CONCRETE MATERIALS

minnesota concrete council
Dedicated to Cast-in-Place Concrete

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Mr. Edwards has over 15 years of engineering, concrete production and materials science experience. He received his B.S. – Civil Engineering from University of Wisconsin and his M.S. – Civil Engineering from the University of Minnesota.

He was a project manager for GME Consultants and American Engineering Testing for 8 years before moving to AVR, Inc. to become the Director of Engineering in 2006.

Mr. Edwards is very active in ACI:

211 – proportioning
213 – Lightweight Aggregates
238 – Workability
555 – recycled materials
601 - certification

and is an active member of MCC, NRMCA, and ASTM.

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1. Introduction
2. History of Concrete
3. Concrete Materials
4. New Technologies & Trends
5. Delivery Ticket Review

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Introduction

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What do we want?

- The owner/designer wants:

5

What do we want?

- The contractor wants:

6

What do we want?

- The producer wants:

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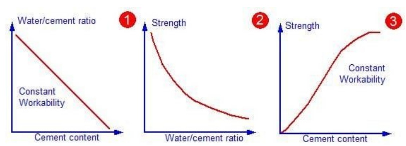
Factors Affecting Workability

- Cement (cementitious) content
  - More cement = more paste to coat aggregates and fibers
- Water content
  - Water/cement ratio is one of the most important factors
  - More water = more paste = better workability



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Effect of Water-Cement Ratio (W/C) on Concrete Properties

Low W/C
- Higher strength
- Lower Permeability
- Increased durability

Higher W/C
- Lower Strength
- Higher Permeability
- Decreased Durability

Low W/C
- Sticky to finish
- Surface drying
- Shrinkage cracking
- Curing essential

Higher W/C
- Better finishability
- Less surface finish issues

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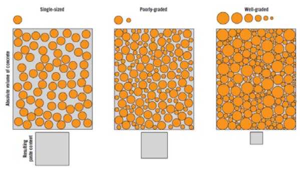
Factors Affecting Workability

- Aggregate Properties
  - Size of aggregates
  - Shape, angularity , and surface texture
  - Aggregate grading



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Factors Affecting Workability

- SCM's
  - Fly ash
  - Slag
  - Silica fume
- Admixtures
  - Superplasticizers
  - Viscosity/Rheology Modifiers
  - Air Entrainment all typically increase workability

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History of Concrete

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3000 BC

- Egyptian Pyramids

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80 AD

- Roman Coliseum

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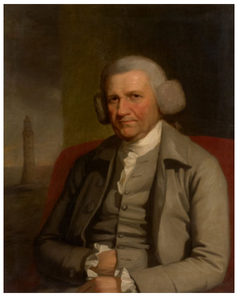
1756



- John Smeaton & the Eddystone Lighthouse

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1824

- Joseph Aspdin

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1849

- Joseph Monier & the Bridge at Chazelet.

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Important dates in history

- 1886 – first rotary kiln for cement production
- 1891 – first concrete street – Bellefontaine, OH
- 1903 – first concrete high rise – Cincinnati, OH
- 1930 – air entraining agents introduced
- 1936 – first major dams (Hoover, Grand Coulee)
- 1970 – introduction of fiber reinforced concrete
- 1980 - introduction of superplasticizers

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Important dates in history

1930	1970	1973	1998	2004	2010
1250 ft.	1368 ft.	1450 ft.	1483 ft.	1671 ft.	2717 ft.

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432 Park Avenue
1776 ft.

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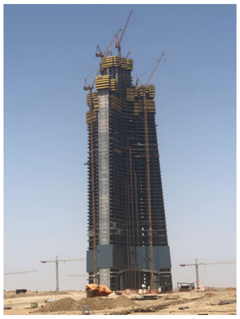
The Future



Jeddah Tower
3300 ft.

Dubai Creek Tower
4265 ft.

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Concrete Materials

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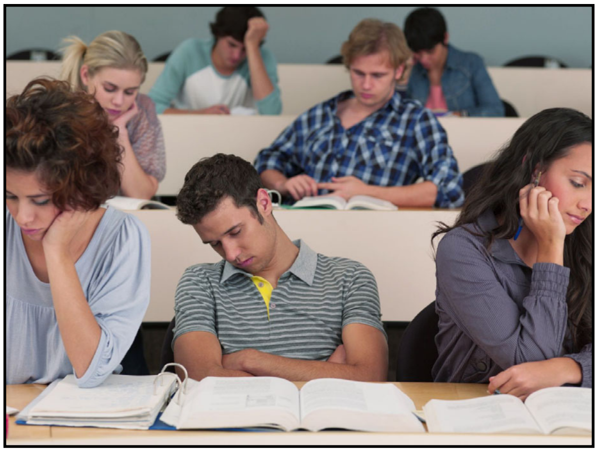

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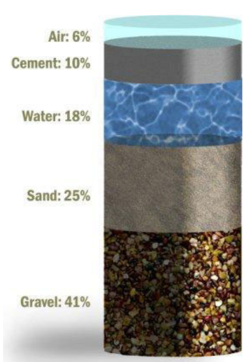
Concrete Ingredients

Cement + Water = Paste

Paste + Sand = Mortar

Mortar + Coarse Aggregate
= Concrete



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The Water-Cement Ratio Law
Duff Abrams

All other things being equal:

The strength of concrete is directly related to the amount of water added to the mix

The higher the w/c, the lower the strength!!!

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Manufacturing Process

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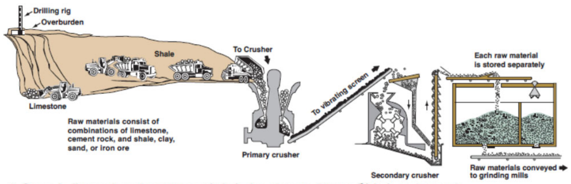
Manufacturing Process



1. Stone is first reduced to 125 mm (5 in.) size, then to 20 mm (3/4 in.), and stored.

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Manufacturing Process

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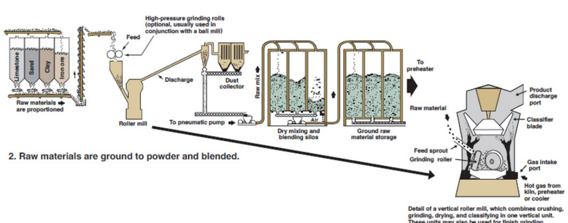
Manufacturing Process



