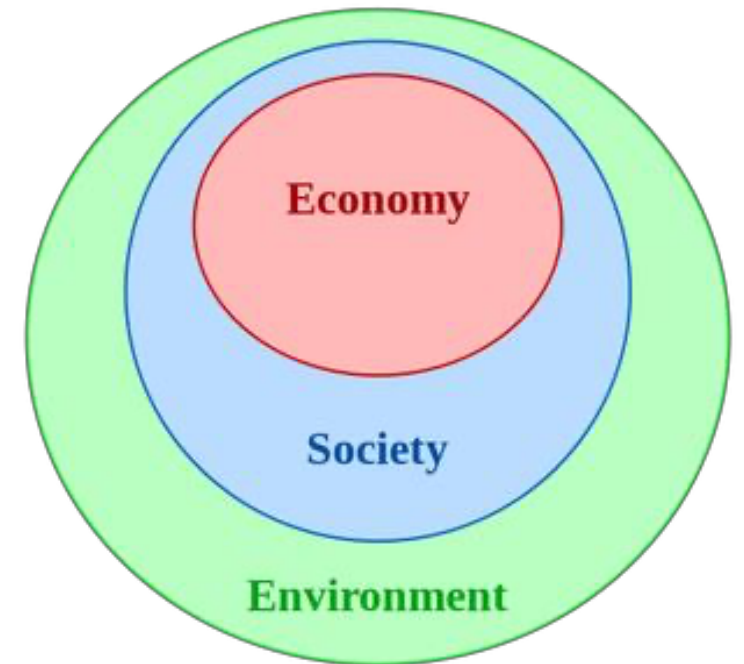
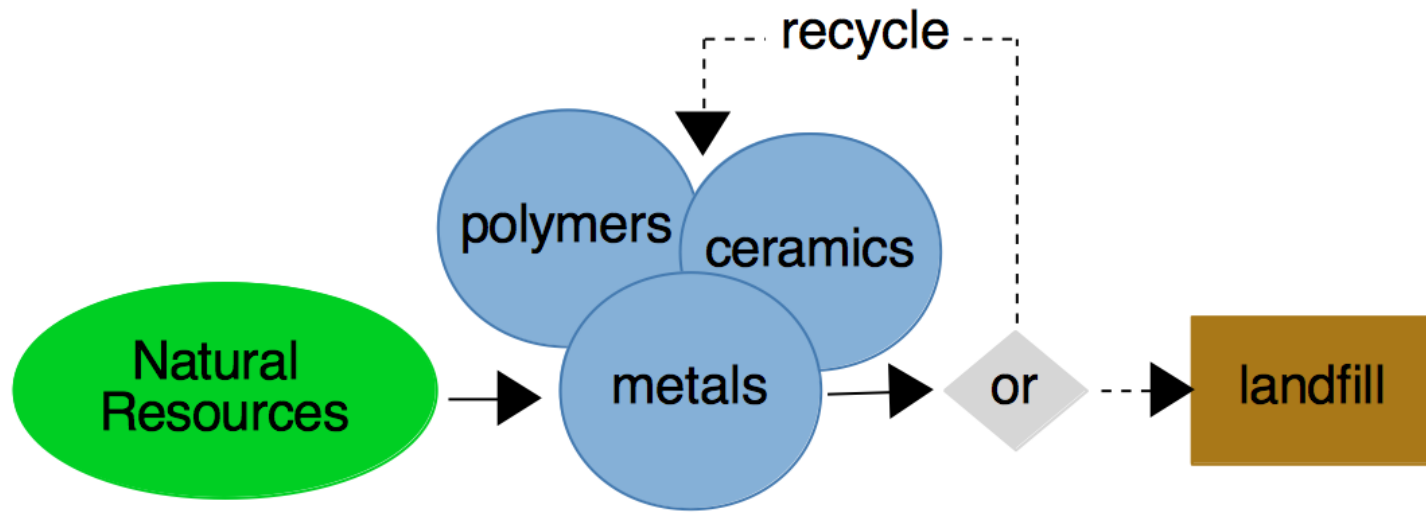




**Performance and Sustainability of**  
**bricks, tiles,**  
**plaster, mortar, concrete**  
compared to  
**metal**  
**wood, vinyl** *not straw*





post - fires of  
1874, 1875



The adobe architecture unique to New Mexico's Pueblo de Taos reflects the Pueblo Indians' heritage [900 CE].

