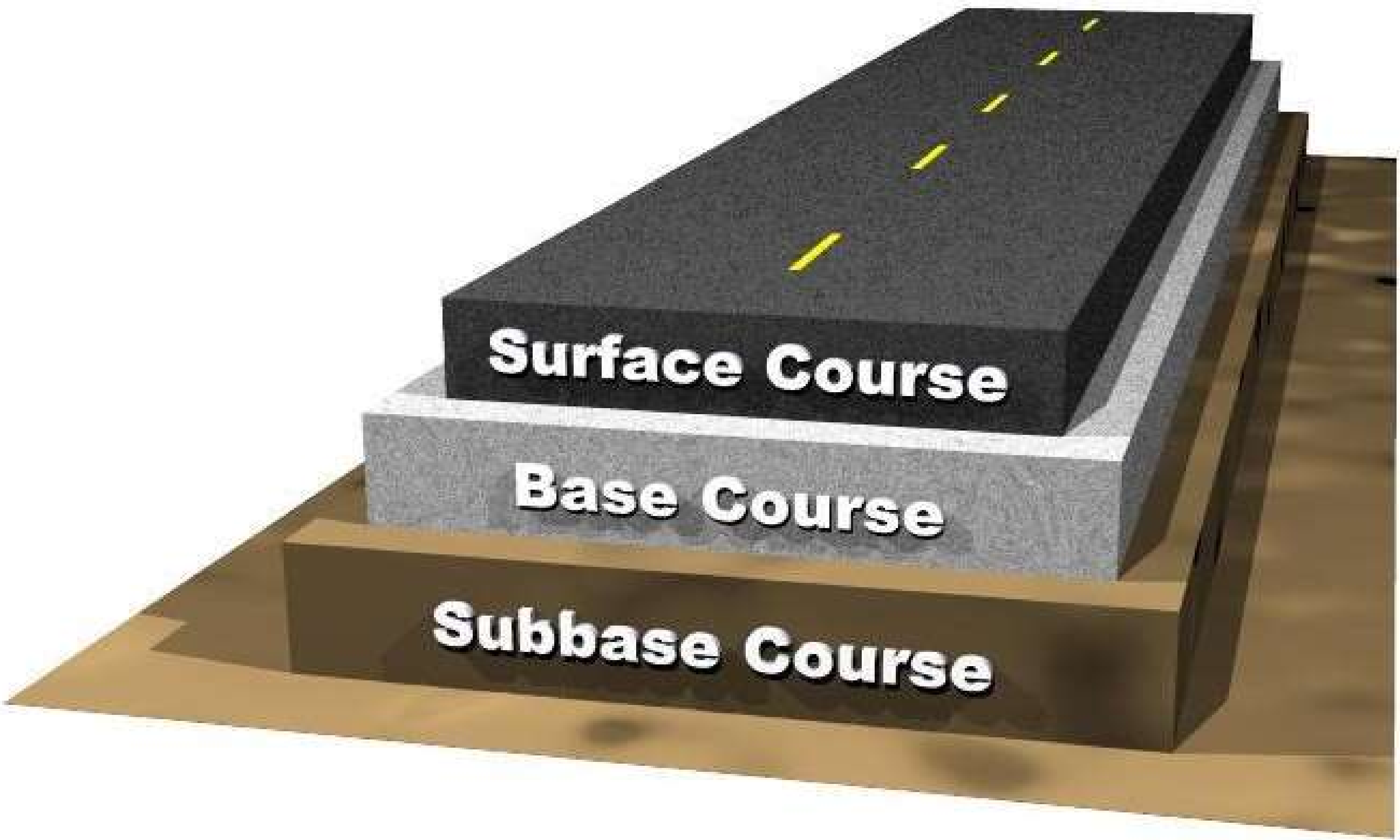
PAVEMENT MATERIALS

Aggregates- Origin, Classification, Requirements, properties and tests on Road aggregates, Concepts of size and gradation- design gradation, maximum aggregate size, aggregate blending by different methods to meet specification.

Bitumen and Tar- Origin, Preparation, Properties and Chemical Constitution of bituminous road binders, Requirements

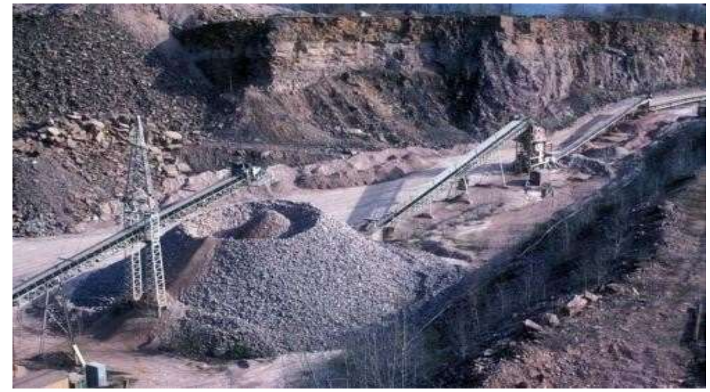
PARTS OF PAVEMENT



PAVEMENT MATERIALS

- **Soil**
- **Aggregates**
- **Binder**
- **Others**

AGGREGATES



Aggregate is a collective term for the mineral materials such as sand, gravel, and crushed stone that are used with a binding medium (such as water, bitumen, Portland cement, lime, etc.) to form compound materials (such as bituminous concrete and Portland cement concrete).

Aggregates are an important ingredient of the materials used in highway construction. Constitutes:

By weight, 70% to 85% by weight of PCC and HMA

By volume, 60% to 75% for PCC and 75% to 85% for HM

AGGREGATES – ORIGIN

Most of the properties of an aggregate is derived from its parental rock chemical and mineral composition which affects strength, stiffness, density, pore structure and permeability.

Aggregates can be classified into two main categories: Natural and Crushed Aggregates

- *Natural aggregates:* Rocks experience geothermal and weathering processes which can produce granular materials in the form of natural gravels and sands, which can be used in construction works without any modification or additional processes
- *Crushed/manufactured:* Granular materials produced by human related activities such as blasting, crushing and so on, have rougher surface and more angular shapes comparing to natural sands.

ORIGIN AND CLASSIFICATION OF AGGREGATES

Natural aggregates come from rock, of which there are three broad geological classifications

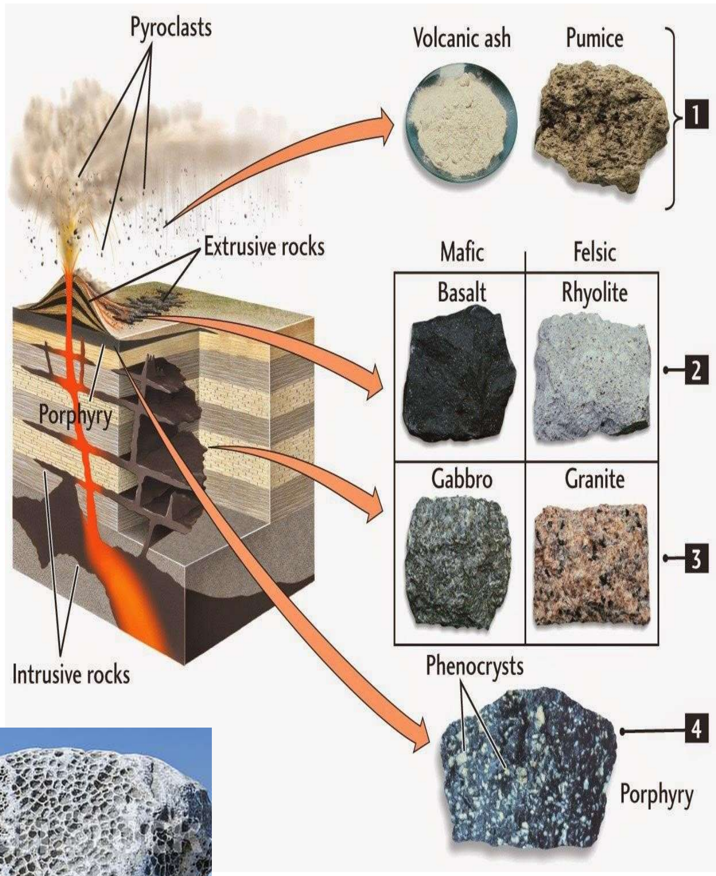
1. Igneous rock: Formed by solidification of molten magma

Based on Crystallinity

a) Intrusive rocks: Solidification occurs slowly and are crystalline in nature.

Example: Granite, Gabbro

b) Extrusive rocks: cools quickly and are fine grained in nature Example: Basalt



Based on size grains

a) Acidic: Free quarts present, with Silica>66% Specific Gravity<2.75.

