American Concrete Institute®
Advancing concrete knowledge

Quality Management Systems in the Concrete Industry Part 2 of 2

ACI Spring 2010 Xtreme Concrete Convention
March 21 - 25, Chicago, IL

ACI WEB SESSIONS

ACI Web Sessions

The audio for this web session will begin momentarily and will play in its entirety along with the slides.

However, if you wish to skip to the next speaker, use the scroll bar at left to locate the speaker's first slide (indicated by the icon in the bottom right corner of slides 9, 28, and 56). Click on the thumbnail for the slide to begin the audio for that portion of the presentation.

Note: If the slides begin to lag behind the audio, back up one slide to re-sync.

ACI WEB SESSIONS

ACI Web Sessions

ACI is bringing you this Web Session in keeping with its motto of "Advancing Concrete Knowledge." The ideas expressed, however, are those of the speakers and do not necessarily reflect the views of ACI or its committees.

Please adjust your audio to an appropriate level at this time.

ACI WEB SESSIONS

ACI Web Sessions

ACI Web Sessions are recorded at ACI Conventions and other concrete industry events. At regular intervals, a new set of presentations can be viewed on ACI's website free of charge.

After one week, the presentations will be temporarily archived on the ACI website or made part of ACI's Online CEU Program, depending on their content.

ACI WEB SESSIONS

ACI Online CEU Program

ACI offers an easy-to-use Online CEU Program for anyone who needs to earn Continuing Education credits.

Once registered, you can download and study reference material. After passing a 10-question exam on the material, you will receive a certificate of completion that you can present to local licensing agencies.

Topics recently added to the program:

- RAP Bulletin 10: Leveling and Reprofiling of Vertical and Overhead Surfaces
- RAP Bulletin 11: Slabjacking
- RILEM Report on Self-Compacting Concrete (Parts 1 and 2)

Visit **www.concrete.org/education/edu_online_CEU.htm** for more information.

ACI WEB SESSIONS

ACI Conventions

ACI conventions provide a forum for networking, learning the latest in concrete technology and practices, renewing old friendships, and making new ones. At each of ACI's two annual conventions, technical and educational committees meet to develop the standards, reports, and other documents necessary to keep abreast of the ever-changing world of concrete technology.

With over 1,300 delegates attending each convention, there is ample opportunity to meet and talk individually with some of the most prominent persons in the field of concrete technology. For more information about ACI conventions, visit www.aciconvention.org.

Chicago, IL, March 21 – 25, 2010

Pittsburgh, PA, Oct. 24 – 28, 2010

ACI WEB SESSIONS

ACI Web Sessions

This ACI Web Session includes 3 speakers presenting at the ACI Xtreme Concrete convention held in Chicago, IL, March 21st through 25th, 2010.

Additional presentations will be made available in future ACI Web Sessions.

Please enjoy the presentations.

ACI WEB SESSIONS

American Concrete Institute®
Advancing concrete knowledge

Quality Management Systems in the Concrete Industry Part 2 of 2

ACI Spring 2010 Xtreme Concrete Convention
March 21 - 25, Chicago, IL

ACI WEB SESSIONS

Thomas Greene is a Regional Technical Services Manager for Grace Construction Products based in Houston, TX. Among his responsibilities are technical support to customers throughout the midwest and southwest U.S., testing and data analysis of new products, troubleshooting concrete problems, and technical training. Tom has worked in the technical aspects of the concrete industry for over 25 years. Prior to joining W.R. Grace, he held technical positions with Rinker Materials and Lone Star Industries. He is active in professional associations including the ASTM International and the American Concrete Institute (ACI), and is a former member of the American Society for Quality (ASQ).

