A practical guide for the application of procedures for designing asphalt mixes as per Sabita Manual 35/TRH8

5. Constituent materials

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Module 5

Introduction

2 Evaluate Design Situation

3 Design Objectives

4 Mix Type Selection

5 Constituent Materials

6 Laboratory Design Procedures

7 Special Mixes

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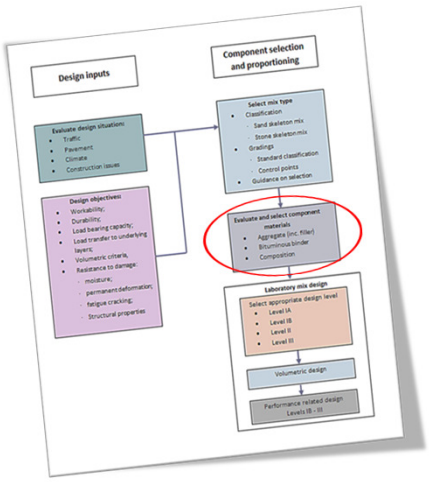
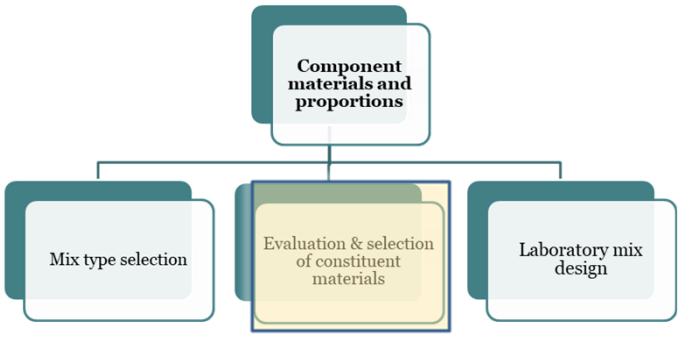
Elements



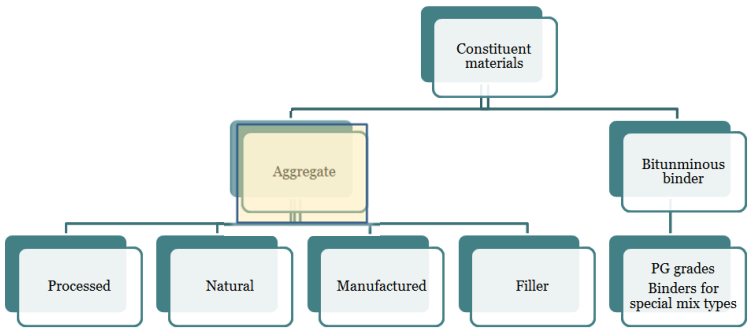
Constituent materials



Evaluation and selection

- ***Aggregate*** materials (processed, natural, manufactured)
  - Stone
  - Slag aggregates
  - Reclaimed asphalt
  - Crusher and natural sands
  - Active / non active fillers
- ***Bituminous*** binders
- Comprehensively covered in Man 35
  - Only key elements covered here

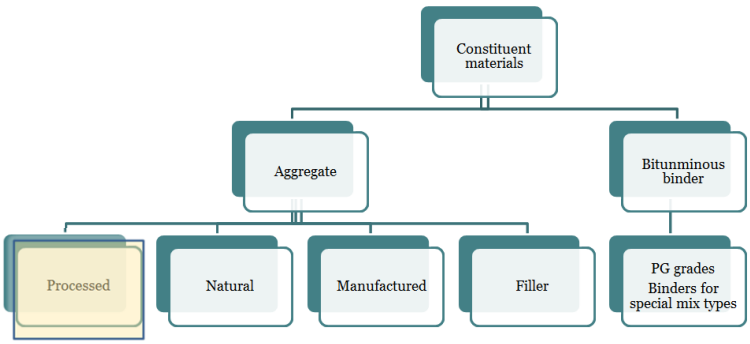
Aggregates



Aggregate materials

- Classified in four groups
  - Processed
  - Natural
  - Manufactured
  - Fillers

