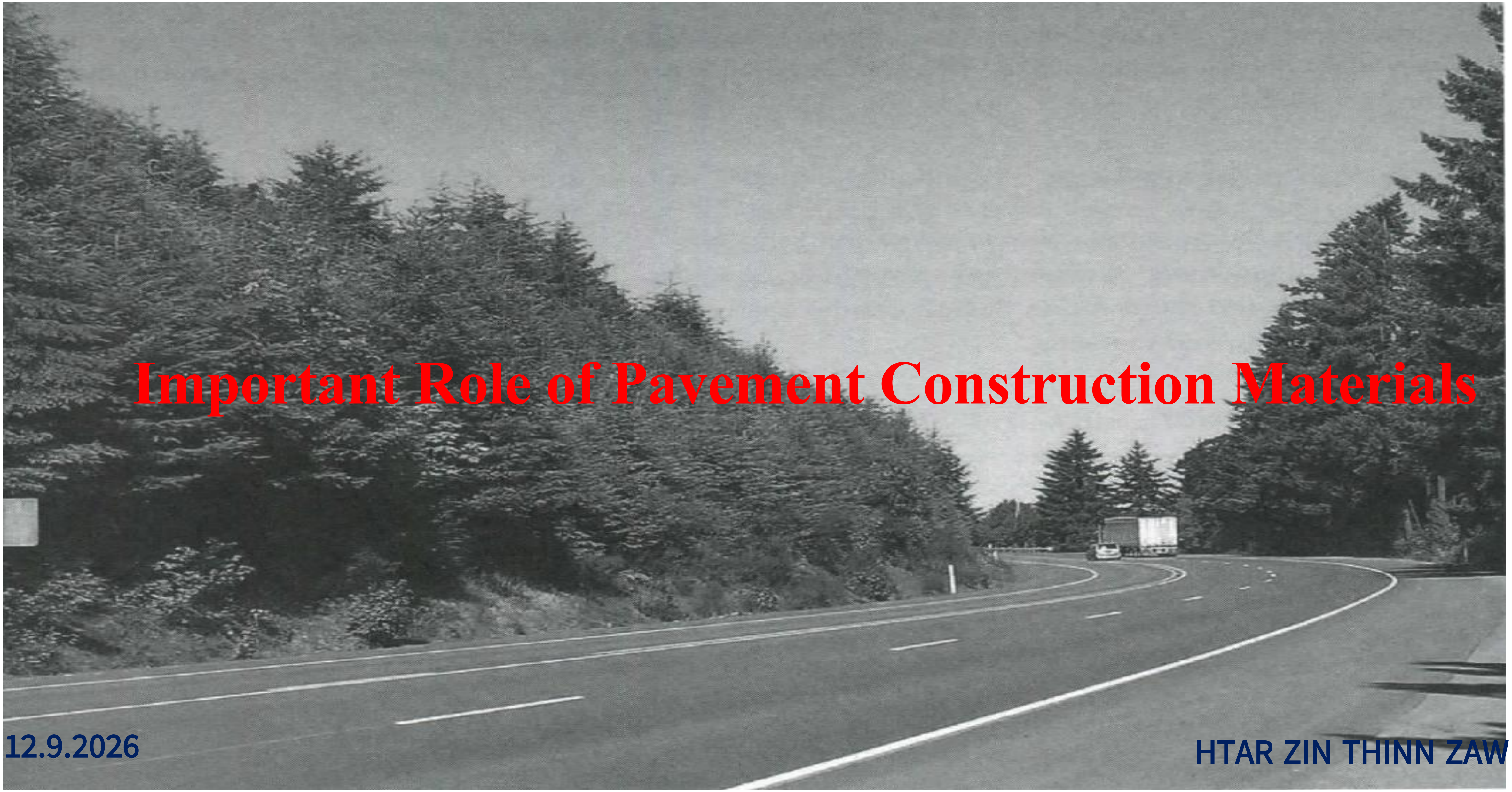
Important Role of Pavement Construction Materials



12.9.2026

HTAR ZIN THINN ZAW

Outline of Presentation

- ✓ Objective
- ✓ Historical Evolution of Road Surfacing
- ✓ Road design(Geometric/Pavement)
- ✓ Important Role of Pavement Construction Materials
- ✓ Pavement Construction Materials and Test Methods
- ✓ Materials Mix Design
- ✓ Soil Improvement and Ground Modification
- ✓ Materials Innovation in Pavement construction
- ✓ Conclusion

Objective

One of the major factors endeavors to preserve the lives of those traveling the roadways all over the world is using **well designed, strong, durable and safe roadways.**

Factors have positive effect on the accidents risk are:

1. Driver training and behaviour,
2. Vehicle maintenance,
3. The road design aspects
4. **The road pavement conditions represented by the pavement age and construction materials types and quality**

(a) Roman road made of stone ; (b) A street paved with granite block historic paving material; (c) Asphalt paved road.

- ✓ Objective
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Historical Evolution of Road Surfacing

- Rocks, pebbles, gravels, wood and pottery fragments were the main forms of pavement materials (before the Christ until the 19th century AD)
- Asphalt was recorded as a material to build road in ancient Babylon(In 615s BC)
- Bituminous macadam paved in highway system (In the 1500s)
- The first road with asphalt Macadam pavement was paved outside of Nottingham, UK, using coal tar as the binder (In 1848)
- Cement concrete and asphalt mixture became the main types of high-grade pavement materials.(in the 19th century)
- A significant boost in pavement service life and stability, with the use of various modified asphalt materials and high-performance cement.(The 20th century)

Historical Evolution of Road Surfacing(Cont:)

To improve on ecological and environmental performance of road infrastructure,

(the beginning of the 21st century)

Six environmentally friendly functional pavement materials, namely

- The permeable asphalt concrete
- Noise-reducing pavement materials
- Low heat-absorbing pavement materials
- Exhaust gas-decomposing pavement materials
- De-icing pavement materials , and
- Energy harvesting pavement materials

- ✓ Objective
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Road Design

Road Design Considers the following data:-

1.**Functional and Geometric Design**(how the road layout matches traffic flow and land use)

2.**Pavement Structural Design**(the materials used to build the road surface)

Geometric Design

- **What is Geometric Design?**
  - the process whereby the **layout** of the road in the **terrain**
  - designed to meet the **needs** of the road users.

- **Basic objectives in geometric design**
  - to optimize efficiency and safety while minimizing cost and environmental damage. (Safety, Comfort, Efficiency, Economy, Environment etc.)

Factors considered in Geometric Design

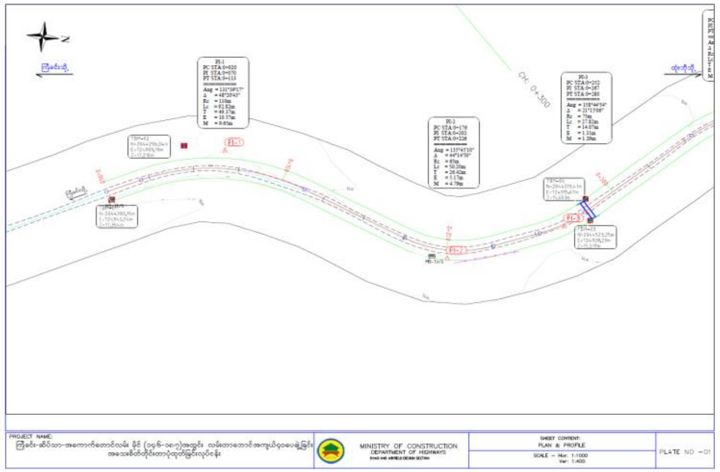
(1)Classification(Urban/Rural, Road, Terrain)

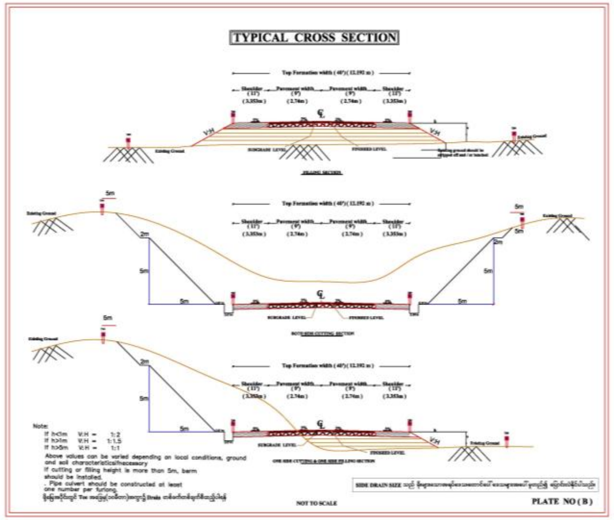
(2)Design Controls and Guidelines(Traffic volumes, vehicle , Speed , Vertical Grade,

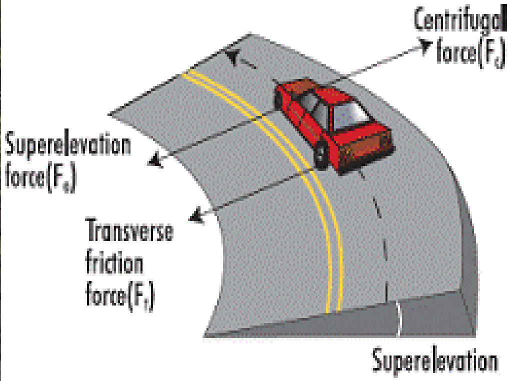
Cutting & Filling heights, ROW, Lane & Shoulder width ,etc.)

(3)Element of Geometric Design[Horizontal/Vertical Alignment Design (Plan/Profile),

Cross - Section Design](Horizontal Curve, Minimum horizontal Curve Radius, Superelevation, Sight Distance, Vertical Curve, Vertical clearance , etc)







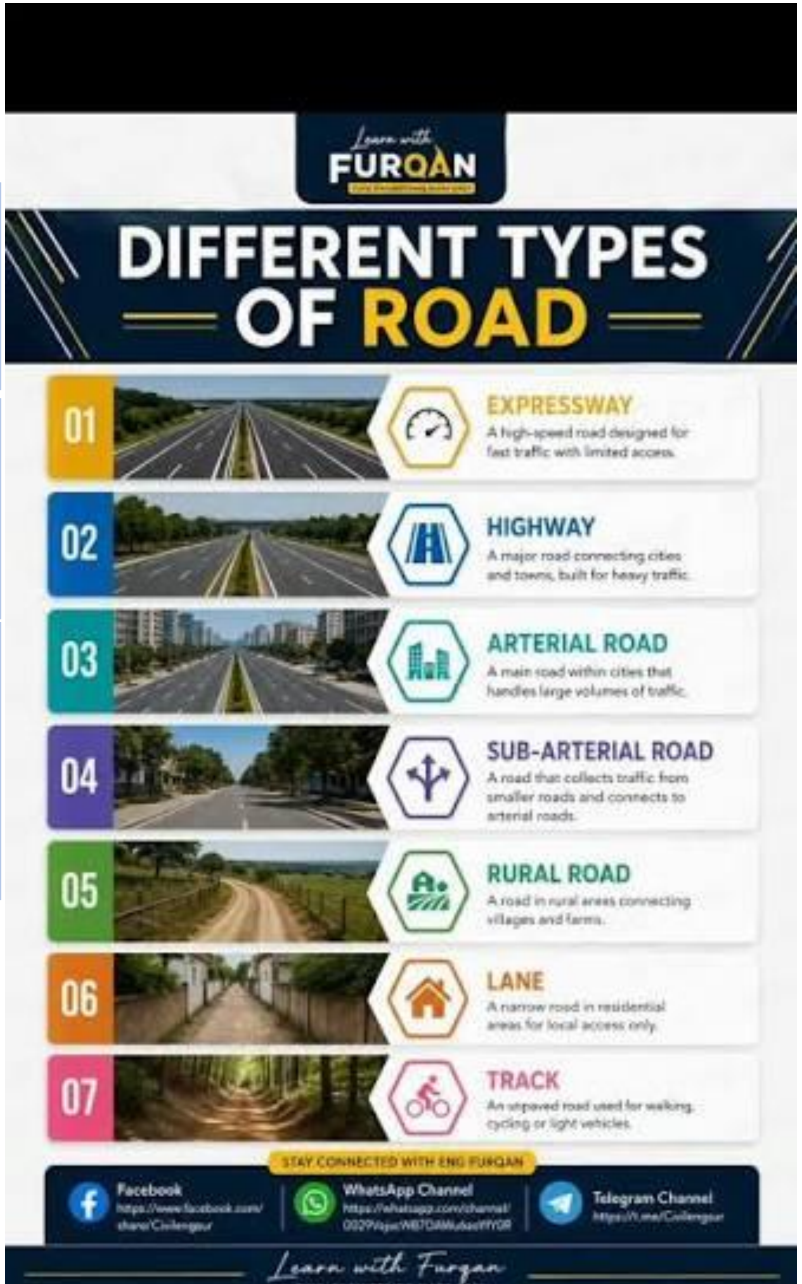
Classification of Road

- Based on the function of the road on road networks (Urban / Rural)

	Local Road	Collector Road	Arterial Road		Expressway
			Sub Arterial	Main Arterial	
Name	Township Road	District Road	Regional/State Road	Union (National) Highway	Expressway
Feature	run within a Township	run within a District	run within a Region/State	Across Regions/States	high Speed with access control

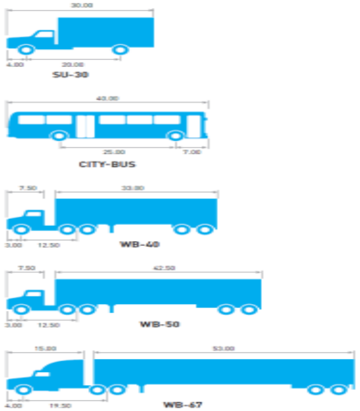
← **Accessibility** (*focusing on*) **Mobility** →

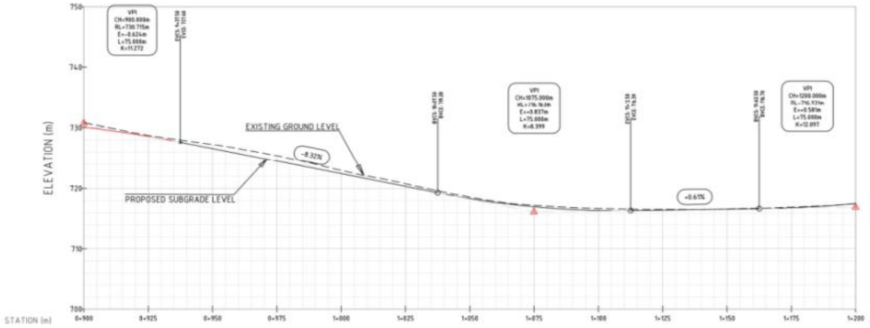
Note:1) The Expressway is Including Urban Expressway



Design Controls and Guidelines

- Traffic volumes
- Design vehicle
- Design speed
- Maximum vertical grade
- Maximum allowable excavation depth and embankment heights
- Lane and shoulder widths



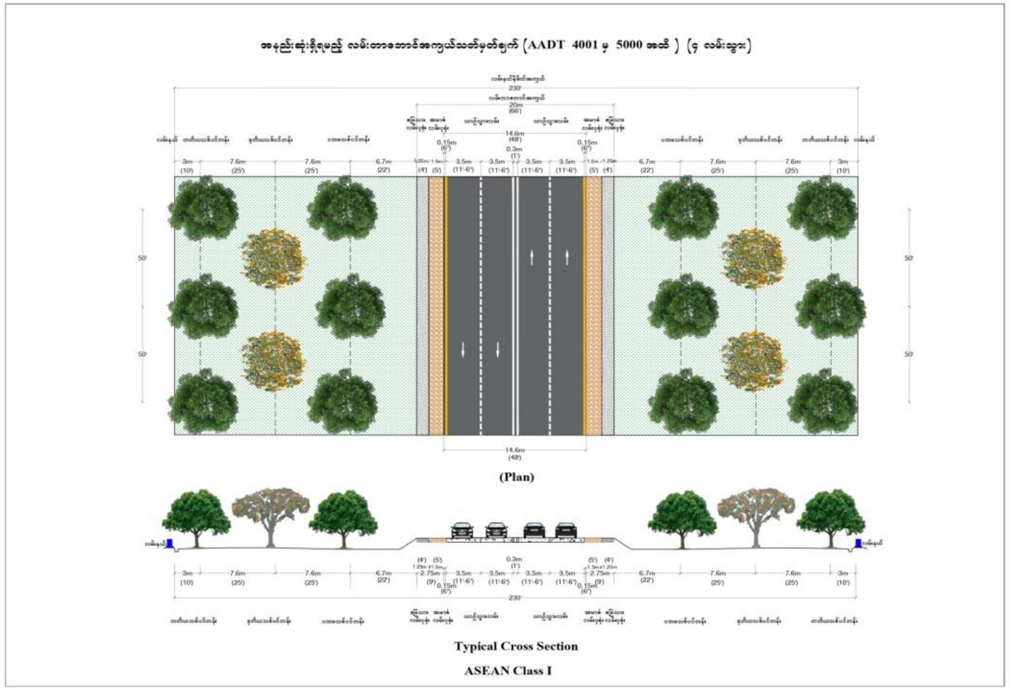


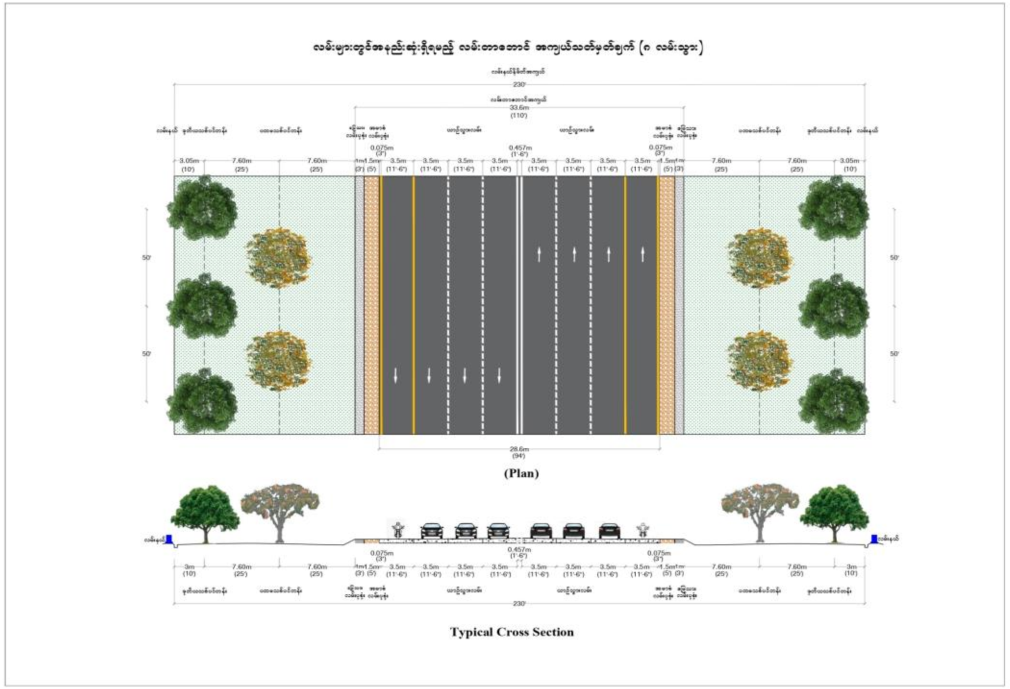
units: m

Right of Way (ROW)

Class	Local Road	Collector Road	Sub Arterial Road	Main Arterial Road	Expressway
Rural/Urban	30.5	45.75	45.75	45.75	122.0
Urban	The width of ROW is determined in the city planning process.				

For international highway (Main Arterial Road) ROW is 70 meter.





