

Ferrocement

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Ferrocement or **ferro-cement** (also called **thin-shell concrete** or **ferro-concrete**) is a system of reinforced mortar^[1] or plaster (lime or cement, sand and water) applied over layer of metal mesh, woven expanded-metal or metal-fibers and closely spaced thin steel rods such as rebar, metal commonly used is iron or some type of steel. It is used to construct relatively thin, hard, strong surfaces and structures in many shapes such as hulls for boats, shell roofs, and water tanks. Ferrocement originated in the 1840s in France and is the origin of reinforced concrete. It has a wide range of other uses including sculpture and prefabricated building components. The term "ferrocement" has been applied by extension to other composite materials, including some containing no cement and no ferrous material.



Lambot's original 1848 bateau in the Brignoles Museum in France.



Ferrocement hull under construction

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Definitions

Cement and *concrete* are used interchangeably but there are technical distinctions and the meaning of *cement* has changed since the mid-nineteenth century when *ferrocement* originated. Ferro- means iron although metal commonly used in ferro-cement is the iron alloy steel. Cement in the nineteenth century and earlier meant *mortar*^[2] or broken stone or tile mixed with lime and water to form a strong mortar.^[3]

Today cement usually means Portland cement,^[4] Mortar is a paste of a binder (usually Portland cement), sand and water; and concrete is a fluid mixture of Portland cement, sand, water and crushed stone aggregate which is poured into formwork (shuttering). *Ferro-concrete* is the original name of reinforced concrete (armored concrete) known at least since the 1890s and in 1903 it was well described in London's Society of Engineer's *Journal*^[5] but is now widely confused with ferrocement.

History

The inventors of ferrocement are Frenchmen Joseph Monier who dubbed it "ciment armé" (armored cement) and Joseph-Louis Lambot who constructed a batteau with the system in 1848.^[6] Lambot exhibited the vessel at the Exposition Universelle in 1855 and his name for the material "ferciment" stuck. Lambot patented his batteau in 1855 but the patent was granted in Belgium and only applied to that country. At the time of Monier's first patent, July 1867, he planned to use his material to create urns, planters, and cisterns. These implements were traditionally made from ceramics, but large-scale, kiln-fired projects were expensive and prone to failure. In 1875, Monier expanded his patents to include bridges and designed his first steel-and-concrete bridge. The outer layer was sculpted to mimic rustic logs and timbers, thereby also ushering Faux Bois (wood grain) concrete. In the first half of the twentieth century Italian Pier Luigi Nervi was noted for his use of ferro-cement, in Italian called *ferrocemento*.

"ferrocement" being referred to as ferro-concrete or reinforced concrete to better describe the end product instead of its components.

Ferro concrete has relatively good strength and resistance to impact. When used in house construction in developing countries, it can provide better resistance to fire, earthquake, and corrosion than traditional materials, such as wood, adobe and stone masonry. It has been popular in developed countries for yacht building because the technique can be learned relatively quickly, allowing people to cut costs by supplying their own labor. In the 1930s through 1950's, it became popular in the United States as a construction and sculpting method for novelty architecture, examples of which created "dinosaurs in the desert".

Construction formwork

The desired shape may be built from a multi-layered construction of mesh, supported by an armature, or grid, built with rebar and tied with wire. For optimum performance, steel should be rust-treated, (galvanized) or stainless steel. (In early practice, in the desert, or for exterior scenery construction, "sound building practice" was not considered, or perhaps unknown as it grew in some cases, from a folk craft tradition of masons collaborating with blacksmiths.) Over this finished framework, an appropriate mixture (grout or mortar) of Portland cement, sand and water and/or admixtures is applied to penetrate the mesh. During hardening, the assembly may be kept moist, to ensure that the concrete is able to set and harden slowly and to avoid developing cracks that can weaken the system. Steps should be taken to avoid trapped air in the internal structure during the wet stage of construction as this can also create cracks that will form as it dries. Trapped air will leave voids that allow water to collect and degrade (rust) the steel. Modern practice often includes spraying the mixture at pressure (a technique called shotcrete) or some other method of driving out trapped air.

Older structures that have failed offer clues to better practices. In addition to eliminating air where it contacts steel, modern concrete additives may include acrylic liquid "admixtures" to slow moisture absorption and increase shock resistance to the hardened product or to alter curing rates. These technologies, borrowed from the commercial tile installation trade, have greatly aided in the restoration of these structures.^[7] Chopped glass or poly fiber can be added to reduce crack development in the outer

skin. (Chopped fiber could inhibit good penetration of the grout to steel mesh constructions. This should be taken into consideration and mitigated, or limited to use on outer subsequent layers. Chopped fibers may also alter or limit some wet sculpting techniques.)

Economics

The economic advantage of ferro concrete structures is that they are stronger and more durable than some traditional building methods. Depending on the quality of construction and the climate of its location, houses may pay for themselves with almost zero maintenance and lower insurance requirements. Water tanks could pay for themselves by not needing periodic replacement, if properly constructed of reinforced concrete.

Ferro concrete structures can be built quickly, which can have economic advantages. In inclement weather conditions, the ability to quickly erect and enclose the building allows workers to shelter within and continue interior finishing.

