CE 244
MATERIALS OF CONSTRUCTION
Course Objectives

- To develop a basic understanding of key material properties, requirements, and related behavior characteristics of typical construction materials.
Course Content

- Types
- Production methods
- Uses in construction
- Properties and related tests of the following materials of construction:
  - Building Stones
  - Metals
  - Clay Products
  - Gypsum
  - Lime
  - Cements
  - Mineral Aggregates
  - Concrete
  - Timber
Course Content

- These materials are used in all civil engineering structures such as; buildings, bridges, highways, railways, tunnels, dams, harbor structures, towers & etc.
CLASSIFICATION OF CIVIL ENGINEERING MATERIALS

1. According to their phases

2. According to their internal structure & chemical composition
Phase Classification

1. **Gases**: Air, oxygen, CO$_2$

2. **Liquids**: Water, chemical admixtures

3. **Semi-solids**: Fresh pastes, mortars, asphalt

4. **Solids**: Metals, hardened concrete
Internal Structure & Chemical Composition Classification

1. **Metals**: (formed by metallic bonds)
   A. Ferrous (iron, cast iron, steel)
   B. Non-ferrous (aluminum, copper, zinc, lead)

2. **Polymers**: (long chains having molecules of C, H, O, N which are formed by covalent bonding. The chains are bound to each other either by covalent bonds or Van der Waal’s forces.)
   A. Natural (rubber, asphalt, resins, wood)
   B. Artificial (plastics)
Internal Structure & Chemical Composition Classification

3. **Ceramics**: (mainly aluminosilicates formed by mixed bonding, covalent and ionic)
   A. Structural clay products (bricks, tiles, pipes)
   B. Porcelains

4. **Composite Materials**:
   A. Natural (agglomerates)
   B. Artificial (Portland cement, concrete)
5. **Reinforced Composite Materials**
   (reinforced concrete, reinforced plastics)

- One of the most important tasks of an engineer is to select the most suitable material for a given civil engineering structure.
Factors Determining the Choice of Proper Material for a Structure

- **Strength, rigidity & Durability Requirements**
  - Permanent loading → Creep Strength
  - Repeated loading → Fatigue Strength
  - Impact loading → Toughness & Resilience
  - Surface loading → Hardness & Resistance to abrasion

- **Environmental Requirements**
  - Temperature change → coefficient of thermal conductivity
  - Moisture movement → permeability
  - Chemical effects → chemical composition
Factors Determining the Choice of Proper Material for a Structure

- Economy. Choose the cheaper & available materials considering
  - Initial cost
  - Useful life
  - Frequency of maintenance
  - Cost of maintenance
  - Salvage value
  - Comfortability
Example: Comparison of concrete pavement vs. asphalt pavement for economy.

<table>
<thead>
<tr>
<th></th>
<th>Concrete</th>
<th>Asphalt</th>
</tr>
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<tbody>
<tr>
<td>Initial Cost</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Useful Life</td>
<td>+</td>
<td>−</td>
</tr>
<tr>
<td>Frequency of Repair</td>
<td>+</td>
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</tbody>
</table>
General Properties of Civil Engineering Materials

- Physical
- Mechanical
- Chemical
- Other
  - Thermal, Acoustical, Optical, Electrical

** Most CE Applications Focus on Physical & Mechanical Properties
Physical Properties

- Properties of physical structure
  - density
  - specific gravity
  - porosity
  - permeability
  - surface energy
  - texture (micro, macro)
  - other (color, thermal expansion, shape)
Mechanical Properties

- Resistance to applied loads (stress) initially & over time
  - stiffness
  - strength
  - fracture / yielding (brittle / ductile)
  - tension
  - compression
  - flexure (bending)
  - torsion
  - direct shear
  - multiaxial
Chemical Properties

- Chemical composition, potential reaction with environment
  - oxide content
  - carbonate content
  - acidity, alkalinity
  - resistance to corrosion
Properties of materials are determined by:
- Laboratory testing
- Field testing.

To avoid inconsistencies in test results, standards are devised which describe the test apparatus and the procedure.
Items that are usually standardized in a test are:

- Obtaining test specimens and number of specimens
- Size and shape of the specimen
- Preparation of specimens for testing
- Temperature & moisture during preparation & testing
- Type of machinery
- Rate of loading
- Interpretation of test results
- Writing a report
Standardization Institutes

- Turkey - Turkish Standards Institute (TSE)
- England - British Standards Institute (BSI)
- Germany - Deutsche Institute Norm (DIN)
- U.S. - American Society for Testing and Materials (ASTM)
- Europe - European Committee for Standardization (CEN)
Although there are several different materials which have adhesive properties, three types are of particular interest to civil engineers.

- **Glues**: materials of gelatinous nature derived from vegetable or animal sources.
- **Bituminous Materials**: complex hydrocarbon
- **Various Compounds of Calcium**: gypsum, lime, cements
Cementitious materials are substances which, upon certain chemical reactions attain binding properties

- Non-hydraulic cements (gypsum and lime)
- Hydraulic cements (portland cement)

**Hydraulicity** is that property of gaining binding value when mixed with water and remaining stable when exposed to water.
SPECIAL PROPERTIES OF CEMENTITIOUS MATERIALS

- **Fineness**: Particle size.
- **Normal Consistency**: A standard amount of water which gives a certain fluidity to the paste.
- **Time of Setting**: Beginning of complete loss of plasticity.
- **Sand Carrying Capacity**: Amount of sand that can be added without harming plasticity.
- **Hardening**: Formation of solid phase; complete loss of plasticity.
- **Yield**: Volume of final product obtained in comparison with volumes of constituent materials.