STATE OF THE ART IN ASPHALT MIX DESIGN: CAN WE DO BETTER?

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Outline

- Introduction
- Properties Considered in Mix Design
- History of Asphalt Mix Design
- Hveem Asphalt Mix Design
- Marshall Mix Design
- Balanced Mix Design
- Superpave Mix Design
- Comparison of the Mix Design Methods
- The Way Forward
- Conclusion

Introduction

- Asphalt mix design refers to the process of proportioning its components, generally aggregates and binder, so that the required properties are achieved. These properties can be volumetric, mechanical (e.g. based on empirical tests), or performance properties (Zunamis et. al., 2018).

- It involves laboratory procedures developed to establish the qualities and necessary proportions of materials for use in the asphalt mixture.

- The procedure for asphalt mix design includes:

  - determining an appropriate blend of aggregates to produce a proper gradation of mineral aggregate and

  - selecting the type and amount of asphalt binder to be used for the gradation.

Introduction

- Well-designed asphalt mixtures are expected to serve successfully for many years under various loading and environmental conditions.
- The overall objective for the design of asphalt paving mixes is to determine the gradation of aggregates and the amount of binder content (optimum) that will result in a mix having:
  - sufficient bitumen to ensure a durable pavement;
  - sufficient mix stability to satisfy the demands of traffic without distortion or displacement;
  - sufficient air voids in the total compacted mix to allow for a slight amount of additional compaction under traffic loading and a slight amount of thermal binder expansion without flushing, bleeding, and loss of stability;

Introduction

- a maximum void content to limit the permeability of harmful air and moisture into the mix;
- sufficient workability to permit efficient placement of the mix without segregation and without sacrificing stability and performance; and
- aggregate texture and hardness to provide sufficient skid resistance in unfavourable weather conditions.
- In many cases, the cause of poor performance of pavements has been attributed to:
- a poor or inappropriate mix design or
- due to the production of a mixture different from what was designed in the laboratory.

Properties Considered in Mix Design

- The properties that are considered in asphalt mix design are:
  - resistance to permanent deformation;
  - resistance to fatigue;
  - resistance to low-temperature cracking;
  - moisture resistance;
  - durability and
  - workability.
- These properties determine the ability of the asphalt pavement to stand the test of time.

Properties Considered in Mix Design

Resistance to permanent deformation

- Permanent deformation results from the accumulation of small amounts of unrecoverable strain (small deformations) from repeated loads applied to the pavement.
- Wheel path rutting is the most common form of permanent deformation. The two primary causes of rutting are subgrade failure and inadequate mix stability. (see Plate 1).

Plate 1: Rutting

Properties Considered in Mix Design

Resistance to Fatigue

- Fatigue resistance is the pavement's resistance to repeated bending under wheel loads (traffic). The result of a fatigue failure is fatigue cracking, often called alligator cracking (Plate 2).
- Producing an asphalt mix with good resistance to fatigue can be achieved by using pavement materials that are not easily weakened by moisture, so, attention must be paid to bitumen stiffness.

Plate 2: A typical pavement with fatigue cracking

Properties Considered in Mix Design

Low-temperature cracking

- This is not a problem in Nigeria but it is given serious attention in temperate climate.
- This is caused by temperature drops in pavement sufficiently to produce thermally induced stress in the HMA layer that exceeds the tensile strength of the asphalt mixture. The result is transverse cracks.
- In general, the solution to this problem is the proper choice of binder. The use of highly absorptive aggregates, or aggregates with high dust content, can aggravate low-temperature cracking.

Plate 3: Transverse crack (Low temperature cracking)

Properties Considered in Mix Design

Moisture resistance

- A major durability problem is associated with moisture damage, commonly referred to as "stripping."
- This typically is the result of water in combination with repeated traffic loadings, causing a scouring effect as the water is pushed into and pulled out of the voids in the pavement.
- The best line of defense against stripping is having sufficient binder in the mix, which can be achieved by:
  - having proper mix design and
  - constructing an impermeable mat by achieving sufficient compaction.

Durability

- The ability to resist factors such as aging of the bitumen, disintegration of the aggregate and stripping of the bitumen film from the aggregate.

Properties Considered in Mix Design

Durability (cont'd)

- Generally, the durability of a mixture can be enhanced by three methods:
  - designing the mix using a dense gradation of moisture-resistant and sound aggregate;
  - maximizing the bitumen film thickness on the aggregate; and
  - compacting the mixture to be impervious (which may be as low as 5 percent in-place air voids, depending on nominal maximum aggregate size and gradation).
- The use of strong, tough, nonporous aggregate and enough bitumen to completely coat all of the aggregate particles (to keep them dry) and fill all of the voids between particles (to slow the oxidation of the bitumen) are important to produce durable asphalt pavement

Properties Considered in Mix Design

Skid resistance

- Ability of an asphalt surface to minimize the skidding or slipping of vehicle tyres, particularly when the roadway surface is wet.
- A rough pavement surface with many little peaks and valleys will have greater skid resistance than a smooth textured surface.
- Also, the aggregates must resist polishing (smoothing) under traffic and the mix must have enough air voids to prevent bleeding.

Workability

- The ease with which asphalt mixtures can be placed and compacted.
- Mixtures with good workability are relatively easy to place and compact; those with poor workability are difficult to place and compact.
- Harsh mixtures (containing a high percentage of coarse aggregate and/or low bitumen content) tend to segregate during handling and may be difficult to compact.
- Tender mixes (having a shortage or excess of mineral filler, excess bitumen, excessive medium-sized sand, and smooth and rounded aggregate particles) are too unstable to place and compact properly.
- High and low temperatures make a mix to be tender and unworkable.

History of Asphalt Mix Design

- Asphalt was first used in pavement in Babylon, between 625 B.C. and 604 B.C., as the "Procession Street" near King Nabopolassar's palace was paved.
- The first asphalt pavements in the United States were built in Newark, New Jersey (1870), and Washington, D.C. (1876), on Pennsylvania Avenue.
- Clifford Richardson of the Barber Paving Asphalt Company in 1908 recognized the importance of air voids (Va) and voids in the mineral aggregate (VMA). The Barber Company paved sheet asphalt, a mixture of asphalt binder (from Trinidad) and clean angular sand and filler.
- Frederick Warren of the Warren Brothers Company(1901) in contrast to Barber, produced mixes (more like HMA) with aggregates up to 3 inches (76.2 mm) in size. Warren called this mix "bitulithic" and received its patents in 1901 and 1903. Bitulithic was improved and later marketed as Warrenite.

History of Asphalt Mix Design

- Prevost Hubbard and Frederick Field of the Asphalt Institute developed a mix design procedure mainly for fine mixes in the 1920s . They determined a minimum Hubbard-Field stability value based on experience with pavements capable of resisting shoving. This method remained in wide use until the 1950s.
- The Smith Triaxial method and the Texas Gyratory method in the 1950s.
- Francis Hveem developed a mix design procedure that introduced the use of a kneading compactor (more representative of the field-produced mixes that were being compacted with steel and pneumatic-tyre rollers) in the 1930s. Additionally, Hveem recognized the need to have a mechanical test to evaluate the performance of the mix and developed Stabilometer, to evaluate the ability of the mix to resist the shear forces applied by the traffic.

