Constructing a Quality Product – Balancing Risk (and Reward) in Changing Times

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National Concrete Consortium

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September 18, 2018

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Overview

- Quality Defined
- Quality Management and “Culture of Quality”
- Changes shifting risk - and reward
- Impacts of these changes
- Role of QC– the key to rewards?
- PEM Implementation in North Carolina
- Closing thoughts - quality from an educator’s perspective

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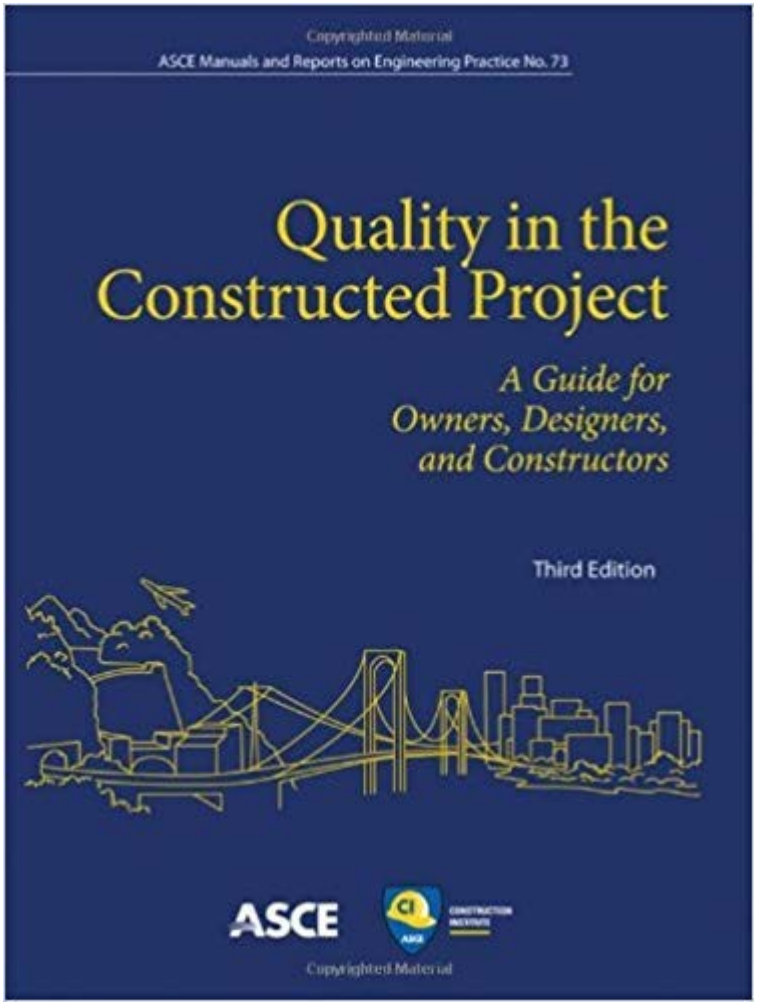
Quality Defined

"Quality is defined as the delivery of products and services in a manner that meets the reasonable requirements of the

- owner,
- design professional, and
- constructor,

including conformance with contract requirements, prevailing industry standards, and applicable codes, laws, and licensing requirements"

(ASCE 2012)



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How Corporations Define Quality

- "Providing customers with products and services that consistently meet their needs and expectations."

  – Boeing

- "Meeting the customer's need the first time and every time."

  – General Services Administration, US Government

- "Performance to the standard expected by the customer."

  – FedEx

- "Doing the right thing right the first time, always striving for improvement, and always satisfying the customer."

  -- US Department of Defense

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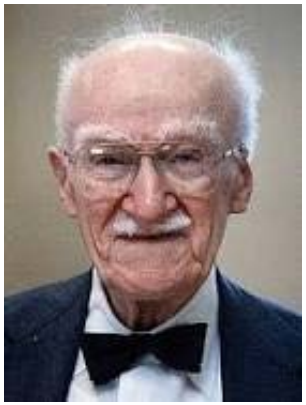
Quality has the following characteristics:

(Tang et al. 2005)

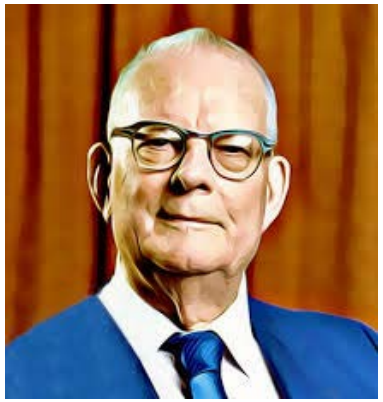
1. It involves meeting or exceeding customer expectations.

2. It applies to products, services, people, processes, and environments.

3. It is an ever-changing state (what is considered quality today may not be good enough to be considered quality tomorrow).



Joseph Juran
1904-2008



W. Edwards Deming
1904-2008

Walter A. Schewart
1891-1967

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Evolution of Quality

- Pre 1900 - Craftsman quality control
- Early 1900's - Foreman quality control
- World War I through 1930s - Inspection quality control
- World War II – Mass production brings statistical quality control
  - Statistical tools (sampling plans, control charts) to help make inspection more efficient
- 1960's to ? – "Total quality control"

