REPUBLIC OF GHANA

Ministry of Transportation

STANDARD SPECIFICATION

FOR

ROAD AND BRIDGE WORKS

JULY 2007

A Review of Ghana's Asphalt Pavement Construction Specifications

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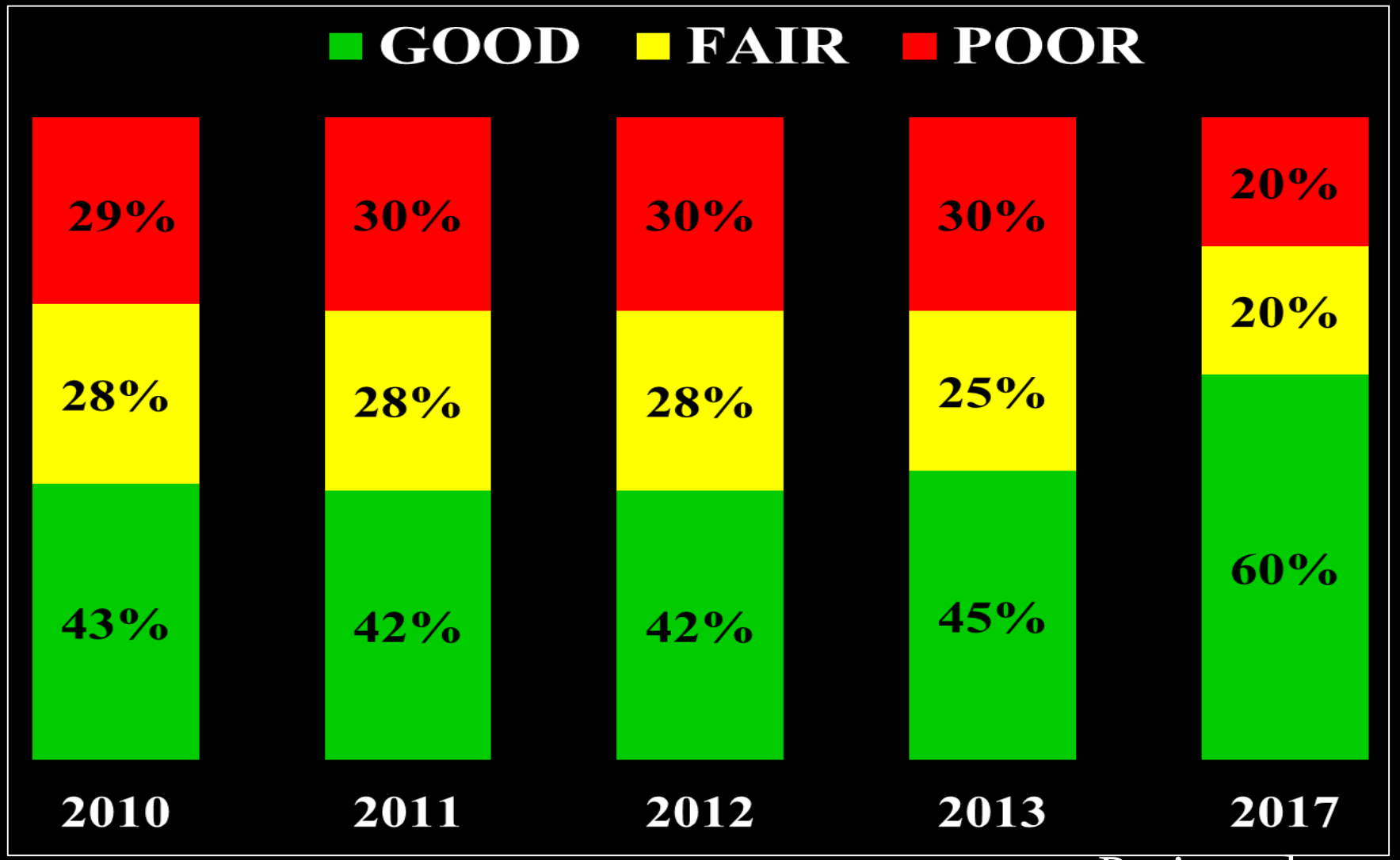
Presentation Outline

