Université d'Ottawa
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uOttawa
L'Université canadienne
Canada's university

University of Ottawa
Faculty of Engineering

Department of
Civil Engineering

CVG 2141
Civil Engineering Materials

FINAL EXAMINATION

Length of Examination: 3 hours **December 9th, 2005, 14:00**

Professor: Dr. B. Martín-Pérez

Family Name: _____

Other Names: _____

Student Number: _____

Number of booklets submitted: _____

Signature: _____

CLOSED BOOK EXAM.

If you do not understand a question, clearly state an assumption and proceed.

Programmable calculators or other electronic devices are not allowed.

At the end of the exam, when time is up:
- Stop working and turn your exam upside down.
- Remain silent.
- Do not move or speak until all exams have been picked up, and a TA or the Professor gives the go-ahead to leave.

QUESTION 1: (25 marks)

A tension test on a steel coupon of an unknown composition gave the following results. Knowing that the specimen has a rectangular cross-section of dimensions 6.35 mm by 12.7 mm, plot the stress-strain curve and determine the following:

(a) Yield stress;

(b) Ultimate (maximum) tensile stress;

(c) Rupture stress;

(d) Modulus of elasticity;

(e) % elongation at rupture;

(f) Modulus of toughness;

(g) Would you consider this steel to be hot-rolled or cold-rolled? Explain your answer.

Load (kN)	Strain ($\times 10^{-6}$)
5	300
10	600
15	900
20	1,200
25	1,500
25	10,000
30	110,000
35	120,000
40	130,000
45	140,000
50	150,000
55	160,000
60	170,000
45	220,000

QUESTION 2: (25 marks)

Specify the mix proportions of a concrete to be used in a bridge deck exposed to de-icing salts and subjected to frequent freezing and thawing in a saturated condition. The 28-day specified compressive strength is 25 MPa. The following materials are available:

Cement:	Type 10 Relative density = 3.15
Coarse aggregate:	20-mm nominal maximum size Oven-dry relative density = 2.70 Absorption capacity = 0.4% Bulk density = 1600 kg/m^3 Coarse aggregate has a moisture content of 0.4%
Fine aggregate:	Oven-dry relative density = 2.65 Absorption capacity = 0.8% Fine aggregate has a moisture content of 1%
Air entrainer:	Wood resin type, ASTM C 260. Recommended dosage is 6.3ml/1% air/100 kg cementing materials

Sieve analysis of the fine aggregate is as follows:

Sieve (mm)	5	2.5	1.25	0.630	0.315	0.160
Percentage of individual fraction passing	98	75	65	45	25	10

QUESTION 3: (20 marks)

Given the following data for a paving mixture, calculate:

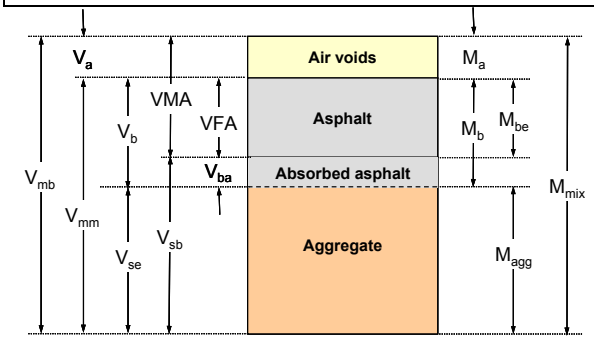
(a) the mass and volume of all mixture components (refer to diagram below);

(b) the percentage of air voids;

(c) the volume of voids in the mineral aggregate, VMA;

(d) the volume of voids filled with asphalt, VFA; and,

Mixture Components				
Material	Specific Gravity		Mix Composition	
		Bulk	% by mass of total mix	% by mass of total agg.
Asphalt cement	1.052 (G_b)		6 (P_b)	
Coarse agg.		2.702 (G_1)		53 (P_1)
Fine agg.		2.621 (G_2)		43 (P_2)
Mineral filler		2.779 (G_3)		4 (P_3)
Paving Mixture G_{mb} = 2.440, G_{mm} = 2.535				



$$G_{sb} = \frac{P_1 + P_2 + \ldots + P_N}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_N}{G_N}} \qquad VMA = \frac{V_a + V_{be}}{V_{mb}} \times 100$$

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}} \qquad VFA = \frac{VMA - V_a}{VMA} \times 100$$

where G_{sb} = bulk specific gravity for total agg. sample, P_i = individual agg. % by mass of total agg., G_i = individual bulk specific gravity of agg., G_{se} = effective specific gravity for total agg., P_b = % of binder by total mass of mixture, G_b = specific gravity of binder, V_a = volume of air voids, V_{be} = volume of effective asphalt binder, and V_{mb} = bulk volume of compacted mix.

QUESTION 4: (30 marks)

1. Selecting the largest practical maximum aggregate size and achieving a smooth grading curve produces which result in concrete?

   (a) Increases relative volume of aggregate (b) Decreases volume of cement paste

   (c) Reduces water demand (d) Reduces shrinkage

   (e) All of the above

A fine aggregate sample of 521.0 g has the following properties: oven-dried mass = 491.6 g, absorption = 2.5%. Based on this information, answer questions 2 and 3.

