# Marshal Mix Design

By Emran Migdadi

- ** > **Our goal is to find the Optimum Asphalt Content.**
- To find it, we have to draw 6 graphs :
- A) Stability (Max load applied before failure) > معطى بالسؤال
- B) Flow ( Deformation due to compaction) > معطى بالسؤال
- C) Air-Content ( $P_a$ or $P_{av}$ )
- D) ( γ )
- E) VMA ( Voids in Mineral Aggregate ) هي المساحة بين الحبيبات التي يشغلها الأسفلت والهواء
- F) VFA (Voids filled with Asphalt) هي المساحة بين الحبيبات التي يشغلها الأسفلت فقط

- Before we draw the past graphs, we need to calculate the following:-

- 1) $G_{mb}$ > Bulk specific gravity of the <u>Mixture</u>

$$G_{mb} = \frac{Dry\ weight}{\text{SSD} - Submerged}$$

OR

$$G_{mb} = \frac{Weight\ of\ sample}{Volume\ of\ sample}$$

<u>اوجدها لكل نسبة اسفلت</u>

*Note :- water absorption = 0 >> means SSD = Dry weight

- 2) Gsb > Bulk specific gravity of the <u>solids</u> ( Aggregates )

$$\bullet\ G_{sb} = \frac{Ps}{\frac{Pca}{Gca}+\frac{Pfa}{Gfa}+\frac{Pmf}{Gmf}}$$

<u>اوجدها لكل نسبة اسفلت</u>

- Ps : Percent of total solids (Course + Fine + Miners), if Asphalt is 5.5%, then Ps = 94.5%
- Pca : Percent of the course aggregate = % (given) * Ps
- Pfa : Percent of the fine aggregate = % (given) * Ps
- Pmf: Percent of the miners aggregate = % (given) * Ps
- Gca, Gfa and Gmf are specific gravities of course, fine and miners ( given )

- 3) Gmm > Max specific gravity of the <u>Mixture ( Also called Rice S.G )</u>

$$\bullet\ G_{mm} = \frac{100}{\frac{Ps}{Gse} + \frac{Pb}{Gb}}$$

- Or

$$G_{mm} = \frac{Wt_{mix-loose}}{Wt_{pyc+w1} + Wt_{loose} - Wt_{pyc+w2+mix}}$$

لا تركز عليه كثير

<u>اوجدها لكل نسبة اسفلت</u>

- Pb : Percent of bitumen ( Asphalt ), 5.5 or 6 or 6.5 or 7 or 7.5
- Ps : Percent of total solids ( Aggregates ) = 100 – Pb
- Gse : effective specifc gravity of aggregates > ( given )
- Gb : Specific gravity of the bitumen > given.

- $G_{se}$ > effective specific gravity of aggregates.
- *** In case the question asks for Gse while Gmm is given :-

$$\bullet\, Gse = \frac{Ps}{\frac{100}{Gmm} - \frac{Pb}{Gb}}$$

Pb = % of asphalt by total wt. of mixture

Gmm = Max. theoretical S.G (Rice S.G )

Gb = Gasp = S.G. of asphalt

- Now for the graphs essentials ;-

- 1) Air-Content ( Pa or Pav ) > لكل نسبة اسفلت

$$\bullet\ P_{av} = \left|1 - \frac{Gmb}{Gmm}\right| * 100$$

*2) ($\gamma$) > لكل نسبة اسفلت

$$\gamma_{mix} = \gamma_{mb} = G_{mb}\gamma_{w}$$

OR

$$= \frac{Wt_{asp} + Wt_{agg}}{V_{asp} + V_{agg-se} + V_{air}}$$

لا تركز عليه كثير

** Density of water = 1000 kg/ m^3 (62.4 lb/ft^3)

- 3) VMA > لكل نسبة اسفلت

$$\bullet VMA = \left|1 - \frac{Gmb * Ps}{Gsb}\right| * 100$$

- 4) VFA > لكل نسبة اسفلت

$$\bullet VFA = \left|\frac{VMA - Pav}{VMA}\right| * 100$$

- 5) Stability & 6) Flow are given

- ** After you find the past numbers for all asphalt ratios, draw them

Then, find the asphalt content at ( from graphs ) :-

1) Air-content = 4%

2) Max Stability

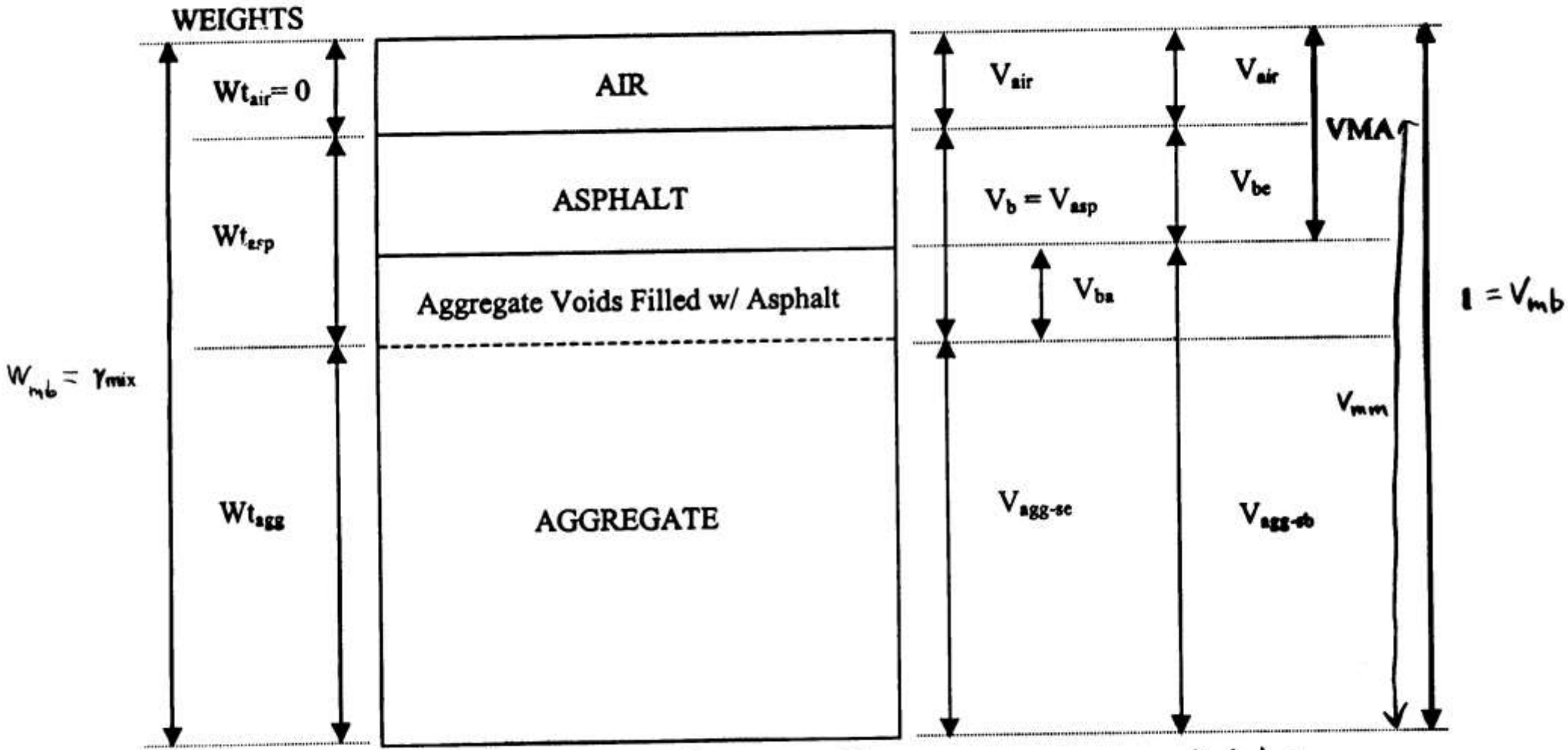
3) Max ( γ )