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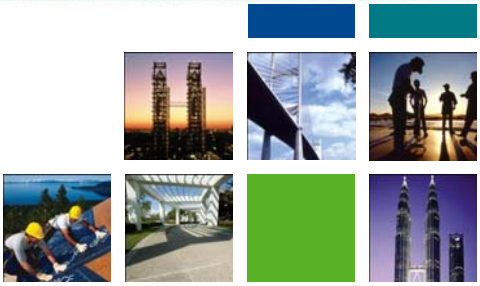

Quality Management Methods for the Manufacture of Chemical Admixtures

Thomas M Greene
ACI Spring Convention
Chicago, IL

GRACE Construction Products

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Quality at Grace

How do we achieve and maintain improvements in Process Capability?

- Standardization: Standard Operating Procedures for the Americas
- Clear Communication, Data Measurement, Analysis and Control
- Focus on Critical to Quality Properties: Dashboard Analysis / Stats Training
- Best Practice Sharing / Technology Standardization / Internal Quality Audits

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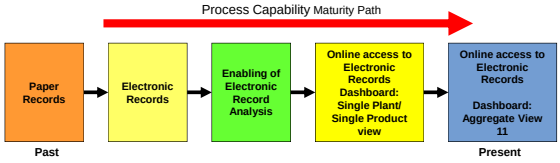
ACI WEB SESSIONS

Quality – Data Visibility Maturity Path



Paper Records
- Difficult to see trends, manufacturing capability, yield (enforces reactive behavior)

Electronic Records
- Data transferred from paper records (lagging)
- SPC analysis possible but is time consuming and resource constrained

Online "Real Time" Electronic Records
- Ability to view SPC / manufacturing capability for products / plants across the regions through automated dashboard (enforces proactive behavior)
- Monthly / Quarterly regional management reviews for Americas
- Standard Global approach to quality metrics via dashboard

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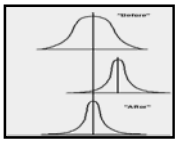
Quality – Visibility to Online & Real-Time Data

- Enhance quality process transparency
- Eliminate over processing
- Improve inventory control
- Meet customer needs
- Improve customer satisfaction
- Produce high quality products quickly
- Robust, simple, standard design



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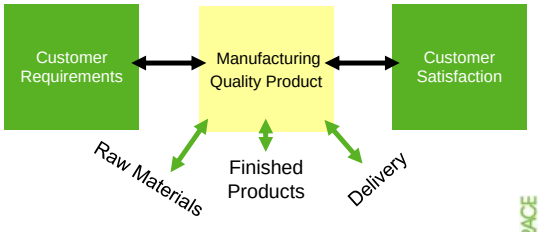
Quality at Grace

Quality Product Manufacturing and Distribution



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Quality at Grace

Customer Requirements

- Voice of the Customer
- Six Sigma tools used to develop products
- Product specifications / test methods
- Consistent product / consistent performance

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Quality at Grace – KPI Identification

- R&D / ASTM define critical to quality properties and specification ranges
- For concrete admixtures the following properties are monitored:
  - pH
  - Specific Gravity
  - Total Solids
  - Appearance
  - Chloride Ion Content

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Quality at Grace

Manufacturing

Raw Materials

- Raw material suppliers are required to submit QA programs for review.
- Supplier scorecards maintained and monitored for conformance / capability / logistics
- Raw material dashboard developed to track raw material performance metrics
- Supplier Corrective Action process documented to ensure root cause identification and corrective action implementation

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Quality at Grace

Manufacturing

Raw Materials

- Raw material inventories constantly monitored for formula compliance verses actual quantity batched. Variations indicate meter, operator or raw material inconsistencies and must be reported and investigated immediately.
- RM Inventory cycle counts compared with electronic inventory data and variation is also used to identify process inconsistencies.

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Quality at Grace

Manufacturing

Finished products

- Online and real-time dashboards utilized to improve manufacturing capability
- QC / QA testing (critical KPI's tested and monitored)
- Process Institutionalization (Standardized Operating Procedures for all plants)
- All manufacturing meters, scales and lab equipment are calibrated at a minimum annually and monitored for consistency daily. Any deviations detected are investigated until the source of the variation is identified and resolved.

