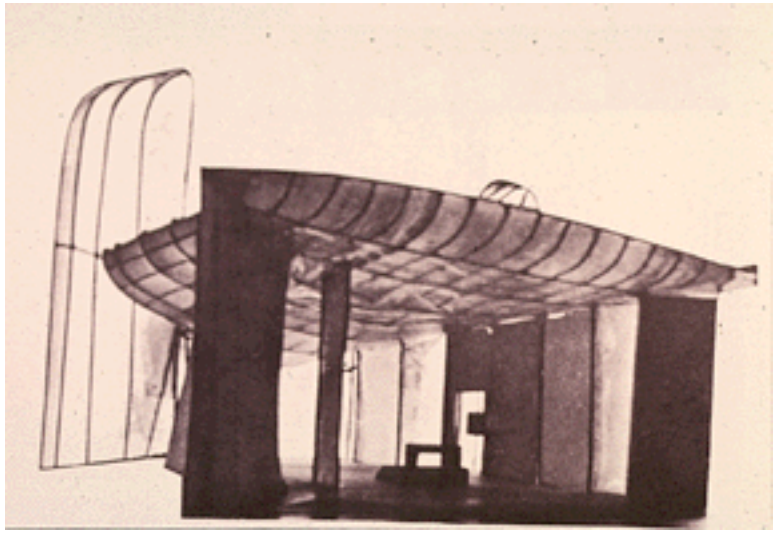
Ronchamp

Concrete is a material, that as a heavy fluid, offers an architect an endless variety of forms and surface quality opportunities.

At an early point in the design process the architect and engineer must have an idea of how the concrete will be used as a structure.

The chapel Notre'Dame du hut at Ronchamp by Le Corbusier has a number of innovative ideas for concrete structure

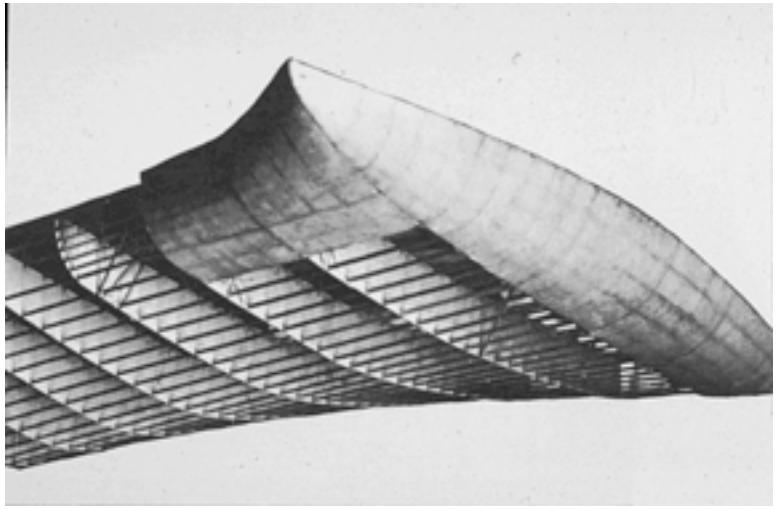
Ronchamp



Despondent about the loss ***(or theft…if you ask Corbu)*** of the United Nations competition, Corbu was walking barefoot on a beach on Long Island when he stepped on a crab shell.

He was impressed that something so light had not crushed under his weight. Upon dissection of the shell, he found it's cellular structure allowed the shell to be both strong, and very lightweight.
From "Corbusier at work"

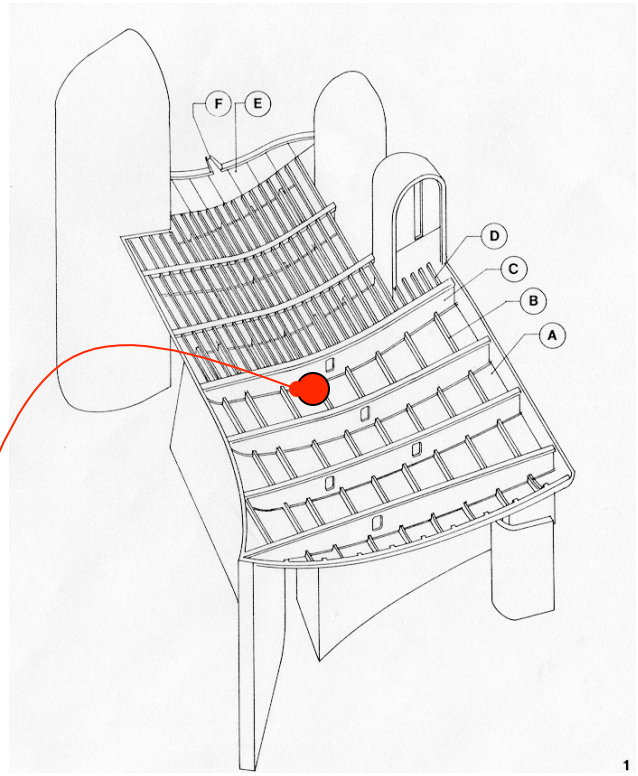
Ronchamp



Corbu had long ago advocated thinking of buildings as designers though of boats and airplanes.