- Pavement Performance Issues
- Overview of Standard Specification
- Areas covered:
  - Material testing
  - Mixture design
  - Construction quality control
  - Joint construction

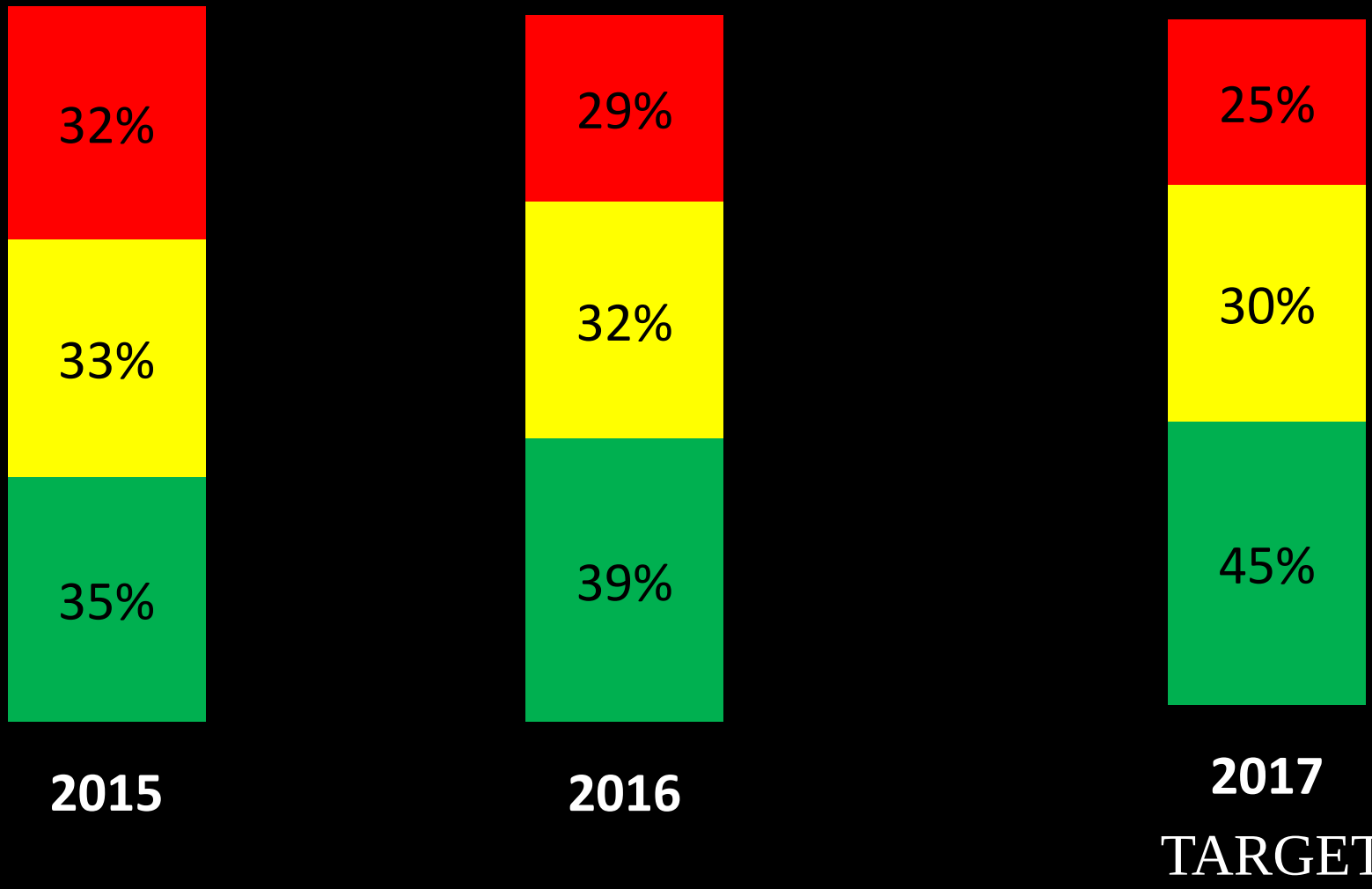
Performance Issues

Road Condition: 2010 - 2017



Projected

Road Condition: 2015 - 2017



Past Research

- **Tuffour et al. (2014)**
  - Asphalt roads (670km) constructed 2000 – 2013
  - Major distresses visible by 6th year
  - Gaps in Standard Spec. blamed for low quality
- **Low road construction quality cited**
  - Attoh-Okine (1992); Ofori-Kuragu (1993)
  - Ampadu et al. (2015); Tuffour et al. (2016)
- **Major asphalt roads are built by foreign contractors, yet quality is an issue**

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Objectives

- Review asphalt road construction specifications
- Suggest recommendations

Overview: Standard Specification

- **Current version:** July 2007 (replaced 1991)
- **Funding:** World Bank (Road Sector Dev't Prog)
- **Specification review consultants:**
  - CSIR Transportek & Stewart Scott International
  - Local collaboration
- **11-year old specification; a lot has happened !**
  - Better design, materials & construction techniques
  - New contract types (e.g., PPP, BOT)

Overview: Standard Specification

- **Specification revision is costly but…**
  - Cursory reviews can effect minor changes
  - Staged review can resolve urgent problems
- **Systematically evaluate Spec. to justify revision**
  - Feedback from projects on Spec. performance
  - Bid analysis for contractors' interpretation of Spec.
  - Database on variation orders & claims

Standard Specification: Hybrid

- It references foreign standards
  - E.g., BS, AASHTO, ASTM
- It has method (recipe) specifications
  - Prescribes some materials & construction methods
  - Payment is not tied to quality; owner is responsible
- It has performance specifications
  - Contractors select materials & construction methods to meet stated quality standards
  - Payment is tied to level of quality achieved

Performance Specification Types

- **End-Result**
