Concrete Durability for 2020 and Beyond
Shea Concrete Products- Technical Engineering Seminar ▪ 8/6/2020

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Outline

1. Introduction
2. Ingredients of Durable Concrete
3. Concrete Made Today for the Future
4. Projects
Lehigh Hanson, Inc. is one of the largest construction materials companies in North America with approximately 550 active operations in the U.S. and Canada.

Approx. 9,400 employees in North America

Lehigh Hanson, Inc. is part of HeidelbergCement, one of the world’s largest integrated manufacturers of building materials with leading market positions in aggregates, cement and ready mixed concrete. The company employs some 58,000 people at more than 3,000 locations in around 60 countries.
Lehigh Hanson – Heidelberg Cement – Company History

- **Lehigh Cement Company**
  - Founded in 1897 by several prominent businessmen from Allentown, Pennsylvania
  - In 1977, Lehigh was acquired by HeidelbergCement is now a top supplier of cement and related materials in the U.S. and Canada

- **Hanson, plc**
  - Hanson Trust was formed in 1964
  - Hanson, plc was acquired by HeidelbergCement in August 2007
  - Lehigh Cement and Hanson, PLC were integrated in 2008

- **Essroc**
  - Started as Coplay Cement in 1872, the company was the first producer of portland cement in North America.
  - Today, the Lehigh Cement Company, Essroc and the Hanson business in North America are collectively known as Lehigh Hanson, Inc
Our Business Lines

- **Cementitious**
  - Gray cement
  - Cement distribution terminals
  - Ground granulated blast furnace slag (GGBFS)
  - White and custom color cement

- **Aggregates and asphalt**
  - Crushed rock, sand & gravel
  - Hot-mix asphalt and construction operations
  - Recycling operations
  - Various other materials

- **Concrete**
  - Ready mixed concrete
  - Concrete block, pipe and other products
Ingredients of Durable Concrete
The Concrete Industry

- Concrete is the most used man-made product in the world

- World Cement production about 4.5 Billion tons in 2018
  - 2018 estimated 97 Million tons produced in the US
  - In 2018 2.6 Billion tons produced in China
Concrete

Mixture Containing:

- Cementitious Materials
- Aggregates
- Water
- Admixtures
THE MANUFACTURING OF CEMENT
How Do We Make Cement?

- Limestone: Quarry
- Silica: Sand
- Alumina: Ash
- Iron: Steel slag

Raw Materials

1450°C / 2640°F
Chemical Transformation

Cement
Kiln

Feed In

Hot Air Flow

Flame

Clinker Out
Flame temperature is 4150 °F/ 2640 °C.
Cement Clinker

Clinker is ground in ball mills to produce the cement
Types of Cement

Portland Cement

ASTM C150 Standard Specification for Portland Cement

- Type I  Normal
- Type II  Moderate Sulfate Resistance
- Type III  High Early Strength – Often used in precast
- Type IV  Low Heat of Hydration
- Type V  High Sulfate Resistance
Types of Cement

Blended Cements

ASTM C595 - Standard Specification for Blended Hydraulic Cement

- Type IL  Portland-Limestone Cement
- Type IS  Portland-Slag Cement
- Type IP  Portland-Pozzolan Cement
- Type IT  Ternary Blended Cement
Beside Cement.....

Supplementary Cementitious Materials (SCM)
Type of SCM’s—Pozzolans and Other Cementitious Materials

- Fly Ash
- Slag Cement
- Silica Fume
Roman Pantheon (ca. 120 AD)

Early SCM’s!
Fly Ash – Class F

- Combustion by-product from coal burning furnace
- Made up of anthracite and bituminous coals
- High percentage of SiO₂, Al₂O₃, and Fe₂O₃ (more than 70%)
- Lower percentage of Calcium Oxide
- Amorphous silica combines with Calcium Hydroxide to form CSH
- Concrete with Class F Ash
  - Lower early strength
  - 95% - 105% of the ultimate strength of a straight portland mixture
Plastic Properties

- Reduced water demand
- Better slump retention
- Enhanced workability
- Easier consolidation
- Improved pumpability
- Good finishability

Hardened Properties

- Improved Compressive Strengths
- Improved Flexural Strengths
- Reduced Permeability
- Improved Corrosion Resistance
- Increased Resistance to Sulfate Attack and Alkali-Silica Reaction

Add for longer lasting durable concrete
**Slag Cement (GGBFS)**

- **Definition:** Finely ground granulated material originating from an iron blast furnace and consisting of primarily calcium and aluminum silicates, used as a partial replacement for portland cement in concrete.
Plastic Properties

- Reduced water demand
- Better slump retention
- Enhanced workability
- Easier consolidation
- Improved pumpability
- Superior finishability
- Consistent air content

Hardened Properties

- Improved Compressive Strengths
- Improved Flexural Strengths
- Reduced Permeability
- Improved Corrosion Resistance
- Increased Resistance to Sulfate Attack and Alkali-Silica Reaction
- Lower Heat for Mass Concrete
- Increased SRI Value

Add for longer lasting durable concrete
Silica Fume

- Silica fume is a by-product of the reduction of high purity quartz in an electric arc furnace during the production of silicon metal or ferrosilicon alloys. Silica fume has a very high content of amorphous silicon dioxide and consists of very fine spherical particles.
Plastic Properties

- Increases water demand
- Lower slump retention
- Easier consolidation
- Decreased pumpability
- Consistent air content