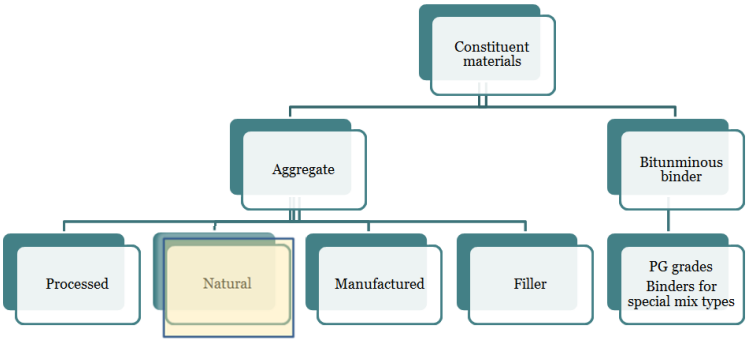
Aggregates



Processed aggregates

- Quarried, crushed and screened
- Conform to standards e.g. SANS 1083
- Cubic, angular crushed shape suitable
- Flat, elongated, aggregates should be avoided.

Aggregates



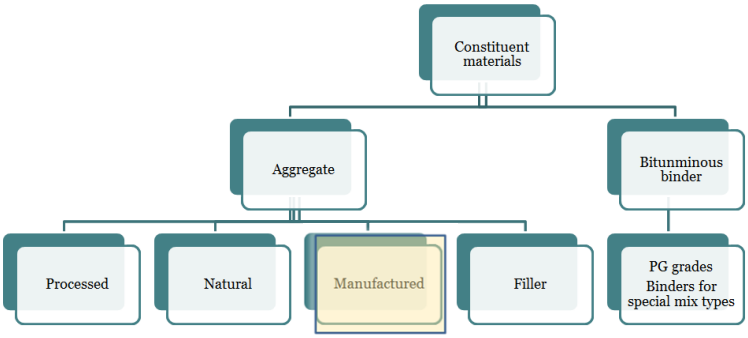
Natural aggregate

- Most common – sand from:
  - River beds
  - Aeolian deposits

Natural Aggregate

- ***River deposits*** may be ***angular*** and afford a degree of interlock
- ***Aeolian*** - ***single-sized, rounded*** particles do not provide the interlocking matrix
- Aeolian deposits may promote workability - may compromise the mix's susceptibility to rutting
- May require measures such as careful selection of binder type and proportion of filler to stiffen up the mix.

Aggregates



Manufactured aggregates - slags

- Steelmaking slags
  - blast furnace (BF) *iron slag*
  - basic oxygen furnace (BOF)
  - electric arc furnace (EAF)
  - ferro-chrome slag,
- Manual 35, listing precautions in their use
- ***Manganese slag should not be used as it poses a severe health risk***

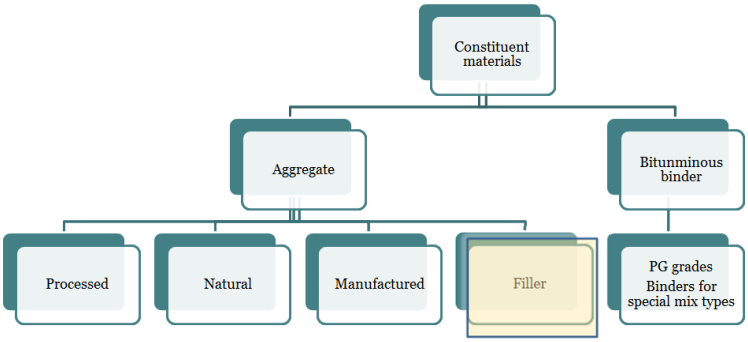
Sabita Man 35

Manufactured aggregate – Reclaimed asphalt (RA)

- RA - 95% of high quality aggregate, 5% of aged bitumen
- ***Valuable non-renewable resources***
- Binder in the RA may have aged and hardened
- Aggregate quality not changed
- RA a ***valuable public asset***
- Obtained from
  - milling or excavation of existing bituminous pavement layers
  - stockpiles of asphalt production overruns and returned material
- Crushed and screened to ensure maximum size and grading
- RA is stockpiled and loaded in such a manner as will enhance the uniformity of the material.