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Quality at Grace

Manufacturing

Finished products

- Raw material storage and production batches sized to customer demand and where possible made to order
- Inventory control of finished product and raw materials through Sales & Operations Planning process (S&OP)

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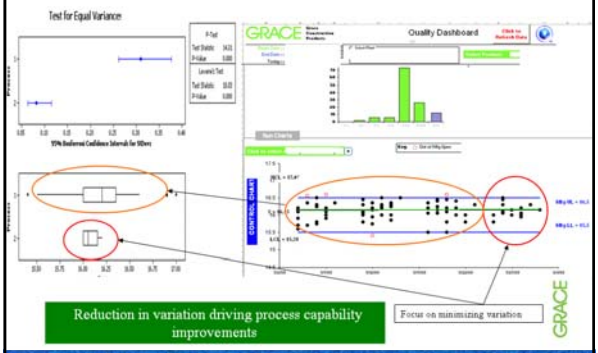
Quality – QA Dashboard



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Quality at Grace

Manufacturing

Delivery and Distribution

- FIFO (First-in, First-out inventory control)
- On-time delivery (service metrics tracked to request and promise)
- Invoicing process tracks and control orders to ensure invoicing accuracy

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Quality at Grace

Customer Satisfaction

Leading Measures

- QA Dashboard (online and real-time statistical monitoring)
- Capability Analysis / Continuous Improvement (variation reduction – establish realistic targets and set accountability to achieve goals)
- First Pass Yield (Goal 100%)

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Quality at Grace

Customer Satisfaction

Lagging Measures

- Customer Complaint / Action Request Database –track and log all customer and internal complaints to ensure root cause and corrective action correctly implemented
- Root Cause Failure Analysis / Root Cause Corrective Action –training to ensure we get to root cause and implement an effective resolution

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Quality at Grace – Summary

Incoming Raw Materials	SOP's	Calibration	QA Testing
• Measure and control variation up front • Supplier Scorecard – Monitor Supplier Performance • SCAR (Supplier Corrective Action Request) to document root cause and corrective action • Raw Material Database – Statistically evaluate raw material performance / Supplier capability for continuous improvement initiatives	• Standardized operating procedures eliminate batch to batch and plant to plant variability • Audits to ensure conformance • Product consistency in performance and appearance • Drives variation reduction	• Ensures we consistently manufacture to formula requirements • Meter / Equipment Variation tracked in numerous systems to ensure rapid detection and repair	• Standardized equipment and procedures for sampling reduces variation • Regular measurement system analyses (Gage R&R) to confirm repeatability and reproducibility and accuracy/precision of testing equipment

Field Technical Services Group Conducts Audits

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Quality at Grace – Summary

- Improved visibility through online and real-time data dashboards enables statistical monitoring to identify and reduce variation which allows better control for production of consistent quality product
- Key sources of variation that have been identified for control and improvement include raw materials, operating procedures, meters / scales for batch production and quality assurance / quality control procedures and testing equipment
- Statistical monitoring allows movement of Grace's Quality Organization to become more predictive verses reactive (helping prevent product quality issues up front)

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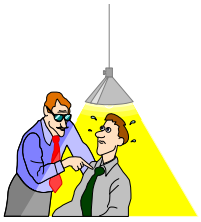
Quality at Grace

Thank You!



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Paul Brooks has more than 27 years of experience in the concrete industry, specializing in sales and technical services. He is currently a Senior Technical Manager with Holcim (U.S.). He also serves as Second Vice President of The Concrete Industry Board, and is a member of ACI Committees 121 (Quality Assurance Systems for Concrete), 229 (Controlled Low-Strength Materials), and 233 (Ground Slag in Concrete).