>> Then, Calculate the average for the 3 numbers.

Now : find the stability, flow, Pav, VMA & VFA for the average number you found, then make sure these numbers meet the specifications ( given )

>> if they don't meet the specifications >> FIX IT ( رح نشوف كيف بالحل )

# WEIGHT-VOLUME RELATIONSHIPS FOR ASPHALT CONCRETE




given $\gamma_{mix}$, % a.c. ⟶ weights

to convert to volumes ⟶ $G_{sb-od}$, $G_{se}$, $G_{mm}$, $G_{asp}$

** يمكن حساب هذه القوانين بأكثر من صيغة, ارجع للرسمه الي قبل ^ ^

- Volume of Asphalt = $V_b = \frac{Wt\ of\ asphalt}{Gb * \gamma_w}$
- Volume of Agg.se ( effective ) = $\frac{Wt\ of\ aggregate}{Gse * \gamma_w}$
- Volume of Agg.sb ( bulk ) = $\frac{Wt\ of\ aggregate}{Gsb * \gamma_w}$
- Volume of Bitumen Absorbed ( $V_{ba}$ ) = $V_{agg.sb} - V_{agg.se}$ OR = Vb – Vbe OR.. ?
- Volume of Bitumen effective ( $V_{be}$ ) = $V_b - V_{ba}$ OR = VMA – Va OR… ?
- Effective Asphalt ($P_{be}$) = $P_b - \frac{P_{ba} * Ps}{100}$

Note >>$P_{ba}$ is the absorbed asphalt, while $P_{be}$ is the NOT absorbed asphalt

# EXAMPLE

**Q3. (13 pts)** The aggregate mix used for the design of an asphalt mixture consists of 42% coarse aggregates, 51% fine aggregates, and 7% mineral fillers. If the respective bulk specific gravities of these materials are 2.60, 2.71, and 2.69, and the effective specific gravity of the aggregates is 2.82, **determine the optimum asphalt content as a percentage of the total mix (using asphalt institute procedure),** if results obtained using the Marshall method are shown in the following table. The specific gravity of the asphalt is 1.02.

*Notes:*

i. *Consider weight (SSD) same as weight in air.*
ii. *Consider the mixture will be designed to serve a medium traffic.*
iii. *The nominal max aggregate size that was used in the mix is (½").*

| % Asphalt | Wt. in air (g) | Wt. in water (g) | Stability (lb.) | Flow (0.01 in) |
|---|---|---|---|---|
| 5.5 | 1325.3 | 785.6 | 1796 | 13 |
| 6.0 | 1330.1 | 793.3 | 1836 | 14 |
| 6.5 | 1336.2 | 800.8 | 1861 | 16 |
| 7.0 | 1342.0 | 804.5 | 1818 | 20 |
| 7.5 | 1347.5 | 805.1 | 1701 | 25 |

***Table: Marshall Limits***

| *Traffic Level* | *Light Traffic* $ESAL < 10^4$ | *Medium Traffic* $10^4 < ESAL < 10^6$ | *Heavy Traffic* $ESAL > 10^6$ |
|---|---|---|---|
| *Compaction* | *35* | *50* | *75* |
| *Stability N (lb.)* | *3336 (750)* | *5338 (1200)* | *8006 (1800)* |
| *Flow, 0.25 mm (0.01 in)* | *8 to 18* | *8 to 16* | *8 to 14* |
| *Air Voids, %* | *3 to 5* | *3 to 5* | *3 to 5* |
| *(VFA) [some agencies]* | *70 to 80* | *65 to 78* | *65 to 75* |

- Solution:-

- Given :-
- 1) % Ca = 42%. 2) % Fa = 51% 3)% Miners = 7% 4) Gse = 2.82
- 5) Gca = 2.6 6) Gfa = 2.71 7) Gmf = 2.69 8) Gb = 1.02

>>> Calculations for Asphalt 5.5%

1) Gmb = $\frac{Dry\ weight}{SSD - Submerged}$ , but SSD = Dry weight ( given in question )

$$= \frac{1325.3}{1325.3 - 785.6}$$

$$= \underline{2.46}$$

2) $G_{mm} = \frac{100}{\frac{Ps}{Gse} + \frac{Pb}{Gb}}$

Pb = 5.5 % , Ps = 100 – 5.5 = 94.5

$= \frac{100}{\frac{94.5}{2.82} + \frac{5.5}{1.02}} = \underline{2.57}$

3) $G_{sb} = \frac{Ps}{\frac{Pca}{Gca} + \frac{Pfa}{Gfa} + \frac{Pmf}{Gmf}}$

$= \frac{94.5}{\frac{0.42*94.5}{2.6} + \frac{0.51*94.5}{2.7} + \frac{0.07*94.5}{2.69}} = \underline{2.66}$