Width of a Lane (minimum based)

Units: m

Classification	Local Road	Collector Road	Sub Arterial Road	Main Arterial Road	Expressway
Rural	3.00m	3.25m	3.50m	3.50m	3.75m
Urban	3.00m	3.00m	3.25m	3.25m	3.75m

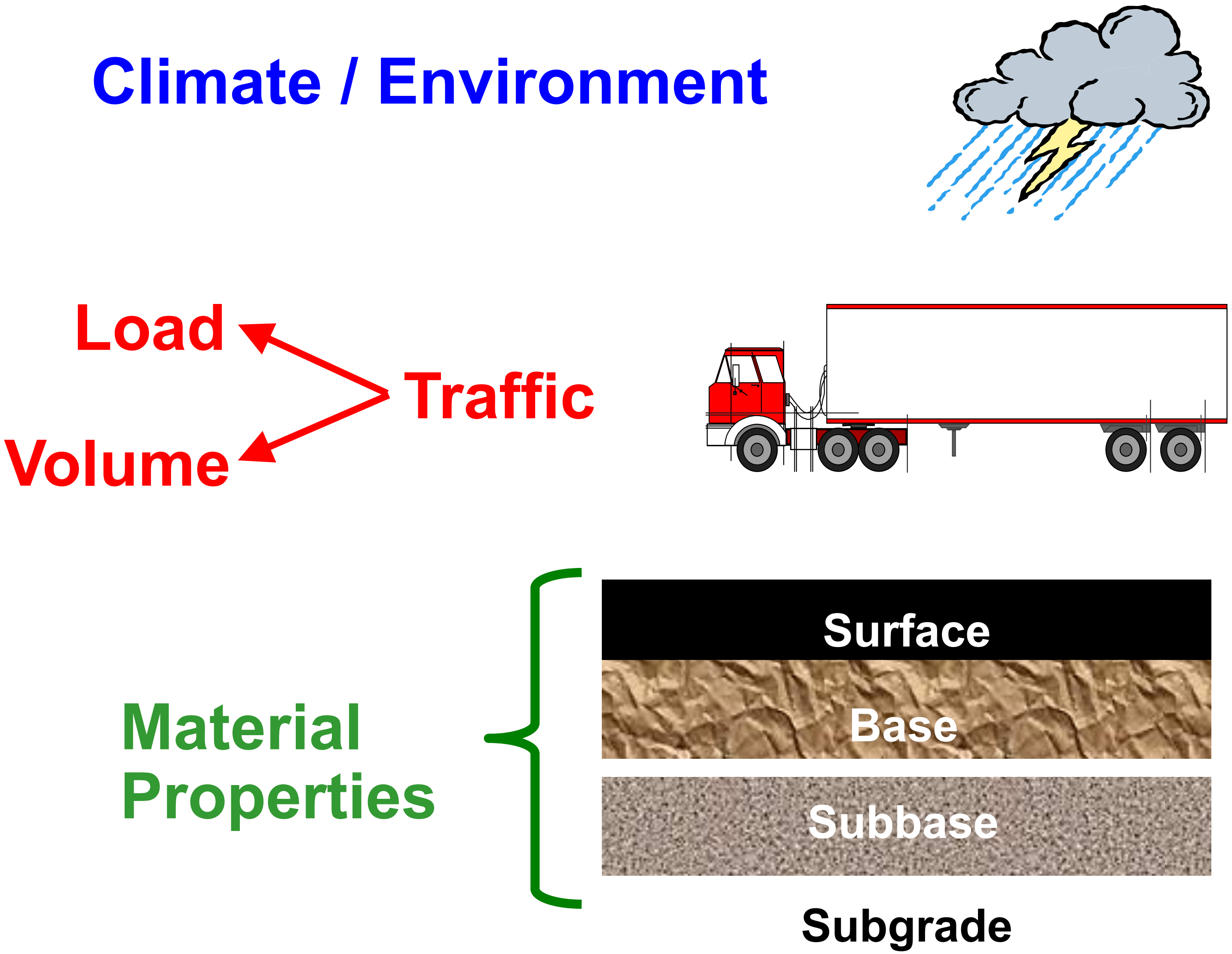
Note: If it is a single lane, the width of the lane should be at least 3.7m

Number of Lanes

- The number of lanes is excepted from an indicator for road classification

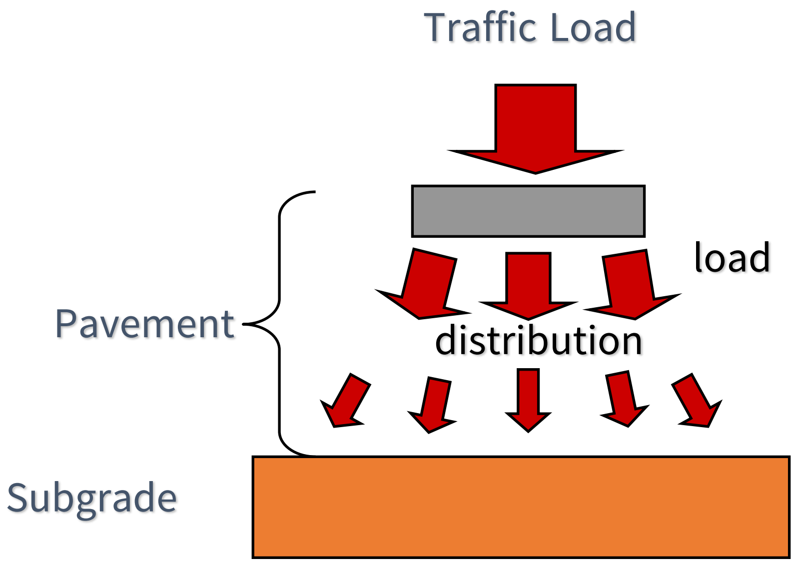
Pavement Structural Design

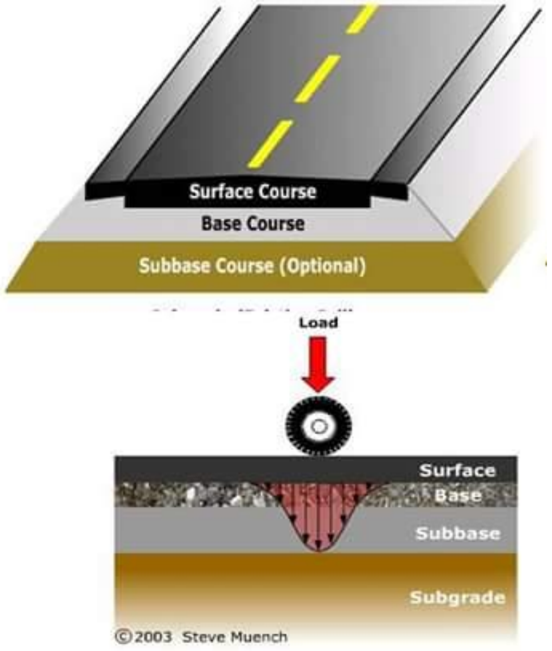
It balances traffic loads, material properties, climate, and subgrade strength to ensure durability and riding.



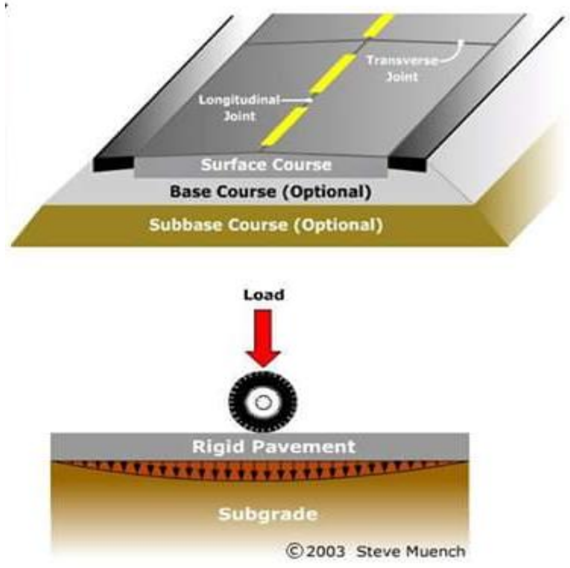
What is the Role of Pavement?

- To distribute traffic load to subgrade
- To make its stress smaller than the bearing capacity of the sub grade





Flexible



Rigid

Factors considered in Pavement Structural Design

The engineering process of determining the correct materials and layer thicknesses for a road or surface to safely distribute vehicle loads to the underlying soil without premature failure.

Factors considered in the Pavement Structural Design

(1) Pavement Performance
(2) Traffic
(3) Roadbed Soil
(4) Materials of Construction
(5) Environment
(6) Drainage
(7) Reliability
(8) Life- Cycle Costs, and
(9) Shoulder Design

AASHTO® Guide for Design of Pavement Structures
1993

Published by the
American Association of State Highway
and Transportation Officials
444 N. Capitol Street, N.W.,
Suite 249
Washington, D.

Types of Pavement layers

PAVEMENT COMPARISON (As per IRC Standards)

Type	Material	Cost	Maintenance	Life
Flexible	Bitumen	Low	High	Medium
Rigid	Concrete	High	Low	Long
Composite	Both	Medium	Medium	Long
Semi-Rigid	Stabilized Mix	Medium	Medium	Medium

FLEXIBLE PAVEMENT vs RIGID PAVEMENT

Flexible pavement is made of bituminous (asphalt) layers.	MATERIAL	Rigid pavement is made of cement concrete slab.
More flexible – can bend or deform under heavy load.	FLEXIBILITY	Less flexible – does not bend, can crack under heavy load.
Lower initial cost.	COST	Higher initial cost.
Requires more maintenance (regular resurfacing).	MAINTENANCE	Requires less maintenance (low maintenance cost).
Shorter design life (10–15 years).	LIFE	Longer design life (20–30 years or more).
More noise due to vehicle movement.	NOISE	Less noise and smoother surface.
Water can penetrate through layers.	WATER RESISTANCE	Impervious surface – water does not penetrate.
Suitable for light to medium traffic roads.	SUITABILITY	Suitable for heavy traffic, expressways, and airports.

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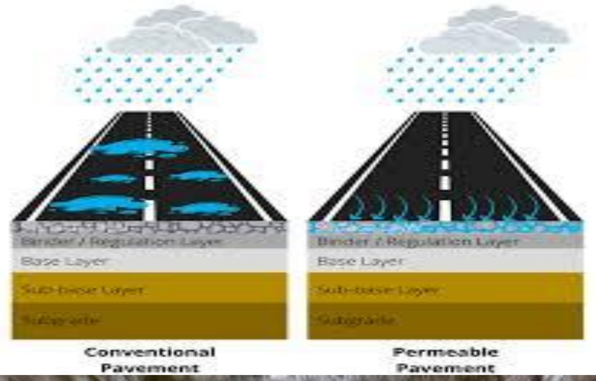
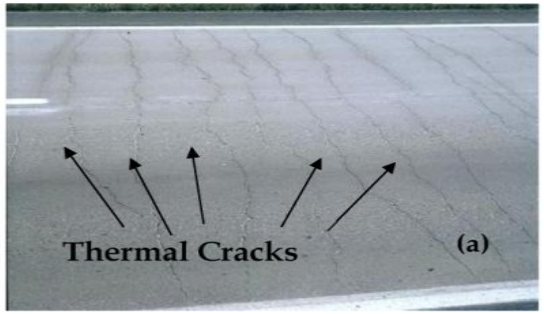
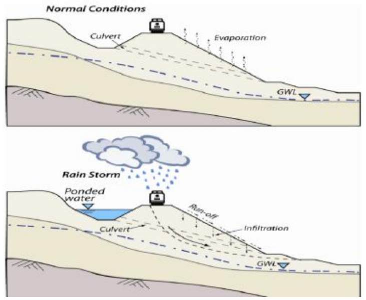
Core Functions of Pavement Materials

- **Load Distribution:** Spread heavy wheel weights safely down to the natural soil.
- **Surface Safety:** Create a skid-resistant texture for safe vehicle control.
- **Weather Resistance:** Protect inner layers from rain, freeze-thaw cycles, and heat.
- **Drainage Support:** Prevent water from pooling or seeping into the subgrade







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Important Role of Pavement Construction Materials

Factors considered in the Pavement construction Materials

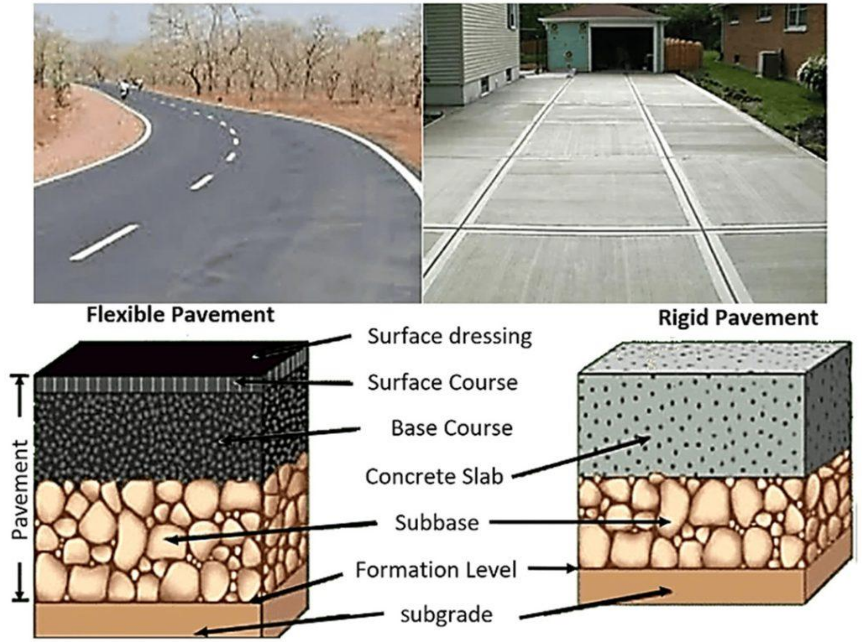
(1) Available Materials(source)

(2) Specification of Materials used in Pavement Layers

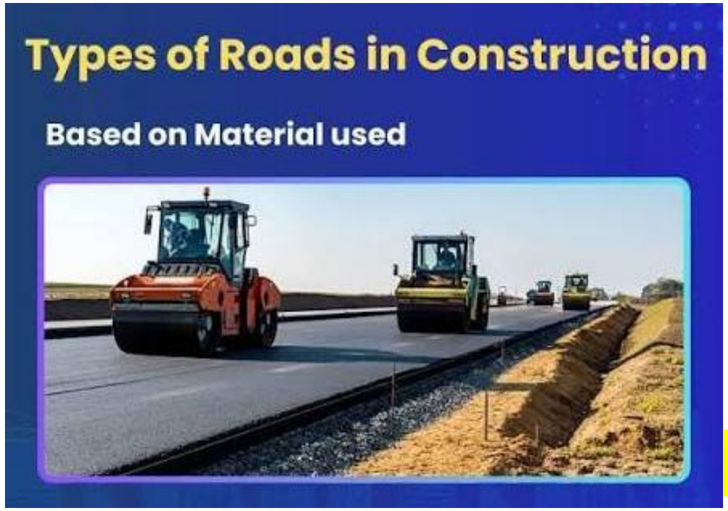
(design)

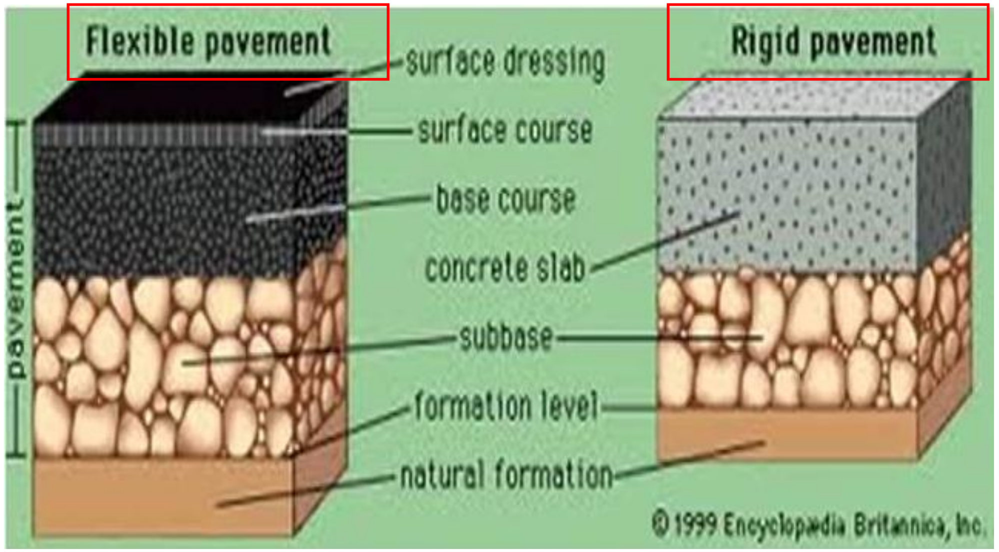
(3) Materials Testing(Material Testing Lab/Field Lab)

(4) Materials Mix Design(Material Testing Lab/Field Lab)



Materials Used in Pavement Layers





Layer

- **Surface (or) Wearing Course**
  - Asphalt Concrete (AC), Prime & DBST
  - Penetration Macadam (Pen.Mac) (Semi-Grout , Full Grout)
  - Plain Concrete (4000 psi)(28 Mpa) (28 days) (cube strength)
- **Base Course**
  - Well-Graded Crushed Rock or Granular Base
  - Cement (or) Lime Stabilized
  - Water Bound or Dry Bound Macadam
- **Subbase Course**
  - Crushed Rock
  - Granular
  - Cement (or) Lime Stabilized
  - Lean Concrete (2000 psi) (14 Mpa) (28 days) (cube strength)

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Pavement Construction Materials and Test Methods

Soil, Aggregates

Natural Earth Materials

Bitumen, Cement, Lime

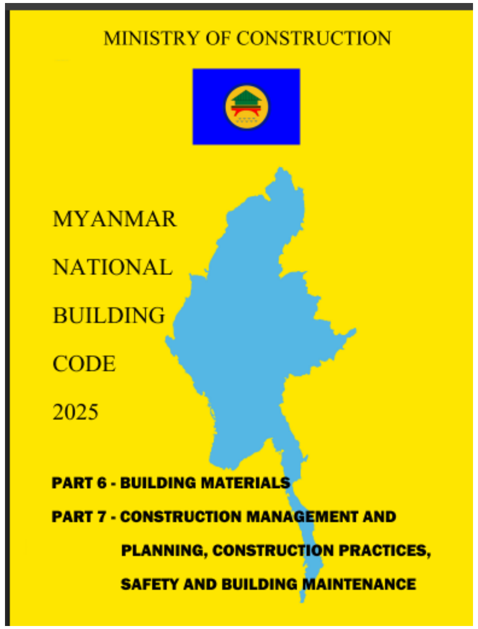
Stabilized Agent

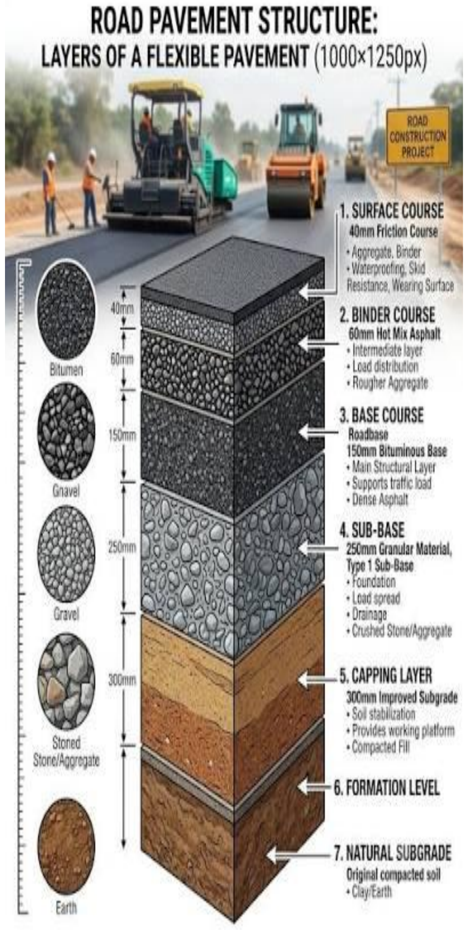
Chemical Admixtures/ Organic Compound

Additives/Catalyst

Geosynthetic, Steel

Reinforcement



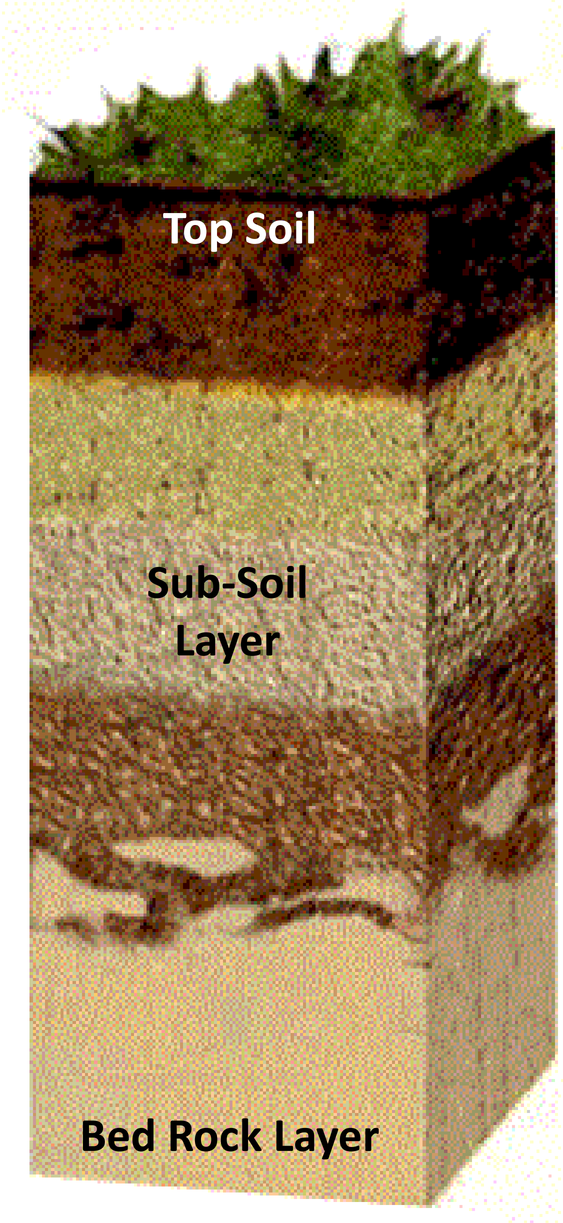


SOIL

Soil Layer = Foundation of Structure

Shallow Foundation

Disturbed Soil Sample



Deep Foundation

Undisturbed Soil Sample

SOIL

What is Soil?

- *For engineering purpose, **Soil** is defined as **uncemented aggregate of mineral grains and decayed organic matter (soil particles) with liquid and gas** in the empty spaces between the solid particles.*
- *Soil is classified "**Individual TYPE**" based on Physical Properties and Chemical Properties.*

What is Specification or Designation?

BS or BS-EN

AASHTO

ASTM

SOIL

Roadbed Soil

Classification	CBR (%)	M_R (MPa)	Typical Description
Good	≥ 10	140 (20,000 psi)	Gravels, crushed stone and sandy soils. GW, GP, GM, SW, SP, SM soils are often in this category.
Fair	5 – 9	70 (10,000 psi)	Clayey gravel and clayey sand, fine silt soils. GM, GC, SM, SC soils are often in this category.
Poor	3 – 5	35 (5,000 psi)	Fine silty sands, clays, silts, organic soils. CL, CH, ML, MH, CM, OL, OH soils are often in this category.

