PHRC Webinar Series | Tuesday, December 13th @ 1pm

Residential Concrete 101

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Description

Concrete is one of the most commonly used building materials in residential construction, but is often over looked. In this webinar we will review the components of concrete and explain how each of them play a critical role in creating long lasting and durable finished product for placement and needs within residential construction. We will also review current code requirements along with guidelines set by the American Concrete Institute.

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Learning Objectives

- Review the components and mixtures of concrete to ensure a durable structure for the occupant.
- Review concrete additives and how they can either enhance or degrade the chemical makeup of concrete with the understanding that degradation can impact the safety of the occupant.
- Review the curing time required for specific concrete mixtures. Premature construction on uncured concrete can increase risks to the tradesman.
- Review current code requirements regarding concrete as set forth in the 2009 IRC along with documentation published by the American Concrete Institute.

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Outline

- **Fundamentals**
  - What is concrete
  - What is some of the chemistry behind cement
  - Code Requirements
- **Understanding Residential Concrete Construction**
  - Installing in weather
  - Workability
  - Review common imperfections or issues

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What is Concrete?

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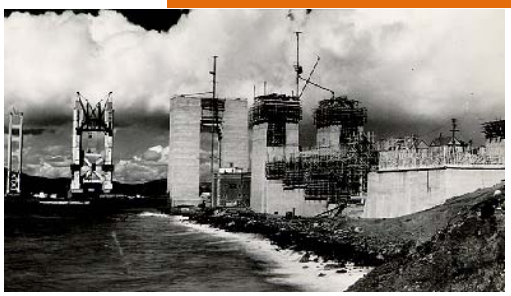
The Unseen Building Block



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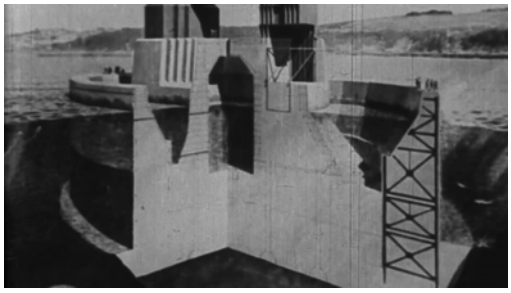
The Unseen Building Block



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Concrete Uses

- **Roads, bridges and other infrastructure**
- **Commercial construction**
- **Residential construction**
  - Foundation walls
  - Slab work
  - Structural columns
  - Retaining walls

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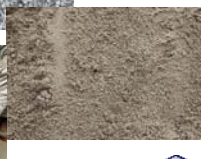
Concrete Materials

- **Cementitious materials**
  - Portland cement
  - Fly ash
  - Slag
- **Coarse aggregate**
  - Gravel
- **Fine aggregate**
  - Sand
- **Water**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Concrete Material Mixing Ratio

- **Mixing ratio will change depending on aggregate size and final use of the concrete, but a good starting point would be:**
  - 1 part cement + 2 parts sand + 3 part aggregate and add water to desired consistency

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Importance of the Mixture Ratio

- **Strength of the concrete depends primarily on the water / cement ratio**
  - As the amount of cement is increased, the strength of the concrete will increase
    - Must still have enough water to hydrate all of the cement
  - Addition of water will increase workability, however it will decrease the strength and increase the potential for shrinkage and development of cracks

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What is Hydration?

- **Hydration**
  - Hydration is NOT drying
  - Hydration is a series of irreversible exothermic **chemical reactions** between cement and water

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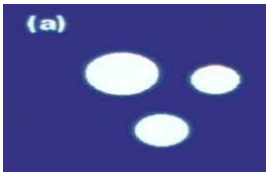
Hydration of Cement

a) Water has been introduced to cement



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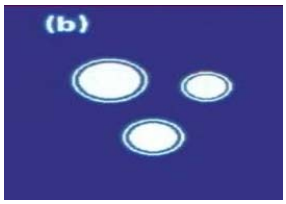
Hydration of Cement

b) The result of the chemical reaction is the growth of Calcium Silicate Hydrate (CSH) gel. This substance is the "glue" to concrete.



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Hydration of Cement

c) Secondary growth of CSH gel and crystallization of Calcium Hydroxide ($Ca(OH)_2$)

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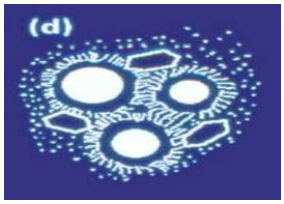
Hydration of Cement

d) **Completion of hydration process where CSH gel and calcium hydroxide infill between cement grains and create a solid material.**



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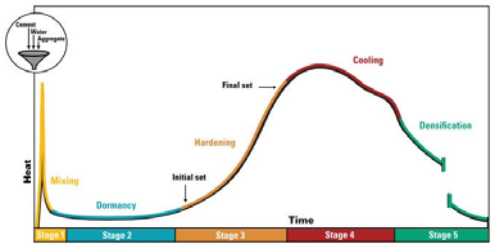
Hydration Curve