- Now :-

$$1)\ Pav = \left|1 - \frac{Gmb}{Gmm}\right| * 100$$

$$= \left|1 - \frac{2.46}{2.57}\right| * 100 = \underline{4.28}$$

2) γ = Gmb * 62.4

= 2.46 * 62.4 = <u>153.5</u>

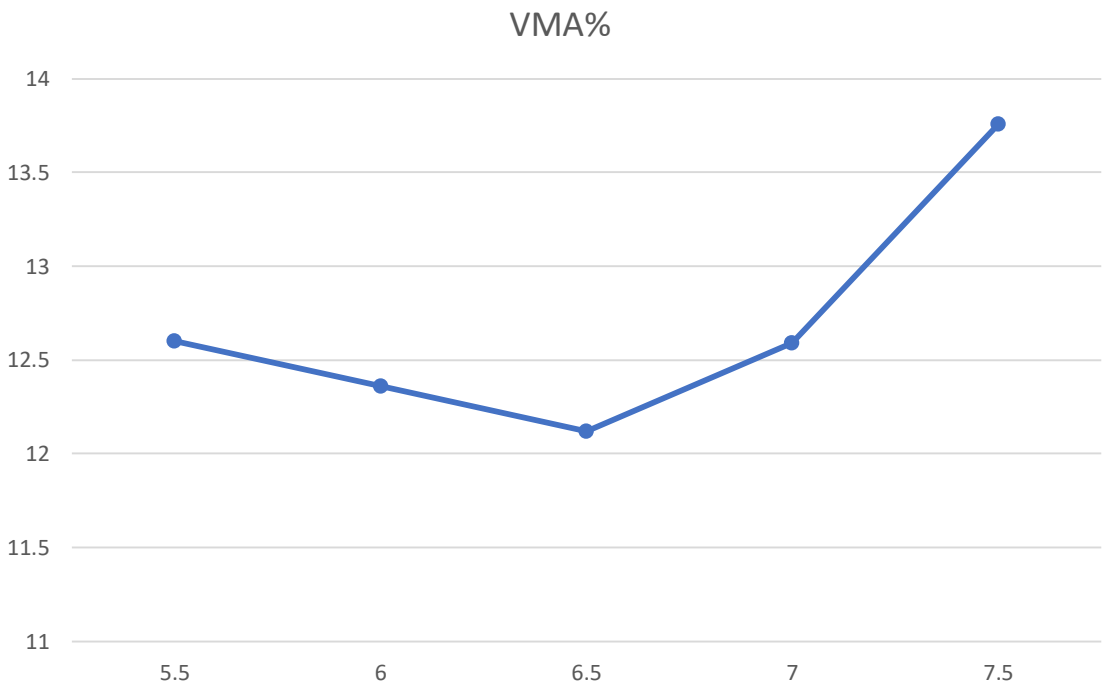
3) $VMA = \left|1 - \frac{Gmb * Ps}{Gsb}\right| * 100$

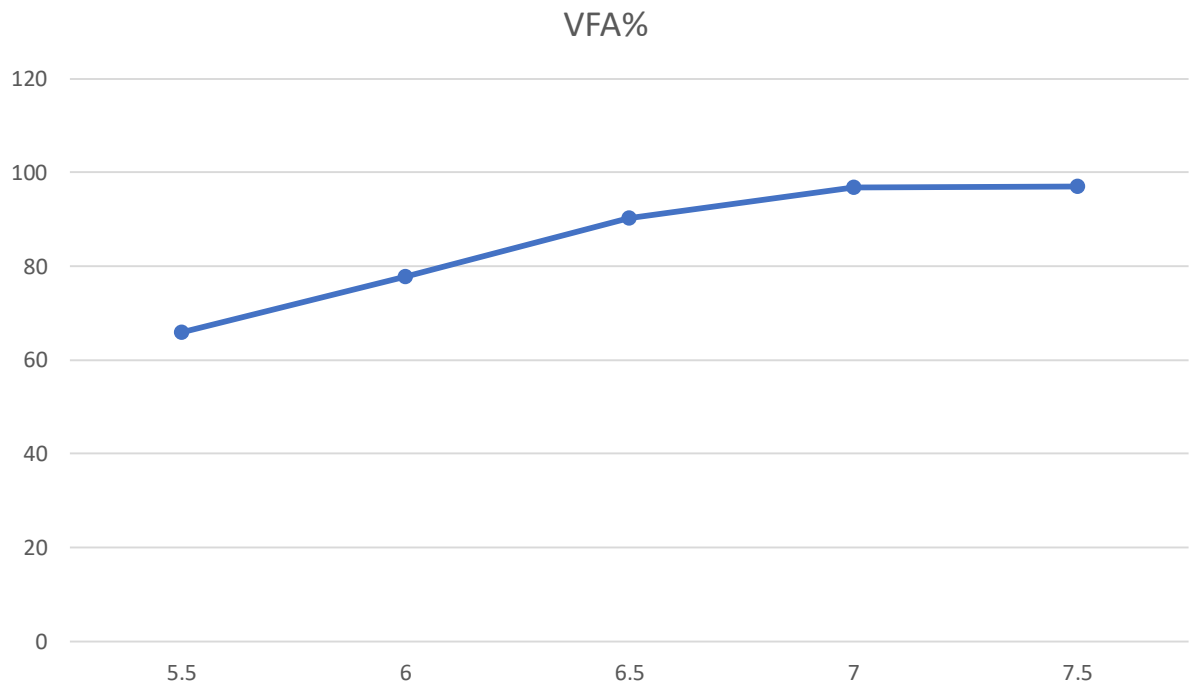
$= \left|1 - \frac{2.46 * 94.5}{2.66}\right| * 100 = \underline{12.6}$

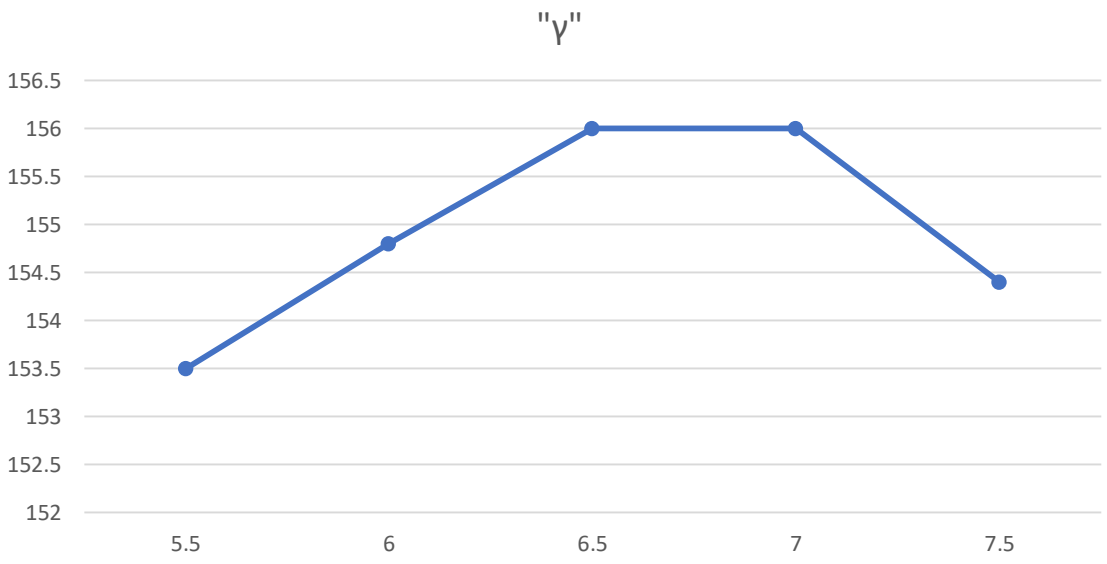
4) $VFA = \left|\frac{VMA - Pav}{VMA}\right| * 100$

