Concrete knowledge

Concrete practice training for ACF

July 14th & 15th in Gulu

Compiled by Franz W. Etges, DED
Concrete works / structures in UGANDA

The FACTS are:

- Buildings frequently collapse
- This is a security relevant issue especially in the rift valley
- Concrete structures are of low quality and degenerate very fast
- There is NO (!) school or institution (known to us) where one can go and acquire the skills needed to produce good quality concrete structures
Craftsmen at construction sites produce, cast and cure concrete. Skills are rarely or not there!

Planning, design and site management teams:

Institutes of higher learning produce engineers with theoretical knowledge referring to British standards but no skills. They join the planning and management teams.

Uganda National Bureau of Standards is supposed to provide standards for concrete.

Industrial Training Council advises the MoES on matters concerning BTWET.

National Curriculum Development Agency is supposed to provide the syllabus to teach concrete practice.

UVQF provides job profiles for different occupations to the vocational institutes.

Vocational institutes: government and private, are supposed to provide skilled craftsmen to build concrete structures. They rarely teach it and just send the students for internships.

Former students become craftsmen and work at building sites. They don’t bring knowledge or skills it needs to build with concrete.

Internships

Uganda National Bureau of Standards

Industrial Training Council

National Curriculum Development Agency

UVQF

No Ugandan standards

Did not yet advice to train in concrete

There is no syllabus

There is no job profile for concrete builders but for BCP.
Cement and Concrete – History and Development

Topics Covered
Background
Portland Cement
Reinforcement
Composition of Portland Cement
Hydration of Portland Cement

Background
Concrete is a compound material made from sand, gravel and cement. The cement is a mixture of various minerals which when mixed with water, hydrate and rapidly become hard binding the sand and gravel into a solid mass. The oldest known surviving concrete is to be found in the former Yugoslavia and was thought to have been laid in 5,600 BC using red lime as the cement.

The first major concrete users were the Egyptians in around 2,500 BC and the Romans from 300 BC. The Romans found that by mixing a pink sand-like material which they obtained from Pozzuoli with their normal lime-based concretes they obtained a far stronger material. The pink sand turned out to be fine volcanic ash and they had inadvertently produced the first ‘pozzolanic’ cement. Pozzolana is any siliceous or siliceous and aluminous material which possesses little or no cementitious value in itself but will, if finely divided and mixed with water, chemically react with calcium hydroxide to form compounds with cementitious properties.
The Romans made many developments in concrete technology including the use of lightweight aggregates as in the roof of the Pantheon, and embedded reinforcement in the form of bronze bars, although the difference in thermal expansion between the two materials produced problems of spalling. It is from the Roman words 'caementum' meaning a rough stone or chipping and 'concretus' meaning grown together or compounded, that we have obtained the names for these two now common materials.

**Portland Cement**

Lime and Pozzolana concretes continued to be used intermittently for nearly two millennia before the next major development occurred in 1824 when Joseph Aspdin of Leeds took out a patent for the manufacture of Portland cement, so named because of its close resemblance to Portland stone. Aspdin's cement, made from a mixture of clay and limestone, which had been crushed and fired in a kiln, was an immediate success. Although many developments have since been made, the basic ingredients and processes of manufacture are the same today.

**Reinforcement**

In 1830, a publication entitled, "The Encyclopaedia of Cottage, Farm and Village Architecture" suggested that a lattice of iron rods could be embedded in concrete to form a roof. Eighteen years later, a French lawyer created a sensation by building a boat from a frame of iron rods covered by a fine concrete which he exhibited at the Paris Exhibition of 1855. Steel reinforced concrete was now born. The man normally credited with its introduction as a building material is William Wilkinson of Newcastle who applied for a patent in 1854 for "improvement in the construction of fireproof dwellings, warehouses, other buildings and parts of the same".

It is not only fire resistance that is improved by the inclusion of steel in the concrete matrix. Concrete, although excellent in compression,
performs poorly when in tension or flexure. By introducing a network of connected steel bars, the strength under tension is dramatically increased allowing long, unsupported runs of concrete to be produced.

Steel and concrete complement each other in many ways. For example, they have similar coefficients of thermal expansion so preventing the problems the Romans had with bronze. Concrete also protects the steel, both physically and chemically.

**Composition of Portland Cement**

Portland cement is a complex mix of many compounds, some of which play a major part in the hydration or chemical characteristics of the cement. It is manufactured commercially by heating together a mixture of limestone and clay up to a temperature of 1300 to 1500°C. Although twenty to thirty percent of the mix becomes molten during the process the majority of the reactions which take place are solid-state in nature and therefore liable to be slow. Once cooled, the resulting clinker is ground to a fine powder and a small amount of gypsum (calcium sulphate dihydrate) is added to slow down the rate at which the cement hydrates to a workable level.

