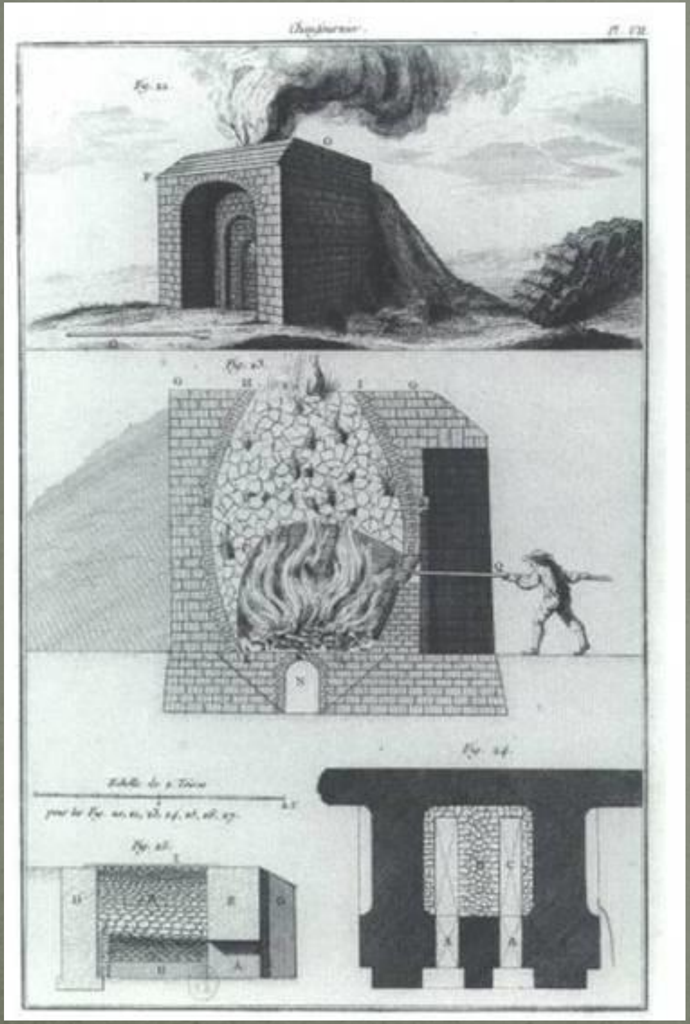
Frank Lloyd Wright

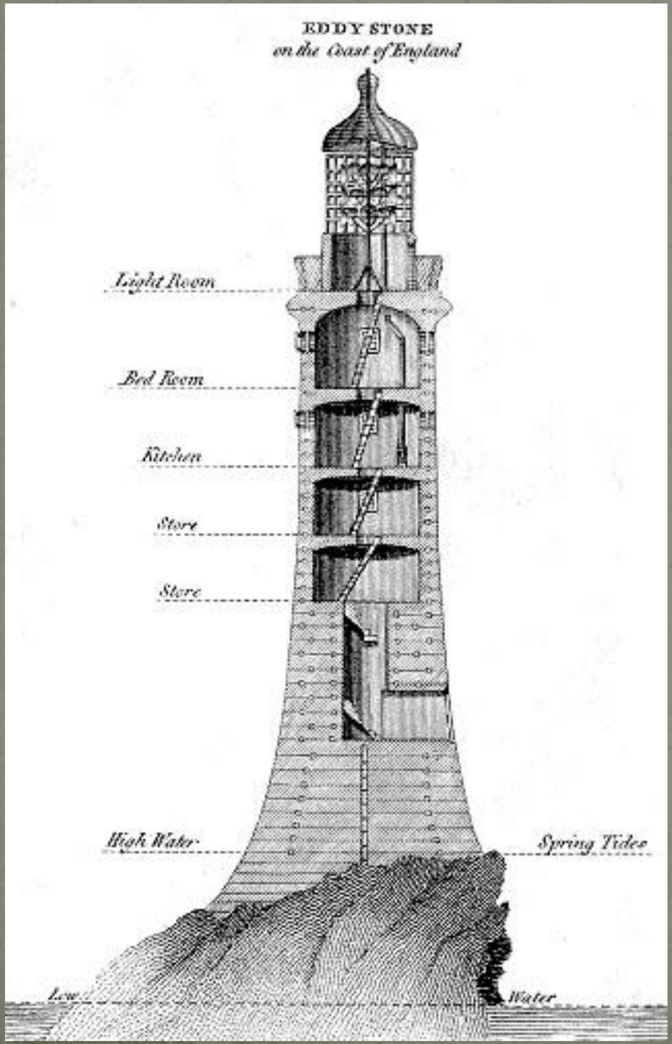
"The Concrete Block …the gutter rat of architecture"

Frank Lloyd Wright and the Concrete



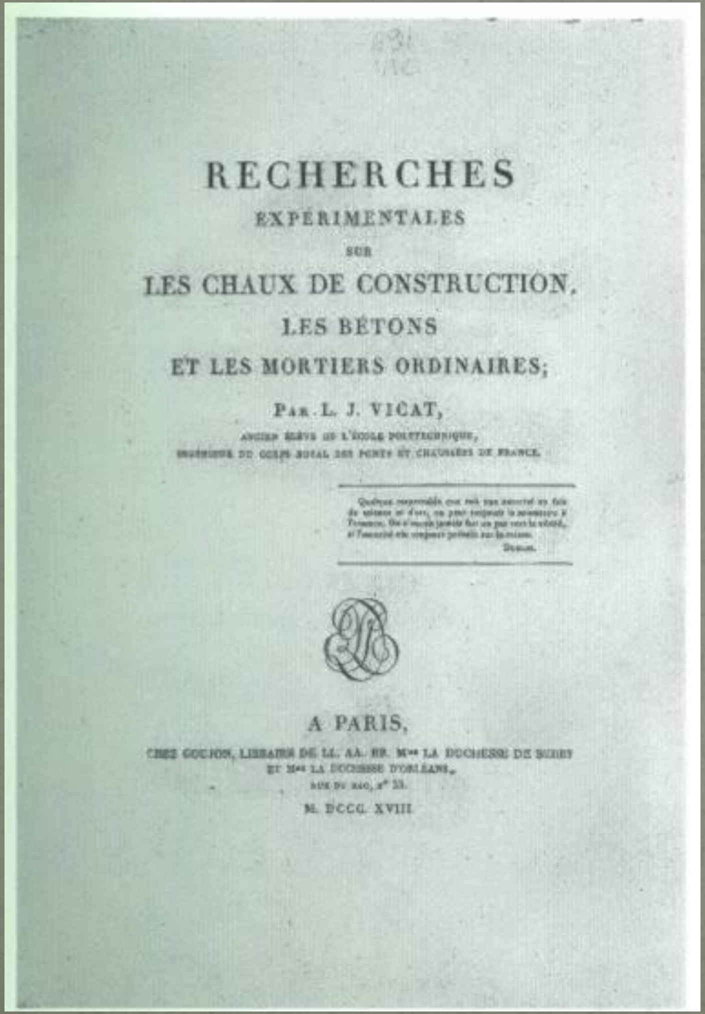
"Encyclopédie, ou Dictionnaire Raisonné des Sciences, des Arts et des Métiers" , 1751-1752, a Lime Kiln.

Frank Lloyd Wright and the Concrete



- It wasn't until **1759** when **John Smeaton** discovered a more modern method for producing hydraulic lime for cement.
- He used limestone containing clay that was fired until it turned into clinker, which was then ground it into powder.
- He used this material in the historic rebuilding of the **Eddystone Lighthouse** in Cornwall, England, since then called the Smeaton's Lighthouse.

Frank Lloyd Wright and the Concrete


RECHERCHES
EXPÉRIMENTALES
SUR
LES CHAUX DE CONSTRUCTION,
LES BÉTONS
ET LES MORTIERS ORDINAIRES;
PAR L. J. VICAT,
ANCIEN ÉLÈVE DE L'ÉCOLE POLYTECHNIQUE,
INGÉNIEUR DU CORPS ROYAL DES PONTS ET CHAUSSÉES DE FRANCE.

[illegible]

A PARIS,
CHEZ GOUJON, LIBRAIRE DE LL. AA. RR. Mme LA DUCHESSE DE BERRY
ET Mme LA DUCHESSE D'ORLÉANS,
RUE DU BAC, n° 33.
M. DCCC. XVIII

Portland cement was introduced as a binder in 1824 by Joseph Vicat. Todays cements cannot be compared with the original cements, as the development has aimed for more strong binders with a shorter hardening time.

Cement was introduced slowly and used firstly in military installations and high-cost constructions.

Industrialization in the last half of the 19th century made it possible to produce locally and therefore available for local – also low-cost use.

Frank Lloyd Wright and the Concrete

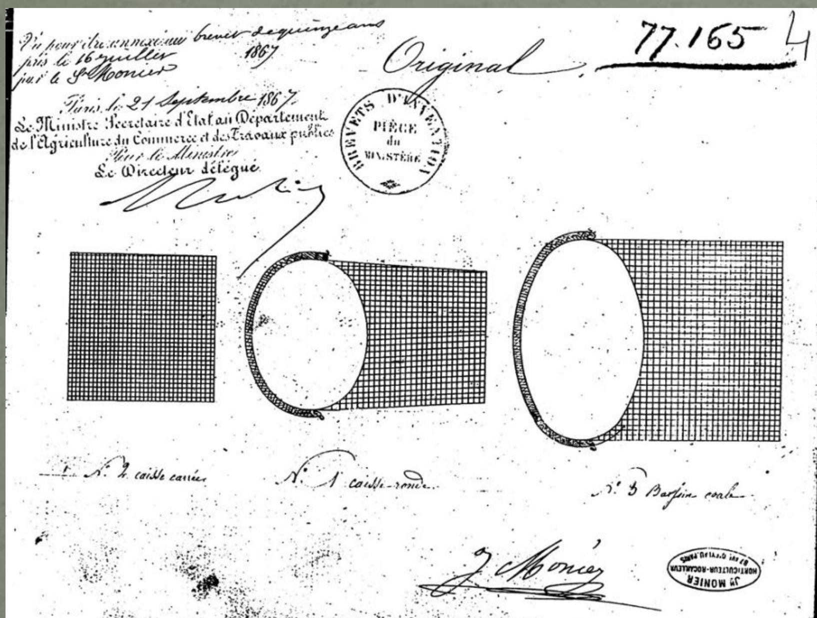
- Finally, in 1824, an Englishman named **Joseph Aspdin invented Portland cement** by burning finely ground chalk and clay in a kiln until the carbon dioxide was removed. It was named "Portland" cement because it resembled the high-quality building stones found in Portland, England.
- Aspdin refined his method by carefully proportioning limestone and clay, pulverizing them, and then burning the mixture into clinker, which was then ground into finished cement.

