CP5 – Troubleshooting Precast Production

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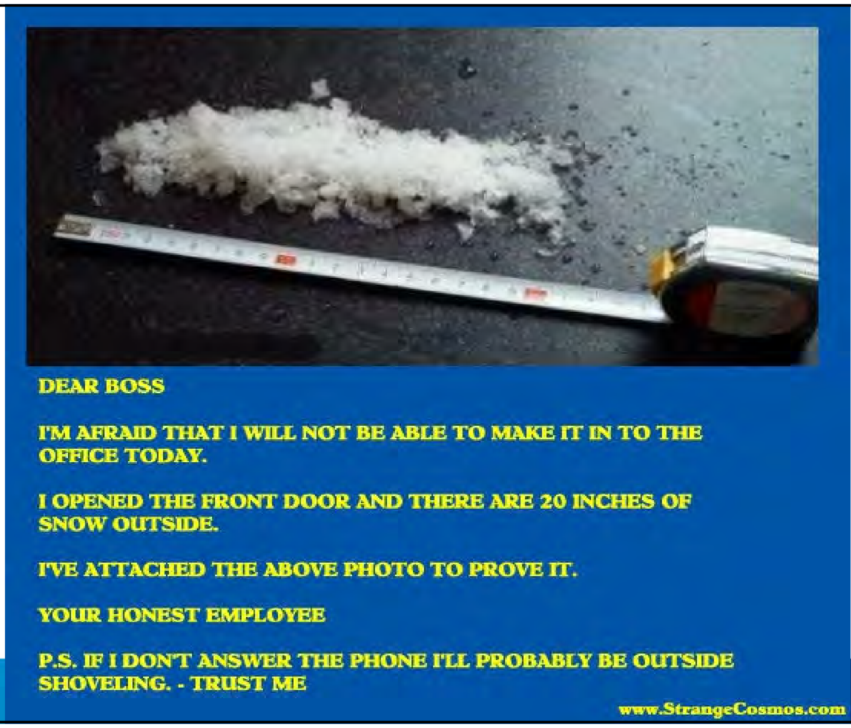
1



2

Houston, We Have a Problem – Now What?

3

Why is it so Challenging to Solve Some Problems?

4

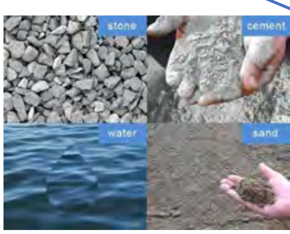
Overview

Need = Expectations → Design → Project

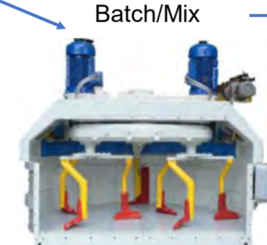
5

Overview

Raw Materials



Batch/Mix



Transport

Cast/Place/Consolidate

Set-Up Forms/Molds

6

Overview

Ship and Install → Owner = Happy

Remove/Handle/Store

7

Overview

- Every step matters!
- Every step in the process is a chance to improve quality or degrade it
- Consistency matters!

8

What Are Some of Your Challenges?

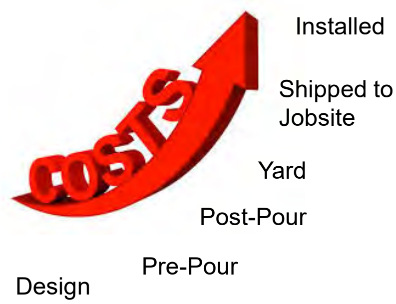
9

Troubleshooting/Problem Solving

10

When is the best time to have a problem?

- At the plant before batching?
- At the plant after batching?
- At the bed before casting?
- At the bed after casting?
- Before you ship?
- After you ship to customer?
- When you get a call from a lawyer?



11

Troubleshooting, Problem Solving & Process Improvement

Troubleshooting
- Designed for “Somebody is mad at me” situations
- Time is of the essence
- Problems that can be solved in a few minutes, hours, or before the next batch

Problem Solving
- Used for more complex problems
- Typically require data analysis and team approach
- May involve processes, products, services or more

Process Improvement
- Ongoing activity
- Typically involves small changes in order to improve output or performance
- Recognized Programs:
  - Total Quality Management (TQM)
  - Six Sigma

12

Trouble Shooting

- Time-sensitive (often need a decision/remedy quickly)
- Have an internal plan (e.g. fire, medical emergency, concrete emergency)
  - Plant-Specific Quality Control Manual (NPCA)
  - Quality Systems Manual (PCI)
- Clear chain of decision makers
- SOP for high-potential issues
- Reach out to your Precast Specialist or Admix rep

13

Problem Solving vs. Process Improvement

Problem Solving

- Identify and quantify the problem
- Assign project team
- Gather and analyze data, and establish measures
- Diagnose cause(s) and ascertain whether cause is sporadic (special) or endemic (common)
- Address cause(s)
- Develop action plan
- Implement plan and prevent recurrence
- Start another problem-solving project

Process Improvement

- Identify and quantify the opportunity
- Define the process and the scope of the project
- Analyze the current process
- Think about future process(s)
- Generate and assess alternatives and recommend changes
- Try out and verify effectiveness of changes
- Implement changes, standardize
- Hold the gains!

14

Using a Process-Driven Method

Six Sigma Methodologies

- Intended for existing process - DMAIC
  - Define
  - Measure
  - Analyze
  - Improve
  - Control

- In other words…ROOT CAUSE ANALYSIS

15

Defining The Problem

- This is the most important part of the procedure, but also sometimes the most difficult to truly ascertain
- The "real" problem is often different from what is initially described
  - Communication difficulties
  - Language barriers
  - Different "slang" terminology
- Develop the problem statement and review it with the appropriate person
  - "The Problem appears to be…
    - low strength" (cylinder strengths were low)
    - retardation" (couldn't strip forms in the morning)
    - high air content" (strength was low and concrete felt "spongy")

16

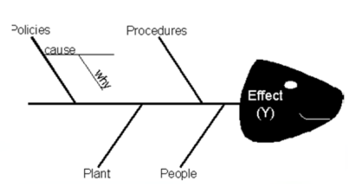
Measurement

- The "True" Process is identified and documented
  - Process steps and corresponding inputs and outputs are identified
- Establish baselines
  - Determine what should be measured and how it will be measured
  - Collect data (internal, external)
  - Identify gaps between current and required performance
- Development of a map of all interrelated business processes
  - Look to clarify areas of possible performance enhancement

17

Analysis

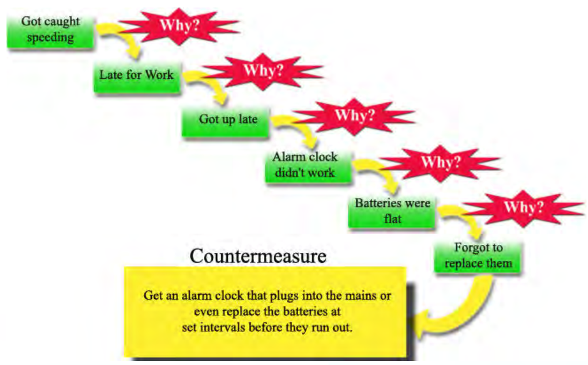
- Primary Objective: Identify the root cause of the Problem
  - 5 Whys
  - Fishbone Diagram
  - Others?
- Multiple root causes may be identified via root cause analysis



18

When 5 Whys is Most Useful

- When problems involve human factors or interactions
- In day-to-day business (or personal) life
  - 5 Whys can be used with or without a project



19

Several Considerations

Materials
OPC
SCM
Aggregates
Fibers
Admixtures
Water

Equipment
Material Haulers
Yard Equipment
Batch Plants
Mixers
Jobsite Equipment

Processes
Material Handling
Material Sequence
Batching
Transporting
Placing
Finishing
Curing

People
Managers
Equip. Operators
Batch Operators
Drivers
Production
Finishers
Testing Labs
Engineers
Owners

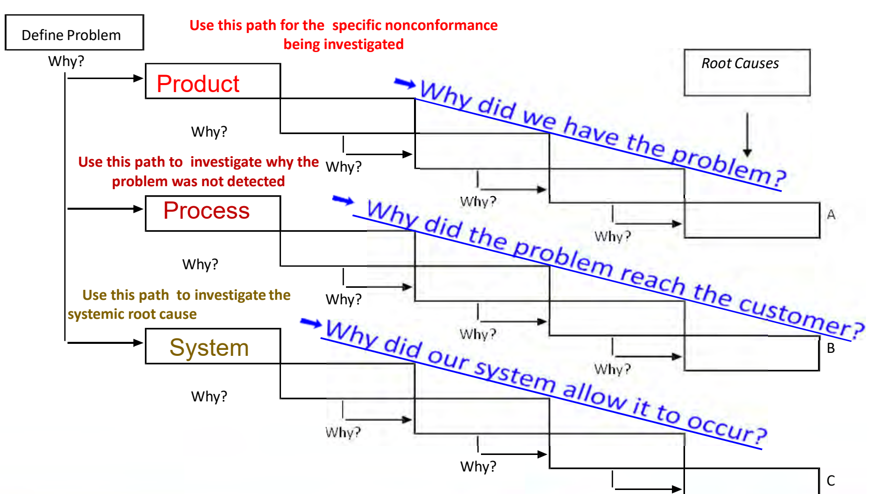
20

Multiple-Legged 5 Whys

Now we know what happened to the concrete, but how did it get to the customer?

21

Multiple-Legged 5 Whys



22

5 Whys Concrete Example:

Background: While testing concrete on a large project, QC reports that the mixture's slumps are "all over the place"

- Question: Why is the concrete performing inconsistently?
  - Answer: I don't know. (they rarely do)
  - Note, the question is vague, may be too open ended, and posed to the wrong person.

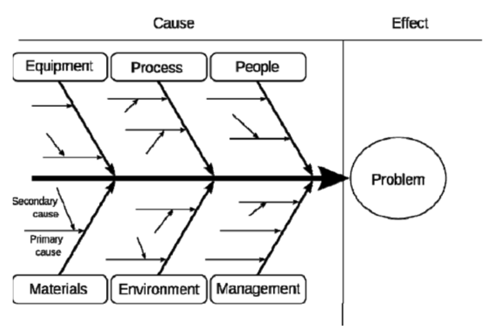
Meanwhile at the batch plant…

- Q1: Why is the slump inconsistent?
  - A: Because there are different amounts of water in the mix.
- Q2: Why is the water content changing?
  - A: Because the batchman has to adjust the water content manually by the load.
- Q3: Why does the batchman have to adjust the water manually by the load?
  - A: Because the moisture probes are broken and haven't been fixed/replaced?
- Q4: Why have the moisture probes not been fixed?
  - A: Because we haven't had enough time to fix the probes.
- Q5: Why haven't we had the time to fix the probes?
  - A: Because we have to meet Production goals.