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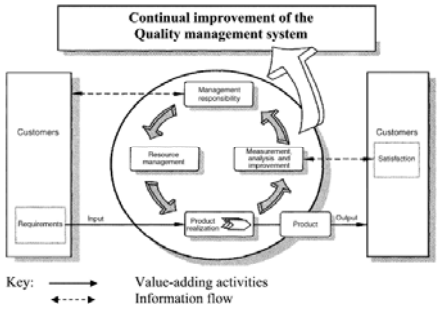
Quality Management System (QMS)

Quality
Management
System
in accordance with the
ISO 9001 Standard

ACI WEB SESSIONS

Quality Management System



ACI 121 R -08

ACI WEB SESSIONS

ISO 9001 Customer Impact

- This International Standard specifies requirements for a quality management system where an organization
  a) needs to demonstrate its ability to consistently provide product that meets customer and applicable regulatory requirements, and
  b) aims to enhance customer satisfaction…
- Customers play a significant role in defining requirements as inputs. Monitoring of customer satisfaction requires the evaluation of information relating to customer perception.

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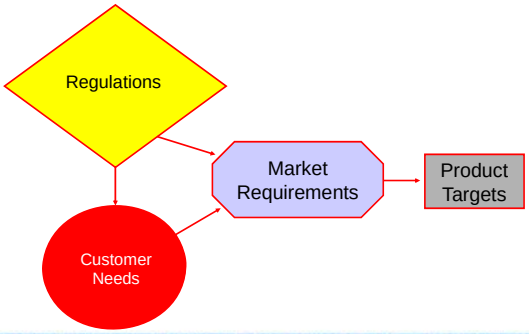
Quality Begins with Customer Needs and Statutes



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Statutes

- DOTs and Industry
  - What Standard?
    - ASTM, AASHTO
  - What Type?
    - I,II,III
  - Optional Tables
    - (i.e., Alkali level, Heat of Hydration, High Sulfate Resistance)
  - Specific State Requirement

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Customer Needs

- Sales' Knowledge of Customer
  - General needs in the marketplace
    - Set times, early strength, 28 day
- Competitive Position
  - Performance vs. Competition
    - Evaluate competitors' performance
    - Compare against individual product performance

ACI WEB SESSIONS

Component in Concrete

- Judged by customer's product - Concrete
- Influenced by other components in mix
  - Slag, Fly Ash
  - Aggregate Changes
  - Admixture Adjustments
- **Provide a consistent and predictable quality level**

ACI WEB SESSIONS

Establishing Targets – All Starts with Concrete

Concrete Targets
Customer Data, In-house Testing, Competitive Position, Admixture Use, Specifications

Cement Performance Targets
Cube Strengths, Flow, Set Time,
ASTM C 150, 595, 1157
AASHTO M 85, 240

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Establishing Targets and Key Performance Indicators

- Manufacturing and Marketing Agree on Targets for Each Plant by Product
- Signed Off by both Marketing and Manufacturing
  - Actual performance of product measured against targets
  - Tied to performance review

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Plant Quality Assurance

Merger of Internal and External Quality Measurements

Cement Performance Targets
Contract with Marketing
↓
Finished Product Makeup
Physical, Chemical Results
↓
Clinker
Chemistry, Physical Makeup
↓
Raw Material
Chemistry, Fineness

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Plant Internal Targets Established

- Based on Concrete Targets
  - Plant establishes internal targets
- Agreement between Plant Production Manager and Quality Control Manager

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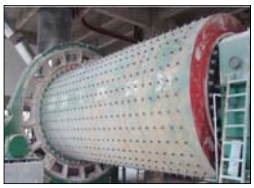
Raw Material Tests

- LSF
- C3S
- CaCO3
- SR
- AR
- Al2O3
- Fe2O3
- MgO
- Alkali
- Moisture [%]



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Clinker Tests

- LSF [%]
- C3S [%]
- SR [%]
- AR [%]
- C3A [%]
- Free lime [%]
- Alkali-Sulfur Ratio

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Finished Cement Tests

- C3S [%]
- C3A [%]
- MgO [%]
- SO3 [%]
- Free lime [%]
- LOI [%]
- 45 µm (-325) [%]
- Blaine [m2 / kg]
- Air [%]
- Pack Set
- Alk [%]
- Color

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ASTM C-150/AASHTO M-85 Tests

- Strength
- Set Time
- Fineness
- Heat of Hydration
- Auto Clave Expansion
- False Set
- Sulfate Expansion
- Chemical Requirements