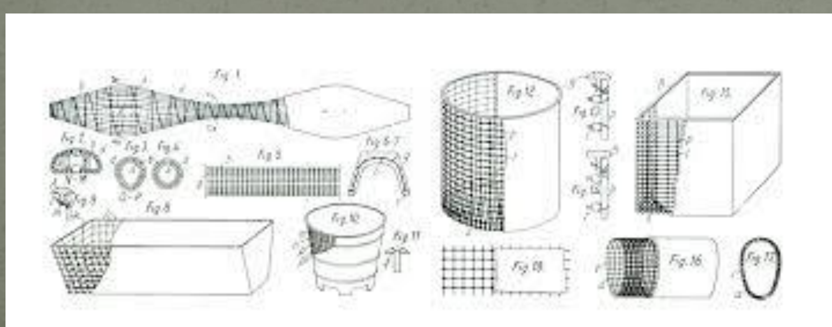
Frank Lloyd Wright and the Concrete

Modern Portland cement is manufactured by heating a mixture of limestone and clay in a kiln to temperatures between 1,300° F and 1,500° F.

Up to 30% of the mix becomes molten but the remainder stays in a solid state, undergoing chemical reactions that can be slow.

Frank Lloyd Wright and the Concrete

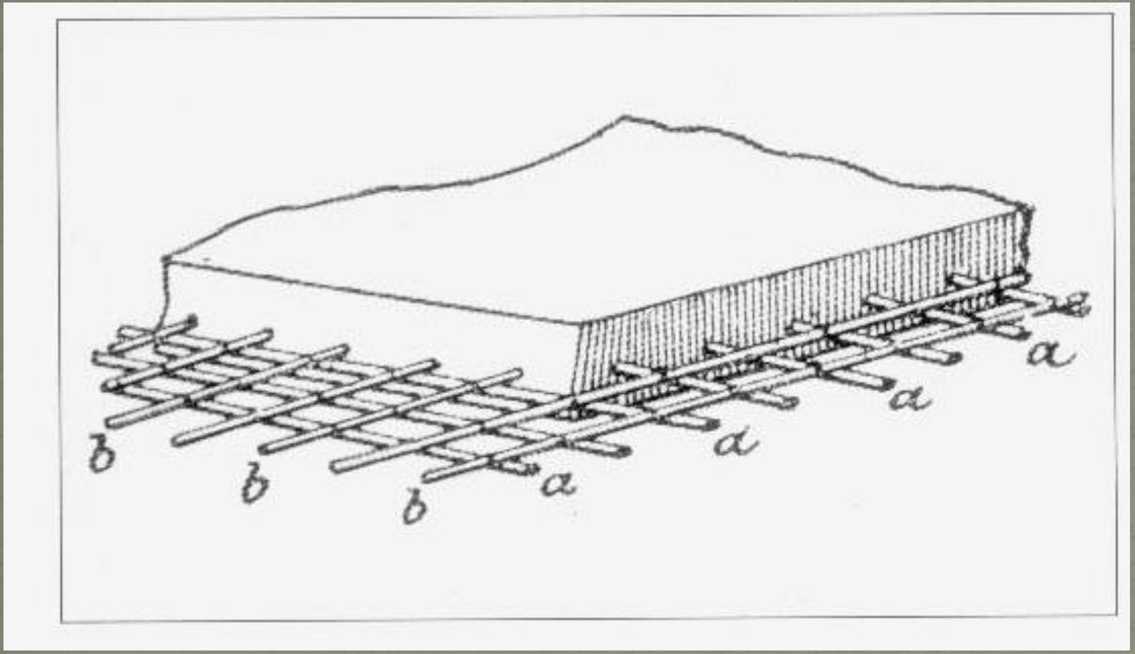




Between 1835 and 1850, systematic tests to determine the compressive and tensile strength of cement were first performed, along with the first accurate chemical analyses.

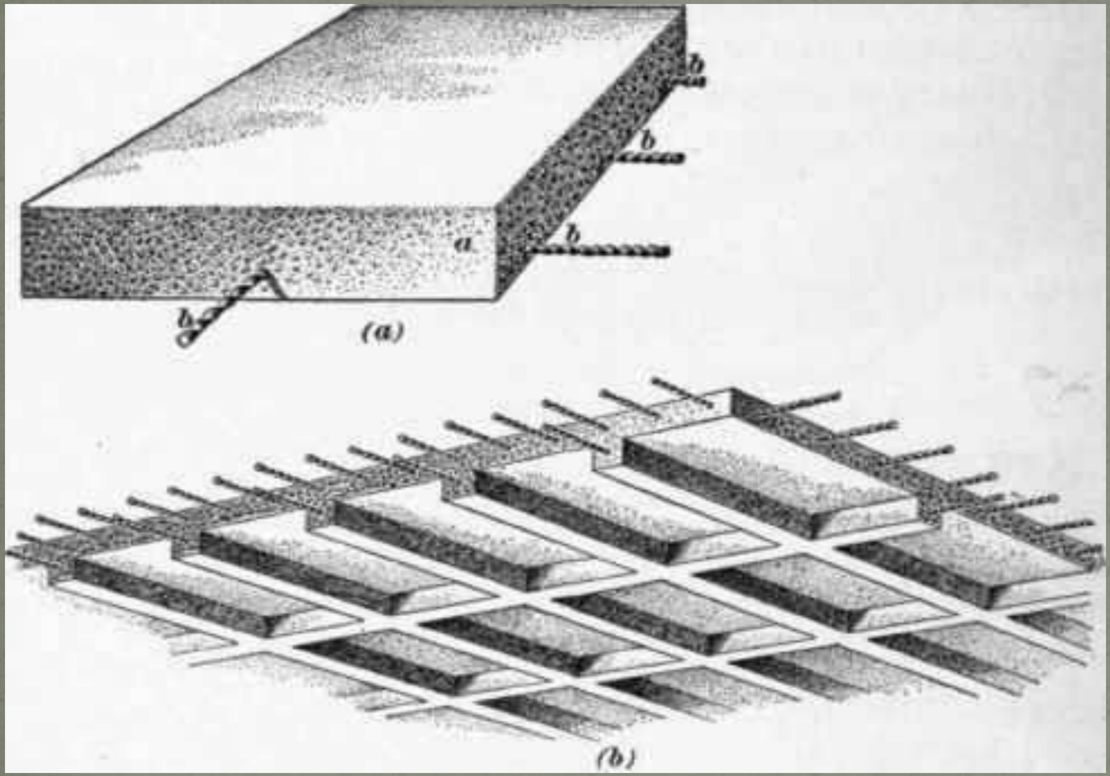
In **1850 Joseph Monier**, a French gardener, developed a flowerpot with reinforced concrete.
In **1867 he patented** reinforced garden tubs and, later, reinforced beams.

Frank Lloyd Wright and the Concrete



In 1879, Wayss bought the rights for the Monier system promoting **the Wayss Monier** system.

Frank Lloyd Wright and the Concrete



The Ransome Floor, 1877

During the late 19th century, the use of steel-reinforced concrete was being developed more or less simultaneously by a German, **G.A. Wayss**, a Frenchman**, François Hennebique**, and an American**, Ernest L. Ransome**.

Ransome started building with **steel-reinforced concrete in 1877** and patented a system that used **twisted square rods** to improve the bond between steel and concrete. Most of the structures he built were industrial.

Frank Lloyd Wright and the Concrete

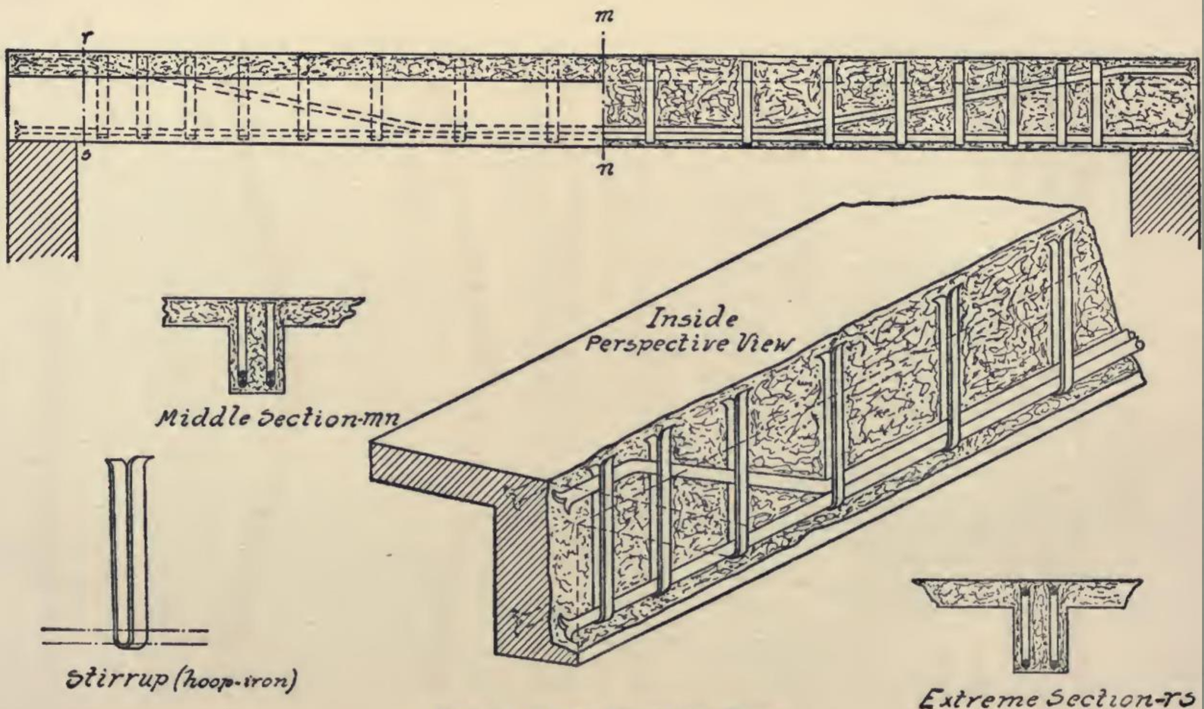
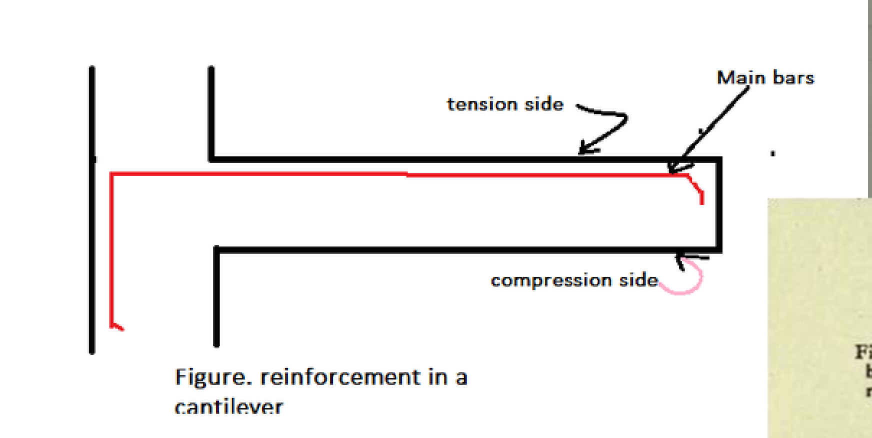


