

23 February 2016  
*Lecture 2 – Introduction to Materials of Construction*

**CE 344**  
**Materials of Construction**

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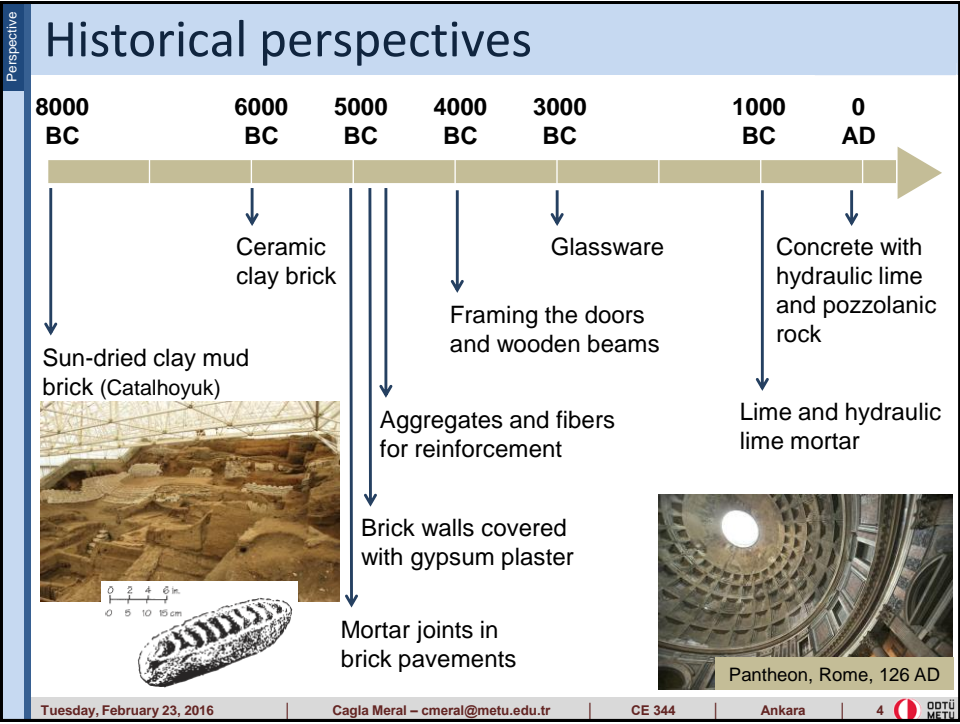
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METU - Ankara*

