İZMİR INSTITUTE OF TECHNOLOGY (IZTECH)

DEPARTMENT: CONSERVATION AND RESTORATION OF CULTURAL HERITAGE

PROGRAM: ARCHITECTURAL CONSERVATION

RES 532: Structural Assessment and Intervention Techniques for Historic Buildings

Fall Semester 2026-2027

Academic Level:	Master of Science (M.Sc.) / Doctor of Philosophy (Ph.D.)
Credit Hours:	3 Credits (Postgraduate Core Framework)
Course Instructor:	Prof. Dr. Sayed Hemeda https://www.scopus.com/authid/detail.uri?authorId=35745991300 https://scholar.google.com/citations?user=tN2VFo4AAAAJ&hl=en
Duration / Pacing:	15 Weeks (Comprehensive Postgraduate Pacing Matrix)
Teaching Language	English

1. COURSE OVERVIEW & DESCRIPTION

This advanced postgraduate curriculum provides deep engineering rigor in the structural conservation, forensic diagnosis, and structural rehabilitation of built cultural heritage. Grounded strictly upon the fundamental conservation paradigm preserving architectural and historical significance while optimizing safety and structural resilience students organically execute the complete scientific decision loop. The coursework moves systematically from diagnostic field testing and advanced non-destructive evaluation (NDE) to complex three-dimensional finite element analysis (FEA) of soil-structure interaction, constitutive multi-axial masonry mechanics, compatible materials design, and the architecture of long-term automated structural health monitoring (SHM) systems.

1.1 Foundational Competencies & Prerequisites

- Geotechnical Engineering: Advanced characterization and constitutive behavior of structural soil typologies.
- Structural Analysis I & II: Boundary mechanics, structural kinematics, and analytical structural behaviors.
- Mechanics of Materials I & II: Micro-mechanical properties, fatigue limits, and stress-strain formulations of structural materials.

- Structural Engineering: Load paths, geometry, and engineering assembly configurations typical of built heritage.
- Intervention Retrofitting Techniques I: Degradation classifications, structural failure modes, and forensic diagnostic protocols.
- Intervention Retrofitting Techniques II: Classical and advanced structural stabilization and retrofitting practices.

2. COURSE INTENT & MEASURABLE LEARNING OUTCOMES

2.1 Core Learning Outcomes (CLOs)

- CLO 1: INTERPRET complex legal, technical, and ethical frameworks for heritage conservation, validating historic significance under ICOMOS evaluation principles and the Venice Charter guidelines.
- CLO 2: APPLY low-impact, non-destructive testing (NDT) methodologies to fragile historical materials to achieve safe physical investigation, forensic characterization, and evidence-based diagnosis.
- CLO 3: DIAGNOSE complex structural failures and distress states associated with differential soil settlement, hydrogeological hazards, and long-term multi-axial fatigue.
- CLO 4: SELECT scientifically compatible repair materials and structural intervention systems that guarantee absolute mechanical compliance, chemical durability, and structural reversibility.
- CLO 5: DESIGN targeted conservation engineering interventions that successfully safeguard structural safety margins and structural integrity without compromising heritage values.

3. THE 15-WEEK POSTGRADUATE TECHNICAL SCHEDULE

Week 1: Ethical & Legal Frameworks in Architectural Heritage Conservation (AHC)

• **Core Lecture Coverage:** Introduction to the scientific decision loop; characterizing heritage significance; application of the Venice Charter; ICOMOS evaluation methodologies.

• **Academic References:** *Hemeda, S. (Ed.). (2025). Safeguarding the World Culture Heritage - Advances and New Perspectives. IntechOpen.* doi: 10.5772/intechopen.1001742

Week 2: Geotechnical Assessment: Subsurface Soils & Differential Settlement Mechanics

• **Core Lecture Coverage:** Geotechnical classifications of historic soils; immediate (elastic) and consolidation settlement equations; numerical deformation profiling along soil-structure boundaries.

• **Academic References:** Hemeda, S. 3D finite element coupled analysis model for geotechnical and complex structural problems of historic masonry structures: conservation of Abu Serga church, Cairo, Egypt. Herit Sci 7, 6 (2019). https://doi.org/10.1186/s40494-019-0248-z.

Hemeda, S., & Barış Can Ülker, M. (Eds). (2020). Geotechnical Engineering - Advances in Soil Mechanics and Foundation Engineering. IntechOpen. https://doi.org/10.5772/intechopen.78196

Week 3: Numerical Modeling of Complex Soil-Structure Interaction (SSI)

• **Core Lecture Coverage:** Advanced finite element method (FEM) techniques using PLAXIS 3D software; numerical stress-strain profiling under colossal historical mass vectors. Case Focus: The Leaning Tower of Pisa (Italy).