23

Fishbone Diagram (Cause and Effect)

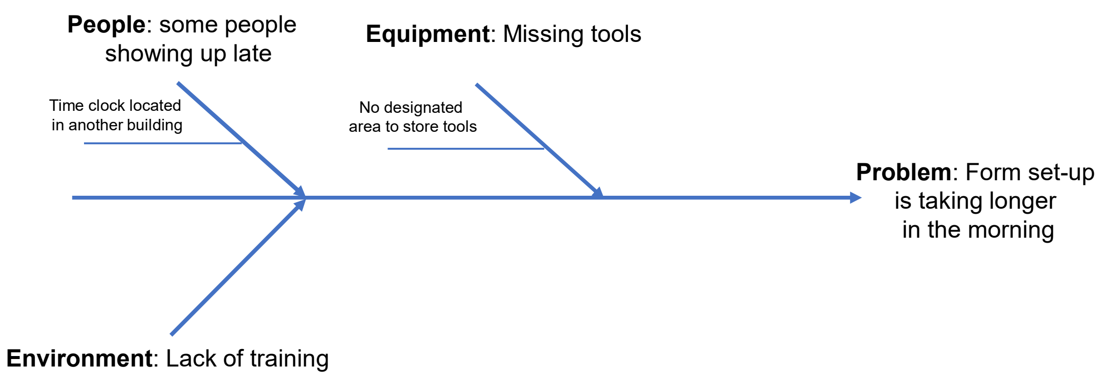
- Help to identify the likely <u>causes</u> of the problem(s)
  - Helps user to think through causes more thoroughly
  - Major benefit: it pushes user to consider all possible causes of the problem(s), rather than the ones that are more obvious, the ones the user "wants", or that of "opinions"
- Helpful in identifying problems with more than one significant root cause



Promotes "System Thinking" through visual linkages.

24

Using the Fishbone



25

The End Game - Process Control

In Summary:

- A systematic approach to solving problems
- Identify and Define the real issue
- Use the tools to determine cause and effect
- Develop a plan for measurable improvements
- Make adjustments one at a time
- Sometimes experimentation is in order
    - Alternate Materials
    - Alternate Equipment
    - Alternate Process
    - Alternate People

26

A Few Case Studies

27

The HRWR isn't working

- Inconsistent slumps
- Batch the same mix all day
- Dosage is "normal"
- Dispensers are working correctly
- Slumps vary from 3" to 9"
- Moisture is "tested" and recorded every few hours

28

The HRWR isn't working

- Six Sigma team determines:
  - The moisture testing equipment isn't calibrated

29

Bleeding Gatorade

- Residential builder experienced extended setting on a project.
- Believes that RMC used fly ash in what is supposed to be straight OPC mixes
- Petrography shows no signs of fly ash
- Contractor convinced they did everything by the book.

30

Bleeding Gatorade

- Contractor noticed that bleeding from the slab was green
- *"We've never seen this before"*
- *"It must be what the problem is because…*
- *…We've done everything by the book.*

31

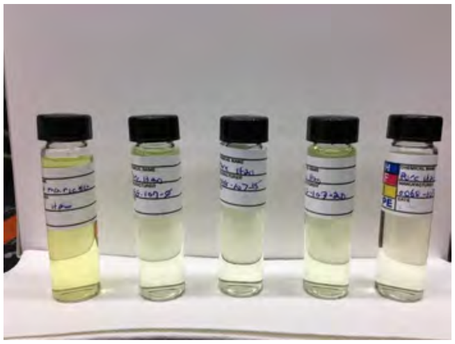
Bleeding Gatorade

The green bleed water 319-0311-1 absorbs in the Ultra violet light at 273 and 371 nm, with the absorption at 371 giving rise to a yellow color. **The measured fluorescence, represents the absorption of light (excitation) at one wavelength and emission at a different wavelength. There are two excitation bands, at 299 and 313 nm** – neither of which are observed in the absorbance spectrum. Likely it is too small to be observed with the UV-vis instrumentation. If the sample is exposed to light at either 299 or 313 (both of which are present in natural day light – but are out of visible range so cannot be seen) the sample emits light at 447, in the blue range. **The combination of absorbing and emitting gives the distinctive fluorescent green/yellow color.**

32

Bleeding Gatorade

XRF analyses of the cement sample indicated chromium level 0.08%. By comparing this figure with some recent cement clinker analyses (typically 0.01-0.03%) it appears this particular cement has a noticeably higher chromium figure than is typically observed.



Chromium solutions are known to exhibit distinctive fluorescent green/yellow color.

RMC Producer: What's up with the Chromium?
OPC Supplier: Oh yea, it's been running pretty high lately. I meant to call you.

33

Materials

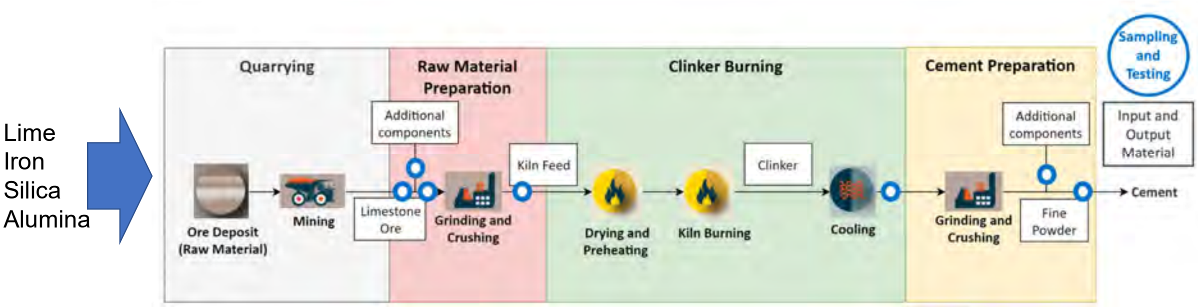
34

Cement

35

What is Cement?

Hydraulic Cement is the binder in concrete



CO2 Release

36

What Happens When Cement and Water are Mixed Together?

Hydration – is an exothermic, chemical process that creates Calcium-Silicate-Hydrate (CSH gel) the binder in concrete.

37

Hydration

- **Tricalcium Silicate (C_3S)** - Hydrates and hardens rapidly and is largely responsible for initial set and early strength.
- **Dicalcium Silicate (C_2S)** - Hydrates and hardens slowly and contributes largely to **strength increase at ages beyond one week**
- **Tricalcium Aluminate (C_3A)** - Liberates a large amount of heat during the first few days of hydration and hardening. It also contributes slightly to early strength development. Gypsum, which is added to cement during final grinding, slows down the hydration of C_3A. Without gypsum, a cement with C_3A present would set rapidly. **Cements with low percentages of C_3A are especially resistant to soils and water containing sulfates.**
- **Tetracalcium Aluminoferrite (C4AF)**- Reduces the clinkering temperature, thereby assisting in the manufacture of cement. It hydrates rather rapidly but contributes very little to strength. **Most color effects are due to C_4AF** and its hydrates.

38

Composition & Fineness of Portland Cements (% by mass)

Type	C_3S	C_2S	C_3A	C_4AF	Blaine Fineness m²/kg
I Normal	57.5 49-62	12.7 9-16	9.3 7-11	7.3 4-11	397.2 375-440
II Sulfate Resistance	59.1 51-68	12.7 7-20	6.4 0-8	10.3 7-13	392.7 305-471
III High-Early	58.0 49-66	13.5 7-20	7.3 4-14	9.1 4-12	560.8 365-723
IV Low Heat	42.2 37-49	31.7 27-36	3.7 3-4	15.1 11-18	339.5 319-362
V High sulfate Resistance	59.2 52-63	14.6 8-22	4.1 2-5	11.7 9-15	401.1 302-551
White	62.7 50.5-72.4	17.8 9.3-25.2	10.4 5.2-12.6	1.0 0.7-1.8	482.4 384-564

PRECAST SHOW

39

Material Certification Report

MILL TEST RESULTS
Laboratory:

Date: June 2022
Cement Type: I Portland

CHEMICAL DATA

ITEM	LIMIT	RESULT
Silicon Dioxide (SiO_2) %	***	20.38
Aluminum Oxide (Al_2O_3) %	***	5.75
Ferric Oxide (Fe_2O_3) %	***	2.05
Calcium Oxide (CaO) %	***	63.38
Magnesium Oxide (MgO) %	<=6.0	3.58
Sulfur Trioxide (SO_3) %	<=3.5*	3.56
Loss on Ignition (LOI) %	<=3.0	1.71
Sodium Oxide (Na_2O) %	***	0.13
Potassium Oxide (K_2O) %	***	1.12
Total Alkali %	***	0.87
Insoluble Residue %	<=0.75	0.40
Limestone	<=5.0	
L Color		63.78
Potential Compounds		
C_3S	***	51.0
C_2S	***	20.0
C_3A	***	12.0
C_4AF	***	6.0

PHYSICAL DATA

ITEM	LIMIT	RESULT
% Air Content		7.10
Blaine (cm^2/g)	>=2800	3880
% Pass 325 Mesh	***	93.60
14 day C1038 Expansion %*	<=0.020%	0.001
% Autoclave Expansion	<=0.80	0.35
Compressive Strength		
1 day	***	2955
3 day	***	3870
7 day	***	4615
28 day	***	5750
Time of set		
Vicat		
Initial(minute)	45>X<375	97
PFS		77.00

PRECAST SHOW

40

Create a Mill Cert. Control Chart

- Since the raw materials are dug out of the ground, their consistency will vary
- Mixture proportions of the raw materials must be continually adjusted, Therefore, the cement characteristics will vary
- Track your Cement

Cement Certification Control Sheet

Cement Supplier:

Cement Plant Location:

Cement Type:

Date Received	C_3S	C_2S	C_3A	Blaine	Alkali

41

Mill Cert. Control Sheet

- Alkali content
  - Na_2O and K_2O shown as Equivalent alkalis on the Cert.
  - As alkali content increases, air entraining agents produce more air. If above 0.60%, change of 0.10% significant. If low (0.30%), even 0.05% change significant
  - Less than 0.60% necessary if ASR potential

MILL TEST RESULTS
Laboratory:

CHEMICAL DATA

ITEM	LIMIT	RESULT
Silicon Dioxide (SiO_2) %	***	20.38
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C_3S	***	51.0
C_2S	***	20.0
C_3A	***	12.0
C_4AF	***	6.0

42

Mill Cert. Control Sheet

- Alkali content
- Blaine fineness
  - Controls early strength
  - Higher the Blaine, higher the water
  - Higher the Blaine, higher the air entrainment admix demand
  - Change in Blaine signals a potential change in concrete performance

Date: June 2022
Cement Type: I Portland

PHYSICAL DATA

ITEM	LIMIT	RESULT
% Air Content		7.10
Blaine (cm^2/g)	>=2800	3880
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7 day	***	4615
28 day	***	5750
Time of set		
Vicat		
Initial(minute)	45>X<375	97
PFS		77.00

388 m^2/Kg

THE PRECAST SHOW

43

Mill Cert. Control Sheet

- Alkali content
- Blaine fineness
- C_3S – higher %, higher early strength
- C_2S – higher %, higher long-term strength
- C_3A – lower %, higher sulfate resistance

MILL TEST RESULTS
Laboratory: Bath, Pennsylvania

CHEMICAL DATA

ITEM	LIMIT	RESULT
Silicon Dioxide (SiO_2) %	***	20.38
Aluminum Oxide (Al_2O_3) %	***	5.75
Ferric Oxide (Fe_2O_3) %	***	2.05
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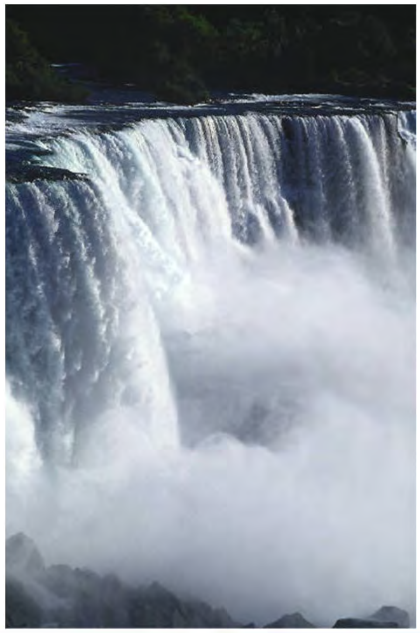
THE PRECAST SHOW

44

Water



45

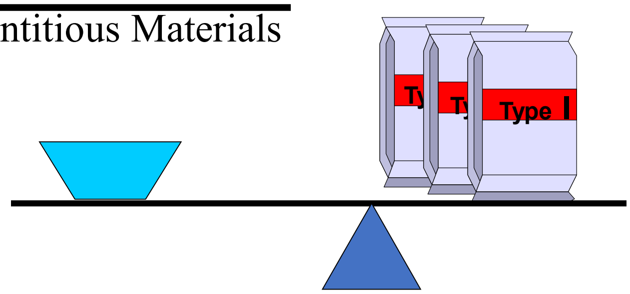
Water

- Purpose
  - Activates hydration
- Specs
  - Potable
  - Non-potable water meeting ASTM C1602 (Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete)
  - Recycled

46

Water/Cementitious Ratio

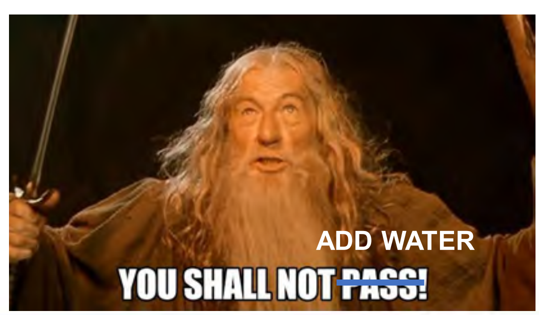
$$\frac{\text{Weight of Water}}{\text{Weight of Cementitious Materials}}$$



Precast/prestressed concrete = typical range of w/c ratio is between 0.30 and 0.45

47

Just Add Water?