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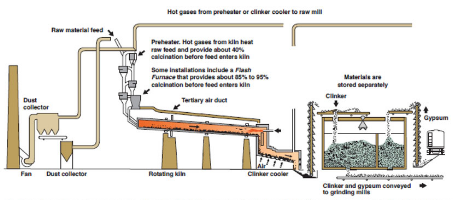
Manufacturing Process



3. Burning changes raw mix chemically into cement clinker. Note four-stage preheater, flash furnaces, and shorter kiln.

PCA

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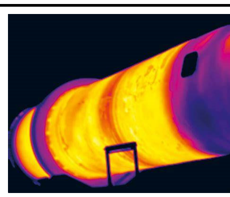

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Manufacturing Process

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Types of Portland Cement

- I – Normal
- II – Moderate Sulfate Resistant
- III – High Early
- IV – Low Heat of Hydration
- V – Sulfate Resistant

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Types I Portland Cement

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Types II Portland Cement

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Types III Portland Cement

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Types IV Portland Cement

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Types V Portland Cement

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Other Types of Cement

- ASTM C 1157 Cements
- Masonry Cements
- Expansive Cements
- Geopolymer Cements
- Calcium Aluminate Cement
- Special Cements………

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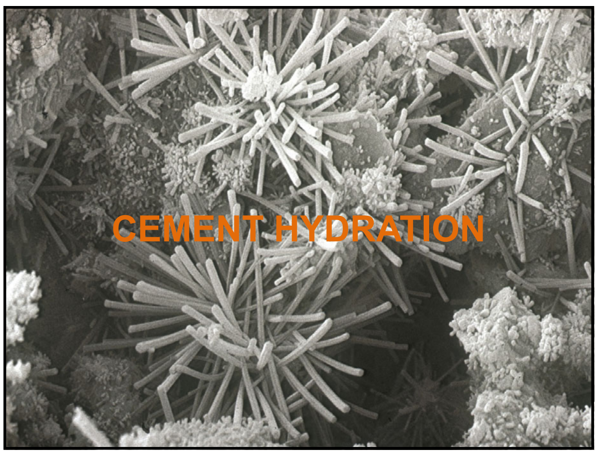

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Cement Hydration

- NOT a drying process
  - Hydration is a term applied to any chemical reaction in which water combines with a material to form some new product, which is called a "hydrate"

C_3S / C_2S (Calcium Silicates) + H_2O = GLUE (Calcium Silicate Hydrate (CSH)) + Free Lime $Ca(OH)_2$ (By-product)

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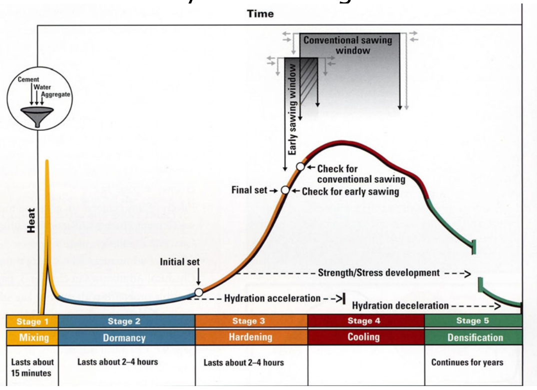
Hydration Stages



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Supplementary Cementitious Materials

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Fly Ash

- What is fly ash?
  - Fly ash, the most widely used supplementary cementitious material in concrete, is a by product of the combustion of pulverized coal in electric power generating plants
- Where does it come from?
  - coal burning power plants
  - pulled from exhaust gases

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Classes

- ASTM C618 Defines two classes of fly ash:
  - Class C
  - Class F
- ASTM C618 requirements:
  - Loss of Ignition (LOI) < 6%
  - 66% of ash must have fineness of 45 μm or less
- Primary difference between Class C and Class F fly ash is the amount of the amount of calcium, silica, alumina, and iron content in the ash

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Class F

- Produced from burning harder, older anthracite and bituminous coal.
- Contains less than 20% lime
- Requires cementing agent like PC, quick lime, hydrated lime
- Used in high sulfate exposure conditions

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Class C

- Produced from burning younger lignite and subbituminous coal
- Higher concentration of alkali and sulfate
- Contains more than 20% lime
- Self-cementing properties

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How do Pozzolans Work?

Hydration Reaction

- Reaction of hydraulic cementitious materials with water results in production of calcium silicate hydrates (C-S-H) and calcium hydroxide (CH), also ettringite and other hydrated aluminate phases (C-A-H)
  - Examples: portland cement, slag cement, Class C fly ash
- **Hydraulic Reaction:**

  Hydraulic Cement + Water → C-S-H + CH

- C-S-H provides strength – desirable product
- CH provides little strength and is soluble, also is a reactant in many MRD mechanisms – undesirable product

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How do Pozzolans Work?

Pozzolanic Reaction

- SCMs consume **CH** through the pozzolanic reaction
  - Improves strength
  - Increases paste density
  - Reduces alkali (ASR mitigation)
  - Reduces rate of heat evolution due to hydration reaction
  - Slower strength development

Hydration Reaction: Cement + Water → C-S-H + CH

Pozzolanic Reaction: Pozzolan + CH + Water → C-S-H

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So why do we use fly ash?

Fly ash improves the properties of concrete and offers other advantages

- Performance – It works!
  - Improved workability
  - Decreased permeability
  - ASR mitigation when necessary
- Reserves – there is nothing else available that provides the same performance and advantages, and is available in comparable quantities
- Sustainability goals

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PROPERTIES

	Fly ash		Slag cement	Silica fume	Natural pozzolans		
	Class F	Class C			Calcined shale	Calcined clay	Metakaolin
Water demand	↓	↓	↓	↑	↔	↔	↑
Workability	↑	↑	↑	↓	↑	↑	↓
Bleeding and segregation	↓	↓	↕	↓	↔	↔	↓
Setting time	↑	↕	↑	↔	↔	↔	↔
Air content	↓	↓	↔	↓	↔	↔	↓
Heat of hydration	↓	↕	↓	↔	↓	↓	↔

Key: ↓ Lowers ↑ Increases ↕ May increase or lower ↔ No impact

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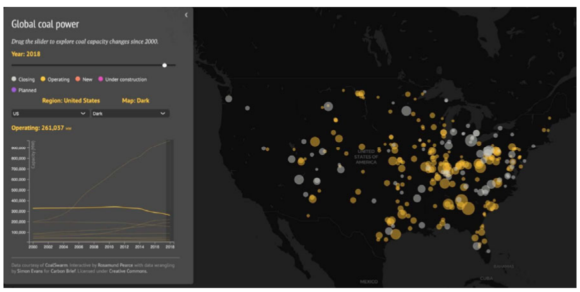
Fly Ash Supply



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What will replace fly ash if needed?