TRH 21

Aggregates



Filler

- Passing the 0.075 mm sieve
- ***Essential*** components
  - Mixes which are dense (where appropriate)
  - Cohesive
  - Durable and
  - Resistant to damaging effects of moisture
- ***Two*** basic types
  - ***Inert*** fillers (natural dust or rock-flour)
  - ***Active*** fillers (hydrated lime, cement)
- Five kinds described in Man 35

Sabita Man 35

Effect on performance

- Effects on the ***rheological properties*** of the ***binder / mastic system***
- Volumetric function to ***fill voids and bind aggregates*** together;
- Improvement of the ***adhesion of binders and aggregates*** – (hydraulic fillers like lime)
- Improvement of ***compactability*** of the layer when using ***fly-ash***

Proportion of filler

- ***Sufficient filler*** to ensure :
  - adequate ***internal tensile strength*** - important for ***sand skeletons***
  - ***Durability***
  - Adequate ***resistance to permanent*** deformation (rutting)
  - Adequate ***mastic viscosity*** (in stone skeleton) mixes to prevent binder ***run-off*** during the manufacturing, transport and laying
- Guard against ***excessive proportions*** of filler
  - increase susceptibility to ***brittle fracture***
  - raising the viscosity of hot mastic to such an extent that ***adequate compaction*** is not possible
- ***Deficiency*** of filler
  - ***High void*** content
  - Soft mix - ***tender during compaction***
  - Inadequate ***resistance*** to ***rutting***

Correct proportion

$$\textbf{filler / binder ratio (FBR)} = \frac{mass\ of\ filler}{mass\ of\ binder}$$

- ≤ 1.5 (especially rapid cooling of thin layers)
- ≤ 1.6 (OK for thicker asphalt layers e.g. bases)

Filler : Binder

- ***Hydrated lime***: large surface area ***≤ 1% (m/m)*** of total aggregate
- Base on ***effective binder*** content (i.e. binder not absorbed into aggregate – covered later)
- Tolerance limit of ±1% rigorously applied

Aggregate standards

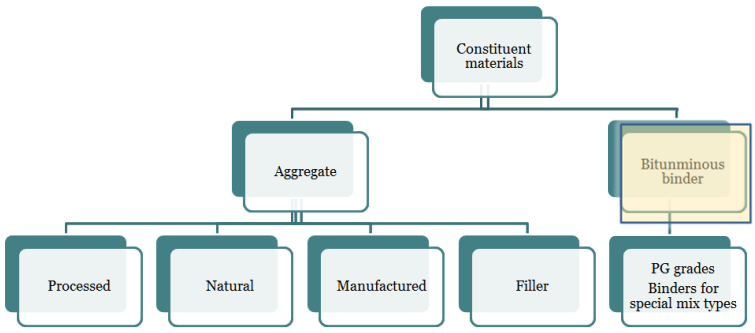
- All aggregates - defined in terms of:
  - ***Type*** (geological or process origin)
  - ***Surface texture*** and ***absorptive*** properties
  - spatial dimensions – ***shape*** and ***size***
  - "***Strength***" as defined by:
    - hardness
    - toughness
    - soundness
    - durability
  - ***uniformity*** of physical properties
  - ***Cleanliness***
- ***SABS 1083: Grading Classes 1 and 2***
- Refer Man 35 Chapter 4

Sabita Man 35

Filler standards

- ***Physical***
  - % mass passing the 0.075 mm sieve: ≥ 70
  - Bulk density in toluene: 0.5 – 0.9 g/mℓ
  - Voids in the compacted filler: 0.3 – 0.5%
- ***Chemical***
  - Guard against ***excess clay minerals*** or adsorption potential - premature hardening and stripping
  - ***Methylene Blue test*** - assessing the amount and activeness of clay minerals in the filler
    - Methylene blue values ≤ 5 high quality filler
    - Methylene blue values > 5 investigate further (hydrometer analysis, Atterberg limits.

Aggregates



Binder

- SATS 3208: Performance Grade (PG) system of ***binder classification*** and ***compliance*** being introduced
- Ultimately will ***replace*** SANS 4001-BT1 & TG1
- Based on ***engineering properties*** of binder
- ***Binder blind*** - does not differentiate between straight and modified binders
- Not the intention to cover this complex topic extensively here.
- ***Refer to the Sabita technical guideline***

The Introduction of a Performance Grade Specification for Bituminous Binders

Performance requirements

Limiting the ***potential*** for the ***binder*** to ***contribute*** to:

- permanent deformation
- fatigue cracking
- low temperature fracture
- Durability (maintain properties for a long period)

Damage resistance

- Damage resistance characteristics (***DRC***) to provide a specification framework
- Gauge the ***binder's resistance to damage*** resulting from:
  - Viscous flow – at ***high temperatures*** and ***slow rates*** of loading
  - (Fatigue and durability) cracking at ***intermediate*** temperatures
  - Fracture at ***low temperatures***

