TRANSPORTATION ENGINEERING I – REVISION

MARSHALL STABILITY TEST

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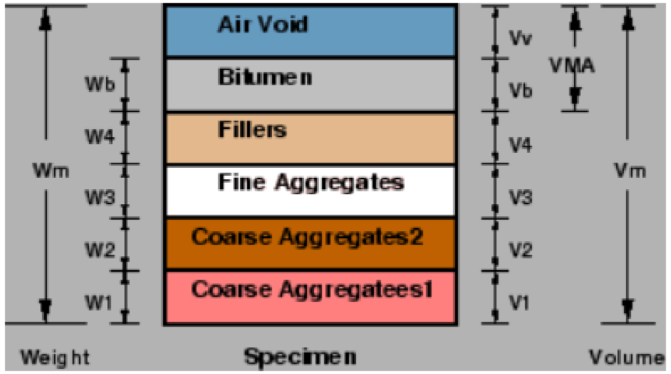
Properties of the mix

The properties that are of interest include the theoretical specific gravity G_t, the bulk specific gravity of the mix G_m, percent air voids V_v, percent volume of bitumen V_b, percent void in mixed aggregate VMA and percent voids filled with bitumen VFB. These calculations are discussed next. To understand these calculation a phase diagram is given in Figure 2.



Theoretical specific gravity of the mix G_t

Theoretical specific gravity G_t is the specific gravity without considering air voids, and is given by:

$$G_t = \frac{W_1 + W_2 + W_3 + W_b}{\frac{W_1}{G_1} + \frac{W_2}{G_2} + \frac{W_3}{G_3} + \frac{W_b}{G_b}} \quad (1)$$

where, W_1 is the weight of coarse aggregate in the total mix, W_2 is the weight of fine aggregate in the total mix, W_3 is the weight of filler in the total mix, W_b is the weight of bitumen in the total mix, G_1 is the apparent specific gravity of coarse aggregate, G_2 is the apparent specific gravity of fine aggregate, G_3 is the apparent specific gravity of filler and G_b is the apparent specific gravity of bitumen,

Bulk specific gravity of mix G_m

The bulk specific gravity or the actual specific gravity of the mix G_m is the specific gravity considering air voids and is found out by:

$$G_m = \frac{W_m}{W_m - W_w} \tag{2}$$

where, W_m is the weight of mix in air, W_w is the weight of mix in water, Note that $W_m - W_w$ gives the volume of the mix. Sometimes to get accurate bulk specific gravity, the specimen is coated with thin film of paraffin wax, when weight is taken in the water. This, however requires to consider the weight and volume of wax in the calculations.

Air voids percent V_v

Air voids V_v is the percent of air voids by volume in the specimen and is given by:

$$V_v = \frac{(G_t - G_m)100}{G_t} \qquad (3)$$

where G_t is the theoretical specific gravity of the mix, given by equation 26.1. and G_m is the bulk or actual specific gravity of the mix given by equation 26.2.

Percent volume of bitumen V_b

The volume of bitumen V_b is the percent of volume of bitumen to the total volume and given by:

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}} \quad (4)$$

where, W_1 is the weight of coarse aggregate in the total mix, W_2 is the weight of fine aggregate in the total mix, W_3 is the weight of filler in the total mix, W_b is the weight of bitumen in the total mix, G_b is the apparent specific gravity of bitumen, and G_m is the bulk specific gravity of mix given by equation 26.2.

Voids in mineral aggregate VMA

Voids in mineral aggregate VMA is the volume of voids in the aggregates, and is the sum of air voids and volume of bitumen, and is calculated from

$$VMA = V_v + V_b \qquad (5)$$

where, V_v is the percent air voids in the mix, given by equation 26.3. and V_b is percent bitumen content in the mix, given by equation 26.4. (4).

Voids filled with bitumen VFB

Voids filled with bitumen VFB is the voids in the mineral aggregate frame work filled with the bitumen, and is calculated as:

$$VFB = \frac{V_b \times 100}{VMA} \tag{6}$$

where, V_b is percent bitumen content in the mix, given by equation 26.4. and VMA is the percent voids in the mineral aggregate, given by equation 26.5.

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super elevation for a national highway.

b) A specimen of asphaltic concrete has height of 6.35cm & diameter 10.2cm. The weights of compacted specimen in air & water are 1180.5m & 678.6gm respectively. The analysis of the specimen yielded the following. 7

Material	Bulk specific gravity	Mix composition (% wt. of mix)	Aggregate composition(%by of total aggregates)
Bitumen	1.02	6	
Course aggregate	2.6	54	55.3
Fine aggregate	2.72	33.5	36.8
Mineral filler	2.7	6.5	7.9
	Total	100	100

Calculate;

i) Bulk density of specimen from dimension & immersion test
ii) Air voids percentage in compacted mix
iii) VMA
iv) VFB

Given,

Height of specimen (H) = 6.35 cm

Diameter of specimen (D) = 10.2 cm

Weight of compacted specimen in air (W_m) = 1180.5 gm

Weight of compacted specimen in water (W_w) = 678.60 gm

Calculation of volume

Volume of specimen (V) = $\frac{\pi D^2}{4} * H$

Volume of specimen (V) = $\frac{\pi * 10.2^2}{4} * 6.35$

Volume of specimen (V) = 518.61 cm^3

i) Bulk density (in air) = $\frac{W_m}{V} = \frac{1180.50}{518.61}$ = 2.27 gm/cm^3

ii) Bulk density (in water) = $\frac{W_w}{V} = \frac{678.60}{518.61}$ = 1.31 gm/cm^3

Bulk specific gravity of the compacted mix

$G_m = \frac{W_m}{W_m - W_w}$

$G_m = \frac{1180.50}{1180.50 - 678.60}$

G_m = 2.35 gm/cm^3

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where, W_1 is the weight of coarse aggregate in the total mix, W_2 is the weight of fine aggregate in the total mix, W_3 is the weight of filler in the total mix, W_b is the weight of bitumen in the total mix, G_1 is the apparent specific gravity of coarse aggregate, G_2 is the apparent specific gravity of fine aggregate, G_3 is the apparent specific gravity of filler and G_b is the apparent specific gravity of bitumen,

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Theoretical specific gravity, $G_t = \frac{54+33.50+6.50+6}{\frac{54}{2.60}+\frac{33.50}{2.72}+\frac{6.50}{2.70}+\frac{6}{1.02}} = \frac{100}{41.37} = 2.42\ gm/cm^3$

Air voids percent V_v

Air voids V_v is the percent of air voids by volume in the specimen and is given by:

$$V_v = \frac{(G_t - G_m)100}{G_t} \quad (3)$$

where G_t is the theoretical specific gravity of the mix, given by equation 26.1. and G_m is the bulk or actual specific gravity of the mix given by equation 26.2.

Air voids percentage in compacted mix,

$$V_v = \frac{G_t - G_m}{G_t} * 100$$

$$V_v = \frac{2.42 - 2.35}{2.42} * 100$$

$$V_v = 2.89\%$$

$$VMA = V_v + V_b$$

$$V_b = \frac{\frac{W_b}{G_b}}{\frac{W_1+W_2+W_3+W_b}{G_m}}$$

$$VFB = \frac{V_b \times 100}{VMA}$$

$$V_b = \frac{\frac{6}{1.02}}{\frac{100}{2.35}} = 13.82\ \%$$

$$VMA = V_v + V_b = 2.89 + 13.82 = 16.71\%$$

$$VFB = \frac{13.82}{16.71} * 100$$

$$VFB = 82.70\%$$

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