27 Picture curtesy of Integrated Materials and Construction Practices

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Code Requirements

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2009 International Residential Code

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R402.2 Concrete

- **Compressive Strength at 28 days**

Table 402.2
MINIMUM SPECIFIED COMPRESSIVE STRENGTH OF CONCRETE

Type or Location of Concrete Construction	Minimum Specified Compressive Strength[a] (f'_c) Weathering Potential[b]		
	Negligible	Moderate	Severe
Basement walls, foundations and other concrete not exposed to the weather	2,500	2,500	2,500[c]
Basement slabs and interior slabs on grade, except garage floor slabs	2,500	2,500	2,500[c]
Basement walls, foundation walls, exterior walls and other vertical concrete work exposed to the weather	2,500	3,000[d]	3,000[d]
Porches, carport slabs and steps exposed to the weather, and garage floor slabs	2,500	3,000[d,e,f]	3,500[d,e,f]

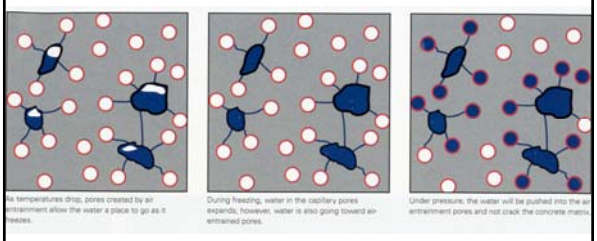
d. Concrete shall be air-entrained. Total air content (percent by volume of concrete) shall be not less than 5 percent or more than 7 percent.
f. For garage floors with a steel troweled finish, reduction of the total air content (percent by volume of concrete) to not less than 3 percent is permitted if the specified compressive strength of the concrete is increased to not less than 4,000 psi.

31 International Code Council (ICC). (2009). *2009 International Residential Code,* Country Club Hill, Ill.

Air-entrained Concrete

- **What does that mean?**
  - Air-entrained concrete contains billions of microscopic air cells per cubic foot. These air pockets relieve internal pressure on the concrete by providing tiny chambers for water to expand into when it freezes. Air-entrained concrete is produced using an air-entraining agent (chemical admixture), under careful engineering supervision, as the concrete is mixed on the job. The amount of entrained air is usually between 4 to 7 percent of the volume of the concrete, but may be varied as required by special conditions.
- **Air-entrainment is not the same as Air-entrapment!**

Air-entrained Concrete



Air-entrainment Concerns

- **Air-entrainment for severe weathering should be between 5-7% depending on aggregate size**
- **Pumping – Reduction in air content by 2-3%**
- **Vibration – Air content decreases under prolonged vibration**
- **Haul time – Long hauls even without agitation can reduce air content, especially in hot weather**

Testing for Air-entrainment

- Testing equipment needed
- Are results provided?

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ACI 332-08

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Referenced Standard

- The ACI 332-08 is a referenced standard in Chapter 44 Referenced Standards in the 2009 International Residential Code

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ACI 332-08

- **Section 1.1.1 – This code, when legally adopted as part of a general building code, provides minimum requirements for design and construction of residential concrete elements.**

American Concrete Institute. (2008). *Code Requirements for Residential Concrete and Commentary*, Farmington Hills, MI

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Difficulties Facing Residential Concrete Construction

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Onsite Variables

Installation of Concrete in Cold Weather

- Ambient temperature is less than 35° F, concrete temperature should be maintained above 35° F until the compressive strength reaches 500 psi
- Frozen material containing ice should not be used
- Below 41° F, hydration slows
- Below 14° F, hydration stops
- If air temp within 24 hours of pour is below 41° F, precautions need to be taken
- Concrete materials, reinforcement, forms and any earth with which concrete is to come in contact shall be free from ice, snow and frost

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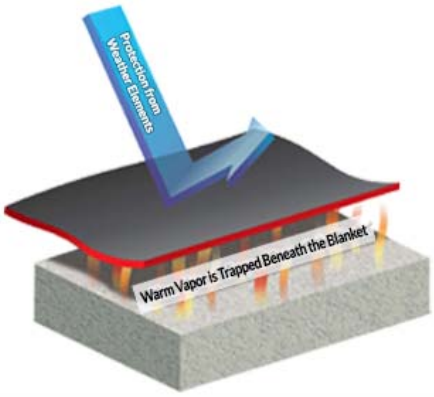

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Installation of Concrete in Hot Weather

- Hot weather can also lower the overall compressive strength of concrete
- Quick evaporation leads to a decreased slump, quicker setting, poor finishing conditions & variable air content
- Loss of water may lead to shrinkage and cracking
- Should not be placed when temperature is above 90° F

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Installation of Concrete in Hot Weather

- Install a wind break to reduce evaporation by air movement
- Cool concrete materials prior to mixing
- Keep mixing drums out of the direct sunlight
- Pour at night