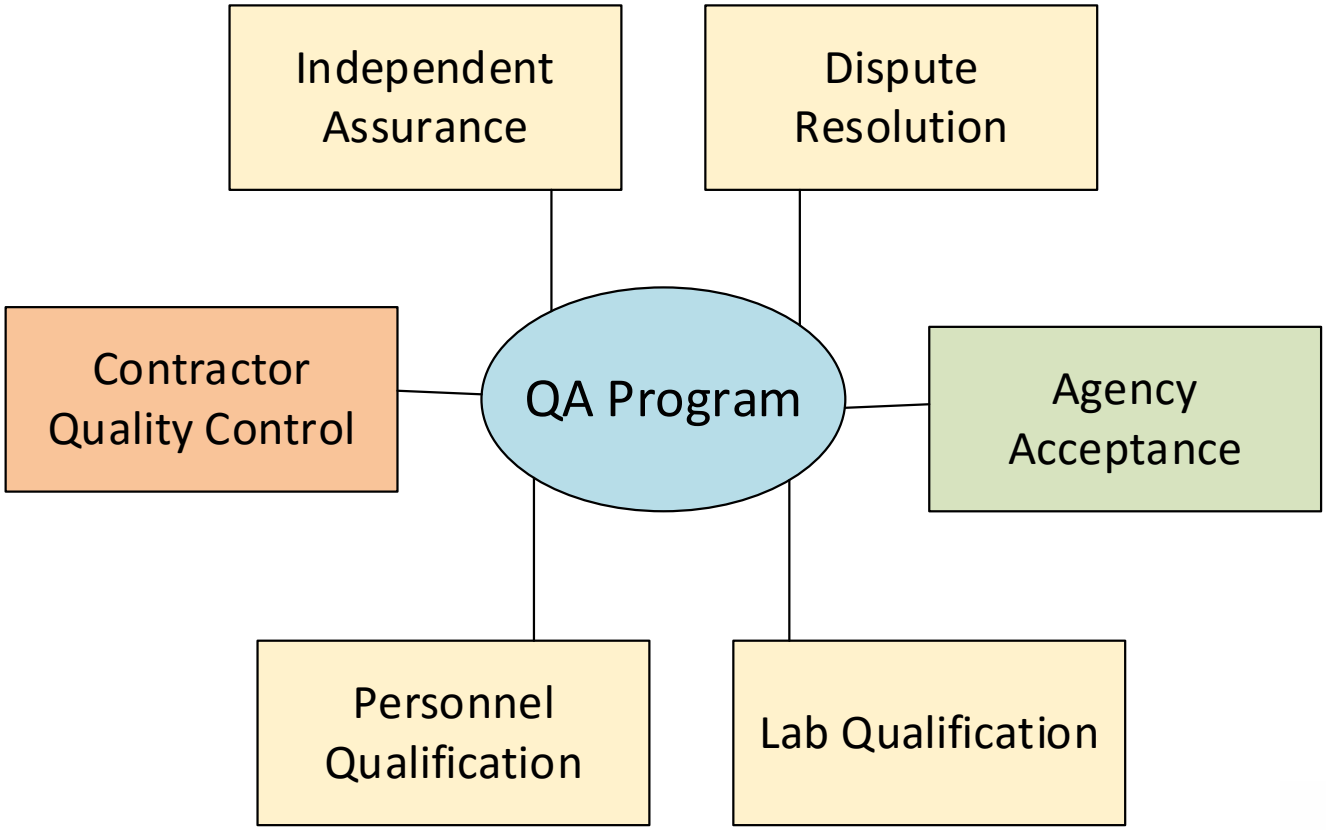
... in manufacturing

Unlike manufacturing, ensuring quality in construction has a unique challenge –

One-of-a-kind delivery of many projects

23 CFR 637, Subpart B

- "Quality Assurance Procedures for Construction."
  - Defines roles, responsibilities, qualifications
  - Provides provisions for acceptance



From Dvorak 2018 and Withee 2018, FHWA

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Quality is more than QC/QA

Core Elements of a Quality Assurance Program

Fick et al. 2012

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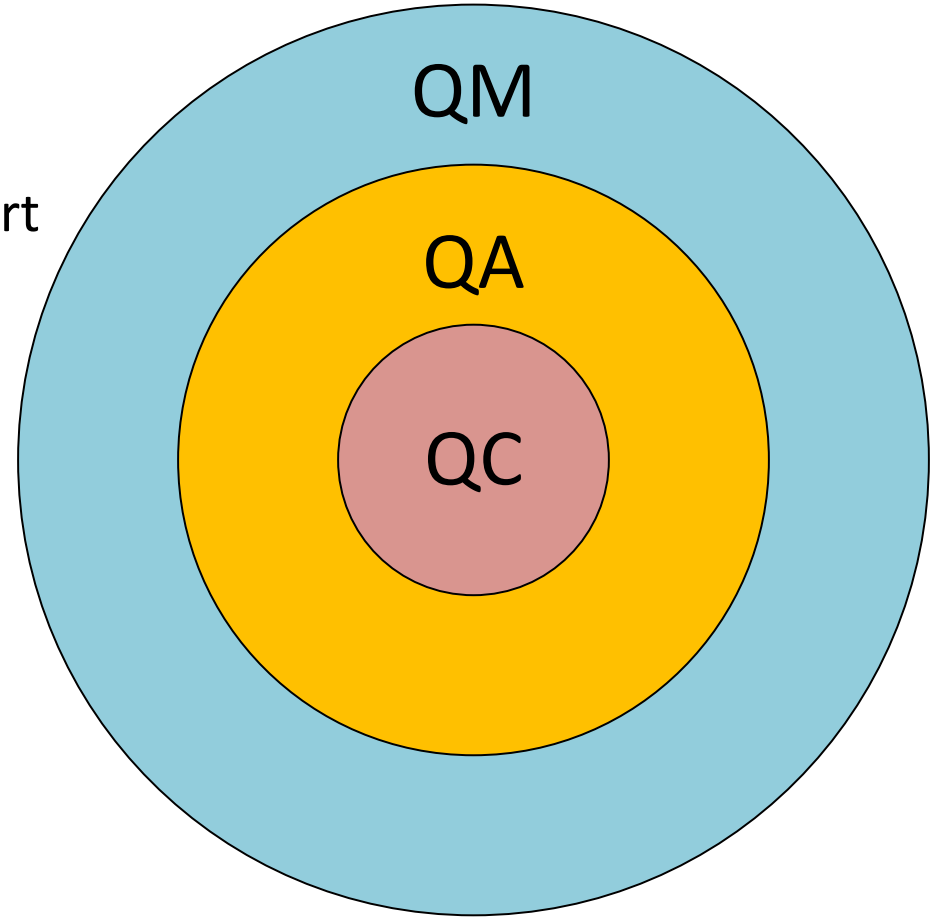
Quality is more than QC/QA

Quality Management

Keys:

- Senior-level management support
- Adequate resources/tools
- Policies



Promoting "Culture of Quality"

- Values of organization are clear
- People need to know what is required of them
- Can use skills to effectively produce, innovate, and compete
- Open communication