Fig. 99. Typical Hennebique Beam.

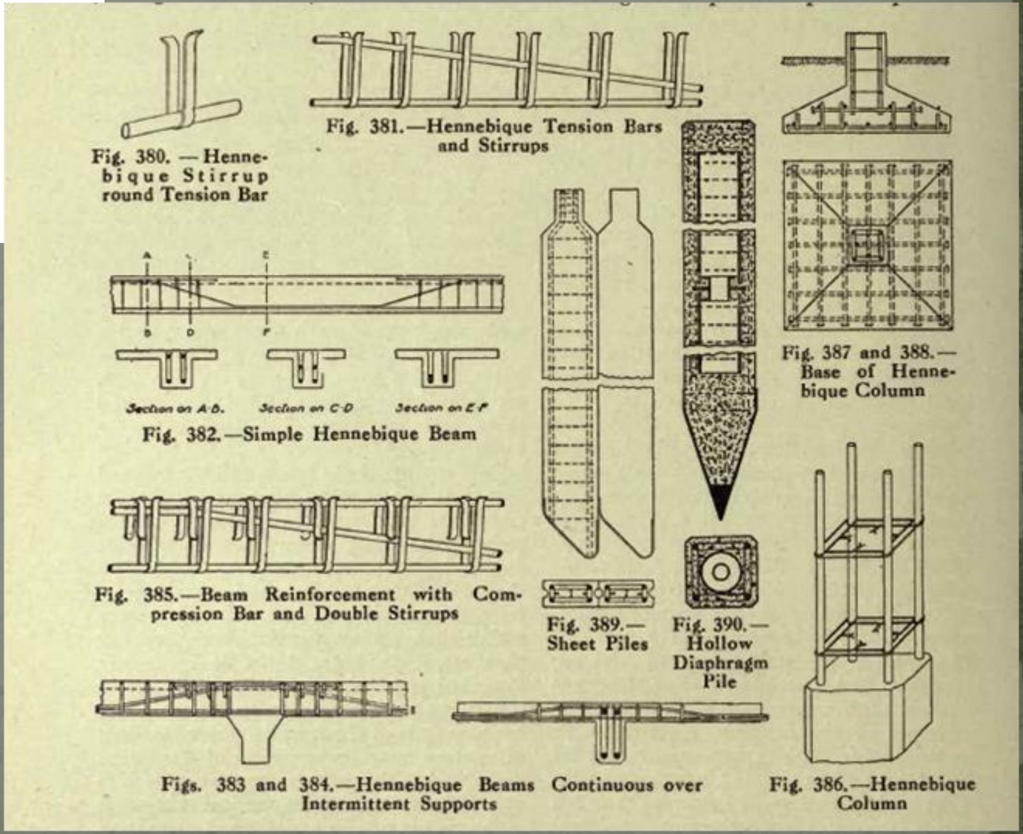
In the Hennebique beam the **concrete is relied upon to resist the compressive stresses in the upper part of the beam, while** the **steel rods** resist all **tensile stresses** in the lower portion. The concrete also forms the connection between the two flanges, assisted by the **stirrups**, generally formed of **hoop steel**.

Besides acting as a connection between the upper and lower parts of the beam, the stirrups take also the **horizontal shear**. For this reason they are placed closer together near the supports.

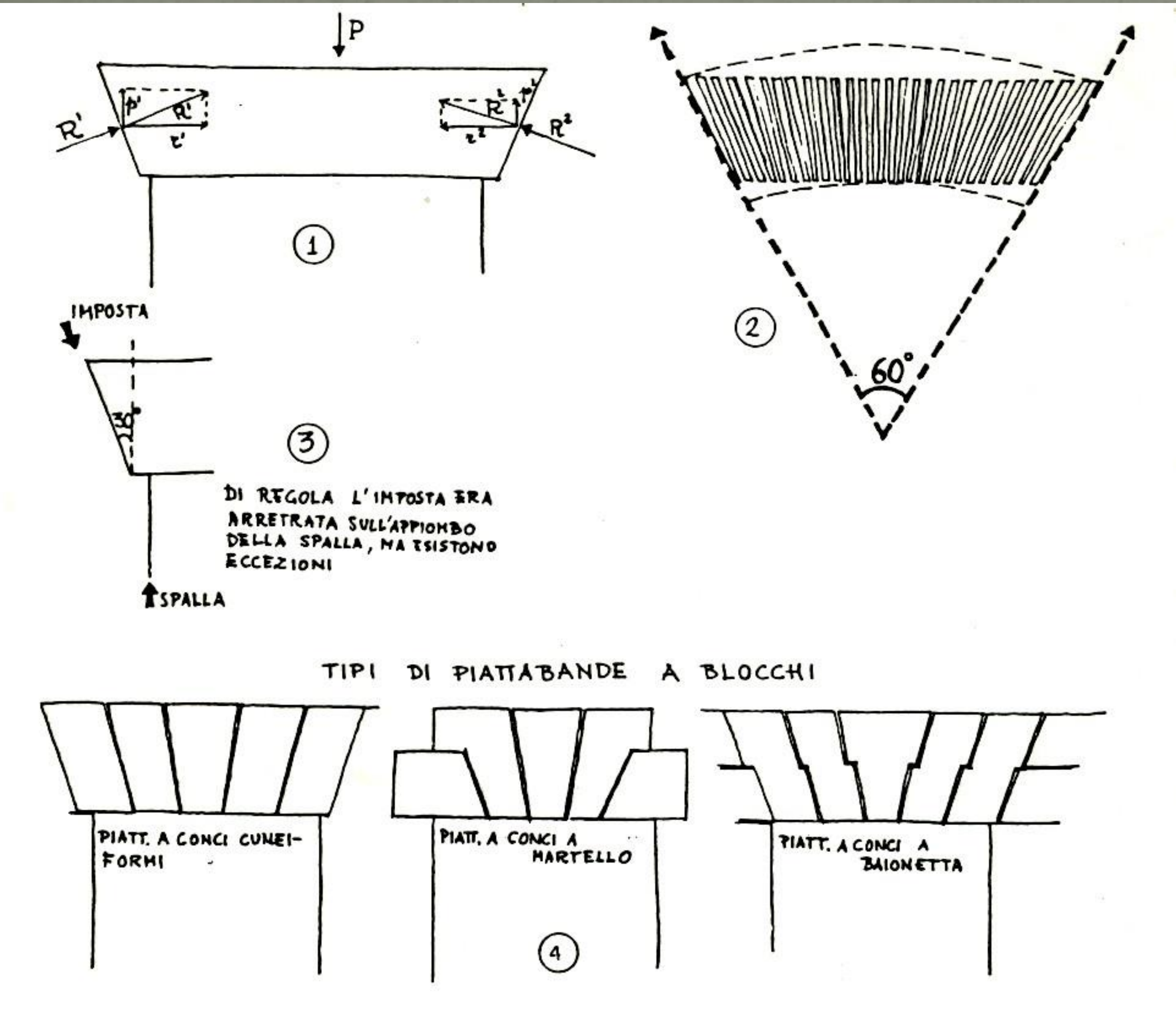
Frank Lloyd Wright and the Concrete



The Hennebique system and the position of tension bars: reasoning on tensile and compressive stresses, without forgetting the shear stresses…



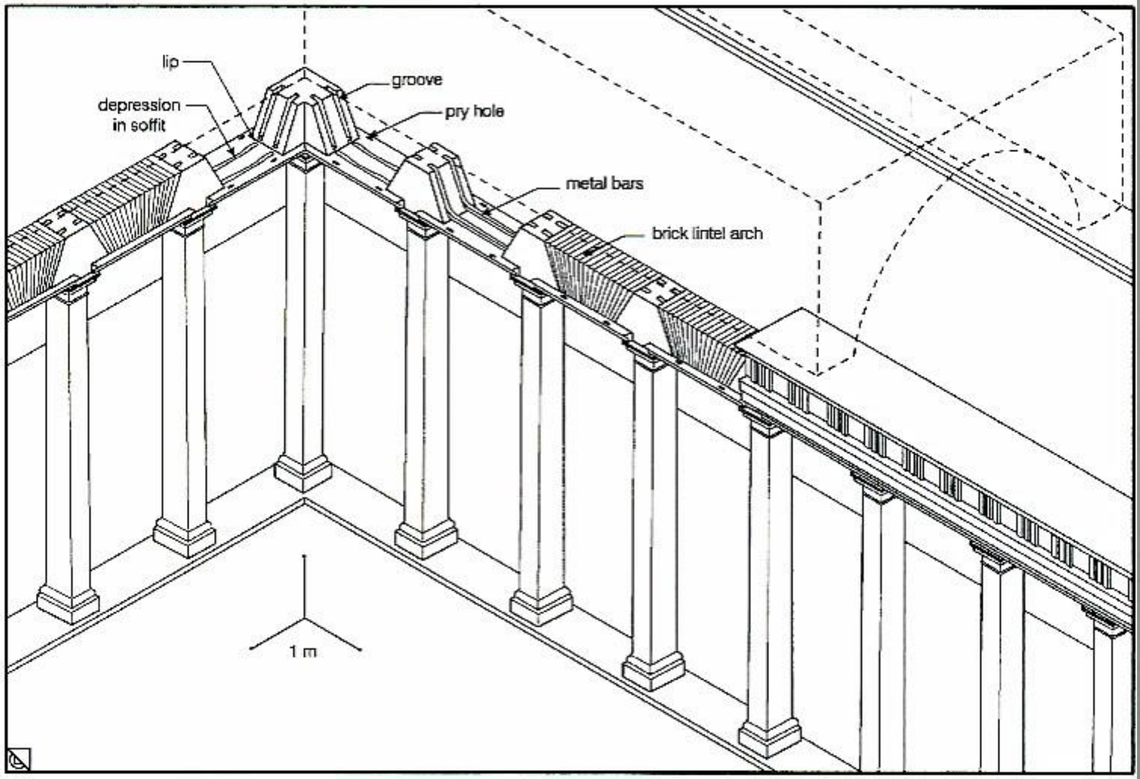
Frank Lloyd Wright and the Concrete



The flat arch (even lintel arch) is very common in architecture, but is not a strong construction.