Short Term

- Straight cement
  - existing solution but performance issues
- Slag cement
  - existing solution but supply limited
  - Need higher replacement levels
  - Curing is essential
- Natural pozzolans
  - geographically limited (western US)

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What will replace fly ash if needed?

Long Term

- Harvested/recovered fly Ash
- Imported fly ash
- Lower quality fly ash
- New materials (colloidal silica, glass)
- Blended ASTM C 595 Cements

Do specifications exist to adequately screen these materials????

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Slag

Ground granulated blast-furnace slag (GGBFS): A hydraulic cement formed when granulated blast-furnace slag is ground to a suitable fineness.

Advantages

- Better concrete workability
- Easier finishability
- Higher compressive and flexural strengths
- Lower permeability
- Improved resistance to aggressive chemicals
- More consistent plastic and hardened properties
- Lighter color

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Silica Fume

Silicon metal are produced in electric furnaces. The raw materials are quartz, coal, and woodchips. The smoke that results from furnace operation is collected and sold as silica fume, rather than being landfilled.

Advantages

- Increased concrete strength (12-15,000 psi)
- Increased modulus of elasticity
- Improved durability
- Lower permeability
- Improved resistance to corrosion

- Very placement sensitive

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Aggregates

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Mineralogy

Igneous

Formed from volcanic processes and the heating and cooling of magma

- Example: granite

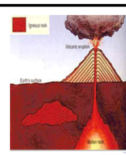
Sedimentary

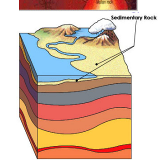
- Formed by the layering of sediments due to the action of wind or water
  - Example: sandstone

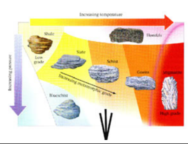
Metamorphic

Result from long-term high temperature and pressure on igneous and sedimentary rocks

- Example: marble







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Coarse Aggregate

- Gravel and crushed stone
- ≥ 4.75 mm (0.2 in.), larger than #4 sieve
- typically, between 9.5 and 37.5 mm (3/8 & 1½ in.)

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Fine Aggregate

- Natural sand, manufactured sand or crushed stone
- < 4.75 mm (0.2 in.), will pass #4 sieve
- F.A. content usually 35% to 45% by mass or volume of total aggregate

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Aggregate Specifications

- ASTM C33 - Normal Weight Aggregates
- ASTM C330 - Lightweight Aggregates
- ASTM C637 - Radiation Shielding Aggregates (Heavyweight)

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Grading Requirements for Coarse Aggregates

Size Number	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square-Openings), Mass Percent													
		100 mm (4 in.)	90 mm (3½ in.)	75 mm (3 in.)	63 mm (2½ in.)	50 mm (2 in.)	37.5 mm (1½ in.)	25.0 mm (1 in.)	19.0 mm (¾ in.)	12.5 mm (½ in.)	9.5 mm (⅜ in.)	4.75 mm (No. 4)	2.36 mm (No. 8)	1.18 mm (No. 16)	300 µm (No.50)
1	90 to 37.5 mm (3½ to 1½ in.)	100	90 to 100	...	25 to 60	...	0 to 15	...	0 to 5	...	...	...	...	...	...
2	63 to 37.5 mm (2½ to 1½ in.)	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...	...
3	50 to 25.0 mm (2 to 1 in.)	...	...	...	100	90 to 100	35 to 70	0 to 15	...	0 to 5	...	...	...	...	...
357	50 to 4.75 mm (2 in. to No. 4)	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	...	0 to 5	...	...	...
4	37.5 to 19.0 mm (1½ to ¾ in.)	...	...	...	...	100	90 to 100	20 to 55	0 to 15	...	0 to 5	...	...	...	...
467	37.5 to 4.75 mm (1½ in. to No. 4)	...	...	...	...	100	95 to 100	...	35 to 70	...	10 to 30	0 to 5	...	...	...
5	25.0 to 12.5 mm (1 to ½ in.)	...	...	...	...	...	100	90 to 100	20 to 55	0 to 10	0 to 5	...	...	...	...
56	25.0 to 9.5 mm (1 to ⅜ in.)	...	...	...	...	...	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	...	...	...
57	25.0 to 4.75 mm (1 in. to No. 4)	...	...	...	...	...	100	95 to 100	...	25 to 60	...	0 to 10	0 to 5	...	...
6	19.0 to 9.5 mm (¾ to ⅜ in.)	...	...	...	...	...	...	100	90 to 100	20 to 55	0 to 15	0 to 5	...	...	...
67	19.0 to 4.75 mm (¾ in. to No. 4)	...	...	...	...	...	...	100	90 to 100	...	20 to 55	0 to 10	0 to 5	...	...
7	12.5 to 4.75 mm (½ in. to No. 4)	...	...	...	...	...	...	...	100	90 to 100	40 to 70	0 to 15	0 to 5	...	...
8	9.5 to 2.36 mm (⅜ in. to No. 8)	...	...	...	...	...	...	...	...	100	85 to 100	10 to 30	0 to 10	0 to 5	...
89	9.5 to 1.18 mm (⅜ in. to No. 16)	...	...	...	...	...	...	...	...	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5
9[A]	4.75 to 1.18 mm (No. 4 to No. 16)	...	...	...	...	...	...	...	...	...	100	85 to 100	10 to 40	0 to 10	0 to 5

[A] Size number 9 aggregate is defined in Terminology C125 as a fine aggregate. It is included as a coarse aggregate when it is combined with a size number 8 material to create a size number 89, which is a coarse aggregate as defined by Terminology C125.