SOIL

Laboratory Tests of Soil in Road Work

Test 1 : Grain Size Analysis Test	ASTM D 422/ 421	Size
Test 2 : Atterberg's Limit Test	ASTM D 4318	Plasticity
Test 3 : Classification of Soil - USCS system	ASTM D 2487	
Test 4 : Proctor Compaction Test	ASTM D 698/1557	
Test 5 : California Bearing Ratio CBR Test	ASTM D 1883	Strength

Why we have to test always ?

- Materials are ***not always stable*** conditions (esp., Grain Size)
- ***Design requirements*** depended on local materials
- ***Varity*** of Source of Materials

Test -1 : Dry Sieving of Particle Size for Coarse Grained Soil over 0.075 mm(ASTM D 421) Division of Particle Size for Fine Grained Soil under 0.075 mm (ASTM D 422)

Divided by Grain Size

Coarse-grained Soil | Fine-grained Soil

Boulders | Cobbles | Gravels | Sand | Silt | Clay | Colloids

Gravels: *coarse* *medium* *fine*

Sand: *coarse* *medium* *fine*

300 mm

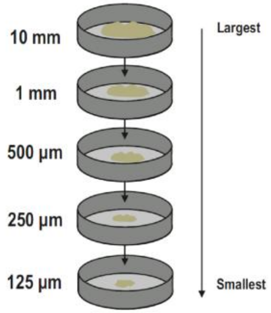
76.2 mm (3-in)

No.4 (4.75 mm)

No.200 (0.075 mm)

0.002 mm

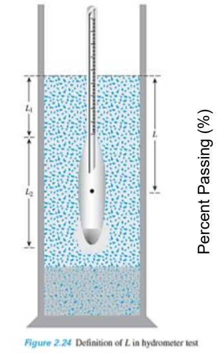
0.001 mm

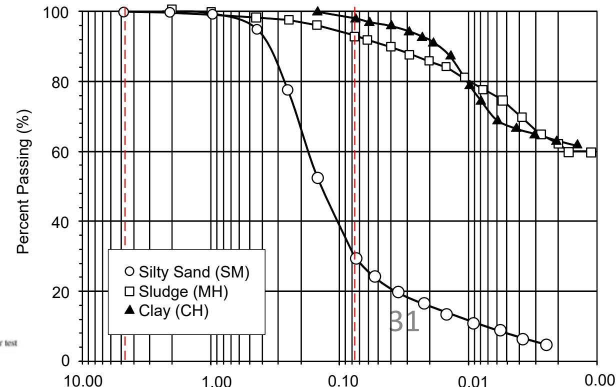


Retained % (R_{xxx})

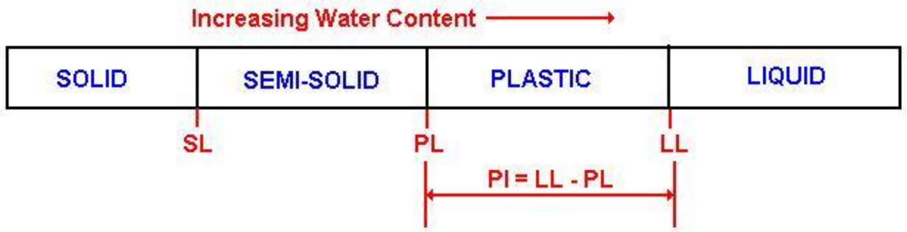
Sieve #

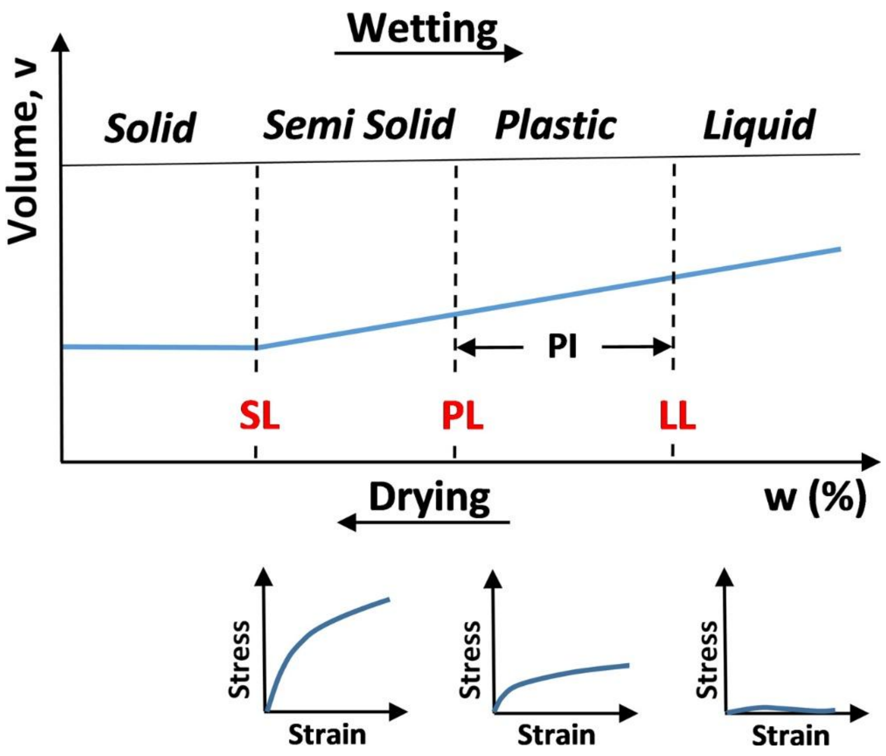
Passing % (F_{xxx})





Test-2 : Atterberg's Limit Test (Soil Plasticity) ASTM D 4318





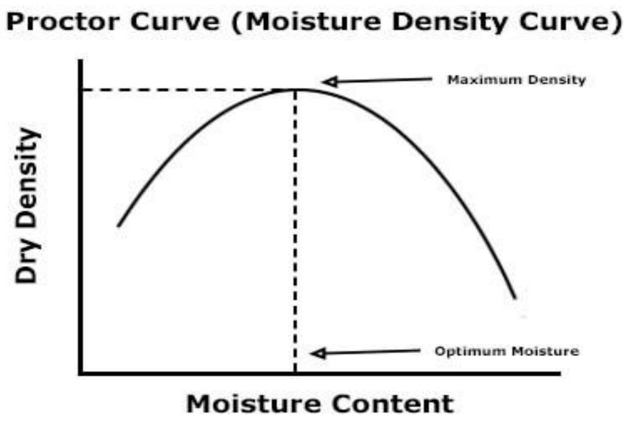
Burmister(1949) classified the Plasticity Index in a qualitative manner as follows:

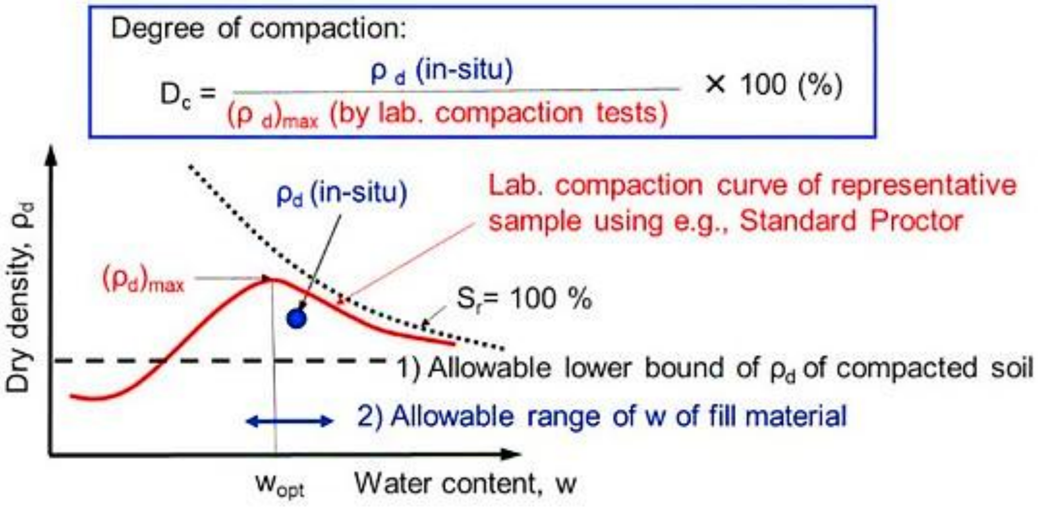
PI	Description
0	Nonplastic
1–5	Slightly plastic
5–10	Low plasticity
10–20	Medium plasticity
20–40	High plasticity
>40	Very high plasticity

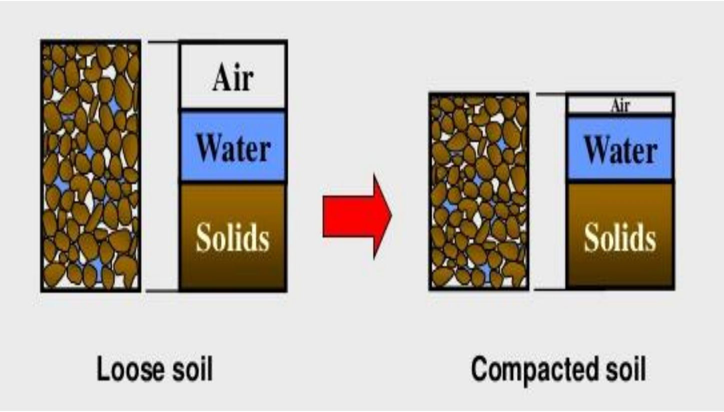
SOIL

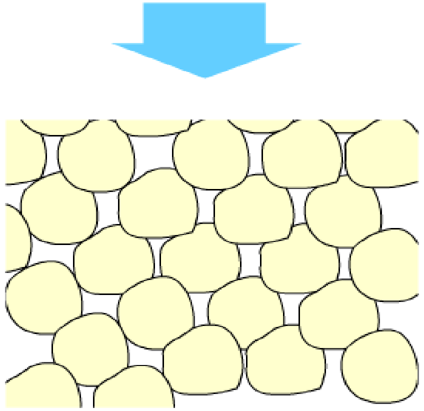
Test-4: Compaction Test ASTM D698/AASHTO T 99 (Standard) and ASTM D1557/AASHTO T 193 (Modified)

- It is the densification of soil by removal of air in mechanical energy.
- Compaction is achieved by a combination of pressure and kneading action









Compaction Test

- Test Method Designation - ASTM D698/AASHTO T 99 (Standard) and ASTM D1557/AASHTO T 193 (Modified)
- Two types of compaction

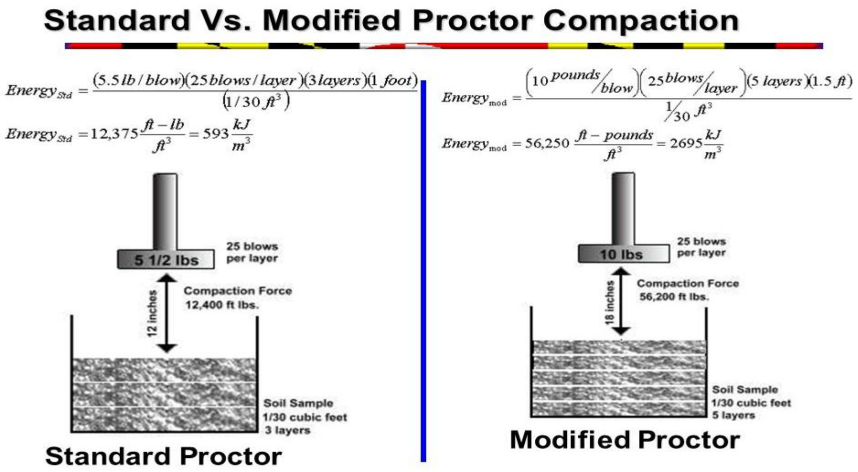
  Standard and Modified by different compacting energy.
- In a same condition,

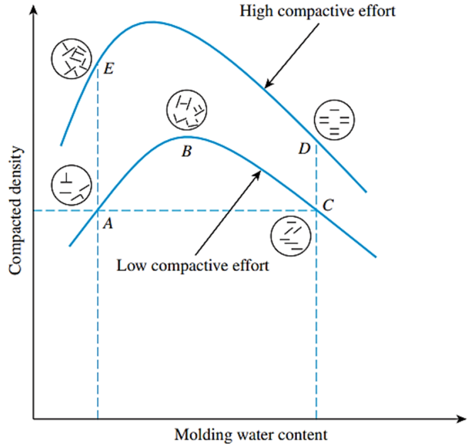
  1) Standard Compaction Test

     (12,400 ft-lbf/ft (600 kN-m/m))

  2) Modified Compaction Test

     (56,000 ft-lbf/ft (2700 kN-m/m)





SOIL

Flow Chart of CBR Laboratory Test

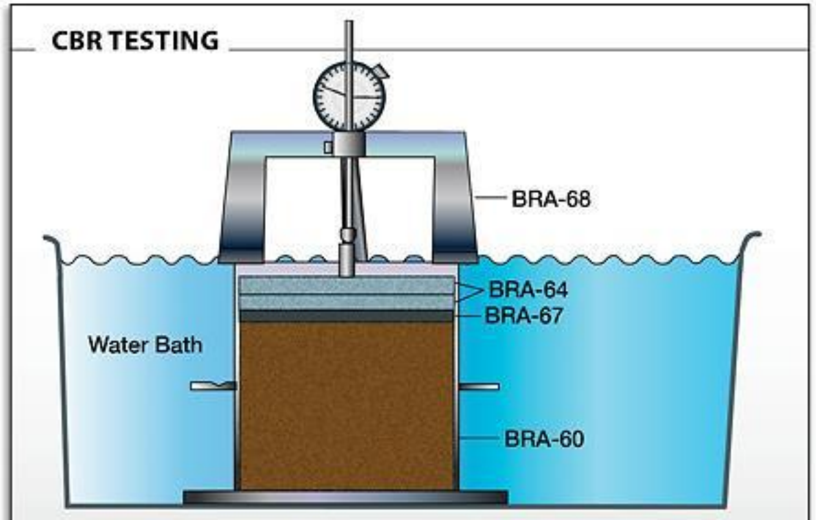
OMC
(Compaction Test 25 blows @ 3/5 layers)

Mould Compaction
(10, 30, 65 blows with same layers in compaction)

Curing
(4 Days Soaked)

Penetration Test
(4 Days Soaked)

CBR Calculation
(Curve Density & CBR %)



Compacted specimens in the mold are immersed in water for soaking. Surcharge weights are placed on top and the molded specimen is monitored to determine swell.

Test-5: Strength Test (CBR Test) – ASTM D 1883

As highway purposes, CBR can be measured by

- Tested in Laboratory & Field Condition

1) **Laboratory CBR Test**

    - CBR value in OMC state

2) **In-situ Field CBR Test** (only in embankment & subgrade)

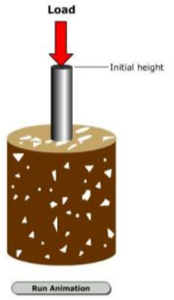
    - Direct CBR

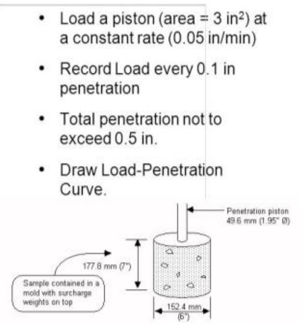
3) **Dynamic Cone Penetration Test**

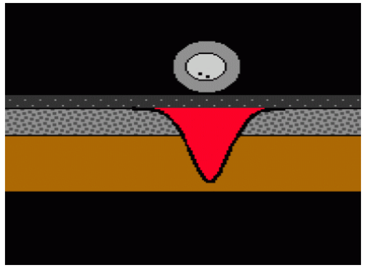
    - Indirect CBR converted from mm/blow

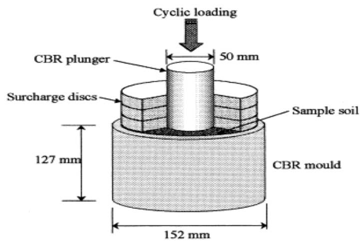
4) **Plate Loading /Bearing Test** (both soil & Crushed Rock Layer)

    - Indirect CBR value converted from modulus of subgrade reaction (k-value)



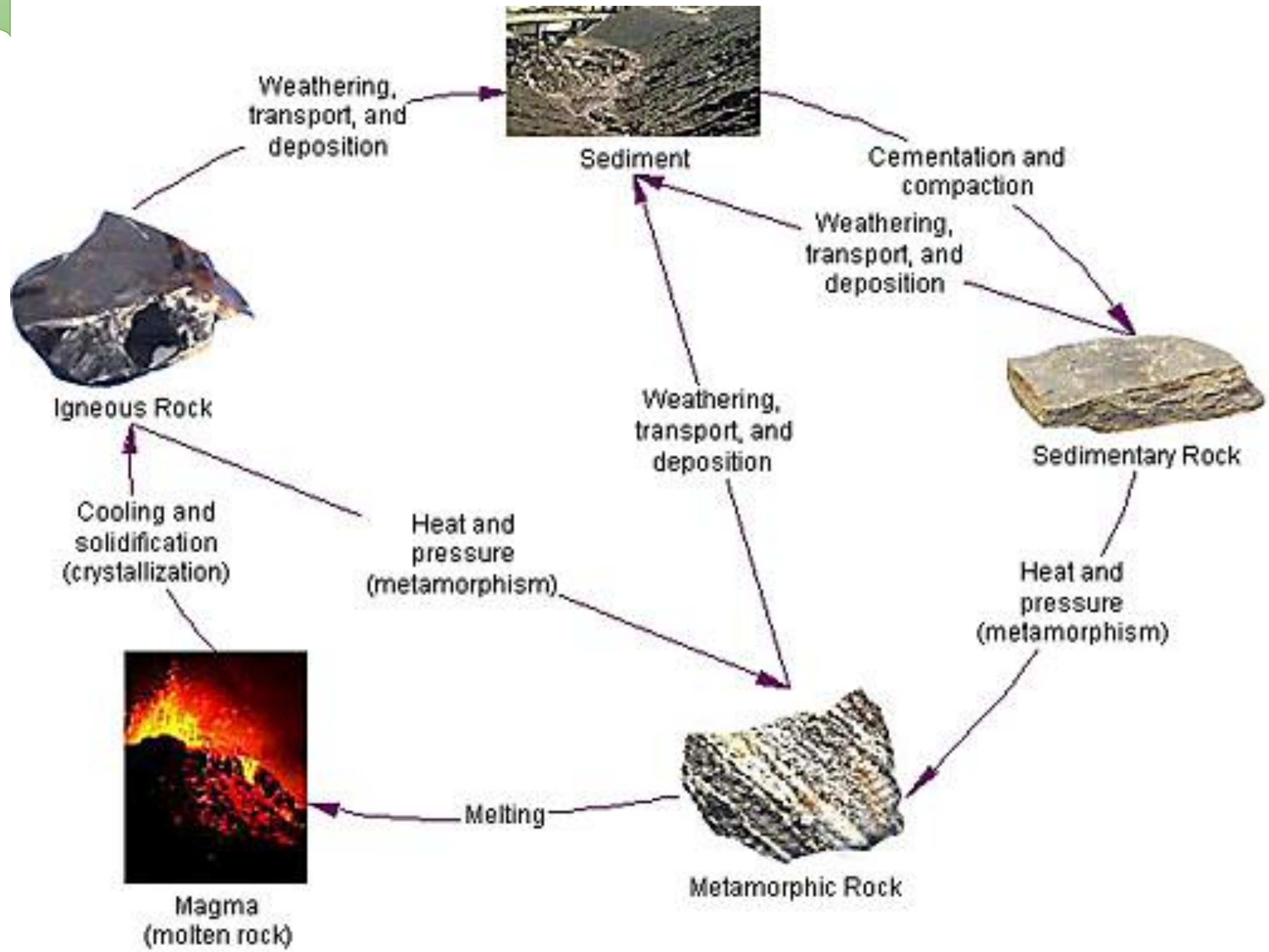






AGGREGATE

Origin of Aggregates



AGGREGATE

Sedimentary rocks are formed from layers of sand, silt, dead plants, and animal skeletons.

AGGREGATE

Metamorphic rocks formed from other rocks that are changed by heat and pressure underground.

AGGREGATE

Igneous rocks are formed from melted rock deep inside the Earth.