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Workability of Concrete

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Workability of Concrete

- **The concrete mix should be workable during placement and finishing. Properties like consistency, setting time and bleeding also affect the strength of concrete.**

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Slump of Concrete

- **The consistency of concrete defines the flowability of concrete and it is measured through the slump test**
  - High slump value of 7”-8” means the concrete is more workable the high water content could result in weak concrete
  - Low slump value of 1”-3” means the concrete is difficult to place and finish
  - The slump value for residential construction should be between 5”-6”

BUT…

  - Because of admixtures, slump is not as reliable as it used to be for checking consistency

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Change Consistency Without Changing Water Content

- **Water-Reducing Admixture (WRA)**
- **Water / Cement ratio of 0.5**
  = 6″ slump

- **Super Plasticizer (Super P)**
- **Water / Cement ration of 0.5**
  = 8″ slump

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Changing of flow

- **Increased haul time can lower water content**
- **Improper addition of chemical admixtures**

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Admixtures

- **Admixtures**
  - Water-reducing admixtures or superplasticizers
  - Retarding admixtures
  - Accelerating admixtures
  - Corrosion-inhibiting admixtures
  - Shrinkage reducing admixtures

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Time isn't always on your side

- **Delivery**
  - Distance
- **Site prep**
  - Site not ready
  - Site access
- **Slow pour time**
  - Large project

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Onsite variables

- **Air-entrainment**
  - Pumping – Reduction in air content by 2-3%
  - Vibration – Air content decreases under prolonged vibration
  - Haul time – Long hauls even without agitation can reduce air content, especially in hot weather
- **Slump**
- **Curing water-cement ratio**
- **Admixtures**
- **Control joints**
- **Time**
  - Delivery
  - Slow pour time
- **Temperature**
  - Hot
  - Cold

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Common Concrete Imperfections

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Cracking

- **Concrete is relatively weak in tension, some cracking can be expected in most concrete construction**
- **Common cause of cracking in residential construction:**
  - Drying shrinkage
  - Plastic shrinkage cracking
  - Temperature effects
  - Soil settlement
  - Structural overloading

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Cracking

- **To minimize cracking potential, concrete should be:**
  - Placed with the lowest possible water content
  - Properly cured
  - Prevent rapid drying
  - Contraction joints

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Dusting

- **Dusting is the development of a fine powdery material due to a thin layer of weak concrete at the surface**
- **Caused by:**
  - Floating bleed water back into the surface
  - Overly wet mixtures
  - Inadequate curing
  - Freezing at the surface
  - Condensation (spring & fall)

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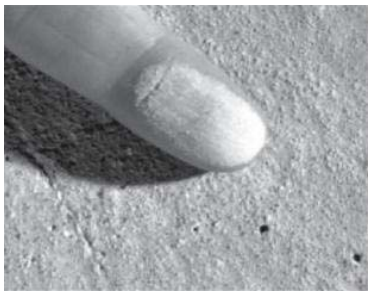

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Dusting

- **To minimize the potential for dusting:**
  - Do not begin finishing until all free water has evaporated or has been removed from surface
  - Vent exhaust fumes to outside (salamanders, heaters power trowels)
  - When high humidity is anticipated, use heated concrete and increase ventilation

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Scaling

- **Scaling is caused by the loss of surface mortar surrounding coarse aggregate particles, leaving the coarse aggregate exposed**
- **Caused by:**
  - Water freezing in the concrete
  - Lack of air entrainment
  - Addition of excessive amounts of calcium
  - High water content at surface of slab
  - Over working the surface during finishing

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Scaling

- **To minimize the potential for scaling:**
  - Concrete exposed to freezing and thawing cycles must be air-entrained to 6-7%
  - Use proper hydration techniques such as covering a new slab with wet burlap to ensure proper curing
  - Do not perform finishing with water present on the surface
  - Float promptly after initial screeding
  - Protect concrete from harsh winter environment

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Popouts

- **Popouts at the surface are usually caused by internal pressures**
- **Caused by:**
  - Water freezing in the concrete
  - Aggregates that swell with moisture
  - Lack of air entrainment

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Popouts

- **To minimize the potential of popouts:**
  - Use durable aggregates (materials with low absorption rate)
  - Use concrete with low water to cement ratios
  - Slope exterior work for proper drainage
  - Use proper curing methods

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Summary

- **Concrete is created by a chemical reaction between cement and water**
- **Chemicals can be added to accommodate most specific site needs**
- **Concrete industry is more like a restaurant and have a variety of batches on their menu**
- **A lot of site related issues can be eliminated if proper environmental variables are taken into consideration**

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Resources

- International Code Council. (2008). *2009 International Residential Code*, ICC, Country Club Hill, Ill.
- American Concrete Institute. (2008). *Code Requirements for Residential Concrete and Commentary*, Farmington Hills, MI

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