History of Asphalt Mix Design

- The Marshall Mix Design procedure was developed by Bruce Marshall of the Mississippi Highway Department in the 1930s. He believed that laboratory compaction must produce a density representing the in-place density after traffic. He recommended selecting the asphalt binder content that produced the highest density while checking the stability and flow to ensure minimum acceptable levels were met.
- The U.S. Army Corps of Engineers adapted the Marshall method to design pavements that would support the increase in aircraft wheel loads and tyre pressures of the new aircraft to address the need for runway construction in remote areas during World War II.
- From 1987 to 1993, the Federal Highway Administration (FHWA) sponsored, and the Transportation Research Board (TRB) administered, the $150 million Strategic Highway Research Program (SHRP). The result of this research was the Performance Grading (PG) system for binders and a new mix design system called Superpave (Superior PERforming Asphalt PAVEments).

History of Asphalt Mix Design

- The former Federal Highway Administration (FHWA) Expert Task Group (ETG) on Mixtures and Construction formed a Balanced Mix Design Task Force that worked on Balanced Mix Design (BMD) in September 2015.
- The task force defined balanced mix design (BMD) as “asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix aging, traffic, climate, and location within the pavement structure.”

Hveem Asphalt Mix Design

- The Hveem mix design method consists of 6 basic steps:
  - aggregate selection;
  - asphalt binder selection;
  - sample preparation (including compaction);
  - stability determination using the Hveem stabilometer;
  - density and voids calculations and
  - optimum asphalt binder content selection.

Hveem Asphalt Mix Design

Aggregate and asphalt binder selection

- Hveem did not specifically develop an aggregate and bitumen evaluation and selection procedure, Agencies follow typical aggregate evaluation.
- The aggregate physical properties are examined.
- The gradation should not be too close to the Federal Highway Administration's (FHWA) 0.45 power maximum density curve.
- Asphalt binder evaluation is based on local experience, previous performance, or a procedure.
- Preliminary tests are run to determine the asphalt binder's temperature-viscosity relationship.

Hveem Asphalt Mix Design

Sample preparation

- Sample size = 102 mm (4-inch) in diameter, 64 mm (2.5 inches) in height.
- The trial blends contain a range of asphalt binder contents both above and below the optimum asphalt binder content. This can be accomplished in either of two ways:
  - Select the asphalt binder content for each trial blend from a predetermined list. Many agencies have predetermined lists that specify the asphalt content for each trial blend.
  - Estimate the optimum asphalt binder content then select trial blends using the coarse aggregate surface capacity can also be determined to establish the binder content.

Hveem Asphalt Mix Design

Sample preparation

- Each sample is then heated to the anticipated compaction temperature and compacted with the California kneading compactor (Plate 4)
- Key parameters of the California kneading compactor are:

Tamper foot = Shield-shaped with an area of 20 cm^2 (3.1 in^2)

Compaction pressure = Ranges from 2.4 to 3.4 MPa (350 to 500 psi)

Number of blows = 150 (plus any preparatory blows at 1.7 MPa (250 psi))

Plate 4: California kneading compactor

Hveem Asphalt Mix Design

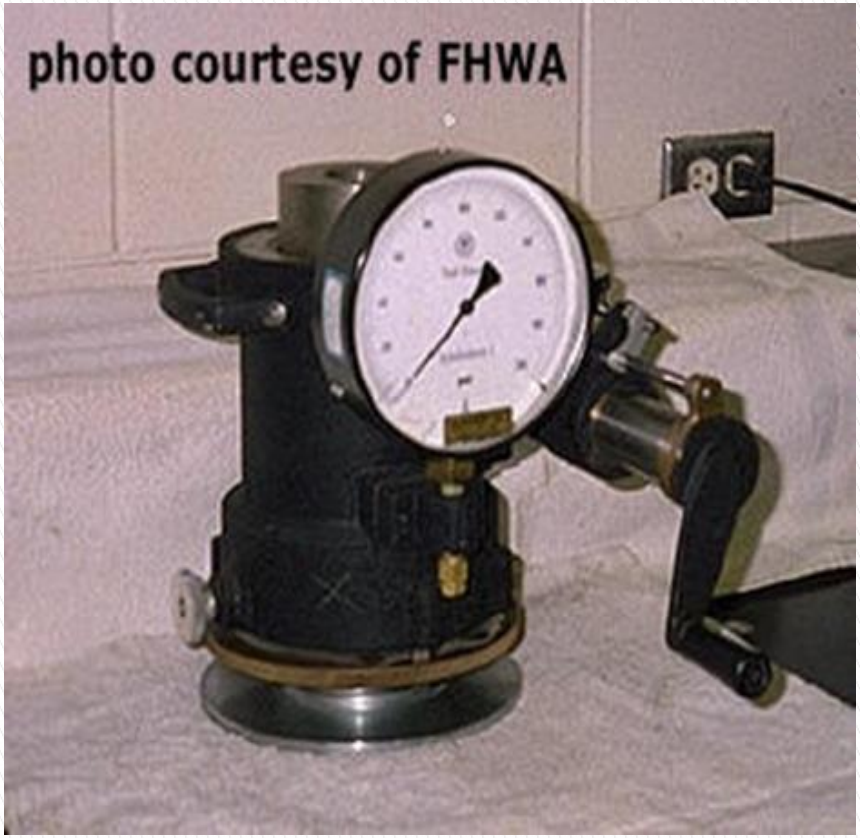


Plate 5: Hveem Stabilometer

- The Hveem stabilometer measures the resistance to deformation of a compacted HMA sample by measuring the lateral pressure developed from applying a vertical load.
- The stabilometer applies an increasing load to the top of the sample at a predetermined rate. The resulting stabilometer value is calculated as:

$$S = \frac{22.2}{\left[\frac{P_h \times D}{P_v - P_h}\right]} - 0.22$$

S = Stabilometer value

P_v = Vertical pressure- typically 2800 kPa (400 psi)

P_h = Horizontal pressure corresponding to Pv in kPa (psi)

D = Displacement of specimen in 0.25 mm (0.01 inch) unit

Hveem Asphalt Mix Design

Specific gravity and voids analysis

- The bulk specific gravity and theoretical maximum specific gravity are determined.
- The volumetric parameters like air voids (Va), sometimes expressed as voids in the total mix (VTM), Voids in the mineral aggregate (VMA), and voids filled with bitumen (VFB) are calculated.
- Generally, these values must meet local or State criteria.

Selection of optimum asphalt binder content

- The optimum asphalt binder content is finally selected based on the combined results of the stabilometer test, density analysis, and void analysis.

