L) Project (P)	Prof. Dr. Guido Morgenthal, Prof. Dr.-Ing. habil. Torsten Wichtmann

Course aim

The objective of this module is focused on deepening the skills of the students to judge the risk of a landslide (secondary hazard) in a given sloping ground caused by a primary hazard (e.g. earthquake, heavy rainfall). The students learn advanced methods for the investigation and monitoring of possibly instable soil and rock masses. They deepen their knowledge with respect to different methods of slope stability analysis under static loading and seismic impact. The students are able to study slope stability by means of the finite element method. They know various methods of slope stabilization. They know and can apply basic methods of Geotechnical Earthquake Engineering. To fix the theoretical background the students have to apply the methods learned at given tasks within a project.

Course content

Different methods of slope stability analysis in cases of static and seismic loading (pseudo-static method, Newmark sliding block analysis); Slope investigation and monitoring; Slope stabilization methods; Analysis of slope stability by means of the finite element method (including computer exercise with finite element program Plaxis); Seismic design of retaining structures; Ground response analysis; Stability of rock masses

Course literature

Lecture Notes for this course
Kramer, S.L., Geotechnical Earthquake Engineering, Prentice-Hall, 1996

Courses

Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Wichtmann, Dr. Prada, Dr. Aselmeyer	Secondary Hazards and Risks (L)	4

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Nonlinear continuum mechanics						**Module-No.: 2402009**
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.	NHRE other	**1 written exam** “Nonlinear Continuum Mechanics “/ 180 min (100%) / **WiSe** + SuSe	Lecture (L) Project (P)	Prof. Dr.-Ing. Timon Rabczuk

Course aim

Course content
1. Motivation and Notations 2. Introduction to tensor algebra and tensor analysis 3. Kinematics of continua 4. Kinetics and governing equations 5. Balance Equations 6. Constitutive models 7. Initial Boundary Value Problems and applications

Course literature
Lawrance E. Malvern: Introduction to the mechanics of a continuous medium, Practice-Hall Inc., 1969

Courses		
Lecturer	**Title of the course**	**Semester periods per week (SPW)**
Prof. Dr.-Ing. Timon Rabczuk	Nonlinear Continuum Mechanics (L/E)	4

Bauhaus-Universität Weimar / Faculty of Civil Engineering
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Advanced numerical mathematics						**Module-No.: 4556105**
Semester No.	**Frequency of the module offering**	**Duration**	**Type of module**	**Credit points (ECTS)**	**Language(s)**	**Student workload**
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 DE CS4MI	1 Project report + Presentation	Lecture (L) Exercise (E) Project (P)	Prof. Dr. rer. nat. habil. Klaus Gürlebeck

Course aim

After the course the students will be able to discretize a given mathematical model and to build the corresponding linear or non-linear system of algebraic equations. They can implement such a system and/or understand a given implementation. They can analyse the obtained system, make a suitable choice of the solver and estimate the numerical costs and the error of the solution. Restrictions for the applicability depending on parameters of the mathematical and numerical can be discussed.

Course content

Efficient solution of linear and non-linear systems of algebraic equations;
- Discretization methods for different types of partial differential equations
- Projection methods, stability and convergence, condition number
- Direct solvers for sparse systems
- Fixed-point theorem, iterative solvers: Total step method, single step method, gradient methods, relaxation methods, multiscale methods and a survey on other approaches
- Eigenvalue problems, iterative solvers
- Domain decomposition methods

The topics will be presented in a lecture, deepened by exercises. In the second part of the semester the students work on individual projects.

Course literature

Will be announced

Courses

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