

- MAKING A DIFFERENCE

*through focused
producer/contractor
commitment to quality control*



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National Concrete Pavement
Technology Center




www.cptechcenter.org

What is Concrete?

- One of the planets' largest CO₂ sources
- Immovable blocks
- Gray, cracked and hard
- Makes our trucks dirty
- Money



- The backbone of civilization



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What is Concrete?

- Versatile
- Beautiful









What was Good Concrete?

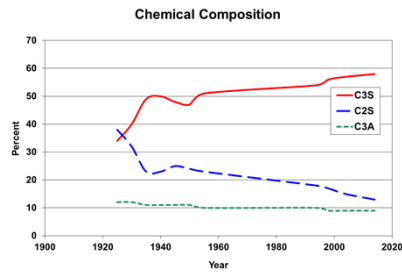
- Easy to work with
- Strong
- Lasts forever
- Cost effective

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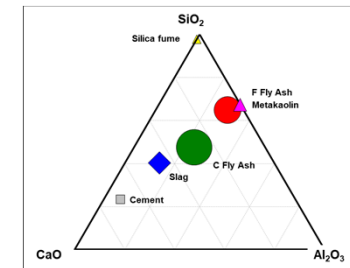
The Way We Were

- Cements
 - Wet kilns
 - High C_2S / low C_3S
 - Straight OPC



The Way We Were

- Cements
 - Dry kilns
 - Low C_2S / high C_3S
- SCMs
 - Slag cement and fly ash
- Admixtures
 - Air entrainers
 - Water reducers



The Way We Were

- Proportions
 - Ordinary 1:2:4
 - Fancy 1:1:1½
- Add water to taste

TABLE OF RECOMMENDED MIXTURES	
<i>1 : 1 : 1 Mixture for</i>	The wearing course of two-course floors subject to heavy trucking, such as occurs in factories, warehouses, on loading platforms, etc.
<i>1 : 1 : 1½ Mixture for</i>	The wearing course of two-course pavements, in which case the pebbles or crushed stone is graded from ¼ to ½ inch.
<i>1 : 2 : 3 Mixture for</i>	Reinforced concrete roof slabs. One-course concrete road, street, and alley pavements. One-course walks and barnyard pavements. One-course concrete floors. Fence posts. Sills and lintels without mortar surface. Watering troughs and tanks. Reinforced concrete columns. Mine timbers. Construction subjected to water pressure, such as reservoirs, swimming pools, storage tanks, cisterns, elevator pits, vats, etc.
<i>1 : 2 : 4 Mixture for</i>	Reinforced concrete walls, floors, beams, columns and other concrete members designed in combination with steel reinforcing.

The Way We Were

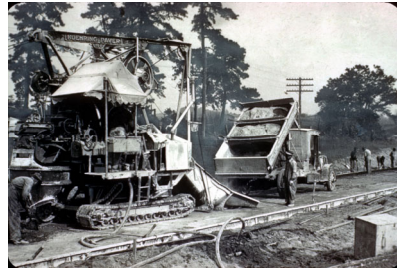
- Proportions
 - Recipes (564/1200/1800/255)
 - ACI 211
 - Guess water
 - Add cement
 - Estimate rock
 - Fill with sand



- Do what you did on the last project

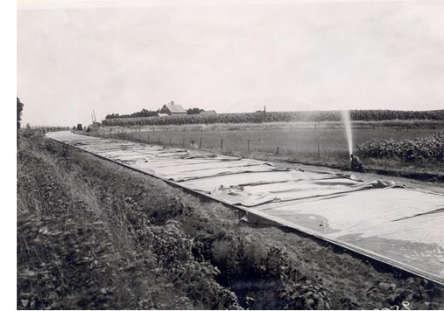
The Way We Were

- Equipment



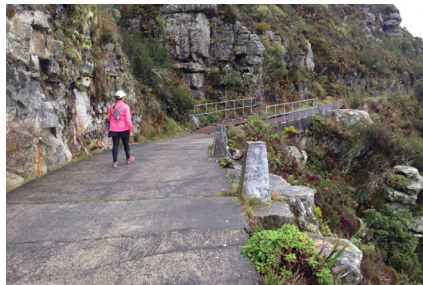
The Way We Were

- Curing



The Way We Were

- Design Life
 - 20 years
 - ...
 - 40 years



The Way We Were

Quality Assurance

- Slump
- Strength
- Thickness



- Air



	1967	2017
No. of ingredients	Cement, water, rock, sand, AEA	Add SCMs, Non-Portland cements, admixtures, intermediate aggregates, limestone...
Opening	Weeks	Days (or hours)
Curing	Weeks	Days
De-icing	Sand, NaCl	Other chlorides, formates, acetates
Design life	20 years	50 years
Knowledge base	In house	Contracted out

Why Bother with Change?