Table 1: Typical stabilometer criteria

Mix Criteria	Light Traffic (Less than 104 ESALs)	Medium Traffic (104 - 106 ESALs)	Heavy Traffic (Greater than 106 ESALs)
Stabilometer value	30	35	37
Air voids	Approximately 4%		

Marshall Mix Design

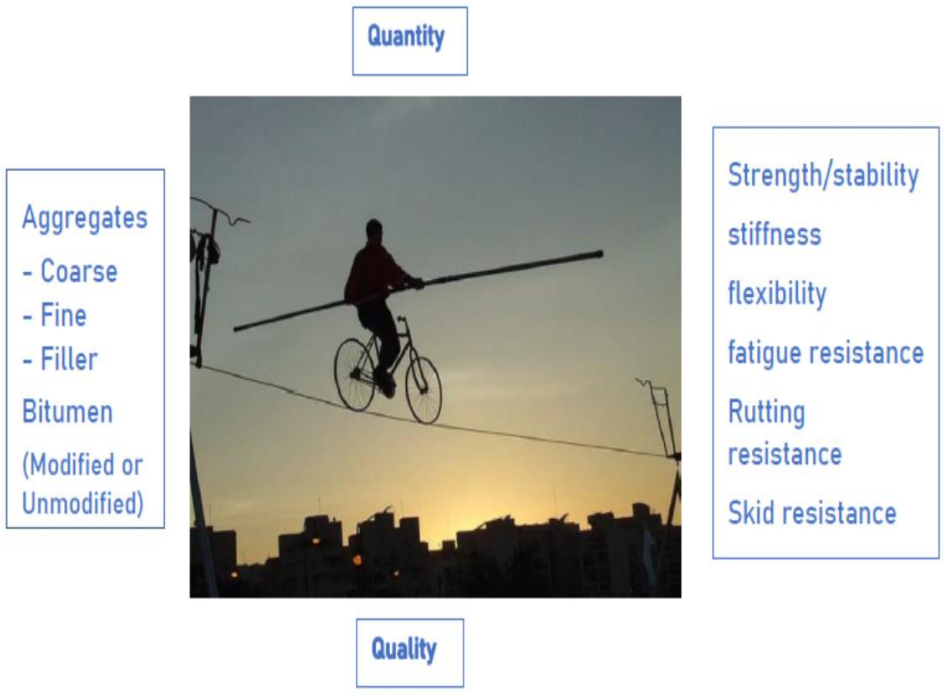


Plate 6: Balancing of asphalt mixtures materials

- Marshall Mix Design is used in Nigeria.
- It is used to determine the optimum bitumen for a given aggregate gradation, which will result in an asphalt concrete mix with desirable properties such as stability, durability, flexibility, and resistance to rutting and fatigue cracking.
- The Marshall Mix Design procedure involves the following steps:
  - aggregate sampling and gradation analysis;
  - asphalt binder selection;
  - preparation of test specimens;
  - specific gravity, stability, and flow testing;
  - determination of the volumetric characteristics; and
  - determination of the optimum binder content.

Marshall Mix Design

Aggregate sampling and gradation analysis: Representative samples of coarse and fine aggregates are collected and tested for gradation according to standard.

Asphalt binder selection: The appropriate grade of asphalt binder is selected based on factors such as climate, traffic conditions, and desired performance characteristics.

Preparation of test specimens: Marshall test specimens, typically cylindrical samples with a diameter of 101.6 mm (4 inches) and a height of 63.5 mm (2.5 inches), are prepared by compacting the aggregate mix with varying asphalt binder contents using a Marshall compactor.

Plate 7: Aggregates, bitumen and test samples

Marshall Mix Design

Specific gravity, stability, and flow Testing: The compacted test specimens are subjected to a series of tests to determine their specific gravity, stability, and flow.

Determination of the volumetric characteristics: The air voids, bitumen content, voids in mineral aggregate, and voids filled with bitumen are calculated.

Determination of the optimum binder content: Multiple test specimens are prepared and tested at different asphalt binder contents.

The stability, flow, and volumetric parameters are plotted against bitumen content to establish the optimum bitumen content.

Plate 8: Marshall stability machine

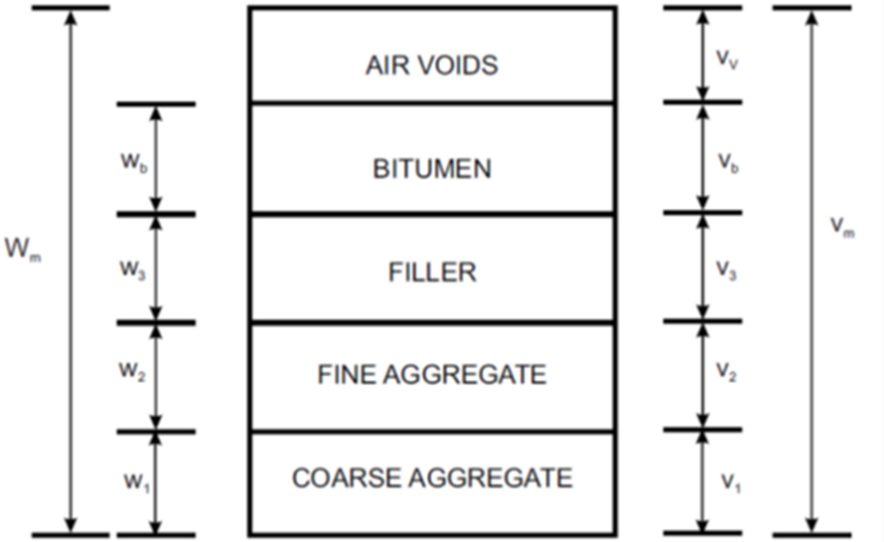


Figure 1: Phase diagram of asphalt mix

Superpave Mix Design

- It is a comprehensive method of designing paving mixes tailored to the unique performance requirements dictated by the traffic, environment (climate), and structural section at a particular pavement site.
- It facilitates selecting and combining asphalt binder, aggregate, and any necessary modifier to achieve the required level of pavement performance.
- It addresses the reduction and control of permanent deformation, fatigue cracking, and low-temperature cracking directly, through materials selection and mix design.
- It also explicitly considers the effects of aging and moisture sensitivity in promoting or arresting the development of these three distresses.

Superpave Mix Design

- The objective of the Superpave mix design system is to define an economical blend of asphalt binder and aggregate that yields a paving mix having:
  - sufficient asphalt binder;
  - sufficient voids in the mineral aggregate (VMA) and air voids;
  - sufficient workability; and
  - satisfactory performance characteristics over the service life of the pavement.

Superpave Mix Design

- The four basic steps of Superpave asphalt mix design (Figure 2) are:
  - materials selection;
  - selection of the design aggregate structure;
  - selection of the design asphalt binder content; and
  - evaluation of the mixture's moisture sensitivity.

