ASPHALT CONCRETE
[Types]

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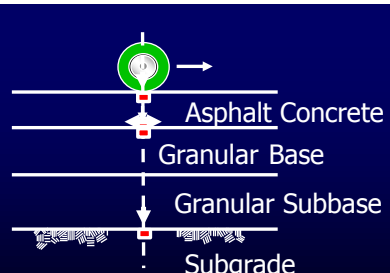
Selected Topics on TR Engineering - CE599

Introduction



Approx. 95% (by weight)

Aggregate

Filler

+

Approx. 5% (by weight)

Bitumen

Workability

- Heat (HMA)
- Cutback
- Emulsion

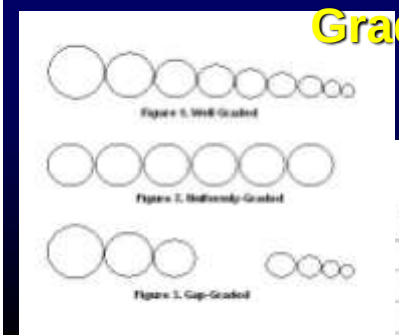
=

Asphalt Concrete AC

Types of Asphalt Concrete Mixes

- ✓Continuously (Dense) Graded Asphalt mix
- ✓Gap-Graded mix
- ✓Porous Asphalt mix
- ✓Sand Asphalt mix
- ✓Stone Mastic Asphalt mix
- ✓Modified Binder Asphalt mix
- ✓Slurry Seal mix

Grading Curves



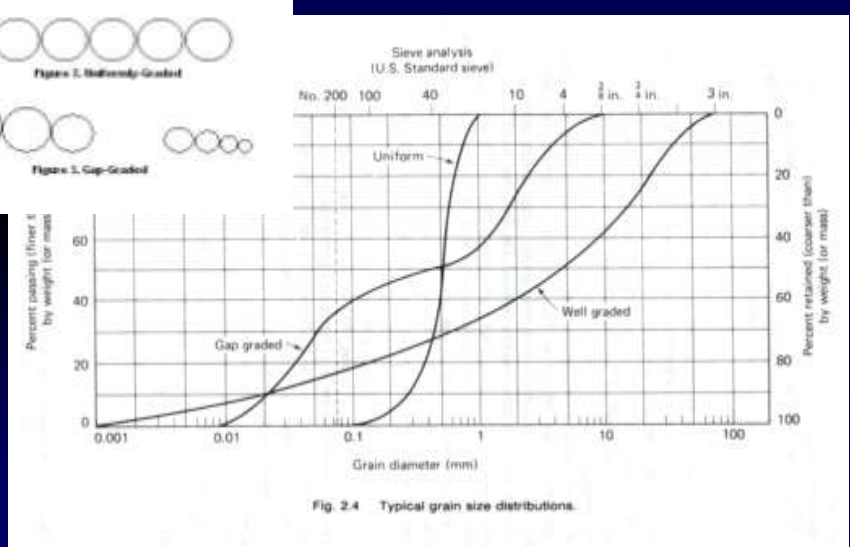
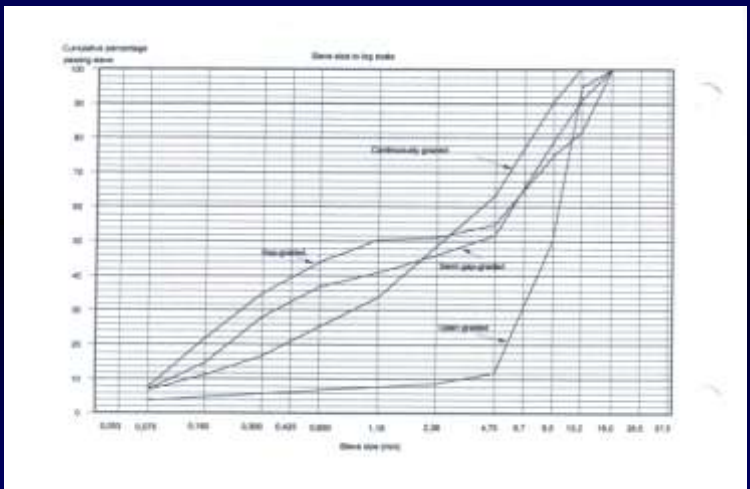


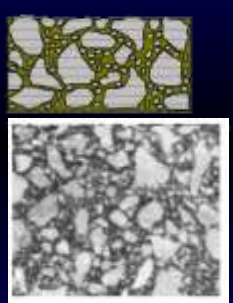
Fig. 2.4 Typical grain size distributions.