Hardened Properties

- Improved Compressive Strengths
- Improved Flexural Strengths
- Reduced Permeability
- Improved Corrosion Resistance
- Increased Resistance to Sulfate Attack and Alkali-Silica Reaction

Add for longer lasting durable concrete
Normal Cement Hydration Process

Cement + Water $\rightarrow$ CSH + Ca(OH)$_2$
Hydration with SCM’s

- Portland Cement
- SAND
- SCM (Supplemental Cementitious Material)
- C-S-H (glue formed when cement hydrates)
- Additional glue (from SCM hydration, including converted Ca[OH]$_2$)
Concrete Admixtures

- Air-entraining admixtures
- Water reducing admixtures
- Retarding admixtures
- Accelerating admixtures
- Workability agents
- Waterproofing admixture
- Air-detraining admixture
- Gas forming admixture
- Fibers
Durable Concrete in 2020

Let’s Put It All Together

NPCA Photo
Old School Concrete Mixtures
Modern Concrete Mixtures

- **Cement**
- **Cementitious Materials**
- **Coarse Aggregates**
- **Fine Aggregates**
- **Water**
- **Chemical Admixtures**
COMPONENTS OF CONCRETE

Concrete is a mixture of two components: aggregate and paste. The paste is made up of portland cement and water, which then binds with sand, gravel or crushed stone (aggregate).

- Up to 8% of air
- 14% - 21% of water
- 7% - 15% of cement
- 60% - 75% of aggregates (Coarse & Fine)
Concrete Made Today For The Future – Projects

Durable Concrete Made Today For The Future

- High Performance Mixes
- Sustainable
- Durable
- Local
Self-Consolidating Concrete (SCC)

- Fluid Mix
- Non-segregating Concrete Mix / Admixture binds material
- “Cleaner” Smooth Finish
- Less Labor
Second Severn Crossing, Bristol-Cardiff United Kingdom

- **Project Summary:**
- **Bridge project:** Crossing point for the M4 motorway, over the Severn Estuary
- **Start/finish dates:** 1992/1996
- **Bridge type:** Cable-stayed
- **Length:** 5km (456m main span)
- **Structure:** 150m concrete pylons, precast cross beams, composite deck and twin box girder viaduct
- **Production:** Precast on shore and shipped into position
- **Tidal range:** 14.5m
- **Main Contractor:** Laing-GTM
Railway Tunnel Ejpovice, Czechia
Completed 2017
Railway Tunnel Ejpovice, Czechia Summary

Precast concrete reinforced with steel fibers.

Construction of two single-track tunnel tubes at Ejpovice, with a length of 4,150 meters (2.6 miles) each, which are part of the new railway line.

Trains will then be able to pass through this section of the railway corridor at speeds of up to 99 miles per hour.
The lining of the tunnel is a ring made from concrete with an outer diameter of 9.5 meters (31.2 feet) and internal diameter of 8.7 meters (28.5 feet).

4,000 rings are required for both tubes. Each ring is 2 meters long (6.6 feet), consists of eight segments and weighs 65 tons (US).

The rings are connected by plastic anchors (longitudinal direction) and steel rods (pulled out after injection).
Concrete for 2020 and Beyond - Femm Singer
TX Active Technology allowing the organically latticed outer wall to filter the air, converting pollutants into inert salts.

Rising 35 meters (115 feet) from the foot to the top of the front wall is a tangle of branch-like concrete elements, constructed using environmentally active titanium-oxide mortar.

The sustainable mortar comprised of 80 percent recycled materials.

More than 700 facing precast panels.
Palazzo Italia Expo 2015 – Milan, Italy

Summary

High-performance cement-based mortar offering high flexural strength.

TX Active Technology allowing the organically latticed outer wall to filter the air, converting pollutants into inert salts.
TX Active - The photocatalytic action eliminates the various pollutants
The photocatalytic action eliminates the various pollutants – vehicle exhaust gas, flue gas from domestic heating, industrial discharges of chemicals, pesticides

Museum covers 250,000 square feet (23,226 m²) and is divided into 4 buildings: a planetarium, an aquarium, and 2 separate wings for the science museum

The precast concrete panels cover the museum façade and the planetarium
Italian Pavilion - Expo Shanghai 2010, China

i.light®
Italian Pavilion - Expo Shanghai 2010, China
i.light® - Summary

The building was built with transparent cement i.light®.

3,774 transparent panels made of i.light® cover a total area of 1,887 m², the equivalent of about 40% of the whole architectural structure.

The exhibition structure is 18 m high, with an area of about 3,600 m², and is configured as a system of separate parts forming a geometrically unitary object.
i.light®, the innovative material that does not contain fiber optics.

Concrete mix ensures transparency by mixing cement and admixtures. The admixtures bind a matrix of plastic resins inside the cement-based material without generating cracks or weakening the structure.

The resins of different colors react both with natural and artificial light creating a warm and soft light inside the building and an image of bright shininess on the outside.
Resources

Lehigh Cement Co.
www.lehighhanson.com

National Precast Concrete Association (NPCA)
www.precast.org

Northeast Concrete Precast Concrete Association (NEPCA)
www.nepca.com

American Concrete Institute (ACI)
www.concrete.org

ACI New England Chapter
www.aci-ne.org

Portland Cement Association (PCA)
www.cement.org

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Thank you!