Example: Granite

b) Basic: Free quarts is not present, with Silica<66%, Specific Gravity>2.75. Example: Basalt

ORIGIN AND CLASSIFICATION OF AGGREGATES

2. Sedimentary rocks: Obtained by deposition of weathered & transported pre-existing rocks or solutions

a) Calcareous: Containing calcium carbonate

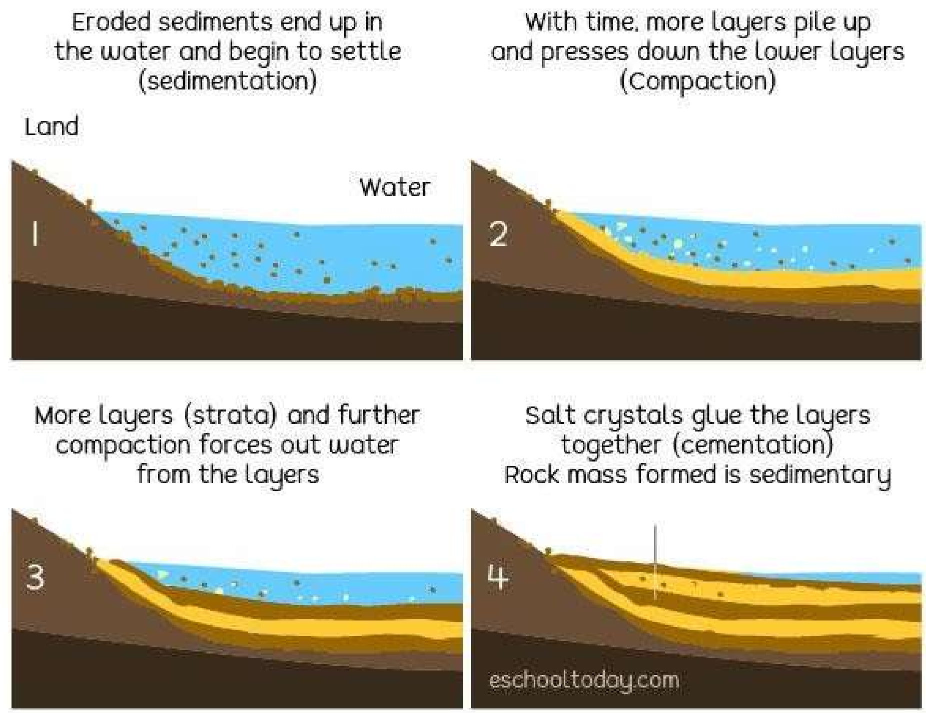
Example: Limestone, Dolomite

b) Siliceous: Containing SiO_2.

Example: Sandstone

c) Argillaceous: Containing clay minerals.

Example: Shale



ORIGIN AND CLASSIFICATION OF AGGREGATES

3.Metamorphic rock: Formed under high heat & pressure alteration of either igneous & sedimentary rocks

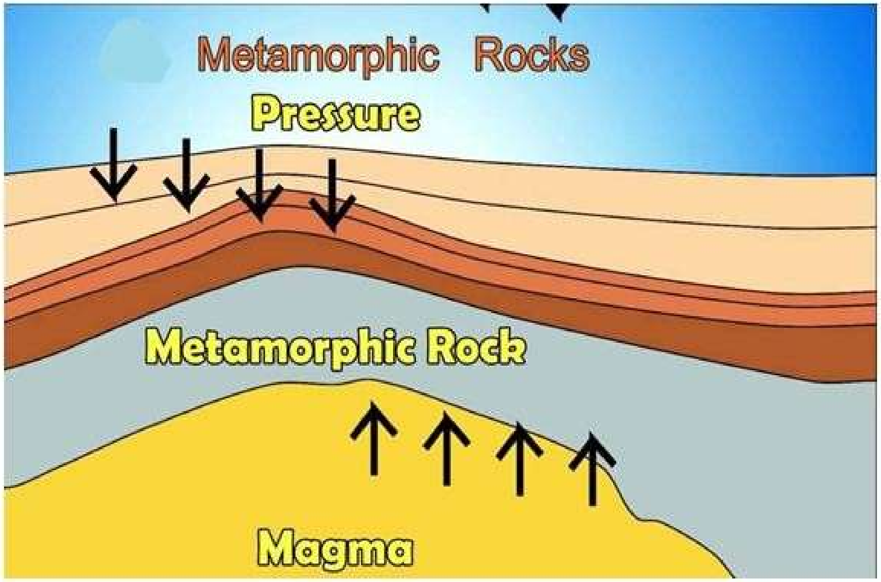
Example: Marble - Limestone

Quartzite - Sandstone Slate

- Shale

Schist - Basalt Gneiss

- Granite



Classification of Aggregates

I. According to source or nature of formation

a) **Natural Aggregate** : found in the natural source like sea bed, slope deposits, river Basin. Example: sand and gravel, pit Run.

b) **Crushed Rock aggregates**: formed by crushing the various Rocks in quarries Example: stone aggregate

c) **Recycled aggregates**: The recycled aggregate is manufactured by crushing inert construction and demolition waste.

d) **Artificial aggregates**: The artificial aggregates are made up by various waste material iron ore, artificial cinders, burnt clay, steel rivet etc.

ATME College of Engineering

Classification of Aggregates

II. Classification of aggregate According to size:

a) Coarse Aggregate : Particles size more than 4.75 (80mm to 4.75 mm)

b) Fine aggregates: : Particles size less than 4.75 (4.75 mm to 150 Micron)

c) All-in-one aggregates: contains both fine aggregate and coarse aggregate

Coarse Aggregate

Fine aggregates

Ranges of particle sizes found in aggregates

Classification of Aggregates

III. Aggregates according to shape

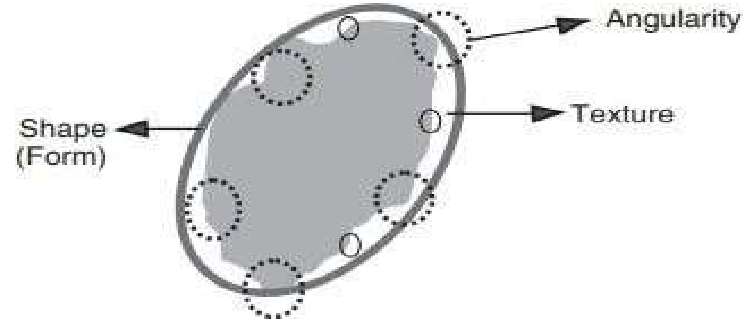
a) Rounded Aggregate

b) Angular

c) Flaky

d) Elongated

c) Irregular or partly rounded



Components of Aggregate Shape Properties: Shape, Angularity, and Texture

(1) Angular (2) Cubical (3) Elongated (4) Flaky&Elongated (5) Flaky (6) Irregular

Classification of Aggregates

According to IRC standards, American Association of State Highway and Transportation Officials (AASHTO) and American Society for Testing and Materials (ASTM) standards

- Coarse aggregate is retained on the 4.75 mm sieve
- Fine aggregate passes through the 4.75 mm sieve and is retained on the 0.075 mm sieve
- Filler aggregates , all particles pass through the 0.075 mm sieve

Fine aggregate	Size variation
Coarse Sand	2.0mm – 0.5mm
Medium sand	0.5mm – 0.25mm
Fine sand	0.25mm – 0.06mm
Silt	0.06mm – 0.002mm
Clay	<0.002

Coarse aggregate	Size
Fine gravel	4mm – 8mm
Medium gravel	8mm – 16mm
Coarse gravel	16mm – 64mm
Cobbles	64mm – 256mm
Boulders	>256mm

DESIRABLE PROPERTIES OR REQUIREMENTS OF AGGREGATES

- Strength
- Hardness
- Toughness
- Shape of aggregates
- Adhesion with bitumen
- Durability
- Free from deleterious particles

TESTS ON AGGREGATES

Aggregate tests

In order to decide the suitability of the aggregate for use in pavement construction, following tests are carried out:

- Crushing test
- Abrasion test
- Impact test
- Soundness test
- Shape test
- Specific gravity and water absorption test
- Bitumen adhesion test

TESTS ON AGGREGATES

Specific gravity and water absorption of aggregates:

1. Crushing test: Aggregate Crushing Value by IRC & MoRTH

A value less than 10% signifies an exceptionally strong aggregate, while above 35% would normally be regarded as weak aggregates and not recommended for pavement construction works.

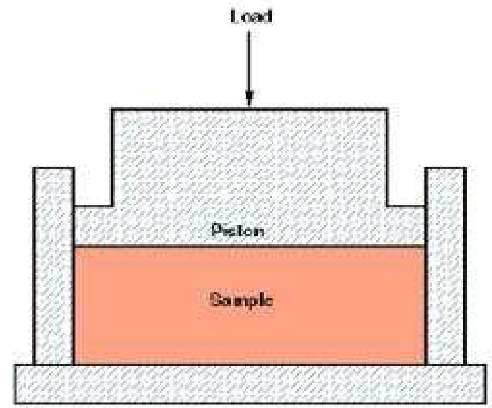


Fig: Aggregate Crushing Test Set up

2. Impact test: Aggregate Impact Value recommended by IRC & MoRTH

Wearing course - shouldn't exceed 30%

Bituminous macadam - shouldn't exceed 35%.

Water bound macadam base courses - shouldn't exceed 40%.