2. What is the moisture content of the aggregate?

   (a) 5.6% (b) 5.9%

   (c) 2.5% (d) 3.4%

   (e) None of the above

3. What is the free moisture content of the aggregate?

   (a) 5.6% (b) 5.9%

   (c) 2.5% (d) 3.4%

   (e) None of the above

4. Which clinker compound is reduced to produce sulphate-resistant portland cement?

   (a) C_3S (b) C_2S

   (c) C_3A (d) C_4AF

   (d) Gypsum

5. Why do we measure the slump of a fresh concrete mix?

   (a) To determine the likelihood of bleeding (b) To determine the likelihood of segregation

   (c) To determine the ease of placement (d) To determine the amount of mixing water

   (e) None of the above

6. In which of the cases listed would you most likely use a set accelerating admixture in concrete?

   (a) To increase time for proper curing (b) In cold weather

   (c) In hot weather (d) To keep concrete workable for longer time

   (e) None of the above

7. What would happen if concrete is not properly cured?

   (a) It dries out (b) It continues gaining strength over time

   (c) Hydration of portland cement takes place (d) It will become a durable material

   (e) All of the above

8. The change in volume of concrete exposed to moisture cycles over a long period of time is due to:
   (a) Plastic shrinkage
   (b) Drying shrinkage
   (c) Creep
   (d) Plastic and drying shrinkage
   (d) Drying shrinkage and creep

9. The compressive strength of concrete:
   (a) Increases with increasing w/c
   (b) Is independent of w/c
   (c) Increases with increasing age
   (d) Decreases with increasing age
   (e) None of the above

10. Corrosion of reinforcement in concrete is caused by:
   (a) A decrease in the pH of the concrete
   (b) A decrease in the amount of chloride ions
   (c) An increase in the amount of sulphate ions
   (d) An increase in the depth of concrete cover
   (e) All of the above

11. Durable concrete is achieved by:
   (a) Decreasing the w/c
   (b) Using mineral admixtures
   (c) Promoting proper curing
   (d) Using inert aggregates
   (e) All of the above

12. Why is cast iron stronger than steel?
   (a) Because of its higher iron content
   (b) Because of its lower carbon content
   (c) Because of its higher carbon content
   (d) It is not stronger than steel
   (e) None of the above

13. Why is the carbon content in structural steel limited to 0.25%?
   (a) To ensure strength
   (b) To ensure ductility
   (c) To ensure resilience
   (d) (a) and (b)
   (e) (b) and (c)

14. What is the process called where steel is heated to the austenite stable range – held there for a period – then slowly cooled – thereby softening the steel and increasing both ductility and toughness?
   (a) Normalizing
   (b) Tempering
   (c) Hardening
   (d) Annealing
   (e) None of the above

15. What is the process called where steel is heated until austenite is formed and then quenched (rapidly cooled)?

(a) Normalizing
(b) Tempering
(c) Hardening
(d) Annealing
(e) None of the above

16. Which properties make aluminium an attractive structural engineering material?

(a) Low thermal conductivity
(b) High modulus of elasticity
(c) High strength-to-weight ratio
(d) Magnetic properties
(e) None of the above

17. How does the moisture content (MC) of lumber in relation to its fibre saturation point (FSP) affect its mechanical properties?

(a) They remain unchanged for MC < FSP
(b) They increase for MC < FSP
(c) They decrease for MC < FSP
(d) They increase for MC > FSP
(d) They decrease for MC > FSP

A wood timber with a diameter of 25 mm has a moisture content of 5%. The fibre saturation point for this wood is 28%. The wood shrinking or swelling is 1% in the radial direction for every 5% change in moisture content below FSP. If the wood's moisture is increased to 43%, answer questions 18 to 20.

18. What would be the percent change in the wood's diameter?

(a) 4.1%
(b) 7.6%
(c) 3%
(d) 4.6%
(d) None of the above

19. What would happen to the wood timber?

(a) It will shrink
(b) It will swell
(c) It will break
(d) It will dry
(e) Nothing

20. What would be the new diameter of the wood timber?

(a) 36.5 mm
(b) 1.15 mm
(c) 26.1 mm
(d) 11.5 mm
(e) 26.9 mm

21. How does the presence of a knot affect wood's tensile strength?

(a) By increasing it parallel to the grain
(b) By increasing it perpendicular to the grain
(c) By increasing it in bending
(d) It does not affect the tensile strength in wood
(e) None of the above

22. The modulus of rupture (MOR) refers to a:

(a) Strain value
(b) Stress value
(c) Moisture content value
(d) Elastic modulus value
(e) None of the above

23. Wood has relatively good fire resistance because:

(a) It burns very quickly
(b) It is a good insulator
(c) It has fire-retardant chemicals
(d) It does not have good fire resistance
(e) None of the above

24. Seasoning of wood is desirable to:

(a) Increase its strength
(b) Minimize shrinkage in the future
(c) Improve its aesthetic properties
(d) Decrease potential for fungal attack
(d) None of the above

25. Bituminous materials are used in the pavement industry because of their:

(a) Binding properties
(b) Plastic deformability at high temperatures
(c) Resistance to water
(d) (a) and (b)
(e) (a) and (c)

26. A pavement made with an asphalt binder with low viscosity at room temperature will perform better:

(a) At high temperatures
(b) At low temperatures
(c) In any type of weather
(d) If properly cured
(e) None of the above

27. The Superpave grading system is preferred to the other classification systems because:

(a) It reduces the likelihood for rutting
(b) It controls thermal cracking
(c) Properties are related to actual performance
(d) It limits the potential for fatigue cracking
(e) All of the above

28. Fatigue cracking refers to cracking due to:

(a) High thermal stresses
(b) Ultimate tensile load
(c) Repeated traffic load over time
(d) High modulus of rupture
(d) None of the above

29. A flexible pavement is preferred to a rigid pavement because:

(a) It has higher load capacity
(b) It experiences less rutting at high temperatures
(c) It requires less maintenance
(d) Traffic riding on it produces more noise
(e) None of the above

30. Binder selection in the Superpave mix-design procedure is based on:

(a) Maximum in-service temperature
(b) Minimum in-service temperature
(c) Average in-service temperature
(d) It is independent of the in-service temperature
(e) None of the above