Université d'Ottawa
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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 12th, 2007, 14:00**

Professor: Adel Bugaldian

Family Name: _____

First Name: _____

Student Number: _____

Number of booklets submitted: _____

Signature: _____

CLOSED BOOK EXAM.

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

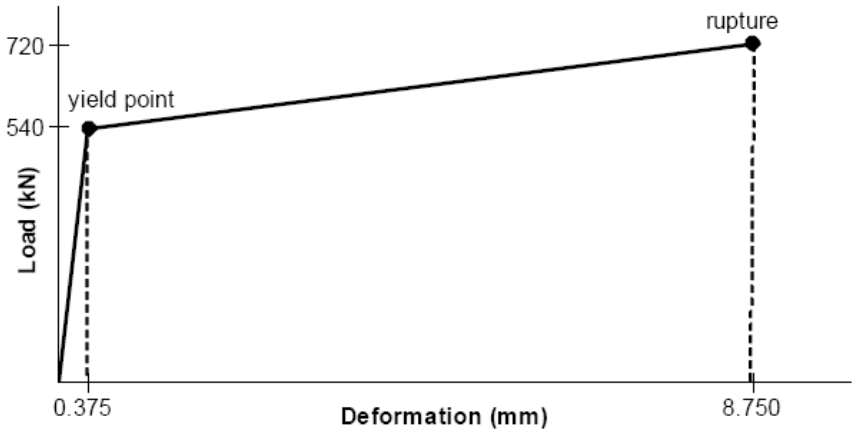
Programmable calculators or other electronic devices are not allowed.

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.

Good luck!

QUESTION 1: (25 marks)

A tension test on a specimen made of an elastoplastic material and loaded along its long axis produced the following load-deformation curve. Knowing that the specimen has dimensions of 30 mm × 30 mm × 300 mm, and that deformation was measured using an extensometer with a 125-mm gauge length, estimate the following:



(a) Yield stress;

(b) Rupture stress;

(c) Modulus of elasticity;

(d) Modulus of resilience;

(e) % elongation of the specimen at rupture;

(f) If a bar made out of this material is subjected to a tensile load of 600 kN, what would be its minimum cross-sectional area so that the material does not yield under the applied load?;

(g) Would you classify this material as brittle or ductile? Explain your answer.

QUESTION 2: (20 marks)

Using the information given, specify the mix proportions of a concrete to be subjected to frequent freezing and thawing in an unsaturated condition. The concrete is to be used for an exterior reinforced concrete wall in Ottawa, and the specified 28-day compressive strength required is 27 MPa. Statistical data indicate a standard deviation of compressive strength of 2.1 MPa is expected (more than 30 samples have been tested). The following materials are available:

Cement: Type GS
Relative density = 3.15

Coarse aggregate: 20-mm nominal maximum size
Bulk oven-dry specific gravity = 2.55
Absorption capacity = 1.5%
Bulk oven-dry rodded density = 1761 kg/m^3
Coarse aggregate has a moisture content of 0.8%

Fine aggregate: Bulk oven-dry specific gravity = 2.66
Absorption capacity = 0.5%
Fine aggregate has a moisture content of 2%

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
Cumulative percentage passing	98	87	65	45	22	3

QUESTION 3: (20 marks)

A compacted asphalt concrete specimen contains 5.9% asphalt binder (G_b = 1.023) by weight of the total mix, and aggregate with a bulk specific gravity of 2.692 and an effective specific gravity of 2.731. The bulk specific gravity of the mix is 2.457.

Calculate the following:

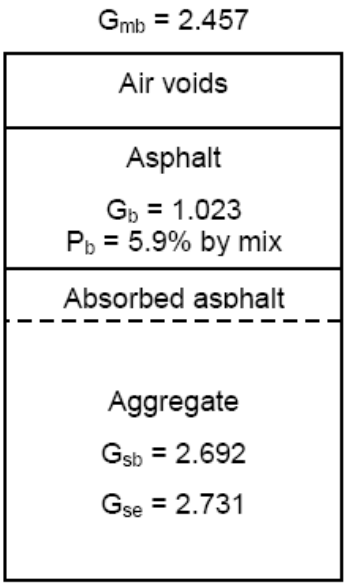
(a) Weights and volumes of all mixture components;

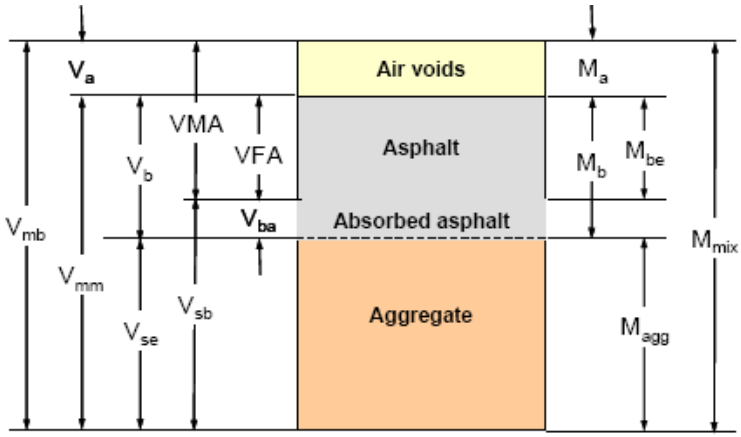
(b) Percentage of air voids;

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

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

(e) Maximum theoretical specific gravity of the mix, G_{mm}.