48

Why Not - Just Add Water?

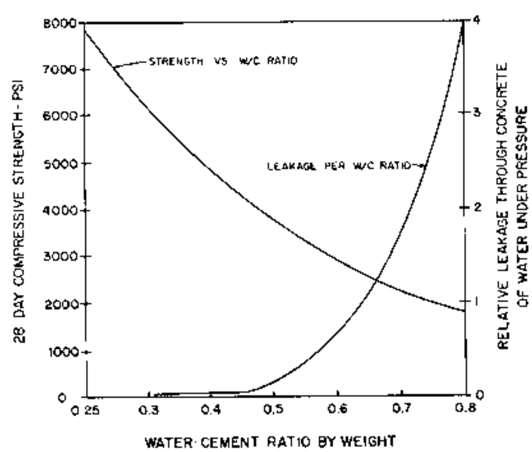
The addition of one gallon of water to standard 3000 psi mix

- Can increase slump by 1”, SCC Spread by 3”
- Increase shrinkage potential by 10%
- Increase potential for seepage up to 50%
- Reduce compressive strength by 200 psi
- Decrease F/T resistance by about 20%
- Waste the impact of ¼ bag of cement

49

What Happens When We Lower The W/C Ratio?

- Greater strengths
- Lower permeability
- Increased durability
- Less color variation
- Why?

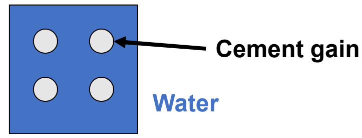


50

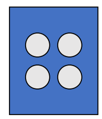
Water/Cementitious Ratio

The answer is in the volume relationship, not mass

$$\frac{\text{Water}}{\text{Cement}} \qquad \frac{300 \text{ lbs}}{600 \text{ lbs}} = 0.50 \rightarrow \frac{4.81 \text{ ft}^3}{3.05 \text{ ft}^3}$$



$$\frac{240 \text{ lbs}}{600 \text{ lbs}} = 0.40 \rightarrow \frac{3.85 \text{ ft}^3}{3.05 \text{ ft}^3}$$



Control w/c ratio (this is critical!)

51

Aggregates

52

Aggregates

Purpose

- Make up the bulk of the mix (60-70% by volume)
- Often strongest part of the mix (e.g. 10 – 45 ksi)
- Typically, most economical part

Specs

- ASTM C33 - Normal Weight Aggregates – be familiar with the required tests
- ASTM C330 - Lightweight Aggregates
- ASTM C637 - Radiation Shielding Aggregates (Heavyweight – Hematite, steel shot, steel shavings)

53

Aggregates

Coarse (stone) and Fine (sand) Aggregate

- Angular
- Round
- Avoid flat or elongated particles
- Aggregates should be clean and free from deleterious substances

54

Gradation

What is aggregate gradation?

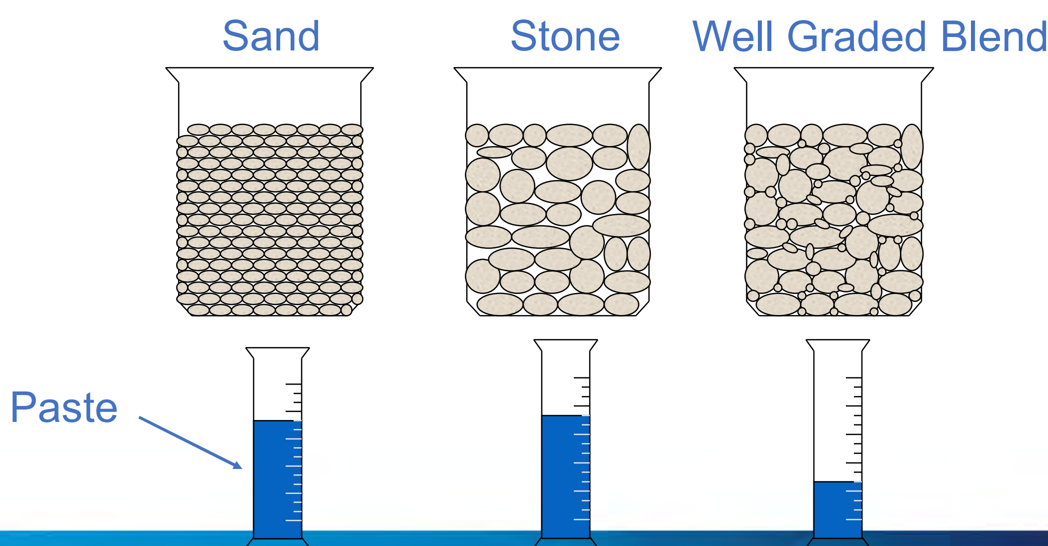
- Distribution of particle sizes

Why do we want gradation of our aggregate?

- Well graded concrete aggregates will result in fewer voids between particles = less cement paste demand

55

Aggregate Gradation



56

Gradation – ASTM C-136

	Sieve Size	Metric Size	International
Nominal Agg. size	1-1/2”	38 mm	37.5 mm
	1”	25 mm	---
	3/4”	20 mm	19 mm
	1/2”	12.5 mm	---
	3/8”	10 mm	9.5 mm
Number of openings per In. in. (e.g. # 100 has 100x100)	#4	4.75 mm	4.75 mm
	#8	2.50 mm	2.36 mm
	#16	1.12 mm	1.18 mm
	#30	0.6 mm	0.6 mm
	#50	0.3 mm	0.3 mm
	#100	0.15 mm	0.15 mm
	#200	0.075 mm	0.075 mm

Not used in FM Calculation

Aggregate Screen Shakers

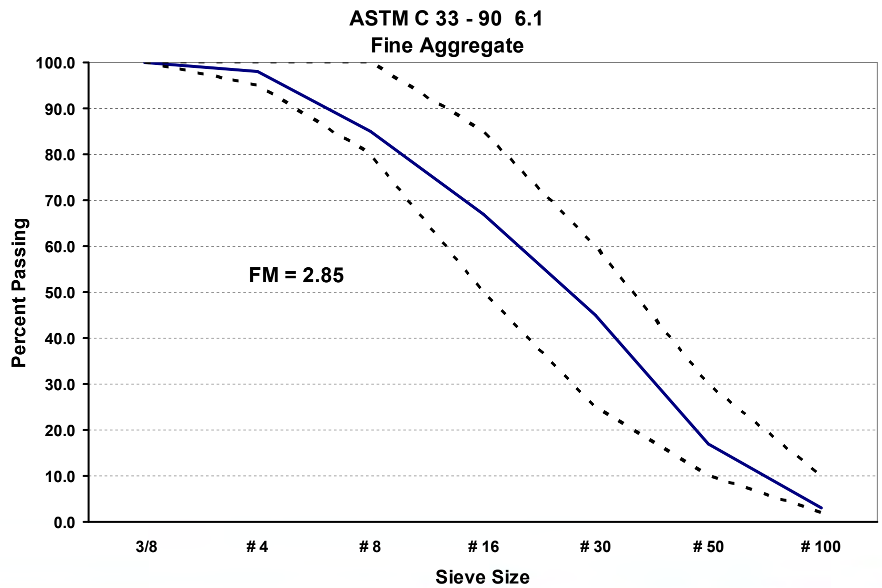
57

Fineness Modulus (FM)

- A single, index number roughly proportional to the average size of particles in a given aggregate, used to express the fineness or coarseness of an aggregate
- Sum of cumulative % retained on the standard sieves
- C33 specifies that FM of sand be between 2.3 and 3.1, Values can’t differ by more than 0.2 for the same mix design
- The coarser the aggregate, the higher the FM
- Several different aggregate gradings can have the same FM

FM & Gradation are NOT the SAME

58



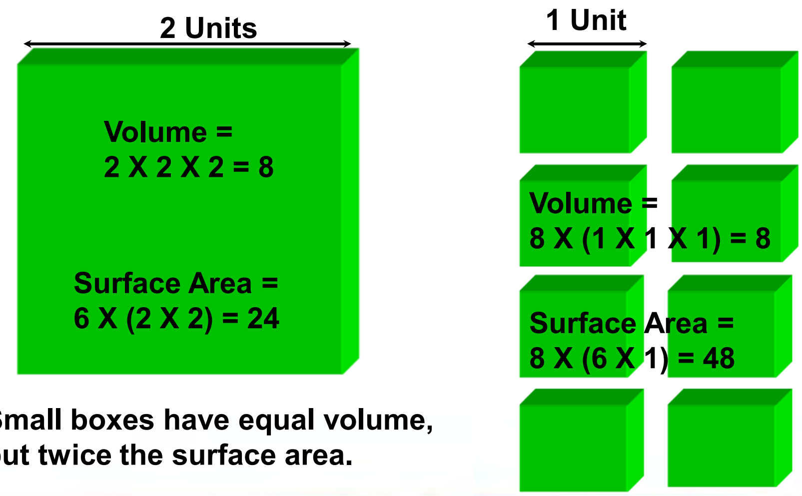
59

Why Are Aggregates Critical to the Water Content of Concrete?

- Aggregates take up the largest amount of volume in concrete.
- Aggregate particle size, distribution, shape, and texture affect the amount of water needed in concrete.
- Therefore, more than any other material, aggregates have the greatest affect on the water needed for a given concrete workability (machine-ability)

60

Why Aggregates Effect Water Demand

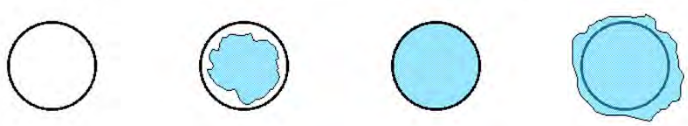


Small boxes have equal volume,
but twice the surface area.

61

Moisture Contents of Aggregate

State	Ovendry (OD)	Air Dry	Saturated Surface Dry (SSD)	Damp or Wet
Total Moisture	None	Less than potential absorption	Equal to potential absorption	Greater than absorption



Adapted from PCA "Design and Control of Concrete Mixtures

62

Free Moisture Calculation for Batches

Total Moisture = Free moisture + Aggregate absorbed moisture

$$\text{\% Total Moisture Content} = \frac{(\text{Wet Wt} - \text{Dry Wt})}{\text{Dry Wt}} \times 100$$

Example:

Wet Wt = 1000 g
Dry Wt = 980 g

$$\frac{1000 - 980}{980} \times 100 = 2.4\%$$

Never include the weight of the pan!

