PAVEMENT COMPONENTS

- The flexible pavement consists of surface-,base-,and subbase course. The surface course often composed of two or three layers from asphaltic concrete mixtures. Rigid pavements composed of surface course from Portland cement concrete layer, often lie on a base course.

Base courses

- -Aggregate gradations required for base courses:
- The base courses must be made according to a specified aggregate gradations to insure adequate stability under repeated loads.

Tab.7:AASHO grading requirements for soil-aggregate mixtures

Sieve Designation	% by weight passing square mesh sieve					
	Grading A	Grading B	Grading C	Grading D	Grading E	Grading F
2 in. (50mm)	100	100				
1 in. (25mm)		75 - 95	100	100	100	100
3/8in.(9.5mm)	30 -65	40 -75	50 -85	60 -100		
#4 (4.75mm)	25 -55	30 -60	35 -65	50 - 85	55-100	70-100
#10 (2 mm)	15 -40	20 -45	25 -50	40 - 70	40-100	55-100
#40 (0.425mm)	8 - 20	15 -30	15 -30	25 - 45	20 -50	30- 70
#200(0.075mm	2 - 8	5 -20	5 -15	10 - 25	6 - 20	6 -25
Usage			For Surface Course			
	For Bases and Subbases					
Soil	Crushed stone, gravel, crushed sand and fine materials				Natural or crushed sand with fines with and without stone or gravel.	
Components	% sieve No.200 $\ngtr$ 2/3 % passing No.40 sieve.					
Consistency	Liquid limit $\ngtr$ 25 & Plasticity Index $\ngtr$6					

The aggregate, which will be used for base courses, must have the following characteristic:

- 1.The percentage of wear by the los Angeles test for coarse aggregate not exceed 50%.

- 2.Percentage passing No.200 sieve not exceed 2/3 passing No. 40 sieve.

- 3.Percentage passing No.40 sieve shall having liquid limit not exceed 25% and plasticity index not exceed 6%.

-Types of Bases:

- 1.Macadam Base Courses:
- The term macadam originally referred to a road surface or base composed of crushed stone was mechanically locked by rolling and cemented together by the application of stone screenings and water.
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- Macadam bases may be classified as dry-bound macadam, water bound macadam and penetration macadam according to the method of construction.

- a-Dry-bound macadam : is a layer from crushed-aggregate base course, which gains its grain interlock through rolling or vibration. This type of base courses is cheap and suitable for low traffic only.

- b-Water-bound macadam: is a layer composed of crushed stone or slag that are bound together by stone dust and water. The layer is compacted by heavy rollers or vibratory compactors. Stability is gained by grain interlock, as well as by cementation of the fine fraction.

- c-Penetration macadam or bituminous macadam is
- crushed stone base in which the components are bound together by bituminous material, the bituminous material is applied to the surface of the layer after its compaction. The bituminous material penetrates into the voids of the layer and serves to bind the components together.
- Asphalt cement 90 to 150 are commonly used. The construction may be made as following steps:
- 1.Spreading and rolling of coarse aggregate;
- 2.Initial application of bituminous materials;
- 3.Spreading and rolling of key aggregate;
- 4.Application of seal coat.

- 2..Soil- Cement Bases
- Soil-cement bases have been used successfully under flexible- and rigid pavements. A soil - cement bases are suitable for a thin wearing surface that will be subjected to light or medium traffic or as a support for a high type flexible or rigid pavements.
- The amount of cement in this type of bases ranging from 7 to 14 Vol.% of compacted mixture. Soils that contain high amounts of fine material, such as silts and clays, generally require large amount of cement for successful stabilization.

- The main steps in the construction of a soil-cement bases are as follows:
- a.Pulverizing of the soil;
- b.Spreading the required amount of cement and mixing with the soil;
- c.Addition of the required amount of water and mixing with the soil- cement mixture;
- d.Compacting and finishing the layer;
- e.Curing the soil- cement layer.