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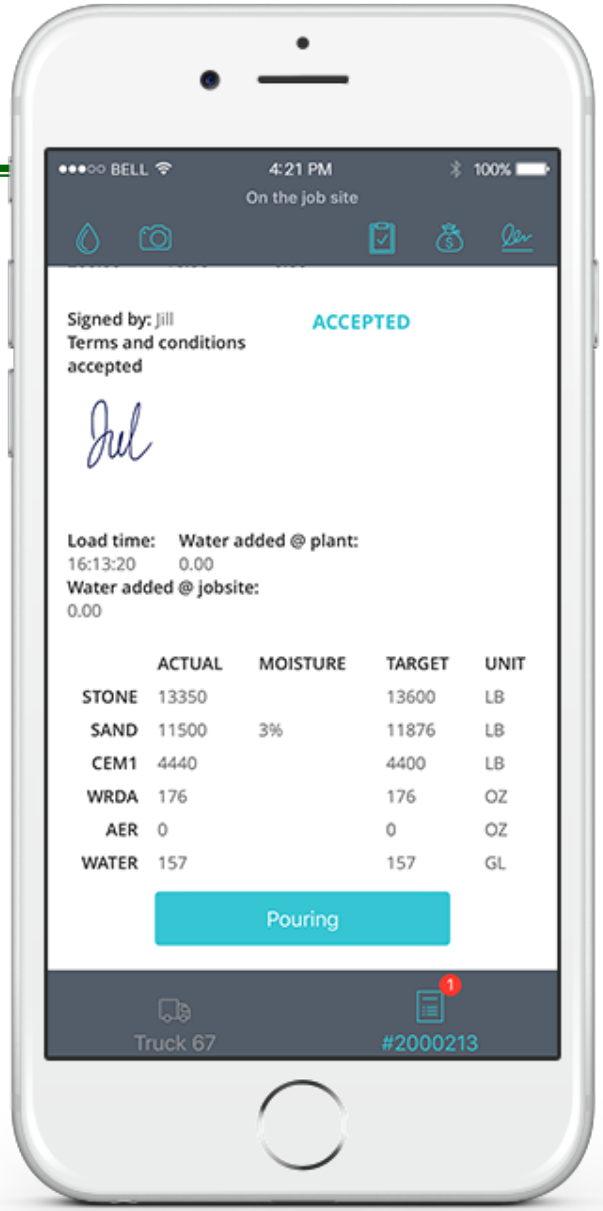
Changing Times

- Materials
- Construction methods
- Types of tests and specifications
- Technology
  - QA/QC Tools
  - QM Tools

- Project delivery methods
- Design-Build and Operate/Maintain
  - 23 CFR 637.207(a) provisions applicable to Design-Build projects and other alternative contracting methods
  - Warranties (23 CFR 637.207(a)(1)(iv))



from istrada.net

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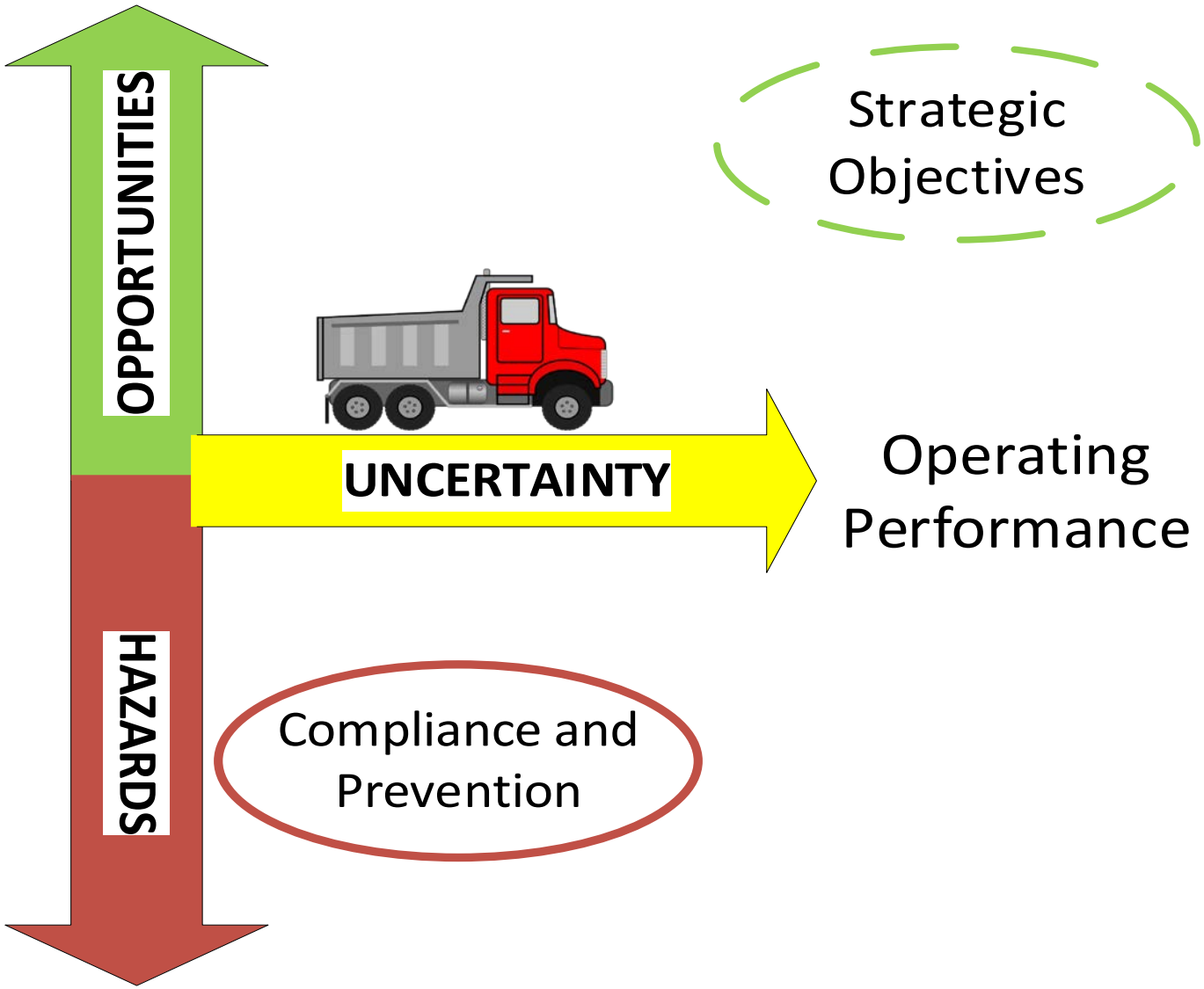
Risk Continuum