TESTS ON AGGREGATES

3. **Abrasion test**: Aggregate Abrasion Value by IRC & MoRTH

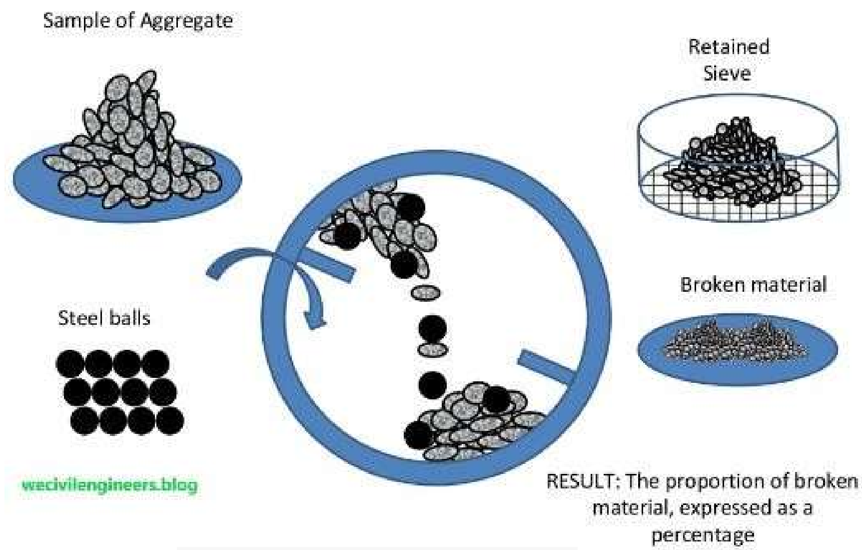
WBM base course - shouldn't exceed 40%

Bituminous concrete - - shouldn't exceed 35%

Grading of test samples

Sieve size (Square hole)		Weight in g of test sample for grade						
Passing through (mm)	Retained on (mm)	A	B	C	D	E	F	G
80	63	-	-	-	-	2500*	-	-
63	50	-	-	-	-	2500*	-	-
50	40	-	-	-	-	5000*	5000*	-
40	25	1250	-	-	-	-	5000*	5000*
25	20	1250	-	-	-	-	-	5000*
20	12.5	1250	2500	-	-	-	-	-
12.5	10	1250	2500	-	-	-	-	-
10	6.3	-	-	2500	-	-	-	-
6.3	4.75	-	-	2500	-	-	-	-
4.75	2.36	-	-	-	5000	-	-	-

* Tolerance of ±2 percent permitted.



TESTS ON AGGREGATES

4. Shape Test

Flakiness Index(FI) & Elongation Index(EI) of aggregates

Bituminous concrete and surface dressing: should not exceed 25%;

Water Bound Macadam should not exceed 15%.

Elongation Index- Length Gauge

Flakiness Index- Thickness Gauge

Combined Index (CI) = FI+EI

Wet Mix Macadam (WMM, Dense Bituminous Macadam (DBM) and Bituminous Concrete (BC) surface, the value : should not exceed 30%

TESTS ON AGGREGATES

5. Specific gravity and water absorption test

- The specific gravity value for rocks generally varies between 2.6 to 2.9.
- Rocks with more than 0.6% water absorption are considered unsatisfactory unless found acceptable based on strength

6. Bitumen adhesion test

- Adhesion problem occurs when the aggregate is wet and cold. The presence of water causes stripping of binder from the coated aggregates.
- Static immersion test is one specified by IRC and is quite simple
- The principle of the test is by immersing aggregate fully coated with binder in water maintained at temperature 40°C for 24 hours
- IRC has specified maximum stripping value of aggregates should not exceed 5%

TESTS ON AGGREGATES

Specific gravity and water absorption of aggregates:

Soundness test:

- Determined using accelerated weathering test cycles. Porous aggregates subjected to freezing and thawing are likely to disintegrate prematurely.
- Aggregates are subjected to cycles of alternate wetting in a saturated solution of either sodium sulphate or magnesium sulphate for 16 - 18 hours and then dried in oven to a constant weight
- After five cycles, the loss in weight of aggregates is determined by sieving out all undersized particles and weighingShape test
- The loss in weight should not exceed:

12 % when tested with sodium sulphate & 18 % with magnesium sulphate solution.

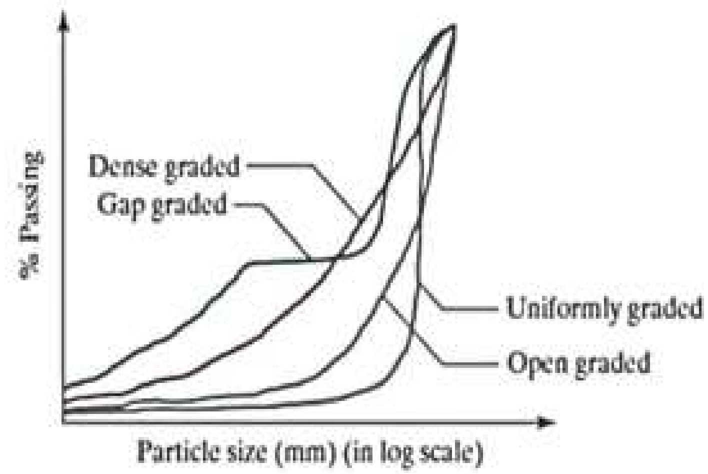
GRADATION OF AGGREGATES

The particle size distribution of an aggregate as determined by sieve analysis is termed as gradation of aggregates.

- The particle size distribution of a mass of aggregate should be such that the smaller particles fill the voids between the larger particles.
- The proper grading of an aggregate produces dense mix. Therefore, it is essential that coarse and fine aggregates be well graded to produce quality concrete.

Types of Grading of Aggregates

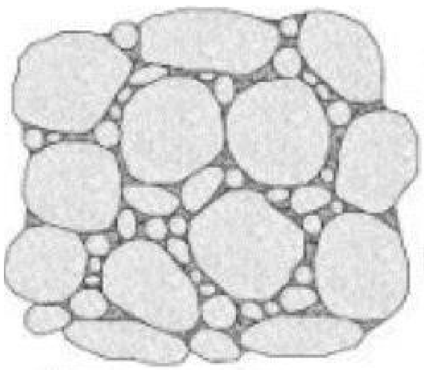
1. Dense-or well-graded aggregate
2. Gap-graded aggregate
3. Uniformly graded aggregate
4. Open-graded aggregate



Grading Curve

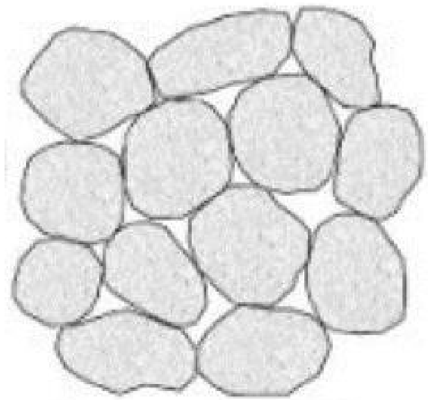
GRADATION OF AGGREGATES

DENSE GRADED



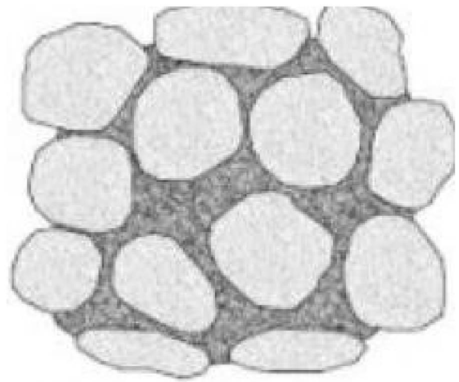
Wide range of sizes
Grain-to-grain contact
Low void content
Low permeability
High stability
Difficult to compact

UNIFORM GRADED



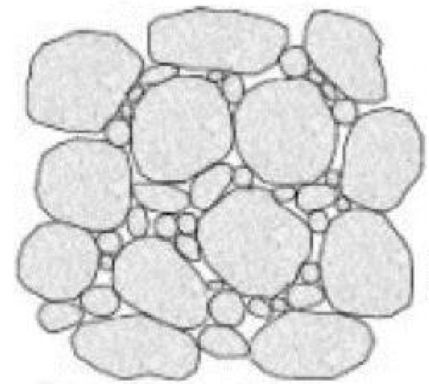
Narrow range of sizes
Grain-to-grain contact
High void content
High permeability
Low stability
Difficult to compact

GAP GRADED



Missing middle sizes
No grain-to-grain contact
Moderate void content
Moderate permeability
Low stability
Easy to compact

OPEN GRADED



Few fine particles
Grain-to-grain contact
High void content
High permeability
High stability
Difficult to compact

GRADATION OF AGGREGATES

- The gradation and size test is used to determine aggregate particle size distribution.
- In a gradation and size analysis, a sample of dry aggregate of known weight is separated through a series of sieves with progressively smaller openings. Once separated, the weight of particles retained on each sieve is measured and compared to the total sample weight.
- Particle size distribution is then expressed as a percent retained by weight on each sieve size.
- Results are usually expressed in tabular or graphical format.

Stacked sieves used for a gradation and size test

GRADATION OF AGGREGATES

Initial Sample Weight = 5.19kg

IS Sieve In mm	Weight retained	Individual %	Cumulative %	% Passing
4.75	0	0	0	0
2.36	0.31	(0.31/5.19)x100= 5.97	(0+5.97) **5.97**	(100-5.97) 94.03
1.18	2.08	40.07	(0+5.97+40.07) **46.04**	53.96
600µ	1.27	24.47	**70.51**	29.49
300µ	1.04	20.03	**90.54**	9.46
75µ	0.36	6.93	**97.47**	2.53
Pan	0.13	2.50	99.97	0.03
Cumulative % wt retained up to 75µ			310.53	

Fineness Modulus = Σ Cumulative % retained up to sieve 75 µ / 100

= 310.53/100

= 3.1

Determination of fineness Modulus (FM).

Sand shall be well graded from coarse to fine within the limits or shall conform to the specified fineness Modulus (FM).

Very Fine Sand	:	< 2.2
Fine Sand	:	2.2 - 2.6
Medium Sand	:	2.6 - 2.9
Coarse Sand	:	2.9 - 3.2

IMPORTANT TERMINOLOGIES

Maximum Size: One size larger than the nominal maximum aggregate size (NMAS)

NMAS: One sieve size larger than the first sieve to retain more than 10% material

Sieve size (mm)	Avg. weight retained	Percentage Weight Retained
45	0	0
37.5	30	2.3
26.5	70	5.39
13.2	500	38.46
4.75	700	53.84

NMAS: 26.5mm

Maximum size: 37.5m

GRADATION OF AGGREGATES

Determination FM of Coarse Aggregate

Sieve No	Sieve size	Weight retained(g)	Cumulative weight retained (g)	Cumulative % retained (g)
-	80mm	0	0	0
-	40mm	250	250	5
-	20mm	1750	2000	40
-	10mm	1600	3600	72
#4	4.75mm	1400	5000	100
#8	2.36mm	0	5000	100
#16	1.18mm	0	5000	100
#30	0.6mm	0	5000	100
#50	0.3mm	0	5000	100
#100	0.15mm	0	5000	100
			=	717

FM =?