To be self-supporting it must be of such a size that a segmental arch of proper radius and sufficient depth can be drawn on its face.

Frank Lloyd Wright and the Concrete

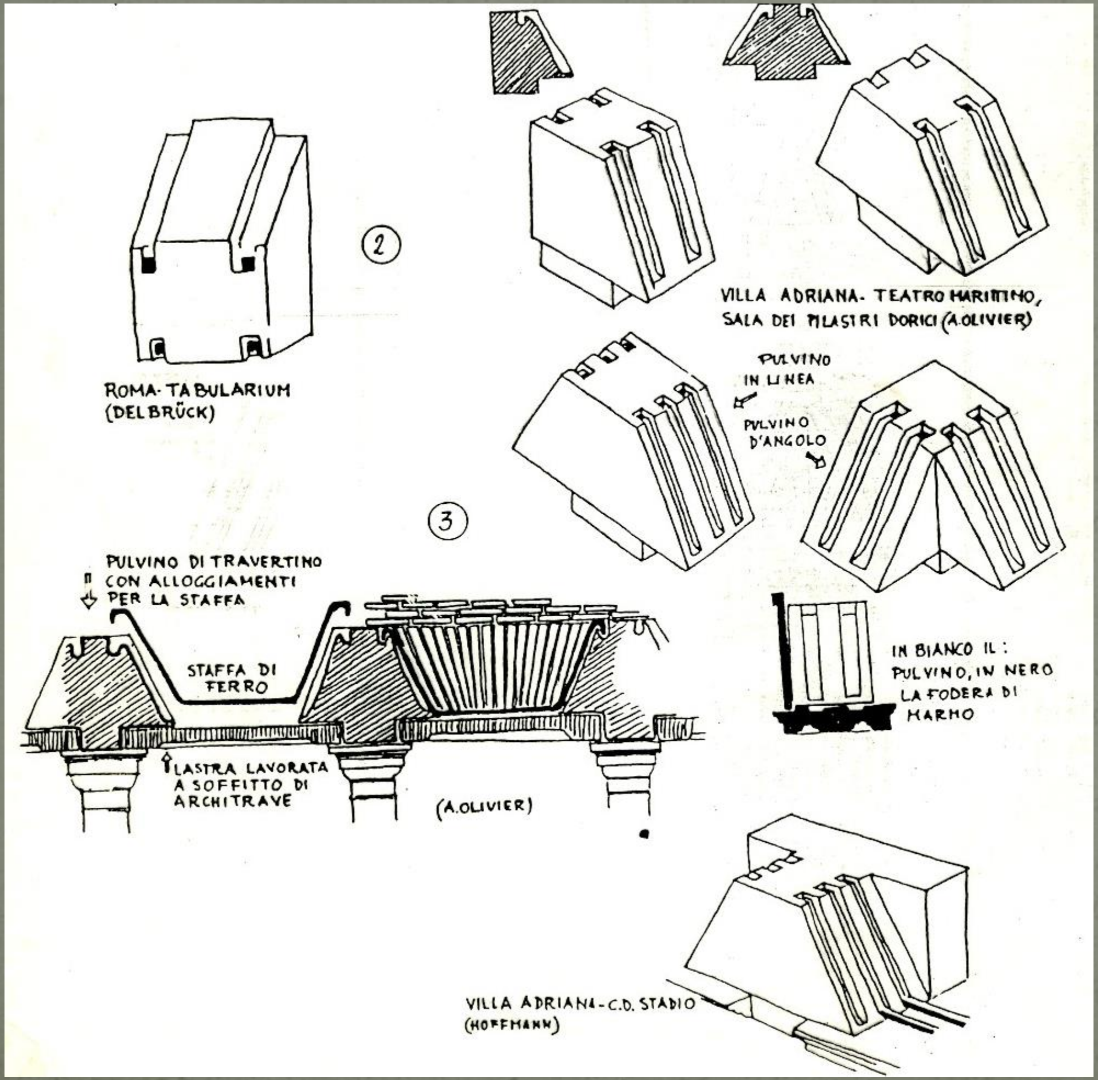


110. Hall of the Doric Pilasters at Hadrian's Villa (A.D. 125–133). Reconstruction of lintel construction.

At Hadrian's Villa a different method of construction was used for architraves of colonnades that support concrete vaulting.

Travertine impost blocks connected with iron bars were combined with brick lintels.

Frank Lloyd Wright and the Concrete



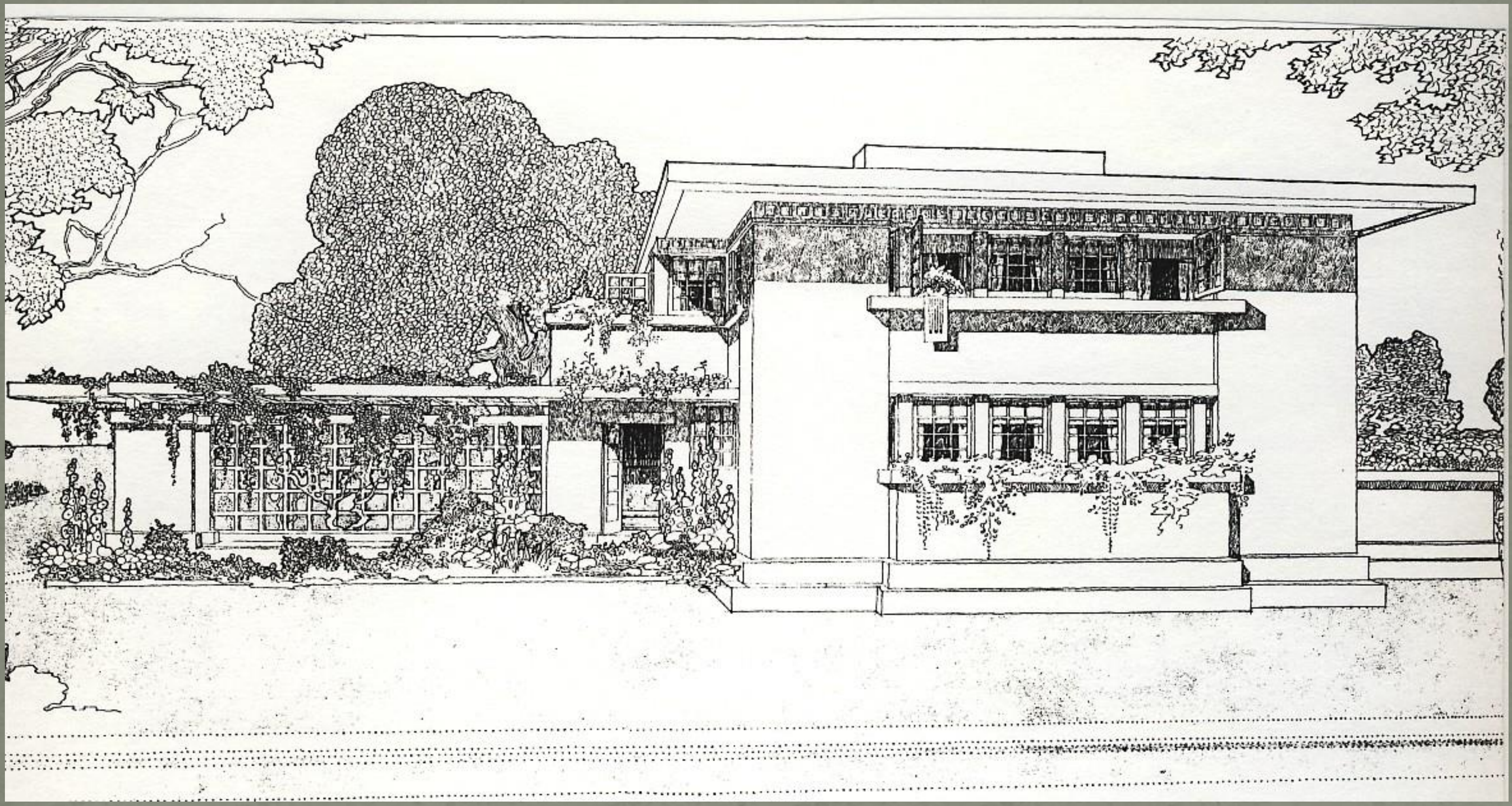
The iron architrave bars were anchored in holes in the top surface of the impost block and then run down grooves carved into the oblique side surfaces under the flat brick arch , and back up grooves in the next block.

The lodging holes in the top of the blocks at the Hall of Doric Pilasters would have accomodated bars 3-4 cm square.

Frank Lloyd Wright and the Concrete

All the examples of impost blocks are trapeziodal in form and raised on a rectangular base to create a slot between the top of the column capital for a marble soffit slab to fit. The soffit panels used to cover the bottom of brick lintel arches are still lying on the ground of the Hall of the Doric Pilasters.