-Bituminous surface courses

- Bituminous surface courses or flexible pavement are widely used in Egypt. In this type of construction, the mineral aggregates and bituminous material are mixed ,placed on the existing surface or base, and compacted. The function of the aggregate is to resist the loads, while the function of the bituminous material is to coat and seal the particles of the aggregate together.

- The surface course must have the following functions:
- 1.provide smooth, quite running surfaces for vehicles;
- 2.have high resistance to wear and deformation;
- 3.able to transmitting the applied wheel loads to the underlying layers;
- 4.have high skid resistance;
- 5.protect the base course and subgrade from the actions of moisture.

- According to the function of surfaces, it can be divided to dense graded, semi-dense or open graded surfaces or surface treatment.
- The two fundamental properties of a bituminous paving mixture are stability and durability. Stability is the property of the compacted mixture to withstand the stresses imposed by moving wheel loads without sustaining substantial permanent deformation, while the durability meant that property of the compacted mixture to withstand the detrimental effects of air, water, and temperature change.

Tab.14:Aggregate gradations required for surface course (A--specifications)

Gradation/sieve size	open – gradation 2B	open - gradation 2C	Coarse Gradation 3A	Coarse Gradatio 3B	Dense Gradatio 4B	Dense gradatio 4C
1 in.						100
3/4 in		100		100	100	80 –100
1/2 in.	100	70 -100	100	75 -100	80 -100	
3/8 in.	70 –	45 - 75	75 -100	60 - 75	70- 90	60 –80
# 4 sieve	100	20 - 60	15 - 55	15 - 55	50 – 70	48 –65
# 8 sieve	20 – 40	5 - 20	20 - 35	20 - 35	30 – 50	35 –50
# 16 sieve	5 – 20					
# 30 sieve			10 - 22	10 - 22	18 - 29	19 –30
# 50 sieve			6 - 16	6 - 16	13 - 23	13 –23
#100sieve			2 -12	2 - 12	8 - 16	7- 15
#200sieve		0 - 4			4 - 10	3 – 8
	0 – 4					

- Course aggregate may be defined as the portion of the aggregate retained on a No. 10 sieve. Fine aggregate passes a No.10 and is retained on a No.200 sieve. Fillers is the material that passes a No.200 sieve.
- The function of course aggregate in contributing the stability is due to interlocking and the frictional resistance of adjacent aggregate particles to displacement. The function of fine aggregate contributes to stability through interlocking and internal friction. Fine aggregates are also held to contribute to stability by their function in filling the voids in coarse aggregate. The Filler is largely visualized as a void-filling agent. Limestone dust, Portland cement, slag dust, local sand and other minerals have been successfully used as fillers.

- Aggregates that are well-graded from coarse to fine are generally sought in bituminous paving mixtures, since well graded materials produce the most dense mixtures and therefore the most durable, requiring minimum bitumen content satisfactory results.
- The kind and nature of bituminous material used have some effect on the properties of the bituminous paving mixtures. The choice of asphalt grade depends on conditions of climate and other factors.

- To summarize, the objectives of asphalt mix design are to select and proportion materials to produce a mix that has:
- 1. Sufficient asphalt to ensure a durable pavement;
- 2. Sufficient mix stability sustain traffic loads without distortion or displacement;
- 3.Sufficient voids in compacted mix to allow for a slight amount of additional compaction under traffic without bleeding or loss of stability;
- 4.Sufficient workability.

- There are two systems for the construction of the bituminous paving mixtures as follows:
- System 1: in this system the aggregate is coated with asphalt by mechanical mixing as central mixing plants. Then, the mixtures are transmitted , placed on base course and compacted.
- System 2: in this system the pavements are formed by placing the asphalt and aggregate in separate cases. there are some types of construction lie under this system as follows:

- a-Seal coats
- A seal coat is a very thin single-surface treatment that is often less than 1/2 in. thick. Seal coat are applied as a final step in the construction of many types of wearing surfaces. It is used also to seal a crack surface to prevent infiltration of surface water, and to provide a nonskid surface. Seal coat may be used as a color coat for visibility.