- FM of coarse aggregate varies from 5.5 to 8.0.

Maximum size of coarse aggregate	Fineness modulus range
20mm	6.0 – 6.9
40mm	6.9 – 7.5
75mm	7.5 – 8.0
150mm	8.0 – 8.5

- For all in aggregates or combined aggregates fineness modulus varies from 3.5 to 6.5

AGGREGATE BLENDING BY DIFFERENT METHODS TO MEET SPECIFICATION

- The properties of the bituminous mix including the density and stability are very much dependent on the aggregates and their grain size distribution.
- The best gradation produces maximum density.
- Provides more particle-to-particle contact, which in bituminous pavements would increase stability and reduce water infiltration.
- However, some minimum amount of void space is necessary to:
  - a) provide adequate volume for the binder to occupy,
  - b) promote rapid drainage, and
  - c) provide resistance to frost action for base and sub base courses.

AGGREGATE BLENDING BY DIFFERENT METHODS TO MEET SPECIFICATION

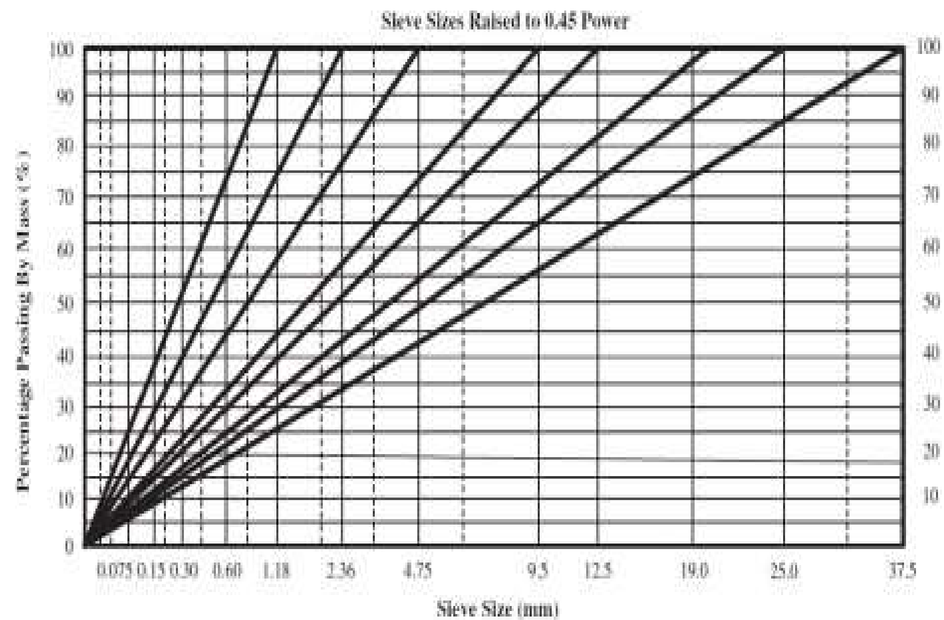
A dense mixture may be obtained when this particle size distribution follows **Fuller law** which is expressed as:

$$p = 100\left(\frac{d}{D}\right)^n$$

where, p = percent by weight of the total mixture passing any given sieve sized,

D = size of the largest particle in that mixture

n = parameter depending on the shape of the aggregate (0.5 – 0.3 depending on shape of aggregate)



Based on this law Fuller-Thompson gradation charts were developed by adjusting the parameter n for fineness or coarseness of aggregates.

AGGREGATE BLENDING BY DIFFERENT METHODS TO MEET SPECIFICATION

For example: Table: 1 provides a Typical gradation for bituminous concrete for a thickness of 40 mm

Sieve size (mm)	Wt passing (%) Grade 1	Wt passing (%) Grade 2
20	-	100
12.5	100	80-100
10.0	80 - 100	70 - 90
4.75	55 - 75	50 - 70
2.36	35 - 50	35 - 50
0.60	18 - 29	18 - 29
0.30	13 - 23	13 - 23
0.15	8 - 16	8 - 16
0.075	4 - 10	4 - 10
Binder*	5 - 7.5	5 - 7.5

Bitumen content in percent by weight of the mix

AGGREGATE BLENDING BY DIFFERENT METHODS TO MEET SPECIFICATION

A good asphalt concrete pavement requires more than asphalt, aggregates and equipment. It also requires knowledge, skill, and workmanship. Part of this knowledge and skill is the ability to blend aggregates to meet a specified target, known as the job-mix formula.

Definition of a Job-Mix Formula

In its simplest form, a job-mix formula consists of two parts:

1. The Combined Gradation of the aggregates to be used in the production of the asphalt concrete mixture.
2. The Asphalt Content necessary to produce a satisfactory mix meeting all the specification requirements.

AGGREGATE BLENDING BY DIFFERENT METHODS TO MEET SPECIFICATION

After selecting the aggregates and their gradation, proportioning of aggregates has to be done and following are the common methods of proportioning of aggregates:

I. Trial and error procedure: Vary the proportion of materials until the required aggregate gradation is achieved.
II. Graphical Methods: Two graphical methods in common use for proportioning of aggregates are

Triangular chart method

Rothfutch's method

Analytical Method: In this method a system of equations are developed based on the gradation of each aggregates, required gradation, and solved by numerical methods.

ATME College of Engineering

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

CIVIL ENGINEERING

Step 1 - Obtain the required data.

a. The gradation of each material must be determined.

b. The design limits for the type of mix must be obtained.

Step 2 - Select a target value for trial blend.

The target value for the combined gradation must be within the design limits of the specifications. This value now becomes the target for the combined gradation.

Step 3 - Estimate the proportions.

Estimate the correct percentage of each aggregate needed to get a combined gradation near the target value. For example, if aggregates are combined, a possible combination may be 30% of Aggregate 1 and 70% of Aggregate 2.

ATME College of Engineering

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

CIVIL ENGINEERING

Step 4 - Calculate the combined gradation.

This calculation will show the results of the estimate from Step 3.

Step 5 - Compare the result with the target value.

- If the calculated gradation is close to the target value, no further adjustments need to be made; if not, an adjustment in the proportions must be made and the calculations repeated.
- The second trial should be closer due to the “experience” received from the first.
- The trials are continued until the proportions of each aggregate are found that will come close to thetarget value.
- If the aggregates will not combine within the materials. design range, it may be necessary to use or add different

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

Trial and Error Method

General Math Conversion:

Convert a percent (%)to a decimal, divide by 100

Example: 75%: 75/100 = 0.75

BLENDING WORKSHEET

Use this worksheet to mathematically blend aggregates by hand.

Mat'l									
% Used									
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2									
1									
3/4									
1/2									
3/8									
No. 4									
No. 8									
No. 30									
No. 50									
No. 100									
No. 200									

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

Example Problem No. 1

Trial and Error Combination of Two Aggregates: Aggregate 1 and Aggregate 2

Mat'l % Used	Aggregate 1		Aggregate 2						
Sieve (in)	**% Pass**	% Blend	**% Pass**	% Blend	% Pass	% Blend	Total Blend	Target Value	**Design Range**
1 1/2									
1									
3/4	**100**		**100**						**100**
1/2	**100**		**94**						**95 – 100**
3/8	**94**		**65**						**90 max**
No. 4									
No. 8	**52**		**27**						**34 – 50**
No. 30									
No. 50									
No. 100									
No. 200	**7.1**		**1.2**						**2 – 10**

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

Step 1 - Enter the data (aggregate gradations and design limits) in appropriate columns.

Step 2 - Determine the target value
Target Value must be within design range.
The Target Value is provided by Mix Design Technician.

Mat'l	Aggregate 1		Aggregate 2						
% Used									
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	**Target Value**	Design Range
1 1/2									
1									
3/4	100		100					**100**	100
1/2	100		94					**98**	95 – 100
3/8	94		65					**88**	90 max
No. 4									
No. 8	52		27					**47**	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1		1.2					**6**	2 – 10

ATME College of Engineering

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

CIVIL ENGINEERING

Step 3 - Estimate the proportions.

The first estimate might be 50% of Aggregate 1 and 50% of Aggregate 2.

Enter these figures on the line marked “% Used”.

Mat'l	Aggregate 1		Aggregate 2						
% Used	50		50						
Sieve (in)	% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
1 1/2									
1									
3/4	100		100					100	100
1/2	100		94					98	95 – 100
3/8	94		65					88	90 max
No. 4									
No. 8	52		27					47	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1		1.2					6	2 – 10

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

Step 4 - Calculate the individual proportions on each sieve for each of the two aggregates and enter in the column "% blend".

Add the two columns for each sieve and enter in the column "Total Blend".