%Free Moisture = Total Moisture - Absorbed Moisture

63

Admixtures

64

Admixtures

Two types of admixtures

- Chemical admixtures - non-pozzolanic admixture in the form of a liquid, suspension, or water-soluble solid.

- Mineral admixtures – (supplementary cementing materials, SCMs), contributes to the plastic and hardened properties of the concrete through hydraulic or pozzolanic reaction or both in the presence of water and cement

65

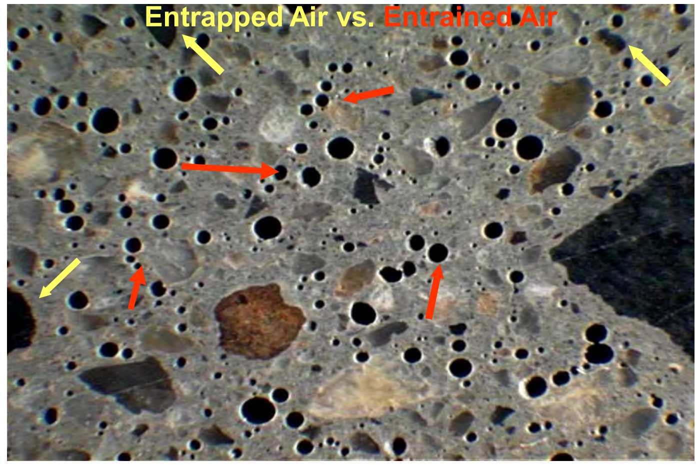
Admixtures

- Air-entraining admixtures
- Water-reducing admixtures (plasticizers)
- Set-controlling admixtures
- Specialty admixtures
- SCMs

66

Air Entrainment

- **All Concrete has air in it**
  - Entrapped air
  - Entrained air
- **Avg yd^3 of concrete contains 600 billion bubbles.**



67

Admixtures

- Air-entraining admixtures
- Water-reducing admixtures (plasticizers)
- Set-controlling admixtures
- Specialty admixtures
- SCMs

68

Admixtures

- Air-entraining admixtures
- Water-reducing admixtures (plasticizers)
- Set-controlling admixtures
- Specialty admixtures
- SCMs

69

Admixtures

- Air-entraining admixtures
- Water-reducing admixtures (plasticizers)
- Set-controlling admixtures
- Specialty admixtures
- SCMs

70

Admixtures

- Air-entraining admixtures
- Water-reducing admixtures (plasticizers)
- Set-controlling admixtures
- Specialty admixtures
- SCMs
  - Pozzolans: Class F Fly Ash, Silica Fume, Metakaolin
  - Hydraulic: Class C fly Ash, Granulated Blast Furnace Slag

71

SCMs

TABLES 1 AND 2: The following tables present a broad generalization on the use of common supplementary cementitious materials and the effects they have on both the fresh and hardened properties of concrete.

TABLE 1: Fresh Properties

	FLY ASH				NATURAL POZZOLANS		
	Class F	Class C	Slag	Silica Fume	Shale	Clay	Metakaolin
Water Demand	↓↓	↓↓	↓	↑↑	↔	↔	↑
Workability	↑	↑	↑	↓↓	↑	↑	↓
Bleeding	↓	↓	↕	↓↓	↔	↔	↓
Setting Time	↑	↕	↑	↔	↑	↑	↔
Air Entrainment Dosage	↑↑	↑	↔	↑↑	↔	↔	↑
Heat of Hydration	↓	↕	↓	↔	↓	↓	↓

TABLE 2: Hardened Properties

	FLY ASH				NATURAL POZZOLANS		
	Class F	Class C	Slag	Silica Fume	Shale	Clay	Metakaolin
Early Age Strength Gain	↓↓	↔	↕	↑↑	↓	↓	↑↑
Long-Term Strength Gain	↑	↑	↑	↑↑	↑	↑	↑↑
Permeability	↓	↓	↓	↓↓	↓	↓	↓↓
Chloride Ingress	↓	↓	↓	↓↓	↓	↓	↓↓
ASR	↓↓	↓	↓↓	↓	↓	↓	↓
Sulfate Resistance	↑↑	↑	↑↑	↑	↑	↑	↑
Freeze-Thaw	↔	↔	↔	↔	↔	↔	↔

↔ = effects may vary ↕ = effects may increase or decrease depending on material properties ↓ = decrease ↑ = increase