The work of early investigators using optical and X-ray techniques, starting in 1882 with Le Chatelier, has shown that most Portland cement clinkers contain four principal compounds. These are tricalcium silicate (3CaO.SiO₂), aluminate (3CaO.Al₂O₃) and a ferrite phase from the (2CaO.Fe₂O₃ - 6CaO.2Al₂O₃.Fe₂O₃) solid solution series that at one time was considered to have the fixed composition (4CaO.Al₂O₃.Fe₂O₃). These phases were named alite, belite, celite and felite respectively by Tornebohm in 1897.

**Hydration of Portland Cement**

When water is mixed with Portland cement a complicated set of reactions is initiated. The main strength giving compounds are the calcium silicates which react with water to produce a calcium silicate
hydrate gel (C-S-H gel) which provides the strength, and calcium hydroxide which contributes to the alkalinity of the cement. Tricalcium silicate reacts quickly to provide high, early strengths while the reaction of dicalcium silicate is far slower, continuing, in some cases, for many years. The other cement compound of particular relevance to steel reinforced concrete is tricalcium aluminate. It reacts rapidly with water to produce calcium aluminate hydrates.

The amount of tricalcium aluminate present may well be limited as in the case of sulphate resisting Portland cement, to prevent adverse reactions between the hydrate and sulphates from the environment which can result in swelling and cracking of the cement matrix.

The great advantage of tricalcium aluminate is its ability to combine with chlorides, so removing them from the liquid phase of the cement. Chloride ions, as will be seen, are one of the major causes of corrosion of embedded steel.

Primary author: Paul Lambert
Source: Abstracted from Corrosion Protection Association monograph 1

For more information on this source please visit The Corrosion Protection Association.
Cement has been a naturally occurring substance for more than 12 million years and was used in rudimentary forms from about 3000 BC by the Egyptians, Chinese and Greeks. In man-made form, however, concrete was first developed by the Romans. Some time in the third century BC, they discovered that mixing volcanic ash with lime mortar, sand and gravel made a rock-hard substance similar to today's concrete. With the addition of animal fat, milk and blood, this substance was called pozzolan cement and was used to construct the Appian Way, the Coliseum and the Pantheon, as well as the Pont du Gard in Southern France.

After the fall of the Roman Empire, the quality of cementing materials diminished rapidly because most people simply were more interested in building with stone. The technique for making pozzolan cement was lost and didn't reappear again until midway through the Middle Ages. In 1414, the manuscripts of the Roman Pollio Vitruvius - which contained information about pozzolan cement - were discovered, thus reviving the interest in concrete. Fra Giocondo used pozzolan cement to build the pier of the Pont de Notre Dame in Paris in 1499, the first modern use of concrete.

Concrete technology took a huge leap in the 1700s. John Smeaton was an English engineer looking for a building material that would not be adversely affected by water. He discovered in 1774 that quicklime made a harder cement. In 1793 he took that discovery another step forward when he realized that the calcinations of limestone that contained clay produced hydraulic lime, a lime that hardens under water. It was this material that was used in the historic rebuilding of the Eddystone Lighthouse in Cornwall, England.

Smeaton's work led to a more widespread use of concrete throughout England and further
advances in technology. James Parker patented a natural hydraulic cement in 1796 that was made by calcining pieces of pure limestone that contained clay. William Jessop used this technology to create the West India Dock in Great Britain, one of the first structures to use concrete on such a large scale.

From there, the popularity of concrete as a building material spread to France, where Louis Vicat developed an artificial hydraulic lime composed of synthetic limestone and clay in 1812. This technology was used in 1816 to build the world's first unreinforced concrete bridge in Souillac, France.

The 19th century saw rapid advances in concrete technology all over the world. One of the most important advancements took place in 1824 when an English bricklayer named Joseph Aspdin made an important discovery. He learned that burning finely ground chalk with divided clay in a lime kiln produced a cement that is much stronger than the previously used crushed limestone cement. This was called Portland cement and is still used in today's concrete production. Four years later, Portland cement was used in its first engineering application for filling a breach in the Thames Tunnel.

Another important technological advance came about in 1849 when the French gardener Joseph Monier began experimenting with ways to make a more durable flowerpot. He reinforced American William Wand's garden pots and tubs with iron mesh and the idea of iron reinforced concrete, or ferroconcrete, was born. Monier exhibited his creation at the Paris Exposition in 1867 and received a patent for it. Because reinforced concrete combines the tensile strength of steel with the compressional strength of concrete, it is able to withstand heavy loads and is commonly used in the building of many commercial structures even today.