In the chapel, Corbu develop what appears to be massively thick concrete elements for roof and wall.

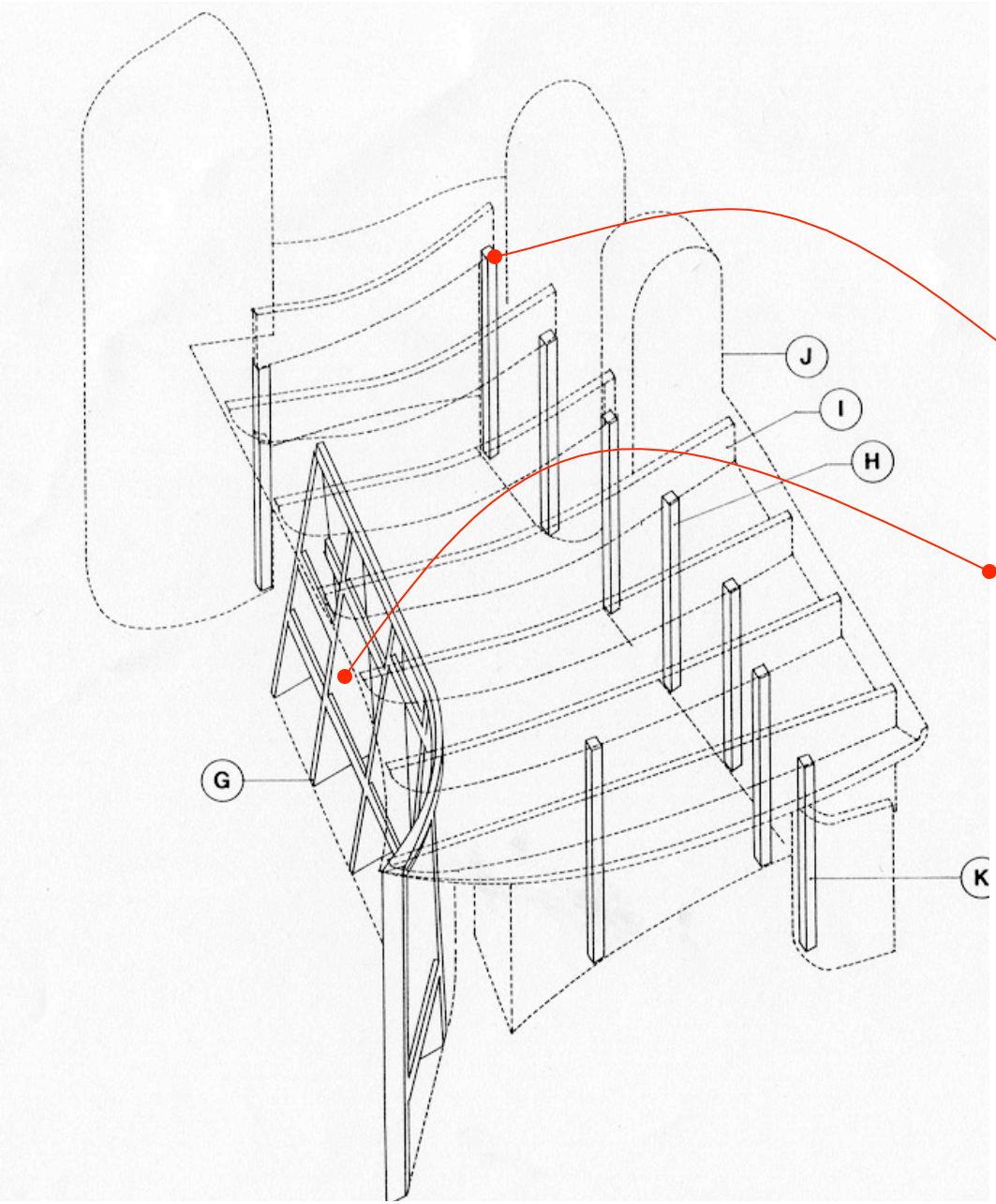
In reality, the roof is a series of parallel concrete beams, cast in concrete, having their bottom chord as part of the ceiling shell slab, and the top chord part of the roof shell slab



Ronchamp

The roof beams are formed and cast after the bottom of the shell was poured, there are small passages to allow movement through the beams and across the attic

Here we see inside of the roof element. The scale of the beam depth is apparent with the man easily sitting between the beams in the roof shell.

