

**53:086 Civil Engineering Materials**  
**Review Materials for Midterm Examination**  
**The University of Iowa**  
**Spring 2008**

During the first half of the course, we've covered (1) some basic ideas of materials science; (2) structural metals steel and aluminum; (3) aggregates; and (4) portland cement concrete. For each of these topics, you should be familiar with the following. **In the exam, you will not be permitted to bring in any notes or crib-sheets.**

**1. Materials Science Concepts**

- types of chemical bonding (ionic, covalent, metallic, Van der Waals)
- Surface energy;
- Microstructure of metals
  - lattice arrangements (BCC, FCC, HCP)
  - grains and how they form
- Weakening mechanisms for materials:
  - Griffith's micro-crack model and the effect of flaw size on fracture stress;
  - Crystalline (or lattice) imperfections
    - grain size effects
- How to use and interpret phase diagrams
- Alloying
- Corrosion, electro-negativity, and the galvanic series (and the practical applications such as which metals can be placed together in electrolytes and which will corrode)

**2. Structural Metals**

- Structure dependent and structure independent properties of metals
- Heat treatment effects
- Work hardening effects
- Steel
  - Basics of the steel-making process
    - Role of carbon and interpretation of the iron-carbon phase diagram
    - Different phases of iron and carbon (ferrite, austenite, martensite, etc).
    - typical carbon contents in structural steels
  - Properties of steel (stiffness, mass density, range of yield stresses, ultimate strengths, and ductilities)
  - When does it make sense to use high-strength grades of steel?
  - Hot dip zinc galvanization (benefits, considerations, limitations)
  - Stainless steel (its properties relative to those of structural steels)
- Aluminum

- Properties of aluminum (stiffness, mass density, range of yield stresses, ultimate strengths, and ductilities)
- Know that the structure-dependent properties of aluminum change significantly with different alloy compositions
- Comparative properties of steel and aluminum in terms of stiffness, strength, density, and melting temperatures.
- Considerations when welding high strength heat-treated or work-hardened metals.

### **3. Aggregates**

- Gradation (also the fineness modulus)
- Definitions of Specific Gravity
- Absorption
- Desired characteristics of aggregates used in PCC

### **4. Portland Cement Concrete**

- Basic components of portland cement (cement chemistry notation)
- The six different types of portland cement, how they differ, and when they're used
- The hydration reaction (time scale, what happens, heat production)
- Composition of the hydrated cement paste as function of water-cement ratio and curing conditions
- Types of pores in hcp and their effect on strength and stiffness of PCC.
- Cement replacement materials and their effects;
- Admixtures and reasons for their usage
- Air entrainment
- Rules of mixtures to predict stiffness of PCC.
- Typical mass densities, stiffnesses, and unconfined compressive strengths of PCC