Adapted from Sharon 2005

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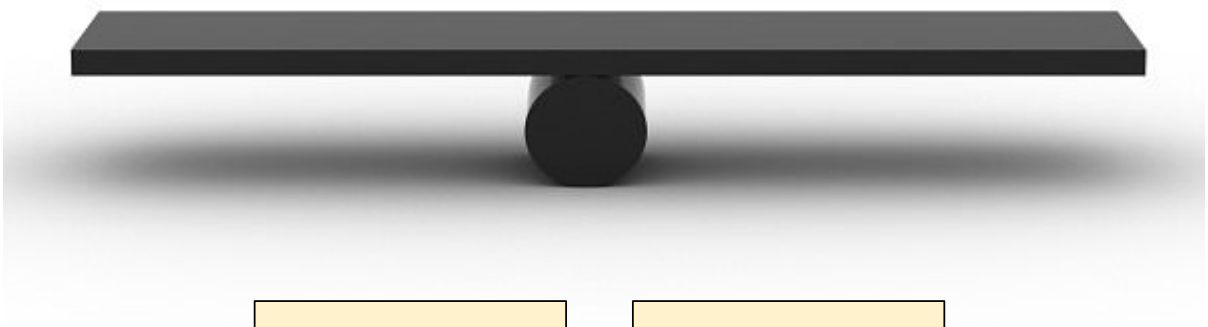
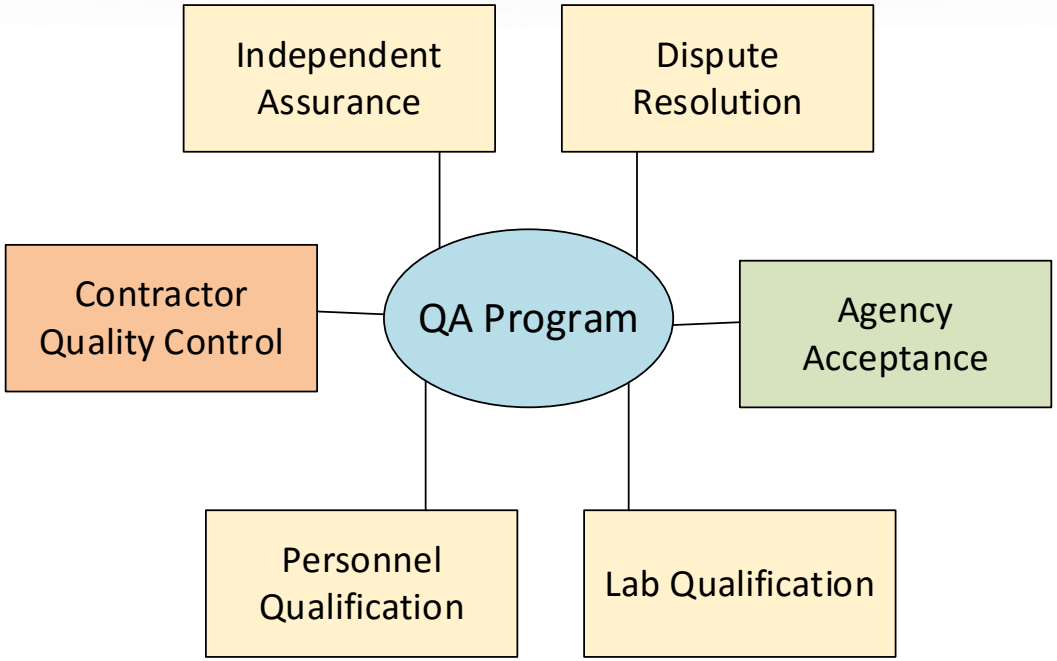
Balancing Acts

Testing and Inspection Costs

Material Quality and Performance Risk





From Dvorak 2018 and Withee 2018, FHWA

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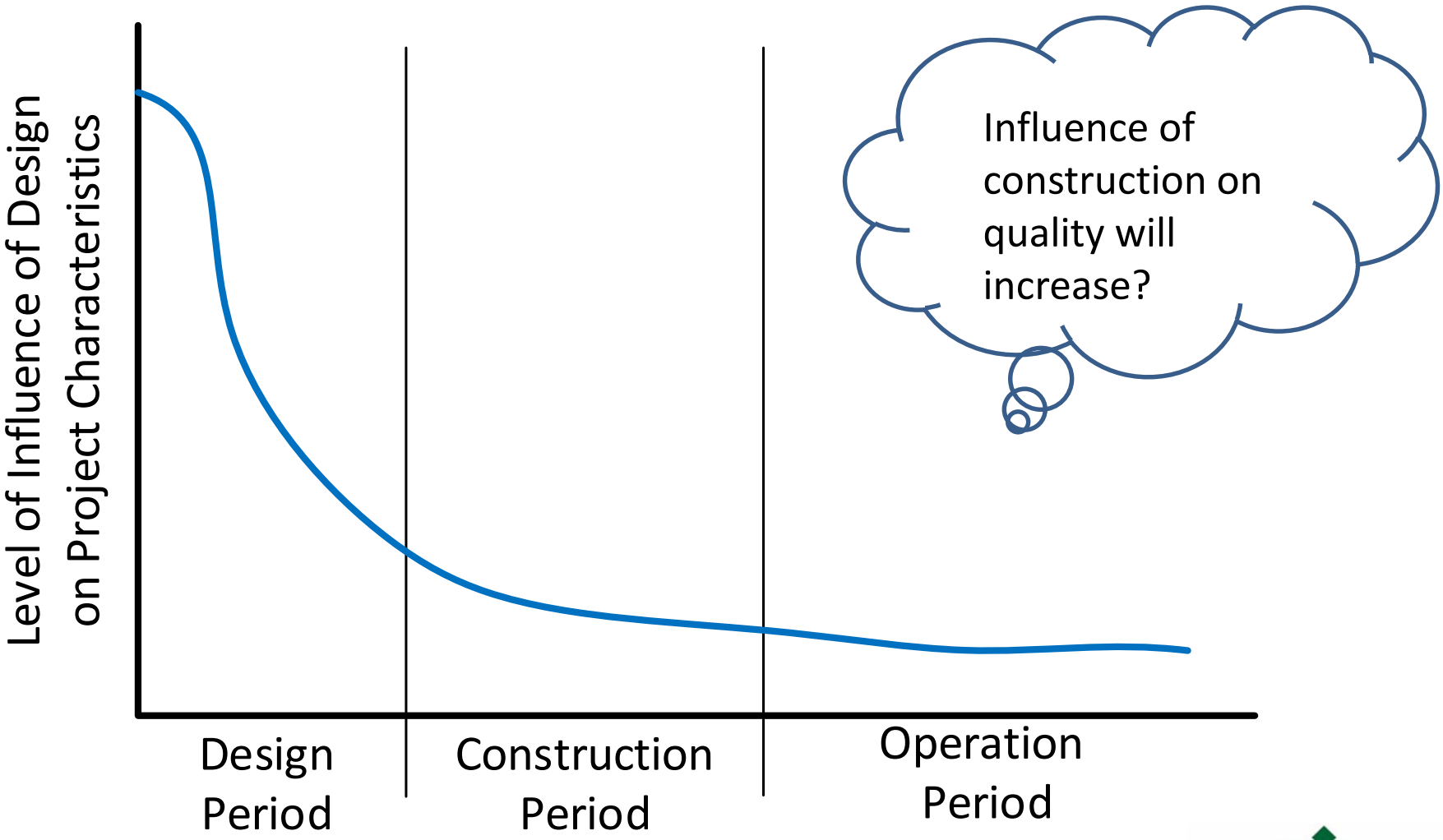
Impact of Changes in Delivery Method