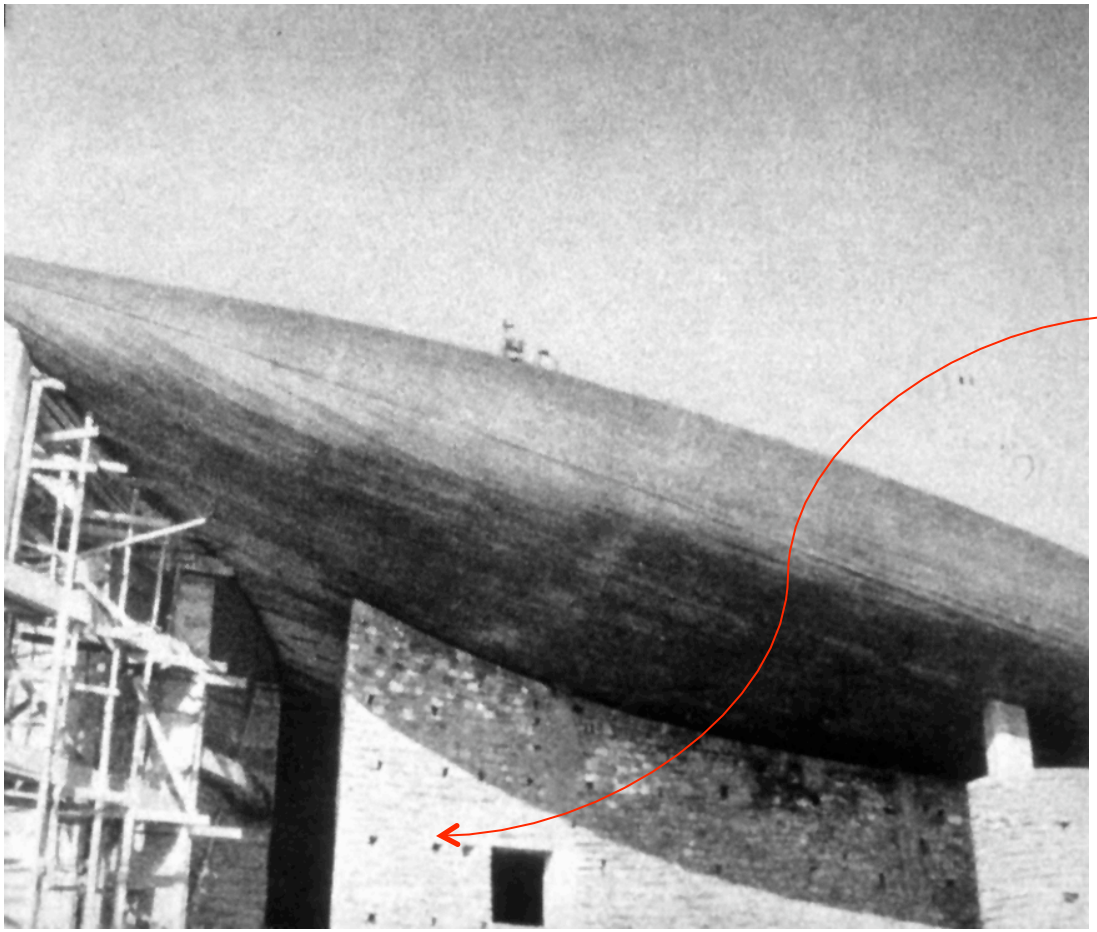


The walls contain two kinds of columns.

The simple extruded square concrete columns in the thin walls

and triangular columns in the thick wall that form the “spars” defining the changing shape of the wall at each gridline

