GX512

OLLSCOIL na hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY
SECOND SEMESTER EXAMINATIONS, 2000

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.

(a) (20%) Three stockpiles of aggregate, 14 mm, sand and filler are available for the production of stone mastic asphalt (SMA). The gap-graded target grading for the SMA and the gradings of the stockpiles are given below. By trial and error, determine the optimum combination of the stockpiles that will meet the target grading. A production tolerance of about ±1% can be used for the 75 μm sieve and the target grading should lie inside the specification limits. One or two iterations are sufficient.

Sieve Size mm	SMA Target grading	Specification Limits	14 mm stockpile	Sand stockpile	Filler (crushed limestone)
20	100	100	100	100	100
14	95	100–90	97.0	100	100
10	47.5	60–35	33.7	99.6	100
6.3	27	35–23	6.8	94.4	100
2.36	21	30-18	3.9	57.5	100
0.6	20	unspecified	3.7	27.0	100
0.075	10.5	13–8	2.1	9.4	93

(b) (10%) The relative densities of the 14 mm, sand and filler are 2.639, 2.724 and 2.670, respectively. The relative density of the bitumen is 1.02 and the relative density of the cellulose fibres if 1.6. For a bitumen content of 6.3%, a cellulose fibre content of 0.3%, both by mass of the total mix, determine the maximum theoretical density of the SMA using your optimum blend of the aggregates.

2. (10%) Show that the expression

$$\frac{(\rho_t - d)}{\rho_t} \times 100$$

where d is the bulk density and ρ_t is the maximum theoretical density, for calculating the voids content of a test specimen of bituminous material is equal to the volume of the air voids expressed as a percentage of the total volume of the test specimen (aggregate + bitumen + air).

3. (10%) Explain how a cationic emulsion, $CH_3\text{-}CH_2\cdots\cdots NH_3^+$, and an anionic emulsion, $CH_3\text{-}CH_2\cdots\cdots COO^-$, coat electropositive aggregate, rich in $CaCO_3$, and electronegative aggregate, rich in SiO_2 .

4. The bulk density of a waxed test specimen is obtained from

$$d = \frac{M_A}{M_{PA} - M_{PW} - \left(\frac{M_{PA} - M_A}{\rho_P}\right)}$$

(a) (10%) Deduce the percentage refusal density of a core of dense bitumen macadam from the following laboratory results:

mass of dry core in air, M_A	3084.6 g
mass of waxed core in air, M_{PA}	3098.8 g
mass of waxed core in water, M_{PW}	1805.1 g
density of the paraffin wax, ρ_P	0.91 g/cm^3
mass of core compacted to refusal in air	3018.1 g
mass of core compacted to refusal in water	1812.8 g

(b) (5%) On the basis of this test, how many kilograms of wax would be required to test 100 cores?

5. (10%) The superage of a 40 mm thick (h=0.04 m) wearing course of hot-rolled asphalt (HRA) is 12.5 m^2/tonne. Its compacted density (ρ) is 2.25 t/m^3.

The speed of the paver is 3 m/s. The width of the paved layer is 4.5 m.

Four (n) passes of a static roller are required.

Calculate the number of rollers that are required given an efficiency factor (f) of 0.6, a drum width (w) of 1.2 m, a rolling speed (v) of 4 km/h. The volume output of a roller in tonne/h (Q_V) is given by

$$Q_V = f\frac{w \cdot v \cdot h \cdot 1000}{n}\rho$$

6. (10%) Explain the roles of the rock breaker, grizzly, jaw crusher and cone crusher at a limestone crushing plant.

7. (15%) A 20 mm dense bitumen macadam (DBM) base course contains 60% coarse aggregate, 35% fine aggregate and 5% filler. The bitumen content is 4.7% by mass of the total mix. The relative densities of the ingredients are 2.9, 2.7, 2.8 and 1.02, respectively. The DBM will be laid to a thickness of 60 mm. The mean voids content after rolling is expected to be 6%.

For a pavement that is 6.8 m wide and 400 m long, determine, to the nearest tonne, the quantities of coarse aggregate, fine aggregate, filler and bitumen that are required.