72

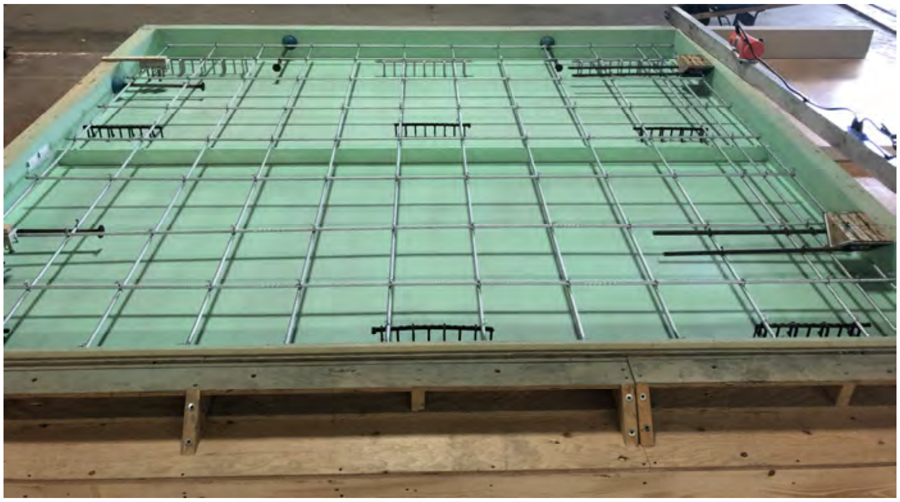
Producing Precast Concrete

73

Forms & Molds

74

Timber

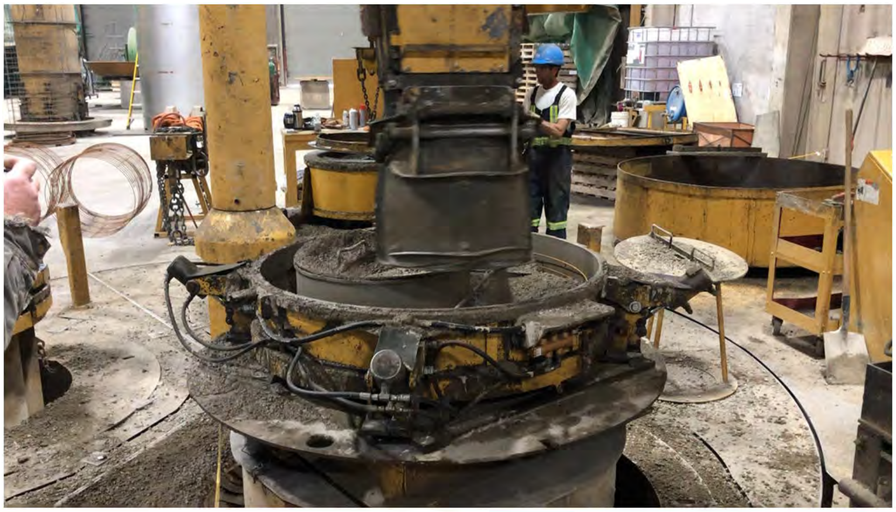


75

Polymer / Polystyrene

76

Dry Cast



77

Dry Cast

78

Wet Cast


79

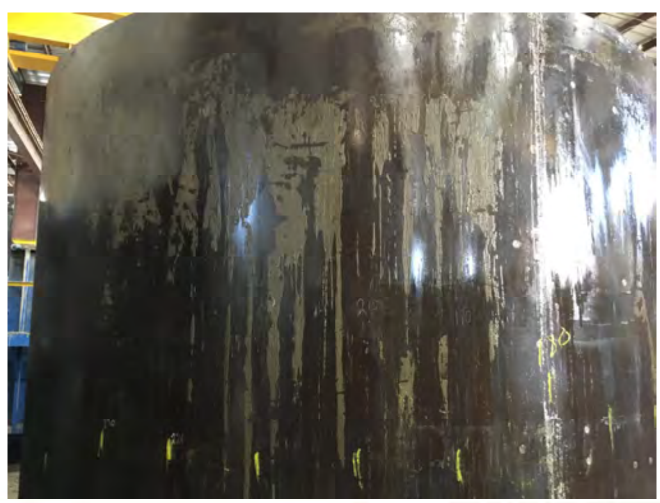
Geometry


80

Geometry

81

Cleaning



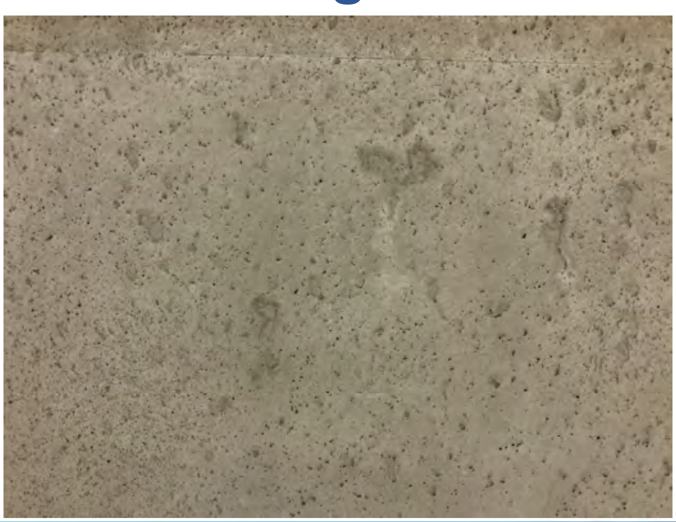
82

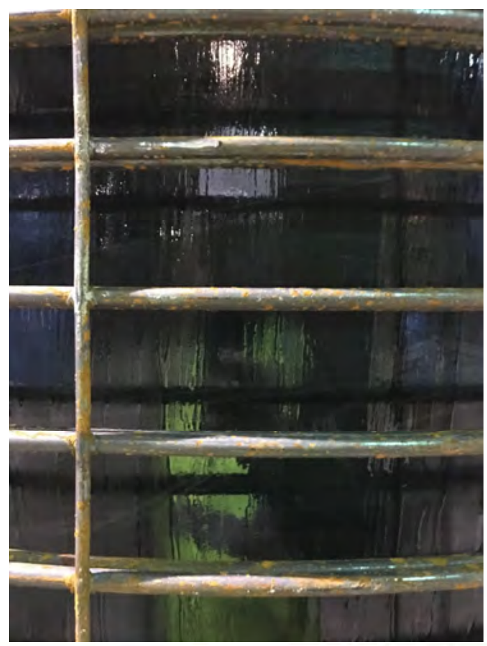
Leakage

THE PRECAST SHOW

83

Release Agent

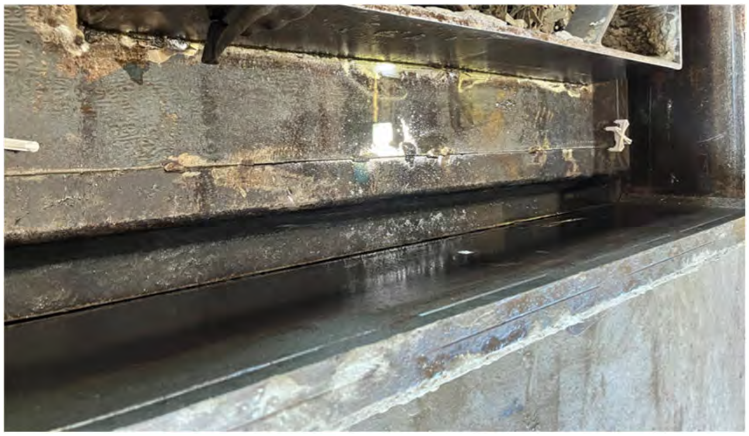




THE PRECAST SHOW

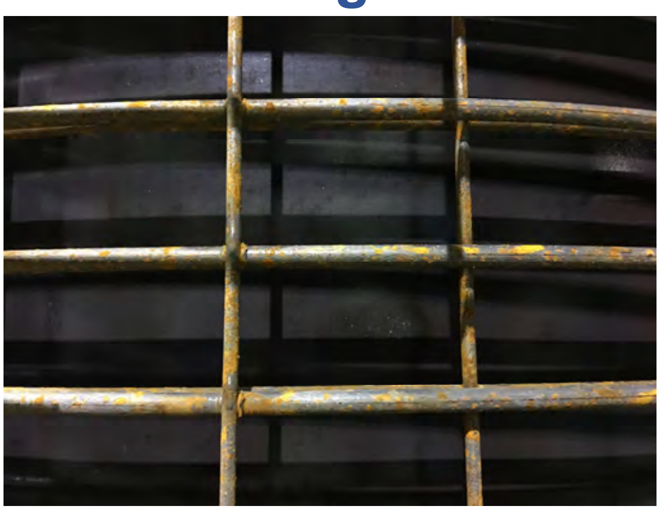
84

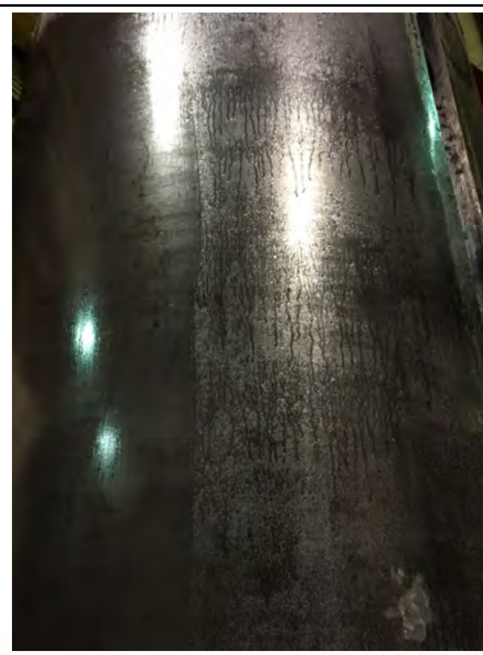
Release Agent



85

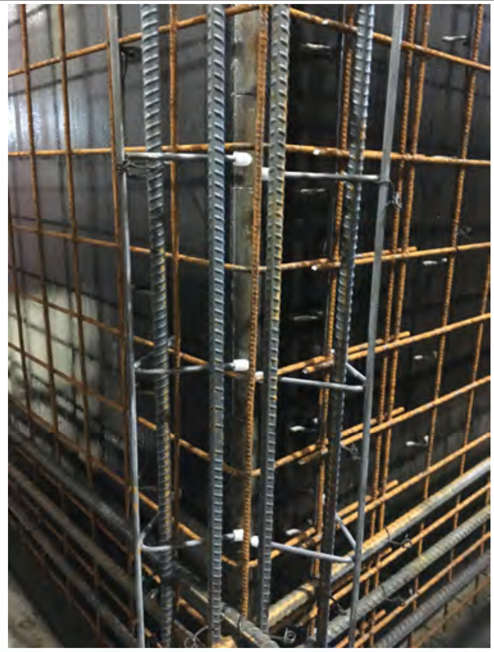
Release Agent





86

Reinforcement

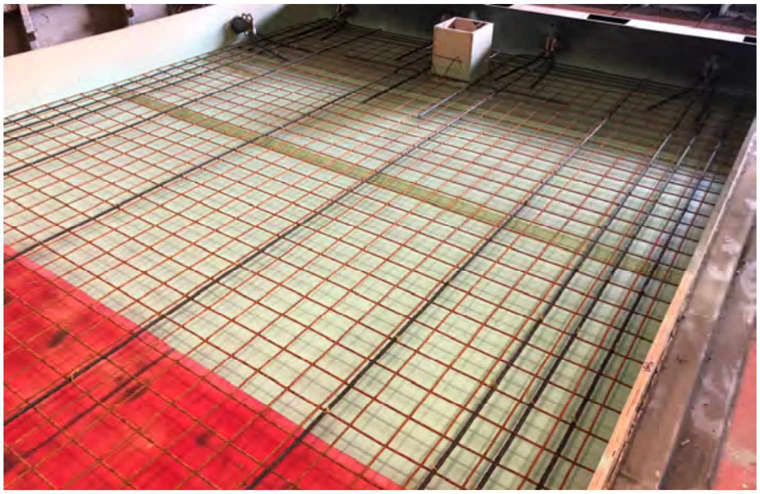


87

Liners

88

Architectural Finishes



89

Architectural Finishes

90

Architectural Finishes

91

Architectural Finishes

92

Batching & Mixing

93

Batch Plants

- Horizontal:

Aggregates are held in bins below the central mixer; conveyed or hoisted during the batch cycle

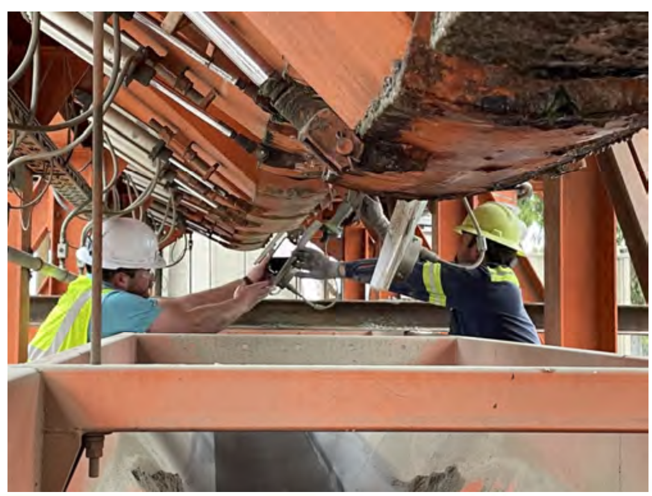
- Vertical:

Aggregates are conveyed to bins that are above the central mixer; gravity to move material downward to scale and mixer

94

Aggregates

Aggregates



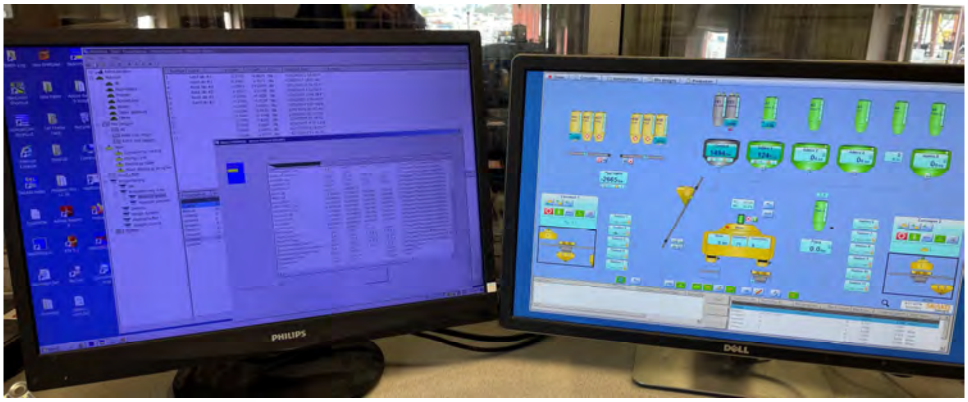
Aggregates

97

Powders

98

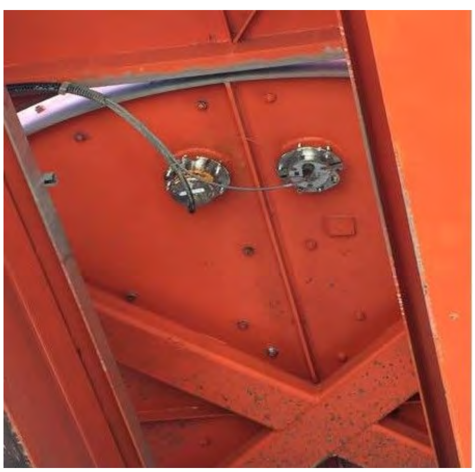
Software



PRECAST SHOW

99

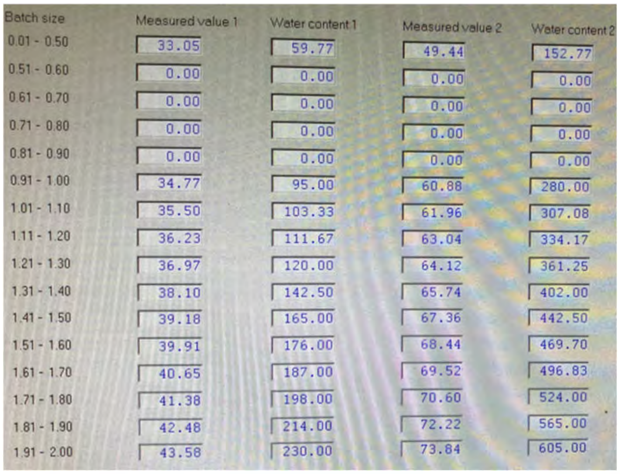
Sensors



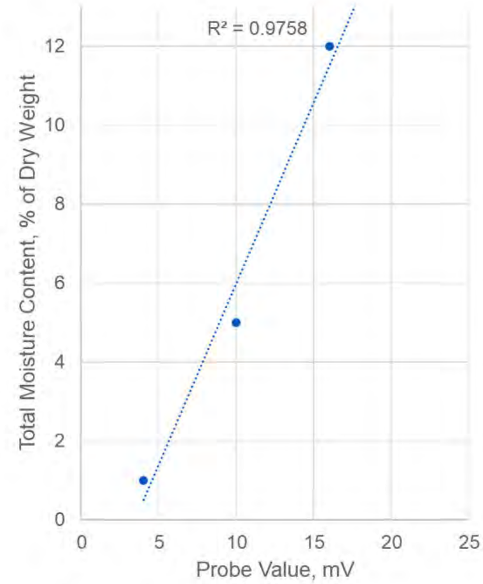
PRECAST SHOW

100

Moisture Control

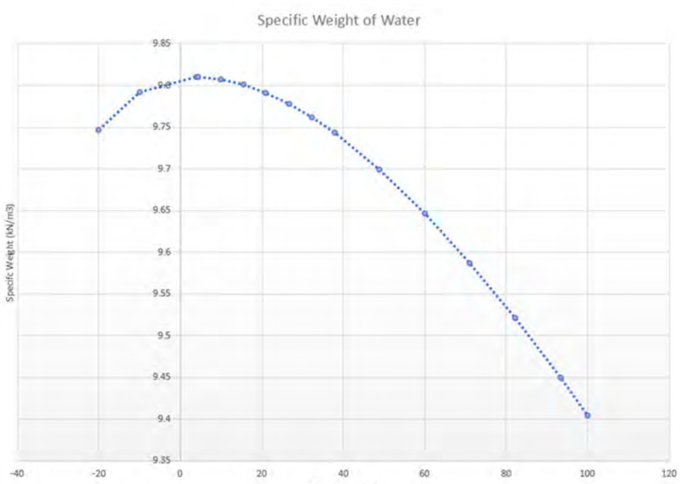


Batch size	Measured value 1	Water content 1	Measured value 2	Water content 2
0.01 - 0.50	33.05	59.77	49.44	152.77
0.51 - 0.60	0.00	0.00	0.00	0.00
0.61 - 0.70	0.00	0.00	0.00	0.00
0.71 - 0.80	0.00	0.00	0.00	0.00
0.81 - 0.90	0.00	0.00	0.00	0.00
0.91 - 1.00	34.77	95.00	60.88	280.00
1.01 - 1.10	35.50	103.33	61.96	307.08
1.11 - 1.20	36.23	111.67	63.04	334.17
1.21 - 1.30	36.97	120.00	64.12	361.25
1.31 - 1.40	38.10	142.50	65.74	402.00
1.41 - 1.50	39.18	165.00	67.36	442.50
1.51 - 1.60	39.91	176.00	68.44	469.70
1.61 - 1.70	40.65	187.00	69.52	496.83
1.71 - 1.80	41.38	198.00	70.60	524.00
1.81 - 1.90	42.48	214.00	72.22	565.00
1.91 - 2.00	43.58	230.00	73.84	605.00