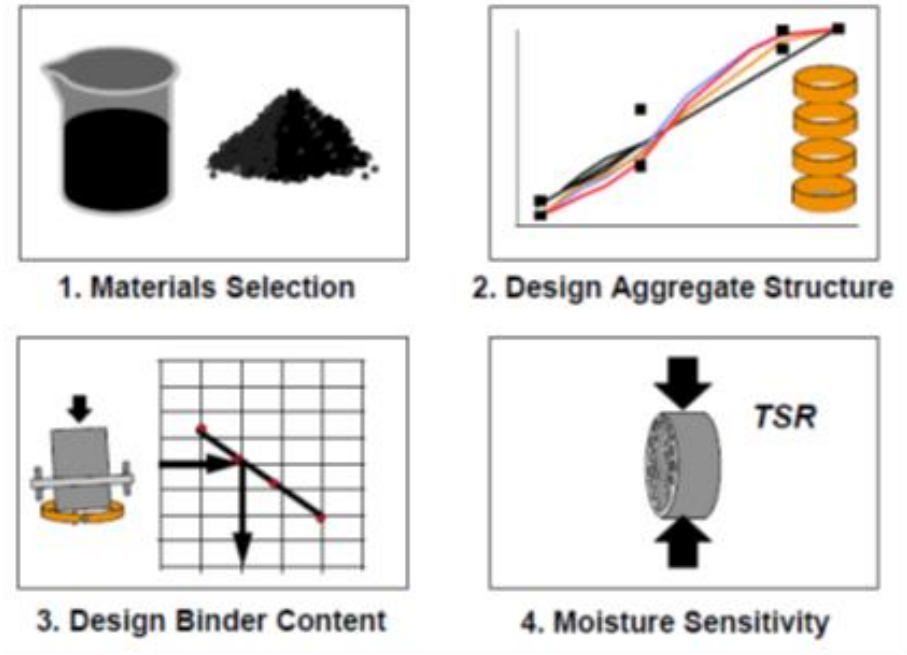


Figure 2: Steps of Superpave mix design

Superpave Mix Design

Materials selection

The properties of the materials are evaluated to select the right materials.

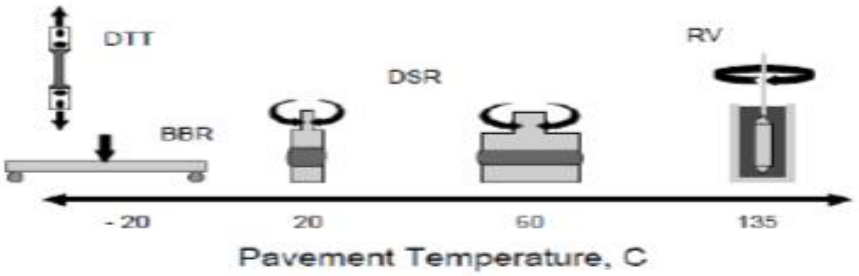
Measurement of the binder's properties

- The new Superpave binder tests measure physical properties that can be related directly to field performance by engineering principles.
- The three most critical stages are:
  - during transport, storage, and handling (unaged binder);
  - during mix production and construction (Rolling Thin Film Oven test); and
  - after long periods in a pavement (Pressure Aging Vessel).
- The tests are shown in Table 2 and Figure 3.

Superpave Mix Design

Table 2: Superpave binder tests

Superpave binder test	Purpose
Dynamic shear rheometer (DSR)	Measure properties at high and intermediate temperatures
Rotational viscometer (RV)	Measure properties at high temperature
Bending beam rheometer (BBR) Direct tension test	Measure properties at low temperature
Rolling thin film oven test (RTFO)	Simulate aging during mix production and construction
Pressure aging vessel (PAV)	Simulate aging a long period of service



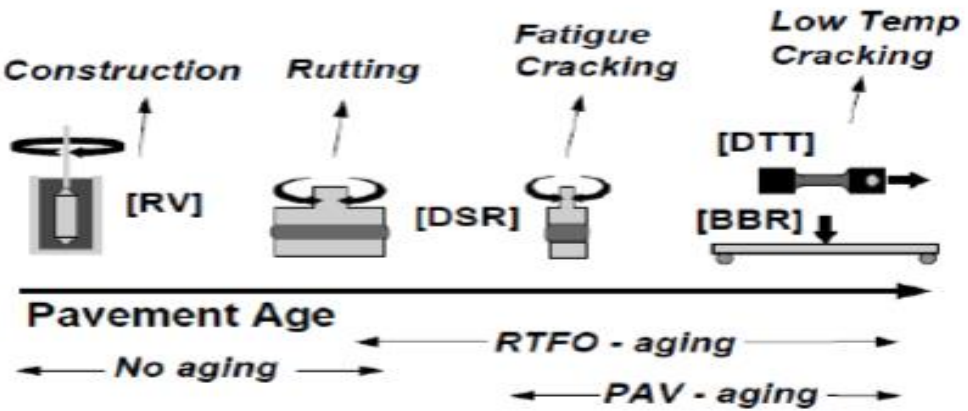


Figure 3: Superpave binder tests

Superpave Mix Design

Materials selection (cont'd)

Measurement of the aggregate properties

- Two categories of aggregate properties were established in the Superpave system: **consensus** and **source** properties.

Consensus Properties

- These characteristics were called "consensus properties" because there was wide agreement in their use and specified values.
- The properties are:
  - coarse aggregate angularity;
  - fine aggregate angularity;
  - flat, elongated particles, and
  - clay content.

Superpave Mix Design

Materials Selection (cont'd)

Measurement of the aggregate properties

Source Properties

- Pavement experts believed that certain other aggregate characteristics were critical. However, critical values of these properties could not be reached by consensus because the needed values were source-specific.
- Consequently, a set of "source properties" was recommended.
- The properties are:
  - toughness;
  - soundness, and
  - deleterious materials.

Superpave Mix Design

Gradation and Design Aggregate Structure

Superpave uses the 0.45 power gradation chart to define a permissible gradation.

Maximum Size: One sieve size larger than the nominal maximum size.

Nominal Maximum Size: One sieve size larger than the first sieve to retain more than 10 percent.

The maximum density gradation: represents a gradation in which the aggregate particles fit together in their densest possible arrangement.

This must be avoided because there would be very little aggregate space within which to develop sufficiently thick bitumen films for a durable mixture.

To specify aggregate gradation, two additional features are added to the 0.45 power chart: control points and a restricted zone. Control points function as master ranges through which gradations must pass.

Superpave Mix Design

Gradation and Design Aggregate Structure (cont'd)

The 0.45 power gradation chart with a maximum density gradation for a 19 mm maximum aggregate size and 12.5 mm nominal maximum size is shown in Figure 4.

The control points and restricted zone for a 12.5 mm Superpave mixture are illustrated in Figure 5.

The term used to describe the cumulative frequency distribution of aggregate particle sizes is the design aggregate structure.