• **Academic References:** Hemeda, S. PLAXIS 3D numerical analysis of complex geotechnical problems of colossal built heritage. *Herit Sci* **12**, 32 (2024). https://doi.org/10.1186/s40494-024-01156-x

* Burland, J., Jamiolkowski, M. & Viggiani, C. Stabilising the leaning tower of Pisa. *Bull Eng Geol Env* **57**, 91–99 (1998). https://doi.org/10.1007/s100640050025

Week 4: Historic Substructures, Foundations & Slope Stability Engineering

• **Core Lecture Coverage:** Engineering properties of traditional timber piles, rubble trenches, and shallow footings; analytical slope-instability modeling affecting adjacent monumental structures.

• **Academic References:** Hemeda. S (2014). Paliradice (Root pile, Micropile) Technology for Preservation of Historical Islamic Monuments in Cairo Egypt" International Journal of Advanced Engineering and Science, Vol. 3, No.2.

Ergenç, D., Aly, N., Fort, R., Hemeda, S., & Alvarez de Buergo, M. (2026). Sustainable Conservation of UNESCO and Other Heritage Sites Through Geotechnical Engineering. Springer.

Week 5: Historic Structural Systems & Multi-Axial Load Paths

• **Core Lecture Coverage:** Mechanical attributes of historical masonry walls; structural performance of traditional arches, vaults, and domes; primary and secondary structural load-bearing configurations.

• **Academic References:** Hemeda, S. (2013). Seismic Hazard Analysis for Archaeological Structures — A Case Study for EL Sakakini Palace Cairo, Egypt. In Engineering Seismology, Geotechnical and Structural Earthquake Engineering. InTech. https://doi.org/10.5772/54395

Hemeda, S. (2016). NON-LINEAR STATIC ANALYSIS AND SEISMIC PERFORMANCE OF MODERN ARCHITECTURAL HERITAGE IN EGYPT. Mediterranean Archaeology and Archaeometry (MAA). Vol 16. No.3. DOI 10.5281/zenodo.35520

Hemeda. S, Elsayed. Y, Hamid, M.(2026). Structural Evolution and Analysis of Complex Historic Brick Masonry Structures: The Fort of Ṭābiyat ʿurābī in Damietta, Egypt. Journal of the General Union of Arab Archaeologists 11 (3), 186-208

Hemeda, S. (2026). STRUCTURAL CHALLENGES IN ADVANCED ANALYTICAL TECHNIQUES FOR CHARACTERISING MODERN BUILT HERITAGE IN EGYPT. NED University Journal of Research 22 (1/2), 83-120

Week 6: Non-Destructive Testing (NDT) & Micro-Geophysical Subsurface Imaging

• **Core Lecture Coverage:** Principles of low-impact structural investigations; Ground Penetrating Radar (GPR) calibration; micro-seismic wave arrays; non-destructive stone and mortar characterization.

• **Academic References:** Hemeda, S. (Ed.). (2019). Sustainable Construction and Building Materials. IntechOpen. https://doi.org/10.5772/intechopen.78713

Hemeda, S. (2013). Geotechnical Characterization of Sakakini's Palace Stones and Other Construction Materials, Cairo-Egypt. Geomaterials, 2013, 3, 38-46 http://dx.doi.org/10.4236/gm.2013.31005

Hemeda, S. (2012). Ground Penetrating Radar (GPR) Investigations for Architectural Heritage Preservation: The Case of Habib Sakakini Palace, Cairo, Egypt. *Open Journal of Geology*, **2**, 189-197. doi: 10.4236/ojg.2012.23019.

Hemeda, S. (2013). Electrical Resistance Tomography (ERT) Subsurface Imaging for Non-destructive Testing and Survey in Historical Buildings Preservation. Australian Journal of Basic and Applied Sciences, 7(1): 344-357, 2013 ISSN 1991-8178

Hemeda, S. (2013). Geotechnical Characterization of Sakakini's Palace Stones and Other Construction Materials, Cairo-Egypt. Geomaterials, 3(1), 43-52.

Week 7: Geo-Environmental Degradation Mechanics & Forensic Classification

• **Core Lecture Coverage:** Fluctuations in regional groundwater tables; capillary action, moisture transport, and kinetics of salt weathering; destructive geo-environmental hazards acting on foundation basements.

• **Academic References:**

Hemeda, S (2012). GROUTING OF MULTIPLE LEAF-MASONRY WALLS: APPLICATION ON SOME ISLAMIC HISTORICAL MONUMENTS IN CAIRO, EGYPT . INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE Volume 3, Issue 4, October-December 2012: 275-288.