Calculations:

% Blend:

Sieve	Aggregate 1	Aggregate 2
3/4	100 x .50 = 50	100 x .50 = 50
1/2	100 x .50 = 50	94 x .50 = 47
3/8	94 x .50 = 47	65 x .50 = 32.5
No. 8	52 x .50 = 26	27 x .50 = 13.5
No. 200	7.1 x .50 = 3.6	1.2 x .50 = 0.6

Total Blend:

Sieve	Aggregate 1	+	Aggregate 2	=	Total Blend
3/4	50	+	50	=	100
1/2	50	+	47	=	97
3/8	47	+	32.5	=	79.5 round off to 80
No. 8	26	+	13.5	=	39.5 round off to 40
No. 200	3.6	+	0.6	=	4.2

Mat'l % Used	Aggregate 1		Aggregate 2						
	50		50						
Sieve (in)	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	% Blend	**Total Blend**	Target Value	Design Range
1 1/2									
1									
3/4	100	**50**	100	**50**			**100**	100	100
1/2	100	**50**	94	**47**			**97**	98	95 – 100
3/8	94	**47**	65	**32.5**			**80**	88	90 max
No. 4									
No. 8	52	**26**	27	**13.5**			**40**	47	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1	**3.6**	1.2	**0.6**			**4.2**	6	2 – 10

AGGREGATE BLENDING - TRIAL AND ERROR METHOD

Step 5 - Compare this combined gradation Compare the Total Blend with the Target Value.

Observations:

Sieves No. 3/8 and No. 8 are not close to target value, therefore an adjustment needs to be made.
Make adjustment to the Aggregate Percentage being used.
For adjustment:
Use one sieve to make adjustment before recalculating all sieve. This example will use 3/8 sieve

Material % Used		Aggregate 1	Aggregate 2
	Trial 1	50	50
	Trial 2	55	45
	Trial 3	60	40
	Trial 4	70	30
	Trial 5	75	25
	Trial 6	45	55
	Trial 7	40	60

		Aggregate 1		Aggregate 2						
Sieve (in)		% Pass	% Blend	% Pass	% Blend	% Pass	% Blend	Total Blend	Target Value	Design Range
3/8	Trial 1	94	47	65	32.5			80	88	90 max
	Trial 2	94	51.7	65	29.3			81	88	90 max
	Trial 3	94	56.4	65	26			82	88	90 max
	Trial 4	94	65.8	65	19.5			85	88	90 max
	Trial 5	**94**	**70.5**	**65**	**16.3**			**87**	**88**	**90 max**
	Trial 6	94	42.3	65	35.8			78	88	90 max
	Trial 7	94	37.6	65	39			77	88	90 max

ATME College of Engineering

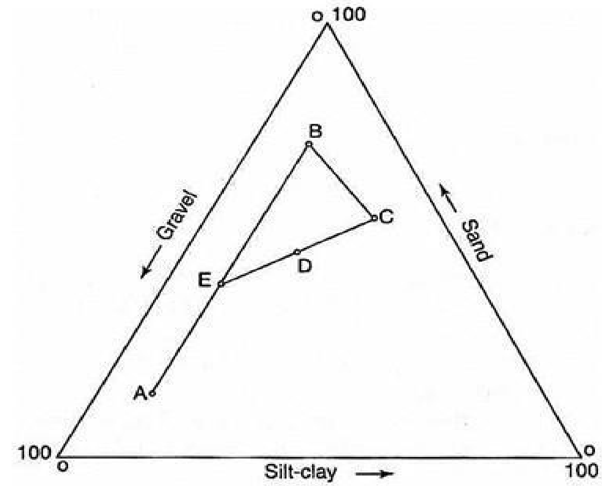
AGGREGATE BLENDING - TRIAL AND ERROR METHOD

Calculate the individual proportions on each sieve for each of the two aggregates with proportions 75% and 25%

Mat'l	Aggregate 1		Aggregate 2						
% Used	75		25						
Sieve (in)	% Pass	**% Blend**	% Pass	**% Blend**	% Pass	% Blend	**Total Blend**	**Target Value**	Design Range
1 1/2									
1									
3/4	100	**75**	100	**25**			**100**	**100**	100
1/2	100	**75**	94	**23.5**			**99**	**98**	95 – 100
3/8	94	**70.5**	65	**16.3**			**87**	**88**	90 max
No. 4									
No. 8	52	**39**	27	**6.8**			**46**	**47**	34 – 50
No. 30									
No. 50									
No. 100									
No. 200	7.1	**5.3**	1.2	**0.3**			**5.6**	**6**	2 – 10

AGGREGATE BLENDING – TRIANGULAR CHART METHOD

- This is convenient when three materials of different gradations, consisting of fractions— gravel, sand and silt-clay
- They are represented on a triangular chart on each side of an equilateral triangle representing the percentages of the three fractions (0 to 100%, below figure)
- Let the three materials available be represented on the triangular chart by points A, B and C, based on their constituent fractions- sand, gravel and silt-clay.
- Let D represent the gradation desired of the material to be obtained by blending the materials A, B and C.
- Join C and D and extrapolate the line to meet the line AB at E.
- Required proportions of A, B and C can be calculated as:



Triangular chart for proportioning materials

$$\text{Proportion of A} = \frac{EB}{AB} \times \frac{DC}{EC}$$

$$\text{Proportion of B} = \frac{AE}{AB} \times \frac{DC}{EC}$$

$$\text{Proportion of C} = \frac{ED}{EC}$$

AGGREGATE BLENDING – TRIANGULAR CHART METHOD

Example:

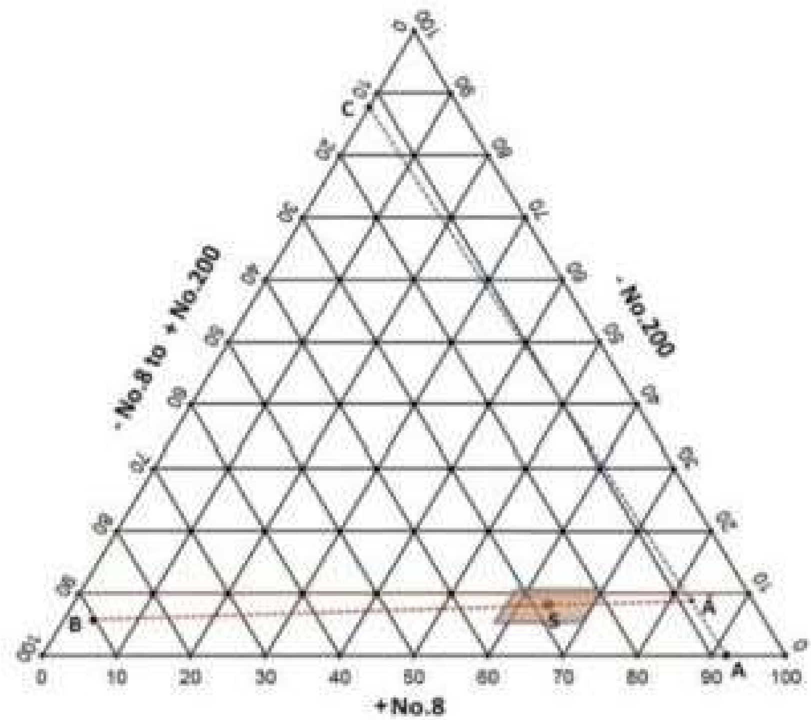
Let us consider three aggregates are to be blend using the triangular-chart method. The gradations of A, B, and C and the specifications given in table:

Sieve Size mm [inches.]	% Passing				
	A	B	C	Mid. Point	Specification
19 [3/4]	100	100	100	100	100
12.5 [1/2]	63	100	100	78	70 - 85
4.75 [No.4]	19	100	100	48	40 - 55
2.38 [No.8]	8	93	100	36	30 - 42
0.3 [No.50]	5	55	100	25	20 - 30
0.15 [No.100]	3	36	97	17	12 - 22
0.075 [No.200]	0	3	88	8	5 - 11
Source Values	a=0.66	b=0.28	c= 0.06		

AGGREGATE BLENDING – TRIANGULAR CHART METHOD

The gradations of A, B, and C and the specifications given in Table 1 are re- tabulated in terms of three separates defined by the No. 8 and No. 200 sieves.

Aggregate	(+ No.8)	(-No.8 to+No.200)	(-No.200)
A	92	8	0
B	7	90	3
C	0	12	88
Specification	58 – 70*	----------	5 – 11**



AGGREGATE BLENDING – TRIANGULAR CHART METHOD

$$A = \frac{CA'}{AC} \times \frac{BS}{A'B} \times 100$$

$$B = \frac{AS}{AB} \times 100$$

$$C = \frac{AA'}{AC} \times \frac{BS}{A'B} 100$$

$$A = \frac{CA'}{AC} \times \frac{BS}{A'B} \times 100$$

$$B = \frac{AS}{AB} \times 100$$

$$C = \frac{AA'}{AC} \times \frac{BS}{A'B} 100$$

AGGREGATE BLENDING – RECTANGULAR-CHART OR STRAIGHT-LINE METHOD

- The table below shows the grain size distribution for two aggregates and the specification limits required for an asphalt concrete.
  - Determine the blend proportion required to meet the specification and gradations of the blend using the aforementioned graphical approach and the gradations of the blend.