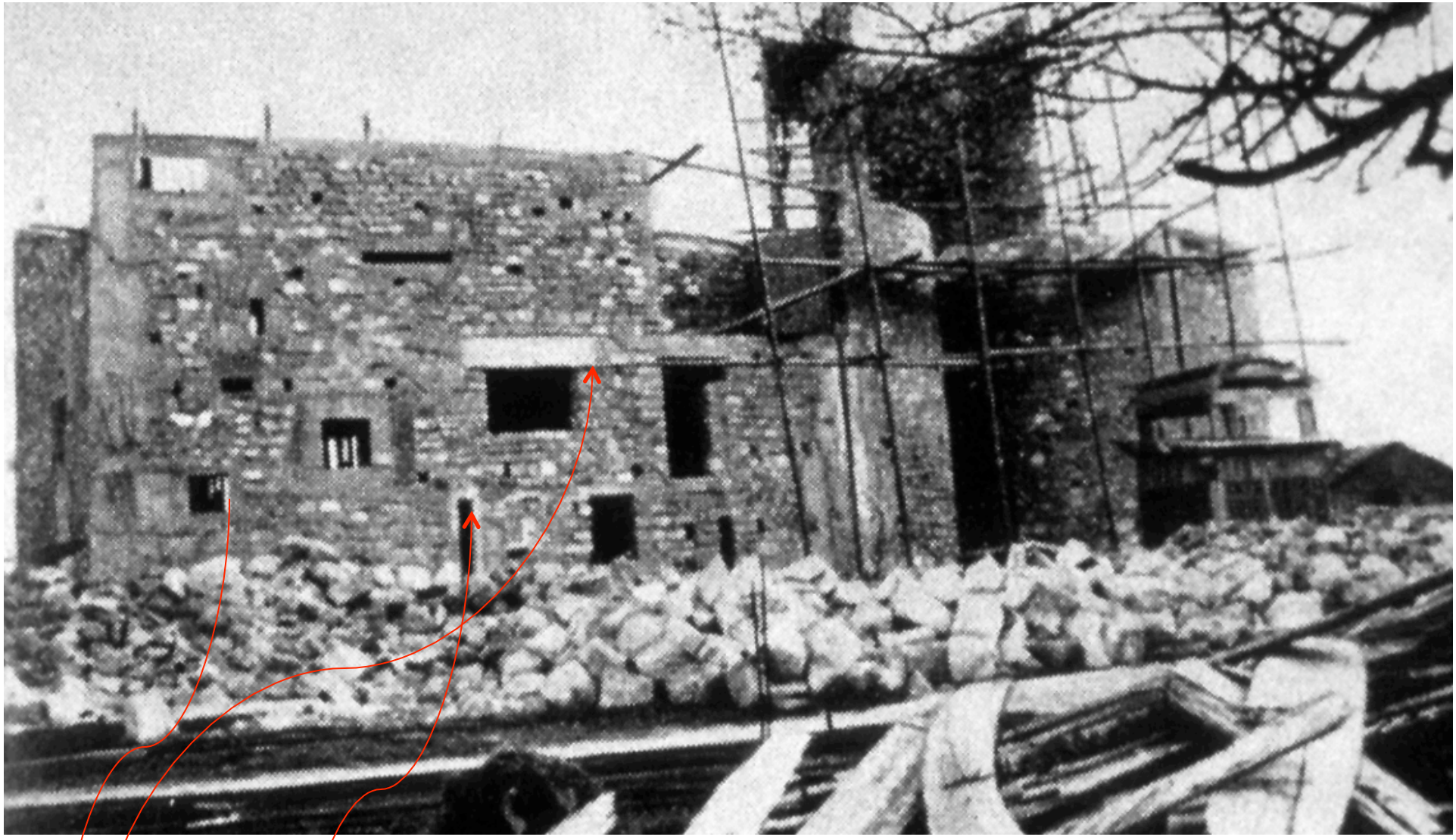
Each column receives a beam



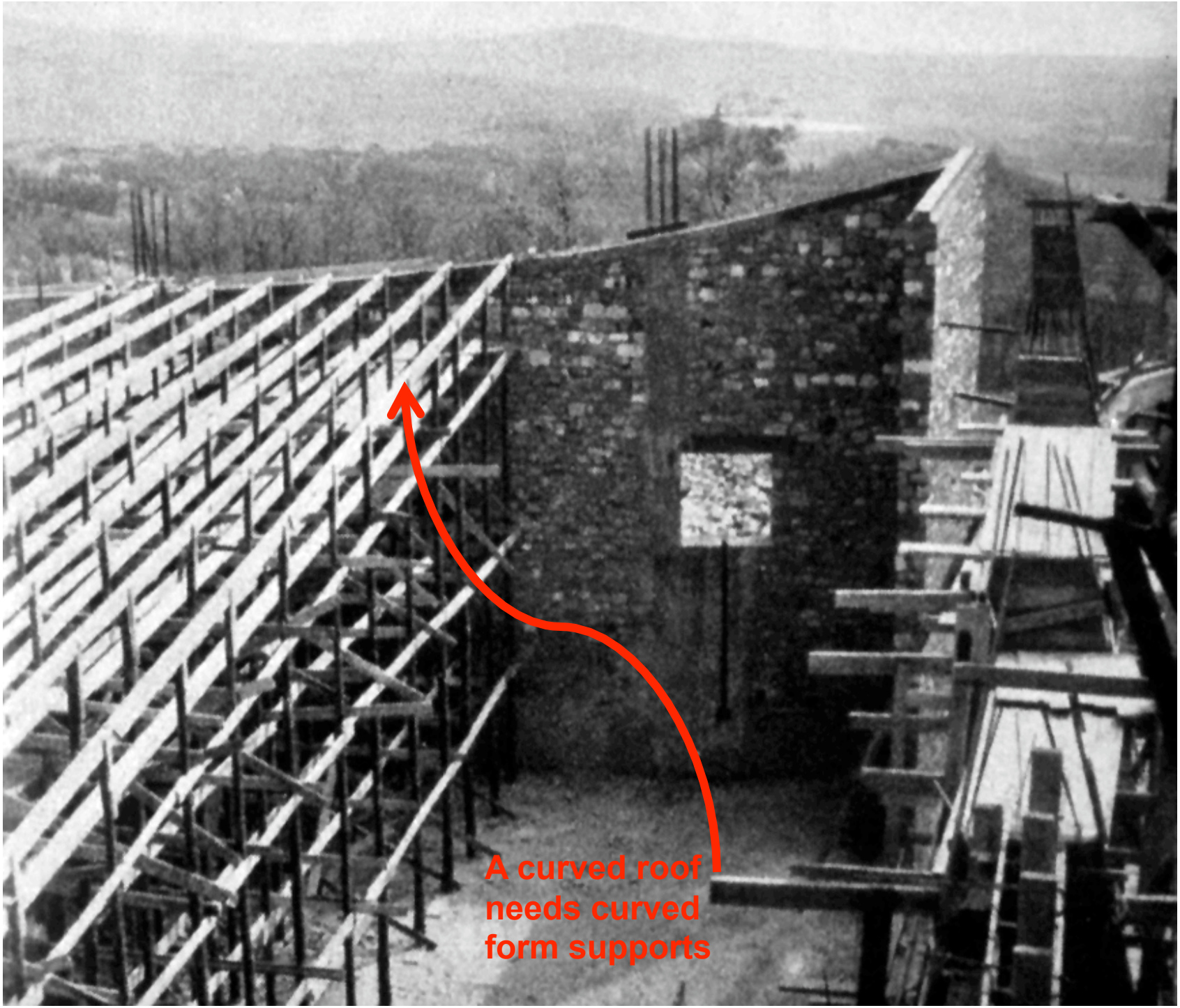
For stained glass? Or putlogs?