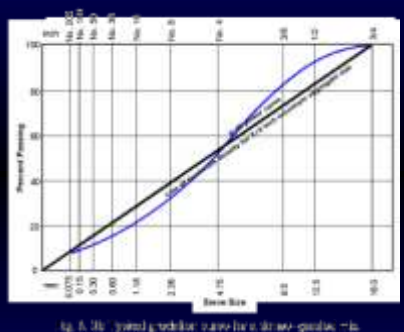
Typical Grading Used in AC



Continuously (Dense) Graded Mix

Grading approaches the maximum density





Idea revolve about smaller particles fit into the voids of larger Particles, to obtain a condition approaching zero voids.

Cont. Continuously (Dense) Graded Mix

❑ Dense-grading provides close aggregate to aggregate contact, thus, load carrying capacity and resistance to deformation is given by the aggregate skeleton.

❑ At high temperature, bitumen will soften and the deformation resistance will rely only on the aggregate interlock.

Cont. Continuously (Dense) Graded Mix

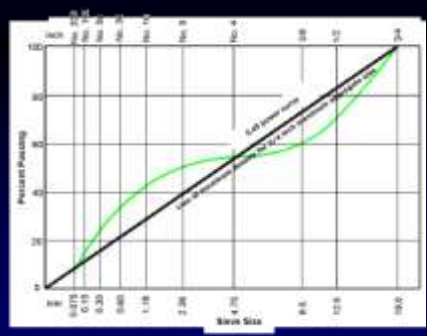
❑ Skid resistance is reasonable at early stages during the life of dense-graded surfaces but deteriorate with time. This is especially true during rainy seasons. Pre-coated chip surface to increase skid resistance.

❑ Dense-graded asphalt concrete is used extensively here in KSA . Typical distresses manifested on surfaces of our roads includes:

- Rutting (permanent deformations) – relates to temperature
- Low skid resistance for aged roads – relates to mix type + aggregate strength

Gap- graded Mix

❑ Sand sheet mixes were altered by coarser aggregates, hence a gap occurs. The aim was to increase the stability of the mix (British standards).



Gap- graded Mix

❑ Load carrying capacity of gap-graded mixes is not dependent on aggregate interlock as in dense-graded mixes but to larger extent on the stiffness of the binder { hard binders are used}

❑ Advantage: gap-grading allows more voids, thus more binder, making a more durable and less permeable compared to dense-graded mixes. + higher skid-resistance.

Porous Asphalt Mix
Open-graded

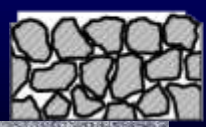


Figure 1. Porous asphalt allows water to flow through it. *Photo courtesy of the National Asphalt Paving Association*

Porous Asphalt Mix
Open-Graded

Open-graded

Description Porous asphalt, also known as pervious, permeable, or open-graded asphalt, is standard hot-mix asphalt with reduced sand or fines.

Advantages:

✓allows water to drain through it (reduce storm water runoff volume and pollutants.

✓Durable and cost competitive compared to traditional mixes

✓Reduces noise {voids absorbs noise}

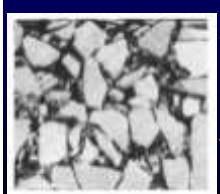
Sand Asphalt Mix

Sand asphalt mixes are usually used where suitable aggregate are scares. {Suffers deformation resistance}

Stiff binder is used to improve deformation characteristics of this mixes.

Stone Mastic Asphalt Mix (SMA)

Originated in Germany



✓SMA is a gap-graded asphalt high % of single size aggregate and sand filler.

✓ Celulose fibre, polymers, silicic acid to enhance binder retention. {prevent binder from draining out}

✓ Celulose fibre, waste paper fibre, extracts from trees ...etc. {typically 0.3 to 1.5% by mass}. various commercial names

✓ Aggregate size of 13.2 mm or 10 mm is used with some sand to fill voids between aggregate.{Grading is still empirical}

✓ Due to stone-to-stone contact is provides resistance to rutting and provides high skid-resistance.

Typical binder content is 6.5 to 7.5% by mass

Modified Binder Asphalt Mix
Rubberized-Bitumen Asphalt

- Bitumen Crumb Rubber Asphalt is a regular asphalt which contains crumb rubber obtained from tyre shredding to improve flexural and elastic recovery properties of an asphalt layer.
  - Rubber shall be free from cord, wire, fluff and other deleterious material
- Asphalt-Rubber is not the solution to the waste tire problem, but when utilized by agencies that prefer its beneficial engineering characteristics such as durability, flexibility, strength, and resistance to cracking, it contributes significantly to the reduction of waste tires.