Specification framework

- Rational basis for the ***selection of binders*** on the basis of:
  - the operating environment i.e.:
    - climate (***max*** and ***min*** temperatures)
    - traffic ***volumes*** and ***speed***
  - resistance to ***viscous flow***
  - adequate ***durability*** against ***fatigue***; and
  - low temperature ***fracture***

Purchasing spec

Climate

Effect of climate is taken into account by a ***grading designation*** related to:

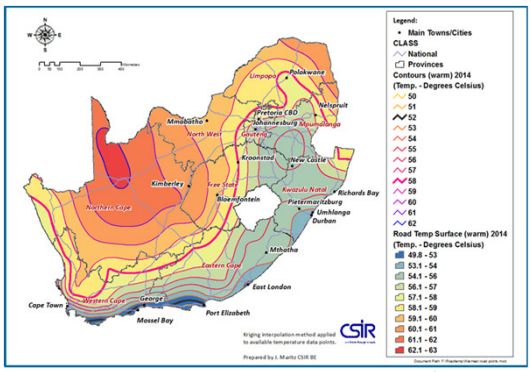
- T_{max} Average 7-day ***max*** pavement design temperature - (***70, 64, 58°C***)
- T_{min} ***Min*** pavement design temperature
  (in SA rarely below -10°C)
  Intermediate temperature
  $$[(T_{max} + T_{min})/2 + 4]°C$$
- Minimum **grading temperature** (linked to US practice to determine test temperature)
  (-10, -16, -22 °C)

Temperature map

Max pavement design temperature for location determined using map

It is possible that in the 64°C region areas exist with a higher T_{max} - 70°C

Provision is made for a PG70-10 binder grade



Traffic

- Traffic classification is based on both traffic ***volume*** and traffic ***speed***
- ***Low operating speed*** requires more ***resistance to viscous flow***
- Traffic classes for ***PG grading***:
  - *Standard - **S***
  - *Heavy - **H***
  - *Very Heavy - **V***
  - *Extreme - **E***

Influence of traffic vols. and speed

Note that for the same traffic volumes different binder grades may be required for a range of operating speeds

Design traffic (million E80)	Mix design level for given traffic operating speed (km/h)		
	< 20	20 - 80	>80
< 0.3	S	S	S
0.3 - 3	H	S	S
> 3 - 10	V	H	S
> 10 - 30	E	V	H
> 30 - 100	E	E	V
> 100	E	E	E

Binder classification

Classification	58S -22	58H -22	58V -22	58E -22	64S -16	64H -16	64V -16	64E -16	70S -10	70H -10	70V -10	70E -10
Maximum pavement design temperature T_{max} (°C)	58				64				70			
Minimum grading temperature T_{min} (°C)	-22				-16				-10			

Grade suitable for max design pavement temperature of **58°C** and ***V***ery heavy traffic
Grade suitable for max design pavement temperature of **64°C** and ***H***igh traffic

Selection of binder grade

- Locate the ***position*** of the project on the map for the ***maximum temperatures***.
- If the location falls wholly or partially within the **> *58˚C Zone***, a ***PG 64*** binder is selected
- If the location falls wholly within the ***≤ 58˚C Zone***, a ***PG 58*** is selected
- Determine the ***traffic level*** and ***average speed*** and choose the correct grade of binder

Notes on binder grade selection

- PG spec - purchasing spec - ***optimal selection*** of ***binder***
- The binder ***alone*** does ***not assure*** adequate performance
- ***Binder films*** operate ***in conjunction*** with the ***aggregate structure***
  - E.g. a high grade, hard binder ***alone*** may not be able to resist plastic flow
  - Aggregate structure (e.g. a stone skeleton) required to resist flow
  - Durability enhanced by
    - low permeability
    - sufficiently thick films of a durable binder
    - an aggregate structure (sand skeleton) to disperse void spaces
  - In high stiffness asphalt viscous properties of binder plays a predominant role
- PG spec ***does not differentiate*** between ***straight*** and ***modified*** bitumen
- ***Manufacturer decides*** to modify (or not) to comply with a grade of binder - designer simply selects a *performance* grade
- 58S and 64S grades likely to be ***straight run bitumen***

THAT WAS MODULE 5