A design aggregate structure that lies between the control points and avoids the restricted zone meets the requirements of Superpave for gradation (Figure 6).

Superpave defines five mixture types as defined by their nominal maximum aggregate size as shown in Table 3

Superpave Mix Design

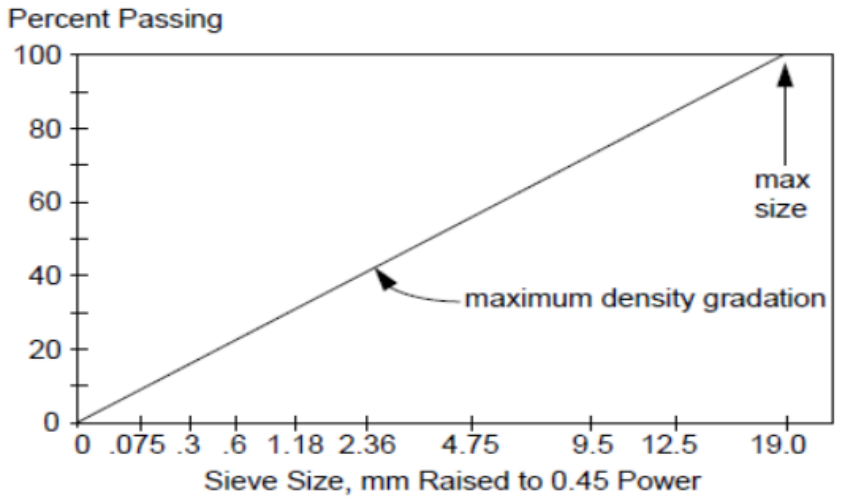


Figure 4: 0.45 Power gradation chart

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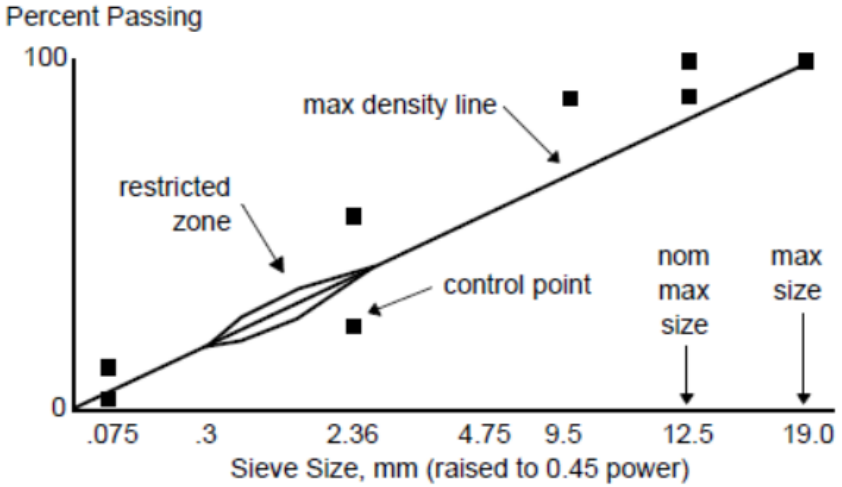


Figure 5: The control points and restricted zone for a 12.5 mm Superpave mixture

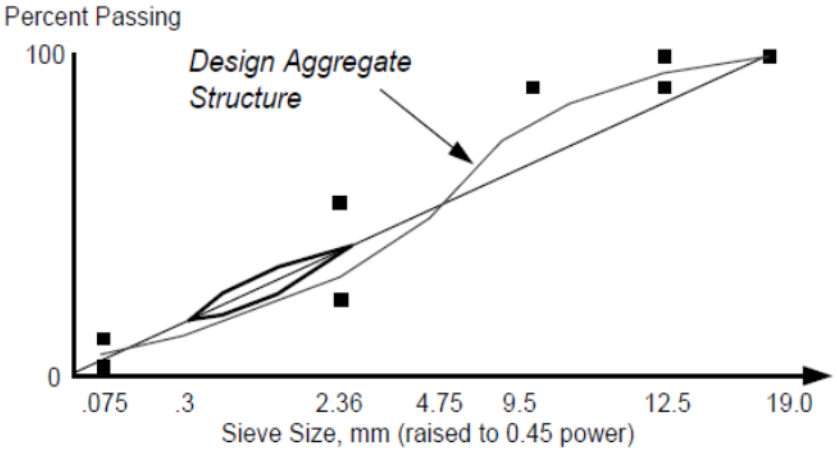


Figure 6: Design aggregate structure

Table 3: Superpave Mixtures

Superpave mixture designation	Nominal maximum size (mm)	Maximum size (mm)
37.5 mm	37.5	50
25 mm	25	37.5
19 mm	19	25
12.5 mm	12.5	19
9.5 mm	9.5	12.5

Superpave Mix Design

Selection of design binder content

The next step is to evaluate the trial blends by compacting specimens and determining the volumetric properties of each trial blend.

For each blend, a minimum of two specimens are compacted using the Superpave Gyratory Compactor (SGC) (Figure 7).

The trial asphalt binder content can be estimated based on experience with similar materials. If there is no experience, the trial binder content can be determined for each trial blend by estimating the effective specific gravity of the blend and

The mix design engineer can also gain insight into the compactibility of HMA during compaction from the data generated.

Superpave Mix Design

Selection of design binder content

- Two new sophisticated testing devices were developed:
  - the Superpave Shear Tester (SST) and
  - Indirect Tensile Tester (IDT).
- The test output from these devices can provide direct indications of behaviour of the mix, or will eventually generate input to performance prediction models.
- Using the mechanical properties of the HMA and these performance prediction models, mix design engineers will be able to estimate the combined effect of asphalt binders, aggregates, and mixture proportions.
- Table 4 shows the compaction parameters for the Superpave gyratory compactor.

Superpave Mix Design

Selection of design binder content

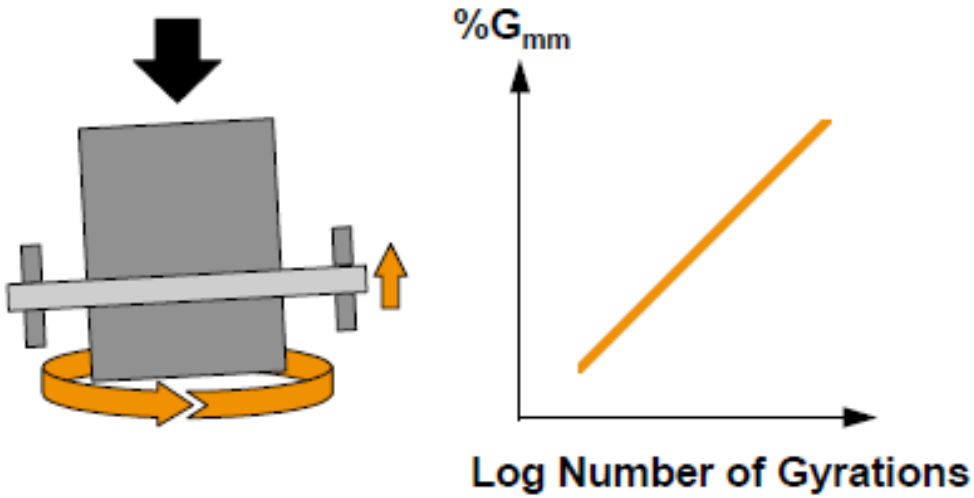


Figure 7: Superpave gyratory compactor (SGC) system

Table 4: Compaction parameters for the Superpave gyratory compactor

Superpave design gyratory compactive effort			
Design ESALS (millions)	Compactive parameters		
	$N_{initial}$	N_{design}	$N_{maximum}$
< 0.3	6	50	75
0.3 to < 3	7	75	115
3 to < 10	8	100	160
≥ 30	9	125	205