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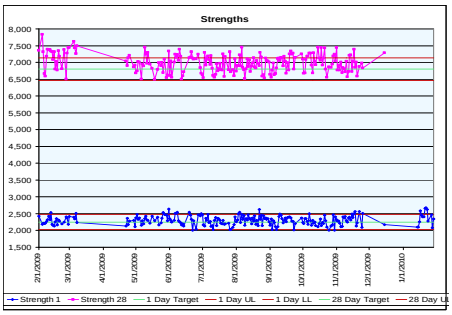
Strengths



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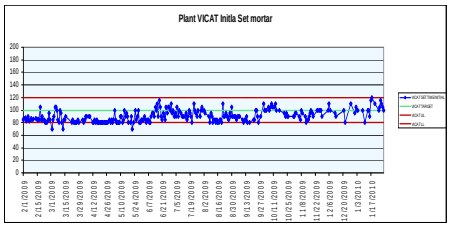
Plant Vicat- Initial Set Mortar



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Concrete Testing

- Each plant tests concrete regularly
  - All testing linked via data tracking system
  - Customized or standard reports
- Competitors
  - Regular Basis
- Specific mix designs upon request

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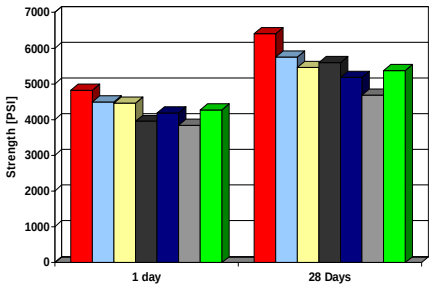
Competitive Concrete Strengths



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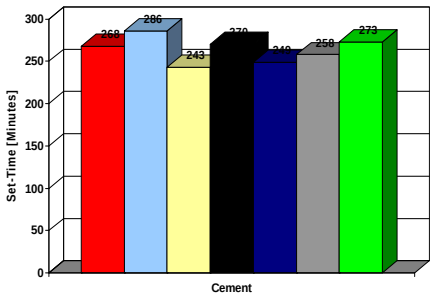
Concrete Set-time



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Retained Samples of Cement

- Daily sample from all shipping points
- Hold for 90 days or longer

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Reporting

- Data Management System
  - Each step of production tied to the next, including concrete
- Real Time, Weekly, Monthly, Quarterly Reports
  - Concrete results
  - Mortar results
  - Quality scorecard
- Easy Customization

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Quality Scorecard

Region							
January 2010	Comparison to Targets			Variation	Comparison to Benchmark		
Cement Plant	Early Strengths	28 Day Strengths	Set Time	28 Day Strengths	Early	28 Day Strenghts	Set Time
Plant A	90.7	94.3	-18	5.7	79.8	98.8	-13
Plant B	109.4	90.6	0	3.6	101.0	92.1	0
Plant C	104.1	98.6	12	4.6	113.2	98.6	23
Plant D	116.1	104.6	2	3.1	111.3	115.0	3

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Real Time Complaint Log

- Tracks any customer complaints
  - Follow through to resolution
  - Point for plant evaluation
  - Customized reporting

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Quality Councils

- Quarterly Review of Product's Performance
  - Sales VP, Quality VP, GM's, Technical, Plant Personnel, Sales Rep
- Position Against Targets
- Competitive Placement
- Complaints
- Change in Market
  - New job requirement
  - New industry or DOT regulation

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Questions?

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Thank You

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Eric Koehler, Ph.D., is a Senior Research and Development Engineer at W.R. Grace & Co. in Cambridge, MA. He obtained his Ph.D. in Civil Engineering at the University of Texas at Austin, and has conducted research in rheology, self-consolidating concrete, and construction aggregates.

Eric is an active member of the American Concrete Institute and ASTM. He can be reached at eric.koehler@grace.com.

ACI WEB SESSIONS

In-Transit Process Control for Quality Management in Ready Mixed Concrete

Eric Koehler, W.R. Grace & Co.
Joe Sostaric, RS Solutions LLC
Tim Durning, W.R. Grace & Co.

