



National University of Engineering (UNI)

School of Civil Engineering

Syllabus 2027-I

1. COURSE

CE2C1. Materials Technology (Mandatory)

2. GENERAL INFORMATION

2.1 Course	: CE2C1. Materials Technology
2.2 Semester	: 3 rd Semester.
2.3 Credits	: 4
2.4 Hours	: 3 HT; 2 HP;
2.5 Duration of the period	: 16 weeks
2.6 Type of course	: Mandatory
2.7 Learning modality	: Face to face
2.8 Prerequisites	: BCH101. Chemistry I. (1 st Sem)

3. PROFESSORS

Meetings after coordination with the professor

4. INTRODUCTION TO THE COURSE

Materials Technology covers the science and technology of the main materials used in construction: traditional and vernacular materials (rocks, adobe, quinchá, rammed earth, bamboo), concrete and advanced cementitious materials, structural metals, polymeric and sustainable composite materials, and standardized quality control and failure analysis testing. The course concludes with design in masonry, timber, and light-gauge steel.

5. GOALS

- Characterize the physical and mechanical properties of traditional and modern construction materials.
- Apply concrete and structural metals technology to the design and quality control of construction elements.
- Perform standardized quality control tests and interpret failure analysis results.
- Design elements in masonry, timber, and light-gauge steel.

6. COMPETENCES

ABET-1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. (Usage)

ABET-2) An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors. (Usage)

ABET-6) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions. (Usage)

7. TOPICS

Unit 1: Construction Materials Science (10 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Physical and mechanical properties of construction materials including density, porosity, strength, and elasticity • Microstructure and phase composition of construction materials • Durability mechanisms including weathering, chemical attack, and environmental degradation • Thermal and moisture properties of construction materials • Crystalline and amorphous structures in construction materials • Material selection criteria based on performance requirements • Degradation mechanisms and service life prediction	• Describe the fundamental physical and mechanical properties of major construction materials [Familiarity] • Analyze the relationship between microstructure and macroscopic properties of materials [Assessment] • Evaluate the durability performance of materials under specific environmental conditions [Usage] • Explain the effects of thermal and moisture variations on material behavior [Familiarity] • Select appropriate construction materials based on design specifications and performance criteria [Assessment] • Predict service life and degradation patterns of materials in various environments [Usage]
Readings : [Neville2011]	

Unit 2: Traditional and Vernacular Construction Materials (18 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Construction stone: classification and properties • Adobe as a construction material: fabrication and properties • Quincha as a construction system: materials and technique • Tapial (rammed earth) as a construction material: fabrication and properties • Bamboo as a construction material: properties and structural applications • Quality control testing for vernacular construction materials	• Classify construction stone by its properties and applications [Familiarity] • Characterize the physical and mechanical properties of adobe, quincha, and tapial [Usage] • Evaluate the suitability of bamboo as a structural material in construction [Assessment] • Perform quality control tests on vernacular construction materials [Usage] • Recommend the use of an appropriate vernacular material based on a project's conditions [Assessment]
Readings : [Blondet2003]	

Unit 3: Concrete Technology and Advanced Cementitious Materials (24 hours)	
Competences Expected: ABET-1,ABET-2,ABET-6	
Topics	Learning Outcomes
• Portland cement chemistry and hydration process • Aggregates properties and grading requirements • Mix design methodology for normal strength concrete • Fresh concrete properties including workability, slump, and setting time • Hardened concrete properties including strength, modulus, and shrinkage • Chemical and mineral admixtures for concrete • High-performance and high-strength concrete design • Self-consolidating concrete and fiber-reinforced concrete • Durability aspects including alkali-silica reaction, sulfate attack, and freeze-thaw • Sustainable and low-carbon concrete technologies including supplementary cementitious materials such as fly ash, slag, and silica fume	• Describe the chemistry of portland cement and the hydration process [Familiarity] • Evaluate aggregate quality and suitability for concrete production [Assessment] • Design concrete mixes for specified strength and workability requirements [Usage] • Test and interpret fresh concrete properties using standard procedures [Assessment] • Predict hardened concrete properties based on mix proportions and curing conditions [Usage] • Explain the function and effects of various concrete admixtures [Familiarity] • Formulate high-performance concrete mixes for demanding applications [Usage] • Select appropriate special concretes for specific construction scenarios [Assessment] • Incorporate supplementary cementitious materials to optimize concrete performance [Usage] • Analyze durability risks and specify protective measures for concrete structures [Assessment] • Compare environmental impacts and carbon footprints of different concrete formulations [Familiarity]
Readings : [Kosmatka2016], [Neville2011]	

