53:086 Civil Engineering Materials
Dept. of Civil & Environmental Engineering
The University of Iowa
Final Examination
Two Hours – 150 Points

Spring Semester 2008 Instructor: C.C. Swan

PART A: Bituminous Materials (33 points)

1. Why is asphalt generally a preferred bituminous binder relative to tar?
2. In what type of special applications would tar be preferred over asphalt?
3. How does oxidation of asphalt change its mechanical and physical properties?
4. Briefly describe the following tests and what information each provides:
    a. TFO or RTFO test
    b. PAV test
5. Describe briefly what is a cationic asphalt emulsion?
6. What is HMA?
7. Define the following for HMA and provide a reasonable range of values:
    a. VTM
    b. VMA
    c. VFA
8. Calculate VTM, VMA, VFA for an asphalt concrete specimen having the following properties:
    - Asphalt content = 5.3% by total weight of the mix
    - Bulk specific gravity of the mix = 2.442
    - Theoretical maximum specific gravity = 2.535
    - Bulk specific gravity of the aggregate = 2.703
9. How do the properties of asphalt cement change?
    a. With increasing temperature above 77°C?
    b. With decreasing temperature below 20°C?
10. For viscoelastic materials in general, and asphalt in particular, how does the apparent stiffness change with loading frequency?
11. Name three specific and desirable characteristics for aggregates used in HMA.

PART B: Masonry (27 points)

12. A contractor who put brick flooring into a building with non-weathering clay bricks has a large surplus of bricks from the job and is considering paving portions of the structure's driveway with the same bricks. Is this a good idea? Why or why not?
13. Consider a concrete masonry unit made in a factory. How would the mix proportions (water, cement, coarse aggregate, fine aggregate) of concrete for such units differ from that of cast-in-place concrete for a building foundation?
14. It is standard practice to let concrete masonry units age or cure for a few months in a dry environment before they are delivered to job sites. Why is this done?
15. A steel-framed office structure with single-wythe exterior concrete masonry walls is under construction on Clinton Street here in Iowa City. Considering the only the energy efficiency of the structure, do you think it more likely that the concrete masonry units are solid, cellular, or hollow? Explain.
16. What is the difference between a hollow masonry wall and a cavity wall?

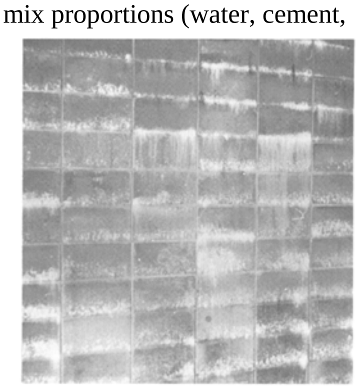

Fig. 1. Photo of masonry wall.

17. In multi-wythe masonry construction here in the Midwest, the exterior wythe contains fired clay bricks and the interior wythe contains concrete masonry units. Over the life of the structure, which do you expect to undergo more shrinkage: the clay bricks, or the concrete blocks? Explain.
18. Consider the photograph of a concrete masonry wall shown above in Fig. 1. Identify anything you find unusual in this photograph and explain what the root causes might be.
19. Provide estimates of the mass density, Young's modulus, and compressive strength of:
    a. Solid, structural concrete masonry units; and
    b. Solid, structural clay bricks.

PART C: Fiber-Reinforced-Polymer Materials (30 points)

20. What is the major difference between a thermoset polymer and a thermoplastic polymer?
21. The tensile strength of glass fibers is a few GPa, whereas the tensile strength of bulk window glass is on the order of a few MPa. Explain why this is true.

Consider an aligned-fiber graphite-epoxy composite having 70% Type-II PAN fibers by volume and 30% epoxy by volume. The properties of the fiber and matrix are provided in the table below.

Material	E	σ_{ult}	ρ (g/cm^3)
Type-II PAN	241 GPa	2.41 GPa	1.75
Epoxy	4 GPa	0.10 GPa	1.30

22. Compute the mass density of the composite.
23. Compute the Young's modulus in the fiber direction.
24. Compute the Young's modulus in the transverse direction (use the iso-stress rule of mixtures to estimate it).
25. Compute the tensile strength of the composite in the fiber direction.
26. Compute (estimate) the tensile strength of the composite in the transverse direction.
27. Although FRPs do not corrode, they do have some potential durability issues. What are they?
28. FRPs may never compete with traditional civil structure materials like steel and concrete for widespread usage in civil engineering. Please list a few specific reasons why this is true.
29. Provide three specific applications where FRPs are actually being used in civil infrastructure.

PART D: Comparative Material Properties (24 points)

Consider the following eight materials at 20°C: A-36 steel, asphalt cement, epoxy, fired severe weathering clay brick, S-glass fiber, graphite Type-II PAN fibers, normal weight portland cement concrete, and pure aluminum.

30. Rank the above materials from least to greatest mass density.
31. Rank the same materials from least to greatest in terms of Young's modulus.
32. Finally, rank the materials from least to greatest in terms of tensile strength.

PART E: Steel (15 points)

In the lab portion of this course, you measured the tensile strength of cold-rolled 1018 steel and then annealed specimens of the same 1018 steel.

33. As specifically as you can, describe how the mechanical properties were different before and after annealing.
34. How did annealing lead to these changes?
35. Why is carbon such an integral part of making steel?
36. All other things being equal, how do the mechanical properties of high-carbon steel differ from those of mild steel?

37. A copper service pipe connects a home to a cast iron water main pipe. Both are buried about four feet underground in soil that goes through varying degrees of saturation throughout the year. Do you anticipate any problems with this arrangement?

PART F: Portland Cement Concrete (17 points)

38. What are the five standard types of ordinary portland cement and under what circumstances would each be used?
39. In portland cement concrete mix design, what are moisture corrections, and why are they important?
40. During the hydration of portland cement, a chemical reaction occurs. What type of chemical bonding occurs during cement hydration, and between what compounds?
41. What are some common cement replacement materials, and what are the corresponding benefits of using them?
42. What are water reducing admixtures, and when might they be used?
43. What are some of the primary benefits being able to use a portland cement concrete mix with a low water to cement ratio?
44. What is the benefit of using air entrainment in portland cement concrete?

PART G: Aggregates (4 points)

45. In testing and inspecting the concrete for a construction job, you've examined the failed cylinders and observe that a lot of the aggregate is being sheared to failure along the fracture surfaces in the cylinders. Overall, the measured compressive strengths for this job are coming in much lower than the expected values called for in the design specifications. Assess the situation and make a recommendation.

46. You have two potential aggregates to be used in a concrete mix for a major concrete highway paving project here in the Midwest. One aggregate has a much higher moisture absorption capacity than the other, but they both give similar concrete strength values in testing. Which aggregate would you recommend for usage, and why?