Column in the shadow gap

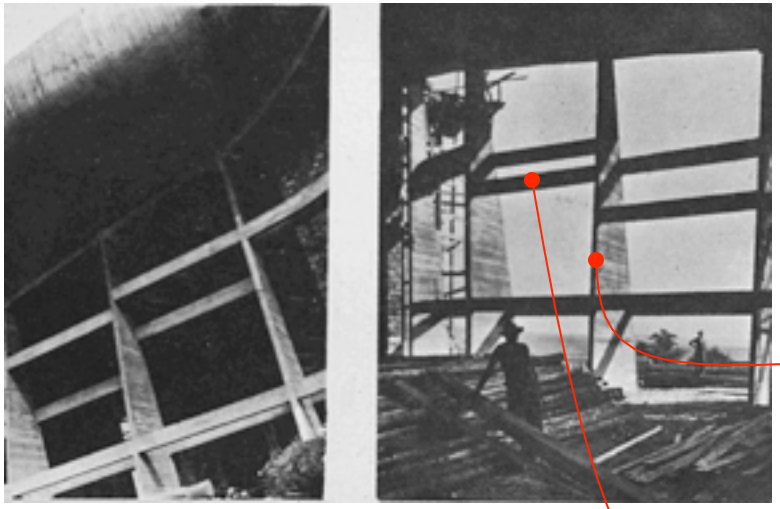
Slicing dark and light

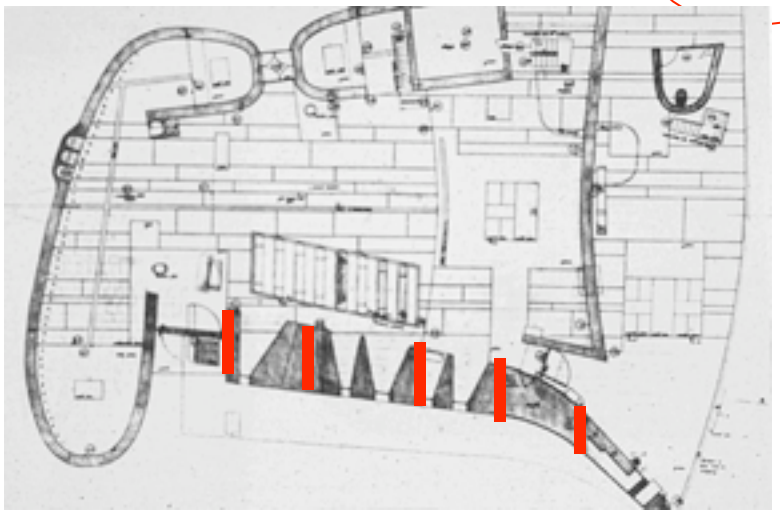


It just looks like a monolithic wall…actually has lots of parts
Lintels
Jambs
Frames


A curved roof
needs curved
form supports

Ronchamp





Corbu thought of the wall as he did the crabshell…and the roof.

The wall employs fin-like columns under each roof truss.

To prevent buckling of the very thin columns, small beams are poured between each to stiffen the column.

Ronchamp

Each fin-column is wrapped with metal lath (like chicken wire) and is sprayed with concrete to make the final heavily textured surface.

Today, gunite or shotcrete spray-applied concrete methods are used for erosion control, swimming pools.

The very dry mix is pumped under pressure to a spray head where compressed air is added to force the concrete through the nozzle onto the wall

The difference between shotcrete and gunite is where the water is added to the mix.

Shotcrete uses water added at the readymix plant for accurate wcr control.