Frank Lloyd Wright and the Concrete

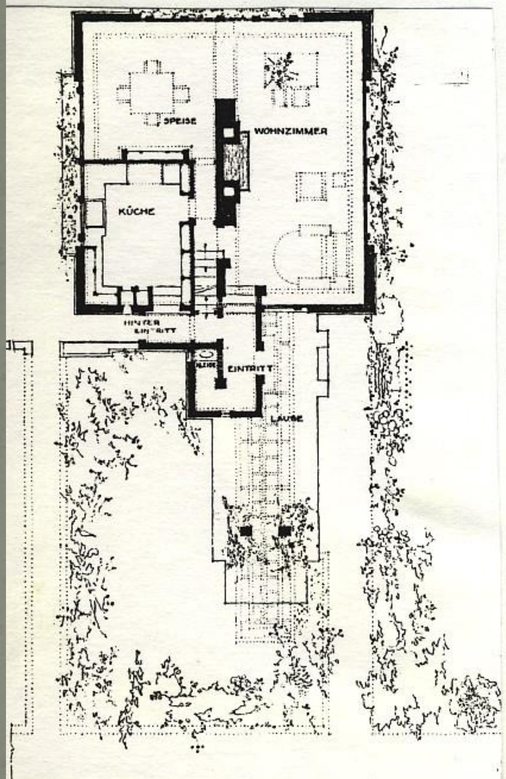


Frank Lloyd Wright, The Fireproof House, “Ladies’ Home Journal”, 1907.

Frank Lloyd Wright and the Concrete

- Wright was a great promoter of reinforced concrete construction—especially as it became more affordable for homeowners. "Changing industrial conditions have brought reinforced concrete construction within the reach of the average home-maker," Wright claims in the article written for the Ladies' Home Journal, where the **Fireproof House** was published.
- The steel and masonry material provides not only fire protection, but also protection from dampness, heat, and cold. "A structure of this type is more enduring than if carved intact from solid stone, for it is not only a masonry monolith but interlaced with steel fibres as well."
- "The walls, floors and roof of this house," writes Wright, "are monolithic casting, formed in the usual manner by means of wooden, false work, the chimney at the centre carrying, like a huge post, the central load of floor and roof construction."

Frank Lloyd Wright and the Concrete



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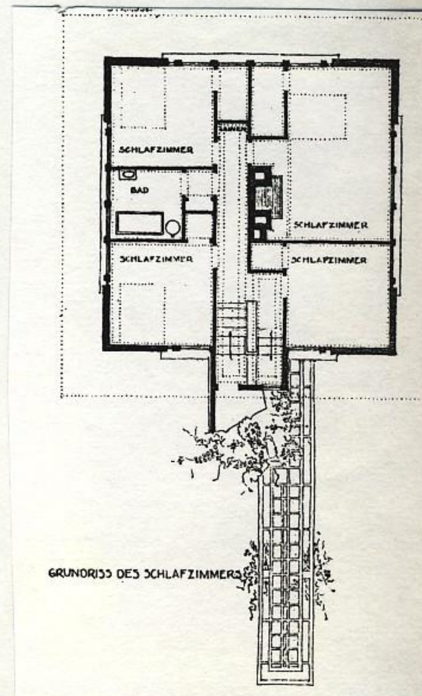
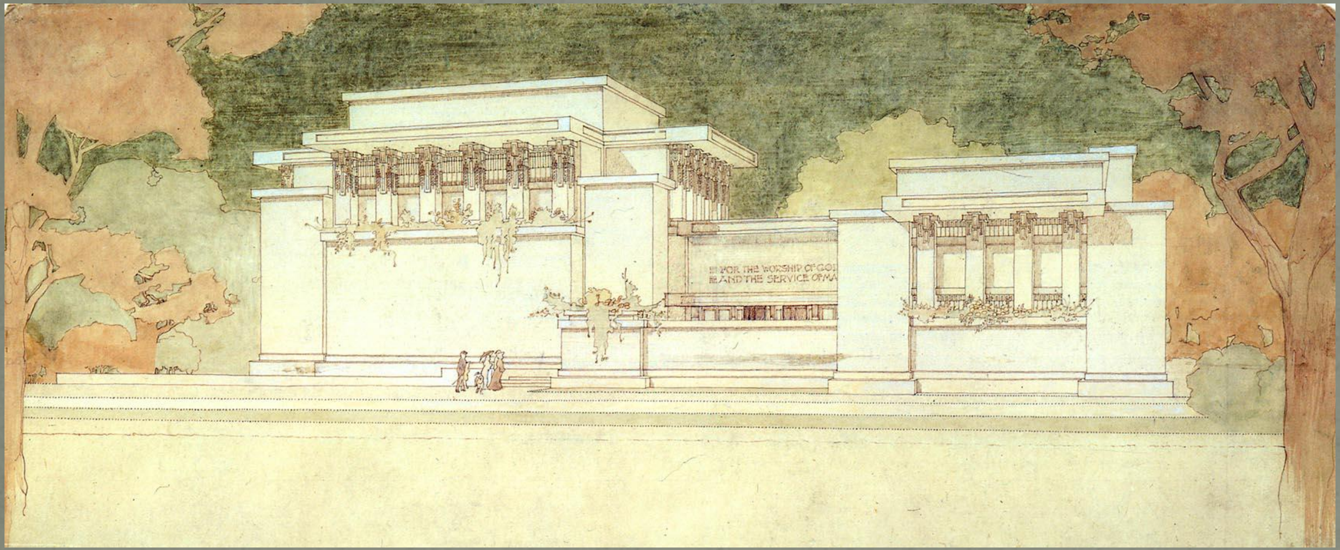
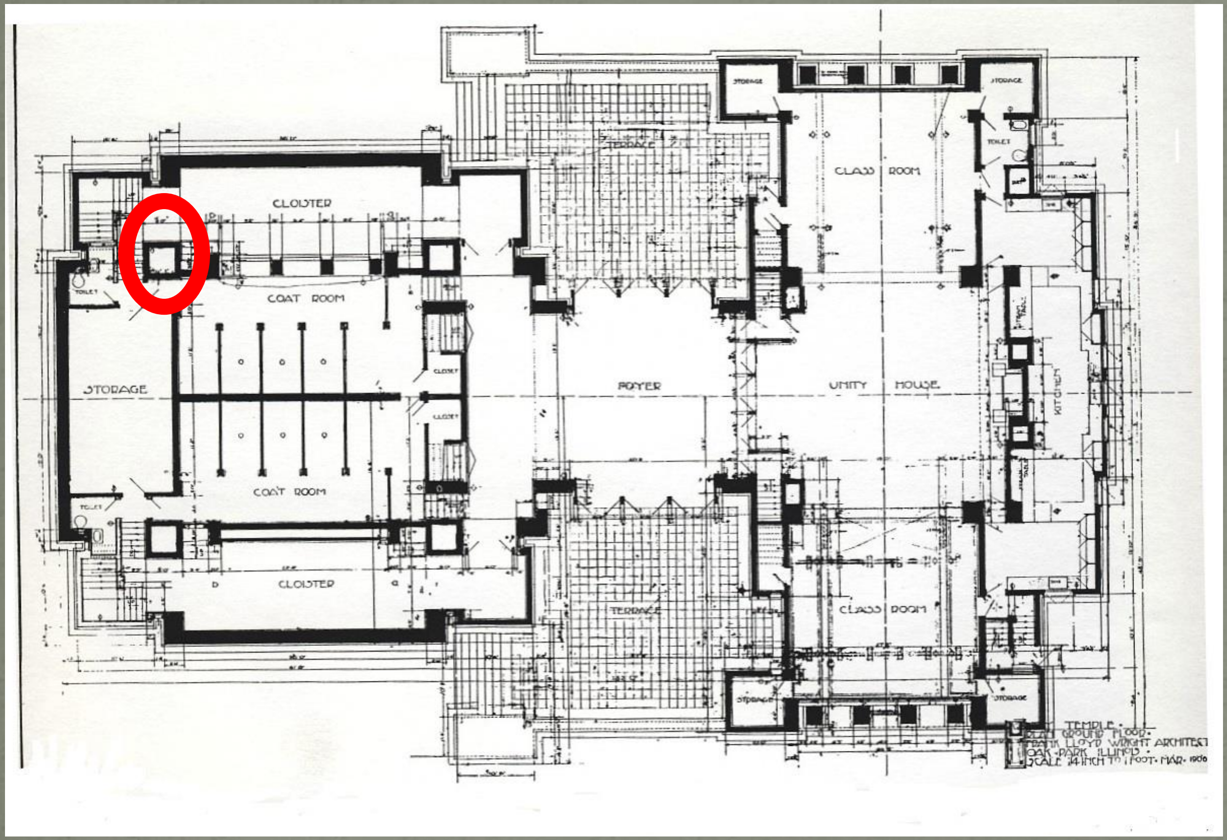


Frank Lloyd Wright and the Concrete



Wright's **Unity Temple** incorporated the use of poured-in-place reinforced concrete, used primarily at that time for industrial structures. In a radical departure from traditional Western religious architecture, Wright designed the building to house two distinct spaces — Unity Temple, a four-level cubic sanctuary for worship, and Unity House, for the congregation's social and cultural gatherings.

Frank Lloyd Wright and the Concrete



"The worship room was built with four interior **free-standing posts to carry the** overhead structures. These concrete posts were hollow and became free standing ducts to ensure economic and uniform distribution of heat" (F.L.Wright).

Frank Lloyd Wright and the Concrete

Frank Lloyd Wright considered the Imperial Hotel in Tokyo, designed and built from 1913 to 1923, to be among his most important works. It was his largest project built to that time, and after its survival in the great Kanto earthquake of 1923, it garnered international fame until its demolition in 1968 to make way for a much taller hotel structure on the site.

The world was astonished to learn that the Imperial Hotel, riding on its concrete "pincushion," had not only withstood the shock that devastated much of the city but had also escaped virtually unscathed. Overnight Wright became an international celebrity, an architect of heroic stature.