ACI Spring Convention | March 24, 2010

ACI WEB SESSIONS

Outline

- **Potential variability in ready mixed concrete production**
- **On-board process control for quality management**
- **Experimental testing**
  - Slump measurement
  - Water management
  - Mixing of water
  - Compressive strength standard deviation
- **Conclusions**

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Introduction

- **Numerous potential variations during ready mixed concrete production can affect concrete performance**
  - Constructability
  - Mechanical properties
  - Durability
- **Ready mixed concrete producers minimize variations and ensure that the performance is achieved through:**
  - Quality control programs
  - Standardized production procedures
  - Overdesign in compressive strength
- **Engineers and owners ensure performance is achieved through:**
  - Intelligent specifications and codes
  - Quality assurance programs
- **The current process is people-dependent and not process-dependent**
- **On-board process control can automate and document ready mixed concrete production and delivery**

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Potential Variations During Ready Mixed Concrete Production

Potential variations can occur from initial batching to final delivery

Batching
- material quality
- material condition
- material quantity
- residual material in drum

Mixing
- rotation speed
- number of revolutions
- mixing time
- mixer geometry
- load sequence
- concrete type

Delivery
- transit time and jobsite delays
- extent of mixing
- ambient and concrete temperature
- jobsite-added water

Different individuals have different responsibilities for production

Batch Operator
- Load proper ingredients
- Correct for aggregate moisture
- Ensure proper initial mixing (central mixer)

Driver
- Adjust load after batching
- Ensure proper mixing and agitation

Contractor/Purchaser
- Request additional water
- Set timing of discharge

Meanwhile, the concrete itself changes over time

Workability changes with time, temperature, mixing, initiation of setting

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Water Control

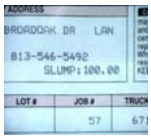
Potential batch-to-batch variations in water are often most consequential.

- Batch water is accurately measured.
- Other water sources, such as aggregate moisture, are less accurately measured.
- Therefore, setting the correct target batch water is challenging and adjustments are typically made after ingredients are loaded and mixed.

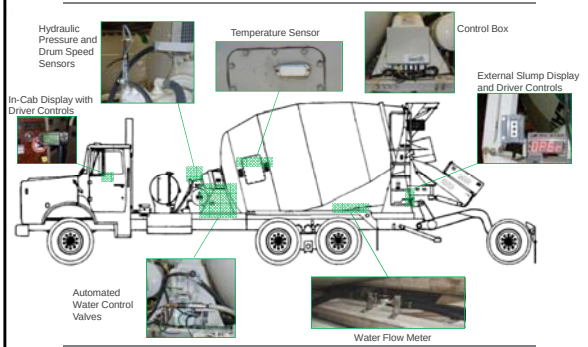
Potential Sources of Water in Batch (% of total water)		
Batch Water	60-90%	accurately tracked
Metered Truck Water	0-10%	
Aggregate Free Water	10-30%	inaccurately tracked
Wash Rack Water	0-5%	
Driver Manual Hose Water	0-5%	
Residual Drum Water	0-10%	

On-Board Slump Management System (SMS)

- **This presentation shows the Verifi Slump Management System (SMS)**
  - Receives ticket/load information electronically
  - Continuously measures slump and temperature of concrete in mixer
  - Provides feedback to batch operator
  - Automatically adds water to adjust slump
  - Prompts driver to ensure concrete is fully mixed
  - Documents delivery process
- **Concrete arrives on jobsite at correct slump and with adjusted water content**

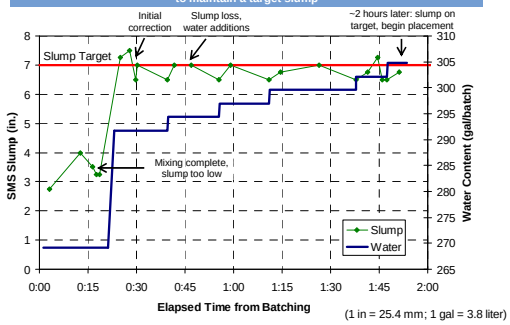


On-Board Slump Management System (SMS): Components



On-Board Slump Management System (SMS): Delivery Cycle

SMS adjusts water and admixture from batching through delivery to maintain a target slump