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Aggregate: properties of interest

Deleterious Materials
Non alkali-reactive
Abrasion Resistance
Frost Resistance
Texture
Aggregates
Absorption
Strength
Shape
Gradation
Size

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Aggregate – deleterious materials

Class Designation	Type or Location of Concrete Construction	Maximum Allowable, %: Clay Lumps and Friable Particles	Chert (Less Than 2.40 sp gr SSD)	Sum of Clay Lumps, Friable Particles, and Chert (Less Than 2.40 sp gr SSD)	Material Finer Than 75-µm (No. 200) Sieve	Coal and Lignite
	Severe Weathering Regions					
1S	Footings, foundations, columns and beams not exposed to the weather, interior floor slabs to be given coverings	10.0	...	...	1.0[C]	1.0
2S	Interior floors without coverings	5.0	...	...	1.0[C]	0.5
3S	Foundation walls above grade, retaining walls, abutments, piers, girders, and beams exposed to the weather	5.0	5.0	7.0	1.0[C]	0.5
4S	Pavements, bridge decks, driveways and curbs, walks, patios, garage floors, exposed floors and porches, or waterfront structures, subject to frequent wetting	3.0	5.0	5.0	1.0[C]	0.5
5S	Exposed architectural or decorative concrete	2.0	3.0	3.0	1.0[C]	0.5

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Choosing Aggregate Size

Maximum nominal size of aggregate
- 1/5 smallest dimension
- 1/3 thickness of slab
- 3/4 clearance between rebars

Congestion

Shrinkage

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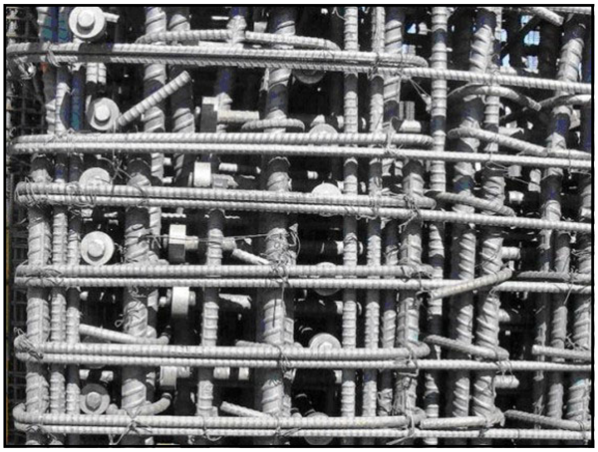

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Aggregate Size

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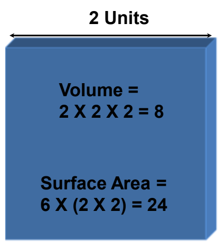
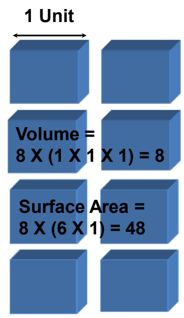
Why Aggregates Affect Water Demand





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

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Aggregate Gradation

- Also known as “sieve analysis”
- It is the distribution of particle sizes
- “Well-graded” aggregates:
  - particles evenly distributed among sieve sizes
  - require less cement and water than “poorly graded” aggregates
- Careful choice of aggregates provides for optimization of cement, water and admixtures

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Concrete Construction

Significance of aggregate grading
- smooth grading curve
  - (sieve size vs. % passing)
- more voids will lead to more cement.
- undersanded mixes tend to be harsh
- large sizes have less surface area

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Aggregate Gradation Affects:

- Workability
- Pumpability
- Economy
- Porosity
- Shrinkage
- Durability

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Gap-Graded Aggregates

- Certain particle sizes omitted, typically one coarse aggregate size
- Excess coarse aggregate – honeycomb, segregate
- Excess fine aggregate – high water demand, shrinkage
- Properly proportioned mixtures are readily consolidated with vibration

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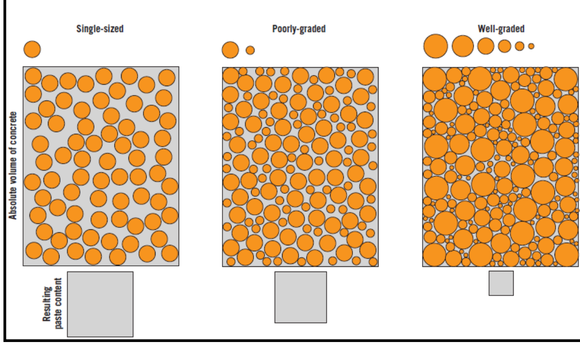
Combined Aggregate Grading



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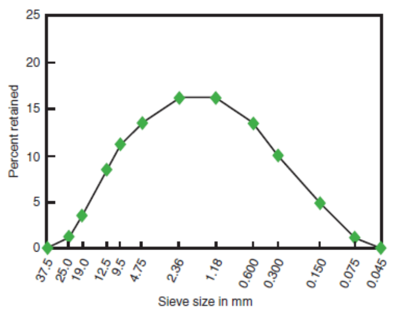
Combined Aggregate Grading



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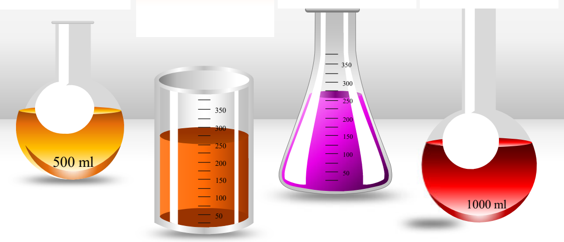
Admixtures

Air Entrainment
- VINSOL ROSIN
- SYNTHETIC
- POWDERED

Water Reducers
- 3 BASIC TYPES
- WRA
- MRWR
- HRWR

Set Controling
- ACCELERATOR
- RETARDERS
- HYDRATION CONTROL

Specialty
- VMA
- CORR INH.
- SHRINKAGE
- ASR
- ETC……



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Why are admixtures used?

- Increase Strength
- Improve Mix Workability
- Improve early strengths
- Control set time
- Reduce Permeability
- Durability Requirements
- Control Shrinkage
- Improve mix economics
- Increased service life!

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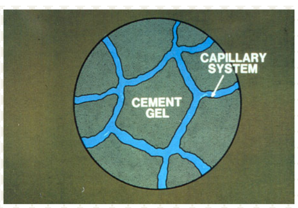
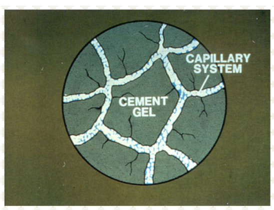
Why Air-Entrainment?

FREEZE/THAW DURABILITY!!!





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How do AEA's work?

- When temperatures surrounding concrete decrease below the freezing point of water, water present in the pores of the concrete starts to freeze and expand
- Air entrained voids act as small reservoirs for freezing water, which can freely freeze and expand without building up the pressure in the concrete.

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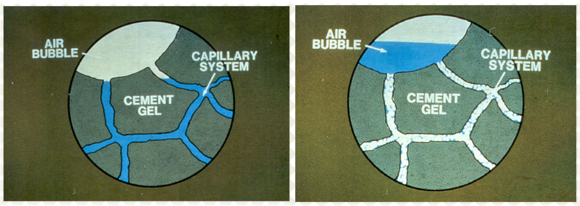
Why Air-Entrainment?

