King Saud University
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Civil Engineering Department

CE 431: Highway Engineering
Tutorial Note 7: Chapter 19
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19-1 Given below are the requirements f a specification related to the grading of the mineral aggregates in an asphaltic concrete mixture and the sieve analysis of two aggregates (A and B) that are economically available for this use. Determine the range of blends of aggregate A and B that will produce a combined aggregate that will meet the limits of specification and given the gradings of aggregate combinations selected.

		Percentage passing (by weight)	
Sieve Designation	***Mix***	***Aggregate A***	***Aggregate B***
1 in.	**100**	**100**	**---**
¾ in.	**95 – 100**	**95**	**100**
3/8 in.	**60 – 75**	**72**	**76**
No. 4	**40 – 55**	**54**	**52**
No. 10	**30 – 40**	**43**	**35**
No. 40	**12 – 22**	**27**	**17**
No. 200	**3 – 6**	**8**	**4**

Let x = fraction of A; (1- x) = fraction of B

Consider the No. 200 fraction:

(x) 8 + (1 - x) 4 = 3 ➔ x = negative

(x) 8 + (1 - x) 4 = 6 ➔ x = 2/4 = 0.5

Consider the No. 40 fraction:

(x) 27 + (1 - x) 17 = 12 ➔ x = negative

(x) 27 + (1 - x) 17 = 22 ➔ x = 5/10 = 0.5

Choose fraction of A = 0.5 ➔ fraction of B = 0.5 and check the blend.

					Blend		
Sieve Designation	*Mix*	*Aggregate A*	*Aggregate B*	*A*	*B*	*Blend*	*Check*
1 in.	100	100	---	100	---	100	✓
¾ in.	95 – 100	95	100	47.5	50	97.5	✓
3/8 in.	60 – 75	72	76	36	38	74	✓
No. 4	40 – 55	54	52	27	26	53	✓
No. 10	30 – 40	43	35	21.5	17.5	39	✓
No. 40	12 – 22	27	17	13.5	8.5	22	✓
No. 200	3 – 6	8	4	4	2	6	✓

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19-2 A design is being prepared for an asphalt concrete paving mixture. The following ingredients are to be used in the preparation of a trial mixture:

	Percentage of total mix by weight	Specific gravity
Coarse aggregate	**55.0**	**2.611 (bulk)**
Fine aggregate	**31.0**	**2.690 (bulk)**
Mineral filler	**7.0**	**3.100**
Asphalt cement	**7.0**	**1.030**

By ASTM D2041, the maximum specific gravity of the paving mixture G_{mm} = 2.478, and by ASTM D2726, the bulk specific gravity of the compacted paving mixture sample G_{mb} = 2.384. Compute the percentage of voids in the compacted mineral aggregate and the percentage of voids in compacted mixture. What percentage of the air voids are filled with asphalt?

Required VMA =? Pa =? VFA =?

by equation 19-6,

$$VMA = 100 - \frac{G_{mb}P_s}{G_{sb}}$$

by equation 19-2,

$$G_{sb} = \frac{P_1 + P_2 + P_3}{\frac{P_1}{g_1} + \frac{P_2}{g_2} + \frac{P_3}{g_3}} = \frac{55 + 31 + 7}{\frac{55}{2.611} + \frac{31}{2.69} + \frac{7}{3.1}} = 2.669$$

Substitute in equation 19-6,

$$VMA = 100 - \frac{2.384 \times 93}{2.669} = 16.93\%$$

By equation 19-7,

$$P_a = 100\frac{G_{mm} - G_{mb}}{G_{mm}} = 100 \times \frac{2.478 - 2.384}{2.478} = 4.2\%$$

By equation 19-8,

$$VFA = \frac{100(VMA - V_a)}{VMA} = \frac{100 \times (16.93 - 4.2)}{16.93} = 75\%$$

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19-3 A sample cut from completed pavement constructed by using the mix of Problem 19-2 weighs 3,538 g in air and 1,960 g in water. Compare the density obtained in the field with that of a laboratory-compacted specimen of the same mixture. Has the rolling processes achieved a satisfactory degree of density in this case?

By equation 19-1, for the field specimen

$$G_{mb} = \frac{W_a}{W_a - W_w} = \frac{3538}{3538 - 1960} = 2.242$$

For the lab. specimen, G_{mb} given = 2.384

$$\% \, compaction = \frac{G_{mb}(field)}{G_{mb}(lab.)} = \frac{2.242}{2.384} = 0.94 = 94\%$$

for a surface course, the compaction should be not less than 95% of the laboratory compacted density. Therefore, the rolling processes was not satisfactory.

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19-4 A bituminous mix has 47.4% coarse aggregate and 47.3% fine aggregate. The bulk specific gravity of the coarse aggregate is 2.716 and of the fine aggregate is 2.689. There is no mineral filler. The asphalt content is 5.3% and its specific gravity is 1.03. the maximum specific gravity of the paving mix, Gmm, is 2.535 and the bulk specific gravity of the compacted mix, Gmb, is 2.442. Calculate the voids in mineral aggregate, the percentage of air voids in the mix, and the percentage of voids filled with asphalt.

by equation 19-2,

$$G_{sb} = \frac{P_1 + P_2 + P_3}{\frac{P_1}{g_1} + \frac{P_2}{g_2} + \frac{P_3}{g_3}} = \frac{47.4 + 47.3}{\frac{47.4}{2.716} + \frac{47.3}{2.689}} = 2.703$$

Substitute in equation 19-6,

$$VMA = 100 - \frac{G_{mb}P_s}{G_{sb}} = 100 - \frac{2.442 \times 94.7}{2.703} = 14.4\%$$

By equation 19-7,

$$P_a = 100\frac{G_{mm} - G_{mb}}{G_{mm}} = 100 \times \frac{2.535 - 2.442}{2.535} = 3.7\%$$

By equation 19-8,

$$VFA = \frac{100(VMA - V_a)}{VMA} = \frac{100 \times (14.4 - 3.7)}{14.4} = 74.3\%$$

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19-6 In a certain city, the average maximum pavement temperature over the hottest seven-day period was 50°C with a standard deviation of 2°C. The average one-day low pavement temperature was –12°C with standard deviation of 4°C. What performance grade asphalt binder should be used to provide a reliability of 98 percent?

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standard deviation of 2°C ➔ average max = 50 ± 2 = 52 °C

standard deviation of 4°C ➔ average low =– 12 ± 4 = – 16°C

reliability of 98 percent!

Recommended grade is PG 58 – 22.

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19-7 Suppose a traffic level of 20,000,000 ESAL is anticipated and slow-moving design loads are expected to occur. What performance grade asphalt binder should be chosen in Problem 19-6?

- If slow-moving loads are anticipated, the binder grade should be selected one high-temperature grade. (one grade warmer).
- If high level of traffic is expected, 20,000,000 which is between (10,000,000 and 30,000,000), the binder grade should be selected one high-temperature grade to the right. (one grade warmer) than the one based on climate.

➔ Choose PG 70 – 22.

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