Gunite adds water at jobsite, not wcr problem if installer doesn’t add too much

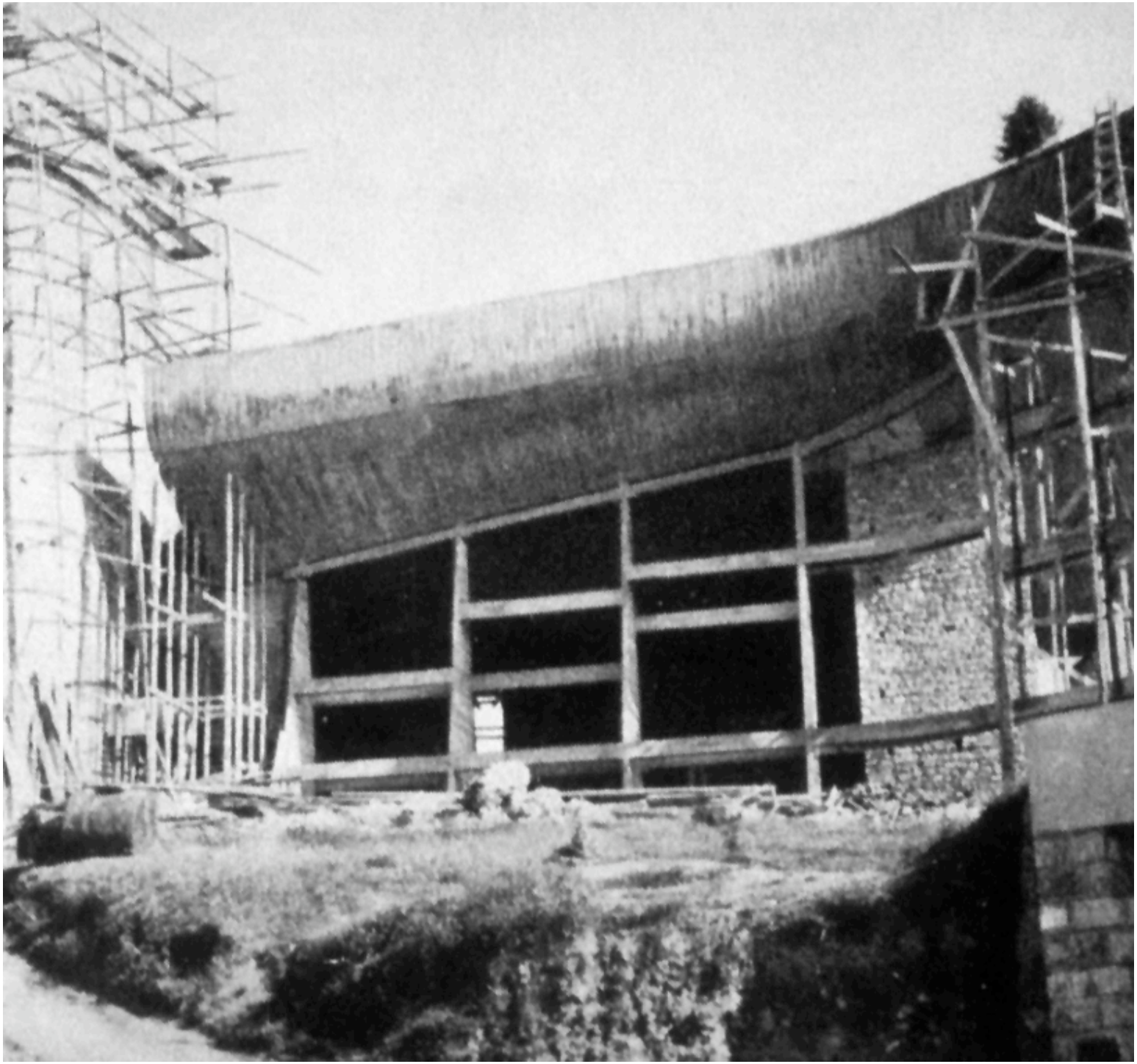
Ronchamp

The great wall of the chapel has openings which clearly express a great thickness.

But this is a modern wall by a modern architect… ***how could a modern advocate like Corbu advocate the use of medieval construction methods?***

Yet this wall has to carry each of the massive concrete roof trusses.

