# The Hard Facts

*Concrete's sturdy beginnings*

By Lisa De Nike

In 2006, a team of French and American researchers rocked the archaeological world with their announcement that the great Egyptian pyramids were not, as always assumed, constructed of 2-ton blocks of limestone that had to be hauled—at the cost of many slaves' lives—from nearby quarries and then hoisted hundreds of feet into the air.

Instead, the team asserted, painstaking modern chemical analysis revealed that the imposing and awe-inspiring structures were built of *blocks* of early concrete made *on site* of liquefied limestone and poured into molds.

If this is indeed true—and many archaeologists and Egyptologists hotly dispute it—it would mark the earliest documented use of concrete, a substance now so ubiquitous in our sidewalks, roads, bridges and buildings that we barely take notice of it and can hardly imagine modern life without it.

In fact, most historians credit the Romans with inventing the ever-changing mixture of volcanic sand, water, lime mortar and stones that comprised early "*caementa*." The Romans reportedly would stir up this composite (sometimes adding the more interesting ingredients of animal fat, milk and even blood) and spread it into big wooden frames that were then placed against facings of stone or brick before being left to dry.

The result—once the frames were removed—was sturdy slabs that could be slathered in stucco later and which cost a lot less than Italian tufa or marble imported from Greece.

So sturdy, in fact, that some of the things the Romans built are still around today.

Before we go on to chronicle the fascinating history of concrete, however, it's important to distinguish between concrete and cement, as many people confuse the two and tend incorrectly to use the terms interchangeably.

Concrete is a material made up of crushed stone, rock, sand and cement. Nearly 6 billion tons of concrete are used each year and some experts estimate that one-half to two-thirds of the world's infrastructures are made of concrete. It's also estimated that concrete is so strong it can last about 50,000 years and that more than 55,000 miles of highways in the United States are paved with this material, which lasts about 2.5 times longer than asphalt.

Cement makes up about 15 percent of the mass of concrete and is made from limestone, silicon, calcium, iron and aluminum, which are heated to 2700 degrees Fahrenheit in a kiln to produce a pebbly mixture called "clinkers." The "clinkers" are ground into a powder and gypsum is added, resulting in a grayish substance we think of as cement. Mix that with water and—voila!—it can be spread into many shapes and as it dries, it hardens into a very solid mass.

A British engineer named John Smeaton is credited with stirring up the first batch of modern concrete by adding powdered bricks and pebbles to cement to give it strength in 1793. Thirty-one years later, another Englishman, inventor Joseph Aspdin, came up with what is considered the first artificial cement (called "Portland cement") by burning clay and ground limestone together, which he knew would make it even stronger.

Concrete has much to recommend it as a building material, but it is far from perfect. Its main deficit is that it has what engineers call "poor tensile strength," which means that it is not well-equipped to withstand cross-structural stressors such as earthquakes or other horizontal forces (such as wind). To remedy this, some concrete is "pre-stressed," meaning that it is reinforced with stretched steel rods. This kind of concrete was invented by a Parisian gardener named Joseph Monier, who patented it in 1867 as a way to reinforce concrete garden pots with steel mesh for added durability. Monier's strong tubs were one of the exhibits at the Paris Exposition of 1867, giving others the idea of using pre-stressed concrete in floors, bridges, arches and even railway ties.

The time-consuming process of mixing concrete by hand came to an end in 1885, when the first rotary kiln allowing for mass production of the substance was introduced in England. Two years later, the first concrete reinforced bridge was built in Golden Gate Park in San Francisco. From then on, concrete technology and the use of the material grew by leaps and bounds.

More recently, in 1990, the tallest reinforced concrete building in the world was erected in Chicago (961 feet/293 meters) and a year later, the very dramatic concrete-and-glass structure known as Boston's JFK Museum—designed by I.M. Pei—was completed.

Of course, most things constructed of concrete are not quite as remarkable as the JFK Museum. Who among us, after all, really notices the roadways, the sidewalks and the buildings that are such an integral part of our everyday lives? Yet where would we be without them?