  - Contractor executes works to meet quality standards
  - Works are accepted or rejected or pay adjusted based on level of specification compliance
  - **No pay adjustments provided; room for litigation and quality compromise**
- **Quality Assurance / Quality Control**
  - Key quality indicators are specified
  - Contractor exercises quality control
  - Owner is responsible for quality assurance
  - Acceptance & payment are based on statistical sampling of quality indicators
  - **Objective approach, but rarely practiced**

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Bitumen Testing

- **Penetration and viscosity tests are listed**
  - Viscosity is a fundamental property
  - Does not fully characterize bitumen
  - Two bitumen sources can have the same viscosity grading but different performance characteristics
- **Performance-based testing recommended**
  - 2015 Argus Africa Bitumen Conference (Tanzania) advocated consistent supply of high-quality bitumen to Africa
- **Superpave bitumen testing is an example of performance-based testing**

Superpave Bitumen Testing

- **Performance tied to climate and traffic**
  - E.g. PG 70 – 22
  - PG: performance grade
  - 1st number: Max. pavement temperature (70^{o}C)
  - 2nd number: Min. pavement temperature (-22^{o}C)

- **Superpave System has three components**
  - Binder selection
  - **Mixture design (specified in Ghana as an option)**
  - Mixture performance testing

Asphalt Moisture Damage

- **Moisture damage**
  - Asphalt mixture loses cohesion and/or adhesion due to moisture
  - Induces bleeding, cracking, rutting, raveling, etc.
  - Moisture damage is costly e.g. $13,000 - $21,000 per lane mile in US (Hicks & Scholz, 2003)
  - **Granite (acidic aggregate) is more vulnerable. Has greater affinity for water (greater loss of adhesion)**

- **Ghana's asphalt concrete contains granite, so moisture damage testing is crucial**

Some Moisture Damage Tests

- **Static immersion test is listed (AASHTO T182)**
  - Asphalt mixture is immersed in water; aggregate surface coated with bitumen is visually estimated