Superpave Mix Design

Selection of design binder content (cont'd)

- Mixture volumetric requirements consist of air voids, voids in the mineral aggregate, voids filled with bitumen, and the mixture density during compaction at N_{ini} and N_{max}.
- The design air void content is 4% in Superpave.

Moisture Susceptibility

- The moisture susceptibility test used to evaluate HMA for stripping is AASHTO T 283, "Resistance of Compacted Bituminous Mixtures to Moisture Induced Damage."
- In the test, two subsets of test specimens are produced, conditioned, and tested for indirect tensile strength.
- The test result is reported as the ratio of the tensile strength of the conditioned subset to that of the unconditioned subset. This ratio is called the "tensile strength ratio" or TSR.
- Superpave requires a minimum TSR of 80 percent. Lower values are indicative of mixtures that may exhibit stripping problems after construction.

Balanced Mix Design

- Balanced mix design (BMD) is asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress considering mix aging, traffic, climate, and location within the pavement structure.
- The complexity of the Superpave tests and increasing concerns about the durability and cracking issues of asphalt pavements along with the growing awareness of the shortcomings of volumetric mix design systems made state highway agencies (SHAs) and the asphalt pavement industry explore the use of BMD.

Balanced mix design approaches

- Four alternate approaches to Balanced Mix Design described in AASHTO PP 105 are as follows:

Balanced Mix Design

Approach A:

- This requires full compliance with the existing volumetric requirements and additional performance requirements.
- It is the most conservative approach and has the lowest innovation potential.

Approach B

- This requires full compliance with the existing volumetric requirements at the preliminary OBC.
- It allows moderate changes in asphalt binder content for performance optimization based on mixture performance test results.
- Although it is slightly more flexible than Approach A, it is still considered a conservative approach with limited innovation potential

Balanced Mix Design

Approach C

- This allows some of the volumetric requirements to be relaxed or eliminated as long as the performance criteria are satisfied.
- The mix design modifications that can be used in performance optimization are not limited to changes in asphalt binder content.
- Therefore, it is less conservative than Approach A and Approach B and provides a medium degree of innovation potential.

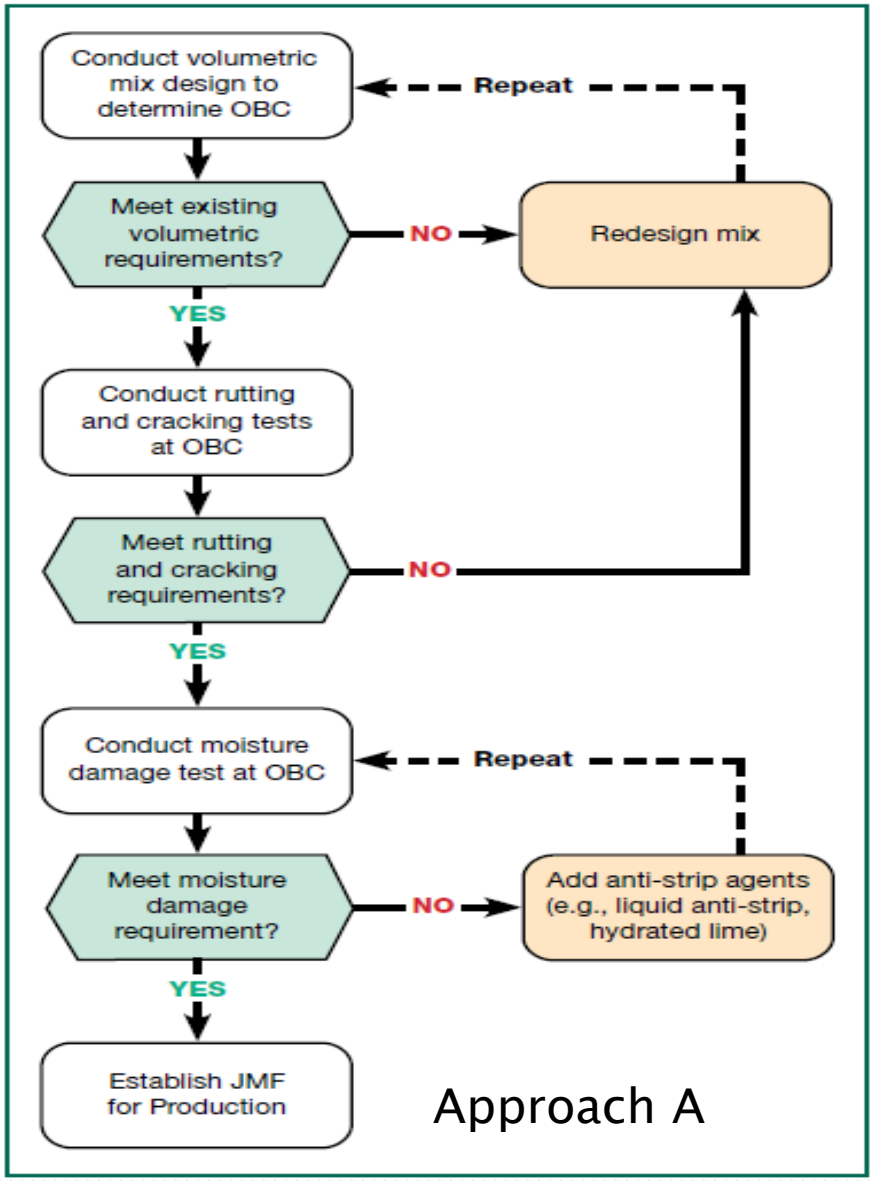
Approach D

- This has no requirement on volumetric properties.
- It relies solely on mixture performance test results for mix design optimization.
- It is considered the least conservative approach with the highest degree of innovation potential.

The guide for the selection and evaluation of materials and the options for performance tests are described in AASHTO Standard Practice MP 46.

The test are shown in Table 5.