Percent Passing									
Size									
	19 mm (3/4 in.)	12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	0.60 mm (No. 30)	0.30 mm (No. 50)	0.15 mm (No. 100)	0.075 mm (No. 200)
Spec. limits	100	80–100	70–90	50–70	35–50	18–29	13–23	8–16	4–10
Aggregate A	100	100	100	79	66	41	38	21	12
Aggregate B	100	92	54	24	3	1	0	0	0

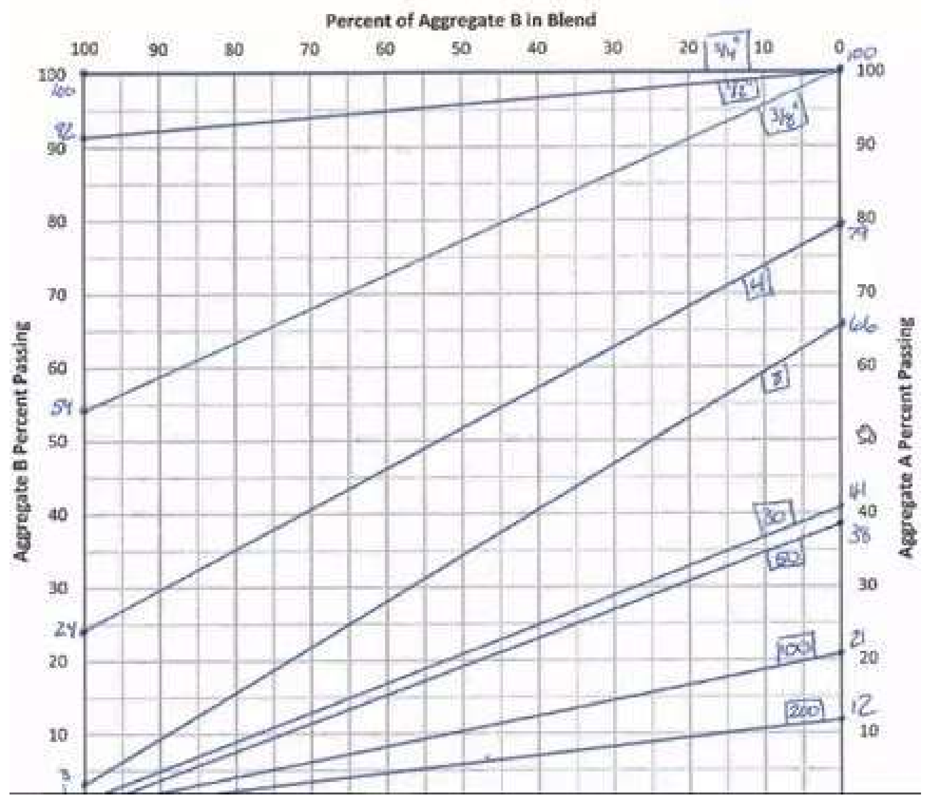
ATME College of Engineering

RECTANGULAR-CHART OR STRAIGHT-LINE METHOD

	Percent Passing								
	Size								
	19 mm (3/4 in.)	12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	0.60 mm (No. 30)	0.30 mm (No. 50)	0.15 mm (No. 100)	0.075 mm (No. 200)
Spec. limits	100	80–100	70–90	50–70	35–50	18–29	13–23	8–16	4–10
Aggregate A	100	100	100	79	66	41	38	21	12
Aggregate B	100	92	54	24	3	1	0	0	0

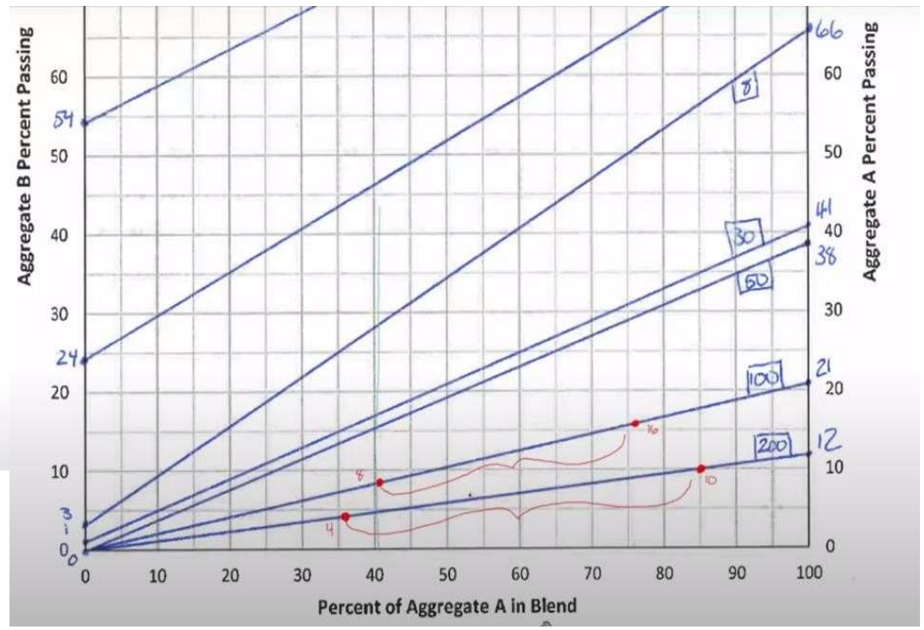
Step 1 • Plot the aggregate gradation for each aggregate on the left and right axes.

Step 2 • For each sieve size draw a line connecting the left and right axes.



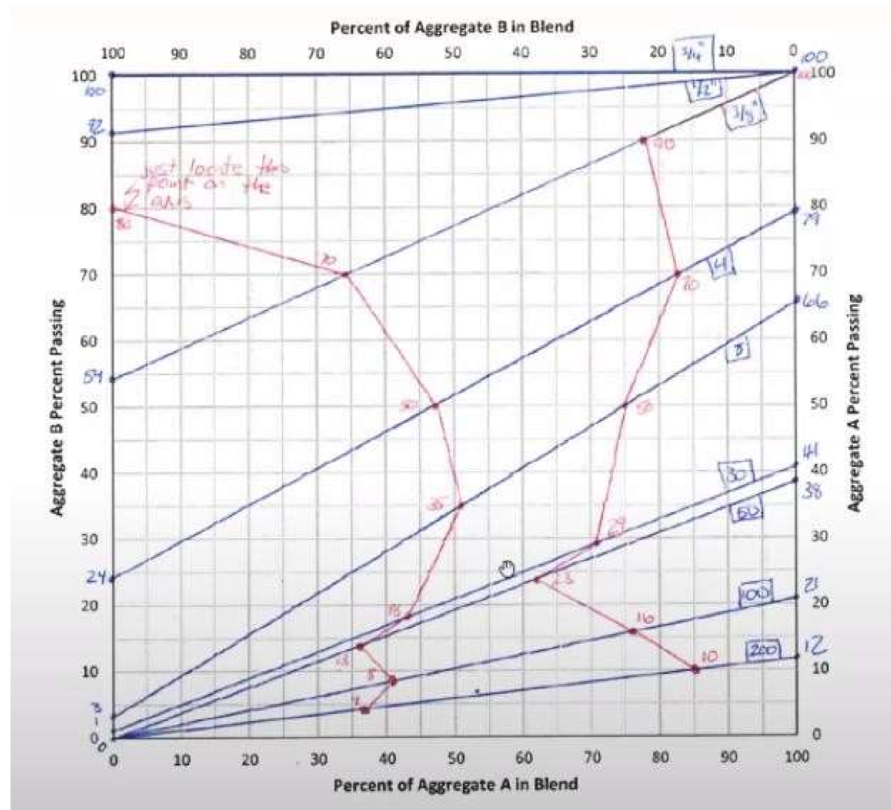
RECTANGULAR-CHART OR STRAIGHT-LINE METHOD

	Percent Passing								
	Size								
	19 mm (3/4 in.)	12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	0.60 mm (No. 30)	0.30 mm (No. 50)	0.15 mm (No. 100)	0.075 mm (No. 200)
Spec. limits	100	80–100	70–90	50–70	35–50	18–29	13–23	8–16	4–10
Aggregate A	100	100	100	79	66	41	38	21	12
Aggregate B	100	92	54	24	3	1	0	0	0



RECTANGULAR-CHART OR STRAIGHT-LINE METHOD

Percent Passing									
Size									
	19 mm (3/4 in.)	12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	0.60 mm (No. 30)	0.30 mm (No. 50)	0.15 mm (No. 100)	0.075 mm (No. 200)
Spec. limits	100	80–100	70–90	50–70	35–50	18–29	13–23	8–16	4–10
Aggregate A	100	100	100	79	66	41	38	21	12
Aggregate B	100	92	54	24	3	1	0	0	0

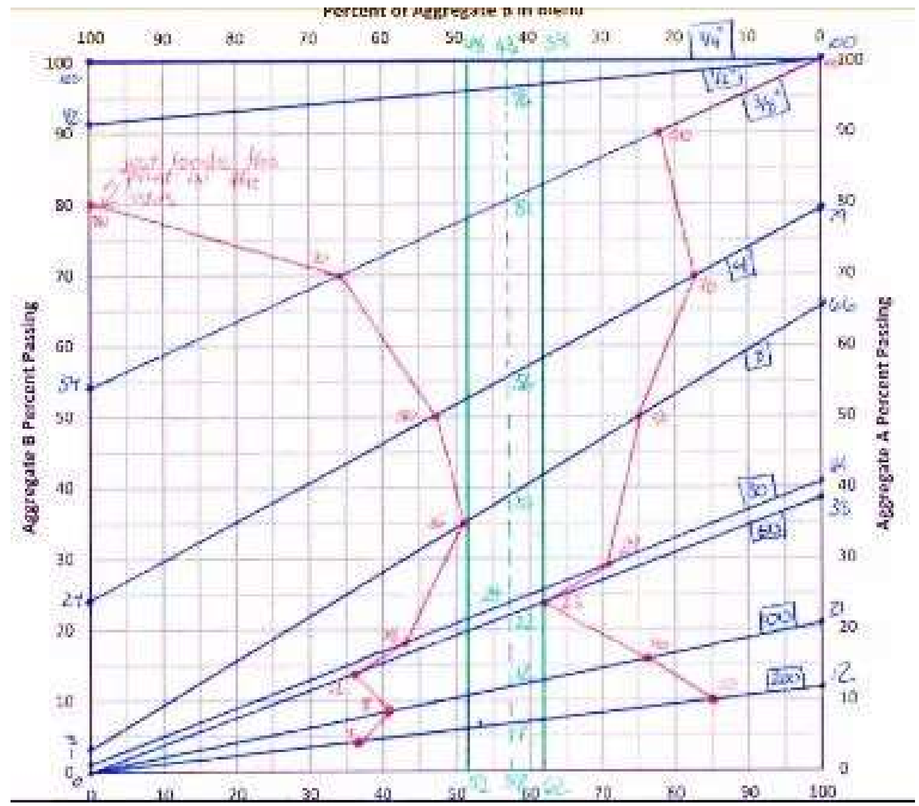


- Plot the specification range on the line representing each sieve.