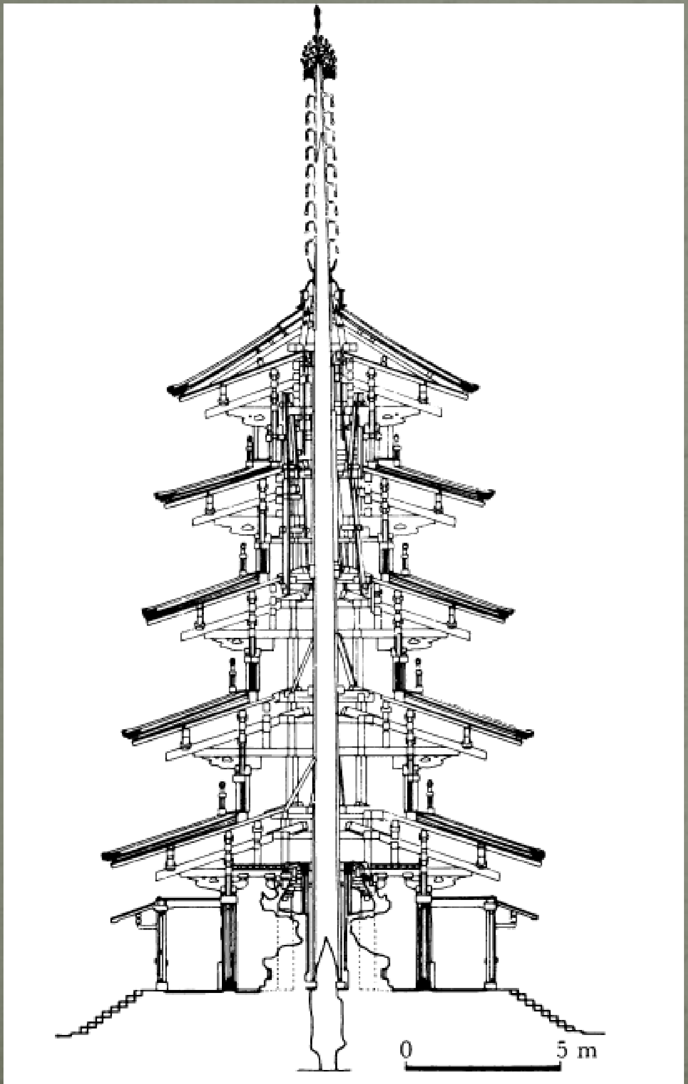
Frank Lloyd Wright and the Concrete

As is well known, Wright had espoused a special interest in and regard for the architecture of Japan since seeing the Ho-oden at the Columbian Exposition in Chicago in 1893. There can be no doubt that, during the years when he lived in Japan (1917-1922), while working on the Imperial Hotel, he was both interested and attentive when he had the opportunity to see something new to him in Japanese architecture.

Frank Lloyd Wright and the Concrete

Wright probably visited the oldest sanctuary in Japan, the Horyu-ji shrine near Nara, preserved from the seventh and eighth centuries.
Wright's attention was kept by a feature in the pagoda that had been consciously adopted from China to help the tower withstand the shock of earthquakes: a rigid central member, or "**heart pillar,**" acting as a **mast.**

Frank Lloyd Wright and the Concrete



Sunk deep into the earth, where it was mounted on stone, **this pillar** stood free within the structure, ready to offer support when the pagoda should sway, due to either earth tremors or heavy winds. The succession of roofs that mounted upward in a vertical stack was composed of a complex combination of members that produced a series of dramatically cantilevered forms.

The central spine of a pagoda serves not only a functional purpose but also an iconographical one. This feature, common in Japanese pagodas, originated not in its Chinese predecessor but in their common ancestor, the **Indian *stupa***, where the central spine is associated with the cosmic pillar or tree, regarded as identical with **the Tree of Enlightenment.**

Frank Lloyd Wright and the Concrete

ARCHITECTS SPECIFICATIONS.

ENGINEERING PRINCIPLES TO BE APPLIED IN CONSTRUCTION OF

IMPERIAL HOTEL, TOKIO, JAPAN.

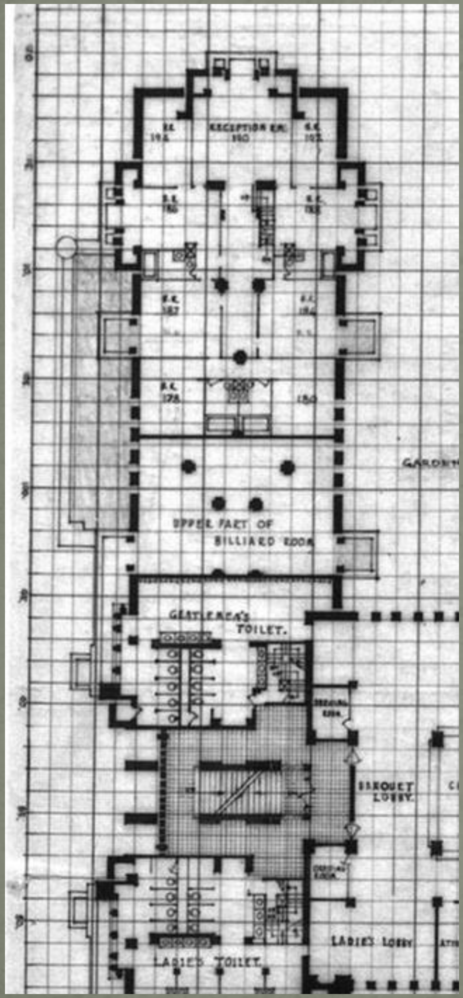
CONDITIONS: Soft ground; Earthquake tremors; High winds; Great humidity; Downpours; No frost.

MATERIALS: No fabricated Steel; Reinforced Concrete; Commercial round rods only; Structure faced with Masonry material throughout; Foundation - Cushion; Soil reinforced to depth sufficient to take loads safely by casting into it's texture small needles of Concrete - 2'-0" on centers - to the required number or to the economic limit.

SUPPORTS: Intermediate, - exaggerated ; horizontal bond; Concrete faced with other material; hollow wherever practicable.

Wright often said that the Imperial hotel's importance in his work was that it demonstrated the **efficacy of cantilevered steel-reinforced concrete** as his preferred system of building. This method he distinguished from the **steel frame**, which he disliked (especially for tall buildings), and he envisioned all his later realized buildings and unbuilt projects for such structures in reinforced concrete as demonstrations of his theory of organic form.

Frank Lloyd Wright and the Concrete

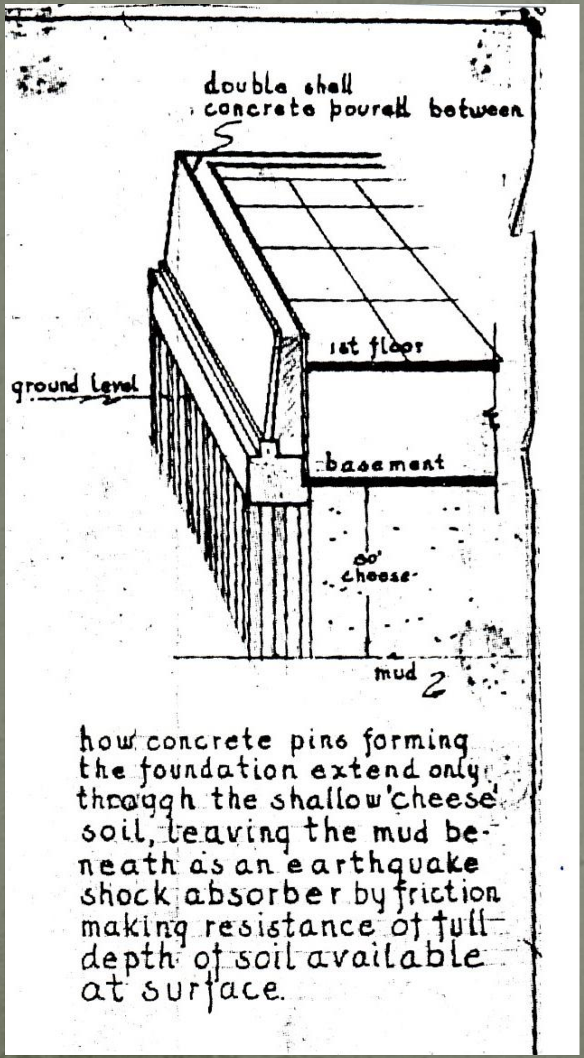


In discussing the Imperial Hotel's earthquake resistance, Wright in different contexts described the building as a monolithic construction of reinforced concrete, yet one whose technical details gave the structure a flexible elasticity.

To limit the transfer of lateral earthquake stresses from one part of the building to another and to accommodate thermal expansion and contraction of the concrete, he divided the building's north and south wings into sections of about 40 feet each, as the intervals between projecting squared balconies.

Imperial Hotel, ground floor plan, showing the modular grid of 4 feet and sections of 40 feet, or the distance between projecting squared balconies in the wings.

