Bituminous Binders
Shared knowledge, current achievements and future trends

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Presentation outline

- Performance requirements for bituminous binders in Qatar
- Modified bituminous binders
- CR modification of bituminous binders in Qatar
- CR modification of bituminous binders – The Italian experience
- Discussion
Performance requirements for bituminous binders in Qatar

Severe climatic conditions and vehicle loading

- Most common pavement type is flexible (2-3 asphalt courses)
- Key role of bituminous binders:
  - Need for enhanced high-temperature stiffness and elasticity (vs bleeding and rutting)
  - Need for improved ageing and fatigue resistance
Performance requirements for bituminous binders in Qatar

Flexible pavements – Cross sections and QCS requirements

- **Wearing Course**: 50 mm
- **Base Course**: 240 mm
- **Sub-base**: 300 mm
- **Subgrade**: 300 mm

Traffic Class T6 - Subgrade Class S1 (QHDM 1997)

**Bituminous binders** (as per QCS 2014):
- Neat 60/70 pen bitumen - Equivalent to PG64-10
- PMB (typically with 3-4% SBS) PG76-10

- PG grading as per AASHTO MP19 focuses on small strain behavior
- Improvement of PG grading as per AASHTO M332 (use of MSCR)
- PG grading is not the only answer to all needs (e.g. true fatigue/healing, ageing, mix design, mix behavior)
Modified bituminous binders

Available options

“Standard” polymers
- Elastomeric polymers (e.g. SBS)
- Plastomeric polymers (e.g. EVA)
- Polymer mixes/compounds
- Well-established production methods
- Excellent understanding of structure and rheology

Recycled polymers
- Crumb rubber (CR) from end-of-life tires (ELTs)
- Refuse derived plastics
- Several alternative production methods
- Good understanding of structure and rheology

Initial mixing → Swelling → Depolymerization → Digestion
Modified bituminous binders

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Motivation

- Relevant quantities of cumulated ELTs in the Rawat Rashid and Umm Al Affai sites
- Continuous generation of ELTs from the expanding vehicle fleet
- Need to maximize self-sufficiency and cut costs (while ensuring adequate pavement performance)
- Availability of local ELT processing plants – PMB producers ready for the “terminal blend” technology
CR modification of bituminous binders in Qatar

Challenges and way forward

- Unproven history of use, not used anywhere else in the GCC (field trials are mandatory)
- QCS to be updated with inclusion of acceptance criteria for component materials and mix design (Draft under revision)
- Need to implement reliable quality control systems (cooperation with Industry necessary)
- Need to build a Qatar-related know-how on materials behavior and pavement performance (goal: end of February 2019)
CR modification of bituminous binders in Qatar

Field trials (feasibility assessment)

- **CR Field Trial #1** – 14/05/2018 – Road #2 off Al Karajat Street, Doha Industrial Area
- Planned by Boom Construction and Raetex
- Assessment of a PMB PG76-10E and a CR-modified binder (CRMB) PG76-10H containing 11% CR -30 mesh (Bright Future)
- Adaptation of an existing Conformity Certificate for Wearing Course with PMB
CR modification of bituminous binders in Qatar

Field trials (feasibility assessment)

- **CR Field Trial #1** – 14/05/2018 – Road #2 off Al Karajat Street, Doha Industrial Area
- Standard quality assurance testing – Minor deviations from JMF
- Issues with volumetrics achieved after field compaction (8-9%)
- Resilient modulus testing on cores
CR modification of bituminous binders in Qatar

Field trials (feasibility assessment)

- **CR Field Trial #1** – 14/05/2018 – Road #2 off Al Karajat Street, Doha Industrial Area
- Performance-based testing on laboratory compacted specimens (reference 7% air voids)
- Ongoing rheological assessment of CRMB and PMB
- Ongoing verification of pavement design implications
CR modification of bituminous binders in Qatar

Field trials (feasibility assessment)

- **CR Field Trial #2** – In preparation
- Planned in cooperation with Boom Construction, Raetex and FUGRO
- Full SUPERPAVE mix design and performance-based assessment of wearing course mix containing CRMB (FUGRO)
- Testing by the QSD-ANAS staff also planned in ACRD
CR modification of bituminous binders in Qatar

QCS 2018 (Draft under review)

- CRMBs admitted for use on roads with design ESALs < 3 Million
- Emphasis on improvement with respect to neat binders and on environmental benefits
- Characteristics of CR in most part as per ASTM D6114
- Recommended percentages of CR in binder: ≥ 10%, ≤ 25%
- CRMB rheological testing as per AASHTO T315 and AASHTO T350 with 2 mm gap
- CRMB grading in accordance with AASHTO M332 (waiver of solubility requirements)
- CRMB storage in continuously agitated tanks
- Declaration of producers on CR use and on CR percentage