Art and Pragmatics…the drip

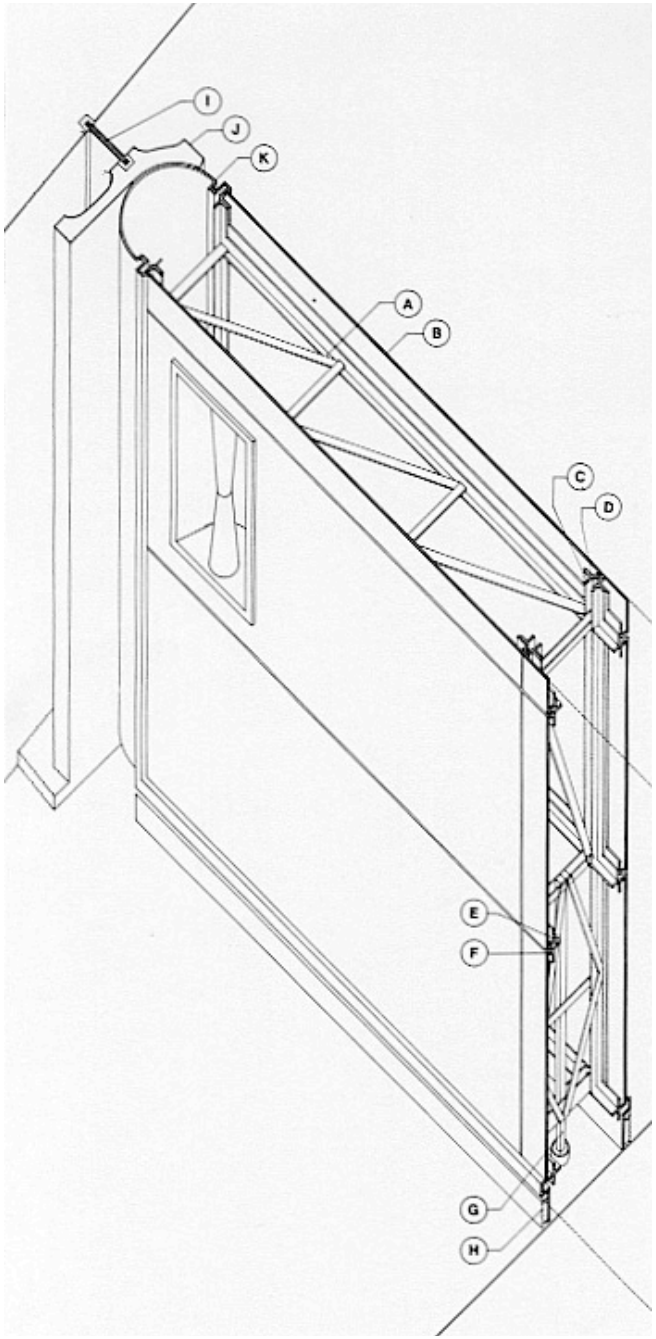


The greatest wall in architecture takes shape

Scooping light from the North, a more even light through the day


Light falling on a rough surface is graded
by the surface so we can know the falloff


Scooping South light, reflecting red
to last as long as possible



Even the pivoting doors at Ronchamp are built like an airplane.

Two skins of porcelain enameled steel panels are fastened to a subframe of lightweight metal trusswork.

This allows the door to be both thick, massive in appearance and lightweight at the same time.

What place does art have with architecture?

A door and light to enter the upper pulpit

Architecture from pragmatics…sculpted scupper

To receive the water from the roof

When you go to Ronchamp

…slow down
…first draw it
…then photograph it

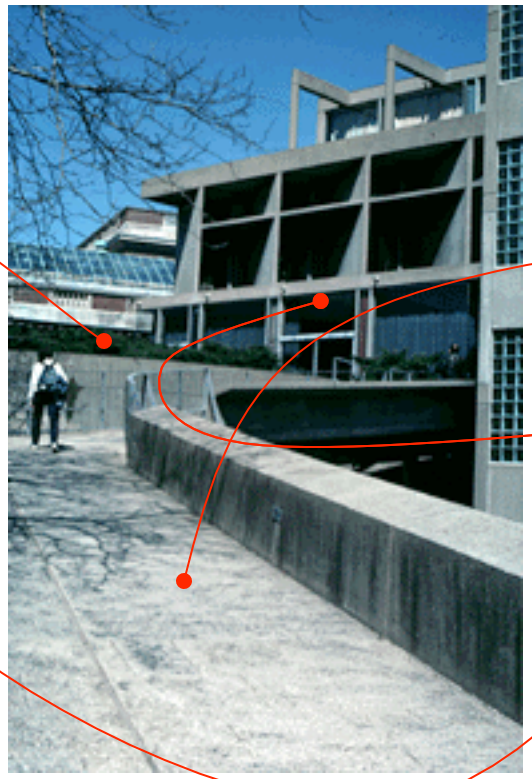
…take photographs, avoid “snap” shots by knowing the building through drawing

Alex and Christina

The Carpenter Center for Visual Arts

Located at Harvard University, the Carpenter Center is Le Corbusier's only project in the United States.

The firm of Jose Luis Sert was the local coordinating architect. Sert was Dean of the Harvard GSD at the time, and was influential in securing the commission for Corbu.

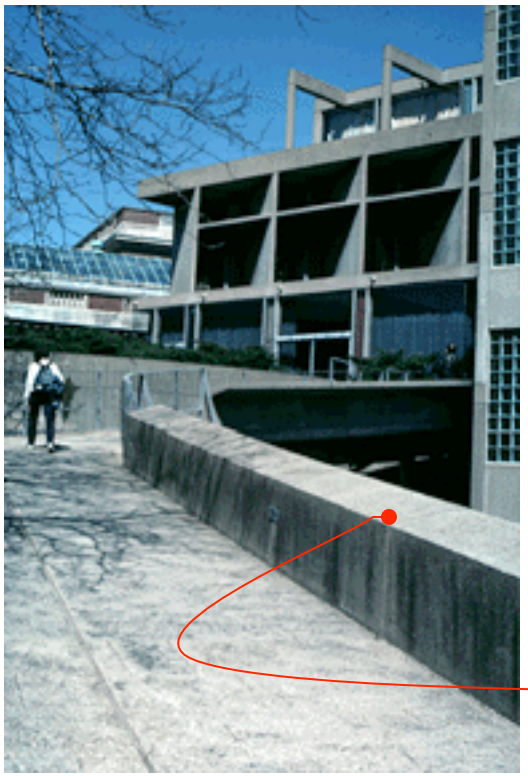


Corbu proposed that the project would have all of his elements of architecture included.