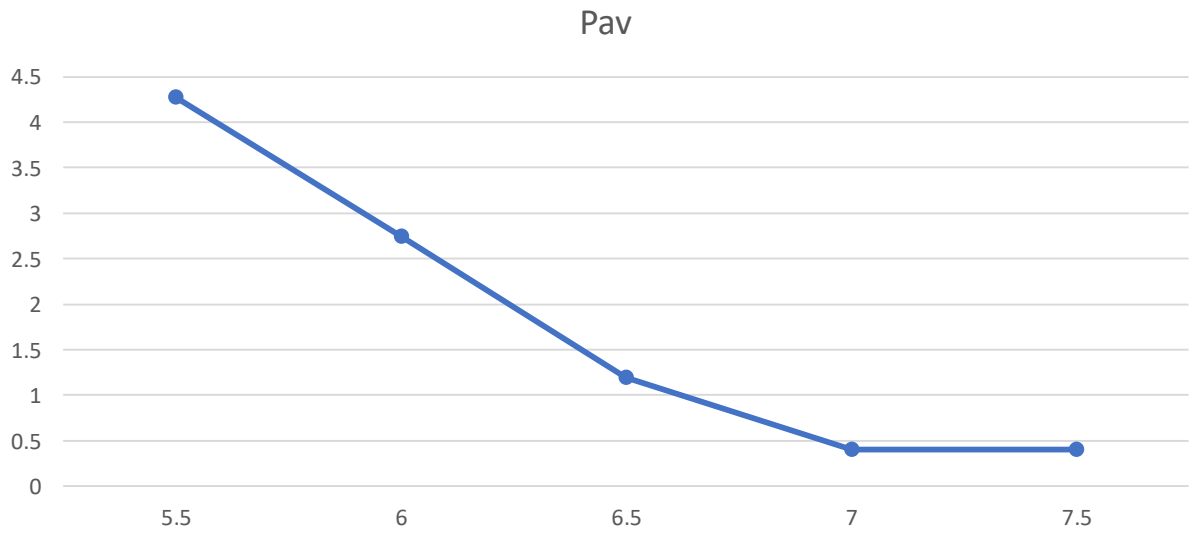
$= \left|\frac{12.6 - 4.28}{12.6}\right| * 100 = 66\%$

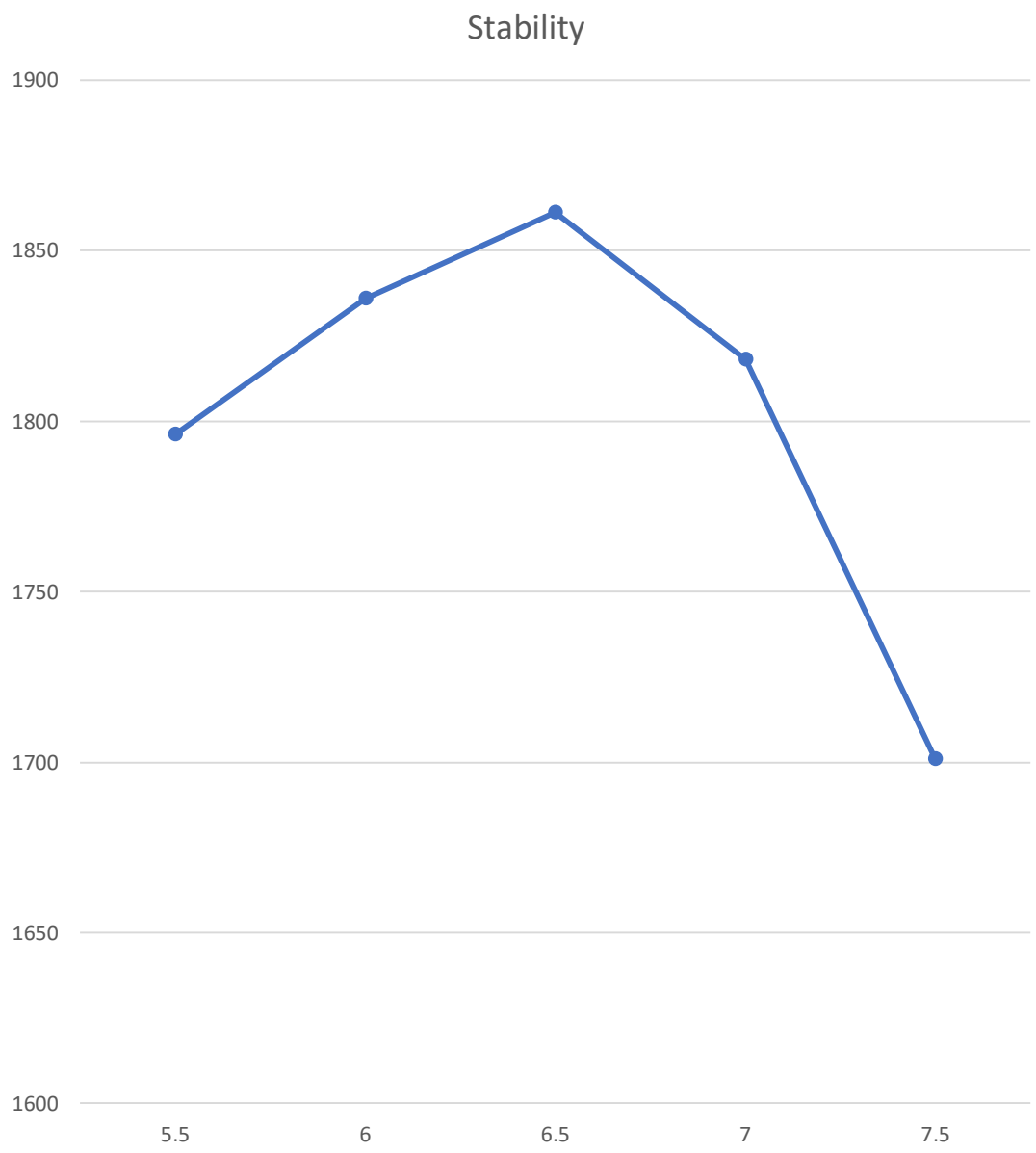
| Asphalt | Gmb | Gmm | Pav% | VMA% | VFA% | γ | Stability (given) | Flow (given) |
|---|---|---|---|---|---|---|---|---|
| 5.5 | 2.46 | 2.57 | 4.28 | 12.6 | 66 | 153.5 | 1796 | 13 |
| 6.0 | 2.48 | 2.55 | 2.75 | 12.36 | 77.75 | 154.8 | 1836 | 14 |
| 6.5 | 2.5 | 2.53 | 1.19 | 12.12 | 90.18 | 156 | 1861 | 16 |
| 7.0 | 2.5 | 2.51 | 0.4 | 12.59 | 96.88 | 156 | 1818 | 20 |
| 7.5 | 2.48 | 2.49 | 0.4 | 13.76 | 97 | 154.4 | 1701 | 25 |