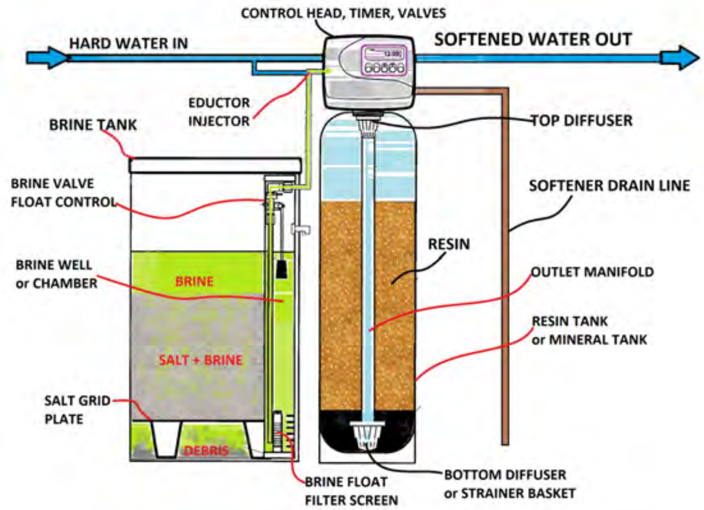
101

Water



102

Water



103

Pigment

- Liquid

- Granular

104

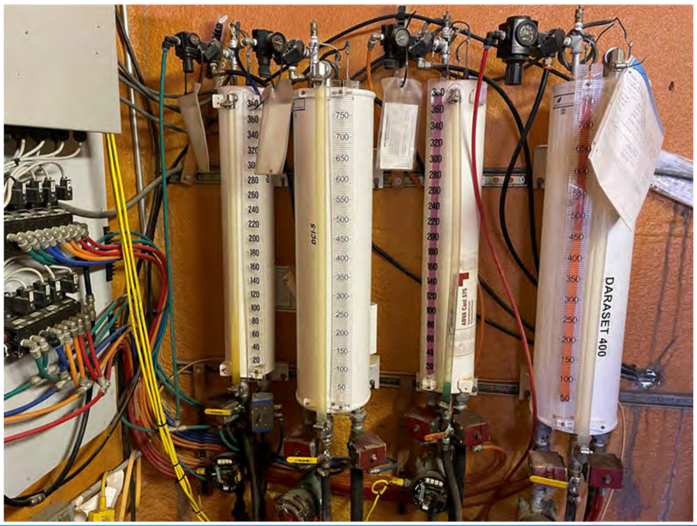
Fibers

105

Fibers

106

Admixture

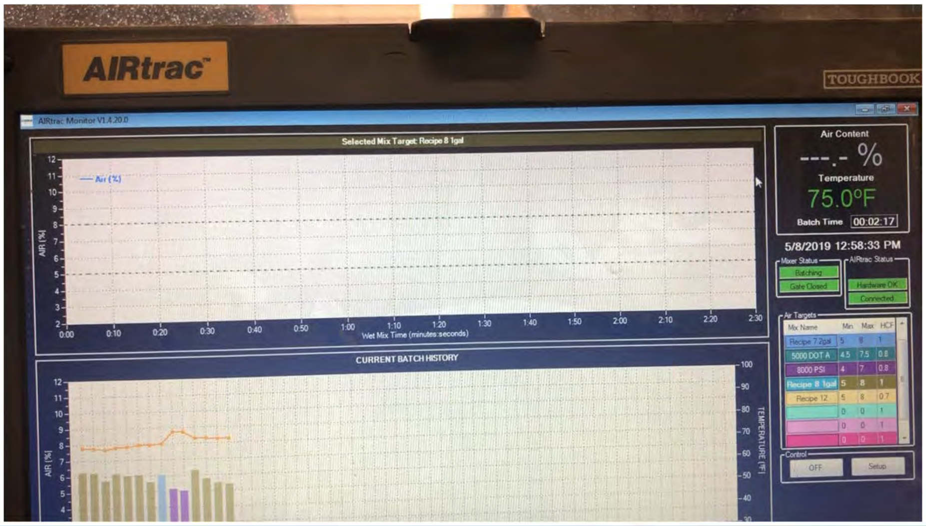


107

Admixtures

108

Mixers

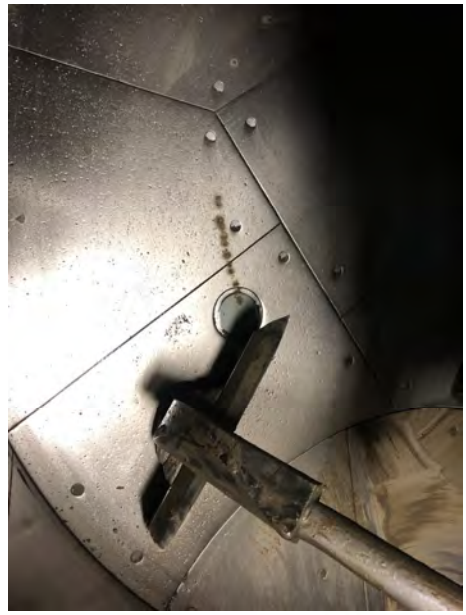


109

Mixers

110

Mixers



111

Mixers

112

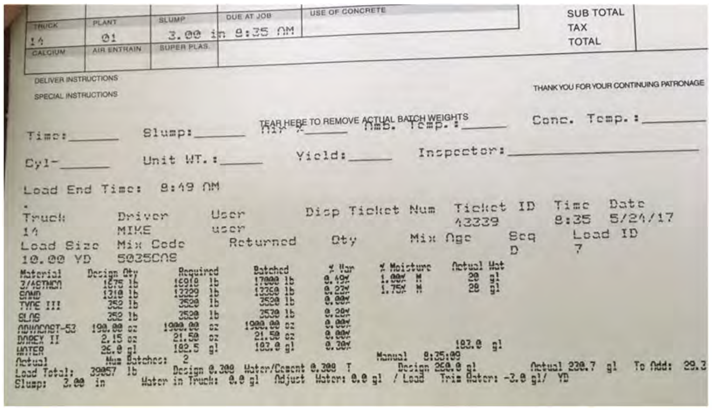
Sequencing

113

Cycle Time

114

Tickets

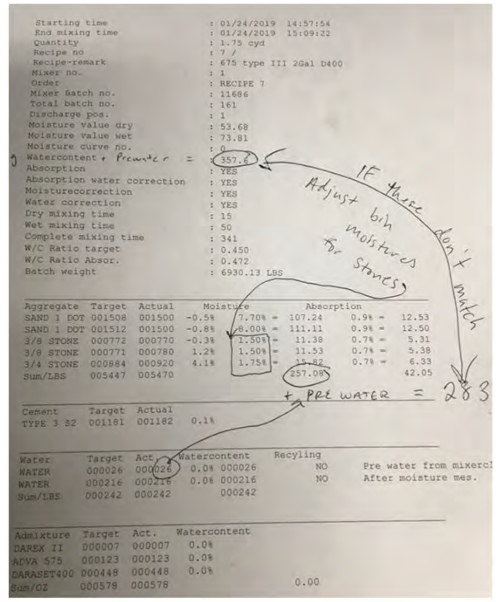

TRUCK 14 | PLANT 01 | SLUMP 3.00 in | DUE AT JOB 8:35 AM | USE OF CONCRETE
CALCIUM | AIR ENTRAIN | SUPER PLAS.
SUB TOTAL
TAX
TOTAL
DELIVER INSTRUCTIONS
SPECIAL INSTRUCTIONS
THANK YOU FOR YOUR CONTINUING PATRONAGE
TEAR HERE TO REMOVE ACTUAL BATCH WEIGHTS
Time:______ Slump:______ Mix %:______ Amb. Temp.:______ Conc. Temp.:______
Cyl-______ Unit WT.:______ Yield:______ Inspector:______
Load End Time: 8:49 AM

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
14	MIKE	user		43239	8:35	5/24/17

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
10.00 YD	5035CAS				D	7

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
3/4STNCA	1675 lb	16918 lb	17000 lb	0.49%	1.00% M	20 gl
SAND	1310 lb	13329 lb	13350 lb	0.23%	1.75% M	28 gl
TYPE III	352 lb	3520 lb	3520 lb	0.00%		
SLAG	352 lb	3520 lb	3530 lb	0.28%		
ADVACAST-53	190.00 oz	1900.00 oz	1900.00 oz	0.00%		
DAREX II	2.15 oz	21.50 oz	21.50 oz	0.00%		
WATER	26.0 gl	182.5 gl	183.0 gl	0.30%		183.0 gl

Actual Num Batches: 2 Manual 8:35:09
Load Total: 39857 lb Design 0.300 Water/Cement 0.300 T Design 260.0 gl Actual 230.7 gl To Add: 29.3
Slump: 3.00 in Water in Truck: 0.0 gl Adjust Water: 0.0 gl / Load Trim Water: -3.0 gl/ YD


Starting time : 01/24/2019 14:57:54
End mixing time : 01/24/2019 15:09:22
Quantity : 1.75 cyd
Recipe no : 7 /
Recipe-remark : 675 type III 2Gal D400
Mixer no. : 1
Order : RECIPE 7
Mixer Batch no. : 11686
Total batch no. : 161
Discharge pos. : 1
Moisture value dry : 53.68
Moisture value wet : 73.81
Moisture curve no. : 0
Watercontent + Prewater = : 357.6
Absorption : YES
Absorption water correction : YES
Moisturecorrection : YES
Water correction : YES
Dry mixing time : 15
Wet mixing time : 50
Complete mixing time : 341
W/C Ratio target : 0.450
W/C Ratio Absor. : 0.472
Batch weight : 6930.13 LBS

Aggregate	Target	Actual		Moisture		Absorption	
SAND 1 DOT	001508	001500	-0.5%	7.70% =	107.24	0.9% =	12.53
SAND 1 DOT	001512	001500	-0.8%	8.00% =	111.11	0.9% =	12.50
3/8 STONE	000772	000770	-0.3%	1.50% =	11.38	0.7% =	5.31
3/8 STONE	000771	000780	1.2%	1.50% =	11.53	0.7% =	5.38
3/4 STONE	000884	000920	4.1%	1.75% =	15.82	0.7% =	6.33
Sum/LBS	005447	005470			257.08		42.05

