Engineering with Reinforced Concrete

Welcome!

Professional Learning Day at IMSA: STEM Education for the Future
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NGSS Performance Expectations

Physical Science:
  MS–PS1-3

Engineering Design:
  MS–ETS1-1
  MS–ETS1-2
  MS–ETS1-3
  MS–ETS1-4

Including Optional Extensions:
  Physical Science:
    MS–PS1-2
  Earth and Space Science:
    MS–ESS3-2
    MS–ESS3-3
Engineering with Reinforced Concrete

Disciplinary Core Ideas

- Asking Questions and Defining Problems
- Developing and Using Models
- Planning and Carrying Out Investigations
- Analyzing and Interpreting Data
- Using Mathematics and Computational Thinking
- Constructing Explanations and Designing Solutions
- Engaging in Argument from Evidence

Science and Engineering Practices

- ETS1.A   Defining and Delimiting Engineering Problems
- ETS1.B   Developing Possible Solutions
- ETS1.C   Optimizing the Design Solution

Crosscutting Concepts

- Patterns
- Cause and Effect
- Scale, Proportion, and Quantity
- Structure and Function

IMSA® Engineering with Reinforced Concrete
In this activity, students will:

- Select and define an engineering problem
- Design and build two potential solutions
- Create a method for evaluating their solutions
- Perform their evaluation
- Synthesize their results with the results obtained by other students
What do I need?

- Classroom with uncarpeted floors and level tables/desks
- 140 minutes of instructional time over 2 - 4 days
- In addition to materials typically available in the average science classroom:
  - $9-bag of Portland cement (90 lbs. only buy once)
  - $3-bag of play sand (50 lbs. only buy once)
  - $20 for miscellaneous testing materials (only buy once)
  - $10/class for consumable materials (paper clips, cups, etc)
History of Reinforced Concrete
The Romans developed a form of concrete made from CaO “quicklime”, volcanic sand, and pumice.

From 300 BCE to 476 CE the Romans used concrete extensively in buildings, bridges, and aqueducts.

Some are still in use today. “Modern” concrete is only expected to last about 100 years.
The Pantheon in Rome, built in 126 AD features a dome which only concrete could allow.

With the fall of the Roman Empire, the art and science of concrete was lost for 700 years.
In the early-19\textsuperscript{th} century, engineers developed Portland cement by grinding and baking a mixture of limestone and clay. No volcanic materials were required.

**Portland cement + water + aggregate = concrete**

Concrete is strong in compression but weak in tension.
In 1849, Joseph Monier added iron reinforcement bars (rebar) to his concrete.

concrete + rebar = reinforced concrete

Iron and steel are strong in tension.

Today, steel reinforced concrete is the most commonly used building material.
Chemistry of Reinforced Concrete
Portland cement reacts with water in a process called “hydration”.

\[ \text{Ca}_3\text{SiO}_5 + \text{H}_2\text{O} = (\text{CaO})(\text{SiO}_2)(\text{H}_2\text{O}) + \text{Ca(OH)}_2 + \text{Heat} \]

- calcium silicate hydrate
- gel hardens into crystal
- calcium hydroxide is a strong base
- exothermic reaction
Concrete does not dry; it cures.

Water remains an essential part of the crystalline structure.

The aggregate does not react chemically with the cement, it is simply locked within a rigid crystal of calcium silicate hydrate.