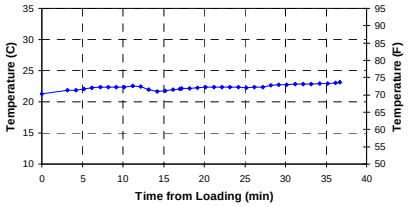


(1 in = 25.4 mm; 1 gal = 3.8 liter)

On-Board Slump Management System (SMS): Temperature

Measurement of temperature throughout delivery can be used to:

- Monitor concrete temperatures throughout the delivery cycle to comply with specification
- Predict concrete slump loss and set times



On-Board Slump Management System (SMS): Documentation

Documentation of load can be used internally and provided to owner and engineer

- Concrete temperature
- Slump measurement
- Water added
- Mixing
- Event times

Example

(1) Initial slump target was 75 mm.

Truck No.	Plant No.	Date	Ticket Time	Ticket Number	Slump	Load Size
		6/6/08	8:21 AM		75 mm	6.0 m^3

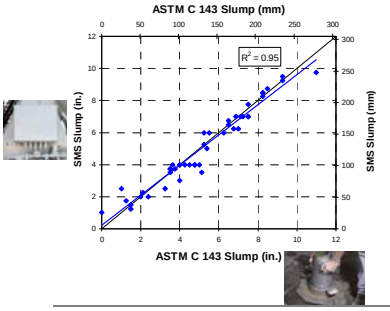
	At Plant Initial Slump	At Plant Adjusted Slump	Leaving Plant	Arriving at Job	Starting to Discharge	During Discharge	Return to Plant	Unknown	Totals
Timestamp	8:40:07	8:40:21	8:40:44	9:04:13	9:10:58	9:19:08	9:44:48	N/A	00:51
Slump (mm)	145	150	150	130	210	210	N/A	N/A	N/A
Auto H2O-Adds (l)	N/A	N/A	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Manual H2O-Adds (l)	N/A	N/A	0.0	0.0	80.3	0.0	0.0	0.0	80.3
Hose H2O-Adds (l)	N/A	N/A	0.4	0.4	0.4	0.0	70.0	0.0	71.2
Drum Count (Total)	N/A	35.6	2.7	118	46.3	0.3	72.3	0	275

(2) But batch operator added too much water and exceeded slump.

(3) Contractor added 80 L of water on site to bring slump to 210 mm.

Experimental Testing: Slump Measurement

SMS slumps match ASTM C 143 manual measurements



Testing conducted on 3 trucks at 2 plants

Initial calibration of each truck conducted on limited set of mixtures

Slump measurement was accurate across much wider range of mixtures and test conditions

- Materials (cement, SCMs, aggregates, HRWR, VMA, AEA)
- Mixture Proportions
- Unit Weight (110 – 150 lb/ft³)
- Multiple Locations
- Load Size
- Transit vs. Stationary

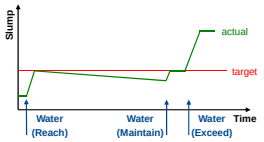
Water Control

Water added during transit can be split into:

1) Water to Reach Target Slump
- Due to uncertainty in water added during batching, additional water may be added to reach the target slump
- Adjusting water content to a consistent target slump is one way to reduce variation in water content; truck added water to reach initial slump may not be counted towards w/c
- Batch operators conservatively hold water and adjust up later
- In wet-batch (central mix) plants, most if not all of this water is added to central mixer
- In dry-batch plants, this water can be added at any time during delivery, but typically at the plant

2) Water to Maintain Target Slump
- Water is added to compensate for slump loss
- Mixture proportions should be set so that this water can be added without exceeding the maximum w/c

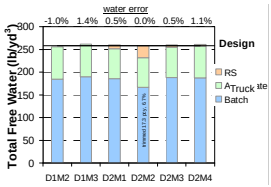
3) Water to Exceed Target Slump
- Water typically added at contractor's request for ease of placement



Water/cement ratio may not be measured directly depending on uncertainty in amount of water initially batched. Manage w/c by:
- Ensuring target slump corresponds to design batch water.
- Setting mixture proportions so that water to maintain slump can be added without exceeding w/c. Enforce maximum allowable water.
- Not allowing water to be added for other reasons.