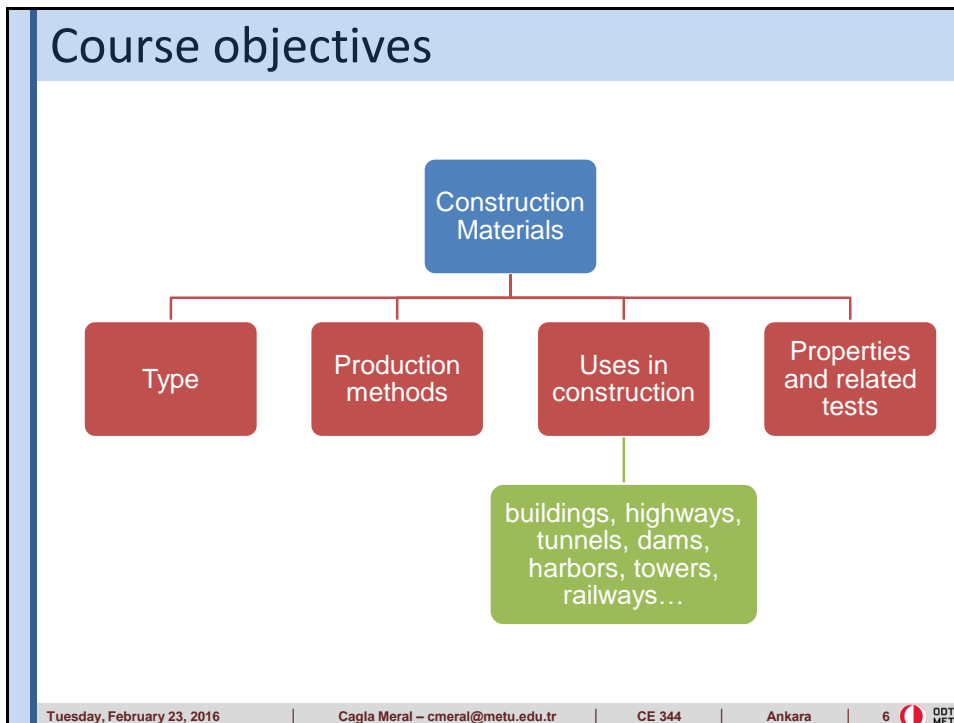
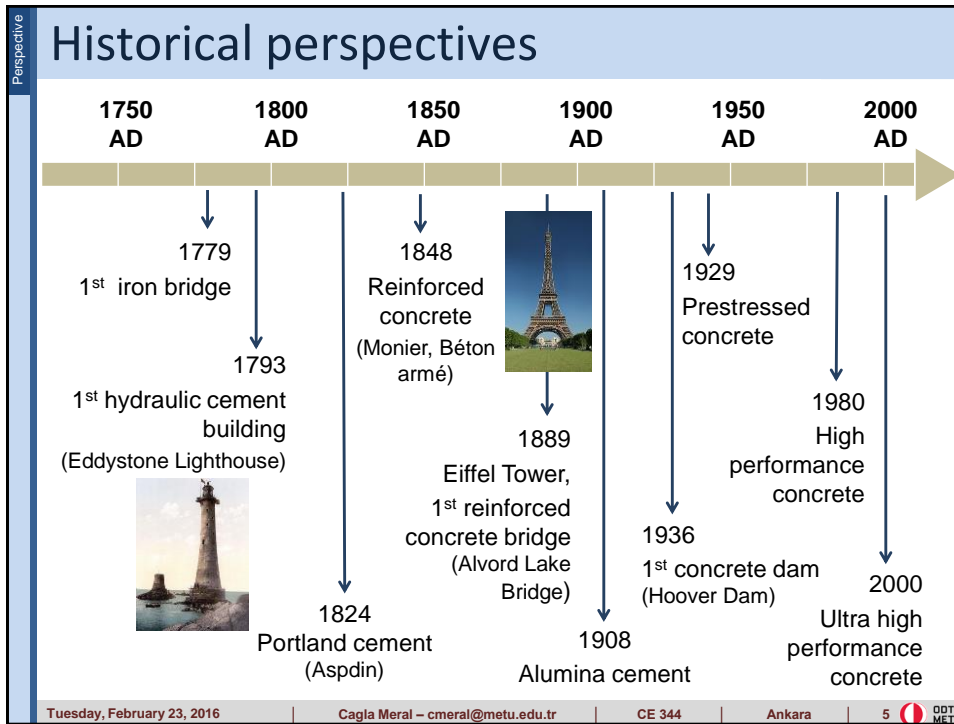
## CE 344 – Materials of Construction