From ASCE 2012

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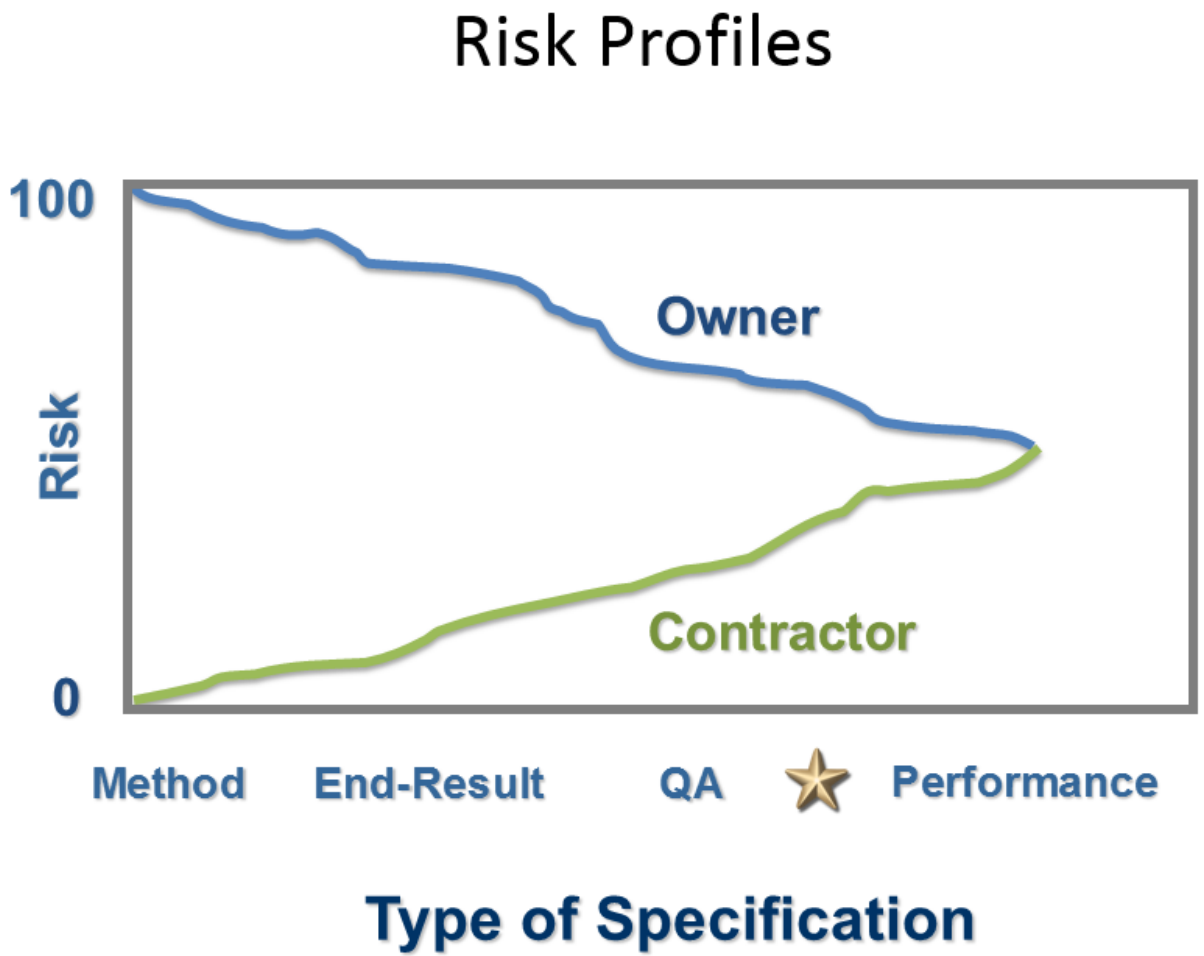
Impact of Changing Specification Type

Risk = exposure to possible loss

Risks must be recognized and assessed.