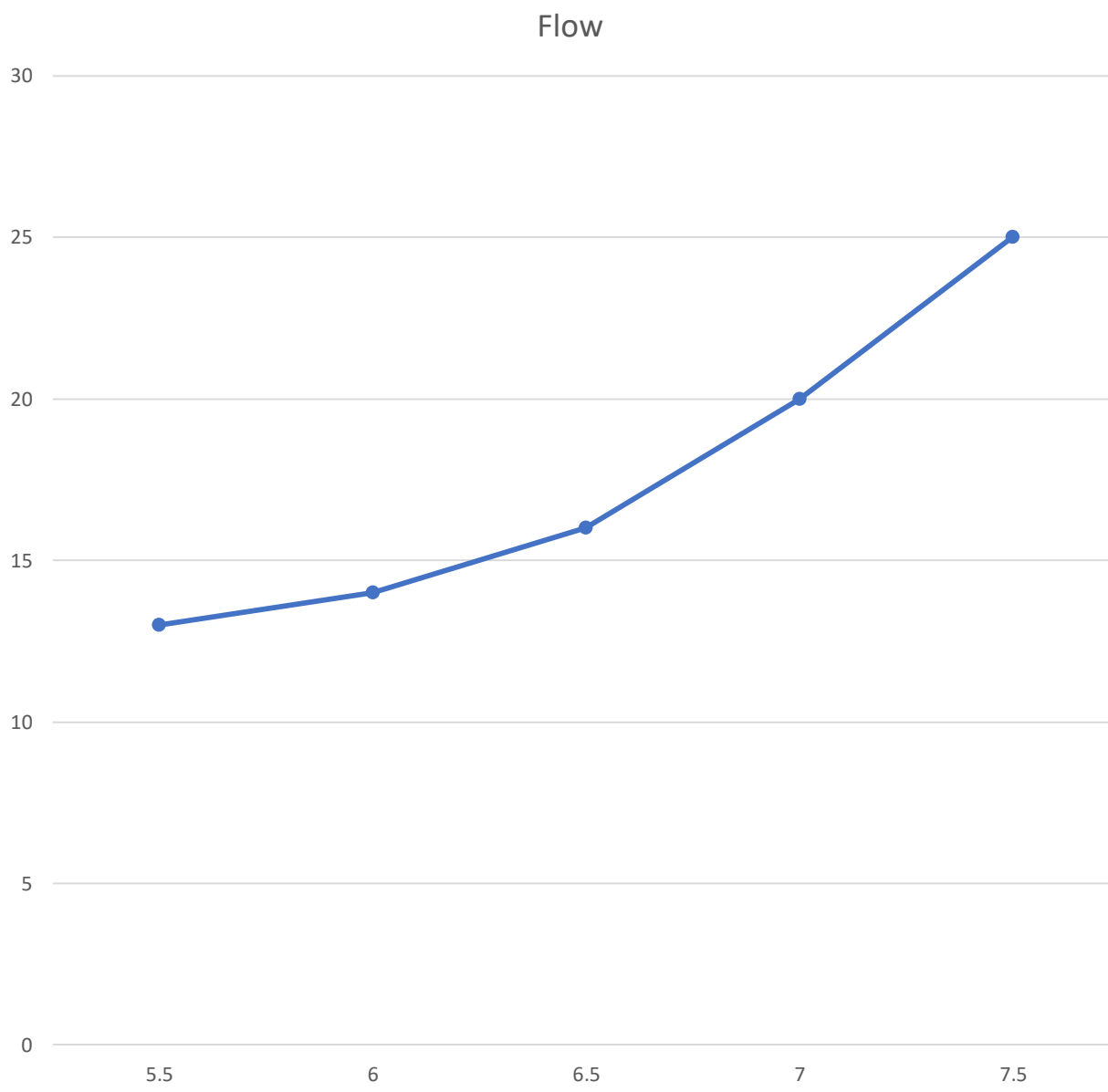

VMA%
14
13.5
13
12.5
12
11.5
11
5.5
6
6.5
7
7.5


VFA%
120
100
80
60
40
20
0
5.5
6
6.5
7
7.5


"γ"
156.5
156
155.5
155
154.5
154
153.5
153
152.5
152
5.5
6
6.5
7
7.5


Pav
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
5.5
6
6.5
7
7.5


Stability
1900
1850
1800
1750
1700
1650
1600
5.5
6
6.5
7
7.5


Flow
30
25
20
15
10
5
0
5.5
6
6.5
7
7.5

- Now,

1 ) Max stability at Ac= 6.5%

2) Max γ at Ac= 6.5%

3) At 4% Pa > Ac = 5.6%

$$Average\ Ac = \frac{6.5+6.5+5.6}{3} = 6.2\%$$

At Ac 6.2% > 1) Pav = 2.3% 2) Stability = 1850 3) flow= 14

4) γ = 155 5) VMA = 12.3% 6) VFA = 84%

*** Pav is less than the specification ( 3 – 5 ) >> then take Pav = 3%

- At Pav = 3% >> Ac = 5.9%

- - At Ac = 5.9%
- 1) Stability = 1830
- 2) Flow = 14
- 3) VFA = 75%
- 4) VMA = 12.4
- 5) γ = 154.5

Done.

- Ex2:- The weight and volume of a sample of Marshall hot mix Asphalt was found to be 1100gm and 475(cm^3) respectively, and the maximum S.G of the sample is 2,406, the asphalt content and specific gravity is 4% and 1,05 respectively. Assume the **absorption of asphalt in the aggregates is zero**, find the following :-

- 1) Volume of air voids
- 2) Volume of asphalt
- 3) Volume of aggregates
- 4) VMA
- 5) VFA

- **Solution:-**
- - Given >>  * Gmm = 2,406 | Ac%=4% | Gb = 1,05 |Weight = 1100gm| Volume = 475(cm^3) | absorption = 0

- 1) Va = Pav * Volume of Sample

> Pav = $\left|1 - \frac{Gmb}{Gmm}\right|$ * 100

– $G_{mb} = \frac{Weight\ of\ sample}{Volume\ of\ sample} = \frac{1100}{475}$ = 2.316

> Pav = $\left|1 - \frac{2,316}{2,406}\right|$ * 100 = <u>3.74 %</u>

➢ Va = 0.0374 * 475 = **17,765** (cm^3)

