

OLLSCOIL na hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY
SECOND SEMESTER EXAMINATIONS, 2001

B.E. DEGREE
 Civil Engineering and Environmental Engineering

BITUMINOUS MATERIALS
 (CE 434)

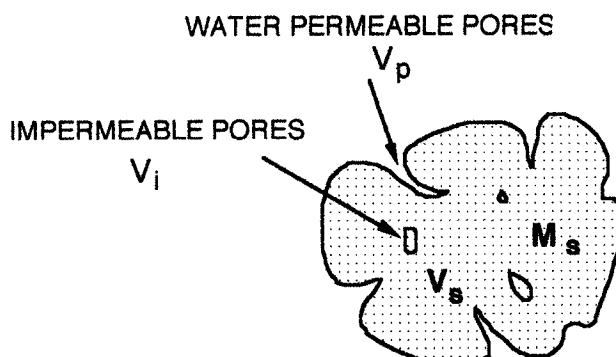
Professor R. Falconer;
 Professor P. E. O'Donoghue;
 M. J. Brennan.

Time allowed: two hours.
 Answer all questions.

1. (20%) Four stockpiles, 14 mm aggregate, sand and filler and a recycled crumbed rubber, are available for the production of a low-noise bituminous surfacing. The gradings of the stockpiles and the target grading, including the rubber crumb, are tabulated below. The rubber crumb content is required to be 2% of the aggregate/rubber crumb combination, i.e. to account for 2% of the blend of the four stockpiles. By trial and error, determine the optimum combination of the stockpiles that will meet the target grading. One iteration is sufficient.

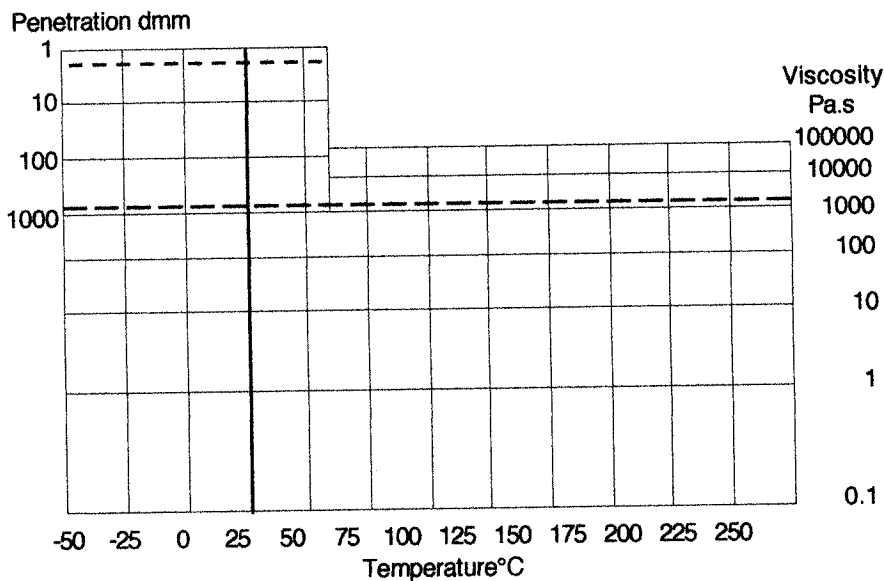
Sieve Size	Target grading	14 mm aggregate	Sand	Filler	Rubber crumb
14 mm	100	100	100	100	100
10 mm	96	96	100	100	100
6.3 mm	37	25	100	100	100
2.36 mm	18	2.3	96	100	100
425 μ m	9	2.0	38	100	25
75 μ m	5.5	1.6	18	99	0

2. (10%) Using the model of a particle of coarse aggregate that is shown below, write down the expression for the density of the particle on an oven dried basis, also known as the bulk density, in terms of its mass, M_s , the volume of the stone, V_s , the volume of the permeable voids, V_p , and the volume of the impermeable voids, V_i . Note that this density is used to calculate the voids in a bituminous material when the bitumen does not enter the permeable voids in the aggregate.



3. (10%) Name the four broad groups of chemicals that control the colloidal behaviour bitumen and note their primary roles.

4. (15%) The Keukelom bitumen test data chart is shown below. Produce an annotated version of the chart noting the significance viscosity-temperature relationship, and deviations from it, for a 100 pen straight-line bitumen.



5. (25%) By equating the difference between the volume of the voids in the coarse aggregate skeleton and the volume of the mastic to the volume of the voids in 1 Mg of stone mastic asphalt, show that the voids content, V , is given by

$$V = 100 - \left(\frac{100Y}{X} \right) \left\{ \frac{100}{\rho_A} + \frac{100}{100 - B - F} \left(\frac{B}{\rho_B} + \frac{F}{\rho_F} \right) \right\}$$

where

B is the % binder content by mass of the total mix;
 F is the cellulose % fibre content by mass of the total mix;
 X is the % coarse aggregate by mass of the aggregate;
 Y is the density Mg/m^3 of the coarse aggregate skeleton;
 ρ_A is the density Mg/m^3 of the aggregate;
 ρ_B is the density Mg/m^3 of the bitumen; and
 ρ_F is the density Mg/m^3 of the fibres.

6. (10%) Giving reasons for your answer, select the best combination of size of chipping and rate of spread of bitumen emulsion for surface dressing a very hard road surface with less than 20 commercial vehicles per day from the following options:

Chipping (mm): 14, 10 and 6

Rate of spread (litre/m^2): 1.1, 1.2 and 1.3

7.

(a) (5%) What are the four types of mixing plant that are used to manufacture bituminous materials?

(b) (5%) For each type of plant, note how the correct combination of aggregates from the cold feed bins is obtained.