FREEZE/THAW DURABILITY!!!



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Effect of Water-Cement Ratio (W/C) on Concrete Properties

Low W/C
- Higher strength
- Lower Permeability
- Increased durability

Higher W/C
- Lower Strength
- Higher Permeability
- Decreased Durability

Low W/C
- Sticky to finish
- Prone to crazing
- Curing essential

Higher W/C
- Better finishability
- Less crazing

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Water Reducer Benefits

- Fresh concrete properties:
  - Lower water-cementitious material ratio
  - Improved workability, flowability, pumpability, and placeability
  - Influence time of setting
  - Improved finishing

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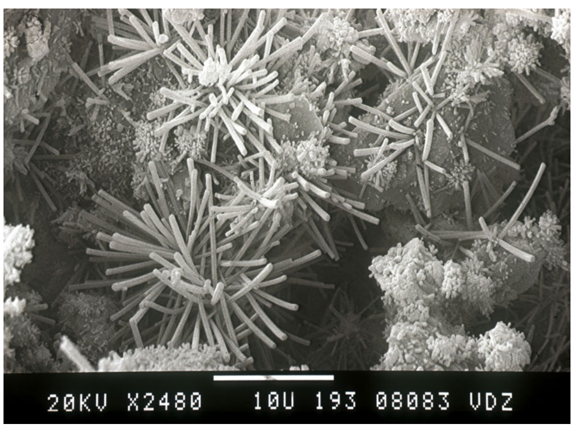

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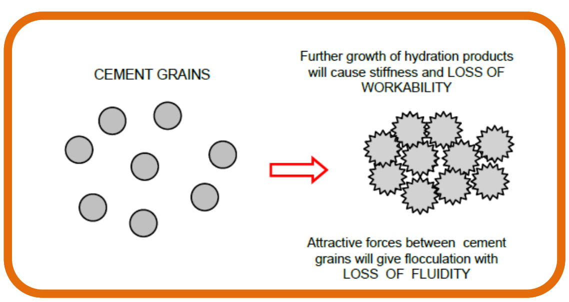
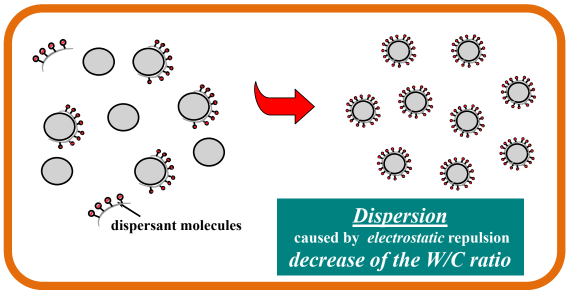
Mechanism of Action Without Dispersant



90

Mechanism of Action for a Standard Dispersant



91

Levels of Concrete Slump

No Admixture

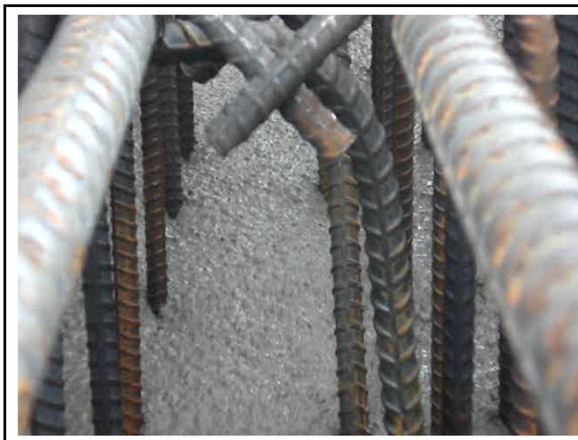
Conventional

695 lbs. Cement
0.40 w/c ratio

Mid-Range Water Reducer

High-Range Water Reducer

92

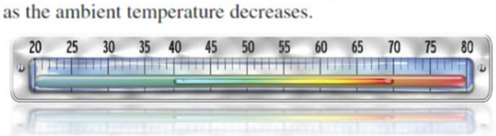


93

94

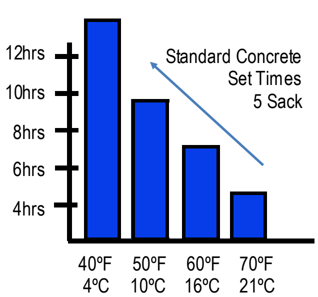
Cold Weather (ACI 306 Definition)

Cold weather exists when the air temperature has fallen to, or is expected to fall below 40°F (4°C) during the protection period. The protection period is defined as the time required to prevent concrete from being affected by exposure to cold weather. Concrete placed during cold weather will develop sufficient strength and durability to satisfy the intended service requirements when it is properly produced, placed, and protected. The necessary degree of protection increases as the ambient temperature decreases.



95

Weather Effects on Concrete



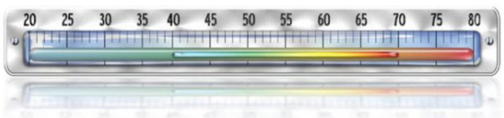
Rule Of Thumb: Each 20°F Drop In Concrete Temperature Will Double Set Time

96

Cold-Weather Concreting

3 methods to accelerate strength gain:

- Type III or HE high-early-strength cement
- Additional cement (100 to 200 lb/yd^3)
- Chemical accelerators



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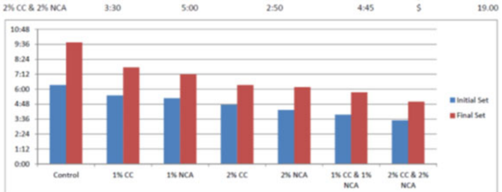
Example of Non-Chloride Accelerator Effect on Set Time

Straight Cement (564# of Cement)

Mix	Initial Set	Final Set	Time Savings Initail	Time Savings Final	Cost
Control	6:20	9:45			
1% CC	5:30	7:45	0:50	2:00	$ 3.00
1% NCA	5:17	7:12	1:03	2:33	$ 6.50
2% CC	4:45	6:20	1:35	3:25	$ 6.00
2% NCA	4:20	6:10	2:00	3:35	$ 13.00
1% CC & 1% NCA	3:58	5:45	2:22	4:00	$ 9.50
2% CC & 2% NCA	3:30	5:00	2:50	4:45	$ 19.00



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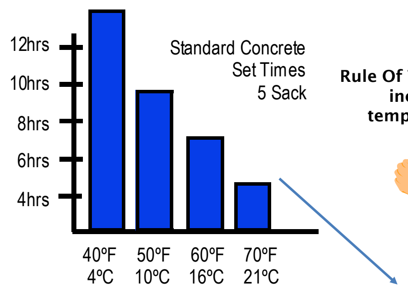
Hot Weather Concrete