- **2)** $V_b = \frac{Wt\ of\ asphalt}{Gb * \gamma_w}$

- Wt of asphalt = 1100 * 0.04 = 44gm

>> $V_b = \frac{44}{1{,}05 * 1} = \underline{41.9}$

- **3)** $V_{agg} = \frac{Wt\ of\ agg}{Gsb * \gamma_w}$ ** Gse = Gsb ( absorption = 0 )

- $Gse = \frac{Ps}{\frac{100}{Gmm} - \frac{Pb}{Gb}} = \frac{96}{\frac{100}{2{,}406} - \frac{4}{1{,}05}} = \underline{2.543}$
- Wt of agg = Total weight – Bitumen weight = 1100 – (1100 * 0.04 ) = <u>1056</u>

>> $V_{agg} = \frac{1056}{2.543 * 1} = \underline{415.25}$

- **4)** $\boldsymbol{VMA} = \left|1 - \frac{Gmb * Ps}{Gsb}\right| * 100$

$>> VMA = \left|1 - \frac{2.316 * 0.96}{2,543}\right| * 100 \quad = \quad \underline{12,57\%}$

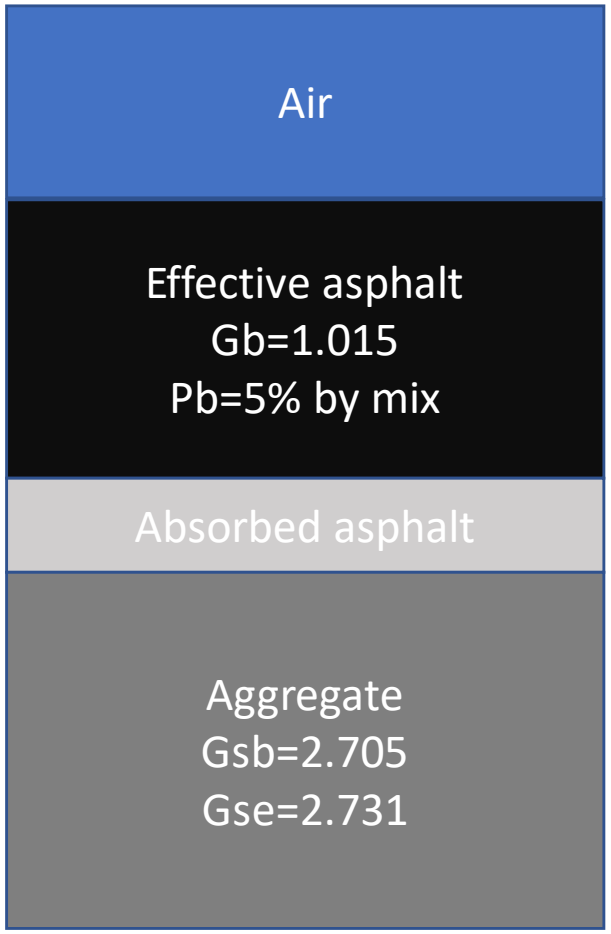
- **5)** $\boldsymbol{VFA} = \left|\frac{VMA - Pav}{VMA}\right| * 100$

- $>> VFA = \left|\frac{12,57 - 3,74}{12,57}\right| * 100 \quad = \quad \underline{70.25\%}$

- Done

*Ex3*:- The Component diagram shows five properties ( four specific gravities and the asphalt content ) of a compacted specimen of HMA that has total volume of 500(cm^3) measured at 25C. Using only these values, find the **volumetric** properties :- **VMA**, **Va**, **V effective asphalt**, **V absorbed asphalt**, **VMM**.

Gmb=2.329



- Solution:-
- **1)** $\boldsymbol{VMA} = \left|1 - \frac{Gmb * Ps}{Gsb}\right| * 100$
- - $= \left|1 - \frac{2.329 * 0.95}{2.705}\right| * 100 = \underline{18.2\%}$

>> VMA as volume = 18.2% * 500 = **91.02(cm^3)**

**2) Pav** $= \left|1 - \frac{Gmb}{Gmm}\right| * 100$

- $G_{mm} = \frac{100}{\frac{Ps}{Gse} + \frac{Pb}{Gb}} = \frac{100}{\frac{95}{2.731} + \frac{5}{1.015}} = \underline{2.518}$
- $\text{Pav} = \left|1 - \frac{2.329}{2.518}\right| * 100 = \underline{7.506\%}$

>>Volume of air voids = 7.506% * 500 = **37.53(cm^3)**

- **3) Volume of effective asphalt (Vbe)** = VMA – Va

>> = 91.02 – 37.53 = **53.49(cm^3)**

- **4) Volume of absorbed asphalt (Vba)** = Vb – Vbe

- Vb = $\frac{weight\ of\ asphalt}{Gb * \gamma_w}$
- Weight of asphalt = Pb * Total weight
- Total weight = Vmb * Gmb * $\gamma_w$ = 500 * 2.329 *1= <u>1164.5g</u>
- Weight of asphalt = 0.05 * 1164.5 = <u>58.225g</u>
- Vb = $\frac{58.225}{1.015 * 1}$ = <u>57.364</u>