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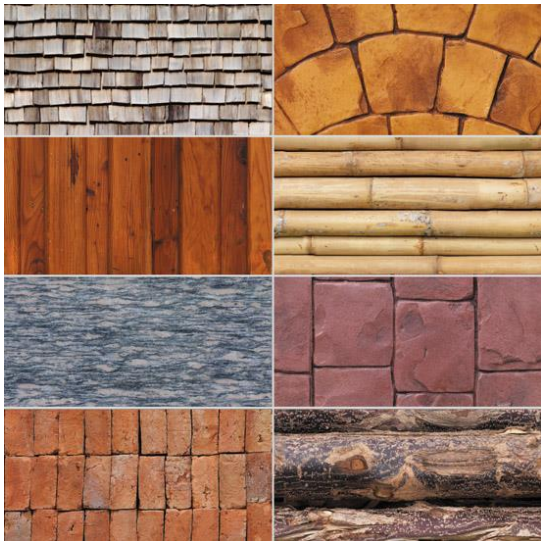
| CE 344 – Tentative Outline  |                   |        |  |
|---|-------------------|--------|--|
| Week  | Dates             |        | Topic  |
| 1   | 22-Feb            | 26-Feb | 1. Introduction to materials of construction         |
|   |                   |        | 2. Gypsum  |
| 2   | 29-Feb            | 4-Mar  | 3. Lime  |
| 3   | 7-Mar             | 11-Mar | 4. Portland cement                                   |
| 4   | 14-Mar            | 18-Mar | (1 <sup>st</sup> Lab around these dates)             |
| 5   | 21-Mar            | 25-Mar |  |
| 6   | 28-Mar            | 1-Apr  | 5. Pozzolans   |
|   | Specific date TBA |        | 1 <sup>st</sup> MIDTERM EXAMINATION                  |
| 7   | 4-Apr             | 8-Apr  | 6. Aggregates  |
| 8   | 11-Apr            | 15-Apr | (2 <sup>nd</sup> Lab around these dates)             |
| 9   | 18-Apr            | 22-Apr | 7. Concrete  |
| 10  | 25-Apr            | 29-Apr | (3 <sup>rd</sup> Lab around these dates)             |
| 11  | 2-May             | 6-May  |  |
| 12  | 9-May             | 13-May |  |
|   | Specific date TBA |        | 2 <sup>nd</sup> MIDTERM EXAMINATION                  |
| 13  | 16-May            | 20-May | 8. Ferrous metals, alloys and concrete reinforcement |
| 14  | 23-May            | 27-May | 9. Polymers  |
|   |                   |        | 20. Clay bricks                                      |
| (*) The detailed course schedule is available at the course web page.                           |                   |        |  |
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# Introduction to construction materials



## Classifying construction materials

|                           |                    |  |
|---------------------------|--------------------|--|
| According to their phases | <b>Gases</b>       | <ul style="list-style-type: none"><li>Air, O<sub>2</sub>, CO<sub>2</sub></li></ul>         |
|                           | <b>Liquids</b>     | <ul style="list-style-type: none"><li>Water</li><li>Chemical admixtures</li></ul>          |
|                           | <b>Semi-solids</b> | <ul style="list-style-type: none"><li>Fresh pastes &amp; mortars</li><li>Asphalt</li></ul> |
|                           | <b>Solids</b>      | <ul style="list-style-type: none"><li>Metals</li><li>Hardened concrete</li></ul>           |

# Classifying construction materials

According to their internal structure & chemical composition

|                                |   |
|--------------------------------|---|
| Metals                         | <ul style="list-style-type: none"><li>• formed by metallic bonds<ul style="list-style-type: none"><li>• Ferrous (iron, cast iron, steel)</li><li>• Non-ferrous (aluminum, copper, zinc, lead)</li></ul></li></ul>   |
| Polymers                       | <ul style="list-style-type: none"><li>• long chains of C, H, O, N based molecules which are formed by covalent bonding</li><li>• chains are bound to each other either by covalent bonds or Van der Waal's forces.<ul style="list-style-type: none"><li>• Natural (rubber, asphalt, resins, wood)</li><li>• Artificial (plastics)</li></ul></li></ul> |
| Ceramics                       | <ul style="list-style-type: none"><li>• (mainly aluminosilicates formed by mixed bonding, covalent and ionic)<ul style="list-style-type: none"><li>• Structural clay products (bricks, tiles, pipes)</li><li>• Porcelains</li></ul></li></ul>   |
| Composite Materials            | <ul style="list-style-type: none"><li>• Natural (agglomerates)</li><li>• Artificial (Portland cement concrete)</li></ul>  |
| Reinforced Composite Materials | <ul style="list-style-type: none"><li>• reinforced concrete</li><li>• reinforced plastics</li></ul>   |

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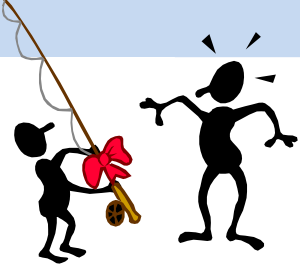
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# Fishing analogy

Finding the most suitable material for a given project!





Poor use!



True understanding

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## How to choose a material?