- Safety
- Cost
- Schedule
- Project quality



From FHWA

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The Math of Quality
Relationship to Other Construction Parameters

- Quality and cycle time
  - Quality improvement efforts will reduce cycle time
- Quality and productivity
  - Productivity = saleable output / resources used
  - Reduction in rework
  - Improvement in quality directly results in an increase in productivity
- Quality and initial cost
  - As the quality of design increases, cost increases
  - As quality standards are increasingly met, cost decreases
- Quality and value
  - Value = Quality / Price
  - Evaluate the value provided, relative to the competition

(from Tam et al. 2005)

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Cost of conformance
Cost of implementing quality

- Know what controls quality and invest in those processes/tools
- Know who controls quality and invest in those people

- Process changes
- Inspection/testing enhancement
- Preventative maintenance
- Process review/audits
- Education and training
- Human resources and recruitment
- Other costs

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Cost of Non-conformance

- Cost of not implementing quality

- Cost of rectifying issues identified during construction
  - Delays
  - Rework
  - Schedule impact

- Non-conformance identified after construction within warranty period
  - Resources/rework/penalties
  - Liability claims
  - Lost opportunities
  - Impact to reputation

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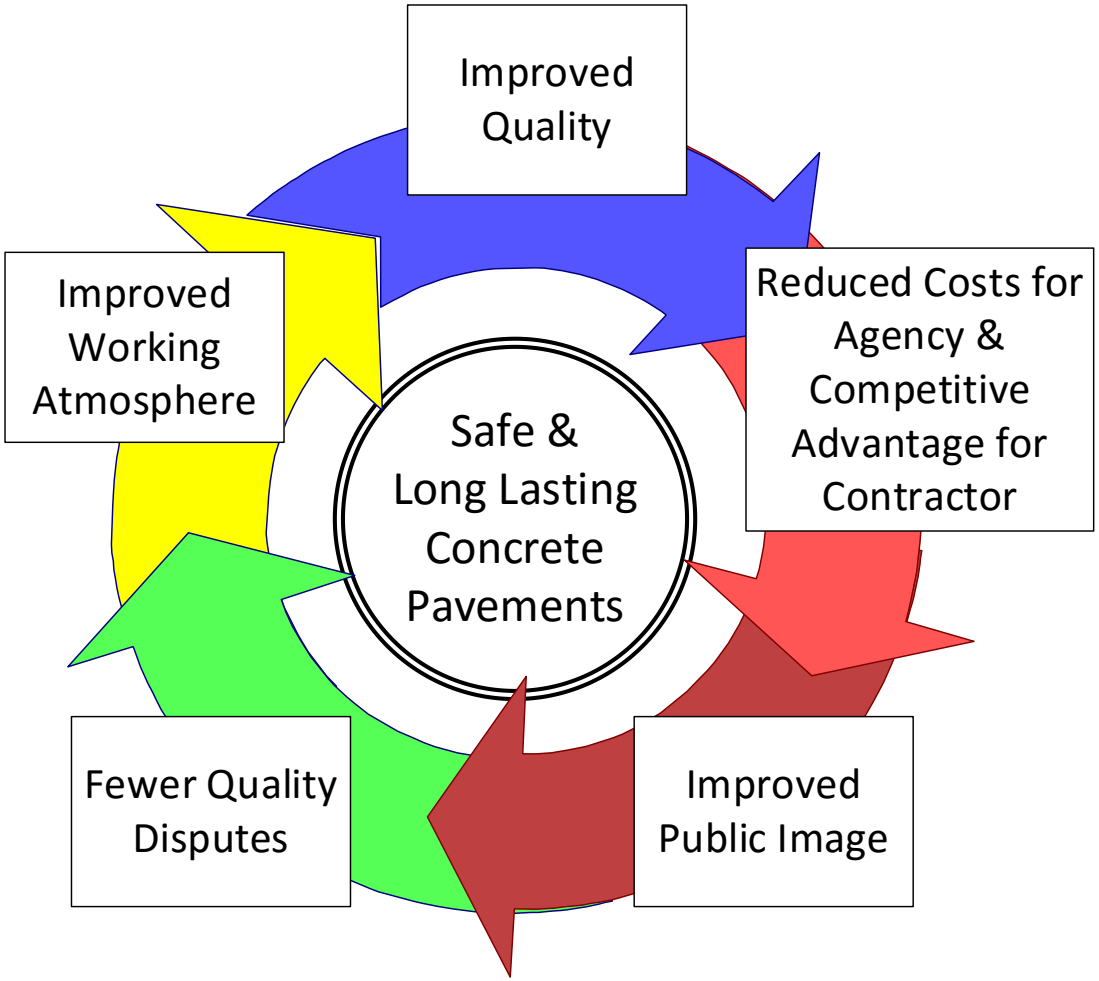
Rewards

- Hard costs
  - $$$ savings
  - longer lasting pavements
  - reduced maintenance
- Soft costs
  - greater productivity
  - reduced personnel turnover
  - user costs to traveling public (safety, inconvenience)



Benefits of Improved Quality for Transportation Facilities - Fick et al. 2012

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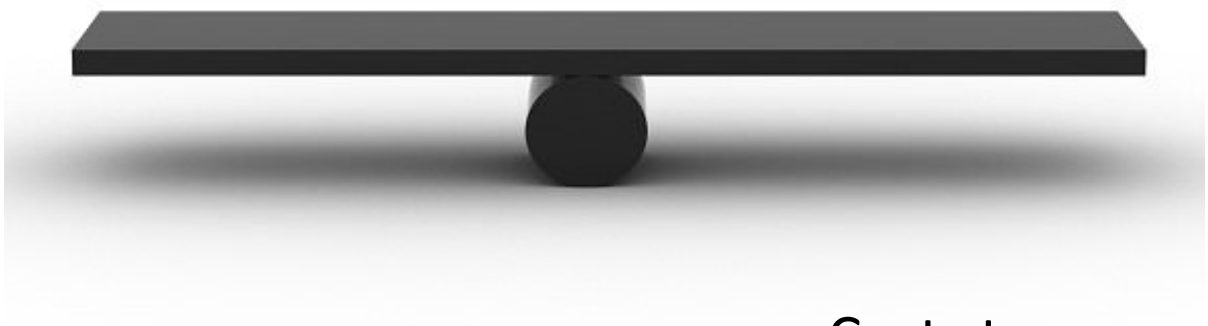
A different way to look at the balancing act

Cost of implementing quality

Cost of NOT implementing quality



Costs to improve

(an investment in agency/business)

Costs to remediate

+

Costs of lost opportunity (rewards)

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Do we have the numbers that we need?

Costs to implement parts of a quality improvement initiative generally can be computed or estimated

Testing Effort by Project Level and Project Stage

Project level	Project stage						
	Mixture design		Mixture verification		Quality control		
	Total duration (days)	Man hours	Total duration (days)	Man hours	Total duration (working days)	Man hours	No. of technicians
A	7*	150	7**	80	5	200	4 & QC manager
B	7*	70	7**	75	5	135	3
C	7*	60	3	30	5	85	2

From Fick 2006

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Do we have the numbers that we need?