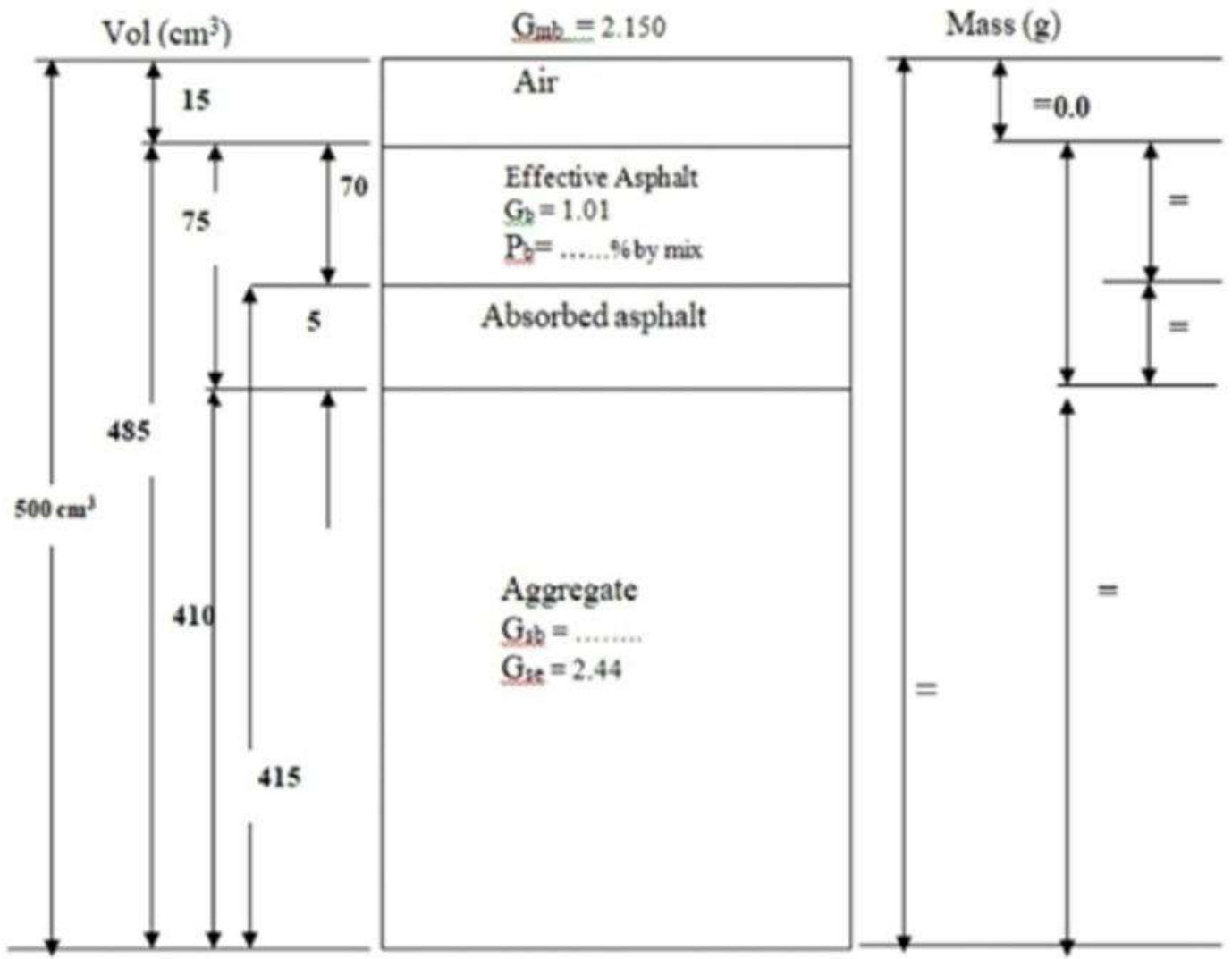
- >> Vba= 57.364 – 53.49 = **3.874(cm^3)**

- 5) Vmm = $\frac{Total\ weight}{Gmm * \gamma_w} = \frac{1164.5}{2.518}$ = **462.47(cm^3)**

- Or Vmm = Total volume – Volume of air = 500 – 37.53 = **462.47**

- **Done**

**EX4:** The Component diagram shows five properties ( four specific gravities and the asphalt content ) of a compacted specimen of HMA that has total volume of 500(cm^3) measured at 25C. Using only these values, Find **1) VFA**, **2) %asphalt by weight of mix**, **3) Max S.G of the mix**, **4)Bulk specific gravity of the aggregates**



- Solution:-
- **1)** $\boldsymbol{VFA} = \left|\frac{VMA - Pav}{VMA}\right|$*100

-- $VMA = \frac{15+70}{500}$ = 17%

-- Pav= $\frac{15}{500}$= 3%

>> $VFA = \left|\frac{0.17 - 0.03}{0.17}\right|$*100 = **82.353%**

**OR**

**VFA =** $\frac{70}{70+15}$*100 = **82.353%**

Note:- 70 is the effective asphalt volume, 15 is the volume of air ( ارجع لثاني سلايد لحتى تفهم )

- 2) % of asphalt = $\frac{weight\ of\ asphalt}{total\ weight}$*100
- - Total weight = 500 * 2.15 (Gmb) = 1075
- - Weight of asphalt = 75 * 1.01 (Gb) = 75.75

>> % of asphalt = $\frac{75.75}{1075}$*100 = **7.047%**

- 3) Gmm

- $P_{av} = \left|1 - \frac{Gmb}{Gmm}\right| * 100$

$0.03 = \left|1 - \frac{2.15}{Gmm}\right| * 100$ >> **Gmm = 2.216**

**OR**

**Gmm = $\frac{1075}{485}$ = 2.216**

بدون حجم الهواء

OR ?

- 4) $Gsb$

- $VMA = \left|1 - \frac{Gmb * Ps}{Gsb}\right| * 100$

➢ $17 = \left|1 - \frac{2.15 * (1 - 0.07047)}{Gsb}\right| * 100$ = **2.41**

➢ **OR ?**

- Done

** Questions:-

- 1. In Marshall stability test, the sample is compacted using a rammer giving
- **(a)50blows**
- (b)20blows
- (c)25blows
- (d)75blows

- 2. The Marshall flow value is expressed in units of
- (a)25mm
- **(b)2.5mm**
- (c)5mm
- (d)3mm

- 3. The Marshall mold size is:-
- (a) 4.5 inch Diameter x 2.5 Inch Height
- **(b) 4 inch Diameter x 2.5 Inch Height**
- (c) 5 inch Diameter x 2.0 Inch Height
- (d) 5.5 inch Diameter x 2.0 Inch Height

- 4. In Marshall Mix Design, the procedure is valid for max aggregate size of :-
- (a) 2 inch
- (b) 1.5 inch
- **(c) 1 inch**
- (d) 0.75 inch

- 5) The loading rate used to measure the Stability is :-
- **(a) (2 in/min).**
- (b) (2 in/sec).
- (c) (2.5 in/min).
- (d) (2.5 in/sec).

- 6) Number of specimens used in the Marshall Mix Design is:-
- (a) 15 specimens
- **(b) 18 specimens**
- (c) 13 specimens
- (d) 19 specimens

# اسئلة حفظ بكل المادة ( اختيار متعدد ) انا كتبت الجواب فقط

- 1 ) If a prime coat is to be sprayed on a granular silica gravel base course, what type of emulsified asphalt would you use ? CATIONIC
- 2) Asphalt cement with low penetration will have a HIGH viscosity , and can be used in HOT regions.
- 3) Bituminous materials are classified or graded based on it's CONSISTENCY
- 4) TACK COATES are single application of bituminous materials to an existing HMA
- 5) Highways and street pavements in Jordan are mainly made of Hot mix asphalt
- 6) Rounded, spherical and smooth > HIGH VOIDS
- 7) Angular, less spherical and rough > LOW VOIDS
- 8) Degree of compaction can be found for embankments using SAND CONE TEST and NUCLEAR GAUGES