Ongoing activities of the QSD-ANAS team

- Characterization of available CR products, CRMBs and asphalt mixes containing CRMBs
- Evaluation of pavement design life implications
CR modification of bituminous binders – The Italian experience

Organization

• Activities carried out by the Politecnico di Torino (European, State and Private funding):
  • Assessment of ELT processing plants
  • Laboratory testing of CR products, CR-modified binders, mixes containing CR-modified binders
  • Field trials and pilot projects
  • Dissemination

• Considered technological solutions:
  • “Wet”: asphalt rubber (AR) and terminal blend (TB) binders
  • “Dry”: CR in partial substitution of fine aggregates
  • “Hybrid”: CR in partial substitution of synthetic polymers in PMBs

• Multidisciplinary study:
  • Pavement engineering
  • Sanitary-Environmental Engineering
# Bitumen-CR-aggregate interactions
- Full understanding of interaction phenomena
- Identification of effects of different factors
- Technical Specifications (CR “certification”)

# True performance potential of CR mixtures
- Rutting and crack propagation resistance (wearing courses)
- Full-scale monitoring and laboratory simulation
- Dense vs. “gap-graded” mixtures
- Standard and non-standard aggregate sources
- Technical Specifications (performance-based)

# Health risks for pavement construction workers
- Monitoring and analysis of gaseous emissions on site
- Laboratory simulation
- Modelling of toxic and carcinogenic effects
- Differential assessment (CR vs. no-CR)

# Life-cycle assessment
- Evaluation of cradle-to-the grave processes
- Modelling of equivalent CO2 emissions
- Differential assessment (CR vs. no-CR)
CR modification of bituminous binders – The Italian experience

CR characterization

• Plant Assessment

Significant variability in arrangement and feed
CR modification of bituminous binders – The Italian experience

CR characterization

• Density

Lack of reference standard
Significant variability (plant- and source-dependent)
Violations to ASTM D6114 ($\rho = 1.15 \pm 0.05$)
Highest value for cryogenic CR

• Particle size distribution

Significant variability (plant- and source-dependent)
Compliance to ASTM D6114 ($D_{\max} < 2.36$ mm)
Identification of “coarse”, “standard” and “fine” CR ($D_{10} - D_{90}$)
CR modification of bituminous binders – The Italian experience

CR characterization

- Morphology (microscopy + image analysis)

Ambient size reduction leads to rougher more irregular particles (plant- and source-dependent)

Quantitative evaluation of particle texture and shape (plant- and source-dependent)
CR modification of bituminous binders – The Italian experience

CR characterization

- Morphology (microscopy + image analysis)
  - Mapping of texture and shape
  - Identification of optimal morphologies for blend design

- Surface area (image analysis + modelling)
  - Significant variability (plant- and source-dependent)
  - Corresponding variability in interactions expected/justified
CR modification of bituminous binders – The Italian experience

CRMB characterization

- Viscosity

15% CR, 90 min mixing and curing
Significant variability
ASTM D6114: $\eta = 1,500-5,000$ mPa·s

- Viscoelastic parameters

15% CR, 90 min mixing and curing
Significant variability
ASTM D6114: no requirement
CR modification of bituminous binders – The Italian experience

CRMB characterization

- Time effects (bitumen-CR interaction)

Reference mixing time (18.5%): 45 min
Mixing time decreases with higher dosages
("overcooking" cancels differences)

Reference mixing time (18.5%): 75 min
Mixing time decreases with higher dosages
(longer "overcooking" time)
CR modification of bituminous binders – The Italian experience

CRMB characterization

- Fatigue resistance

Time sweep tests in equistiffness conditions (300 kPa) 10 Hz
Damage rate decreases with increasing CR dosage
Rutting resistance

Creep compliance tests on binders and flow number tests on mixes

CRMB (code D) outperforms PMB (code C)

Excellent correlation between binder and mix data
CR modification of bituminous binders – The Italian experience

Asphalt mix characterization

- Permanent deformation
- Crack propagation

Identification of limiting volumetrics
Comparative assessment of CRMBs and mixes

Results sensitive to composition and volumetrics
CR modification of bituminous binders – The Italian experience

Asphalt mix characterization

- Full-scale monitoring of trial sections

[Image of road construction with equipment and map of Italy]
Thank you
For further information please visit the “Qatar Future Roads” website
http://www.q-roads.com.qa/