- **AASHTO T182 discontinued**
  - Qualitative results: hardly repeatable and reproducible
  - Poor correlation of results to field performance
  - No simulation of traffic and pore water pressure effects

- **The Standard Specification requires lime for aggregate gradation and adhesion improvement**
  - But no criteria are provided for lime use
  - Room for subjectivity

Mix Design: Marshall vs Superpave

- **Marshall (AASHTO T 245)**
  - Volumetric design
  - Impact compaction
  - No bitumen and aggregate selection methods
  - Performance tests (stability and flow)

- **Superpave (AASHTO T 312)**
  - Volumetric design
  - Gyratory compaction
  - Bitumen and aggregate selection methods
  - Performance test: moisture damage (AASHTO T 283)
  - Kumasi-Konongo Highway, Contractor AARSLEFF

Trending: Balanced Mix Design

What is balanced mix design?

‘Asphalt mix design using performance tests … [to] address multiple modes of distress taking into consideration mix aging, traffic, climate and location within the pavement structure’

Asphalt Technology News (2017)

Balanced Mix Design

- **Cracking Test Examples:**
  - Illinois flexibility index test (AASHTO TP 124)
  - Semi-circular bend test (ASTM D 8044)
  - Texas overlay test (TxDOT Tex-248-F)

- **Rutting Test Examples:**
  - Hamburg wheel tracking (AASHTO T 324)
  - Asphalt pavement analyzer (AASHTO T 340)

Hamburg wheel tracking test also evaluates moisture damage

Tack Coating

- **Tack coat -** thin bituminous application between pavement lifts to promote bonding

- Poor bonding causes distresses. E.g., slippage failure, fatigue cracking

Tack Coating Practices

- **Recommended practice**
  - Construction specs set ranges for tack coat application rates
  - Engineer sets target rates for specific projects
- **Ghana's tack coating practices**
  - Standard Spec. provides no ranges to select from
  - Varied practices, based on Engineer's preferences

Tack Coating Guidelines are Needed

- Should heavier tack coat application be made on an old asphalt pavement or concrete pavement?
- Should a light application or no tack be applied on a freshly-placed asphalt pavement?
- Should application rates for asphalt emulsions be based on the total emulsion or the residue?
- Should emulsions be diluted at paving sites?

Longitudinal Joint

- **Longitudinal joint:** interface between parallel asphalt pavement lanes
- Longitudinal joint cracking emerged the second most prevalent crack type, second to fatigue cracking (Tuffour et al., 2014)

Longitudinal Joints

- **Standard Spec. specifies cut back joint**
  - Trim edge of existing lane, tack coat the cut face and pave adjacent lane
  - Less effective

- **Notched-wedged joint most effective**

(Kandhal and Mallick 1997; Mallick et al. 2007)

  - A simple device is attached to paver to create a sloped step at the edge of the first lane
  - Adjacent lane overlaps the step on the first lane

Types of Longitudinal Joints

Standard or Tapered Joint

Cut Back Joint

Wedge Joint

Notched Wedge Joint

Longitudinal Joint Density

- **Some road agencies specify joint density and make it a pay item to ensure greater attention to joint quality**

- **Standard Spec. indicates no joint density**
  - Min. of 93% compaction is specified for entire mat
  - No requirement to test joint density

Recommendations

- Systematic evaluation of effectiveness of Standard Specification to guide revisions
- Discussion is needed on tailoring specifications for contemporary contracting methods (e.g. PPP)
- Performance-based bitumen testing needed to address concerns about quality of bitumen supplied to Africa, pavement performance issues and high-volume traffic
- Clear specifications needed on moisture damage testing given the predominant use of granitic aggregates

Recommendations

- The Standard Spec. allows Superpave mix design; it should also allow Superpave's bitumen testing
- Rutting and cracking tests should be adopted to start building local experience on balanced mix design
- Training is needed on statistical quality control to encourage its use. It prevents capricious decisions and engenders pursuance of high construction quality
- Guidance is needed on tack coating to minimize variation in construction practices.
- Joint specifications should include more effective joint types and joint densities


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