Experimental Testing: Water Management

- Control of water by adjusting to a constant slump was evaluated by
  - Measuring water content from all sources
  - Setting on-board slump management system to adjust all loads to a constant slump
- By withholding water and then adding water after batching to reach target slump, variation in water content is reduced
- If initial slump exceeds target, this additional water can be counted towards water to maintain slump

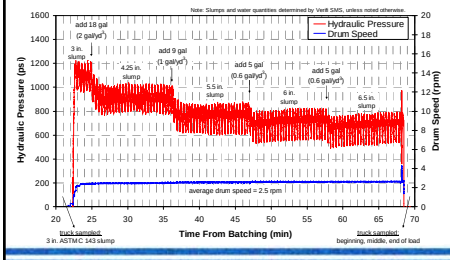


By controlling to constant slump, variation in total water was less than +/- 1.5% for 6 loads tested over 2 days

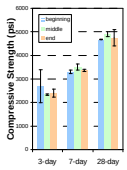
Experimental Testing: Mixing of Water in Transit

- On-board slump management system adds water in route to maintain slump
- Test data shows water is fully mixed even at agitation speed
- Truck can arrive at jobsite on slump and ready to pour

Change in raw hydraulic pressure readings after water addition.

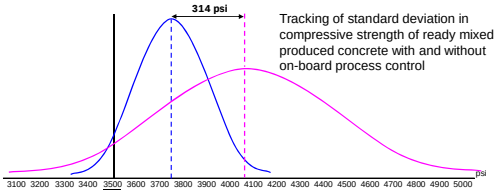


Compressive strength measured throughout final discharge

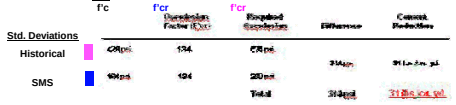


Experimental Testing: Reduced Variability in Strength

Reduced Variability = Reduced Overdesign = Less Cement = Reduced CO_2 Emission



Tracking of standard deviation in compressive strength of ready mixed produced concrete with and without on-board process control



Conclusions

- New, truck-mounted process control technology is available to automate and document concrete production, thereby reducing variability in final product performance and enabling easier production of high technology concrete mixtures
- Test results showed that
  - Slump calculation provided by the on-board process control technology was correlated to manual ASTM C143 slumps over a range of mixtures and materials
  - The on-board process control equipment was capable of managing a load of concrete to constant slump by adjusting water
  - Water could be mixed uniformly through the load even at agitation speed
  - Greater control of water resulted in less standard deviation in compressive strength

Thank You

Related Documents

Quality in Concrete Construction

- ACI 121R-08: Guide for Concrete Construction Quality Systems in conformance with ISO 9001
- ASCC-1(05): The Contractor's Guide to Quality Concrete Construction
- ACI 363.2R-98: Guide to Quality Control and Testing of High-Strength Concrete
- SP-2(07): Manual of Concrete Inspection
- ACI 311.4R-05: Guide for Concrete Inspection
- ACI 311.5-04: Guide for Concrete Plant Inspection and Testing of Ready-Mixed Concrete
- ACI 311.6-09: Specification for Ready Mixed Concrete Testing Services
- SP-229: Quality of Concrete Structures and Recent Advances in Concrete Materials and Testing

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Related Documents

Quality in Concrete Construction

- ACI 301: Specifications for Structural Concrete
- ACI 228.1R-03: In-Place Methods to Estimate Concrete Strength
- ACI 214.4R-03: Guide for Obtaining Cores and Interpreting Compressive Strength Results

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