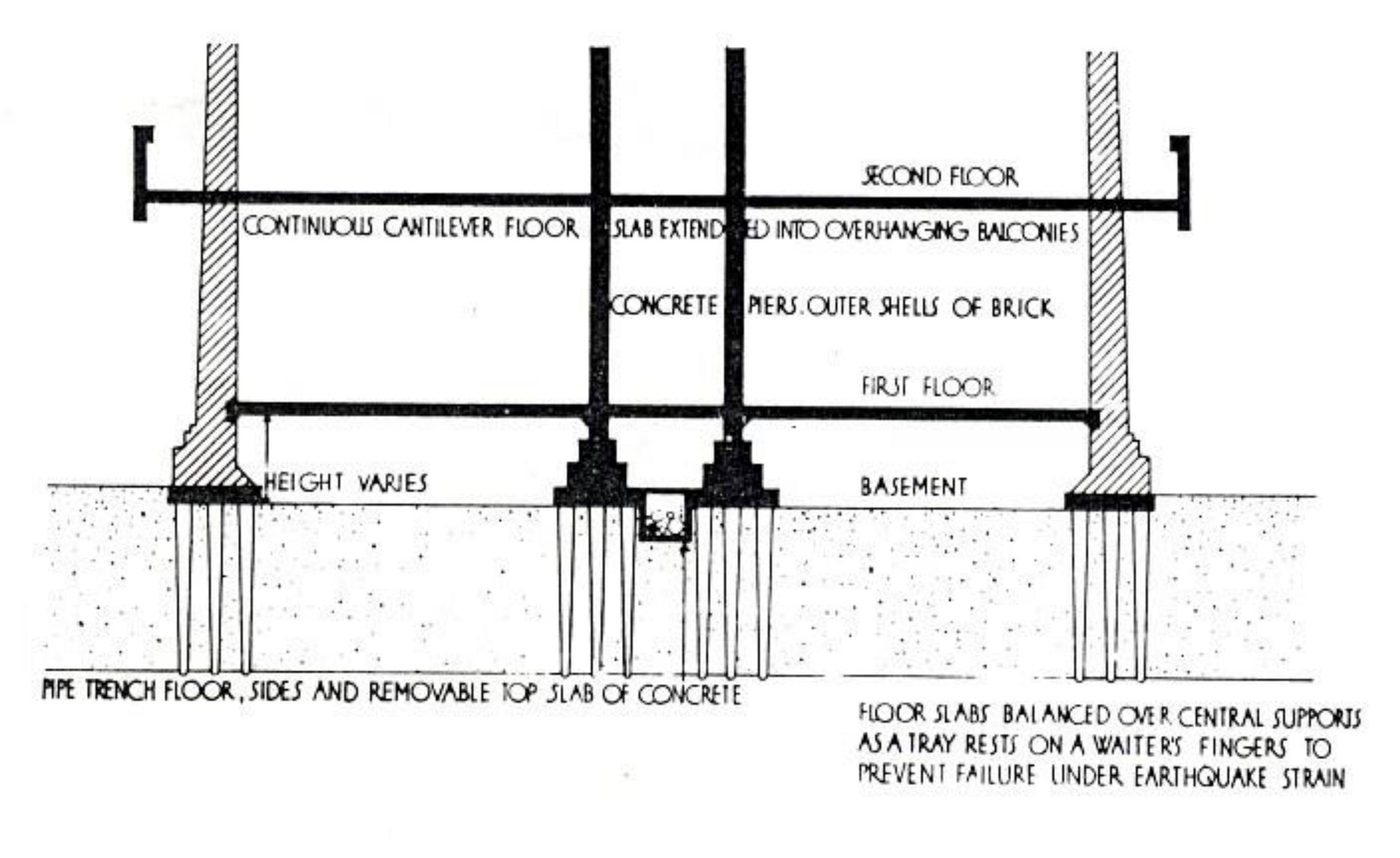
Frank Lloyd Wright and the Concrete



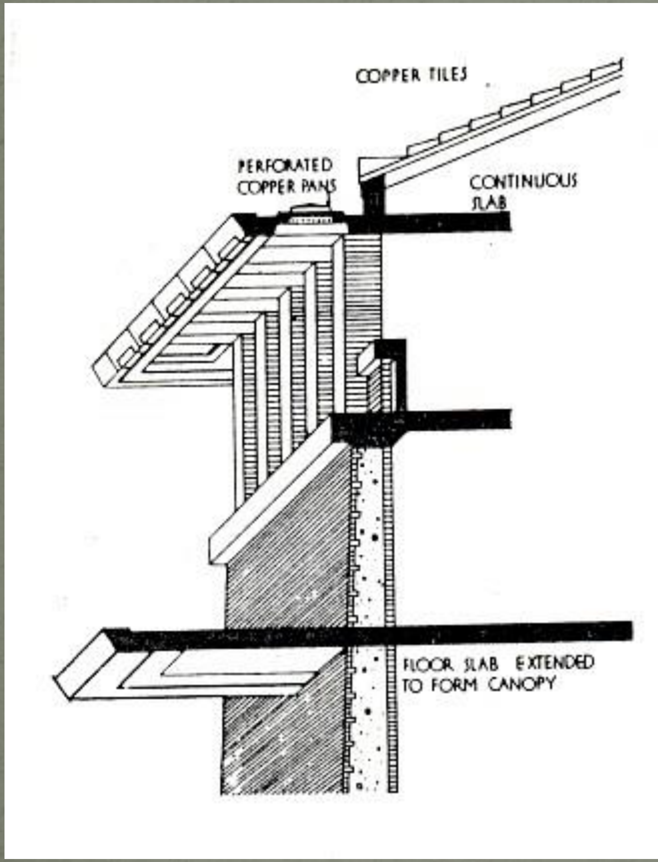
The most controversial aspect of Wright's structural design was the hotel's foundations, which he described as giving the building flexibility in response to lateral seismic shocks. The site had roughly 8 feet of **alluvial soil** above 60 feet of liquid mud, then compact clay.

Some architects and engineers in Tokyo believed that piles should be deep enough to connect with the hardpan, whose **rigidity** would help insure the building's stability. Yet Wright was among those who believed that the optimal technique for resisting earthquake damage was the **floating foundation** on **short concrete piles**; he theorized that the building then would ride with the lateral seismic shocks like a ship floating on waves along the water's surface, instead of resting on deep piles transferring lateral ground motion to the building and damaging it.

Frank Lloyd Wright and the Concrete



Frank Lloyd Wright and the Concrete

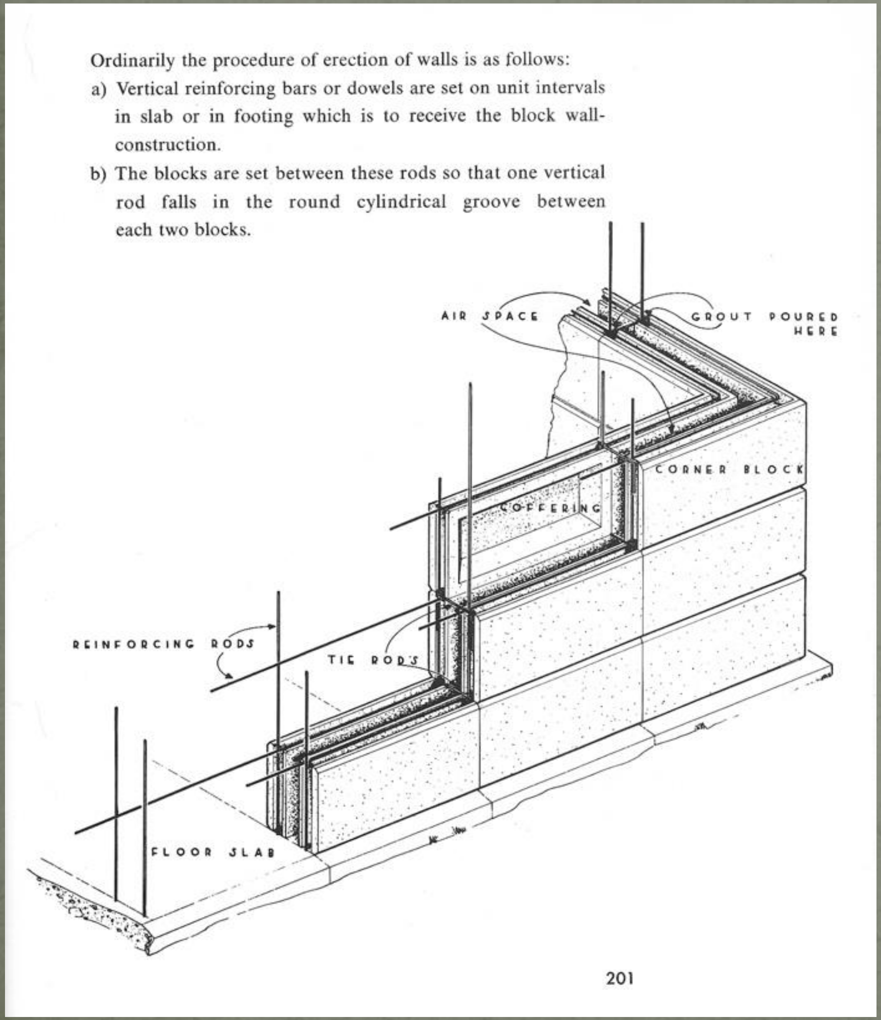


Imperial Hotel, view from northeast, showing north entrance to social section, with reinforced-**concrete floor slabs** cantilevered outward as balconies .

Frank Lloyd Wright and the Concrete

At the same time he was building the monolithic concrete houses, Wright began experimenting a different kind of articulation realizing in 1906 the project for E.G. Browne's precast block house.

Frank Lloyd Wright and the Concrete



Ordinarily the procedure of erection of walls is as follows:

a) Vertical reinforcing bars or dowels are set on unit intervals in slab or in footing which is to receive the block wall-construction.

b) The blocks are set between these rods so that one vertical rod falls in the round cylindrical groove between each two blocks.

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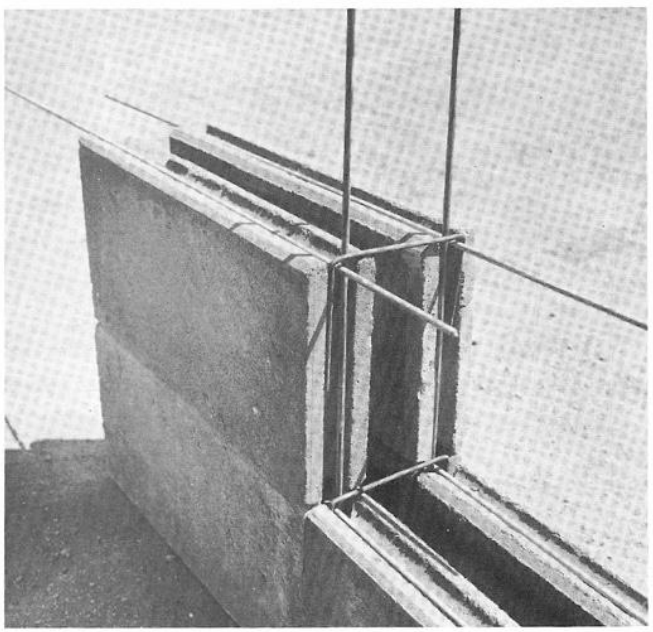
Frank Lloyd Wright *In the Realm of Ideas*: "What about **the concrete block**? It was the **cheapest** (and ugliest) thing in the building world. It lived mostly in the architectural gutter as an imitation of rock-faced stone. Why not see what could be done with that **gutter rat**? Steel rods cast inside the joints of the blocks themselves and the whole brought into some broad, practical scheme of general treatment, why would it not be fit for a new phase of our modern architecture? It might be permanent, noble beautiful."