Photograph by Mark Newman, Corbis Images  
*National Geographic* November 15, 2010

# Colonial Williamsburg



brick kiln

## Were bricks expensive in the 18th century?

Bricks were quite expensive. The resources a client had to provide made brick too pricey a building material for many Virginians.

A client would be expected to provide

- the land where the brickyard would be set up,
- sand to dust the molds and lay out new bricks,
- firewood to burn the bricks,
- enslaved labor to mold and stack the bricks.

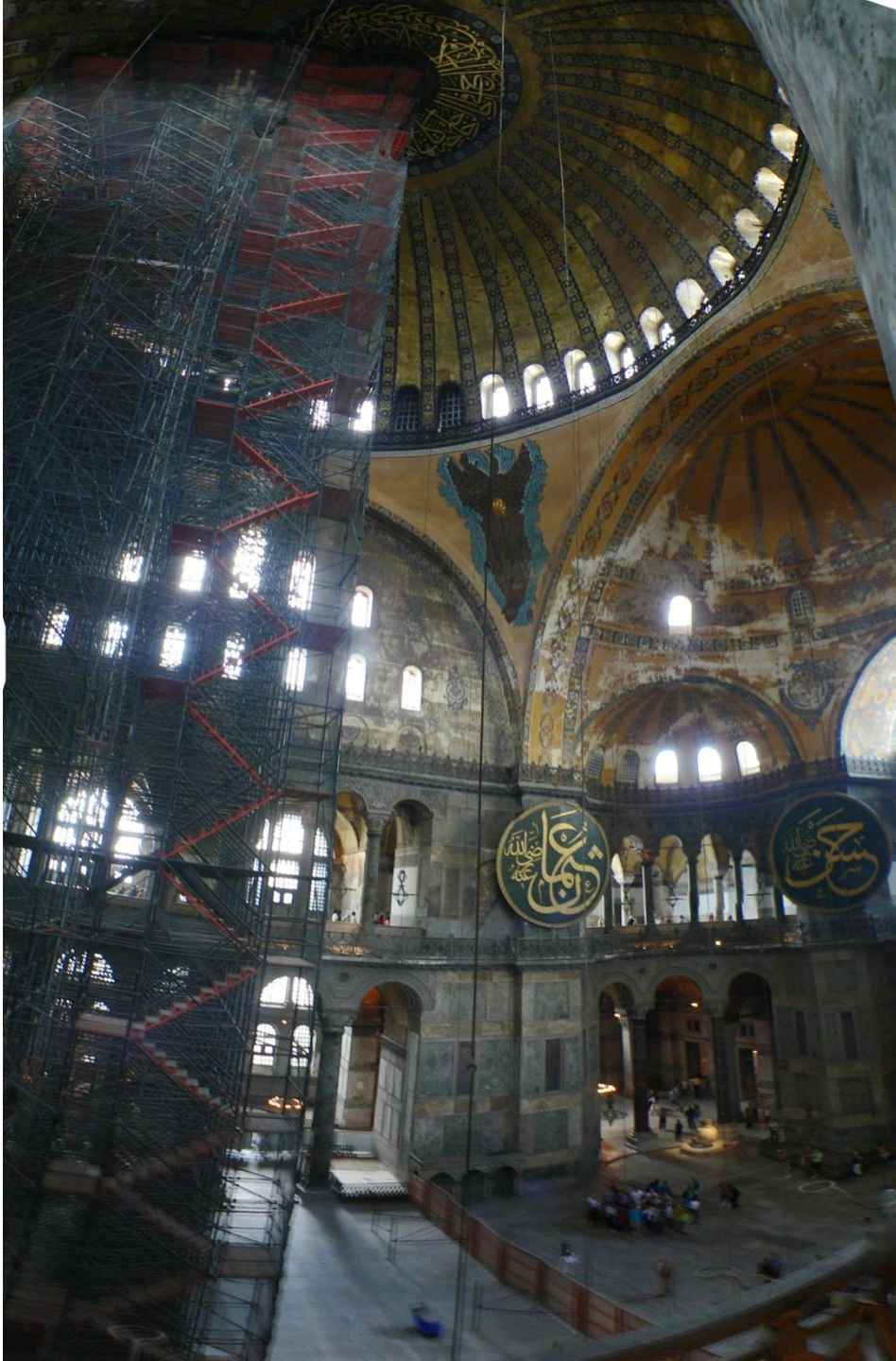
Most Virginians lived in wooden houses.