+ PRE WATER = 283

Cement	Target	Actual	
TYPE 3 S2	001181	001182	0.1%

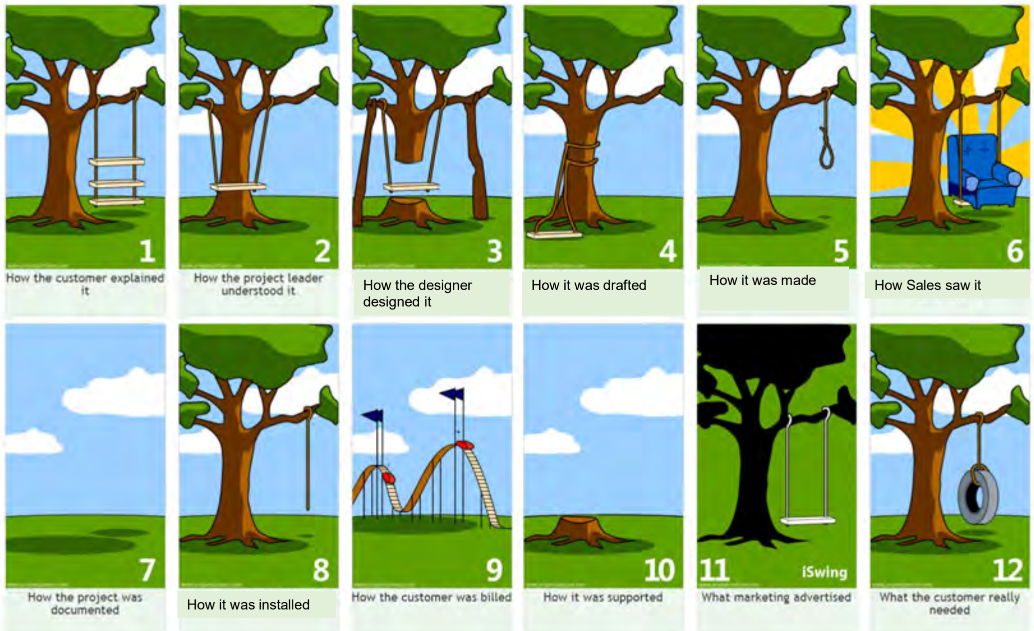
Water	Target	Act.	Watercontent		Recyling	
WATER	000026	000026	0.0%	000026	NO	Pre water from mixercl
WATER	000216	000216	0.0%	000216	NO	After moisture mes.
Sum/LBS	000242	000242		000242		

Admixture	Target	Act.	Watercontent
DAREX II	000007	000007	0.0%
ADVA 575	000123	000123	0.0%
DARASET400	000448	000448	0.0%
Sum/OZ	000578	000578	0.00

115

Transporting

116



117

Transporting Concrete

You have just mixed perfect concrete , and now you need it to get delivered to your forms

118

Transporting Concrete

119

Bucket

Pros:

- Lift height limit based on crane
- Controlled discharge
- Easy to position

Cons:

- 1-2 yds
- No blending or altering
- Higher segmentation potential

Tucker

Pros:

- Deliver uphill, higher reach
- Controlled discharge
- 4-6 yrds

Cons:

- Small loads
- No blending or altering
- Some segregation potential

RMX Truck

Pros:

- Blend multiple batches
- Make adjustments to mix
- 10 yds

Cons:

- Plastic properties can change
- Truck and driver dependent
- Maintenance often neglected

120

Some Suggestions

Bucket

- Concrete must meet spec before dumping
- Do not drive over bumps, rough roads
- Keep gate, seals, and controls clean and functioning well

Tucker

- Concrete must meet spec before dumping
- Develop SOPs for drivers
- Have inspection schedule and proactive maintenance plan

RMX Truck

- Develop SOPs for drivers
  - Rotation speed for transit (3-6 RPM)
  - If additions are made required rotations and speed
- Determine condition assessment for each truck, and adjust SOP accordingly
- Have inspection schedule and proactive maintenance plan

121

Casting and Consolidation

122

Concrete Placement

What are trying to accomplish?

Place the concrete in a way that it is:

- Uniform (does not segregate)
- Ensure that all reinforcement is completely encapsulated, and all cover requirements are met
- Provides a good finish and appearance in alignment with customer expectations

123

Placement Concrete - Guidelines

- Keep drop height minimized

124

Placing Concrete - Guidelines

- Keep drop height minimized
- Pour from one side of the form and let the concrete flow
- Place concrete on top of concrete
  - Create a flowing front

125

Placing Concrete - Guidelines

- Keep drop height minimized
- Pour from one side of the form and let the concrete flow
- Place concrete on top of concrete
  - Create a flowing front
- If raking is needed, do not rake over the top

126

Placing Concrete - Guidelines

Architectural
- Cast face mix in one placement – do not use leftover in next form

127

Tonight's Winning Lottery Numbers

2 30 8 26 45 33

128

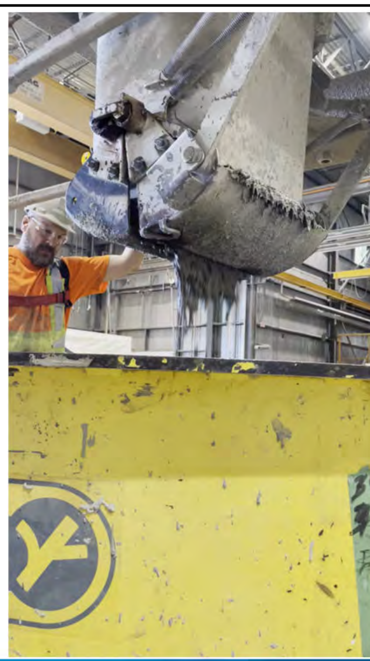
Placing Concrete - Guidelines

Architectural

- Cast face mix in one placement – do not use leftover in next form
- Do not join two pours – pour one direction
- Do not walk on freshly placed concrete

129

Placing Concrete - 1



130

Placing Concrete - 2

131

Placing Concrete - 3

132

Placing Concrete - 4

What is Consolidation?

Process that evens the distribution of all ingredients in a mix, and removes unwanted air

Why Consolidate?

- **Freshly placed wet cast concrete can contain as much as 20% entrapped air**
- **Proper consolidation increases density by driving out entrapped air and helps ensure concrete uniformity around steel, hardware, etc.**
- **Results in:**
  - Optimum strength
  - Improved Durability
  - Improved finish and appearance
  - Watertightness
  - Encapsulated steel and helps ensure bond

135

Methods of Consolidation

- **Compaction**

136

Methods of Consolidation

- **Compaction**
- **Vibration**
  - Vibration – reduces the yield stress making the concrete fluid therefore allowing air to rise and particles to move closer together.
    - Internal Vibration – applied within the concrete
    - External Vibration – applied to the formwork or concrete surface

137

Frequency and Amplitude

Frequency

- Number of vibration cycles per minute
- Expressed as rpm or vpm
- Speed

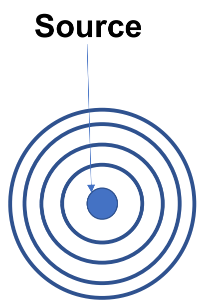
Amplitude

- Maximum distance a point on the vibrator head moves from its position of rest
- Shake or Impact

Both are necessary for proper consolidation

138

Frequency and Amplitude



Frequency = number of waves per minutes

Note: frequency will be reduced about 20-25% when immersed in concrete

Amplitude = (magnitude of the wave – how far it influences

139

Amplitude & Frequency

Amplitude	Frequency
Effects Heavier Mass	Effects Lighter Mass
Moves the Aggregate	Moves Sand & Slurry around Aggregate
Determines Radius of Action	Governs Liquefication

Architectural Precast: Med to deep - exposures **Light - exposures**

140

Frequency and Amplitude Guidelines

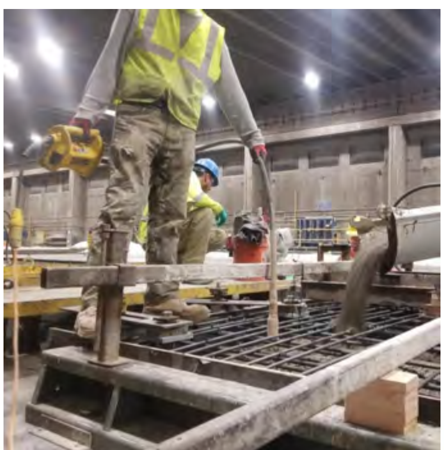
- Fine particles respond to high frequency vibration 12,000 being the optimum

VPM Range	Type	Particle size
3,000 – 6,000	External Vibrator	Small to large stone
6,000 – 9,000	High-Frequency External Vibrator	Coase sand to med. stone
9,000 – 12,000	Internal Vibrators	Fine sand to small stone

141

Internal Vibration

- **Stingers, spuds**
- **Electric, pneumatic, or hydraulic**

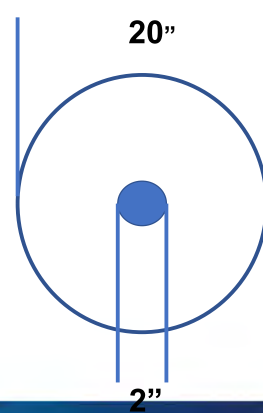


142

Area of Compaction

The general rule of thumb is the area of compaction is approximately 10 times the diameter of the head.

Example, a standard 2" head will have an effective area of compaction approximate 20" in diameter.

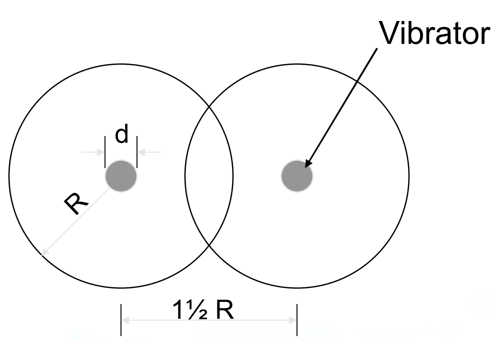


143

Internal Vibration - Radius of Action

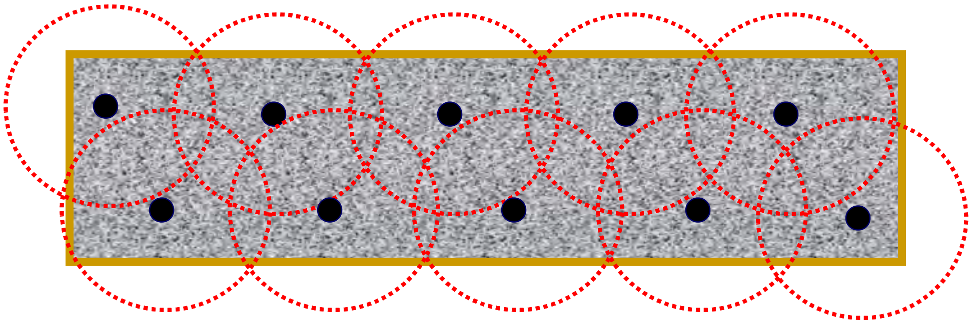
Radius of Action – used to calculate insertion pattern

- 1 1/2 R = insertion spacing



144

Correct Insertion Method



Done properly there will be very few defects in the finish

145

Stinger – Best Practice

- Drop vertically under its own weight (≈1 sec./ft)
- Withdraw slightly slower (≈3 sec./ft)
- Place into each area only once, overlapping vibrating radius
- Each lift or layer of concrete should not exceed 20" to 24"
- Penetrate the last layer by a minimum of 6", bond the two layers together for 5 - 10 seconds
- Avoid touching the form or mold skin, and reinforcement with the vibrator
- Avoid running the head outside the mix
- Do NOT use vibrators to move a concrete mix laterally

146

Fishing?

147

External Vibration

- Form vibrators
- Vibrating screeds

148

External Vibration

External vibrators are often used when geometric or time constraints make the use of internal vibrators difficult or impossible:

- Complicated construction geometry (e.g. undercuts, canted or inclined surfaces, large box forms)
- Narrow or confined entry spaces
- Tight spacing between rebar preventing access by internal vibrators
- Time constraints due to labor

149

External Vibration

Proper location and sizing of external vibrators is important!