Note that:

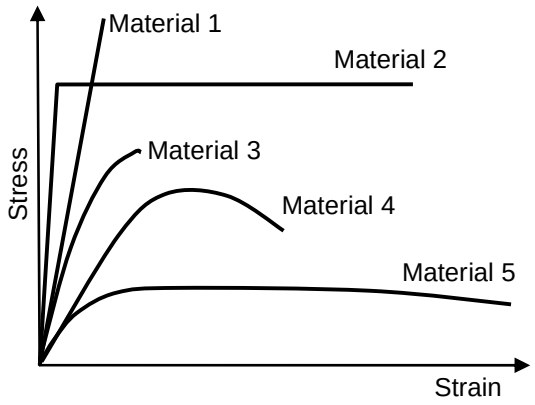
$$\%\,\text{air voids} = \frac{V_a}{V_{mb}} \times 100 \qquad VMA = \frac{V_a + V_{be}}{V_{mb}} \times 100 \qquad VFA = \frac{VMA - V_a}{VMA} \times 100$$

$$G_{mm} = \frac{M_{mix}}{(V_{mb} - V_a) \times SG_{H_2O}}$$

Where V_a = volume of air voids, V_{be} = volume of effective asphalt binder, V_{mb} = bulk volume of compacted mix, and M_{mix} = total mass of asphalt concrete mix.

QUESTION 4: (35 marks)

Based on the five different stress-strain curves shown below, answer questions 1 to 6:



1. Which material has the highest ductility?

   (a) Material #1 (b) Material #2

   (c) Material #3 (d) Material #4

   (e) Material #5

2. Which material has the highest modulus of resilience?

   (a) Material #1 (b) Material #2

   (c) Material #3 (d) Material #4

   (e) Material #5

3. Which material has the highest toughness?

   (a) Material #1 (b) Material #2

   (c) Material #3 (d) Material #4

   (e) Material #5

4. Which stress-strain curve represents concrete under uniaxial compressive loading?

   (a) Material #1 (b) Material #2

   (c) Material #3 (d) Material #4

   (e) Material #5

5. Which material is the most brittle?

(a) Material #1 (b) Material #2

(c) Material #3 (d) Material #4

(e) Material #5

An aggregate sample of 830 g has the following properties: oven-dried mass = 821 g, saturated surface dry mass = 840 g, and submerged mass = 522 g. Based on this information answer questions 6 and 7.

6. What is the moisture content of the aggregate?

(a) Air dry (b) Saturated surface dry

(c) Wet (d) None of the above

7. What is the absorption of the aggregate?

(a) 2.26% (b) 2.31%

(c) 3.8% (d) None of the above

8. Which of these features is characteristic of a low-heat Portland cement?

(a) Reduced C_3S (b) Increased C_2S

(c) Decreased C_3A (d) Lower fineness

(e) All of the above

9. What type of cement is often used in a moderate sulphate environment?

(a) Type10 or GU (b) Type 50 or HS

(c) Type 30 or HE (d) Type 20 or MS

(e) Type 40 or LH

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

(a) To increase productivity (b) In cold weather

(c) In hot weather (d) To open a concrete pavement early for service

(e) None of the above

11. Which of the following does affect concrete workability?

(a) Amount of mixing water
(b) Aggregate-mix proportion
(c) Aggregate shape
(d) Loss of water through evaporation
(e) All of the above

12. How do air-entraining agents function?

(a) By plasticizing the concrete
(b) By stabilizing air bubbles introduced by mixing
(c) By causing cement particles to flocculate
(d) By creating air bubbles by chemical reaction
(e) None of the above

13. The dynamic modulus of elasticity of concrete:

(a) Is equal to the elastic modulus
(b) Is higher than the elastic modulus
(c) Is lower than the elastic modulus
(d) Cannot be related to the elastic modulus

14. 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

15. What material is produced in a blast furnace?

(a) Steel
(b) Iron ore
(c) Pig iron
(d) Carbon steel
(e) None of the above

16. In steel production limestone is used to:

(a) Reduce iron oxides in the ore
(b) Increase iron oxides in the ore
(c) Help remove impurities
(d) Reduce carbon steel
(e) None of the above

17. Why is wrought iron more ductile 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 more ductile than steel
(e) None of the above

18. What is the maximum carbon content found in steel?

(a) 0.30%
(b) 5%
(c) 2%
(d) 6.1%

19. Which of the following materials exhibits higher strength?

(a) Iron ore
(b) Steel
(c) Wrought iron
(d) Cast iron

20. What is the process called where steel is work hardened at near ambient temperature to increase the yield strength?

(a) Normalizing
(b) Tempering
(c) Hardening
(d) Annealing

21. The fact that wood has different properties along its principal directions makes it:

(a) Isotropic
(b) Homogeneous
(c) Orthotropic
(d) None of the above

22. A wood specimen displays higher strength when subjected to:

(a) Tension perpendicular to the grain
(b) Compression parallel to the grain
(c) Compression perpendicular to the grain
(d) Tension parallel to the grain

23. Fungal attack occurs in an environment where wood is:

(a) Dry
(b) Under water
(c) Below 0°C
(d) None of the above

24. Moisture in wood exists in two forms:

(a) Free water
(b) Cellulose
(c) Bound water
(d) Hemicellulose
(e) (a) and (b)
(f) (a) and (c)

25. What is the fibre saturation point (FSP) of wood?

(a) MC at which cell walls are saturated (b) MC at which cell cavities are filled with water

(c) MC at which cell cavities are empty (d) (a) and (b)

(e) (a) and (c)

26. How much tangential shrinkage will occur if Douglas fir lumber is dried from FSP to 19%MC? The FSP for Douglas fir is 26%, & its tangential shrinkage from FSP to OD is 7.5%.

(a) 1% (b) 2%

(c) 3% (d) 4%

27. A piece of wood has a MC of 18%. What must its weight have been before OD if it has a constant weight of 140 g after drying?

(a) 153.2 g (b) 160.2 g

(c) 165.2 g (d) 175.2 g

28. 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

29. 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

30. 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

31. 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)