Quantified benefits of implementing quality initiatives are harder to find

- Rupnow and Icenogle (2012) resistivity study for Louisiana DOTD
- Implementing resistivity in lieu of ASTM C 1202 rapid chloride permeability tests
  - $101,000 personnel cost savings in first year
  - Indirect cost savings for outside tests by contractors $1.5 million/yr
  - Project cost $102,878
  - Estimated combined savings of $1.6 million in first year of implementation

"Balancing risk and reward" is better accomplished when reward is quantified.

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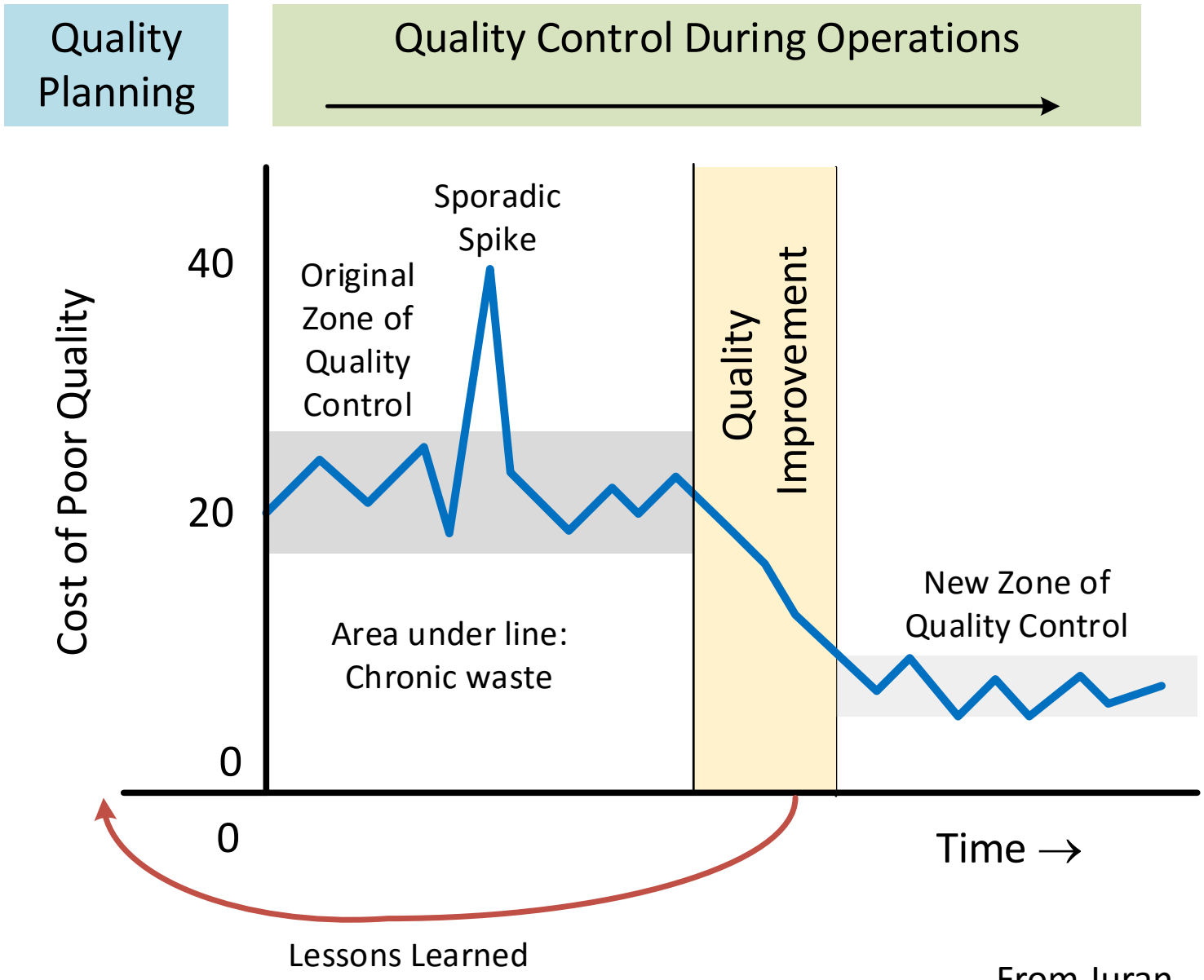
QC plan reduces variability, increases rewards



Control charts –

- reduce common / chance variability
- could help quantify benefits

From Juran

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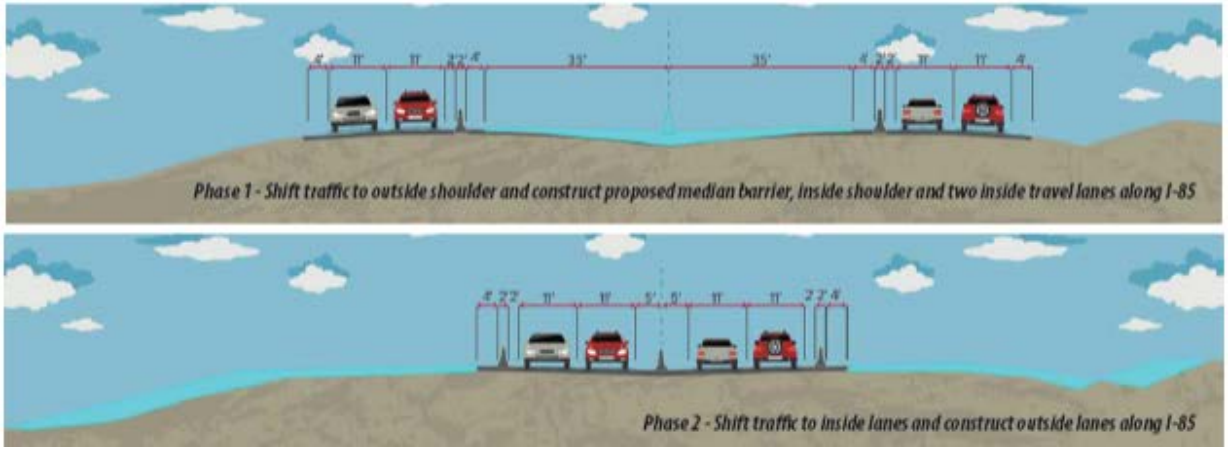
PEM Implementation Site in North Carolina

- I-85 widening project north of Charlotte – 8 miles in length
- Addition of 4 travel lanes (2 each direction)
- 12-inch thick mainline JPCP
- Two phases



- Contractor-led involvement
- Motivated staff
  - "We know PEM is coming, and we want to get on board."
  - "We already do some of this QC but want to do more."
  - "How can we help?"

