

53:086 Civil Engineering Materials
Review Materials for Midterm Examination
The University of Iowa
Spring 2007

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