Frank Lloyd Wright and the Concrete

"How then, you might ask, can people with limited means even more experimental release, the sense of freedom that comes with true architecture? This problem will probably always exist in one way or another. But we have come a long way in solving this general problem with the natural house of concrete blocks is called "Usonian Automatic".
This house Usonian incorporates innovations that reduce many of the largest construction costs, particularly labor. The earliest versions of these houses built of concrete blocks in Los Angeles around 1921 to 1924 can also be seen in the cabins-Arizona Biltmore. Millard House was first "- Frank Lloyd Wright

Frank Lloyd Wright and the Concrete

All edges of the blocks, having a semi-circular groove (vertically and horizontally), admit the steel rods. When blocks are placed, edges closely adjoining, cylindrical hollow spaces are formed between them in which the light steel "pencil" rods are set and into which semi-liquid Portland cement grout is poured.

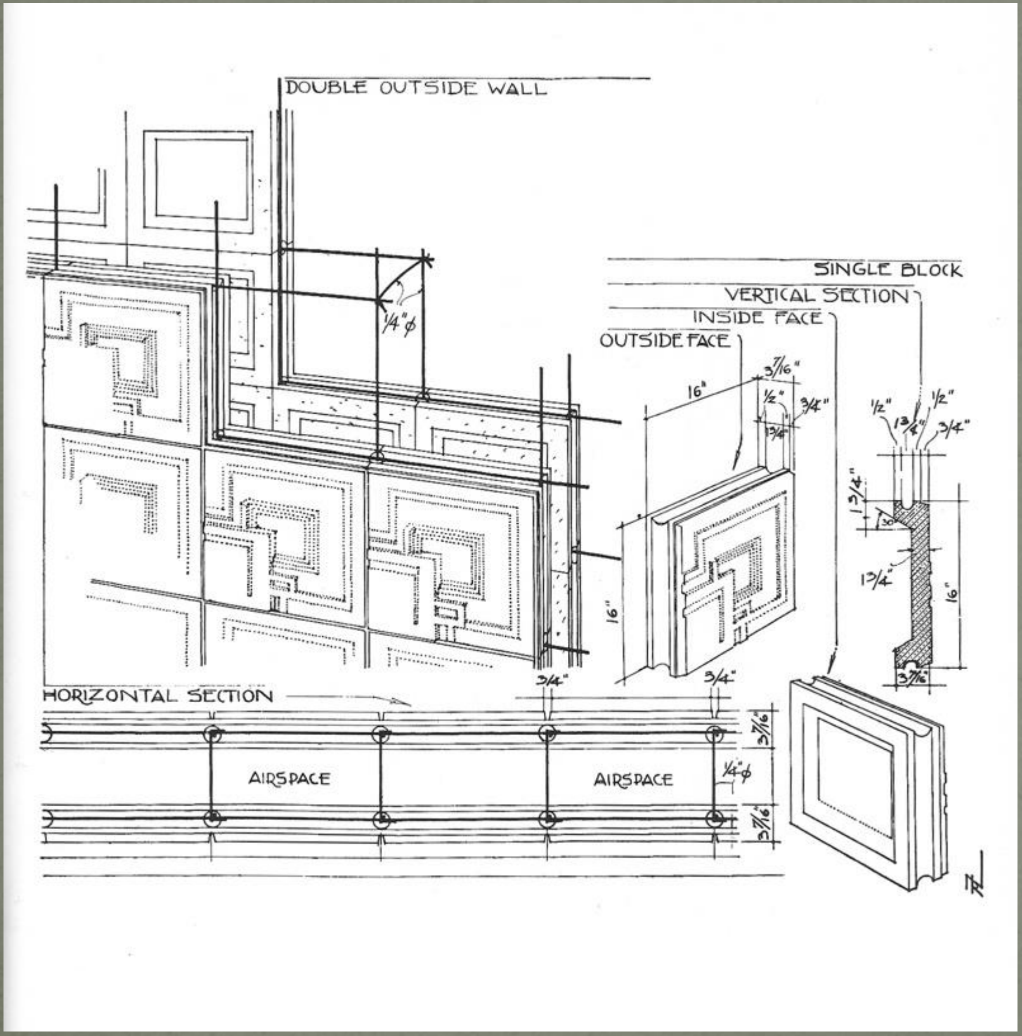


Walls may be either *single* (one layer of blocks), the coffered back-face forming the interior wall surface, or *double* with two layers of blocks, with an interior insulating air space between.

“All edges of the blocks, having a semi-circular groove (vertically and horizontally), admit the steel rods. When blocks are placed, edges closely adjoining, cylindrical hollow spaces are formed between them in which the light steel pencil rods are set and into which semi-liquid Portland cement grout is poured. Walls may be either single (one layer of blocks, the coffered back-face forming the interior wall surface, or double with two layers of blocks, with an interior insulating air space between”.

Frank Lloyd Wright, The Natutal House.

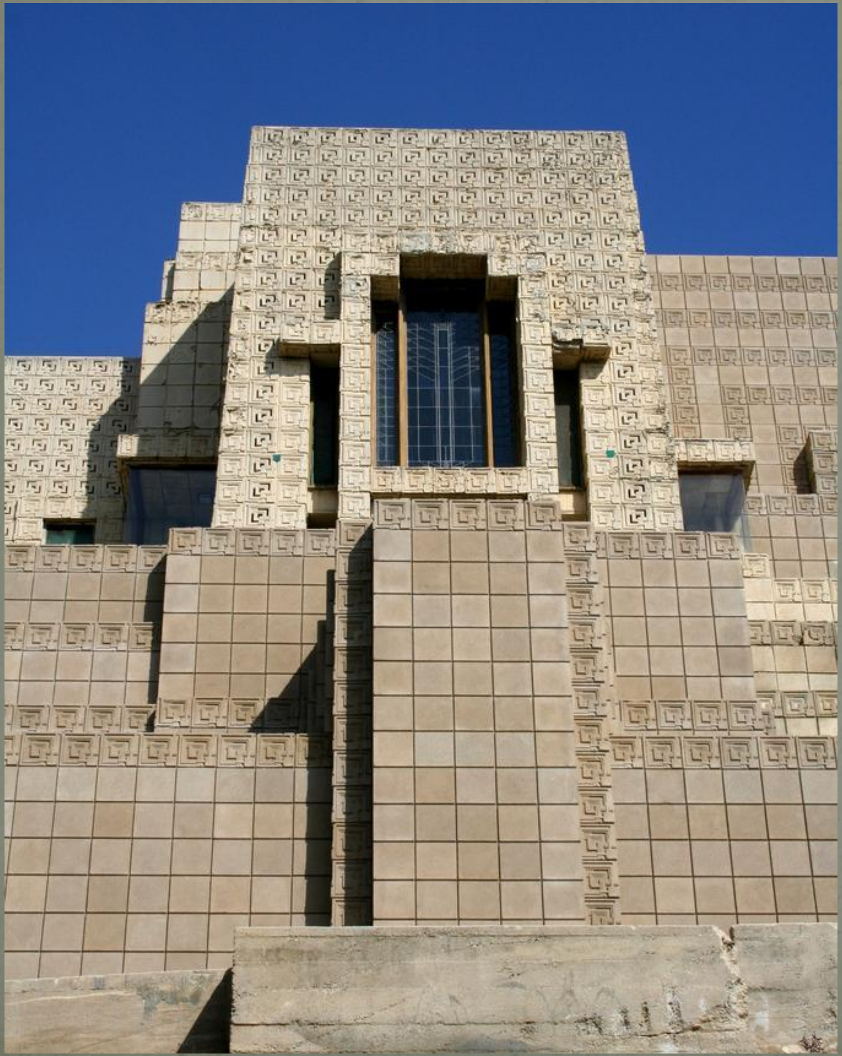
Frank Lloyd Wright and the Concrete



Wright designed a block that could be molded on site into different patterns, some of them solid, some perforated for glass inserts, some perforated for clear openings. The blocks themselves were made of a size and a weight that could be easily handled by one person, able to lift and place them one upon the other, and then pour concrete grout down inside the grooved edges, bonding the whole wall together without the customary concrete mason's mortar course.

This method of construction rendered the use of skilled masons unnecessary.

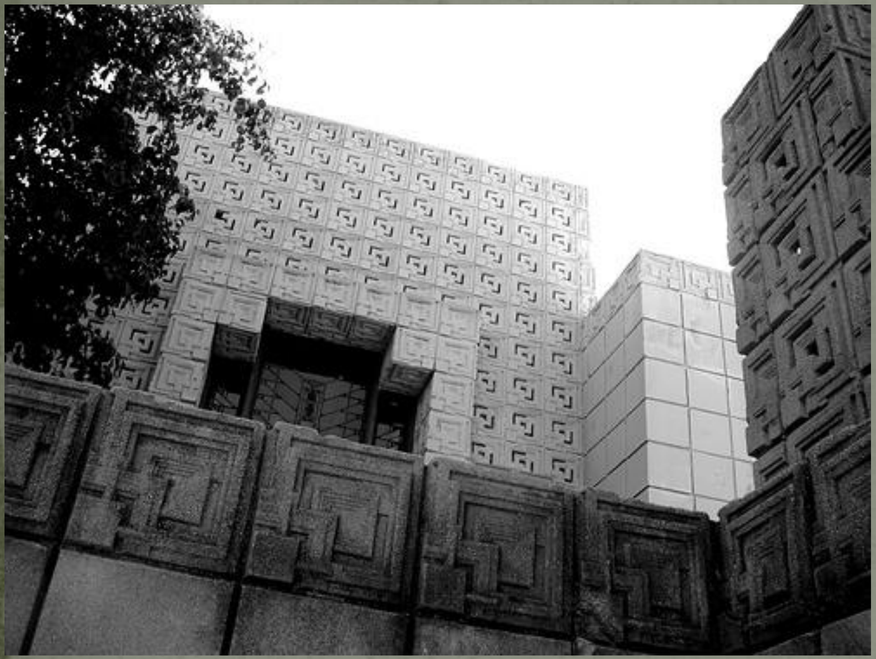
Frank Lloyd Wright and the Concrete



Near the top of Vermont Avenue sits the **Ennis House** done by Frank Lloyd Wright **in 1924,** which dominates its surroundings as a modular masonry structure composed of square concrete bricks.

Its inspiration is rather obvious, as Wright's love for **Mayan art** and architecture connects this residence to the culture's highly ornamented, symmetric and organized structures.

Frank Lloyd Wright and the Concrete



Ennis House (left) and the Governor's Palace at Uxmal Mexico, Yucatan peninsula(right).

Frank Lloyd Wright and the Concrete

Frank Lloyd Wright and the Concrete