99

Weather Effects on Concrete



Rule Of Thumb: Each 20°F increase in concrete temperature will halve set time

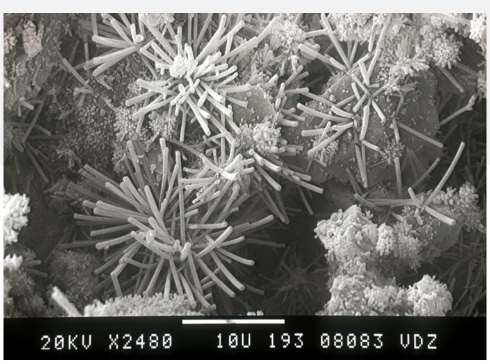
100

Retarders/Hydration Control Admixtures

- Can completely stop hydration process for several hours or days
- Provide more control than conventional retarders
- Little risk of over dosing – very linear in dosage
- Enhance late age strength

101

Without HC After 1 hour



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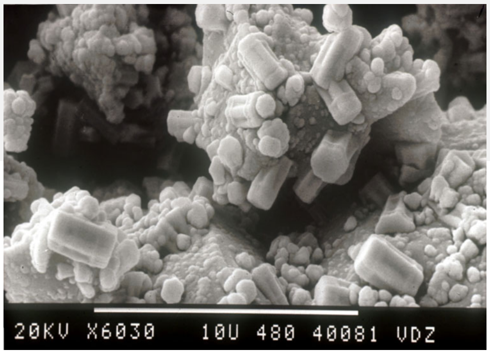
With HC After 1 hr



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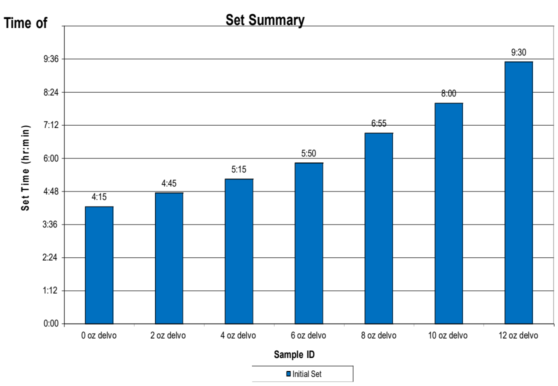

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4

Concrete Delivery Ticket

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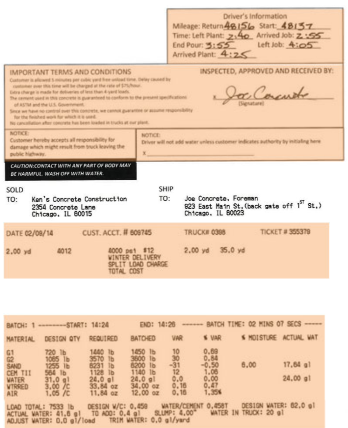

Driver's Information
Mileage: Return 48156 Start: 48137
Time: Left Plant: 2:40 Arrived Job: 2:55
End Pour: 3:55 Left Job: 4:05
Arrived Plant: 4:25

IMPORTANT TERMS AND CONDITIONS
Customer is allowed 5 minutes per cubic yard free unload time. Delay caused by customer over this time will be charged at the rate of $75/hour.
Extra charge is made for deliveries of less than 4-yard loads.
The cement used in this concrete is guaranteed to conform to the present specifications of ASTM and the U.S. Government.
Since we have no control over this concrete, we cannot guarantee or assume responsibility for the finished work for which it is used.
No cancellation after concrete has been loaded in trucks at our plant.

INSPECTED, APPROVED AND RECEIVED BY:
x Joe Concrete
(Signature)

NOTICE:
Customer hereby accepts all responsibility for damage which might result from truck leaving the public highway.

NOTICE:
Driver will not add water unless customer indicates authority by initialing here
x

CAUTION:CONTACT WITH ANY PART OF BODY MAY BE HARMFUL. WASH OFF WITH WATER.

SOLD TO: Ken's Concrete Construction
2354 Concrete Lane
Chicago, IL 60015

SHIP TO: Joe Concrete, Foreman
923 East Main St.(back gate off 1st St.)
Chicago, IL 60023

DATE 02/08/14 CUST. ACCT. # 609745 TRUCK# 0398 TICKET # 355379

2.00 yd 4012 4000 psi #12 2.00 yd 35.0 yd
WINTER DELIVERY
SPLIT LOAD CHARGE
TOTAL COST

BATCH: 1 --------START: 14:24 END: 14:26 ------ BATCH TIME: 02 MINS 07 SECS -----

MATERIAL	DESIGN QTY	REQUIRED	BATCHED	VAR	% VAR	% MOISTURE	ACTUAL WAT
G1	720 lb	1440 lb	1450 lb	10	0.69		
G2	1065 lb	3570 lb	3600 lb	30	0.84		
SAND	1255 lb	6231 lb	6200 lb	-31	-0.50	6.00	17.64 gl
CEM TII	564 lb	1128 lb	1140 lb	12	1.06		
WATER	31.0 gl	24.0 gl	24.0 gl	0.0	0.00		24.00 gl
WTRRED	3.00 /C	33.84 oz	34.00 oz	0.16	0.47		
AIR	1.05 /C	11.84 oz	12.00 oz	0.16	1.35%		

LOAD TOTAL: 7533 lb DESIGN W/C: 0.459 WATER/CEMENT 0.458T DESIGN WATER: 62.0 gl
ACTUAL WATER: 41.6 gl TO ADD: 0.4 gl SLUMP: 4.00" WATER IN TRUCK: 20 gl
ADJUST WATER: 0.0 gl/load TRIM WATER: 0.0 gl/yard

Concrete Delivery Ticket

1. Terms & Conditions
2. Batch & Delivery Times
3. Mix ID# & Quantity
4. Mix Constituents
5. Water

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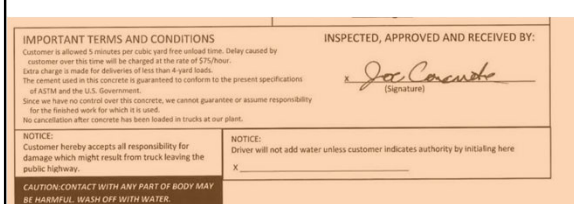
1. Terms and Conditions



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NOTICE:
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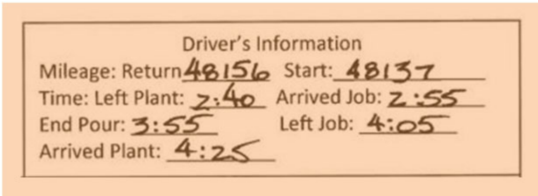
x

CAUTION:CONTACT WITH ANY PART OF BODY MAY BE HARMFUL. WASH OFF WITH WATER.