Balanced Mix Design



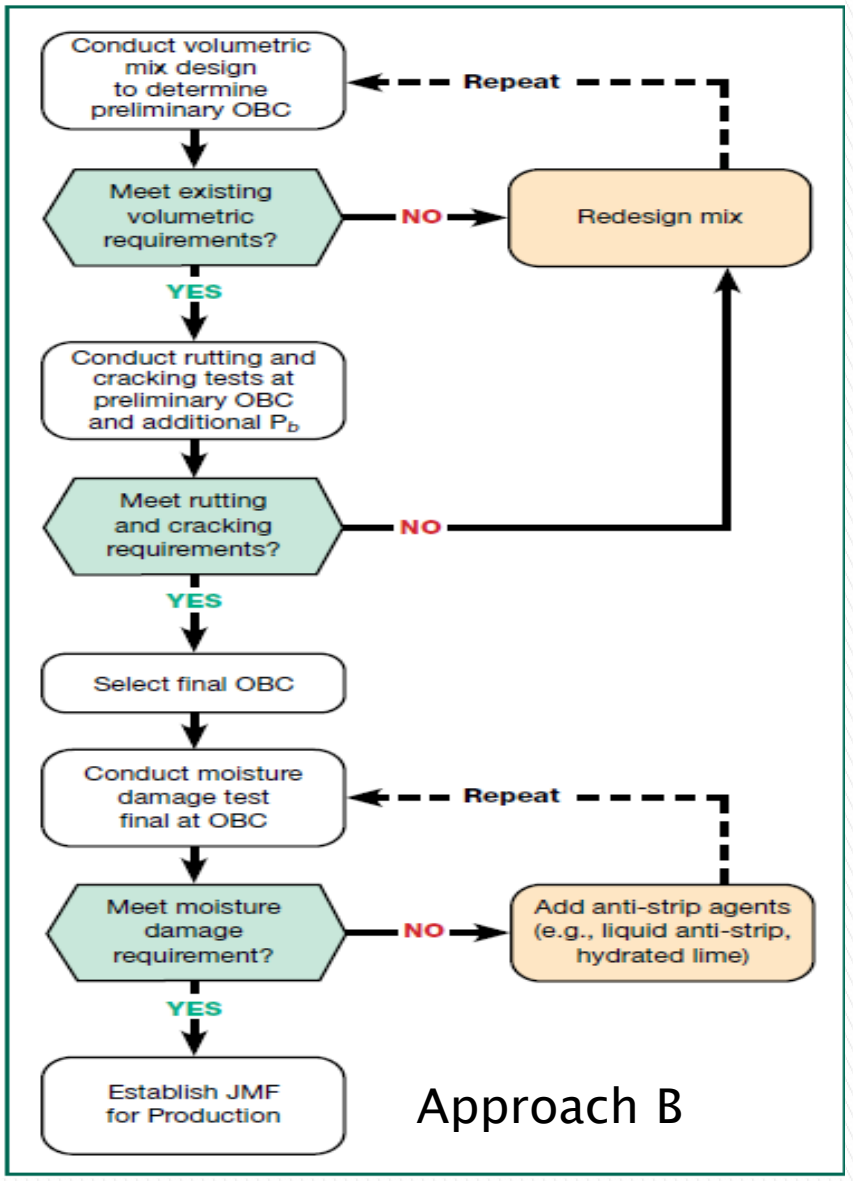
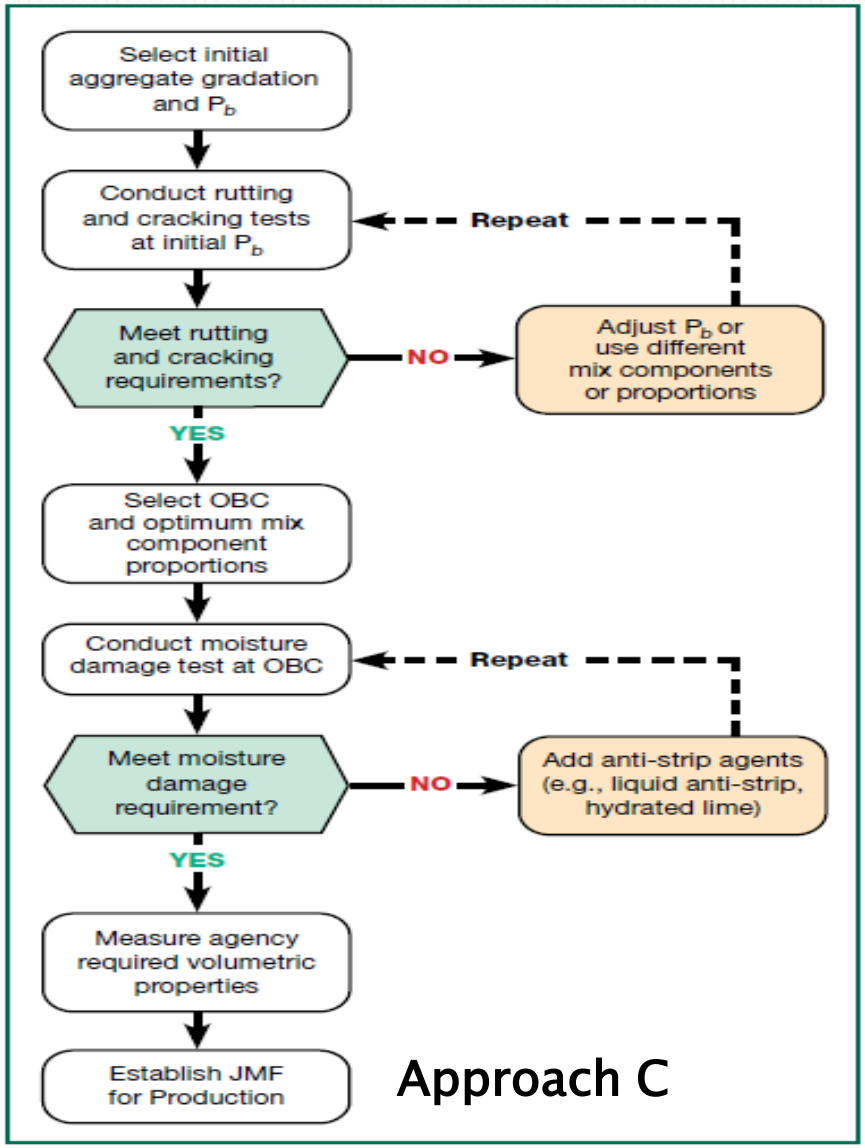