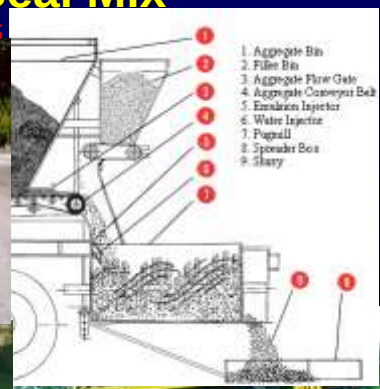
Modified Binder Asphalt Mix
Rubberized-Bitumen Asphalt

Advantages:

- ✓ Reduces Reflective Cracking in Asphalt Overlays
- ✓ Reduces Maintenance Costs
- ✓ Improves Resistance to Cracking in New Pavements
- ✓ Improves resistance to rutting in new pavements
- ✓ Decreases Noise Levels
- ✓ Consumes 500 -2,000 scrap tires per lane mile

Slurry Seal Mix

Thin layer to seal surface cracks and smoothen rough surface



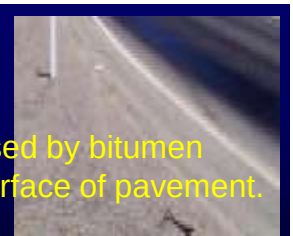
Considered as a cold mix asphalt – Fine aggregate + Emulsion

ASPHALT CONCRETE DISTRESSES

Distress Modes

- Surfacing Distress
  - Bleeding
  - Cracking
  - Raveling
  - Potholing
- Deformation Distress
  - Rutting
  - Shoving and pushing delamination
- Surface Texture Distress
  - Polishing

Bleeding



A shiny, black surface caused by bitumen (binder) migrating to the surface of pavement.

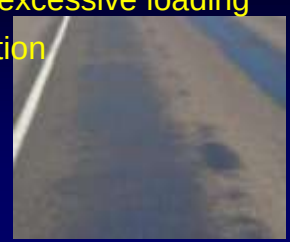
Consequences

Loss of surface texture → reduction in skid resistance

Causes

✓Too high bitumen content
✓Low air void content + high temperature **or** excessive loading

Prevention → Proper design and construction



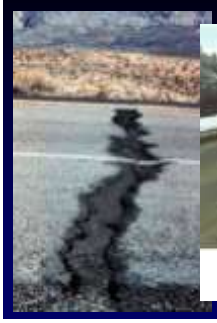
Cure

- Remove and replace the asphalt layer
- Overlay with thin skid resisting layer

Cracking

Includes the following types

- ✓ Fatigue cracking (alligator/crocodile)
- ✓ Longitudinal cracking (wheel path)
- ✓ Reflective cracking
- ✓ Thermal cracking



Cracking - Fatigue

Interconnected cracking with a pattern resembling crocodile skin.

Causes Cracks caused by heavy traffic and load repetition.

- ✓Inadequate pavement structure
- ✓Ageing of asphalt concrete
- ✓Poor drainage (water ingress)

Prevention

Adequate design and construction

Regular maintenance

Use of PG bitumen

Cure: fatigue cracks are indication of structural failure

- ➢Full depth reclamation
- ➢Adequate overlay

Cracking – Longitudinal Cracking

Cracking in the direction of flow of traffic, at the edge of wheel path

Causes: Pavement that is fatigued by

- Heavy traffic (high pressure truck tires)
- Unstable base
- Poor Construction.

Prevention

✓Adequate design and construction

✓Regular maintenance

✓Meeting the PG requirements.

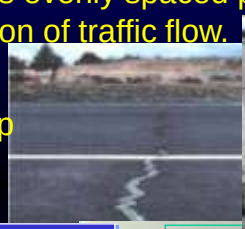
Cure:

➢ Minor cracking requires crack seal (prevent water ingress)

➢ Severe cracking indicates structural problem (full depth treatment or overlay)

Cracking – Thermal Cracking

When a pavement cools, it contracts. The internal stresses result in a series of cracks evenly spaced perpendicular (transverse) to the direction of traffic flow.



Causes

✓ sharp temperature drop

Prevention

✓ Use of quality materials [the Superpave PG ?]

Cure:

➢ If it occurs, then crack seal is necessary to prevent water ingress.

Cracking – Reflective Cracking

Cracks from existing pavement that come up through a new surface or overlay.