Hemeda, S., & Hamed, M. (2026). Comprehensive structural soundness and geo-environmental assessment for the restoration of Al-Baron Palace, Cairo. Journal of the General Union of Arab Archaeologists, 11(3).

Week 8: MIDTERM EXAMINATION I & FORENSIC DIAGNOSTIC MILESTONE

• **Core Lecture Coverage:** Formal administration of Midterm Examination I. Mandatory Submission: Technical Field Forensic Structural and Geotechnical Diagnostic Case Report.

• **Academic References:** *Course Core Technical Benchmarks & Evaluation Deliverables.*

Week 9: Seismic Vulnerability, Ambient Noise Profiling & Kinematic Collapse States

• **Core Lecture Coverage:** Dynamic performance criteria of unreinforced masonry; evaluating fundamental frequencies using ambient vibrations and ReMi profiles; kinematic limit analysis of overturning rocking mechanisms. Case Focus: El-Sakakini Palace and Abu Serga Church.

• **Academic References:** *Hemeda, S. (2022). Dynamic characteristics of built heritage using ambient noise recordings and ReMi profiles. npj Heritage Science, 10, Article 73.*
** Hemeda, S. (2011). Seismic analysis and inelastic performance of El-Sakakini Palace in Cairo. Mediterranean Archaeology and Archaeometry, 11(1).*

Week 10: Quantitative Metrics for Reversible & Compatible Interventions

• **Core Lecture Coverage:** Defining exact chemical, mineralogical, and mechanical compatibility thresholds; mathematical formulations of structural reversibility constraints; operational limits of minimal intervention.

• **Academic References:** *Feilden, B. M. (2003). Conservation of Historic Buildings. Routledge.*

Week 11: Foundation Consolidation & Subsurface Grouting Engineering

• **Core Lecture Coverage:** Structural configuration and execution of micropiling patterns; high-pressure jet grouting mechanics; finite element stability evaluation of ancient subterranean spaces via structural soil modeling.

• **Academic References:**

Hemeda, S (2012). GROUTING OF MULTIPLE LEAF-MASONRY WALLS: APPLICATION ON SOME ISLAMIC HISTORICAL MONUMENTS IN CAIRO, EGYPT . INTERNATIONAL JOURNAL OF CONSERVATION SCIENCE Volume 3, Issue 4, October-December 2012: 275-288.
Hemeda . S (2014) Paliradice (Root Piles, Micropiles) technology for preservation of historic Islamic monuments in Cairo Egypt" December 2014.

Week 12: Masonry Strengthening, Multi-Grout Injection & Advanced Composites

• **Core Lecture Coverage:** Gravity and low-pressure fluid grout injections; mechanical calibration of Carbon Fiber Reinforced Polymers (CFRP) and Textile Reinforced Mortars (TRM) vs. timber elements; post-tensioning engineering. Case Focus: Hibis Temple (Kharga Oasis) & Stavronikita (Greece).

• **Academic References:** Sayed Hemeda "Grouting of multiple leaf-masonry walls: application on some islamic historical monuments, Cairo, Egypt" Volume 3, Issue 4, December 2012.
Hemeda, S. (2019). Carbon Fiber Reinforced Polymers (CFRP) for Strengthening and Seismic Retrofitting of Historic Circular Masonry Stone Columns. In: Rodrigues, H., Elnashai, A. (eds) Advances and Challenges in Structural Engineering. GeoMEast 2018. Sustainable Civil Infrastructures. Springer, Cham. https://doi.org/10.1007/978-3-030-01932-7_11

Week 13: Structural Health Monitoring (SHM) System Architecture

• **Core Lecture Coverage:** Design metrics for continuous sensory telemetry; installation of digital tiltmeters, vibrating-wire crack displacement gauges, and triaxial accelerometers; engineering threshold triggers.

• **Academic References:** *Balageas, G., Fritzen, C. P., & Güemes, A. (Eds.). (2010). Structural Health Monitoring. Wiley.*

Week 14: Long-Term Creep Performance, Predictive Risk Assessment & Climate Adaptation

• **Core Lecture Coverage:** Analysis of multi-axial stone creep and relaxation metrics under sustained dead loads; structural fatigue modeling; proactive preventive maintenance planning against flash flooding and thermal variations.

• **Academic References:** *Hemeda, S. (2023). Uniaxial and Triaxial Creep Performance for Stability Analysis of Roman Rock-Cut Tombs in Alexandria, Egypt. In Failure Analysis, IntechOpen.*

Week 15: Capstone Project Defense & Comprehensive Peer Evaluation

• **Core Lecture Coverage:** Oral defense and formal technical jury submission of the comprehensive Monitored Conservation and Engineering Intervention Design Capstone Project.

