Université d'Ottawa · University of Ottawa

Faculté de génie
Génie Civil

Faculty of Engineering
Civil Engineering

**CVG 2141 – CIVIL ENGINEERING MATERIALS**

FINAL EXAM
December 17th, 2004

Dr. B. Martín-Pérez

**Closed book exam**
**Calculators permitted**
**Time allowed: 3 hours**

**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 circular cross-section with a diameter of 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) If a bar made out of this steel is subjected to a tensile load of 80 kN, what would be its minimum cross-sectional area so that the material does not yield under the applied load?; and,

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

| Load (kN) | Strain ($\times 10^{-6}$) |
|---|---|
| 10 | 400 |
| 20 | 800 |
| 30 | 1,200 |
| 40 | 1,600 |
| 50 | 2,000 |
| 50 | 10,000 |
| 60 | 110,000 |
| 70 | 120,000 |
| 80 | 130,000 |
| 90 | 140,000 |
| 100 | 150,000 |
| 110 | 160,000 |
| 120 | 170,000 |
| 90 | 220,000 |

**QUESTION 2:** (25 marks)

Specify the mix proportions of a concrete to be used in reinforced foundation walls and footings subjected to moderate sulphate attack and frequent freezing and thawing in unsaturated conditions. The 28-day average (not specified) compressive strength required is 30 MPa. The following materials are available:

| | |
|---|---|
| Cement: | Type 10<br>Relative density = 3.15 |
| Coarse aggregate: | 14-mm nominal maximum size<br>Oven-dry relative density = 2.70<br>Absorption capacity = 0.4%<br>Bulk density = 1600 kg/m$^3$<br>Coarse aggregate has a moisture content of 0.2% |
| Fine aggregate: | Oven-dry relative density = 2.65<br>Absorption capacity = 0.8%<br>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 |
|---|---|---|---|---|---|---|
| Percentage of individual fraction passing | 95 | 90 | 85 | 80 | 70 | 80 |

**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:

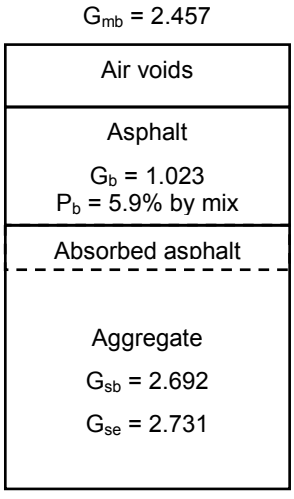
(a) weights and volumes of all mixture components;

(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:

$$VMA = \frac{V_a + V_{be}}{V_{mb}} \times 100$$

$$VFA = \frac{VMA - V_a}{VMA} \times 100$$

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

with $V_a$ = 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:** (10×3 marks)

Write a short description (4-6 lines) on each of the following. Use a sketch if appropriate.

(a) What are the ideal aggregate particles for Portland cement concrete and asphalt concrete? Justify your answer.

(b) A concrete specimen is loaded with a constant load that is maintained for several weeks and then removed. Plot the approximate deformation versus time curve assuming all creep deformation is reversible. Label elastic deformation, creep deformation, elastic recovery, and creep recovery.

(c) Difference between segregation and bleeding

(d) Effect of carbon content on the mechanical properties of steel

(e) Strengthening mechanisms used in the manufacture of steel products

(f) Causes of wood deterioration

(g) Sketch a curve showing compressive strength versus moisture content for a wood species that has a fibre saturation point of 30%

(h) Seasoning in wood

(i) Properties that make bituminous materials useful in the pavement industry

(j) Distress modes for which Superpave (performace-based specifications) was developed