AGGREGATE

CLASSIFICATION OF AGGREGATES

AGGREGATES

NATURAL AGGREGATES

QUARRY

NATURAL DEPOSITS

SAND

CRUSHED STONE

GRAVEL

ARTIFICAL AGGREGATES

CONSTRUCTION WASTE/RECYCLED

MANUFACTURED

AGGREGATE

Requirements of Good Aggregates

Strength	withstand high stresses
Attrition	aggregate wear, moisture ,traffic
Toughness	resistance to crack, binding strength, energy dissipation
Durability	Traffic volume, temperature, precipitation
Shape	Interlocking and stability, load bearing capacity
Bitumen Adhesion Property	Physical, chemical. Surface characteristic

Physical Requirements

- ❑ Resistance to crushing
- ❑ Resistance to abrasion
- ❑ Resistance to impact
- ❑ Good shape

Chemical Requirements

- ❑ Reactive
- ❑ Non-reactive

AGGREGATE

Road Base Materials

Common Materials Used for Road Base

1. **WBM (Water Bound Macadam)**
   Crushed stone aggregates compracted with water and screenings
2. **WMM (Wet Mix Macadam)**
   Mechanically mixed graded aggregates with water, compacted for strength
3. **Granular Sub-base (GSB)**
   Layer of well-graded material placed below WMM for load distribution
4. **Crushed Stone / Gravel**
   Provides strength and drainage to the base layer
5. **Soil Stabilized with Lime or Cement**
   Used to improve weak soil strength and reduce deformation
6. **Recycled Aggregates**
   Crushed concrete or reclaimed asphalt used as eco-friendly alternatives

Type of Mixture	Coarse stone low fines	Well-graded coarse to fine	Excess fines
Compaction	Difficult	Moderate	Easy
Flexibility	Relatively stiff after compaction	Moderate	Relatively pliant
Stability	Variable	Good	Fair
Frost	Not affected	Susceptible	Very susceptible
Drainage	Good	Low	Variable
Effect of water saturation on strength	Not much	Moderate	Very significant strength loss
Chemical stabilisation	Not very suitable	Suitable	Very suitable
Dust	Low	Moderate	High
Roughness	High	Moderate	Variable
Capillary effects	Very low	Beneficial	High suction potential instability

AGGREGATE

TESTING DESIGNATION

ASTM (American Standard Test Method)

AASHTO (American Association of State Highway and Transportation Officials)

BS (British Standard)

Figure (1) Quarry in MDY Region

Figure (2) Collection of Crushed Rock for Road Construction

AGGREGATE

TEST METHODS FOR AGGREGATES USED IN PAVEMENT STRUCTURE

No	Name of Test	Test Designation
1	Sieve Analysis	AASHTO T-27 ASTM C-136
2	Specific Gravity and absorption	AASHTO T-85 ASTM C- 127
3	Clay Lump and Friable Particle	AASHTO T- 112 ASTM C- 142
4	Crushing Value	BS- 812(1990)
5	Impact Value	BS- 812 Part-112 (1990)
6	Los-Angeles Abrasion Value	AASHTO-T 96
7	Ten Percent Fine Value	BS- 812 Part-111 (1990)
8	Flakiness Index	BS- 812 Part-105.1 (1990)
9	Unit Weight (Loose Density/Rodded Density)	AASHTO T- 19 ASTM C- 29

AGGREGATE

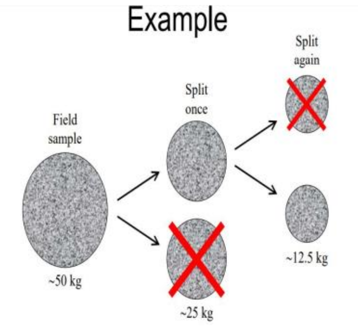
Why do we conduct tests and Experiments?

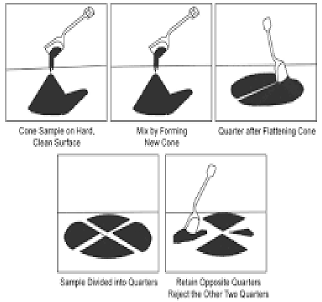
Sieves analysis Test	To determine the distribution of aggregate particles by size within a given sample.
Sampling Metod	To test the truly representative of the nature and condition of the aggregate in the stockpile, bin or transfer point ASTM C702
Absorption Test	The increase in mass due to water in the pores of the material
Specific Gravity Test	To determine approximately where the object will float at the surface of the liquid.
Clay Lump	To determine clay lumps and friable particles percent in aggregates
Crushing Test	To determine a relative measure of resistance to crushing under a gradually applied compressive load.
Impact Test	To determine relative measure of the resistance of the. aggregate to sudden shock or impact
Abrasion Test	To determine the relative quality, toughness, and durability of mineral aggregates subjected to impact and abrasion
Shape Test	To evaluate the particle shape, angularity, and surface texture

AGGREGATE

TEST METHODS FOR AGGREGATES USED IN PAVEMENT STRUCTURE

Sampling





Sieves analysis or Grading

Abrasion Test

Absorption , Specific Gravity & Clay Lump Test

Crushing Value Test

Impact Value Test

Shape Test

AGGREGATE

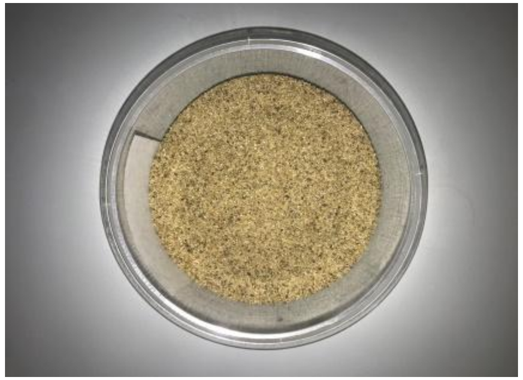
CLASSIFICATION OF AGGREGATES

COARSE AGGREGATES

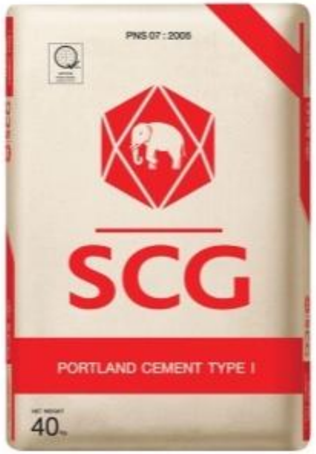
> 4.75mm

FINE AGGREGATES

< 4.75-0.075 mm



Stabilized Agent



Bitumen Used in Pavement Layers

- Bituminous Surface or wearing course (A.C)
- Bituminous Binder Course
- Bituminous Base Course
- Modified Bitumen

- Prime Coat
- Tack Coat
- Seal Coat
- Double Bituminous Surface Treatment Course (DBST).

Asphalt/Bitumen

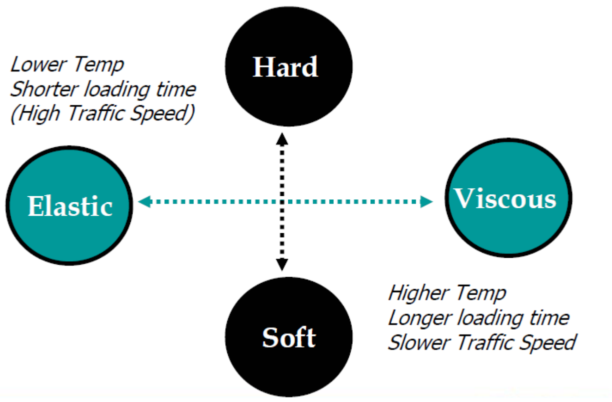
- Non-crystalline viscous material
- Black or dark brown
- Soluble in carbon disulphide (CS_2)
- Adhesive and waterproofing qualities

- Consists essentially of hydrocarbons (80% carbon, 15% hydrogen, the remainder being oxygen, sulphur, nitrogen and various metals)
- It has thermoplastic and viscoelastic properties.

Principal Sources

1. Natural Bitumen (Rock/ Lake Asphalt)
2. Coal Tar Pitches. (Destructive distillation of coal)
3. Petroleum Bitumen (Distillation of Crude oil)

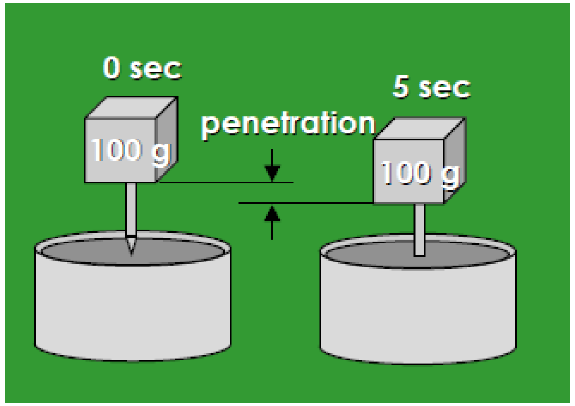
Selection of Bitumen

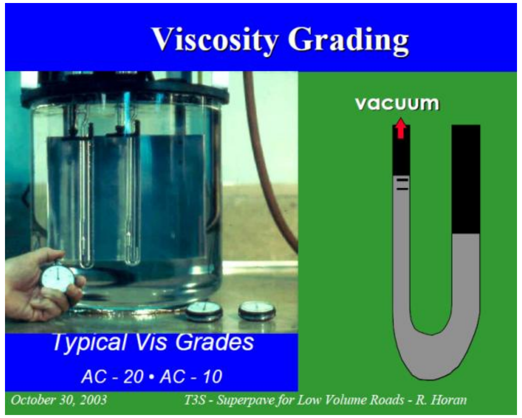


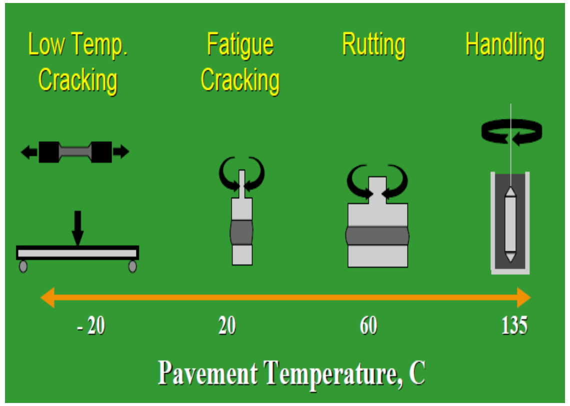
- Geographic Area:
  - -Air Temperature, solar radiation
  - - Pavement Temperature: Max & Min
- Constructability / Workability at construction temperature
- Performance (Rutting, Fatigue Cracking, Thermal Cracking)
  - - Rutting at high pavement temperature
  - - Fatigue cracking at average pavement temperature
  - - Thermal cracking at low temperature
- Durability (Short term & long term)

Classification of Bitumen

1. Penetration Grade Bitumen (Pen */*)
2. Viscosity Grade Bitumen (AC*/AR*)
3. Performance Grade Bitumen (PG* - *)



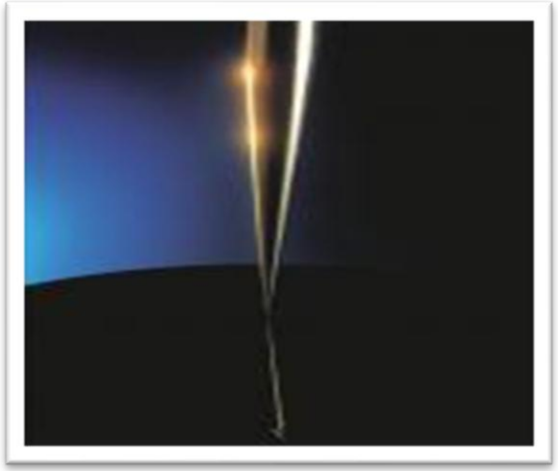




Bitumen

1. Penetration Grade Bitumen {ASTM Standard D946}

- The first standard method adopted by ASTM in 1900s.
- Penetration test represents the stiffness of the asphalt at average temperature 25º C.
- A needle loaded with 100 g is allowed to penetrate the bitumen maintained at temperature 25º C, for 5 seconds.
- The higher number is the softer bitumen.
- There are five penetration grades for bitumen
  - 40/50 (hardest bitumen grade)
  - 60/70, 85/100, 120/150, 200/300 (Softest bitumen grade)



2. Viscosity Grade Bitumen { ASTM D 3381 (8) }

- It is a measure of resistance to flow, conducted at 60º C and 135º C (near the maximum pavement temperature during summer)
- Viscosity grading can be done on original asphalt binder (AC grading) or aged residue samples (AR grading)
- Six viscosity grade,{ AC -2.5 (Softest)}, {AC -5, AC -10, AC -20, AC - 30, AC -40 (hardest)}
- Low viscosity grades (AC -2.5, AC-5) are used for cold climate and high viscosity grades (AC -10 , AC -40) are used for hot climate .
- AR Grading is based on residue from rolling thin-film oven test {ASTM D 3381 (8)}

3. Performance Grade Bitumen

- Based on the pavement temperatures
- PG grading is considered in resisting three main distress mechanism affecting pavement performance

Rutting resistance → measure at maximum pavement temp: favours a more elastic and stiffer binder

Fatigue resistance → most critical at average pavement temp: favours an elastic and softer binder

Thermal cracking → critical only at minimum pavement temp: favours a less elastic and soft bitumen

PG 64 - 22

Performance Grade → PG

Avg: 7 days max: pavement Design Temp: → 64

Min: pavement Design Temp: → 22

Standard Specification for Penetration-Graded Asphalt Binder for Use in Pavement Construction
MMS ASTM D946/D946M-20

TABLE 1 Requirements for Penetration-Graded Asphalt Binder for Use in Pavement Construction

	Penetration Grade									
	40–50		60–70		85–100		120–150		200–300	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Penetration at 25 °C [77 °F], 100 g, 5 s	40	50	60	70	85	100	120	150	200	300
Flash point, °C [°F] (Cleveland open cup)	230 [450]	. . .	230 [450]	. . .	230 [450]	. . .	220 [425]	. . .	175 [350]	. . .
Ductility at 25 °C [77 °F], 5 cm/min, cm	100	. . .	100	. . .	100	. . .	100	. . .	100[A]	. . .
Solubility, %[B]	99.0	. . .	99.0	. . .	99.0	. . .	99.0	. . .	99.0	. . .
Retained penetration after thin-film oven test, %	55+	. . .	52+	. . .	47+	. . .	42+	. . .	37+	. . .
Ductility at 25 °C [77 °F], 5 cm/min, cm after thin-film oven test[C]	. . .	. . .	50	. . .	75	. . .	100	. . .	100[A]	. . .

[A] If ductility at 25 °C [77 °F] is less than 100 cm, material will be accepted if ductility at 15 °C [60 °F] is 100 cm minimum at the pull rate of 5 cm/min.
[B] Use Test Method D2042 or D7553.
[C] The reference test method is D1754/D1754M. Optionally, Test Method D2872 may be used as agreed between the purchaser and the seller. The two test methods give different degrees of heat conditioning (D2872 is more severe), so the two methods may give different results for retained penetration and ductility.

TABLE 2 Requirements for Penetration-Graded Asphalt Binder for Use in Pavement Construction

	Penetration Grade									
	40–50		60–70		85–100		120–150		200–300	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Penetration at 25 °C [77 °F], 100 g, 5 s	40	50	60	70	85	100	120	150	200	300
Softening Point, °C [°F]	49 [120]		46 [115]		42 [108]		38 [100]		32 [90]	
Flash point, °C [°F], (Cleveland open cup)	230 [450]	. . .	230 [450]	. . .	230 [450]	. . .	220 [425]	. . .	175 [350]	. . .
Ductility at 25 °C [77 °F], 5 cm/min, cm	100	. . .	100	. . .	100	. . .	100	. . .	100[A]	. . .
Solubility, %[B]	99.0	. . .	99.0	. . .	99.0	. . .	99.0	. . .	99.0	. . .
Retained penetration after thin-film oven test, %	55+	. . .	52+	. . .	47+	. . .	42+	. . .	37+	. . .
Ductility at 25 °C [77 °F], 5 cm/min, cm after thin-film oven test[C]	. . .	. . .	50	. . .	75	. . .	100	. . .	100[A]	. . .

[A] If ductility at 25 °C [77 °F] is less than 100 cm, material will be accepted if ductility at 15 °C [60 °F] is 100 cm minimum at the pull rate of 5 cm/min.
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Bitumen

Certificate of Accreditation & Scope

- ၂၀၂၅-၂၀၂၆ ဘဏ္ဍာရေးနှစ်တွင် ကတ္တရာစမ်းသပ်ခြင်းအတွက် Quality and Accreditation Institute (QAI, India) ဘက်မှ ပေးအပ်သော နိုင်ငံတကာ အသိအမှတ်ပြုလက်မှတ် ISO/IEC 17025:2017 အား (၃.၅.၂၀၂၅) ရက်နေ့တွင် ရရှိခဲ့ပါသည်။

Quality And Accreditation Institute
Centre for International Accreditation
(formerly Centre for Laboratory Accreditation)

ilac-MRA QAI

Certificate of Accreditation

Bitumen Testing Laboratory
Road Research Laboratories, Research and Development Section,
Department of Highways, Ministry of Construction
Corner of Kamarkyi & Myawuttyee Road, Thuwanna,
Thingangyun Township, Yangon, Myanmar

has been assessed and accredited in accordance with the Standard
ISO/IEC 17025:2017
"General Requirements for the Competence of Testing and Calibration Laboratories"
In the field of
Testing

This certificate remains valid for the Scope of Accreditation as specified in the annexure subject to continued compliance to the above standard & any other requirements specified by QAI.

MARK OF SUSTAINED QUALITY QAI ACCREDITED

QAI/CIA/TL/2025/0114

Valid from: 03 May 2025

Valid until: 02 May 2027

Dr. Bhupendra Kumar Rana
Chief Executive Officer

Prof. Vikram Kumar
Chair, CIA

User is advised to verify the current scope of accreditation by visiting our website: www.qai.org.in

Quality And Accreditation Institute
Centre for International Accreditation
(formerly Centre for Laboratory Accreditation)

ilac-MRA QAI

Scope of Accreditation
Bitumen Testing Laboratory
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QAI/CIA/TL/2025/0114

Valid from: 03 May 2025
Valid until: 02 May 2027

Accreditation Standard: ISO/IEC 17025:2017

Chemical Testing			
Sl. No.	Product(s)/Material of Test	Specific Tests Performed	Test Method
	Building, Infrastructure & Construction Material		
1.	Bitumen	Penetration at 25 °C (0.1mm)	ASTM D5-20
2.		Softening Point (Ring & Ball)	ASTM D36-14 (Reapproved 2020)
3.		Solubility in Trichloroethylene	ASTM D2042-22
4.		Ductility at 25 °C	ASTM D113-17
5.		Flash Point	ASTM D92-18

This is annexure to 'Certificate of Accreditation' and does not require any signature.

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1 of 1

Bitumen Emulsion

Bitumen Emulsion is a liquid product consisting of three things, (i.e. **Water + Emulsifier + Bitumen**) where droplets of bitumen are suspended in water.

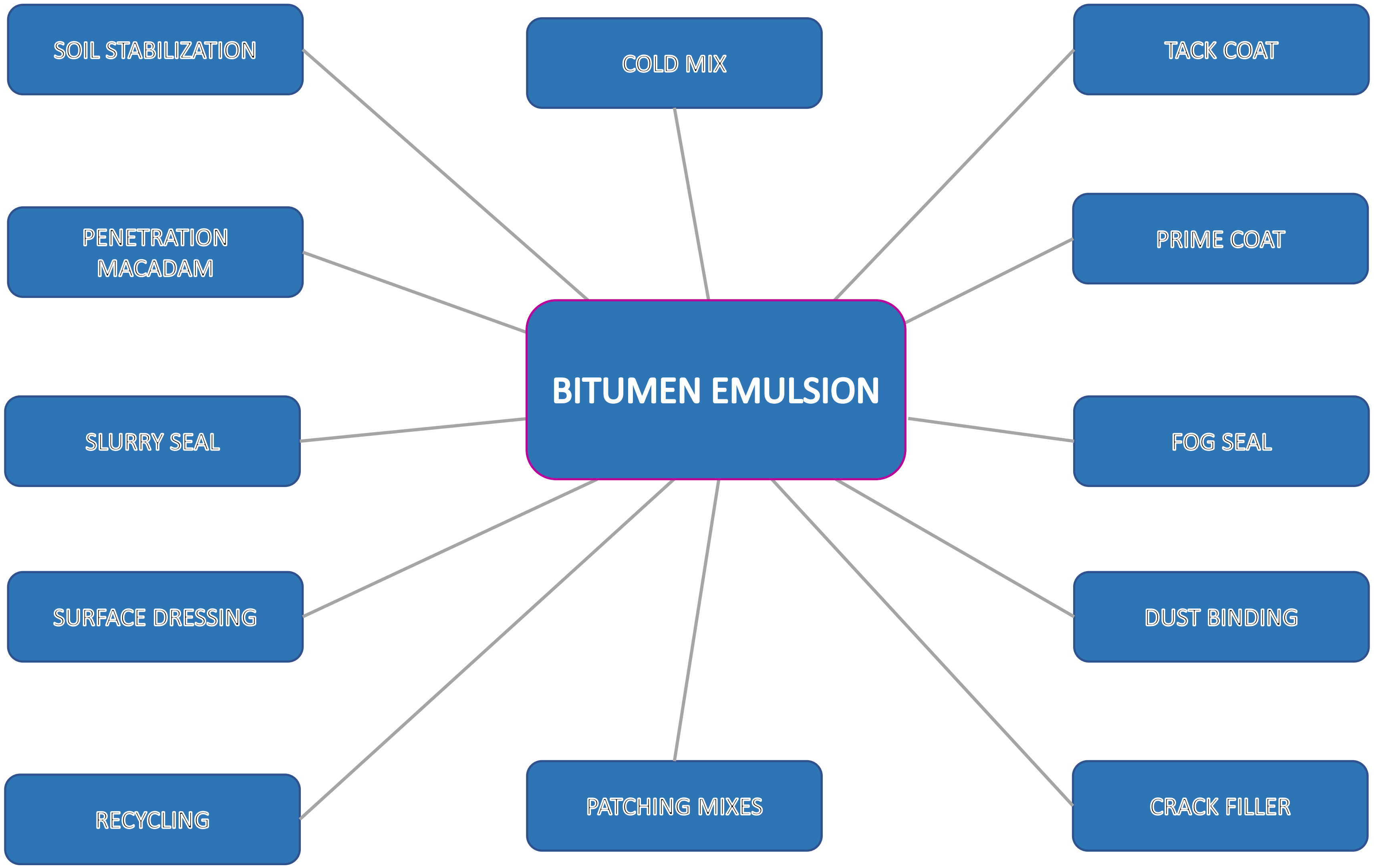
Bitumen

Water ↔ Emulsifier

Emulsion

- Based On Surface Charges →
  - ❑ Anionic Bitumen Emulsion
  - ❑ Cationic Bitumen Emulsion
- Based On Setting Time →
  - ❑ Rapid Setting Emulsion (RS)
  - ❑ Medium Setting Emulsion (MS)
  - ❑ Slow Setting Emulsion (SS)