After its inception, Portland cement became the focal point of concrete technology and many scientists and engineers turned their focus to it. One of the first patents for its production was issued to J. M. Mauder, Son & Co. in 1843. In 1845, Isaac Johnson claimed to have burned its raw materials to clinkering temperatures. However, it was American David O. Saylor who first demonstrated the importance of true clinkering in 1871 and he received the first American patent for Portland cement. J. Grant of England took Saylor's ideas a step forward by chemically analyzing the key ingredients of Portland cement and showing the importance of using the hardest, densest portions of the clinker.

In those days, the kilns used to make concrete were vertical and stationary, and were allowed to cool down after each use—a big waste of energy. A more efficient kiln was needed, and in 1885 an English engineer developed a kiln that was slightly tilted, horizontal and could be rotated. This was called the rotary kiln and allowed for better temperature control and more efficient mixing of materials. This resulted in a more consistent output of high quality concrete. By 1890, most kilns used in concrete production were rotary.

American inventor Thomas Edison advanced rotary kiln technology when he introduced the first long kiln in 1902 in his Edison Portland Cement Works in New Village, New Jersey. His kiln was 150 feet long, 70 feet longer than the kilns used at that time, and paved the way for today's kilns that are sometimes more than 500 feet long. Edison received a patent for his kiln in 1909.

The late 19th and early 20th centuries saw many firsts in concrete history, including:

- the first reinforced concrete bridge in 1889;
- the first American concrete street, placed by George Bartholomew in Bellefontaine, OH in 1891;
- the Ingalls Building, the first concrete high rise, in Cincinnati, OH in 1903;
- the first mile of rural pavement for automobiles in the U.S. (Wayne County, Michigan) in 1909.

Other important concrete structures were built later in the 20th century and include the first major dams,
Concrete is now the most frequently used material in the construction industry, finding its way into roads, bridges and the majority of commercial building structures - like this distribution center in Arlington, Texas, which is made up of tilt-up concrete wall panels.

The Grand Coulee Dam, built in 1933 and Hoover Dam, built in 1936; the first concrete domed sport structure, the Assembly Hall built at The University of Illinois in Urbana-Champaign in 1967; and the tallest reinforced concrete building in the world, built in Chicago, Illinois, in 1992.

Today concrete is the most frequently used material in the building industry and can be found everywhere in the world - in roads, houses, bridges, and many other structures. There are even concrete canoe and Frisbee competitions. The legacy of concrete is as enduring as the material itself. All around you is evidence of our technology and an important part of human history: concrete.
A Brief History of Concrete Ships

The oldest known concrete ship was a dingy built by Joseph Louis Lambot Southern France in 1848. The boat was featured in the 1855 World's Fair in France.

In the 1890's, an engineer in Italy named Carlo Gabellini built barges and small ships out of concrete. The most famous of his ships was the Liguria.

On August 2, 1917, N.K. Fougner of Norway launched the first ocean-going concrete ship, an 84 foot long boat named Namsenfjord. With the success of the ship, several more small concrete vessels were built.

Numerous small concrete boats were built in the U.K in the 1910’s. One of these ships, the Violette, was built in 1917 and is currently used as a boating clubhouse on the Medway River in England. This makes her the oldest concrete ship still afloat.

In 1917, the United State finally entered World World I and steel became scarce while the demand for ships went up. The US government invited N.K. Fougner to head a study into the feasibility of concrete ships.
Meanwhile, businessman W. Leslie Comyn took the initiative and formed the San Fransisco Ship Building Company (in Oakland, California) to begin constructing concrete ships. He hired Alan Macdonald and Victor Poss to design the first American concrete ship, a steamer named the S. S. Faith.

The Faith was launched March 18, 1918. She cost $750,000 to build. She was used to carry cargo for trade until 1921, when she was sold and scrapped as a breakwater in Cuba.

President Woodrow Wilson finally approved the Emergency Fleet program which oversaw the construction of 24 concrete ships for the war. However, only 12 were under construction and none of them had been completed by the time the war ended. The 12 ships were completed and sold to private companies who used them for light-trading, storage and scrap.

With the advent of World War II, steel once again was in short supply. In 1942, the US government contracted McCloskey & Company of Philadelphia, Pennsylvania to construct a new fleet of 24 concrete ships. Construction of the fleet started in July, 1923 in Tampa, Florida. Innovations in cement mixing and composition made these ships stronger than the previous fleet.

Other companies were contracted to build barge ships. These too were large vessels, but they lacked engines to propel them. Instead, they were used for storage and towed around by other ships.

After the war, several of the ships were turned into a floating breakwater in Canada and ten more were sunk as a breakwater in Virginia.

Although the end of WWII marked the end of large-scale concrete ship building, to this day, smaller recreational boats are still being made from concrete.
Related Links

- FerroBoats.com

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## What a proper concrete can bear

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