In India, ferro concrete is used often because the constructions made from it are more resistant to earthquakes. Earthquake resistance is dependent on good construction technique and additional reinforcement of the concrete.

In the 1970s, designers adapted their yacht designs to the then very popular backyard building scheme of building a boat using ferrocement. Its big attraction was that for minimum outlay and costs, a reasonable application of skill, an amateur could construct a smooth, strong and substantial yacht hull. A ferrocement hull can prove to be of similar or lower weight than a fiber reinforced plastic (fiberglass), aluminum, or steel hull. New methods of laminating layers of cement and steel mesh in a mold may bring new life to ferro-cement boat-building. A thorough examination of reinforced concrete and current practice would benefit the boat builder. An example of a well known ferro-cement boat is *Hardiesse*, the Falmouth sail-training ship.

There are basically three types of methods of ferrocement. They are following

1. Armature system: In this method the skeleton steel is welded to the desired shape on either of sides of which are tied several layers of stretched meshes. This is strong enough, so that mortar can be filled in by pressing for one side and temporarily supporting from the other side. Filling in of mortar can also be administered by pressing in the mortar from both the sides. In this method the skeletal steel (bars) are at centre of the section and as such they add to the dead weight of without any contribution to strength.
2. Closed mould systems: Several layers of meshes are tied together against the surface of the mould which holds them in position while mortar is being filled in. The mould may be removed after curing or may remain in position as a permanent part of a finished structure. If the mould is to be removed for reuse, releasing agent must be used.
3. Integrated mould system: Using minimum reinforcement any integral mould is first to be considered to act as a framework. On this mould layers of meshes are fixed on either side and plastering is done onto them from both sides. As the name suggests, the mould remains permanently as an integral part of the finished structure. (e.g. double T-sections for flooring, roofing etc.) Precaution should be taken to have firm connection between the mould and the layers filled in later, so that finished product as a whole integral structural unit.

Advantages

The advantages of a well built ferro concrete construction are the low weight, maintenance costs and long lifetime in comparison with purely steel constructions.^[8] However, meticulous building precision is considered crucial here. Especially with respect to the cementitious composition and the way in which it is applied in and on the framework, and how or if the framework has been treated to resist corrosion.

When a ferro concrete sheet is mechanically overloaded, it will tend to fold instead of break or crumble like stone or pottery. As a container, it may fail and leak but possibly hold together. Much depends on techniques used in the construction.

Disadvantages

The disadvantage of ferro concrete construction is the labor-intensive nature of it, which makes it expensive for industrial application in the western world. In addition, threats to degradation (rust) of the steel components is a possibility if air voids are left in the original construction, due to too dry a mixture of the concrete being applied, or not forcing the air out of the structure while it is in its wet stage of construction, through vibration, pressurized spraying techniques, or other means. These air voids can turn to pools of water as the cured material absorbs moisture. If the voids occur where there is untreated steel, the steel will rust and expand, causing the system to fail.

In modern practice, the advent of liquid acrylic additives and other advances to the grout mixture, create slower moisture absorption over the older formulas, and also increase bonding strength to mitigate these failures. Restoration steps should include treatment to the steel to arrest rust, using practices for treating old steel common in auto body repair.

See also

- Types of concrete
- François Hennébique
- François Coignet
- Faux Bois
- Concrete ship

References

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5. Augustus de Rohan Galbraith, "The Hennebique System of Ferro-Concrete Construction". *Journal*, P. F. Nursey, ed. Society of Engineers. London. E & F. N.Spon. 1903. 177-208. Print.
6. Nedwell, P. J.. *Ferrocement: Proceedings of the Fifth International Symposium on Ferrocement*. UMIST, Manchester, 6–9 September 1994. London: E & FN Spon, 1994. 28-30. Print.

7. fauxboisconcrete.info
8. Jackson, G and Sutherland, W. *Concrete Boatbuilding*. George Allen and Unwin Ltd, 1969, p43

External links

- by Peter Harris builder of ferrocement cafe Eutopia. Ferrocement Constructions in New Zealand and elsewhere. (<http://www.fantasticferrocement.com>)
- Ferrocement Construction (<http://www.ferrocementconstruction.webs.com>)
- FerroBoats.com (<http://www.ferroboats.com/>)
- Ferrocement.com (multi-lingual) (<http://www.ferrocement.com/>)
- Ferrocement Educational Network (<http://www.ferrocement.net/>)
- Flying Concrete (<https://web.archive.org/web/20100216203637/http://www.flyingconcrete.com:80/index.htm>)
Steve Kornher's light weight concrete structural & sculptural forms
- Studio Cortes (<http://studiocortes.com>) Carlos Cortes creates beautiful, sturdy, functional art pieces out of ferrocement, formed and stained to look like wood or stone.
- Mother Earth News: How To Build A Ferrocement Boat (<http://www.motherearthnews.com/Do-It-Yourself/1972-07-01/How-To-Build-A-Ferrocement-Boat.aspx>)
- [1] (<http://www.fauxboisconcrete.info>) Terry Eagan restores faux bois concrete at The Huntington Library, Art Collections and Botanical Gardens
- <http://wordpress.ferrocement-ships.com/>
- REPAIRS AND JOINTS IN FERROCEMENT (<http://www.fao.org/docrep/003/v9468e/v9468e0a.htm>)

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