compression/tension in domes

Pantheon 28 CE  
concrete

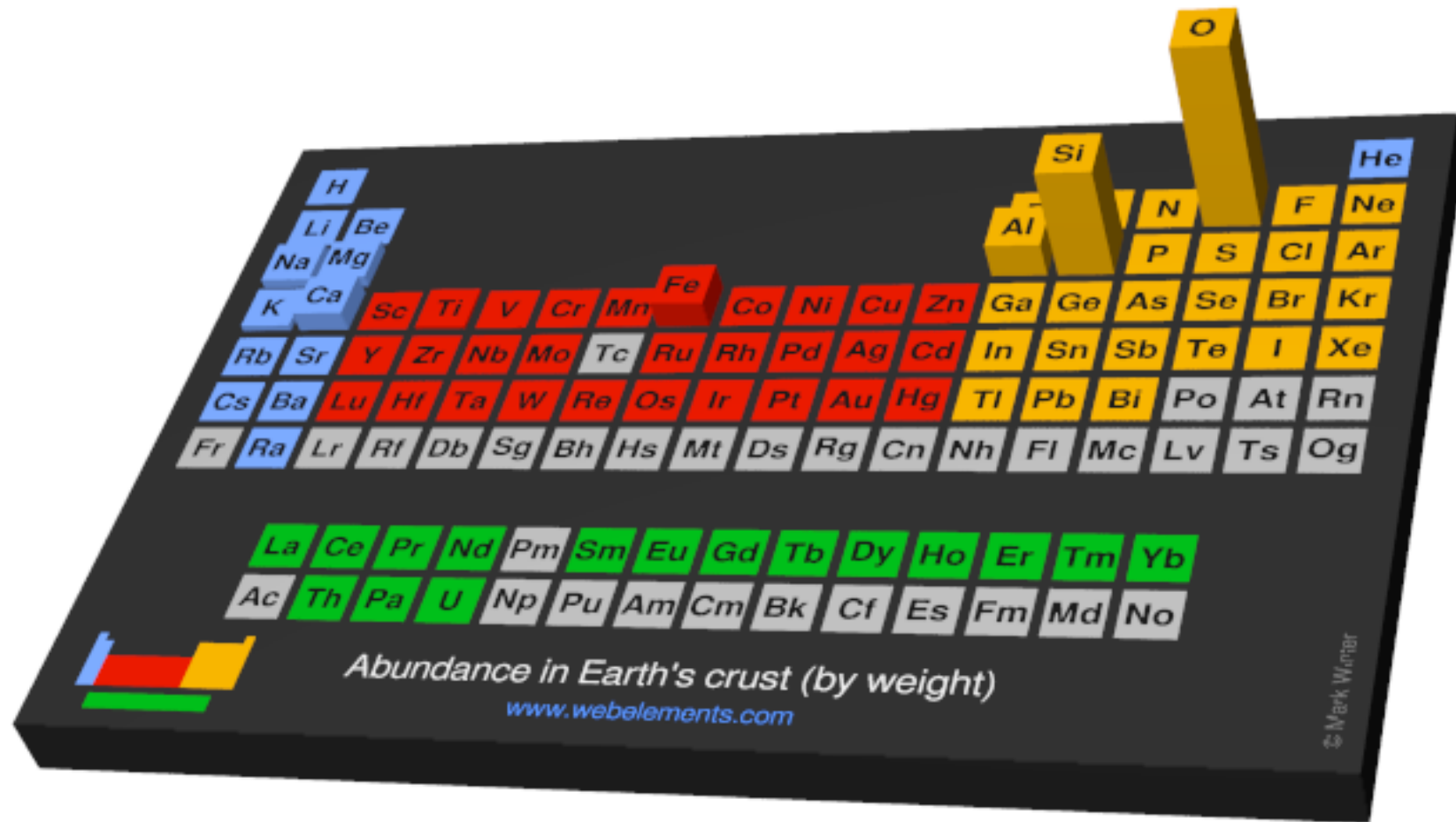


Hagia Sophia  
537 CE  
brick



## Table 3.1 Polyatomic Ions

name	formula	charge
carbonate	CO <sub>3</sub>	-2
chromate	CrO <sub>4</sub>	-2
dichromate	Cr <sub>2</sub> O <sub>7</sub>	-2
hydroxide	OH	-1
phosphate	PO <sub>4</sub>	-3
sulfate	SO <sub>4</sub>	-2



## DISASTER &amp; FAILURE STUDIES

Champlain Towers  
South Collapse

*NY Times*  
September 1, 2021  
[The Surfside Condo  
Was Flawed and Failing.](#)

The site of the Champlain Towers South partial collapse in Surfside, FL 6/24/21.

# Curing Cement's CO<sub>2</sub> Weakness

C&E News September 8, 2014

For every ton produced, close to a ton of CO<sub>2</sub> is emitted.

- main reaction involves heating limestone [CaCO<sub>3</sub>], silica [SiO<sub>2</sub>], and other minerals in a kiln at 1,450°C.
- heat splits CaO from the limestone and releases CO<sub>2</sub> into the atmosphere.
- about half of the emissions come from the reaction; the rest is from burning fossil fuels—usually coal—to heat the kiln

This process is responsible for about 5-8% of global human-based CO<sub>2</sub> emissions.

But the cement itself may help offset some of those climate-changing emissions, according to a new study. A team of researchers estimate that **43% of the CO<sub>2</sub>** released by cement calcination between 1930 and 2013 **was reabsorbed by the cement** created during that period (*Nat. Geosci.* 2016, DOI: [10.1038/ngeo2840](https://doi.org/10.1038/ngeo2840)).

# *BBC News* **The battle to curb our appetite for concrete**

By Tim Bowler, Business reporter

24 October 2018

We extract billions of tonnes of sand and gravel each year to make concrete for the building industry, and this is having an increasing environmental impact as beaches and river beds are stripped, warn campaigners.

Alongside this environmental damage, the building industry is also a major contributor to greenhouse gases - cement manufacturing alone accounts for 7% of global CO<sub>2</sub> emissions.

**Match 7 strategies described in the article to Principles of Green Engineering**

1. Bath University researchers say [up to 10% of sand in concrete can be replaced by plastic](#) without significantly affecting concrete's structural integrity - crucial in determining whether to use plastic in concrete for buildings.

"There's a serious issue with plastic waste. Anything we can do to address this and find alternatives to putting plastic in landfill is welcome," says Dr Richard Ball, of Bath University's architecture and civil engineering department.