- 9) Compaction of asphalt can only be achieved if mixture is confined and HEATED TO COMP TEMP
- 10 ) Plasticity Index (PI) indicated the range of moisture content over which the soil is in plastic condition
- 11) Apparent SG is the higher than Bulk SG and Effective S.G
- 12) Volatile solvents are mixed with asphalt cement to make a liquid asphalts that known as CUTBACKS
- 13 ) Solubility test of asphalt is one of the tests that are used to measure the PURITY of asphalt
- 14) Flash point of asphalt is one of the tests that are used to measure the DURABILITY of asphalt
- 15) The type of rigid pavements that has no joints is CRCP.
- 16) The type of rigid pavements that has no joints is JPCP

- 17) The type of rigid pavements that is used more for airports is PCP.
- 18) SEAL COAT is a thin asphalt surface treatment.
- 19) FULL DEPTH ASPALT pavements are constructed by placing one or more layers of HMA directly on the subgrade and used for heavy traffic.
- 20) Asphalt is LESS susceptible to temp than tar.
- 21) Tar is LESS susceptible to weathering than asphalt.
- 22) Asphalt CONSISTENCY can be controlled by the amount of heavy gas oil removed.
- 23) BLOWN ASPHALT is relatively stiff and not used as paving material, it is suitable as roofing material and joint filler for concrete pavements.
- 24) CUTBACK asphalts are less safer and more costly than EMULSIONS asphalts
- 25) If emulsified asphalt is to be used as a prime coat on a granular lime stone base coarse, then it must be of the ANIONIC type.
- 26) In addition to exposed surface area and age hardening, the factors influencing weathering of asphalt are OXIDATION , VOLATILAZATION, and TEMPERTURE.
- 27) The inherent factors that affect the rate of curing of cutback asphalts are VOLATILITY OF SOLVENT, QUANTITY OF SOLVENT and CONSISTENCY OF THE BASE MATERIAL.
- 28) In THIN FILM OVEN test, penetration is conducted before and after aging to measure asphalt hardening.
- 29) Original asphalts will have LOWER viscosity than residual asphalts

1)when preparing marshal specimens aggregate quantity can be adjusted using the formula ?

Q=(2.5/h1)*1150

2) number of compacted specimens in marshal mix design procedure is ?

15 specimens

3) ……. is the ratio of the weight in air of compacted bituminous paving mixture at a stated temperature to the weight of an equal volume of water?

Rice SG (theoretical max density)

4) ……..is the volume of intergranular space between the agg. Particles of a compacted potting mixture that includes the air voids and volume of the asphalt not absorbed into the agg.?

Voids in mineral agg (VMA)

5)……. asphalt is the asphalt portion that is available for coating , binding and filling voids ?

effective

6)……. defines the damage per pass on pavement by axle in question relative to the damage per pass of a standard axle load (80KN – 18Kips )?

EALF

7) defines the damage per pass on pavement by axle in question relative to the damage per pass of a standard axle load (80 KN – 18 Kips ) ……. And …….?

sand cone test

nuclear gauges

8) Compaction of asphalt can only be achieved if mixture is ……. And ……..?
confined
heated to compaction temp.

9)…… is the property of the compacted asphalt mixture to withstand the detrimental effects of air, water, and temp. changes ?
durability

10) ……is the property of the compacted asphalt mixture that enables it to withstand the stresses imposed on it by moving wheel loads ?
stability

11) mineral filler in HMA function as ……?
voids filling

12)design of hot asphalt mixture is known as …….?
Job mix formula ( JMF)

13)asphalt that have more viscous grades are recommended for ……. Traffic and …… eliminates ?
heavy
hot

14)marshal procedure is valid for max agg. Size of ……. Inch when using a ……. Inch diameter mold ?
1
4

15) marshal stability is conducted at temp of ……. And …….. rate of loading ?
60 C
2in/min

16) the marshal flow is measured in unit of …… mm ?
0.25

17) in asphalt institute procedure , the target optimum asphalt content = average asphalt content at ……. Air voids , max ……. ,and max …… ?
4%
stability
unit weight (density )

18) the type of pavement used in high ways and streets of Jordan is ……. Pavement ?
flexible

19) the available mix design methods differ in …….. and …… ?
compaction procedure
strength test

20)in marshal mix design if the mix has low voids and low stability , what adjustment may be recommender here ……..?
increase VMA by adding more course agg or reduce the asphalt content only if the asphalt is more than normal

21) in marshal mix design the case that require improvement of agg quality is when ……. ?
satisfactory voids & low stability

22) emulsified and low viscosity cut back asphalts are used to produce the following type of asphalt concrete mix …….?
cold mix , cold laid

1)Asphalt Cement with low softening point is expressed to have LOW viscosity, and used in Cold Regions .

2) Bituminous material are classified or graded based on

Consistency .

3) Doesn't Require the Penetration of asphalt into the underlying layer

Tack Coat .

4) The type of rigid Pavement that has No Joint (transversed)

CRCP .

5) load transfer Between transverse Joints in Rigid Pavements Slabs using

Dowels .

6) Pavement of Highways and Streets in Jordan are mainly

conventional .

7) Asphalt is different than tar in:

more resistance to weathering .

8) residual Asphalt ..... (AR) have viscosity than original Asphalt Cement .

AR Does Not exist .

9) if a VG 40 Asphalt will be tested for Penetration, what is the expected Penetration grade for this asphalt,

**40- 50** .

10) The Pavement type that is used more frequently for airport Pavements than for Highway Pavements because the layering of Thickness for airport Pavements is much Greater than for Highways.

**PCP**

11) Base Coarse use in rigid Pavements helps in increasing:

**drainage .**

13) The rigid Pavement type that will have more Joints than any other type

**JPCP** .

14) The rigid Pavement type that will have fewer Joints/ Km than any other types is

**CRCP.**

15) Seal Coat is Recomended to Be used when

**good night visibility** .

16) Cut back asphalt when compared to emulsified asphalt :

**Not cheaper , Not safer , less energy efficient** .

17) AC (85-100) means :

**Asphalt with pentration grade of 85-100 mm .**

18) Thin film oven test is a **Durability** Test for bitumen .

19) one of the following is not a durability test? **Solubility**

23) The factors influencing weathering of asphalt are :

**Oxidation , Volatilization , Surface area**

24) if emulsified asphalt is to be mixed in place with lime stone aggregate for maintenance and Patching purposes , then it must be **RS**

25) Emulsified and low viscosity cut back asphalt are used to produce the following type of asphalt mixes :

**Cold mix , Cold laid**

26) The Gradation that has few points of contact between The Particles , high permeability and poor interlock is

**Uniform .**

27) The property that Reflects the variation in the proportions of an aggregate particles is ?

**form**

28) Aggregate surface chemistry affects :

**mix durability .**

29)load transfer Between longitudinal Joints in Rigid Pavements using ?

**Ties only**

30) in a CBR test for subgrade soil material if the stress at 0.1 is 750 psi and at 0.2 = 1150 , the CBR value to be used for the material is? **Repeat test** .