Figure 8: Approaches A and B for BMD

Balanced Mix Design



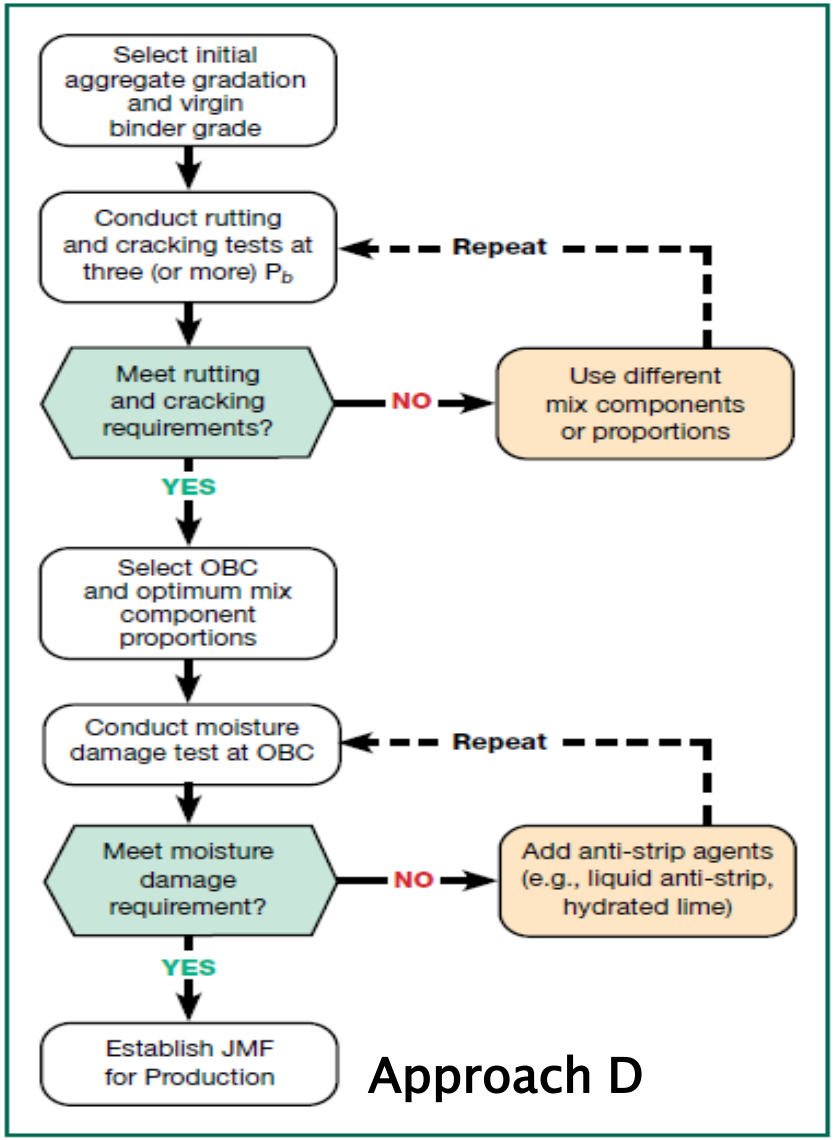


Figure 9: Approaches C and D for BMD

Balanced Mix Design

Table 5: Performance tests for BMD

Distress mode	Performance Tests	Test Method
Cracking	Disk-Shaped Compact Tension Test (DCT)	ASTM D7313
	Illinois Flexibility Index Test (I-FIT)	AASHTO T 393
	Low-Temperature Semi-Circular Bend Test (SCB)	AASHTO T 394
	IDT Creep Compliance and Strength Test	AASHTO T 322
	Texas Overlay Test (OT)	TXDOT Tex-248-F
	Direct Tension Cyclic Fatigue Test	AASHTO TP 107 AASHTO TP 133
	N flex Factor	AASHTO TP 141
	Flexural Bending Beam Fatigue Test	AASHTO T 321
	Semi-Circular Bend Test (Louisiana method)	LADOTD TR 330 ASTM D8044
	Indirect Tensile Asphalt Cracking Test (IDEAL-CT)	ASTM D8225
Rutting	Hamburg Wheel Tracking Tester (HWTT)	AASHTO T 324
	Asphalt Pavement Analyzer (APA)	AASHTO T 340
	High-Temperature Indirect Tension (HT-IDT)	ALDOT-458 ASTM D6931
	Rapid Shear Rutting Test (IDEAL-RT)	ASTM Work Item (WK 71466)
	Flow Number Test (FN)	AASHTO T 378
	Stress Sweep Rutting (SSR)	AASHTO TP 134
Moisture Damage	Tensile Strength Ratio (TSR)	AASHTO T 283
Abrasion loss	Cantabro Abrasion Loss Test	AASHTO TP 108

Comparison of the Mix Design Methods

- The different mix design methods have strength and weaknesses.
- The attempt to rectify the weakness in a particular method resulted in another method.
- The strength and the weaknesses are highlighted in Table 6.
- However, the balanced mixed design addresses the shortcomings in these methods.
- BMD gives rooms for more flexibility in the design approaches.
- It hands the initiative to the agencies to determine the best approach to adopt in a particular situation.

Comparison of the Mix Design Methods

Table 6: Strengths and weaknesses of mix design methods

Marshall mix design	Hveem mix design	Superpave mix design
It is most common, simple to implement and not expensive	It is easy to implement. However, it is expensive and not portable	It more complex and more expensive
The impact compaction used with the Marshall method does not simulate mixture densification as it occurs in a real pavement	The kneading method of laboratory compaction is thought to better simulate the densification characteristics of HMA in a real pavement.	It is able to compact trial mix specimens to densities achieved under actual pavement climate and loading conditions.
Marshall stability does not adequately estimate the shear strength of HMA.	Hveem stability is a direct measurement of the internal friction component of shear strength. It measures the ability of a test specimen to resist lateral displacement from application of a vertical load.	The Superpave Shear Tester (SST) and Indirect Tensile Tester (IDT) provide direct indications of mix behaviour.
This does not take into consideration aging of the binder during storage, mixing, compaction and when the pavement is in service	This does not take into consideration aging of the binder during storage, mixing, compaction and when the pavement is in service	It takes into consideration aging of the binder during storage, mixing, compaction and when the pavement is in service
It pays attention to density and voids properties of asphalt materials.	The Hveem method also entails a density-voids analysis	Also, It involves the density and voids analysis.
Moisture sensitivity test is not considered.	The mixture's resistance to swell in the presence of water is also determined.	Moisture sensitivity test is carried out.

The Way Forward

- As mentioned earlier, the Marshall mix design method is used in Nigeria for the design of asphalt mixtures.
- Many believe that the Marshall mix design method has outlived its usefulness.
- The answer to the question of whether we can do better as far as the asphalt mix design being used in the country is yes, so we must look for a better mix design.
- The Superpave mix design, although complex, can be simplified and adopted for asphalt mix design in the country.
- The right binder for different regions of the country can be established through nationwide research and included in the General Specifications for roads.

The Way Forward

- Also, this will save practitioners the headache of having to undertake series of tests to select the right binder.
- The balanced mix design is still being experimented and will require that a nationwide study be conducted and guidelines prepared for its adoption and the approach to be used at a particular situation must be established.

Conclusion

- The asphalt mix design methods have evolved over the years
- Work is still being done to improve and simplify the processes to ensure that the mix design guarantees the production of asphalt mixtures that are durable, stable, flexible impermeable, workable, and have good resistance to fatigue and permanent deformation.

Thank you
For your
Attention