MULTIPLE USAGE OF BITUMEN EMULSION IN ROAD WORK



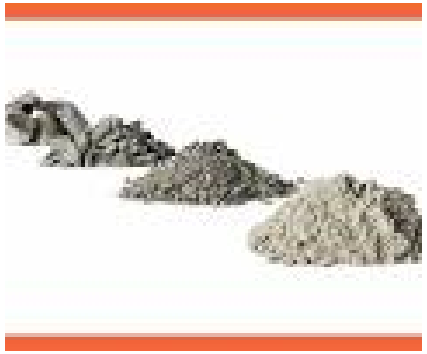
Bitumen Emulsion

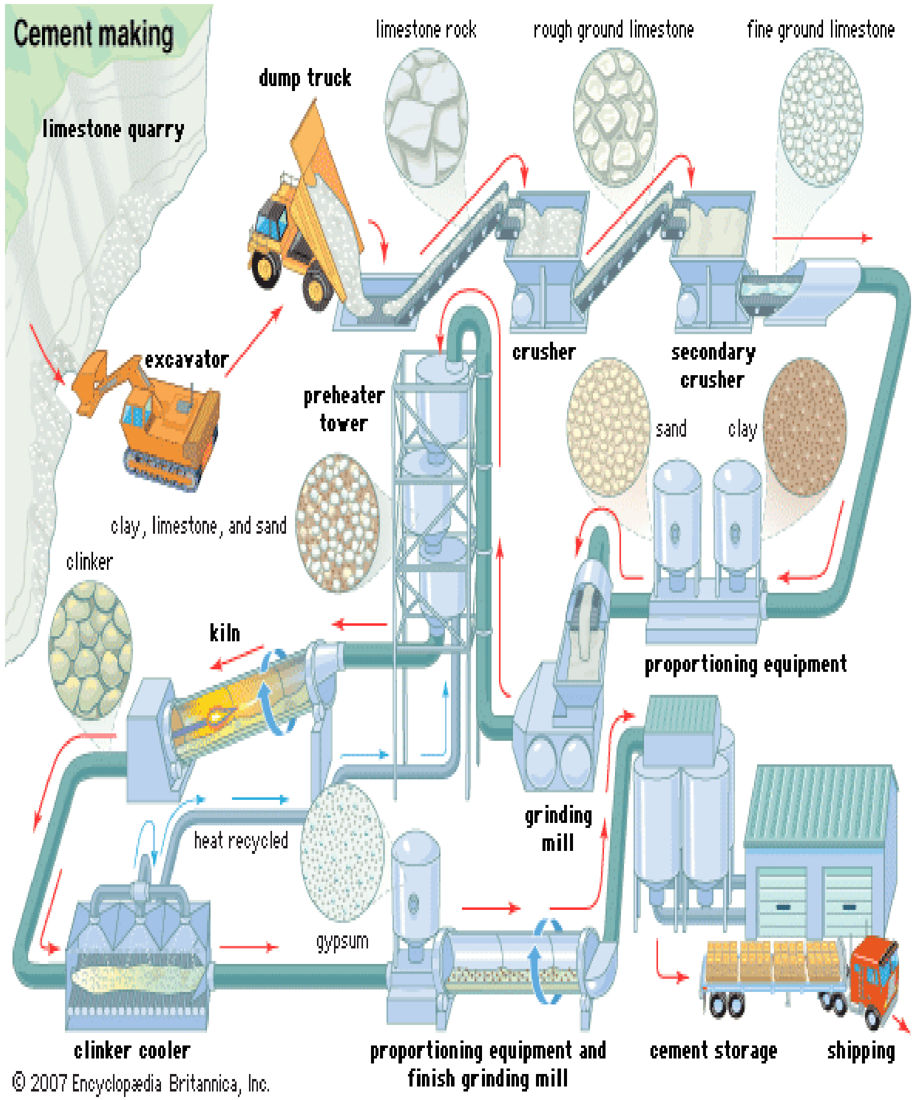
Laboratory Testing

No	Testing Method	Designation (ASTM)
1	Saybolt Furol Viscosity test at 50°C(Sec)	D88-81
2	Storage Stability of Emulsion test	D24-81
3	Specific Gravity	-
4	Sieve Test	D244-81

Cement

Cements are materials that exhibit characteristic properties of setting and hardening when mixed to a paste with water.





Cement

Types of Cement

Traditional British Description	ASTM Description
Ordinary Portland Cement	Type - I
Rapid Hardening Portland Cement	Type- III
Low Heat Portland Cement	Type IV
Modified Cement	Type II
Sulfate Resisting Portland Cement	Type V
Portland Blast Furnace (Slag Cement)	Type IS Type S Type I (SM)
White Portland Cement	-
Portland-Pozzolana Cement	Type IP Type P Type I (PM)

Table 2.3-1 Types of cement are categorized in AASHTO M85

Type	For use
Type I	For use when the special properties specified for any other type are not required
Type IA	Air-entraining cement for the same uses as Type I, where air entrainment is desired
Type II	For general use, more especially when moderate sulfate resistance is desired
Type IIA	Air-entraining cement for the same uses as Type II, where air entrainment is desired
Type II(MH)	For general use, more especially when moderate heat of hydration and moderate sulfate resistance are desired
Type II(MH)A	Air-entraining cement for the same uses as Type II(MH), where air entrainment is desired
Type III	For use when high early strength is desired; Type IIIA—Air-entraining cement for the same use as Type III, where air entrainment is desired
Type IV	For use when low heat of hydration is desired
Type V	For use when high sulfate resistance is desired

Chemical Composition of Portland Cement

Main Compounds	Oxide Composition	Abbreviation
Tricalcium silicate	$3CaO.SiO_2$	C_3S
Dicalcium silicate	$2CaO.SiO_2$	C_2S
Tricalcium aluminate	$3CaO.Al_2O_3$	C_3A
Tetracalcium aluminoferrite	$4CaO.Al_2O_3 .Fe_2O_3$	C_4AF

[$CaO = C$, $SiO_2 = S$, $AL_2O_3 = A$, $Fe_2O_3 = F$]

Minor Compounds

MgO, TiO_2, Mn_2O_3, K_2O, Na_2O

- Change from a fluid to rigid stage
- Hydration starts with C_3S and C_3A
- Initial Set & Final Set used to describe the stages of setting.
- Setting time of cement decreases with a rise in temperature(at low temperature, setting is retarded)

Cement

Testing of cement

- Setting time (ASTM C-191)
  - *initial setting time*
  - *final setting time*
- Fineness(ASTM C-204)
- Soundness (ASTM C-151)
- Strength of cement (ASTM C-109)

- *Vicat needle Apparatus*

- *Blain Air -Permeability Apparatus*

- *Autoclave Expansion Apparatus*

Specification of Ordinary Portland Cement For Concrete

Sr No	Name of Test	Designation	Specification ASTM C150
1	Time of Setting of Hydraulic Cement	ASTM C191	Initial setting time- 45min(Min) Final setting time- 375min(Max)
2	Autoclave Expansion of Hydraulic Cement	ASTM C151	0.80%(Max)
3	Fineness of Hydraulic Cement	ASTM C204	260 m2/kg(Min)
4	Compressive Strength of Hydraulic Cement	ASTM C109	3 Days- 12MPa(Min) 7 Days- 19MPa(Min)

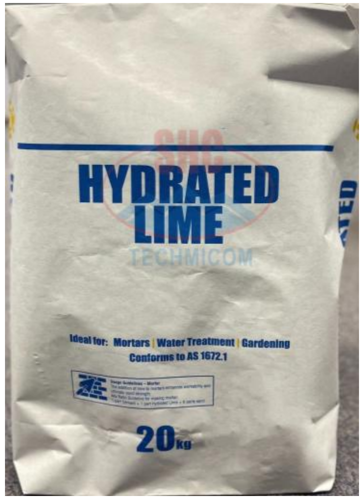
Table 2.6: **BS EN 197–1: 2000 and ASTM C 150–05 requirements for minimum strength of cement (MPa (psi))**

Age (days)	BS EN 197–1: 2000 (mortar prism), strength class					
	32.5 N	**32.5 R**	**42.5 N**	**42.5 R**	**52.5 N**	**62.5 R**
2	– –	10 (1450)	10 (1450)	20 (2900)	20 (2900)	20 (2900)
7	16 (2300)	– –	– –	– –	– –	– –
28	32.5* (4700)	32.5* (4700)	42.5 (6200)	42.5** (6200)	52.5 (7600)	62.5 (9100)

Age (days)	ASTM C 150–05 (mortar cube), cement type (Table 2.7)							
	I	**IA**	**II#**	**IIA#**	**III**	**IIIA**	**IV**	**V**
1	– –	– –	– –	– –	12.0 (1740)	10.0 (1450)	– –	– –
3	12.0 (1740)	10.0 (1450)	10.0 (450)	8.0 (1160)	24.0 (3480)	19.0 (2760)	– –	8.0 (1160)
7	19.0 (2760)	16.0 (2320)	17.0 (2470)	14.0 (2030)	– –	– –	7.0 (1020)	15.0 (2180)
28	28.0[a] (4060)	22.0[a] (3190)	28.0[a] (4080)	22.0[a] (3190)	– –	– –	17.0 (2470)	21.0 (3050)

* and not more than 52.5 (7600); ** and not more than 62.5 (9100)
# Strength values depend on specified heat of hydration or chemical limits of tricalcium silicate and tricalcium aluminate
[a] Optional

Lime



Standard Specification for

Lime for Soil Stabilization

AASHTO Designation: M 216-05
ASTM Designation: C 977-03

1. SCOPE

1.1. This specification pertains to quicklime and hydrated lime, either high calcium, dolomitic, or magnesian lime, for use in stabilization of soils. (See Note 2.)

Note 1—Quicklime and hydrated lime act upon clay soils and may render such soils suitable for highway construction and for other load-bearing applications. In most cases, lime causes finely divided clay particles to agglomerate into coarser particles which improves load-bearing properties and subsequently the lime-treated soil hardens by chemical reaction.

Note 2—No attempt is made to present requirements for by-product lime, commercial lime slurry, etc. Specification requirements for these materials could be better determined on a local basis.

1.2. *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *ASTM Standards*:

- C 25, Test Methods for Chemical Analysis of Limestone, Quicklime, and Hydrated Lime
- C 50, Practice for Sampling, Sample Preparation, Packing, and Marking of Lime and Limestone Products
- C 51, Terminology Relating to Lime and Limestone (as used by the Industry)
- C 110, Test Methods for Physical Testing of Quicklime, Hydrated Lime, and Limestone
- D 6276, Test Method for Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization

3. CHEMICAL COMPOSITION

3.1. Unless otherwise specified, for definitions of terms used in this specification, refer to Definitions of Terms, ASTM C 51.

What is Lime?

- An inorganic **material** ,
- Composed of calcium oxides and hydroxides.
- Various forms of lime are used in environmental , metallurgical , construction and chemical/industrial applications, and more.
- In construction, the dominant use of lime is in soil stabilization for roads, earthen dams, airfields, and building foundations.

Lime

❑ Lime (AASHTO M 216)

Particular	Hydrated Lime(	Quick Lime
Chemical Composition -Calcium & Magnesium Oxides - Carbon Dioxide - Free Moisture Content	 90 % Min. 5% Max. 5% Max.	 90 % Min. 5% Max. 5% Max.
Physical Properties	1. Retained on 0.6 mm (No. 30) – 3 % Max. 2. Retained on 0.075 mm (No.200) – 25% Max.	1. Fineness – 100% passing 25 mm (1.0 in) sieve. 2. Slaking Rate – at least Medium Reactive (ASTM C 110)
Some Other Specifications		1. Pebble Form – 55-60 lb/ft3 (by weight) 2. ¼ in or less – 65 lb/ft3 (by weight) 3. Sp.gr – 3.2 to 3.4

Admixture

Types of Admixture

- Admixtures are commonly classified by their function

Type A – Water- reducing

Type B – Retarding

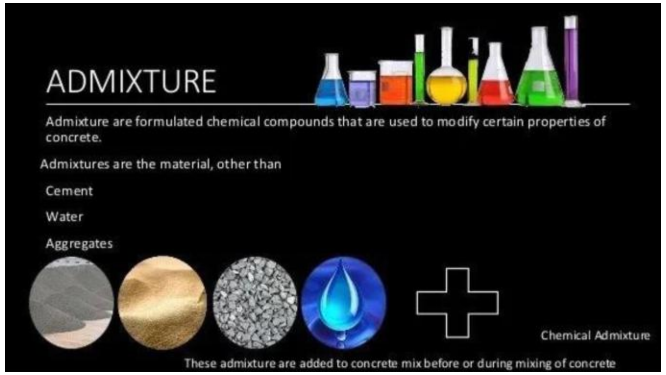
Type C – Accelerating

Type D – Water- reducing and retarding

Type E – Water- reducing and accelerating

Type F – High- range water- reducing

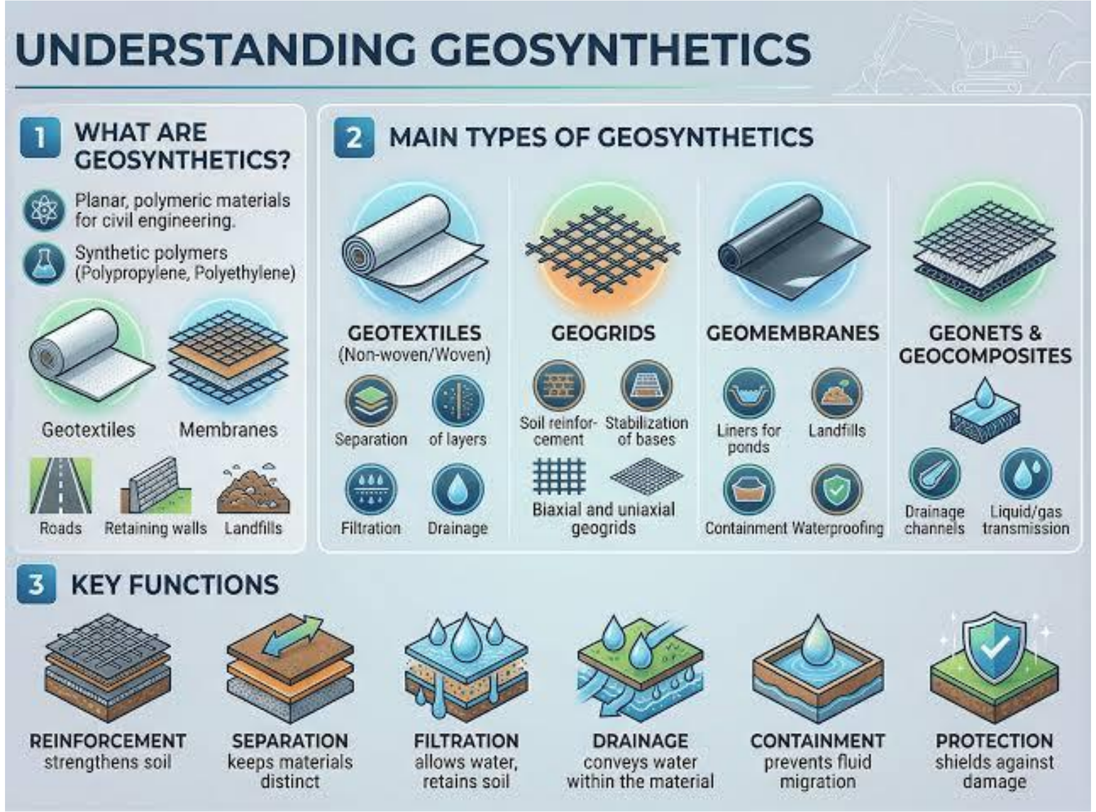
Type G – High- range water- reducing and retarding



Geosynthetic Reinforcement

-Synthetic or polymer-based products used in civil engineering and construction.

-To strengthen, stabilize, permeate and enhance the load-bearing capacity of soil, sand, or gravel structures.



Primary Applications

These materials are heavily relied upon in modern infrastructure development:

1.Roads and Pavements

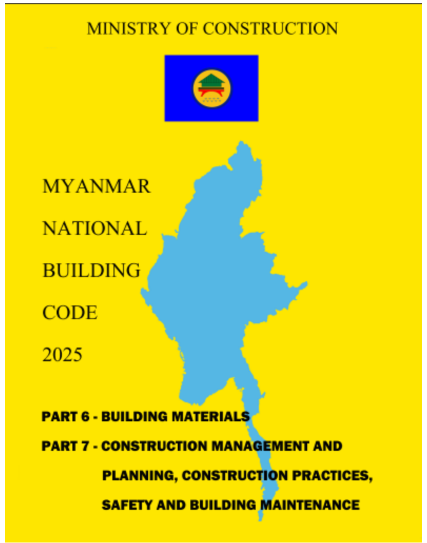
2.Retaining Walls and Slopes

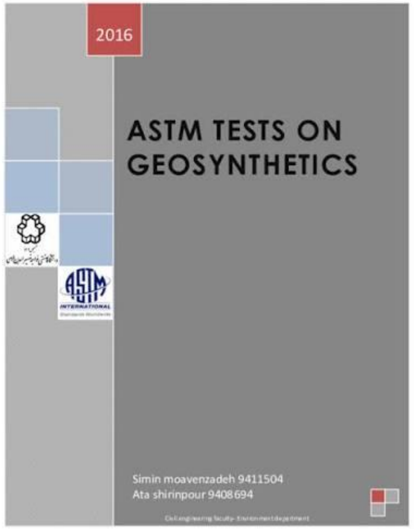
3.Embankments over Soft Soil

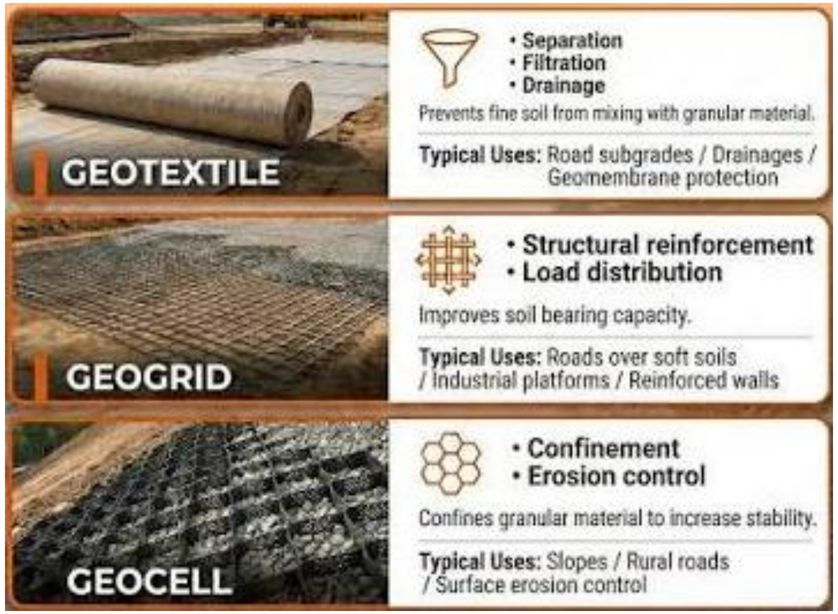
Geosynthetic Reinforcement

Polymers, Plastic and Geosynthetics/Geotextiles(MNBC-2025)

ASTM D 4354	Standard practice for sampling of Geosynthetics for testing
ASTM D 4355	Standard test method for deterioration of geotextiles from exposure to ultraviolet light and water (Xenon-arc type apparatus)
ASTM D 4491	Standard test methods for water permeability of geotextiles by permittivity
ASTM D 4533	Standard test method for trapezoid tearing strength of geotextiles
ASTM D 4595	Standard test method for tensile properties of geotextiles by the wide-width strip method
ASTM D 4751	Standard test method for determining apparent opening size of a geotextile
ASTM D 4833	Standard test method for index puncture resistance of geotextiles, geomembranes, and related products
ASTM D 4886	Standard test method for abrasion resistance of geotextiles (sand paper/sliding block method)
ASTM D 5199	Standard test method for measuring nominal thickness of geotextiles and geomembranes
ASTM D 5261	Standard test method for measuring mass per unit area of geotextiles
ASTM D 5262	Standard test method for evaluating the unconfined tension creep behavior of geosynthetics
ASTM D 5321	Standard test method for determining the coefficient of soil and geosynthetics and geosynthetics friction by the direct shear







STEEL

Designation: A706/A706M – 09b

Standard Specification for
Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement[1]

Designation: A 615/A 615M – 04a

Ame

Standard Specification for
Deformed and Plain Carbon Steel Bars for Concrete Reinforcement[1]

ASTM A706

Use Case:
High Performance, Seismic Zones
(Complex structures, high integrity needs)

Weldability:
Excellent - Designed for welding
(C.E. ≤ 0.55%, usually no preheat)

Ductility:
Superior - Handles deformation
(Important for earthquake resistance)

Grades:
Typically Grade 60

Cost:
Generally Higher

Carbon Equivalent:
Controlled (Max 0.55%)

ASTM A615

Use Case:
General Construction
(Wide range of standard projects)

Weldability:
Variable - Not guaranteed
(No C.E. limit, may need preheat)

Ductility:
Standard - Meets basic needs
(Less critical than A706)

Grades:
Multiple (40, 60, 75, 80)
(Offers strength flexibility)

Cost:
Cost-Effective / Economical

Carbon Equivalent:
Not Specified (Variable)

TABLE 1 Deformed Bar Designation Numbers, Nominal Weights [Masses], Nominal Dimensions, and Deformation Requirements

Bar Designation No.^A	Nominal Weight, lb/ft [Nominal Mass, kg/m]	Nominal Dimensions^B			Deformation Requirements, in. [mm]		
		Diameter, in. [mm]	Cross-Sectional Area, in.^{2} [mm^2]	Perimeter, in. [mm]	Maximum Average Spacing	Minimum Average Height	Maximum Gap (Chord of 12.5 % of Nominal Perimeter)
3 [10]	0.376 [0.560]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.668 [0.994]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	1.043 [1.552]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	0.437 [11.1]	0.028 [0.71]	0.239 [6.1]
6 [19]	1.502 [2.235]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	2.044 [3.042]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	2.670 [3.973]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	3.400 [5.060]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
10 [32]	4.303 [6.404]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
11 [36]	5.313 [7.907]	1.410 [35.8]	1.56 [1006]	4.430 [112.5]	0.987 [25.1]	0.071 [1.80]	0.540 [13.7]
14 [43]	7.65 [11.38]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	13.60 [20.24]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

^A Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars [bar numbers approximate the number of millimetres of the nominal diameter of the bar].