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GSI
GSI
LANE

PEM Tests and QC activities

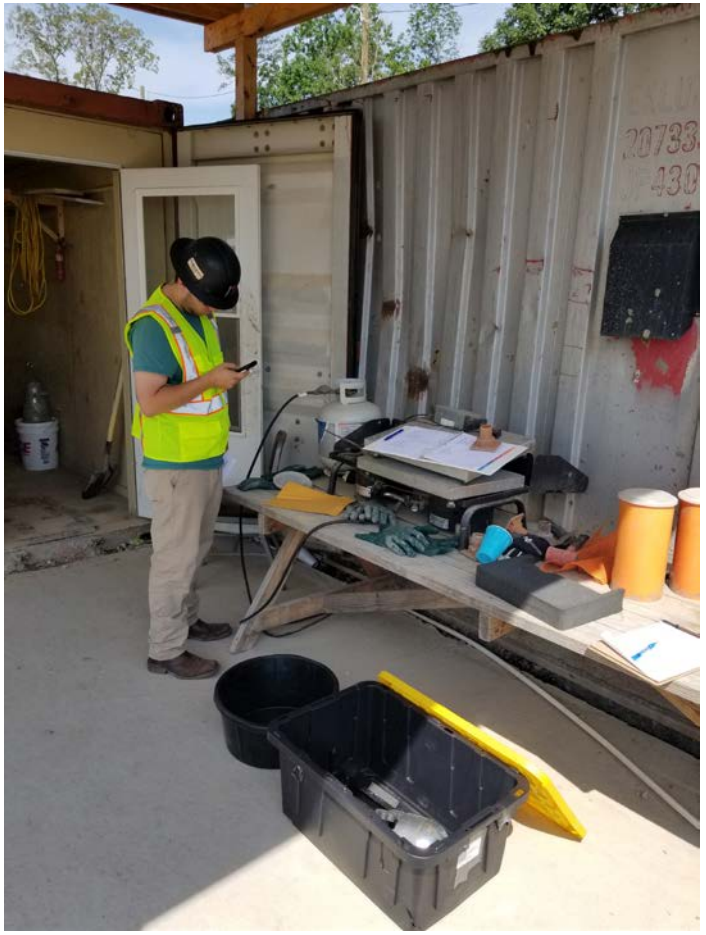
Category A: Mixture design and approval

- Resistivity test results
- SAM test results
- Box test results

Category B: Acceptance tests

- NCDOT standard requirements
  - 28-day compressive strength (4,500 psi)
  - Air content (6.0% ± 1.5%)
  - Max slump 1.5 in
- Shadow Tests
  - SAM test results
  - Resistivity test results

VKelly is being utilized on a trial basis



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PEM Tests and QC activities

Category D: Control Charts

- Air content, slump, unit weight, concrete temperature
  - One test per lot
  - PEM tests
  - SAM – once per day target
  - Resistivity – all cylinders tested for compressive strength
  - Bucket test – performed at UNC Charlotte
- Other control charts may be developed
  - Moisture content of aggregates
  - Fly ash LOI

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Current Status

Implementation Site

- Phase 1 paving complete
- Data analysis ongoing
- Phase 2 paving begins April 2019

- Simultaneous lab study at UNC Charlotte for targeted mixtures
  - implementation of resistivity, SAM
  - demonstrating benefits of increased fly ash contents
  - continuing to demonstrate benefits of Type IL (portland limestone cements)

Quantifying benefits of implementation is a key goal

- Benefits to contractor
- Benefits to agency

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Thoughts on Future

- Construction Quality Management continues to evolve
  - Transformational technologies
  - Project delivery methods
  - Specification approaches
  - Testing technologies
  - Workforce experience
  - Resource allocation

- Responsibilities should be clearly delineated in contract documents, regardless of delivery method

- Communication will be increasingly critical
  - People to people
  - Database to database

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Thoughts on Future

How will risk/reward shift with movement towards PEM?

- "Agency makes the choice that best fits their situation and willingness to share risk." - Cecil Jones

- Better quantification of benefits of quality initiatives should help balance risk and reward, and promote innovation/quality

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Thoughts on Future

- **Quality Management may be the "critical Q"**
- Promoting "Culture of Quality" will be critical to ensuring quality despite widespread changes
- Investment in education/training will be critical for quality "buy in"

Typical undergrads entering workforce do not have a good handle on QM/QA/QC

My opinion

- How are we incorporating QM/QA/QC into our courses?
- How are we incorporating QM/QA/QC training into our workplaces?

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CP ROAD MAP
shaping the future of concrete pavement

www.cproadmap.org

July 2017

"Moving Advancements into Practice"

MAP Brief July 2017

Best practices and promising technologies that can be used now to enhance concrete paving

Developing a Quality Assurance Program for Implementing Performance Engineered Mixtures for Concrete Pavements

U.S. Department of Transportation
Federal Highway Administration

Field Reference Manual for Quality Concrete Pavements

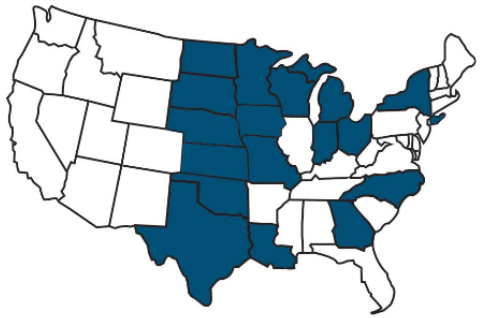
Publication No. FHWA-HIF-13-059

September 2012

Testing Guide

for Implementing Concrete Paving Quality Control Procedures

March 2008



National Concrete Pavement Technology Center

CP Tech Center

ctre Center for Transportation Research and Education

Iowa State University

This testing guide is a product of an FHWA 17-state pooled fund: **Material and Construction Optimization for Prevention of Premature Pavement Distress in PCC Pavements, TPF-5(066)**

Original Title Suggested by Steve:

Methods of Acceptance for a Quality Product – Balancing Risk

Potential States Survey topic?

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