• **Academic References:** *Course Technical Jury Panel & Design Matrix Approvals.*

4. ASSESSMENT PLAN & GRADING WEIGHTS

Assessment Component	Weight	Postgraduate Evaluation Scope
Class participation	10%	Attendance and contribution. Analytical engineering problem sets focusing on differential settlement formulas, NDT data stream interpretations, and intervention retrofitting techniques.
Midterm Forensic &Field Diagnostic Report (Week 8)	20%	Written Exam & An exhaustive forensic engineering structural and geotechnical analysis of an un-restored monument based on raw physical constraints.
Peer-Review Research Seminar Presentation	20%	Oral delivery, analytical critique, and scientific defense of major published research papers and contemporary engineering code frameworks.
Capstone Monitored Intervention Design Project	50%	A full engineering conservation workflow proposal incorporating validated 3D software simulations (PLAXIS 3D), strict material compliance charts, and sensory health tracking metrics.

5. EDITABLE POLICY PLACEHOLDERS

5.1 Core Attendance Protocol

Course Requirement: Regular seminar attendance is expected due to the active-learning finite element training modules, sensor mapping sequences, and case data peer investigations.

5.2 Academic Integrity & Research Honesty

Course Requirement: Every analytical evaluation model, PLAXIS 3D mesh matrix, and diagnostic field report must represent absolute original student output. Plagiarism of peer-reviewed articles or synthesis of fraudulent data will be handled via strict disciplinary procedures.

5.3 Comprehensive Accessibility & Support

Course Requirement: Academic accommodations will be fully customized in immediate alignment with the relevant university accessibility offices to ensure barrier-free software, laboratory, and evaluation environments.

6. MASTER BIBLIOGRAPHY

Hemeda, S. (2013). Seismic Hazard Analysis for Archaeological Structures — A Case Study for EL Sakakini Palace Cairo, Egypt. In Engineering Seismology, Geotechnical and Structural Earthquake Engineering. InTech. https://doi.org/10.5772/54395

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Hemeda, S. (2021). An Integrated Geophysical and Geotechnical Assessment of Hazards Around the Abu Serga Church. DOI: https://doi.org/10.2174/9789814998727121010l

Hemeda. S, Elsayed. Y, Hamid, M.(2026). Structural Evolution and Analysis of Complex Historic Brick Masonry Structures: The Fort of Ṭābiyat ʿurābī in Damietta, Egypt. Journal of the General Union of Arab Archaeologists 11 (3), 186-208

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Hemeda, S. Dynamic characteristics of built heritage using ambient noise recordings. Herit Sci 10, 100 (2022). https://doi.org/10.1186/s40494-022-00730-5

Hemeda, S., & Hamed, M. (2026). Engineering Failure Analysis in Safety Evaluation for Preservation of Modern Built Heritage. With application on Al Baron Palace in Cairo.. Journal of the General Union of Arab Archaeologists, 11(3).

Lourenço, P. B. (2019). Structural Analysis of Historical Constructions: Possibilities and Challenges. International Journal of Architectural Heritage, 13(1), 1-15.

Balageas, G., Fritzen, C. P., & Güemes, A. (Eds.). (2010). Structural Health Monitoring. Wiley.

Ergenç, D., Aly, N., Fort, R., Hemeda, S., & Alvarez de Buergo, M. (2026). Sustainable Conservation of UNESCO and Other Heritage Sites Through Geotechnical Engineering. Springer.

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Hemeda, S. (2026). FEA structural stability assessment of the ancient Serapeum tunnels beneath Pompey's Pillar using SSI modelling. npj Heritage Science, 14, Article 25.

Horie, C. V. (2010). *Materials for conservation: Organic consolidants, adhesives and coatings* (2nd ed.). Butterworth-Heinemann.

Djabarouti, J. (Ed.). (2025). *Critical built heritage practice and conservation: Evolving perspectives*. Routledge.

Orbasli, A. (2007). *Architectural conservation: Principles and practice*. Wiley-Blackwell. https://www.wiley.com/en-us/shop/general-introductory-civil-engineering-construction/architectural-conservation-principles-and-practice-p-9780632040254

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Hemeda, S. (2019). Carbon Fiber Reinforced Polymers (CFRP) for Strengthening and Seismic Retrofitting of Historic Circular Masonry Stone Columns. In: Rodrigues, H., Elnashai, A. (eds) Advances and Challenges in Structural Engineering. GeoMEast 2018. Sustainable Civil Infrastructures. Springer, Cham. https://doi.org/10.1007/978-3-030-01932-7_11