- b-Single-and multiple- asphalt surface treatments
- Single applications of asphaltic material and aggregate are applied to newly constructed flexible bases. This type of surface treatments are constructed in the same manner as seal coats except that the rate of application of each material is generally greater. If the wearing surface is to be a multiple-surface treatment, the single course is repeated one or more times. The single surface treatment is used as a flexible base wearing course for light traffic, while multiple surface treatment suitable for light and heavy traffic.

-Bituminous mixtures

- The bituminous wearing surfaces are widely used on rural highways and on city streets that are subjected to large volumes of traffic. The high-type bituminous mixtures are hot mixes that are prepared in central mixing plants. The thickness of these surface courses may vary from lightly less than 1 in. to several inches, according to the type of surface and its purpose.

Design of hot asphaltic concrete mixes

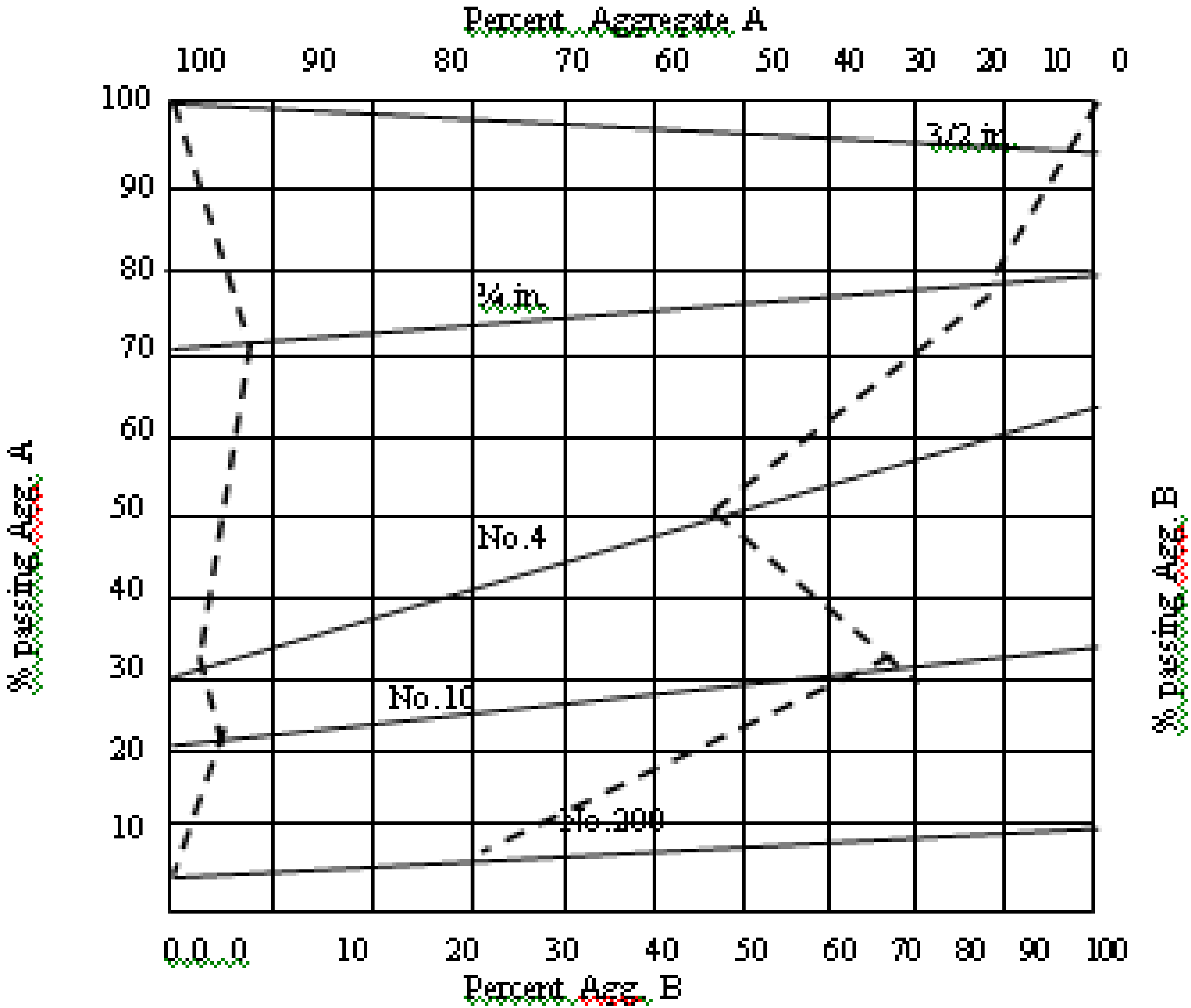
- Marshall method of mix design:
- This method was originally developed by Bruce Marshall (Mississippi Highway Department).
- This method is applicable only to hot mixtures using penetration grades of asphalt cement and aggregates with maximum size of 1 in. or less. The Marshall method uses standard test specimens 2.5 in. high and 4 in. in diameter. The specimens are prepared by use of a standard procedure for heating, mixing and compacting the mixtures.

