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2018 Materials Exam Learning Objectives

(All new additions since the 2017 Learning Objectives have been Italicized)

Introduction to Material Science:

1. Explain the difference between the three types of primary atomic bonds: ionic, covalent, and metallic.
2. Describe the predominant bonding type in metals, ceramics, and polymers and how these bond types influence the mechanical and thermal behavior of materials.
3. Explain secondary bonding in terms of the partial electronic charge between species.
4. Sketch typical stress-strain curves for metals, ceramics, plastic polymers, network polymers and elastomers.
5. Identify each of the following on a typical stress-strain curve for a metal: Hooke's Law, Plastic deformation, Tensile strength, Ductility, Toughness.
6. Discuss the mechanism of plastic deformation in metals.
7. Discuss basic structure-property relationships in polymers (low and high density polyethylene, polypropylene, polyvinyl chloride) and in building enclosure materials (Tyvek, HD polyethylene film, Building paper, Asphalt-saturated felt, EPDM Rubber, TPO, SBS).
8. Explain how temperature and strain rate affect the mechanical behaviour of polymers.
9. Explain the influence of porosity on a ceramic.

Thermal Insulation and Membranes:

10. Identify common products used as air barrier systems (i.e. different sheet goods, fluid applied air barriers, boards and spray foam) and their application, benefits, and drawbacks.
11. Discuss different types of insulation, various insulation products and their respective common thermal resistance values, application, benefits, and drawbacks and how they each impede heat transfer.
12. Identify factors that reduce effectiveness of insulation in real world applications

Masonry:

13. Describe the different materials of which a masonry wall system is comprised and the function of each.
14. Define the standard masonry terminology, including different masonry material types, units, dimensions, shapes, unit area and voids (nominal versus actual dimensions, net area, cores or cells, frogs, face shells, webs, semi-hollow unit, hollow unit, and solid unit).
15. Define four facets of concrete block classification (solid content, minimum compressive strength, concrete type and shrinkage).
16. Explain how masonry material properties, such as compressive strength, tensile strength, cold water absorption, boiling water absorption, c/b ratio, and freeze-thaw mass loss are used to describe the Grade and Type of clay brick and influence performance of masonry.
17. Compare and contrast different types of mortar (Portland Cement-Lime, Masonry Cement and Mortar Cement) and types of cement (M, S, N, O, and K)
18. Describe the manufacturing process of clay brick and concrete block.
19. Explain the difference between block strength and masonry strength.
20. Describe the use, role, classification, types, and desirable fresh and hardened properties of mortar and grout.

21. Describe the most common mortar joint thickness and the profiles in masonry construction that are considered best practice.
22. Describe the role of movement joints in masonry.
23. Explain the Canadian requirements for masonry connectors, including labeling, corrosion protection, strength, location, and movement.
24. Describe the structural backup and anchor design for dimension cut stone and random ashlar.
25. Identify moisture related issues that can arise in masonry construction, such as efflorescence and spalling, their causes and how to avoid them.

Mechanisms of Deterioration:

26. Discuss basic electrochemical corrosion in metals.
27. Discuss galvanic corrosion between dissimilar metals.
28. Explain the circumstances leading to and the mechanism of crevice corrosion and stress-corrosion cracking.
29. Explain how cathodic protection can protect a metal from corrosion.
30. Explain how galvanized coatings can protect metals from corrosion.
31. Explain three basic mechanisms for degradation of polymers.
32. Explain carbonation and its effect on concrete and embedded metals

Concrete:

33. Define the roles of the phases in Portland cement (alite, belite, aluminate and ferrite).
34. Identify the purpose of main components in concrete (water, cement, aggregates, various chemical admixtures, and different supplementary cementing materials).
35. Describe various types of cement, such as Portland Cement (GU, HE, HS), Portland Limestone Cements, Blended Cements, and their uses.
36. Define water-to-cementitious materials ratio and how it affects concrete properties.
37. Describe the process of hydration and how concrete gains strength.
38. Describe how air entrainment reduces the effect of freeze-thaw and the characteristics of air entrained concrete.
39. Explain the deterioration mechanisms (including freeze-thaw, chloride attack on rebar, carbonation corrosion, alkali-aggregate reactivity, sulfate attack and fire) and measures that can be taken to prevent/mitigate the various durability issues for concrete.
40. Describe the exposure requirements (C, F, N, S and A exposure classes) of the various durability issues for concrete.
41. Define permeability and the factors that affect fluid penetration resistance of concrete.
42. Describe the factors that affect workability.
43. Identify the various ways and equipment to mix, transport and place concrete.
44. Identify the various fresh concrete tests conducted and the fresh concrete properties they measure (i.e. slump/flow test, density, yield, and air content).
45. Explain why plastic shrinkage cracks form and the influencing factors.
46. Identify the factors affecting when finishing of flatwork can be done.
47. Identify the various curing methods used onsite, and the importance of curing on concrete strength development.
48. Discuss how strength test cylinders are made, cured and tested.
49. Describe the volume changes that concrete can undergo (i.e. swelling and shrinkage).

Cementitious Repair Materials:

50. Describe the constituent materials used to produce the various cementitious repair materials.
51. Identify advantages, limitations and applications of the common cementitious repair materials, including conventional concrete, polymer modified concrete, fibre-reinforcement, cementitious grouts, rapid-setting cement, preplaced aggregate concrete, shrinkage-compensating concrete and shotcrete.
52. Select appropriate repair materials best suited for cases with varying environments, building materials, performance criteria, and repair application requirements.

Sealants:

53. Discuss curing, physical and chemical properties of various types of sealant materials (polyurethane, silicone, acrylic, butyl, and polymer modified bitumen).
54. Describe function and use of different sealants.
55. Explain standard sealant testing procedures.
56. Describe various sealant joint types such as expansion, termination, butt (tensile), fillet, cap (needle) bead, lap, bridge (band-aid), and their applications.
57. Describe relationship between joint design including joint profile, joint backing, substrate properties and expected joint movement.
58. Discuss sealant application process and the importance of surface preparation, tooling, and curing.
59. Describe laboratory and field testing of sealants with respect to compatibility, adhesion, and solvent migration.
60. Identify two mechanisms of sealant failure (cohesive and adhesive) and what leads to them.

Glass:

61. Describe manufactured glass used in buildings, its primary components, and types.
62. Describe where laminated, tempered, and float glass are used and why.
63. Describe the principal properties that characterize glass of various types.
64. Describe the defects incorporated into glass during manufacture and the effect on performance including various inclusions.
65. Describe the ways in which glass of various types fails and causes of failure.