- Current approaches
 - May not measure critical parameters
 - Are often built around previous failures – thereby introducing unintended consequences
 - Limit innovation
- Need to reduce risk of premature failure



Why Bother with Change?

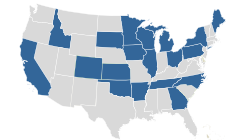
- Economics
- Public perception
- **Sustainability**



The Journey Toward Performance Engineered Mixes (PEM)



- Near the millennium, concerns about concrete durability and poor pavement performance became a common topic of discussion in many concrete intensive states.



What is Good Concrete?

- Constructible (Workable)
- Dimensionally stable
 - Aggregates
 - Shrinkage
- Impermeable (Transport properties)
- Cold weather resistant
 - Freeze thaw
 - Salt attack
- Strong (enough)



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A Better Specification

- Require the things that matter
- Measure them at the right time
 - Prequalification
 - Process control
 - Acceptance



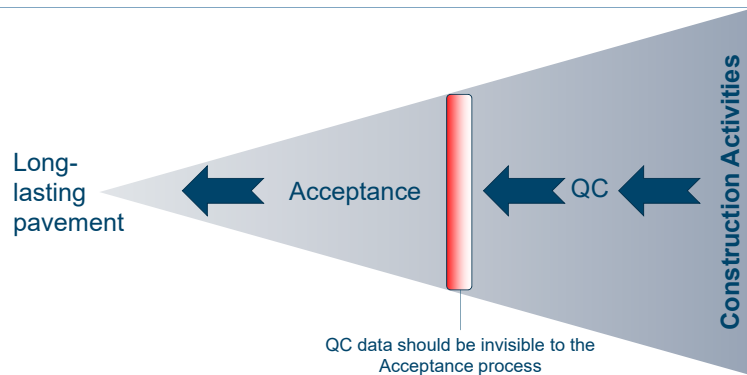
Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures

AASHTO Designation: PP 84-171
 Tech Section: 3c, Hardened Concrete
 Release: Group 1 (April 2017)
 Tech Brief: www.aashtotechbrief.com

American Association of State Highway and Transportation Officials
 404 North Capitol Street N.W., Suite 200
 Washington, D.C. 20001

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The Goal...



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Quality Control and Agency Acceptance

Quality Assurance

Quality Control (circled in red)

Agency Acceptance (circled in red)

Independent Assurance Qualified Labs

Dispute Resolution Qualified Personnel

Learning Outcomes

- Understand the purpose of producer/contractor QC
- Recognize that QC includes both inspection and testing
- Describe the relationship between QC and acceptance



Quality Control

- A good Producer/Contractor QC system:
 - Doesn't try to accommodate Agency requirements
 - Implements QC procedures as a standard practice
 - Isn't just paperwork...it's a mindset
- Uses real time feedback

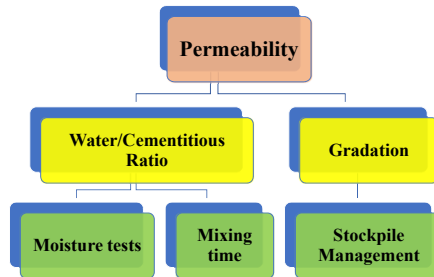


QC Tests are the Building Blocks for Acceptance

Acceptance tests

QC tests

Process control



QC is NOT doing more of what the Agency does for acceptance!



Producer/Contractor Responsibility for QC

- Agencies assumed the QC Responsibility under Method Specifications
- QA Specifications transferred the QC Responsibility to the Producer/Contractor
- Party producing/placing the product controls quality
- Agencies communicate what they are willing to accept
- Agency ensures QC takes place



Scope of Quality Control Activities

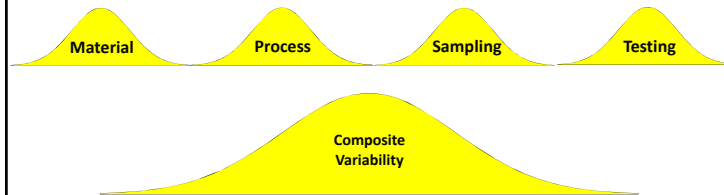
Producer/Contractor's QC system should address:

- Materials production processes
- Materials transportation and handling
- **Field placement procedures**
- Calibration and maintenance of equipment
- Activities (sampling, testing and inspection) to maintain each process in control
- Means to make timely adjustments and corrections



Variability in Quality Control

Material *Process* *Sampling* *Testing*



Quality Control Function

- Should be integrated throughout the organization
- QC not just the responsibility of QC personnel
- Quality can only be achieved by skilled and properly trained workers



QC Personnel Requirements

- QC Laboratory Personnel
- Field QC Technicians/Inspectors
- Production Personnel