RECTANGULAR-CHART OR STRAIGHT-LINE METHOD

Step 4

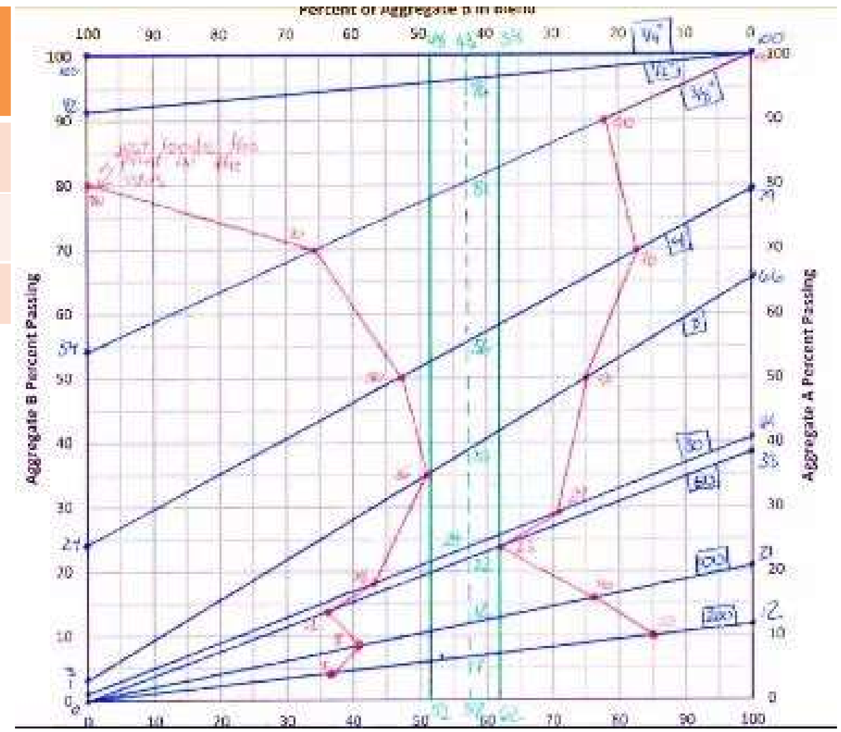
- Draw a vertical line through the rightmost point of the upper limit and through the leftmost point of the lower limit.
- Any vertical line drawn between the vertical limit lines will meet the specification.
- Where the vertical line intersects the top and bottom axes indicates the percentage of Aggregate A & B required.



ATME College of Engineering

RECTANGULAR-CHART OR STRAIGHT-LINE METHOD

Aggregate / sieve size	19mm	12.5mm	9.5mm	4.75mm	2.36mm	0.60mm	0.30mm	0.15mm	0.075mm
A (blend % - 57%)	100x .57 = 57	100x .57 = 57	100x .57 = 57	79x .57 = 45.03	66x .57 = 37.62	41 x .57 = 23.37	38 x .57 = 21.66	21 x .57 = 11.97	12 x .57 = 6.84
B (blend % - 43%)	43	39.56	23.22	10.32	1.29	0.43	0	0	0
Total blend	100	96.56	80.22	55.35	38.91	23.8	21.66	11.97	6.84



	19 mm (3/4 in.)	12.5 mm (1/2 in.)	9.5 mm (3/8 in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	0.60 mm (No. 30)	0.30 mm (No. 50)	0.15 mm (No. 100)	0.075 mm (No. 200)
Spec. limits	100	80–100	70–90	50–70	35–50	18–29	13–23	8–16	4–10
Aggregate A	100	100	100	79	66	41	38	21	12
Aggregate B	100	92	54	24	3	1	0	0	0

Blending Proportion

Aggregate A = 57%

Aggregate B = 43%

BITUMEN AND TAR- ORIGIN

Bitumen is a solid or semisolid, black, sticky, ductile substance, obtained as an important byproduct from the distillation of crude petroleum. Bitumenimplies a group of often mixed with some organic hydrocarbon matter. It is known as petroleum in the fluid state and asphalt in the solid state. Bitumen will be dissolved in petroleum oils.

Formation of Bitumen

Bitumen usually forms in environments with abundant algae, plants, and other organic matter. Because of this, it typically forms under the same conditions as coal, namely in lakes, marshes, and areas of high vegetation where plant matter can be preserved in mud deposits which become altered due to heat and pressure as they get buried. The main geological source for bitumen is organic shale.

BITUMEN AND TAR- ORIGIN

Tar is a black solid mass that is formed during the destructive distillation of coal, peat, wood, or other organic material.

It contains 75 to 95% of bituminous contents. It has higher percentage of carbon and is soluble in carbon disulphide.

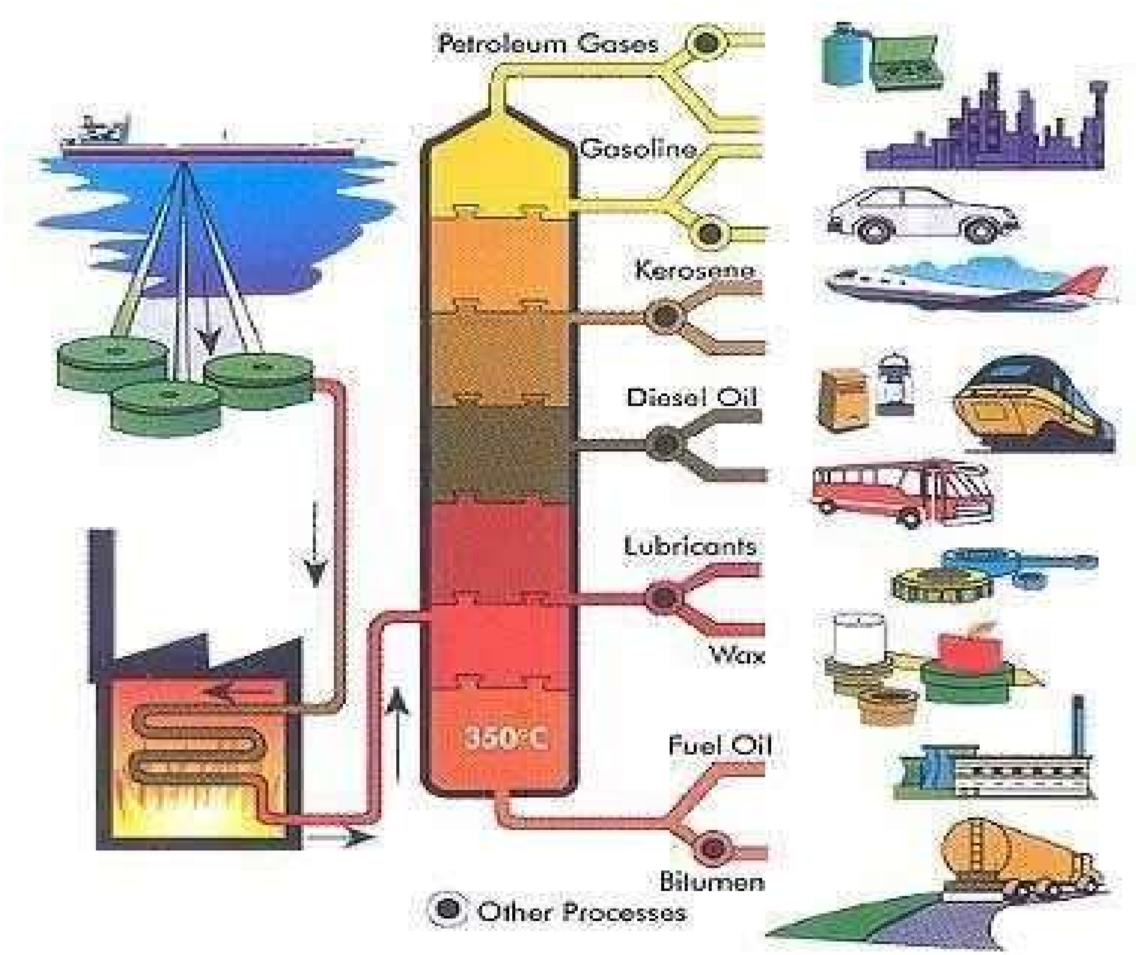
Formation of Tar

Tar can form in a variety of ways and tar will have different properties depending on how it forms. Two common types are coal tar and wood tar. Coal tar is distilled from petroleum and coal sources while wood tar is obtained from vegetation through a similar destructive distillation process.