Concrete can contain up to 10% plastic before it affects its strength significantly, say Bath researchers

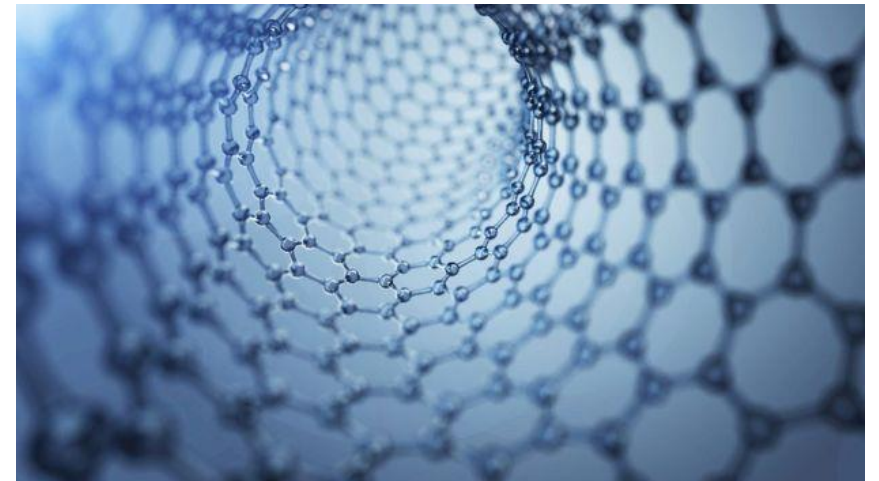
Image copyright John Orr

2. In Australia, engineering firm [Fibercon](#) has developed a technology that uses recycled plastic for reinforcing concrete instead of the traditional steel mesh - this is now being used in footpaths.

Fibercon says by using 100% recycled plastic, the plastic-reinforced concrete gives a 90% reduction in CO<sub>2</sub> compared to conventional steel mesh-reinforced concrete.

3. At Exeter University, researchers are using nano-engineering technology to add graphene to concrete - [making it twice as strong and four times more water-resistant than conventional concrete](#).

This new graphene-reinforced concrete also has huge efficiency savings, [cutting the raw materials required to make concrete by some 50%](#)



Graphene consists of a single layer of carbon atoms in a hexagonal lattice.

Image copyright Getty Images

4. Currently, [when buildings and structures are demolished, less than a third of the construction waste is reused](#), according to the World Economic Forum. It argues the construction industry needs to move from a linear "use, then throw away" model, to a circular economy.

"If you design-in the ability to take components apart - to become a catalogue of beams and so forth - you allow for more re-use," says Dr John Orr of Cambridge University's engineering department.

"The apartment blocks, the boring offices that we need for our daily lives - these we need to change how we build and dismantle because we're an economy built on sand and concrete."

It may make construction more expensive, and when a building is due for demolition after 40 years or so, those who built it will probably have retired so those taking it down may not know exactly how to dismantle it.

5. Companies and scientists are now devising ways to **capture CO<sub>2</sub> in concrete**, to soak up more of the CO<sub>2</sub> released when cement is manufactured.

Canadian firm CarbonCure has developed a way of locking in more carbon by injecting liquefied CO<sub>2</sub> into wet concrete. Not only is the concrete stronger, the firm says it could save up to 700 million tonnes of CO<sub>2</sub> emissions a year. So far, 100 producers have adopted the technology.

6. Concrete will naturally reabsorb some atmospheric CO<sub>2</sub>, but only very slowly. [Researchers at France's technology institute, Ifsttar, are looking at ways to speed this up](#), to get recycled concrete to absorb far higher levels of CO<sub>2</sub>.

Ifsttar hopes its recycled concrete aggregates could help absorb significant levels of CO<sub>2</sub>.



Image copyright Ifsttar

7. Another approach that could revolutionise the industry is the **3D printing of houses**.

"We could cut up to 40% of the concrete we use, and that would have a huge impact on the sand we are using. There's no penalty for over-design, and so designers and engineers will understandably err on the side of safety," says Dr John Orr of Cambridge University's engineering department.

Crucially, concrete shapes from a 3D printer are self-supporting. This means they eliminate the metal or wood moulds into which concrete is traditionally poured - additionally saving on raw materials. Eindhoven is now spearheading what it says is [the world's first commercial housing project based on 3D concrete printing](#).

[3-D printing with Soil](#)



Images copyright Project Milestone