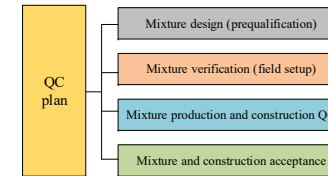
Quality Control Plan

- Project specific document
- Prepared by the Producer & Contractor
- Identifies QC personnel and procedures
- Used to maintain control of production and placement processes



QC for Concrete Pavement Construction

- Implementation of a QC Process



See Section 5 in *Quality Control for Concrete Pavements* (Cavaline, Fick, Innis. 2021)
 heavily based on materials presented in:
Field Reference Manual for Quality Concrete Pavements (Fick et al. 2012)
Integrated Materials and Construction Practices Manual (Taylor et al. 2019)



QC Plan Review Objectives

- QC plan may serve as an extension of the project specifications
- Agency should review the QC plan to ensure:
 - Includes all required items
 - Contains sufficient detailed content addressing project specifics
- When the QC plan is deficient, agency should require revision



Inspection by Production Personnel

- Adopt Safety Culture Philosophy for Quality
- Contractors should strive to create a “Quality Culture” throughout the company
- Personnel are aware of how their actions can affect the quality of the product
- Contractors must invest in the continual education and training of their work force in order to maximize their involvement in Quality Control



Inspection by Production Personnel

- Should take initial responsibility for accepting or rejecting it
- Should always communicate their findings and proposed actions with their QC staff



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Visual Inspection for Quality Control

- Visual inspection is also essential to achieving quality
- Observations and measurement of
 - Equipment
 - Materials
 - Environmental conditions
 - Workmanship
- Prevention based
 - *See something, say something*



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QC Testing

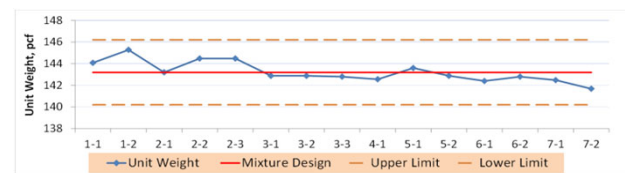
- Testing is not done just for the sake of testing
- Test results are used to assess production consistency
- Use control charts to monitor trends in production
- Control charts are tools to identify when a production adjustment is necessary



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Control Charts

- Used to plot and monitor consecutive test results
- Results can be tracked against a process target/limits
- Can help identify whether the process is in control
- May indicate that adjustments process is necessary



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Concrete Pavement Resources for Industry/Agency/Academia

Quality Control for Concrete Paving: A Tool for Agency and Industry

Improved Quality

Improved Working Atmosphere

Reduced Costs for Agency & Competitive Advantage for Contractor

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DECEMBER 2021

Quality Control Fundamentals

- Introduction to QC

1. PLAN

- identify problems
- define desired outcomes
- identify potential solutions
- develop policies and procedures

2. DO

- test potential solutions
- create process structure
- establish systems
- conduct training
- measure quality characteristics
- collect data

4. ACT

- identify lessons learned
- implement the most promising corrective and preventative actions

3. CHECK

- monitor and analyze data
- study the results
- draw conclusions

"Any product, process, or service can be improved, and a successful organization is one that consciously seeks and exploits opportunities for improvements at all levels." (Swift et al. 1998)

Introduction

In this age of high demands on quality and dependability of engineering materials and systems, and the manufacturer's potential involvement in product liability, *well-developed quality control systems have become an indispensable part of doing business in many industries.* Ready-mixed concrete involves several unique factors which require attention.

QUALITY CONTROL GUIDE FOR READY MIXED CONCRETE PRODUCERS

National Ready Mixed Concrete Association
66 Cedar Street, 3rd Fl., Haverhill, MA 01830
(978) 768-8800 • www.nrmca.org

RMC Research & Education Foundation
Because the best can become better!

Quality Management System for Ready Mixed Concrete Companies

- Part A: Preparation Guidelines for Quality Manual for Ready Mixed Concrete Companies
- Part B: Sample Quality Manual: Global Ready Mixed Company
- Part C: Ready Mixed Concrete Company External Quality Audit Checklist for Compliance with Quality Plan

Parts A and B prepared by:
William C. Tostoy, Jr., P.E.

Part C Developed by the NRMCA P2P Steering Committee

Reviewed and Approved by the
NRMCA P2P Steering Committee

Closing

- Contractor QC is an integral part of QA
- Agencies have various requirements for QC, but those requirements are only minimum provisions
- A successful QC program/plan
 - engages the appropriate personnel
 - manages the necessary processes
 - measures what matters, and
 - uses the appropriate test methods.
- QC required for each project will differ, and approaches will be unique to the contractor
- QC programs achieve success over time, and provide benefits to both agency and contractors

UNC CHARLOTTE

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