Université d'Ottawa · University of Ottawa

Faculté de génie
Génie Civil

Faculty of Engineering
Civil Engineering

**CVG 2141 – CIVIL ENGINEERING MATERIALS**

FINAL EXAM
December 19th, 2002

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

**QUESTION 1:** (25 marks)

A tension test on a specimen loaded along its long axis produced the following load-deformation curve. Knowing that the specimen has dimensions of 25 mm × 50 mm × 300 mm and that deformation was measured using an extensometer with a 127-mm gauge length, estimate the following:

(a) Yield stress

(b) Rupture stress

(c) Modulus of elasticity

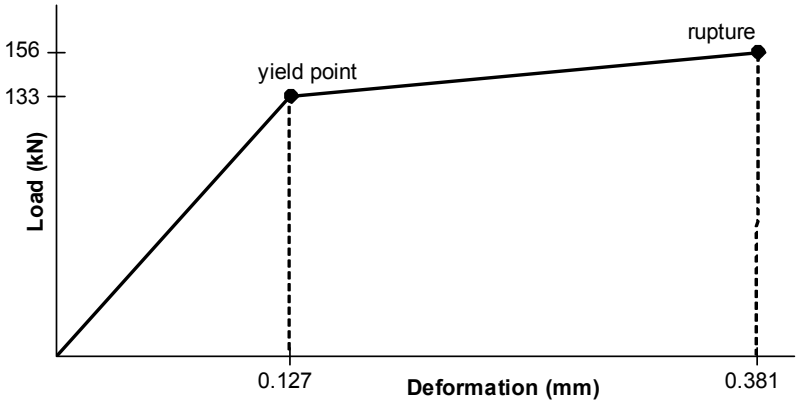
(d) Modulus of resilience

(e) Modulus of toughness

(f) % elongation of the specimen at rupture

(g) % elongation of the specimen when subjected to a tensile load of 100 kN

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



**QUESTION 2:** (25 marks)

Specify the mix proportions of a concrete to be used in a precast concrete tunnel lining, which will be exposed to groundwater with high levels of chloride (C-1 exposure) and sulphate (155 mg/L) ions and will not be subject to freezing and thawing conditions. A compressive strength $f'_c$ of 35 MPa at 28 days is specified. A slump of 100 mm is required. Fly ash and silica fume are to be used at a dosage of 30% and 6% by mass of cementing materials, respectively. The following materials are available:

| | |
|---|---|
| Cement: | Type 10<br>Relative density = 3.15 |
| Fly ash: | Class F<br>Relative density = 2.44 |
| Silica fume: | Class SF<br>Relative density = 2.25 |
| Coarse aggregate: | 20-mm nominal maximum size<br>Oven-dry relative density = 2.68<br>Absorption capacity = 0.4%<br>Bulk density = 1650 kg/m$^3$<br>Aggregate has a moisture content of 3% |
| Fine aggregate: | Oven-dry relative density = 2.64<br>Absorption capacity = 0.8%<br>Aggregate has a moisture content of 4% |
| 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 | 1.75 | 0.630 | 0.315 | 0.160 |
|---|---|---|---|---|---|---|
| Percentage of individual fraction passing | 98 | 90 | 85 | 80 | 71 | 79 |

**QUESTION 3:** (20 marks)

Tension and compression tests parallel to the grain on spruce specimens gave the following results:

**Tension parallel to the grain**
(section of 25 mm × 14 mm)

| Strain ($\times 10^{-5}$) | Load (kN) |
|---|---|
| 42 | 2 |
| 94 | 4 |
| 146 | 6 |
| 198 | 8 |
| 296 | 10 |
| | Maximum load 14.5 |

**Compression parallel to the grain**
(section of 50 mm × 50 mm)

| Strain ($\times 10^{-5}$) | Load (kN) |
|---|---|
| 22 | 2.5 |
| 37 | 5 |
| 53 | 7.5 |
| 68 | 10 |
| 84 | 12.5 |
| 99 | 15 |
| 114 | 17.5 |
| 130 | 20 |
| 150 | 22.5 |
| 170 | 25 |
| | Maximum load 52 |

(a) For the tension test parallel to the grain, plot the stress-strain curve and calculate the proportional limit, the ultimate stress at failure and the modulus of elasticity.

(b) For the compression test parallel to the grain, plot the stress-strain curve and calculate the proportional limit, the ultimate stress at failure and the modulus of elasticity.

(c) Discuss the reasons for the difference in values in the tensile and compressive strengths parallel to the grain of wood specimens.

**QUESTION 4:** (10×3 marks)

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

(a) Types of Portland cement manufactured in Canada and their uses

(b) Curing in concrete and its importance

(c) Effect of w/c on concrete strength

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

(e) Measures to control corrosion in steel

(f) Effect of moisture content on the mechanical properties of wood

(g) Given a quarter sawn board of a species that shrinks 3% in the radial direction when dried from the fibre saturation point of 28% down to an equilibrium moisture content of 8%, what is the final width of the board if initially it was 190 mm wide? What steps are taken during lumber production to reduce in-service shrinkage?

(h) Temperature susceptibility of asphalt cement

(i) Superpave

(j) Why would you use an asphalt pavement in preference to a Portland cement concrete pavement?