108

2. Batch & Delivery Times



Driver's Information

Mileage: Return 48156 Start: 48137

Time: Left Plant: 2:40 Arrived Job: 2:55

End Pour: 3:55 Left Job: 4:05

Arrived Plant: 4:25

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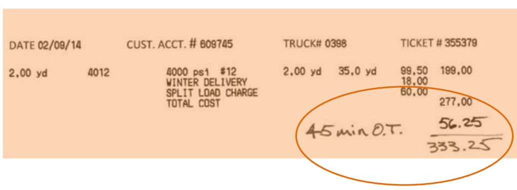
3. Mix ID & Quantity

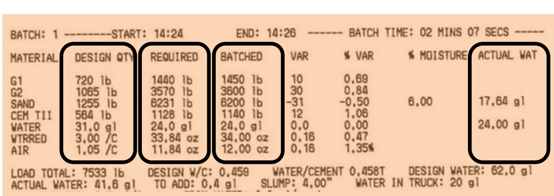


DATE 02/09/14 CUST. ACCT. # 609745 TRUCK# 0398 TICKET # 355379

2.00 yd	4012	4000 psi #12	2.00 yd	35.0 yd	99.50	199.00
		WINTER DELIVERY			18.00	
		SPLIT LOAD CHARGE			60.00	
		TOTAL COST				277.00
			45 min O.T.			56.25
						333.25

110

4. Mix Constituents



BATCH: 1 --------START: 14:24 END: 14:26 ------ BATCH TIME: 02 MINS 07 SECS -----

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SAND	1255 lb	6231 lb	6200 lb	-31	-0.50	6.00	17.64 gl
CEM TII	564 lb	1128 lb	1140 lb	12	1.06		
WATER	31.0 gl	24.0 gl	24.0 gl	0.0	0.00		24.00 gl
WTRRED	3.00 /C	33.84 oz	34.00 oz	0.16	0.47		
AIR	1.05 /C	11.84 oz	12.00 oz	0.16	1.35%		

LOAD TOTAL: 7533 lb DESIGN W/C: 0.459 WATER/CEMENT 0.458T DESIGN WATER: 62.0 gl

ACTUAL WATER: 41.6 gl TO ADD: 0.4 gl SLUMP: 4.00" WATER IN TRUCK: 20 gl

111

5. Water, Water, Water

BATCH: 1 --------START: 14:24 END: 14:26 ------ BATCH TIME: 02 MINS 07 SECS -----

MATERIAL	DESIGN QTY	REQUIRED	BATCHED	VAR	% VAR	% MOISTURE	ACTUAL WAT
G1	720 lb	1440 lb	1450 lb	10	0,69		
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SAND	1255 lb	6231 lb	6200 lb	-31	-0,50	6,00	17,64 gl
CEM TII	564 lb	1128 lb	1140 lb	12	1,06		
WATER	31,0 gl	24,0 gl	24,0 gl	0,0	0,00		24,00 gl
WTRRED	3,00 /C	33,84 oz	34,00 oz	0,16	0,47		
AIR	1,05 /C	11,84 oz	12,00 oz	0,16	1,35%		

LOAD TOTAL: 7533 lb DESIGN W/C: 0,459 WATER/CEMENT 0,458T DESIGN WATER: 62,0 gl
ACTUAL WATER: 41,6 gl TO ADD: 0,4 gl SLUMP: 4,00" WATER IN TRUCK: 20 gl

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5

Emerging Trends

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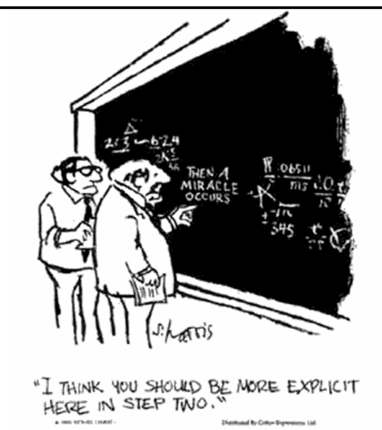

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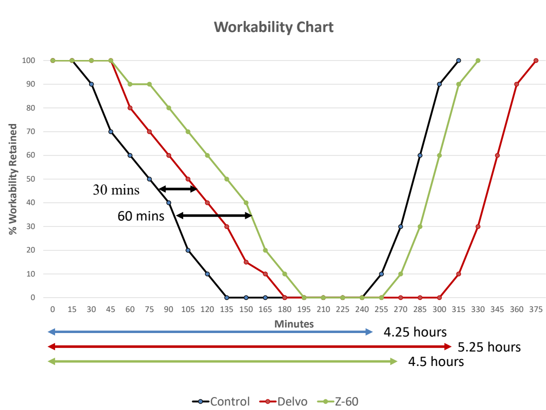
Workability Retaining Admixtures

- Maintain fresh concrete characteristics throughout transport, placing, consolidation, and finishing without affecting the time of setting and hardened

- Batch a 6” slump and deliver a 6” slump

116



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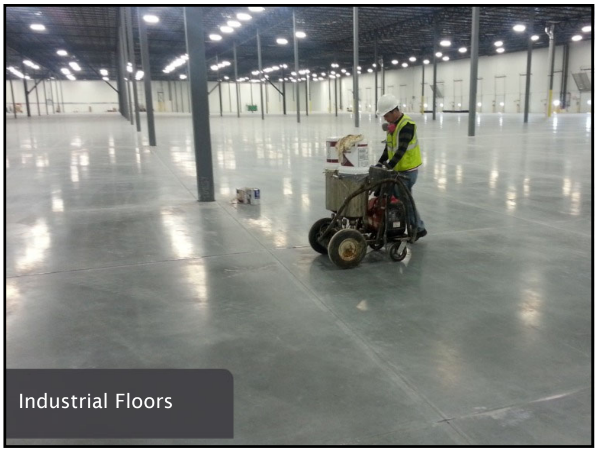