1.Mixing two or more aggregates to meet a certain gradation requirements:

Example:

Blend the two materials A and B to meet the shown specific gradation

Sieve size	A	B	Desired blend
2 in.	100	100	100
3/2 in.	100	95	90 -100
¾ in.	70	80	72 - 78
# 4	30	55	32 - 50
# 10	20	35	22 - 32
# 200	2	10	0 - 5



Percent Aggregate A
100
90
80
70
60
50
40
30
20
10
0
3/2 in.
¾ in.
No.4
No.10
No.200
% Passing Agg. A
% Passing Agg. B
0.0 0 0
10
20
30
40
50
60
70
80
90
100
Percent Agg. B

- 2. Determination approximate value for bitumen content
- *a-Aggregate-surface-area method:*
- This method is based on the concept that the bitumen content of a bituminous mixture is a function of the surface area of the aggregate to be coated.
- $$P = 0.015\,a + 0.03\,b + 0.17\,c$$
- where
- P = bitumen in the mix, wt-% ;
- a = aggregate retained on No.10 sieve, wt-%;
- b = aggregate passing No.10 and retained
- No.200 sieve,wt- %;
- c = aggregate passing No.200 sieve, wt.-%.

- *b-Nebraska formula:*
- There are some factors that could affect surface area formulas and not take into consideration as:
- 1.Specific gravity of the aggregate and bitumen;
- 2.Shape, surface texture and absorption of aggregate;
- 3.Voids content in aggregate structure;
- 4.Type of bitumen;
- 5.Character of mineral fillers.
- Nebraska formula take into account these factors, this formula is as follows:
- $$P = AG\ (0.02\ a) + 0.06\ b + 0.10\ c + sd$$
- where
-

- P= bitumen, wt.-%
- A= absorption factor for aggregate retained on
- No.50 sieve;
- G= specific gravity correction factor of
- aggregate retained on No.50 sieve;
- a= aggregate retained on No. 50 sieve;
- b= aggregate passing No.50 and retained
- No.100 sieve, wt.-%;
- c= aggregate passing No.100 and retained
- No.200 sieve,wt.-%;
- d= aggregate passing No.200 sieve,wt.-%;
- s= factor depends on character of Fillers.

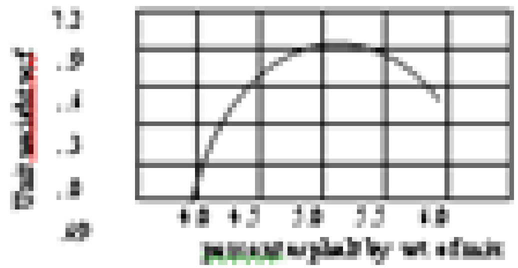
- <u>Density - voids analysis</u>
- The bulk specific gravity of the compacted mixture may be expressed as follows:
  - $d = W1 / (W1 - W2)$
- where
- d = bulk density;
- W1= weight of test specimen in air;
- W2= weight of test specimen in
- water.