Causes

✓Existing cracked asphalt surface

Prevention

✓ Remove existing surface before overlay

✓Provide stress absorption membrane [geotextiles or reinforcement to bridge the crack]

Cure:

➢ preventable but not curable

Raveling

Loose aggregate that 'ravel' from the surface of the pavement. It causes pavement depression and loose material can cause safety hazard

Causes

➢ Use of dusty aggregate.
➢Segregation of the mix during construction.
➢Inadequate compaction
➢Aged bitumen
➢Stripping due to moisture damage

Cont. Raveling

Prevention

- ✓ Use clean aggregate
- ✓Do good compaction
- ✓Use anti-stripping agents
- ✓Good asphalt concrete mixing
- ✓Provide adequate drainage

Cure

- ➢ Apply surface treatment (e.g. Slurry seal)

Potholing

Potholes occur when water gets into cracks and destroys the underlying layers.

Causes

- ✓ Inadequate pavement structure
- ✓ Poor drainage
- ✓ Damage accumulation
- ✓Aging of bitumen

Prevention

- ✓ Proper pavement design
- ✓ Adequate drainage
- ✓ Use quality materials

Cure

- ✓ We need to fix the cause and then we can patch the pothole

Rutting

Rutting is permanent deformation of the pavement surface at Slow lane/truck lane {channelized at wheel path}, and at intersections {stopping vehicles}

Causes

- ✓ Heavy slow-moving traffic
- ✓ Stopping traffic
- ✓ Poor aggregate
- ✓Poor construction
- ✓Weak base-course
- ✓High temp. performance condition
- ✓Post-construction – compaction by traffic

Cont. Rutting

Prevention

- ✓ Proper pavement design
- ✓ Adequate drainage
- ✓ Use quality aggregate
- ✓ Use of proper bitumen spec. (PG?)

✓Rutting can be confined to the surface layer or it can extend to include the base-course layer

Cure

- ✓ We need to replace the surface if rutting confined to the surface layer
- ✓ treat the base-course and the surface layers if rutting effect extends to the lower layers

Shoving and Pushing

Pushing and Shoving is deformations of the pavement surface, most common in intersections, where there is braking and stopping traffic. It is easiest to detect at intersections where transverse striping becomes "wavy".

Sections of a surface layer become loose from the pavement

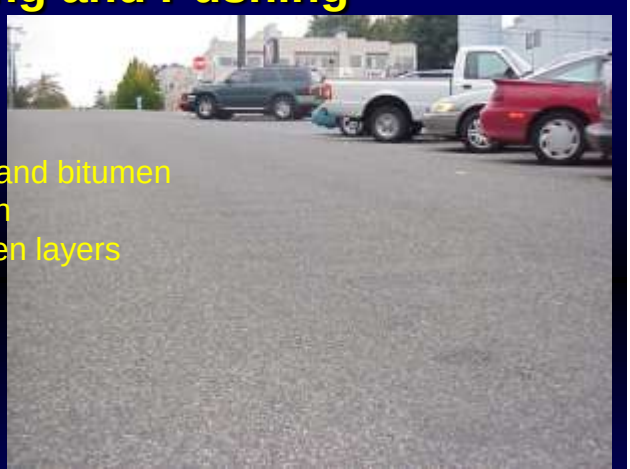
Causes

- ✓ Unstable mix {Marshall stability!}
- ✓Breaking, stopping and accelerating vehicles
- ✓Poor construction
- ✓Poor interlayer bond – slippage between layers { tack coat, prime coat}

Cont. Shoving and Pushing

Prevention

- ✓Proper design
- ✓Quality aggregate and bitumen
- ✓Proper construction
- ✓Proper tack between layers



Cure

- ✓ Remove and replace

Polishing

Bitumen worn away from the pavement surface by traffic, eventually surface aggregate loses micro-texture and surface loses macro-texture

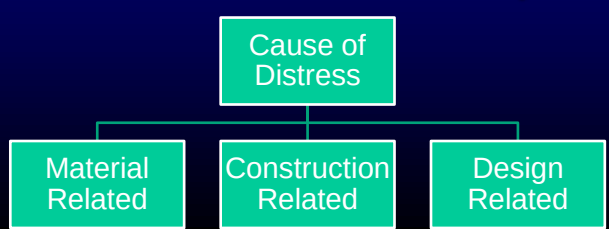
Causes
- ✓ Soft aggregates
- ✓ Heavy traffic

Consequences
- ✓ Reduces skid-resistance

Prevention
- ✓ Use of polish resistant aggregate
- ✓ Use PG bitumen

Cure
- ✓ Overlay using a thin layer of a high macro-texture asphalt concrete {materials with various commercial names are available for this purpose}

Rehabilitation of Pavement Surface Layer



Minor cracks → clean and fill with hot bitumen

Major cracks (especially alligator cracks) that exist on the full depth of AC layers shall be repaired by removing the whole AC layers and Base-course layer (if needed) locally, laying down new layers and compacting.

Reinforcement is required to mitigate the risk of reflective cracks when overlying an existing cracked pavement surface


Questions