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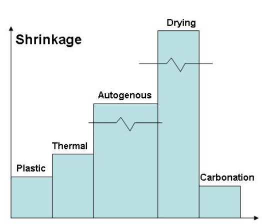
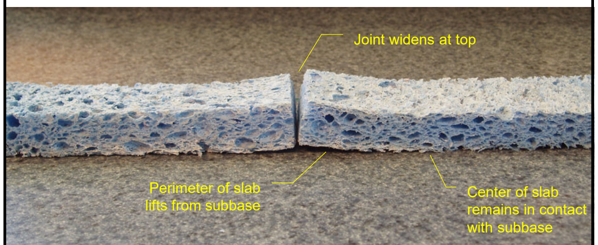
Concrete Shrinkage

- Types of Shrinkage
- Plastic
- Drying (only one we measure)
- Autogenous/chemical
- Thermal
- Carbonation



120

Sawcut joints start life flat, but drying causes upward warping:



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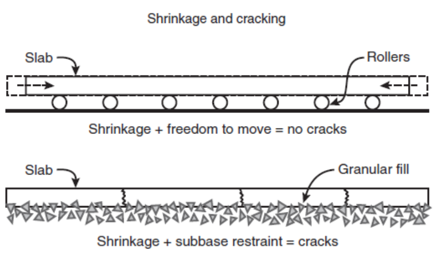
Why Joint Slabs-on-Ground?



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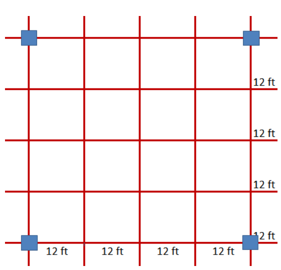
ACI 360R Recommended Joint Spacing



Concrete panels are typically square

The squares are normally sized equally Between the column lines.

123

New Crack-Reducing Admixture

Admixture, crack-reducing – a special class of shrinkage-reducing admixture that produces a maximum initial crack width of 175 μm in high-performance, crack-prone (HPCP) concrete mixtures tested in accordance with ASTM C 1581.

HPCP mix cracks in < 10 days and has an initial crack width of at least 1 mm.

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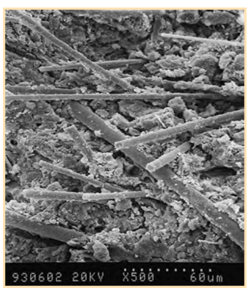
Macro Synthetic & Steel Fibers

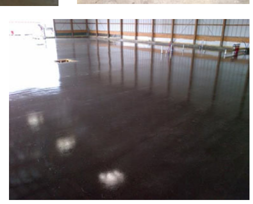


125

Extended Joint Spacing

Application: Slab on ground - 8 in. [200 mm] thick, 60 ft x 90 ft [27.4 m x 18.3 m]

Results:
- Easy to place and finish



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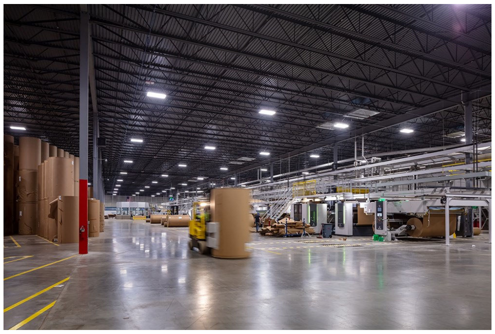
Extended Joint Spacing

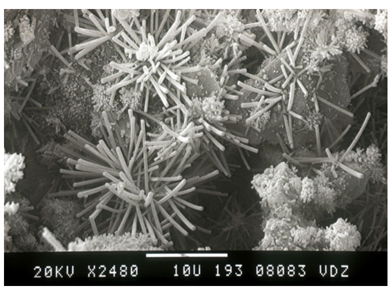


Application: Industrial slab on ground - 6 in. thick, 100 ft x 100 ft

127

Strength on Demand

Cement + Water = Calcium silicate hydrate (CSH) + $Ca(OH)_2$



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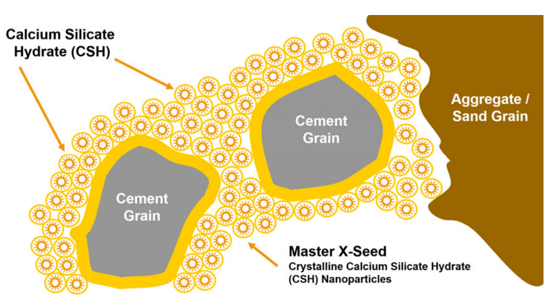
Strength on Demand



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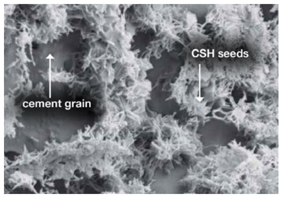
Crystalline Calcium Silicate Hydrate (CSH) Nanoparticles

Admixture Includes CSH Seeds
- Nanoparticles improve cement hydration
- Breakthrough technology – creating a new category of admixture performance

Unmatched Strength Enhancement
- Improves early- and late-age strength development
- Ability to increase the use of supplementary cementitious materials

Improving Concrete Performance
- Provides for strength safety factor and expanded performance space
- CSH nanoparticles provide flexibility in concrete design and production



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Strength on Demand

Type I Cement - Lbs.	564	564	658
Class C Fly Ash - Lbs.	0	0	0
Coarse Aggregate - Lbs.	1720	1720	1720
Fine Aggregate - Lbs.	1360	1360	1300
Water - Lbs.	261	261	263
w/cm ratio	0.43	0.43	0.4
Air Entrainment - oz/cwt	0.9	0.9	0.9
Mid Range - oz/cwt	4	4	4
Superplasticizer - oz/cwt	---	---	---
Master X-Seed 55 - oz/cwt	0	8	0
Properties			
Slump - In.	6	6.25	6.5
Air Content - %	4.5	5	5.1
Unit Weight - pcf	147.8	146.6	147.2
Temperature - °F	74	74	75
Strength - psi			
1 Day	1469	3577 *	2613 *
2 Day	3107	4797	3982
7 Day	4561	6893	5390
28 Day	5635	7662	6461

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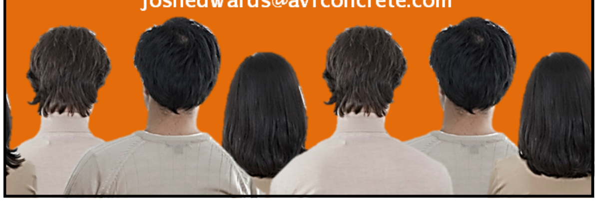
QUESTIONS?

joshedwards@avrconcrete.com



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