Unit 4: Concrete Transport and Placement (20 hours)	
Competences Expected: ABET-1,ABET-2,ABET-6	
Topics	Learning Outcomes
• Transit mixer transport: maximum delivery time, slump verification, and admissible conditions • Concrete pumping: pumpable mix design, operating pressure, reach, and blockage prevention • Placement methods: direct discharge, chutes, buckets, and crane placement • Concrete consolidation: internal and external vibration, frequency, amplitude, and insertion depth • Underwater concrete placement by tremie method and in restricted-access conditions • Belt conveyor and pneumatic transport systems for large-volume concrete • Concrete surface finishing: leveling, troweling, texturing, and immediate curing	• Plan concrete transport considering delivery distance, setting time, and environmental conditions [Usage] • Execute standardized concrete placement procedures for different types of structural elements [Usage] • Apply correct vibration techniques to achieve uniform concrete consolidation [Usage] • Evaluate concrete placement quality and identify deficiencies such as segregation, honeycombs, and cold joints [Assessment] • Design pumpable concrete mixes for specific pumping height and distance conditions [Usage] • Specify placement methods for restricted-access structures or underwater placement conditions [Assessment] • Develop placement plans minimizing cold joints and ensuring concrete continuity in large structural elements [Usage]
Readings : [Neville2011]	

Unit 5: Statistical Quality Control of Concrete (20 hours)	
Competences Expected: ABET-1,ABET-2,ABET-6	
Topics	Learning Outcomes
• Sampling procedures and fresh concrete specimen preparation according to ASTM standards • Compressive strength testing: procedure, minimum frequency, and testing conditions • Basic statistics applied to concrete: mean, standard deviation, and coefficient of variation • Concrete acceptance criteria according to ACI 318 and equivalent standards • Statistical control charts ($\bar{X}$, R) for continuous monitoring of concrete production • Non-conforming results analysis: investigation procedures, additional tests, and structural decisions • Process capability indices (C_p, C_{pk}) and target mean strength adjustment	• Apply standardized sampling and specimen fabrication procedures for concrete on site [Usage] • Interpret compressive strength test results and determine their validity [Assessment] • Calculate basic statistical parameters from series of concrete strength test results [Usage] • Evaluate concrete acceptance or rejection applying ACI 318 normative criteria [Assessment] • Construct statistical control charts for continuous monitoring of concrete production [Usage] • Diagnose causes of excessive variability and propose corrective actions in concrete production [Assessment] • Determine the target mean strength (f'_{cr}) considering the statistical variability of the production process [Usage]
Readings : [Neville2011], [Rivva2000]	

Unit 6: Structural Metals, Alloys, and Corrosion Engineering (5 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Steel composition, classification, and grade designations • Mechanical properties of structural steel including yield strength and ductility • Heat treatment processes and their effects on steel properties • Weldability and connection behavior of structural metals • Corrosion mechanisms in metallic structures • High-strength and weathering steel applications • Aluminum alloys and their structural applications • Fatigue behavior and fracture toughness of metals • Corrosion protection methods including coatings and cathodic protection • Material selection for corrosive and high-temperature environments	• Identify different steel grades and their appropriate structural applications [Familiarity] • Interpret stress-strain curves and determine mechanical properties of metals [Assessment] • Explain how heat treatment affects the microstructure and properties of steel [Familiarity] • Evaluate weldability of metals and specify appropriate welding procedures [Usage] • Describe the electrochemical basis of metallic corrosion [Familiarity] • Select high-strength or weathering steel for specific structural requirements [Usage] • Compare aluminum alloys with steel for lightweight structural applications [Assessment] • Analyze fatigue loading scenarios and predict service life of metal components [Assessment] • Design corrosion protection systems for metallic structures in aggressive environments [Usage] • Specify appropriate materials for structures exposed to extreme conditions [Assessment]
Readings : [Callister2020]	