^B The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [metre] as the deformed bar.

TABLE 2 Tensile Requirements

	Grade 40 [280]^A	Grade 60 [420]	Grade 75 [520]^B
Tensile strength, min, psi [MPa]	60 000 [420]	90 000 [620]	100 000 [690]
Yield strength, min, psi [MPa]	40 000 [280]	60 000 [420]	75 000 [520]
Elongation in 8 in. [203.2 mm], min, %:			
Bar Designation No.			
3 [10]	11	9	...
4, 5 [13, 16]	12	9	...
6 [19]	12	9	7
7, 8 [22, 25]	...	8	7
9, 10, 11 [29, 32, 36]	...	7	6
14, 18 [43, 57]	...	7	6

^A Grade 40 [280] bars are furnished only in sizes 3 through 6 [10 through 19].

^B Grade 75 [520] bars are furnished only in sizes 6 through 18 [19 through 57].

TABLE 3 Bend Test Requirements

Bar Designation No.	Pin Diameter for Bend Tests^A		
	Grade 40 [280]	Grade 60 [420]	Grade 75 [520]
3, 4, 5 [10, 13, 16]	3½ *d* ^B	3½ *d*	...
6 [19]	5*d*	5*d*	5*d*
7, 8 [22, 25]	...	5*d*	5*d*
9, 10, 11 [29, 32, 36]	...	7*d*	7*d*
14, 18 [43, 57] (90°)	...	9*d*	9*d*

^A Test bends 180° unless noted otherwise.

^B *d* = nominal diameter of specimen.

TABLE 1 Deformed Bar Designation Numbers, Nominal Weights [Masses], Nominal Dimensions, and Deformation Requirements

Bar Designation No.	Nominal Weight, lb/ft [Nominal Mass, kg/m]	Nominal Dimensions[A]			Deformation Requirements, in. [mm]		
		Diameter, in. [mm]	Cross-Sectional Area in.^{2} [mm^2]	Perimeter, in. [mm]	Maximum Average Spacing	Minimum Average Height	Maximum Gap (Chord of 12.5 % of Nominal Perimeter)
3 [10]	0.376 [0.560]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.668 [0.994]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
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8 [25]	2.670 [3.973]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	3.400 [5.060]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
10 [32]	4.303 [6.404]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
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14 [43]	7.65 [11.38]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	13.60 [20.24]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

[A] The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [metre] as the deformed bar.

6.4 The heat analysis shall be such as to provide a carbon equivalent (C.E.) not exceeding 0.55 % as calculated by the following formula:

$$\text{C.E.} = \%\,\text{C} + \frac{\%\,\text{Mn}}{6} + \frac{\%\,\text{Cu}}{40} + \frac{\%\,\text{Ni}}{20} + \frac{\%\,\text{Cr}}{10} - \frac{\%\,\text{Mo}}{50} - \frac{\%\,\text{V}}{10}$$

A706/A706M – 13

TABLE A1.2 Tensile Requirements

	Grade 60 [420]	Grade 80 [550]
Tensile strength, min, psi [MPa]	90 000 [620][A]	105 000 [725][A]
Yield strength, min, psi [MPa]	60 000 [420]	80 000 [550]
Yield strength, max, psi [MPa]	78 000 [540]	98 000 [675]
Elongation in 8 in. [200 mm], min, %		
Bar Designation Nos.		
10, 12, 16, 20	14	12
25, 28, 32, 36	12	12
40, 50, 60	10	10

[A] Tensile strength shall not be less than 1.25 times the actual yield strength.

TABLE A1.3 Bend Test Requirements

Bar Designation No.	Pin Diameter for 180° Bend Tests	
	Grade 60 [420]	Grade 80 [550]
10, 12, 16	3*d*[A]	3½*d*[A]
20, 25	4*d*	5*d*
28, 32, 36	6*d*	7*d*
40, 50, 60	8*d*	9*d*

[A] *d* = nominal diameter of specimen.

6.2 The chemical composition as shown by heat analysis shall be limited by the following:

Element	max, %
Carbon	0.30
Manganese	1.50
Phosphorus	0.035
Sulfur	0.045
Silicon	0.50

6.5 *Product (Check) Verification Analysis*—A product check analysis made by the purchaser shall not exceed the following percentages:

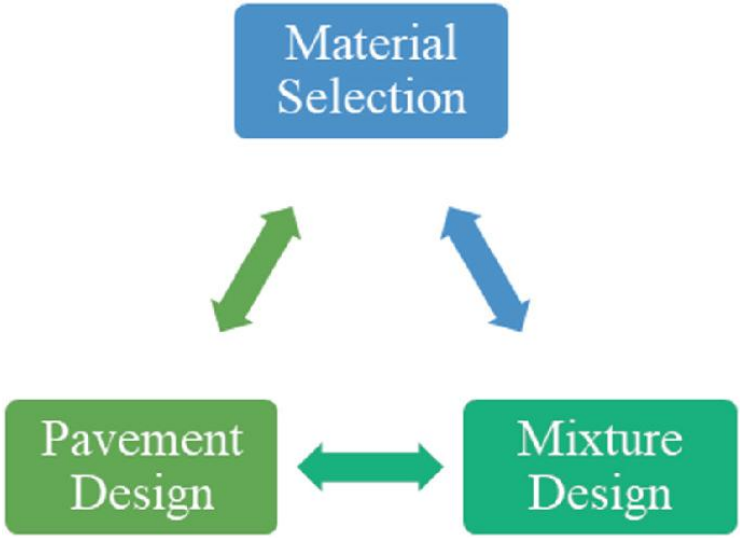
Element	max, %
Carbon	0.33 %
Manganese	1.56 %
Phosphorus	0.043 %
Sulfur	0.053 %
Silicon	0.55 %

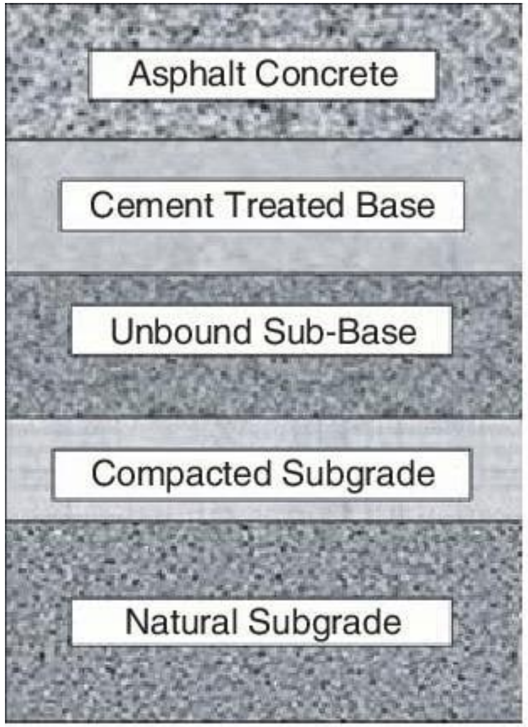
Outline of Presentation

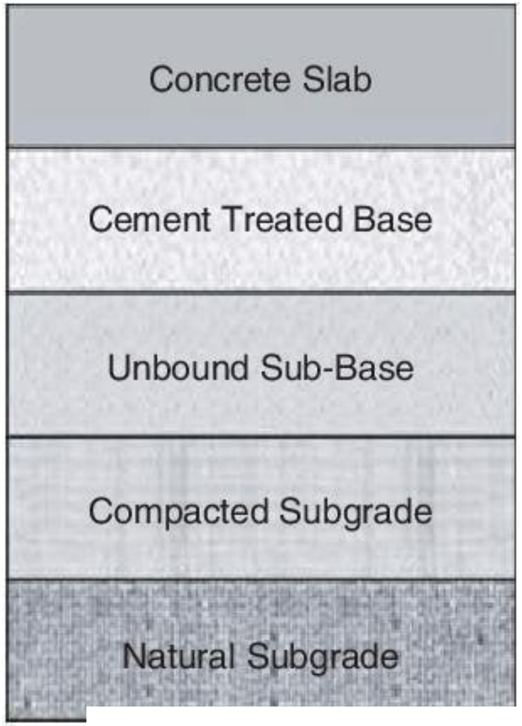
- ✓ Objective
- ✓ Historical Evolution of Road Surfacing
- ✓ Road design(Geometric/Pavement)
- ✓ Important Role of Pavement Construction Materials
- ✓ Pavement Construction Materials and Test Methods
- ✓ **Materials Mix Design**
- ✓ Soil Improvement and Ground Modification
- ✓ Materials Innovation in Pavement construction
- ✓ Conclusion

Materials Mix Design

Materials Mix Design for Pavement Layers







Main Objective of Material Mix Design

To find the most economical and high-performing combination of ingredients that safely supports traffic loads.

- **Ensure Structural Strength:** Calculates exact ratios so flexible asphalt or rigid concrete layers resist heavy loads without cracking, rutting, or deforming.
- **Improve Durability:** Controls air voids and the water-cement or binder ratio to prevent water damage, frost heaving, and long-term wear.
- **Optimize Cost:** Uses local materials efficiently while avoiding excess binder or cement, reducing overall project expenses.
- **Guarantee Workability:** Ensures the fresh mix can be easily placed, spread, and compacted on the job site.
- **Prevent Premature Failures:** Avoids common issues like bleeding (too much binder) or raveling (too little binder) in asphalt and low flexural strength in concrete.

Types of Mix Design for Pavement Layers

1.Flexible Pavement (HMA,WMA,CMA)

- Asphalt concrete Mix Design(HMA)(Dense graded, open Graded, Gap Graded , etc.)

2.Rigid Pavement

-Jointed Plain (JPCP),Jointed Reinforced(JRCP),Continuously Ranforced Concrete Pavement(JRCP), Lean concrete(LC)

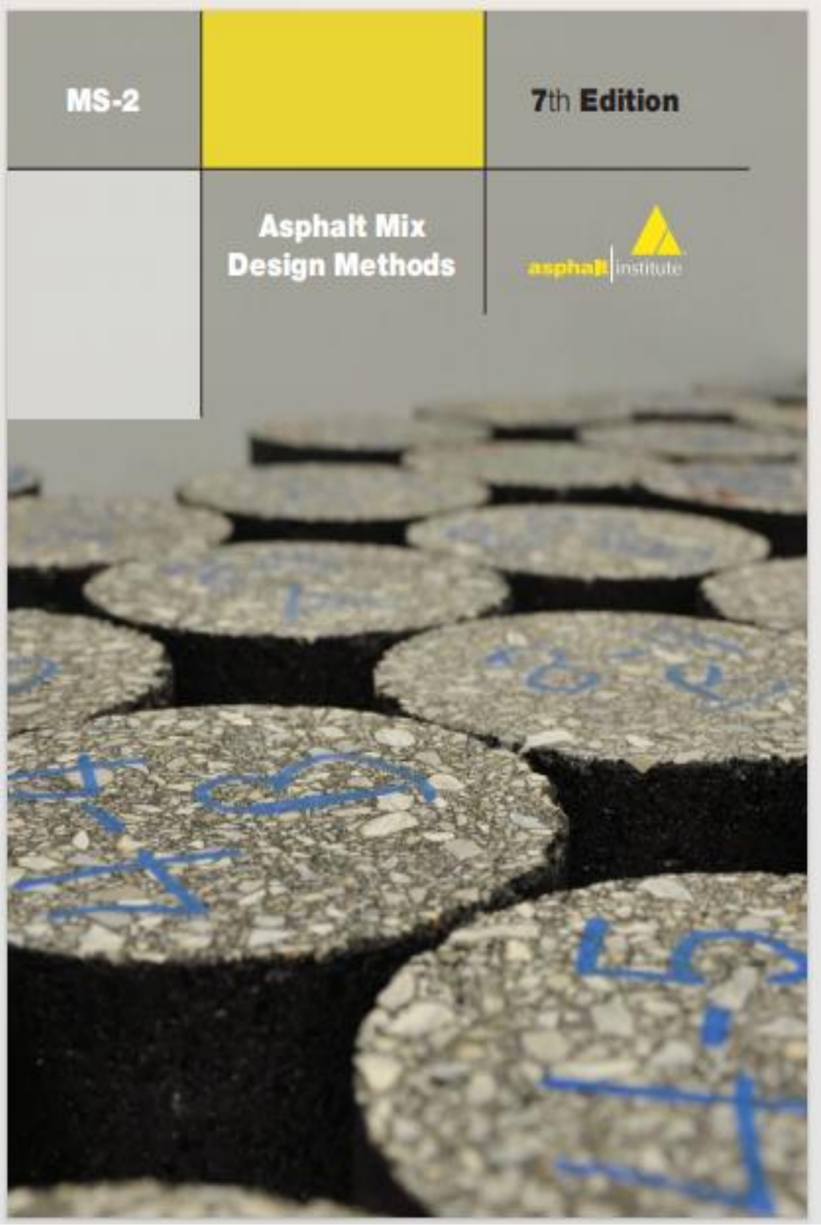
3. Base and Subbase Layers(Stabilized & Hydraulically Bound)

- Well graded Crushed Rock
- Cement treated Base/subbase Course(CTB)
- Hydraulically Bound Mixture(HBM)
- Bitumen Stabilized Base(BSB/RAP)

4.Improved subgrade

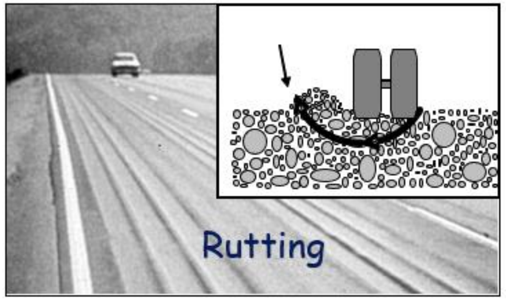
- Soil-Lime Stabilized Mix Design
- Granular Mix Design

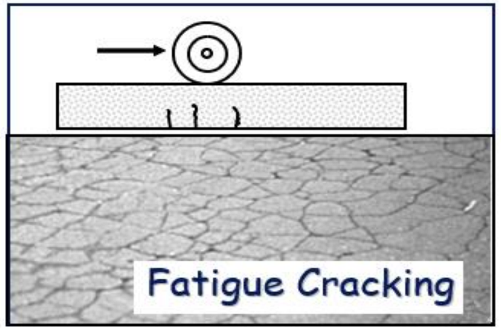
Asphalt Concrete Mix Design

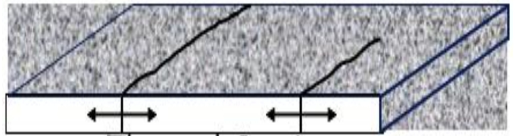


Desire Properties considered for AC mix Design

- Fatigue Resistance
- Low temperature cracking resistance
- Moisture Resistance
- Surface skid resistance
- Durability
- Workability
- Im-permeability and
- Economical design
- Resistance to performance deformation (stability)







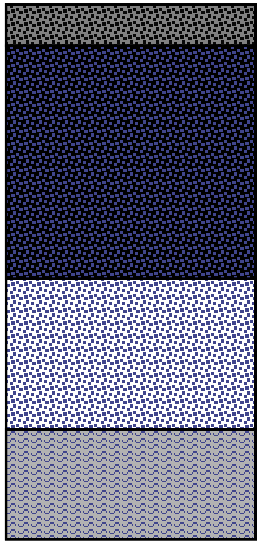
objective of AC Mix Design

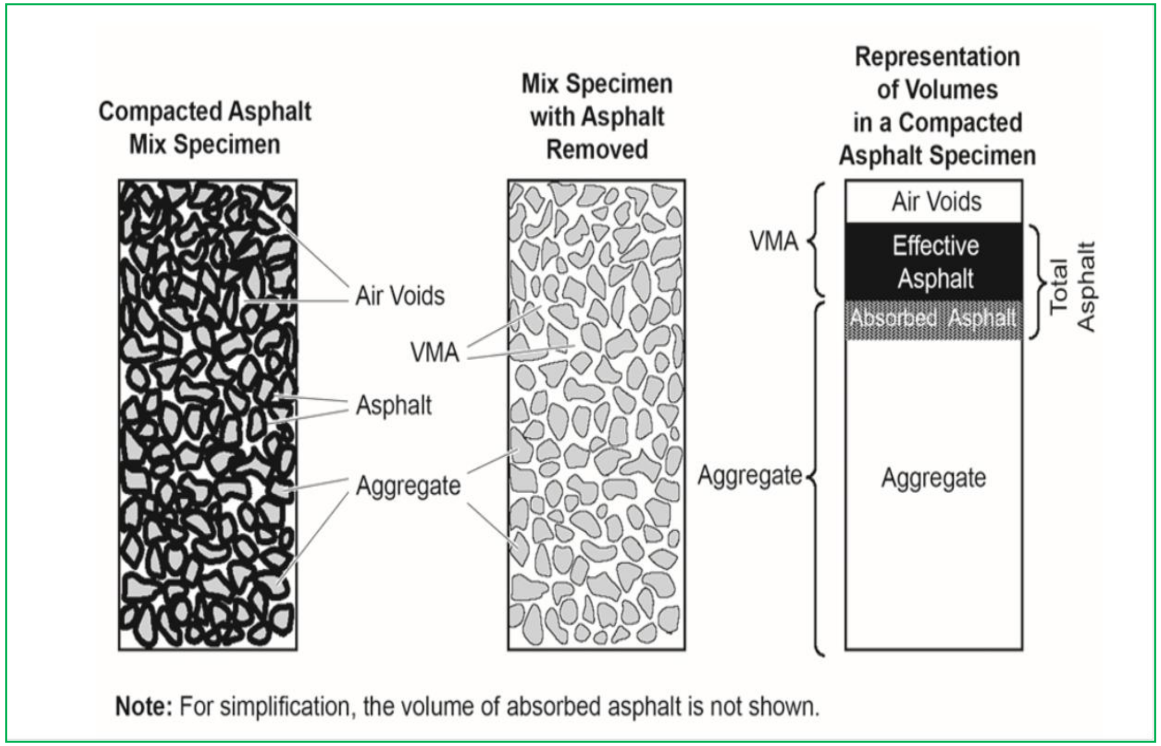
To determine a cost-effective blend of asphalt and mineral aggregate including filler, if any, with appropriate gradation which will yield a durable and serviceable pavement layers.