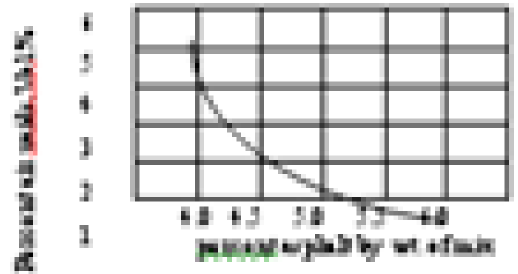
- $Vair = 1- [Vbit. + Vmf + Vfa + Vca]$

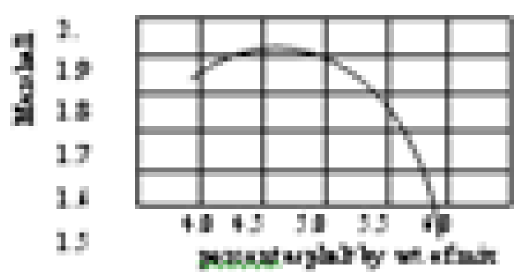
- where
- Vair =volume of air voids in the mix;
- Vbit =volume of bitumen in the mix;
- Vmf =volume of mineral fillers in the mix;
- Vfa =volume of fine aggregate in the mix;
- Vca =volume of coarse aggregate in the mix.

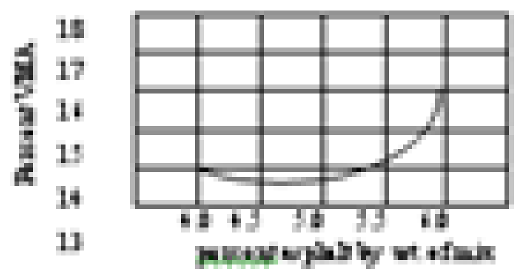
- V_{bit} = (% bit x100xd) / [(100 +% bit) x δbit x
- δw]
- V_{mf} = (%mf x 100 x d) / [(100+%bit) x δmf x δw]
-
- V_{fa} = (% fa x 100 x d) / [(100+%fa) x δfa x δw]
- V_{ca} =(% ca x 100 x d) / [(100+%ca) x δca x δw]
- where
- δbit=specific gravity for bitumen;
- δmf =specific gravity for mineral filler;
- δfa =specific gravity for fine aggregate;
- δca =specific gravity for coarse aggregate
- δw =specific gravity of water =62.4 Ib or
- g/cm3;
- d =density for compacted specimen.

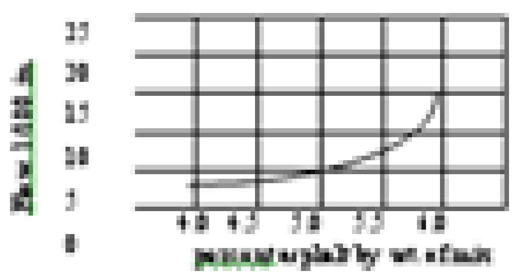
- <u>-Determination of voids filled with bitumen:</u>
  - $\% \text{ Vfb} = (\text{V bit} / \text{Vair} + \text{V bit})$
- where
- %Vfb = % Voids filled with bitumen











Tab.15: Marshall Design Criteria

Traffic category No.of compaction blows on each side	Heavy & very heavy. 75		Medium 50		Light 35	
Test property	Min.	Max.	Min.	Max.	Min.	Max.
Stability (all mix)	750		500		500	
Flow (all mix)	8	16	8	18	8	20
% Air voids						
-Surfacing or leveling	3	5	3	5	3	5
- Sand or Stone sheet	3	5	3	5	3	5
- Sand Asphalt	5	8	5	8	5	8
- Binder or Base	3	8	3	8	3	8