Unit 7: Polymeric, Composite, and Sustainable Construction Materials (4 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Polymer chemistry and classification of construction polymers • Mechanical and thermal behavior of polymeric materials • Fiber-reinforced polymer composites and their structural applications • Adhesives, sealants, and waterproofing materials • Composite material mechanics and laminate theory • FRP strengthening and rehabilitation of concrete and masonry structures • Bio-based and recycled materials for sustainable construction • Geopolymers and alternative binder systems • Environmental degradation and long-term performance of polymers and composites	• Classify polymers used in construction and describe their basic properties [Familiarity] • Characterize the mechanical and thermal behavior of polymeric materials [Assessment] • Apply fiber-reinforced polymers in structural design and retrofitting applications [Usage] • Select appropriate adhesives and sealants for specific construction applications [Familiarity] • Analyze composite laminates using classical lamination theory [Usage] • Design FRP strengthening systems for existing concrete or masonry structures [Assessment] • Evaluate the sustainability and life-cycle performance of bio-based construction materials [Assessment] • Compare geopolymer binders with traditional portland cement systems [Familiarity] • Predict long-term degradation of polymers and composites under environmental exposure [Usage]
Readings : [Callister2020]	

Unit 8: Standardized Testing, Quality Control, and Failure Analysis (5 hours)	
Competences Expected: ABET-6	
Topics	Learning Outcomes
• Standard test methods for material characterization and acceptance testing • Sampling procedures and representative sample selection • Quality control and quality assurance protocols in construction • Statistical analysis of test data and acceptance criteria • Non-destructive testing methods for materials and structures • Advanced material characterization techniques including microscopy and spectroscopy • Failure analysis methodology and root cause investigation • Forensic engineering and distress evaluation • Performance-based testing and specification approaches • Certification, compliance, and third-party testing requirements	• Perform standard material tests according to ASTM or equivalent specifications [Usage] • Develop appropriate sampling plans for construction material acceptance [Assessment] • Implement quality control procedures for construction materials and processes [Usage] • Analyze test data using statistical methods and establish acceptance criteria [Assessment] • Apply non-destructive testing techniques for in-situ material evaluation [Familiarity] • Utilize advanced characterization techniques to investigate material microstructure [Usage] • Conduct systematic failure analysis to determine root causes of material distress [Assessment] • Investigate structural failures using forensic engineering methodologies [Assessment] • Design performance-based test protocols for innovative materials [Usage] • Interpret certification requirements and coordinate third-party testing programs [Familiarity]
Readings : [Neville2011]	

Unit 9: Masonry Structural Design (4 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Masonry materials, units, and mortar properties • Unreinforced masonry wall design for compression and flexure • Reinforced masonry design and detailing • Seismic design of masonry and timber structures	• Identify masonry unit types and specify appropriate mortar for applications [Familiarity] • Design unreinforced masonry walls for gravity and lateral loads [Assessment] • Proportion reinforced masonry elements and specify reinforcement details [Usage] • Implement seismic design provisions for masonry and timber buildings [Usage]
Readings : [Drysdale2008]	

Unit 10: Timber and Light-Gauge Steel Framing Design (6 hours)	
Competences Expected: ABET-2	
Topics	Learning Outcomes
• Timber properties, grading, and design values • Sawn lumber and glued-laminated timber design • Timber connections including nails, bolts, and metal connectors • Cold-formed steel members and sectional properties • Light-gauge steel framing systems and design • Engineered wood products including I-joists and structural composite lumber	• Select timber species and grades based on structural requirements [Familiarity] • Design timber beams, columns, and combined load-ing members [Assessment] • Specify timber connections and calculate their ca-pacity [Usage] • Calculate effective section properties for cold-formed steel members [Assessment] • Design light-gauge steel wall studs and floor joists [Usage] • Apply engineered wood products in floor and roof systems [Assessment]
Readings : [Drysdale2008]	

Unit 11: Site Visits (6 hours)	
Competences Expected: ABET-1	
Topics	Learning Outcomes
• Technical visit to a construction materials produc-tion plant or an active construction site. • Observation of manufacturing processes, quality con-trol, and the field use of traditional materials, con-crete, metals, and composites. • Preparation of a technical visit report.	• Relate the properties and processes of construction materials studied in the course to their real applica-tion on site [Usage].
Readings :	

8. WORKPLAN

8.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

8.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

8.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

9. EVALUATION SYSTEM

***** EVALUATION MISSING *****

10. BASIC BIBLIOGRAPHY