- Often over and under vibration can occur due to improper placement and design of the vibrators

- Precasters are better off to reduced the force and apply in more positions on the formwork/mold. This will result in a better product finish and lower noise levels

150

Vibration

151

Vibration

152

Vibrate when you need to, not just because:

• Conventional Concrete	Vibrated
• Flowable Concrete 18”- 24” slump flow	Vibrated
• SCC: >24”	Typically not vibrated

153

Quality Control Testing

154

Frequency

- Aggregate: sieve analysis
  - Fine – every 1,500 tons (1,350 metric tons)
  - Coarse – every 2,000 tons (1,800 metric tons)
- Aggregate: moisture content
  - With probes – Weekly
  - Without probes –
    - Conventional Slump = daily
    - Self-Consolidating = every 4 hours

155

Test Methods

- ASTM C136, “Standard Test Method of Sieve Analysis of Fine and Coarse Aggregates”
- ASTM C70, “Standard Test Method for Surface Moisture in Fine Aggregate”
- ASTM C566, “Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying”

156

Sampling

157

Frequency

- Slump: every 150 cubic yards (115 cubic meters); minimum once per production day. Dry-Cast concrete excluded.
- Spread / VSI: One of the first two batches each day
  - Whenever the mix design changes
  - Whenever the raw materials change
- Air Content:
  - Entrained = every 150 cubic yards (115 cubic meters); minimum once per production day. Dry-Cast concrete excluded.
  - Not Entrained = once per week or whenever test cylinders are made
  - Dry Cast concrete excluded

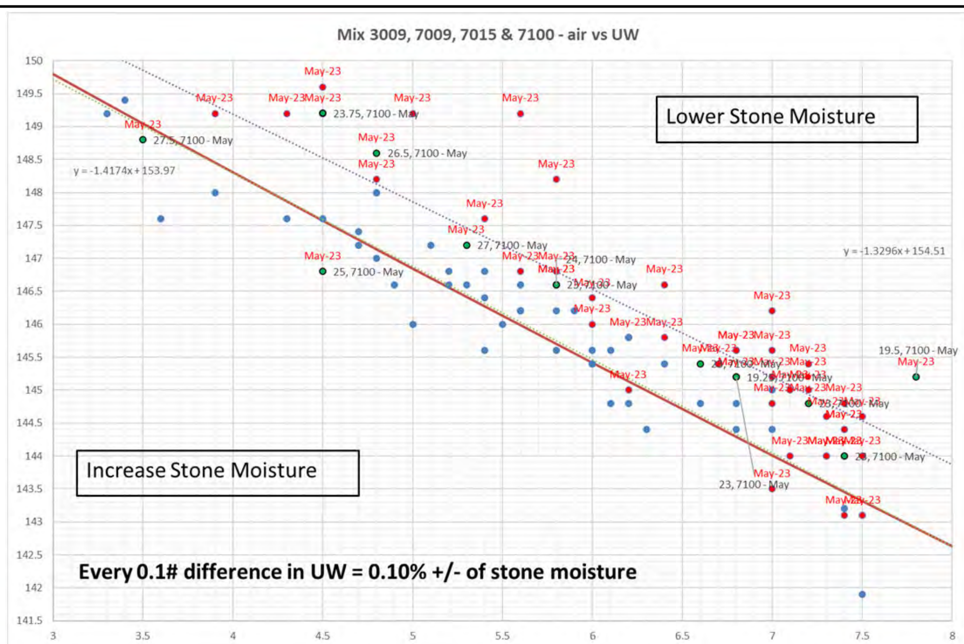
158

Test Methods

- Slump: ASTM C143, “Standard Test Method for Slump of Hydraulic-Cement Concrete”
- Spread / VSI: ASTM C1611 “Standard Test Method for Slump Flow of Self-Consolidating Concrete”
- Air Content: ASTM C231, “Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method”
- Lightweight: ASTM C173, “Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method”
- ASTM C1064, “Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete”

159

Unit Weight



160

Cylinders

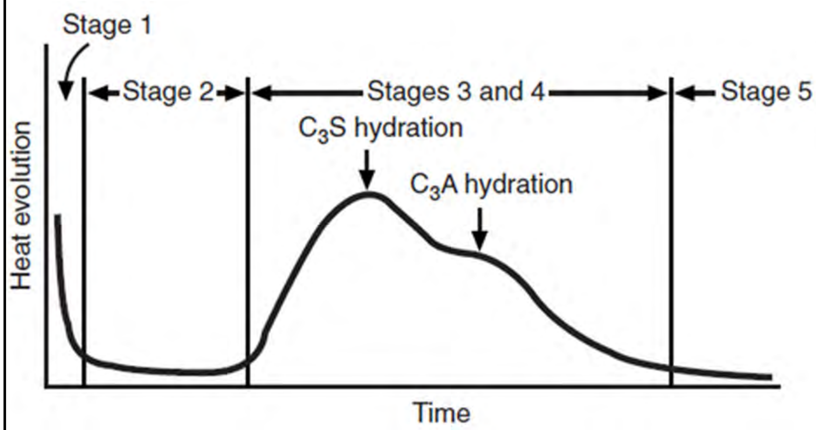
- (4) per 150 cubic yards (115 cubic meters); min once per week
- Conventional Slump, SCC, Dry-Cast fabrication process
- Specimens shall be cured in a manner consistent with the curing of the concrete products represented by the specimens

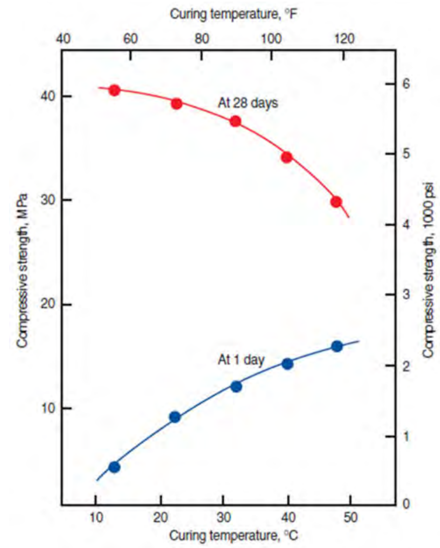
161

Curing

162

Stages





PRECAST SHOW

163

Retain Moisture

PRECAST SHOW

164

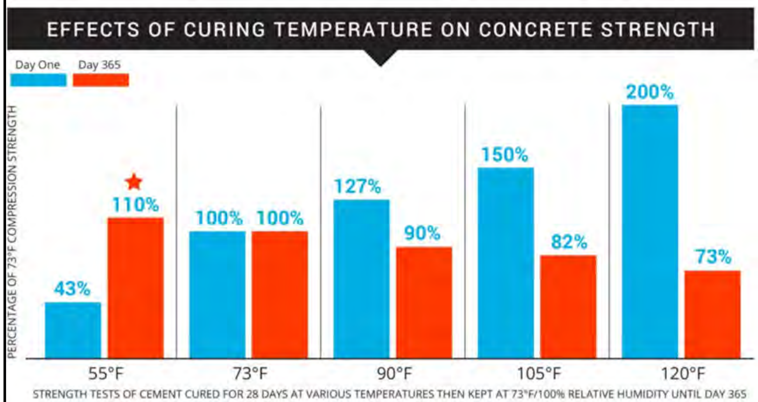
Retain Heat & Moisture

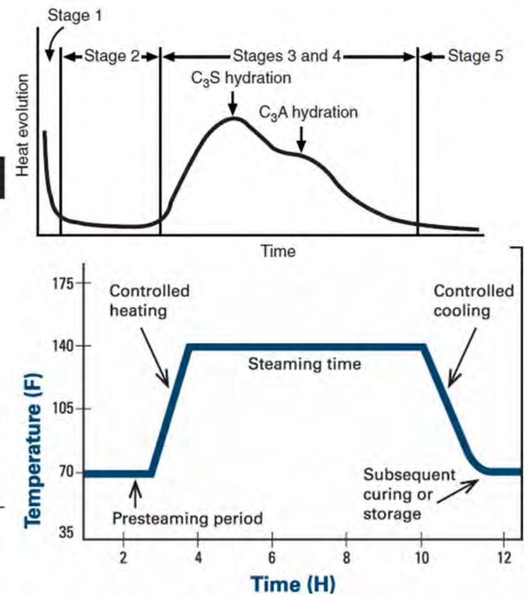
165

Retain Moisture, Add Heat

166

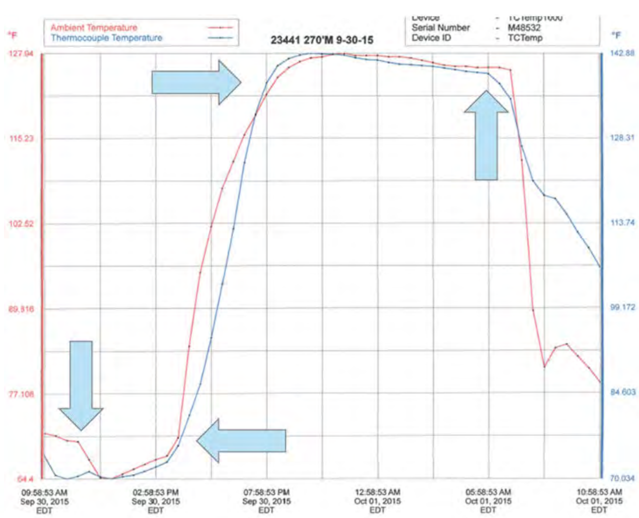
Accelerated Curing





167

Temperature Control



168

Representative Cylinders

169

Chipping & Handling

170

Geometry

171

Slip Formed

172

Rotating

173

Storage & Shipping

174

Storage

175

Storage

176

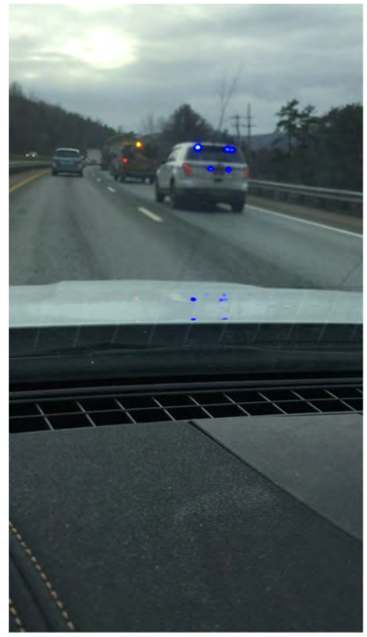
Storage

177

Shipping

178

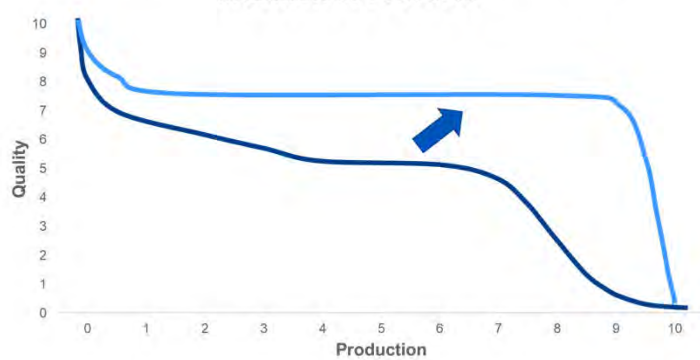
Shipping



179

Optimization

"the *action* of making the most effective use of a situation or resource"



180

Thank you!
Questions

181

Excess Concrete

182

Excess Concrete

183

CP5 – Troubleshooting Precast Production

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184