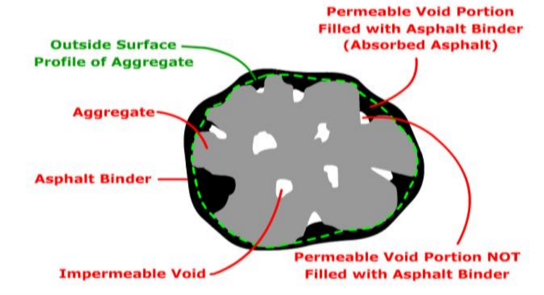
What is Air Void, Voids in Mineral Aggregate and Voids filled

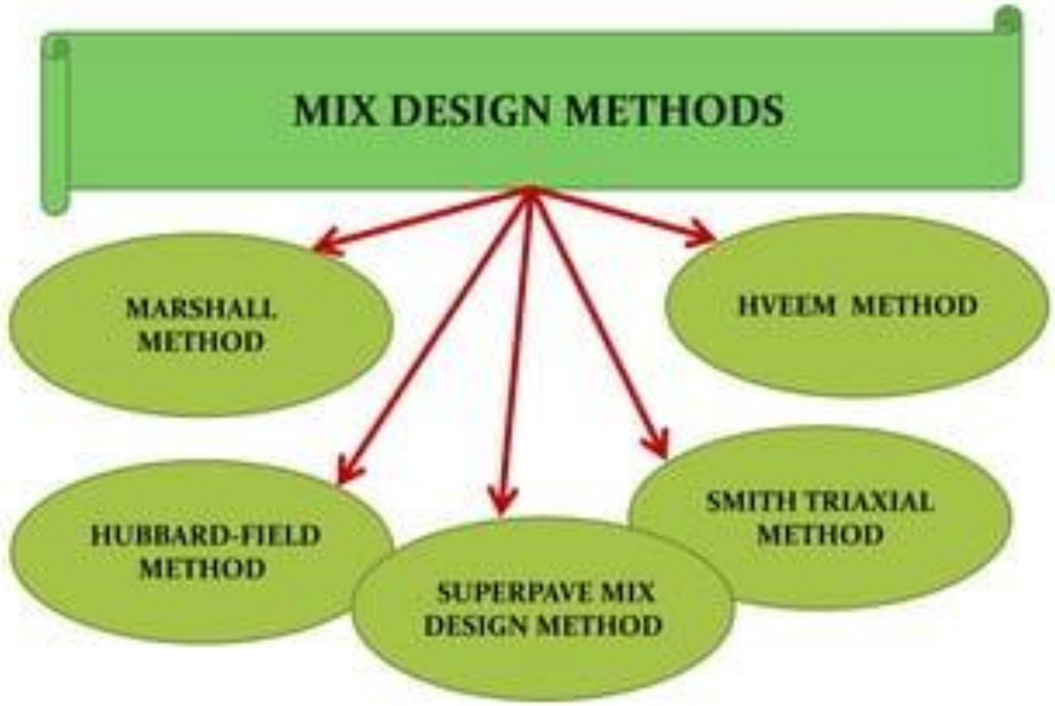
AC Surface

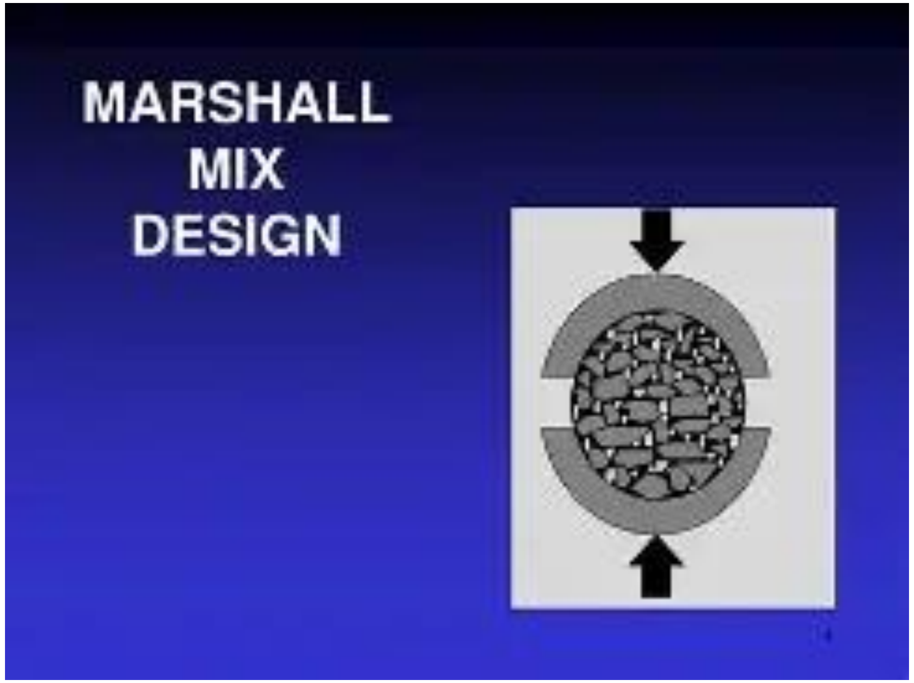
AC Base











Marshall Method: developed by **Bruce Marshall**, a former bituminous engineer with Mississippi State Highway Department and further improved by US army crops of Engineers. Guideline : ASTM D 1559 ,MS-2 (Asphalt Institute, USA)

Materials Mix Design

Marshall Method Criteria[1]	Light Traffic[3] Surface & Base		Medium Traffic[3] Surface & Base		Heavy Traffic[3] Surface & Base	
	Min	Max	Min	Max	Min	Max
Compaction, number of blows each end of specimen	35		50		75	
Stability[2], N (lb.)	3336 (750)	–	5338 (1200)	–	8006 (1800)	–
Flow[2,4,5], 0.25 mm (0.01 in.)	8	18	8	16	8	14
Percent Air Voids[7]	3	5	3	5	3	5
Percent Voids in Mineral Aggregate (VMA)[6]	See Table 7.3					
Percent Voids Filled With Asphalt (VFA)	70	80	65	78	65	75

NOTES:

1. All criteria, not just stability value alone, must be considered in designing an asphalt paving mix.
2. Hot mix asphalt bases that do not meet these criteria when tested at 60°C (140°F) are satisfactory if they meet the criteria when tested at 38°C (100°F) and are placed 100 mm (4 inches) or more below the surface. This recommendation applies only to regions having a range of climatic conditions similar to those prevailing throughout most of the United States. A different lower test temperature may be considered in regions having more extreme climatic conditions.
3. Traffic classifications
   Light Traffic conditions resulting in a 20-year Design ESAL $< 10^4$
   Medium Traffic conditions resulting in a 20-year Design ESAL between 10^4 and 10^6
   Heavy Traffic conditions resulting in a 20-year Design ESAL $> 10^6$
4. The flow value refers to the point where the load begins to decrease. When an automatic recording device is used, the flow should be corrected as shown in section 7.3.3.3.
5. The flow criteria were established for neat asphalts. The flow criteria are often exceeded when polymer-modified or rubber-modified binders are used. Therefore, the upper limit of the flow criteria should be waived when polymer-modified or rubber-modified binders are used.
6. Percent voids in the mineral aggregate are to be calculated on the basis of the ASTM bulk specific gravity for the aggregate, as discussed in chapter 5.
7. Percent air voids should be targeted at 4 percent. This may be slightly adjusted if needed to meet the other Marshall criteria.

GRADING ANALYSIS OF AGGREGATE

Table 2.1 – **Composition of asphalt paving mixtures (ASTM D3515)**

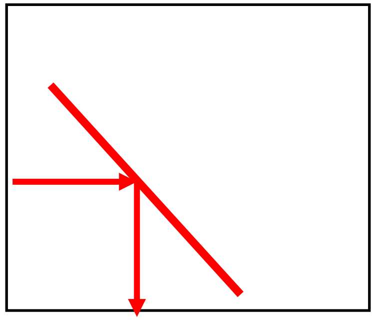
Sieve Size	*Dense Mixtures*								
	Mix Designation and Nominal Maximum Size of Aggregate								
	2 in. (50 mm)	1 1/2 in. (37.5 mm)	1 in. (25.0 mm)	3/4 in. (19.0 mm)	1/2 in. (12.5 mm)	3/8 in. (9.5 mm)	No. 4 (4.75 mm) (Sand Asphalt	No. 8 (2.36 mm)	No. 16 (1.18 mm) (Sheet Asphalt)
	Grading of Total Aggregate (Coarse Plus Fine, Plus Filler if Required) Amounts Finer Than Each Laboratory Sieve (Square Opening), Weight %								
2 1/2 in. (63-mm)	100	...	...	...	...	...	...	...	...
2 in. (50-mm)	90 to 100	100	...	...	...	...	...	...	...
1 1/2 in. (37.5-mm)	...	90 to 100	100	...	...	...	...	...	...
1 in. (25.0-mm)	60 to 80	...	90 to 100	100	...	...	...	...	...
3/4 in. (19.0-mm)	...	56 to 80	...	90 to 100	100	...	...	...	...
1/2 in. (12.5-mm)	35 to 65	...	56 to 80	...	90 to 100	100	...	...	...
3/8 in. (9.5-mm)	...	...	...	56 to 80	...	90 to 100	100	...	...
No. 4 (4.75-mm)	17 to 47	23 to 53	29 to 59	35 to 65	44 to 74	55 to 85	80 to 100	...	100
No. 8 (2.36-mm)[A]	10 to 36	15 to 41	19 to 45	23 to 49	28 to 58	32 to 67	65 to 100	...	95 to 100
No. 16 (1.18-mm)	...	...	...	...	...	...	40 to 80	...	85 to 100
No. 30 (600-µm)	...	...	...	...	...	...	25 to 65	...	70 to 95
No. 50 (300-µm)	3 to 15	4 to 16	5 to 17	5 to 19	5 to 21	7 to 23	7 to 40	...	45 to 75
No. 100 (150-µm)	...	...	...	...	...	...	3 to 20	...	20 to 40
No. 200 (75-µm)[B]	0 to 5	0 to 6	1 to 7	2 to 8	2 to 10	2 to 10	2 to 10	...	9 to 20

Materials Mix Design

According to Asphalt Institute

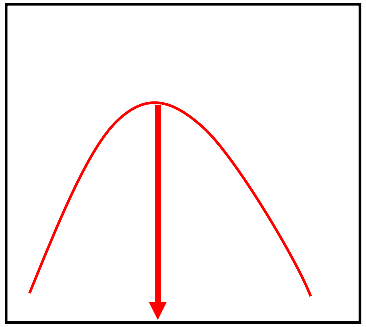
Air Viod, %

4%



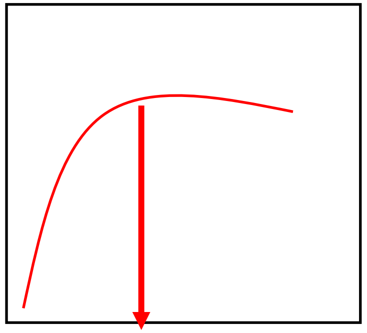
Asphalt Content, %

Stability



Asphalt Content, %

Unit Wt.



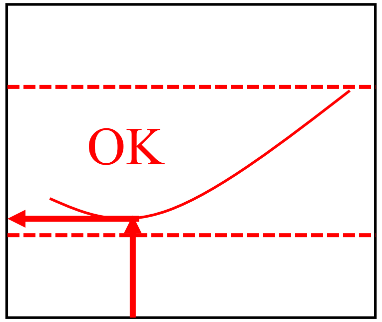
Content

Target optimum asphalt content = average

Flow

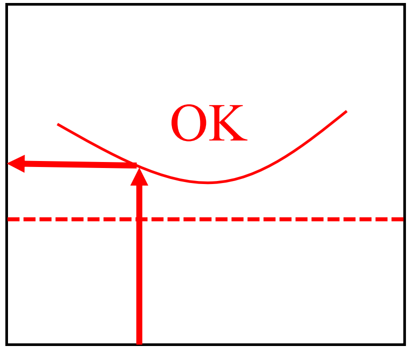
Upper Limit

Lower Limit



VMA, %

Minimum



	Test Result	Specification (Asphalt Institute)
Stability (KN)	11.3	Min. 8
Flow (0.01 in)	12.0	8-14
Air Voids (%)	4.2	3-5
VMA (%)	16.4	Min. 13
Density (g/cc)	2.39	-
Rut Depth (mm)	8.97	Max.12.5
Bitumen Content (%) (By weight of total mix)	5.3	(4 % -10 %)

Crushed Rock (3/4")	-	18.9 %	By weight of total mix
Crushed Rock (1/2")	-	20.8 %	
Crushed Rock (3/8")	-	24.7 %	
Crusher Dust	-	15.2 %	
Sand	-	12.3 %	
Cement Powder	-	2.8 %	
Bitumen	-	5.3 %	

(60/70 Penetration Grade Bitumen)

Materials Mix Design

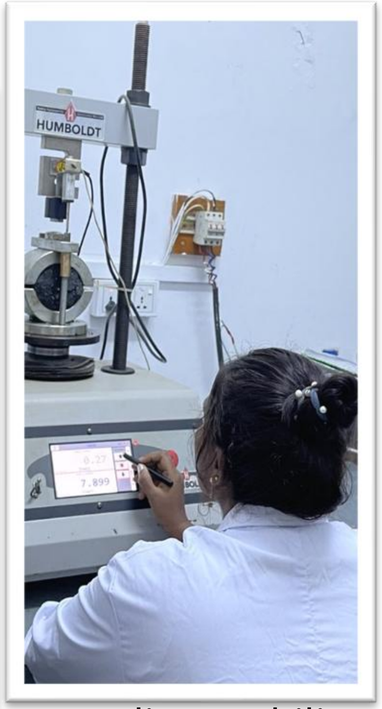
Making & Testing of Asphalt Concrete Mix

Sieve Analysis with Sieve Shaker

Mixing material with AC Mixer Machine

Making Specimen with Automatic Compactor Machine

Boiling with Water Bath



Reading Stability & Flow Value

Materials Mix Design

Testing Rut Depth with **Humburg Wheel Trucking (HWT)** **(Predominance Test)**

Automated Universal Asphalt Saw


Testing of Max. theoretical Density with Pycnometer

Making Specimen with Roller Compactor


Placing Specimen in HWT machine

Specification limit = 12.5mm depth at 5000 cycle

Temperature = 50 ± 2 ˚C

Wheel Passes = 20000 passes (10000 cycles)

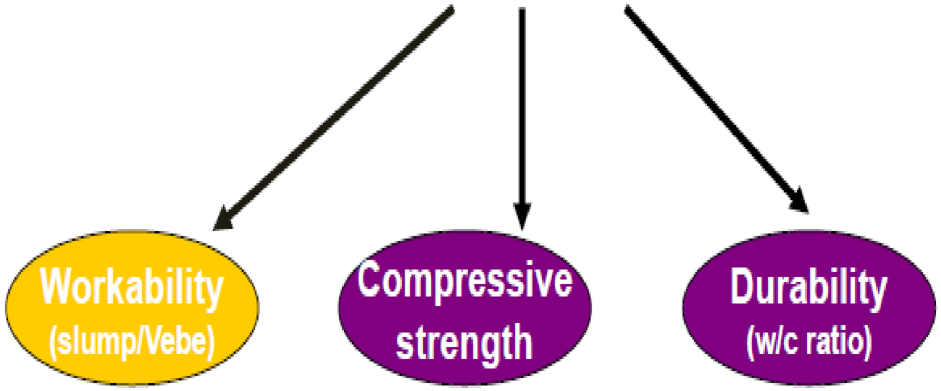

Testing two specimens with HWT machine

Cement Concrete Mix Design

Materials
Mix Design

What is Concrete Mix Design!

❖**Concrete mixes should meet;**



❖**Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.**

ACI Method of Proportioning Concrete Mixes

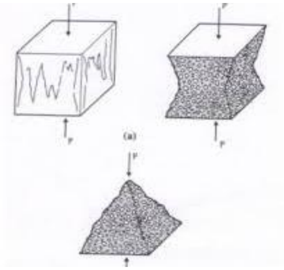
The ACI Standard 211.1 is a "*Recommended Practice for Selecting Proportions for Concrete*".

The procedure is as follows:

- **Step 1. Data to be collected**
- **Step 2. Target mean strength**
- **Step 3. water/cement ratio**
- **Step 4. Maximum size of aggregate and workability**
- **Step 5. cement content**
- **Step 6. Weight of coarse aggregate**
- **Step 7. Weight of Fine Aggregate**
- **Step 8. Mix proportions**
- **Step 9. Adjustments for Aggregate Moisture**
- **Step 10. Final design proportions**

Materials Mix Design

Workability & Strength Test



Flexural strength test

Compressive strength test

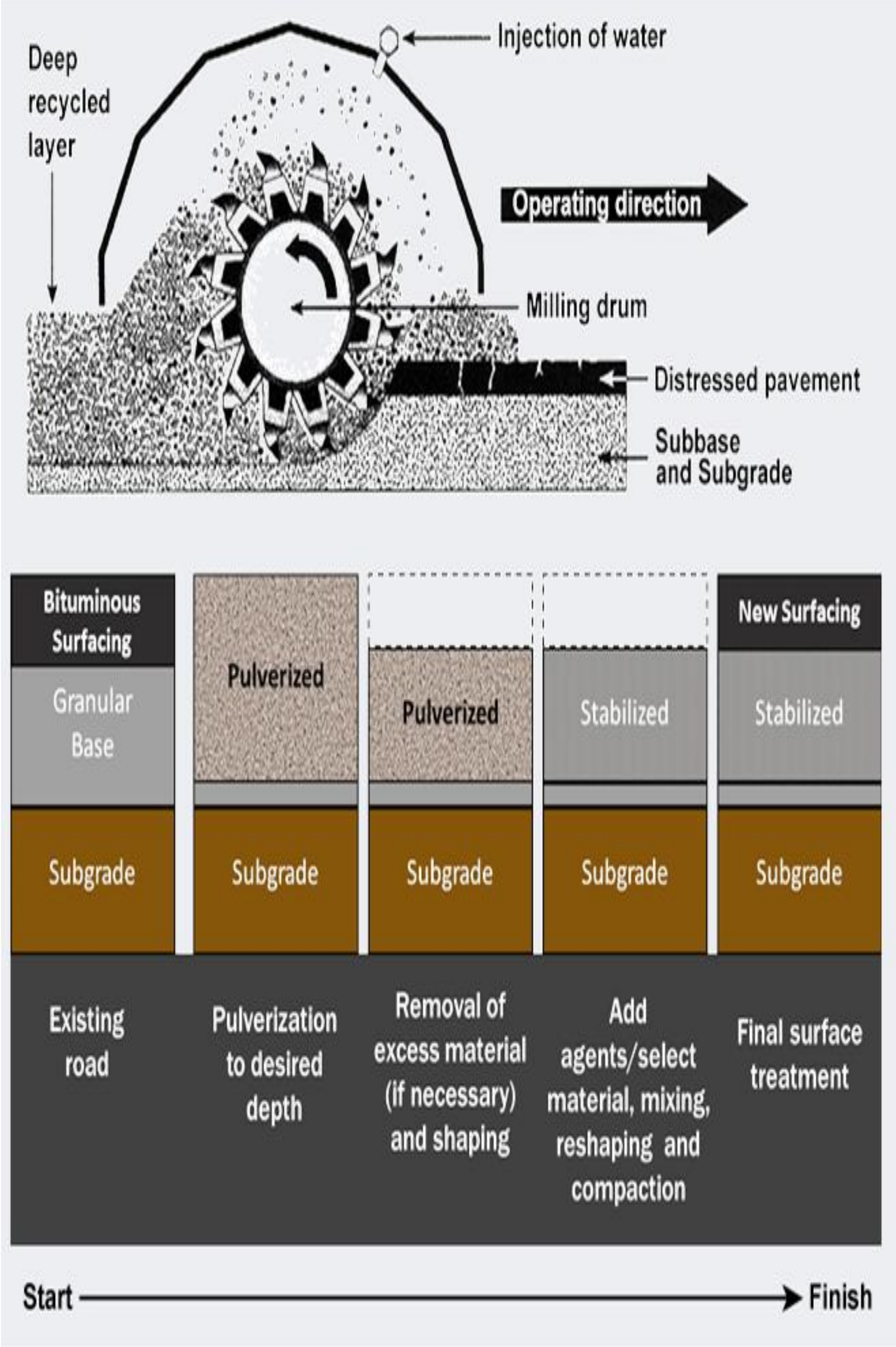
Soil /Aggregate Stabilized mixed with Lime/Cement/Fly Ash/Bitumen Emulsion

Common Purpose

- ❑ To improve physical properties of soil

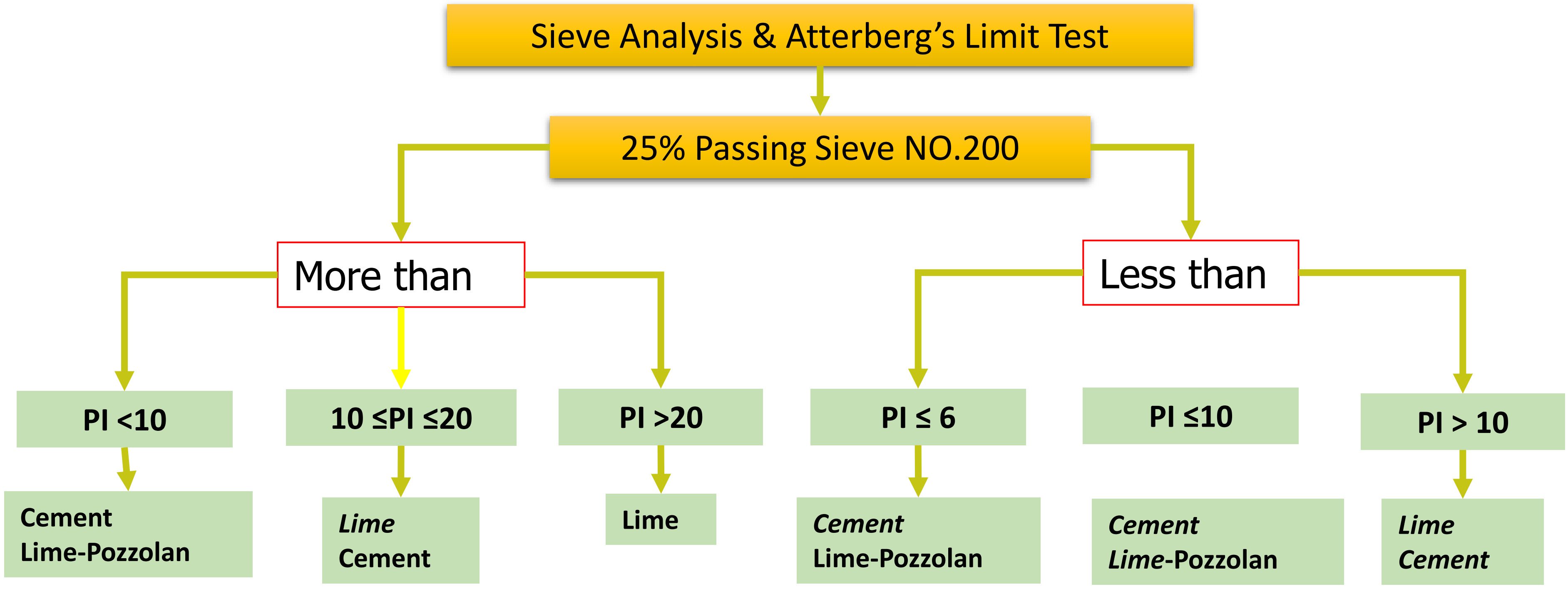
Objectives

- ❑ To enhance shear strength
- ❑ To reduce permeability
- ❑ To control shrinkage
- ❑ To improve durability
- ❑ To increase load bearing capacity of a subgrade to support pavement and foundations.
- ❑ To achieve promoting quality of local sub-standard pavement materials by stabilized with additives.