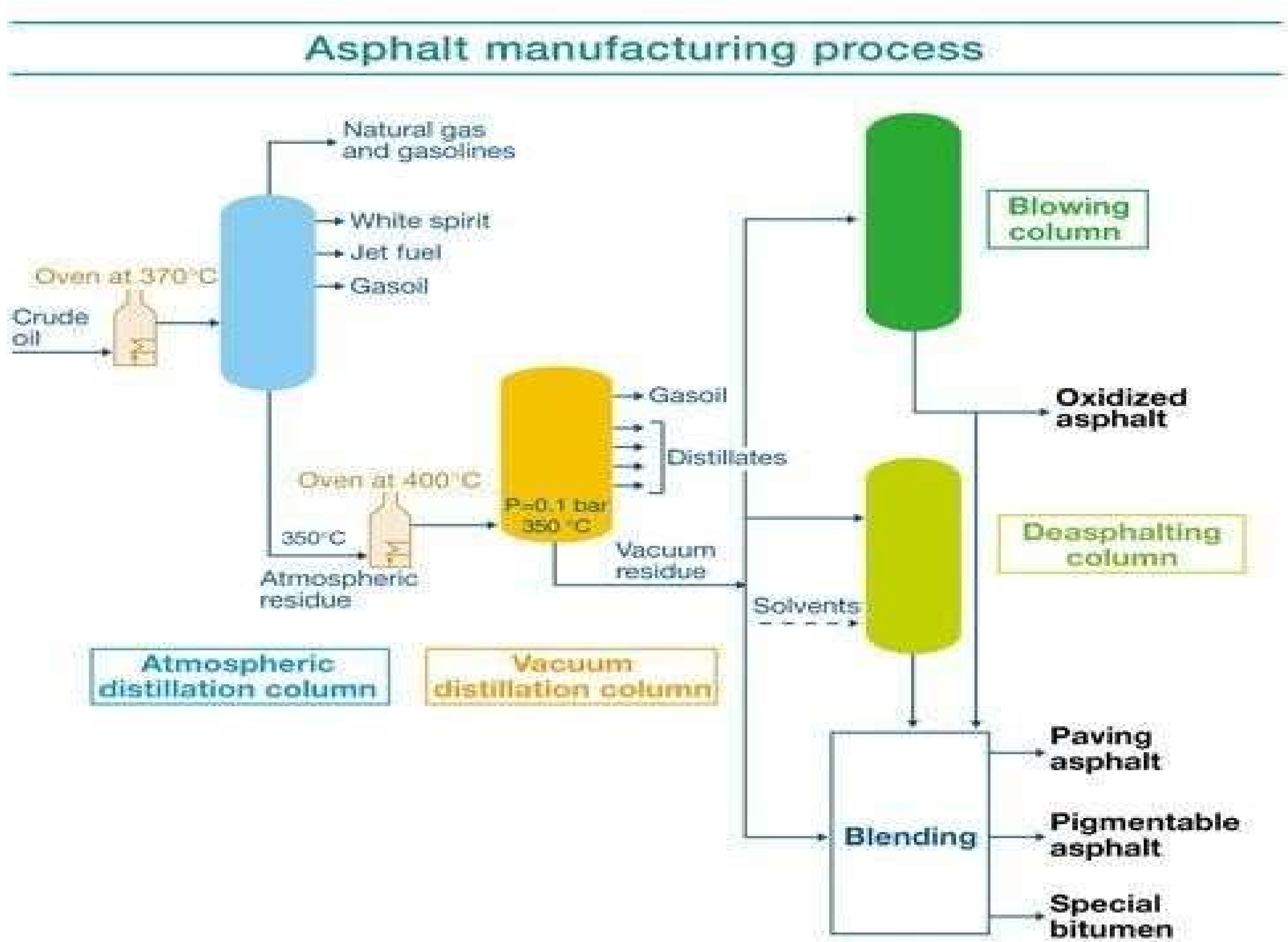
DIFFERENCE BETWEEN BITUMEN AND TAR

Sl No	Bitumen	Tar
1	Bitumen is found in black to brown in colour	Tar is usually found in brown colour
2	Bitumen is obtained from fractional distillation of crude oil	Tar is obtained by destructive distillation of coal or wood
3	Bitumen is soluble in carbon disulphide and carbon tetra chloride	Tar is soluble in toluene
4	Molecular weight range for road bitumen is 400 to 5000	Molecular weight range for road tar is 150to 3000
5	Bitumen consists of large amount of aromatic hydrocarbon	Tar consist of large amount of oily matter with lower molecular weight
6	Bitumen show resistance to coating road aggregate and also does not retain in presence of water	Tar coats more easily and retain it better in presence of water
7	Free carbon content is less	Free carbon content is more
8	It shows more resistance to weathering action	It shows less resistance to weathering action
9	Less temperature susceptibility	More temperature susceptibility

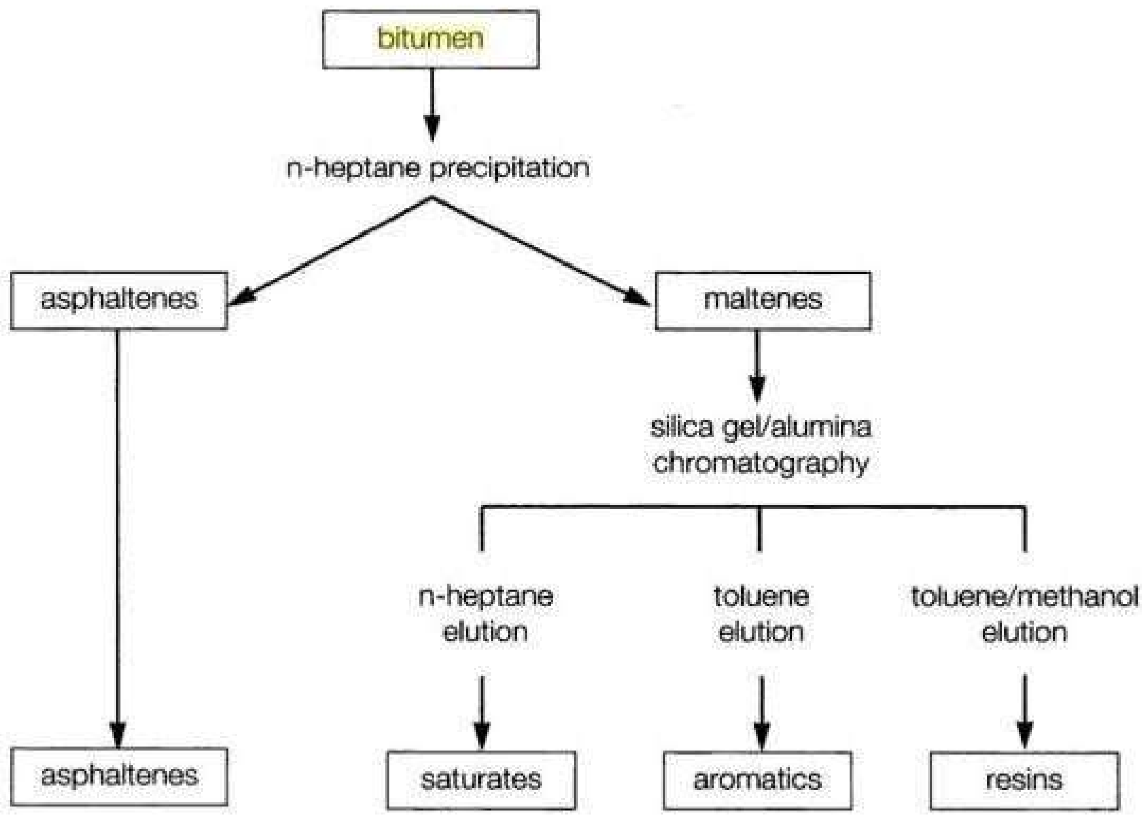
BITUMEN MANUFACTURING PROCESS



BITUMEN MANUFACTURING PROCESS



CHEMICAL CONSTITUTION OF BITUMINOUS ROAD BINDERS



Schematic for the separation of chemical constituents in bitumen

PROPERTIES OF BITUMEN

Adhesion: It should bind materials together properly without affecting the properties of other materials.

Resistance to Water: Bitumen should be highly resistive towards the water Lower water-resistive property leads to lower durability and lower strength of bitumen. It also leads to low adhesion

Strength: Binding material should also have sufficient strength to resist different live & dead loads (like self-weight and wheel load)

Viscosity and Flow: Viscosity should not be very low as well as very high because high viscosity leads to difficulties in the application of bitumen and low viscosity leads to improper binding of materials as it flows fast.

Softening point: Higher the softening point value, lower will be the temperature susceptibility. So, bitumen with high softening value is preferred for hot climates

PROPERTIES OF BITUMEN

- **Ductility:** Ductility is the property of bitumen that permits it to undergo great deformation or elongation.
- **Specific Gravity:** The property is determined at 27 °C and varies from 0.97 to 1.02.
- **Durability:** Bitumen durability refers to the long-term resistance to oxidative hardening of the material in the field. **Versatility:** Bitumen should show a versatile nature. It must be workable during the construction phase and must be rigid in the operation phase.
- **Economical:** The cost of bitumen depends upon its grade but should be economical to use.
- Chemical Resistive: Bitumen has to tackle with different chemicals directly or indirectly (Eg: It has to tackle with acids in the form of acid rain). So, it should be highly resistive against chemicals.

REQUIREMENTS OF BITUMEN

The desirable properties of bitumen depend on the mix type and construction.

a) Mixing: type of materials used, construction method, temperature during mixing, etc.
b) Attainment of desired stability of the mix
c) To maintain the stability under adverse weather conditions
d) To maintain sufficient flexibility and thus avoid cracking of bituminous surface
e) To have sufficient adhesion with the aggregates in the mix in presence of

Bitumen should posses following desirable properties.

- Viscosity
- Susceptibility
- Adhesion Property

- http://mynotetransengg.blogspot.com/2014/12/bl ending-of-__aggregates.html
- https://www.civil.iitb.ac.in/tvm/1100_LnTse/406_lnTse/plain/pl ain.ht ml#Grade