- 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

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## How to choose a material?

- Economy: Choose the cheaper & available materials considering:
  - Initial cost
  - Useful life
  - Frequency of maintenance
  - Cost of maintenance
  - Salvage value
  - Comfortability



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## Example: Pavements Economy!



- Concrete pavements vs. asphalt pavements for economy :

|                            | Concrete       | Asphalt |
|----------------------------|----------------|---------|
| <b>Initial Cost</b>        | More expensive | Cheaper |
| <b>Useful Life</b>         | Longer         | Shorter |
| <b>Frequency of Repair</b> | Lower          | Higher  |
| <b>Cost of Repair</b>      | Higher         | Lower   |
| <b>Salvage Value</b>       | +              | +       |
| <b>Comfort</b>             | Lower          | Higher  |

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## Properties of Construction Materials

Properties of Construction Materials

### Physical

- properties of physical structure

### Mechanical

- resistance to applied loads initially & over time

### Chemical

- chemical composition, potential reaction with the environment

### Other

- Thermal, acoustical, optical, electrical, ...

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## Properties of Construction Materials

- **Physical** : properties of physical structure
  - Density, specific gravity
  - porosity, permeability
  - surface energy, texture (micro, macro)
  - other (color, thermal expansion, shape, ... )
- **Mechanical** : resistance to applied loads initially & over time
- **Chemical** : chemical composition, potential reaction with the environment
- **Other** : Thermal, acoustical, optical, electrical, ...

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## Properties of Construction Materials

- **Physical** : properties of physical structure
- **Mechanical** : resistance to applied loads initially & over time
  - Stiffness, strength
  - fracture/ yielding (brittle / ductile),
  - tension, compression, flexure (bending),
  - torsion, direct shear, multiaxial
- **Chemical** : chemical composition, potential reaction with the environment
- **Other** : Thermal, acoustical, optical, electrical, ...

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## Properties of Construction Materials

- **Physical** : properties of physical structure
- **Mechanical** : resistance to applied loads initially & over time
- **Chemical** : chemical composition, potential reaction with the environment
  - Oxide content
  - carbonate content
  - acidity, alkalinity
  - resistance to corrosion
- **Other** : Thermal, acoustical, optical, electrical, ...

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## To determine properties of a material...

- Laboratory testing
- Field testing



- To avoid inconsistencies in test results use **STANDARDS** that describe the test apparatus and the procedure.
 

|   |  |
|---|--|
| <ul style="list-style-type: none"> <li>○ Obtaining test specimens and number of specimens</li> <li>○ Size and shape of the specimen</li> <li>○ Preparation of specimens for testing</li> <li>○ Temperature &amp; moisture during preparation &amp; testing</li> </ul> | <ul style="list-style-type: none"> <li>○ Type of machinery</li> <li>○ Rate of loading</li> <li>○ Interpretation of test results</li> <li>○ Writing a report</li> </ul> |
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## 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)

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## Cementitious Materials

- 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 hydrocarbons
  - **Various Compounds of Calcium** : gypsum, lime, cements

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## Cementitious Materials

- **Cementitious materials** are substances which, upon certain chemical reactions attain binding properties:
  - Non-hydraulic cements (gypsum and lime)
  - Hydraulic cements (portland cement): will set and harden under water
- **Hydraulicity** is that property of gaining binding value when mixed with water and remaining stable when exposed to water.

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## Some properties of cementitious materials

Properties of cementitious materials

|                               |  |
|-------------------------------|--|
| <b>Fineness</b>               | • Particle size  |
| <b>Normal Consistency</b>     | • A standard amount of water which gives a certain fluidity to the paste   |
| <b>Time of Setting</b>        | • Beginning of complete loss of plasticity   |
| <b>Sand Carrying Capacity</b> | • Amount of sand that can be added without harming plasticity  |
| <b>Hardening</b>              | • Formation of solid phase; complete loss of plasticity  |
| <b>Yield</b>                  | • Volume of final product obtained in comparison with volumes of constituent materials<br>• (10 cc water + 30 cc cement ≠ 40 cc paste) |

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## Next lecture...

- Gypsum