Materials
Mix Design

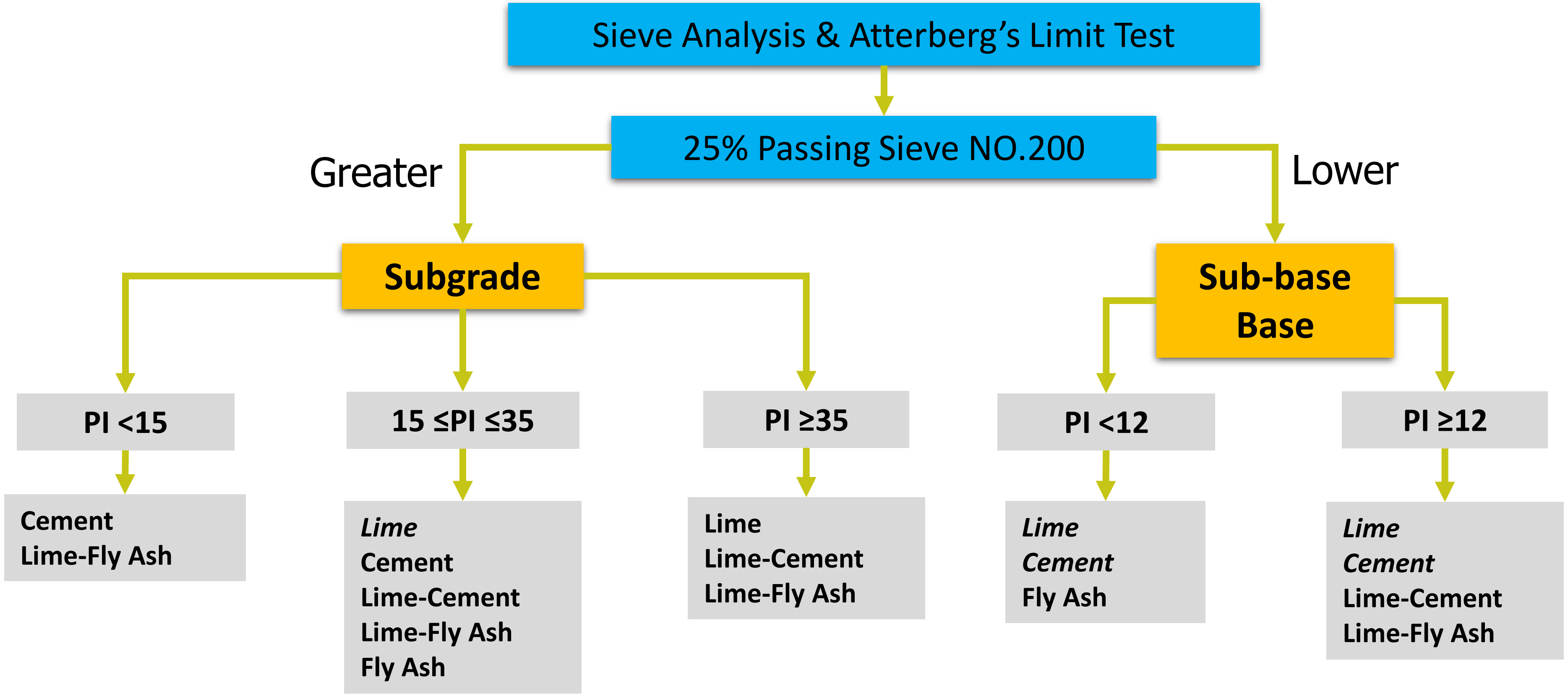
Guideline for Types of Stabilization (Oversea Road Note 31)



Ref: Oversea Road Note 31

Materials
Mix Design

Guideline for Types of Stabilization (Texas DOT)



Ref: developed by *Currin, et al.* in 1976, *A.Smith* and *J.Epps* in 1975, *D.N.Little*, et al. in 1995

Specification : Subbase and Base Course Layer

Thuwanna, Yangon

TABLE 7.1

Properties of cement and lime-stabilised materials

Code	Description	Unconfined compressive strength* (MPa)
CB1	Stabilised roadbase	3.0 - 6.0
CB2	Stabilised roadbase	1.5 - 3.0
CS	Stabilised sub-base	0.75 - 1.5

* Strength tests on 150 mm cubes (see Section 7.4)

TABLE 7.2

Guide to the type of stabilisation likely to be effective

Type of stabilisation	Soil properties: *More than 25% passing the 0.075 mm sieve*			*Less than 25% passing the 0.075 mm sieve*		
	PI≤10	10<PI≤20	PI>20	PI≤6 PP≤60	PI≤10	PI > 10
Cement	Yes	Yes	*	Yes	Yes	Yes
Lime	*	Yes	Yes	No	*	Yes
Lime-Pozzolan	Yes	*	No	Yes	Yes	*

Notes. 1. * Indicates that the agent will have marginal effectiveness
2. PP = Plasticity Product (see Chapter 6).

TABLE 7.3

Desirable properties of material before stabilisation

BS test sieve (mm)	Percentage by mass of total aggregate passing test sieve: CB1	CB2	CS
53	100	100	-
37.5	85 - 100	80 - 100	-
20	60 - 90	55 - 90	-
5	30 - 65	25 - 65	-
2	20 - 50	15 - 50	-
0.425	10 - 30	10 - 30	-
0.075	5 - 15	5 - 15	-
	Maximum allowable value		
LL	25	30	-
PI	6	10	20
LS	3	5	-

Note. It is recommended that materials should have a coefficient of uniformity of 5 or more.

As an alternative, the strength of cement stabilised sub-base material may be measured by the CBR test after 7 days of moist curing and 7 days of soaking and should be 70 % minimum.

The curing period for lime-stabilised materials is 21 days of moist cure followed by 7 days of soaking.

Curing Temperature for stabilized samples are better around at 25’C.

- ✓ Objective
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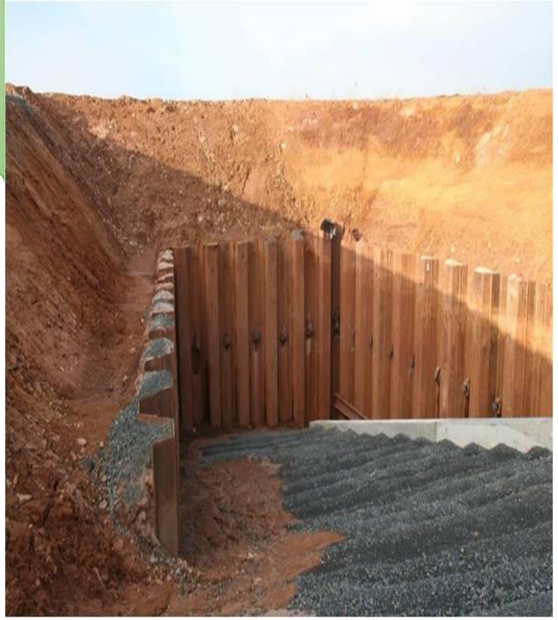
- ✓ Pavement Construction Materials and Test Methods
- ✓ Materials Mix Design
- ✓ **Soil Improvement and Ground Modification**
- ✓ Materials Innovation in Pavement construction
- ✓ Conclusion

Soil Improvement and Ground Modification



Soil improvement generally includes the modification of the soil in its original place.

Ground modification is more inclusive as it can even comprise soil layer replacement, reinforcement, or mixing activities.

Soil Improvement

Types of Soil Improvement Techniques

Technique	Purpose	Typical Use Cases
1.Mechanical Compaction	Increases density and strength	Roads, embankments
2.Preloading & Surcharging	Reduces future settlement	Reclaimed lands, highways
3.Chemical Stabilization	Enhances cohesion and strength	Clayey soils, pavements
4.Geosynthetics Reinforcement	Provides tensile strength and separation	Retaining walls, slopes
5.Drainage Improvement	Enhances consolidation	Soft clay areas
6.Grouting	Fills voids, strengthens soils	Underpinning, tunneling
7.Deep Soil Mixing	Combines soil with binders	Foundations, liquefaction control
8.Vibroflotation	Rearranges granular soils to increase density	Port structures, sandy soils

Mechanical compaction

One of the oldest and cheapest soil modification techniques, is also the first job.

The volume of soil can be reduced by using equipment such as rollers, vibrators, or rammers.

Benefits:

- ❑ Simple and immediate
- ❑ No chemical hazards
- ❑ Raises the load-bearing capacity

Limitations:

Does not work for water-saturated clays

For the deep layers, more waves may be needed.

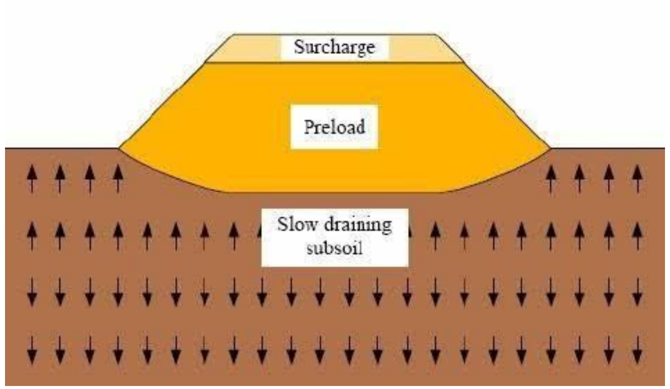
This is especially useful for shallow foundations, road bases, and embankments, and remains one of the most widely used soil improvement and ground modification methods globally.

Preloading and Surcharging Ground Improvement

Surcharging ground improvement is a passive method where an extra load is temporarily placed on the ground to accelerate soil consolidation before actual construction begins.

How It Works:

The surcharge compresses the soil, expelling pore water and reducing settlement after construction.



Applications:

- Reclaimed land
- Soft clay improvement
- Airport runways

To enhance the efficiency of this ground improvement method, vertical drains are often used to speed up water removal. It's one of the most time-tested soil improvement and ground modification methods for deep compressible soils.

Soil Improvement

Chemical Soil Stabilization

Chemical methods modify the internal structure of the soil by adding binders such as lime, cement, fly ash, or polymers.

Advantages:

- Improves strength and durability
- Effective for clayey soils
- Resistant to weathering

Disadvantages:

- Environmental considerations
- Requires skilled handling

This soil improvement method is commonly used for subgrade stabilization in roads and pavements and can be integrated with other soil improvement and ground modification methods for even better results.

Ground Modification Techniques Using Geosynthetics

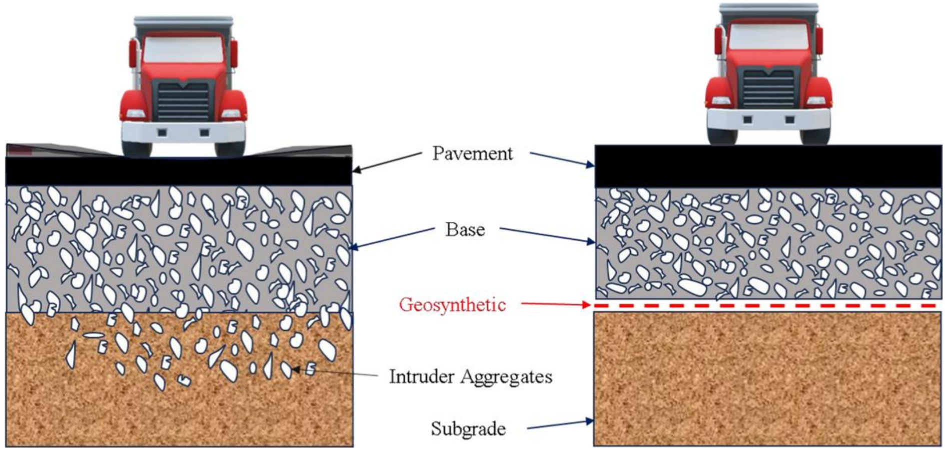
Geosynthetics are materials such as geotextiles, geogrids, and geomembranes. They are instrumental in soil stabilization by:

- ❑ Providing tensile strength
- ❑ Separating different soil layers
- ❑ Improving drainage

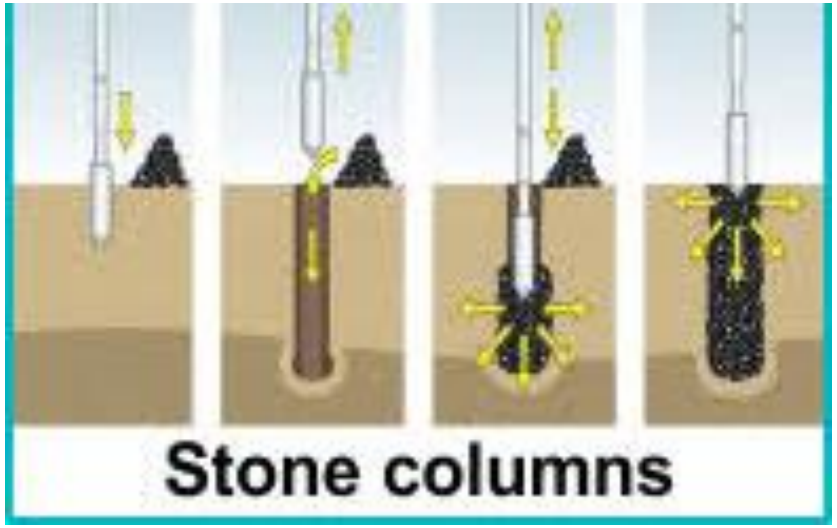
This ground modification technique is a widely recognized one in the sectors of:

- ❑ Road and rail embankments
- ❑ Retaining wall systems
- ❑ Landfill liners

Geosynthetics are sustainable and can easily be incorporated into hybrid soil improvement and ground modification systems



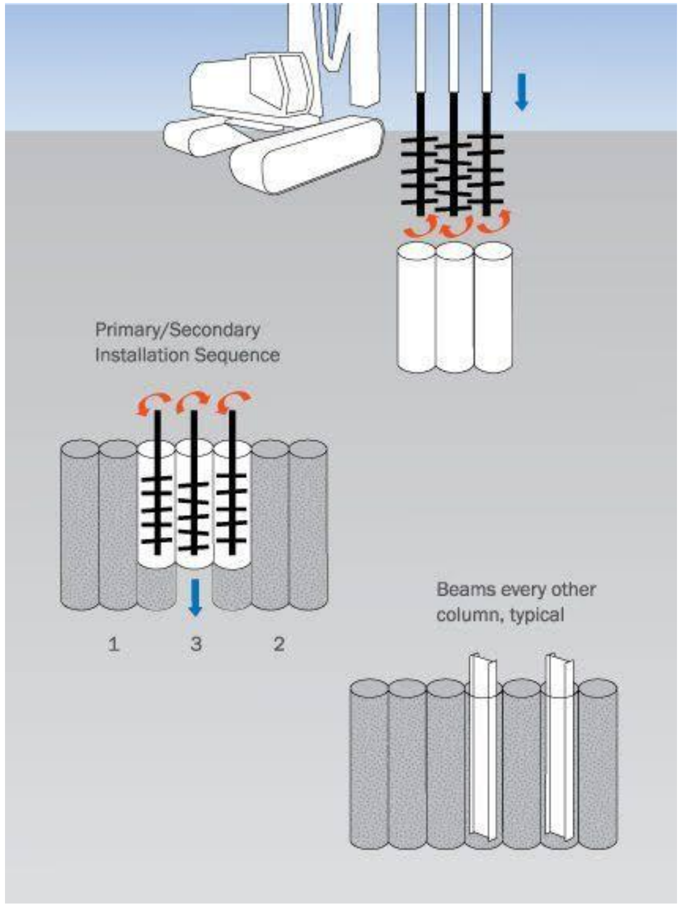
Ground Modification



Prefabricated Vertical Drains(PVD)

Deep Soil Mixing

In deep soil mixing, binders are mixed into the soil using rotating augers. The resulting soil-cement columns enhance the ground's shear strength and reduce permeability.



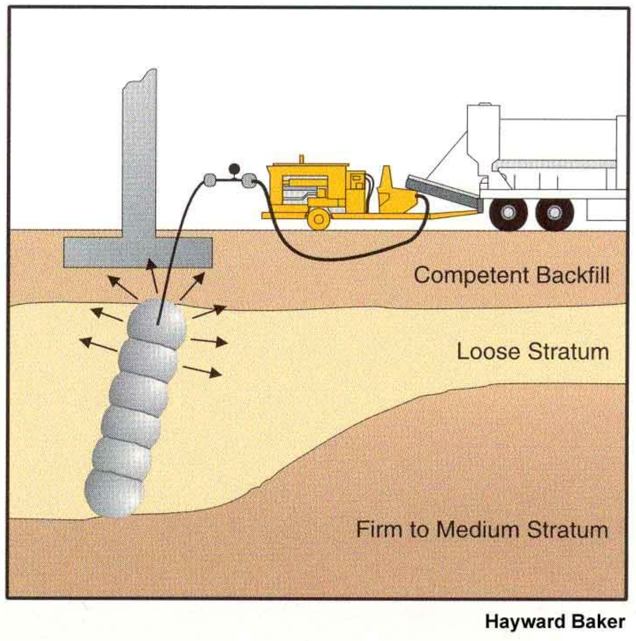
Applications:

- Liquefaction mitigation
- Embankment support
- Foundation soil reinforcement

This soil improvement technique is ideal for stabilizing soft, high-water-content soils, especially in urban areas where excavation is limited. It's frequently combined with other soil improvement and ground modification methods for maximum effect.

Vibroflotation Method of Ground Improvement

The vibroflotation method of ground improvement is used to densify loose granular soils using a vibrating probe. The probe is inserted into the ground, and water is used to assist penetration. As it vibrates, soil particles rearrange and compact.



Ideal Conditions:

Sandy or gravelly soils

Deep foundations

Marine structures

This ground modification technique is effective up to 40 meters deep and is widely used in port construction and offshore platforms. As one of the more specialized soil improvement and ground modification methods, it is ideal for granular soil profiles

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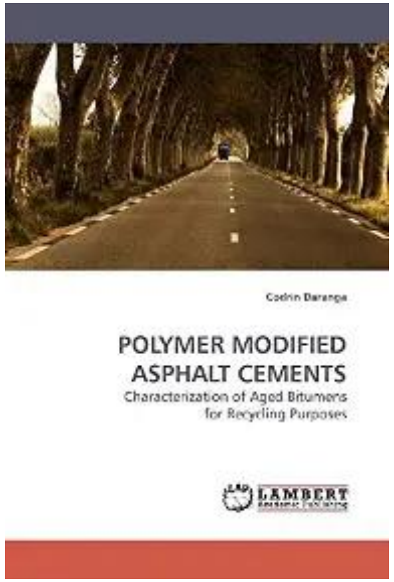
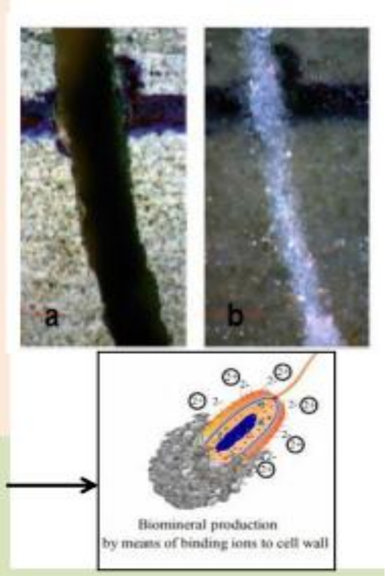
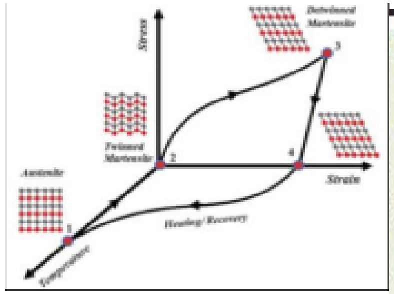
Materials Innovation in Pavement construction

To use of better materials and technologies for the purpose of road construction.

1. **Polymers**
   a. Using fiber-reinforced polymer (FRP) composites
   b. Utilization of Polymers in Asphalt Pavement
   c. Utilization of Geopolymers
2. Bio asphalt
   a. Biopolymers
   b. Bio-modifiers derived from wastes
3. Self-healing pavement
4. Shape Memory Alloys (SMA)
5. Plastic Road Technology
6. Solar roads
7. Illuminating cement (Glow-in-the-dark concrete)







Polymer Modified Binder

- **Polymers**
  - large molecules that are used to enhance the performances of asphalt cement and asphalt concrete pavement, particularly at high temperatures. Specifications and Testing
- **Polymer Modified Binders**
  - Styrene Butadiene Copolymer (radial and linear) (SBS)
  - Polyethylene (PE)
  - Styrene Butadiene Rubber (SBR)
  - Polybutadiene (PB)
  - Ethylene Vinyl Acetate (EVA)
  - Ehtylene Methyl Acrylate (EMA)
  - Atactic Polypropylene (PP)
  - Epoxies and Urethanes
  - Tire Rubber (Crumb)

Conclusions

- ✓ Pavement construction materials serve as the structural backbone of roadway infrastructure ,directly determining load–bearing capacity , durability, and overall service life.
- ✓ The selection of the appropriate materials for road construction is an essential element in road construction projects.
- ✓ The application of innovative materials and advanced technologies enable the construction of high quality and long service life road pavements .
- ✓ By properly selecting appropriate high-quality pavement construction materials, engineers can effectively mitigate dynamic traffic stresses and environmental deterioration.
- ✓ Ensuring each structural functions as intended minimizes long-term maintenance costs and delivers a safe, and high-performance pavement networks.


Thank you