- Ramp
- Piloti
- Free plan
- Bris Solei
- Roof Garden

The ramp is both an access through the building to the neighborhood beyond Harvard and is the path to the front door

One answer to two problems



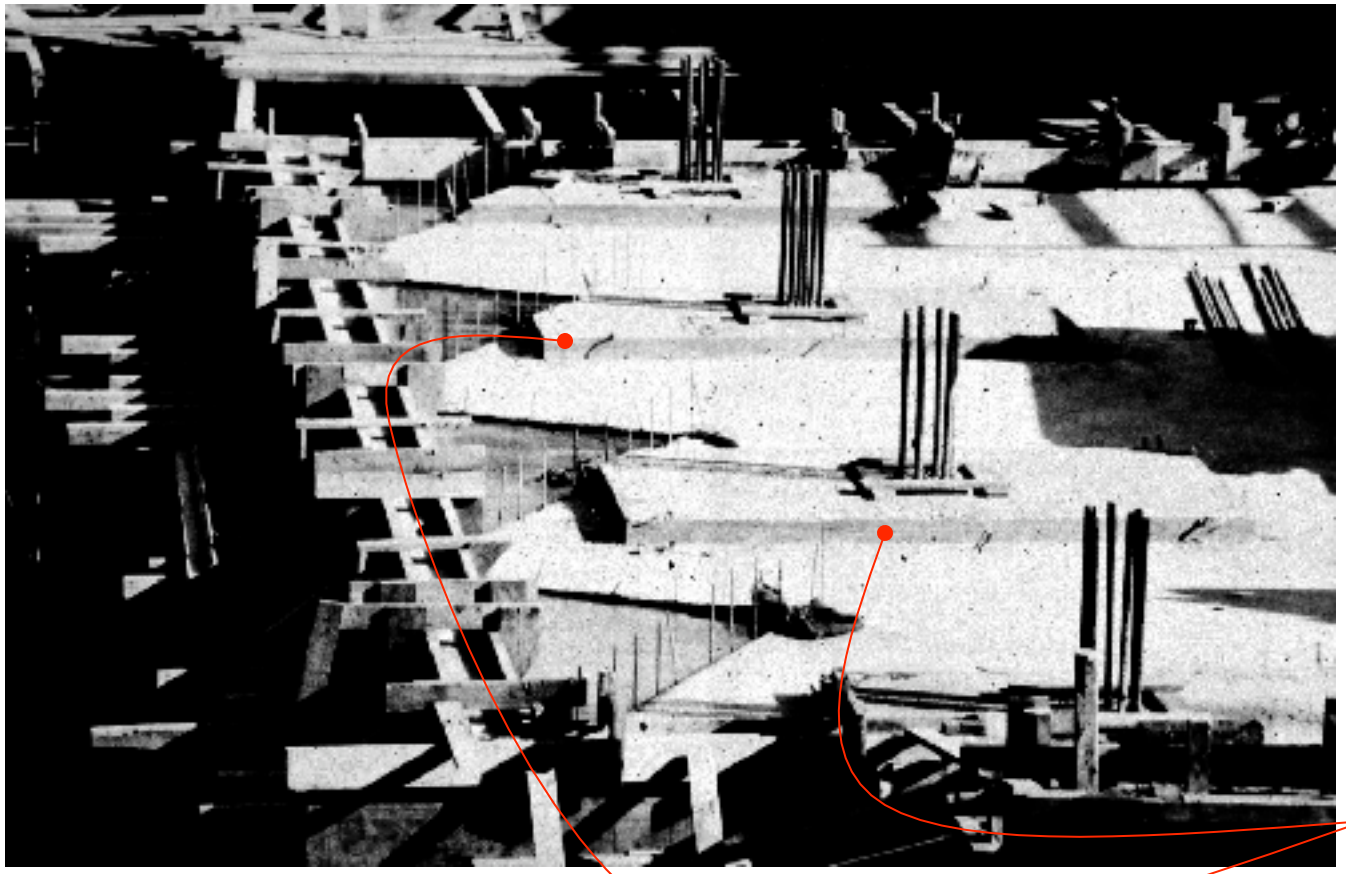
- Another concern Corbu had was the visual weight of the ramp.
- Engineers were planning to place a beam below the ramp to carry it from piloti to piloti.
- To address Corbu's concern that a beam below made the ramp seem to heavy, the engineers took advantage of the monolithic nature of concrete and put the beam above the slab to carry it…where it also acts as a guard rail!

Problem...

Slabs supported on piloti's challenged the structural engineers working with Sert.

The floor loads of the studio's above were too high for a simple flat plate… Shear forces indicated that drop panels would be necessary at each column head.

Corbu said no, nothing can interrupt the piloti meeting the slab.



This is where the magic of cast in place concrete comes in.

To resist shear at the piloti head, additonal material and steel is needed. This is usually added below the slab to form a shear head or drop panel.

Sert's engineers proposed placing the shear heads *above* the slab instead!

Another problem...

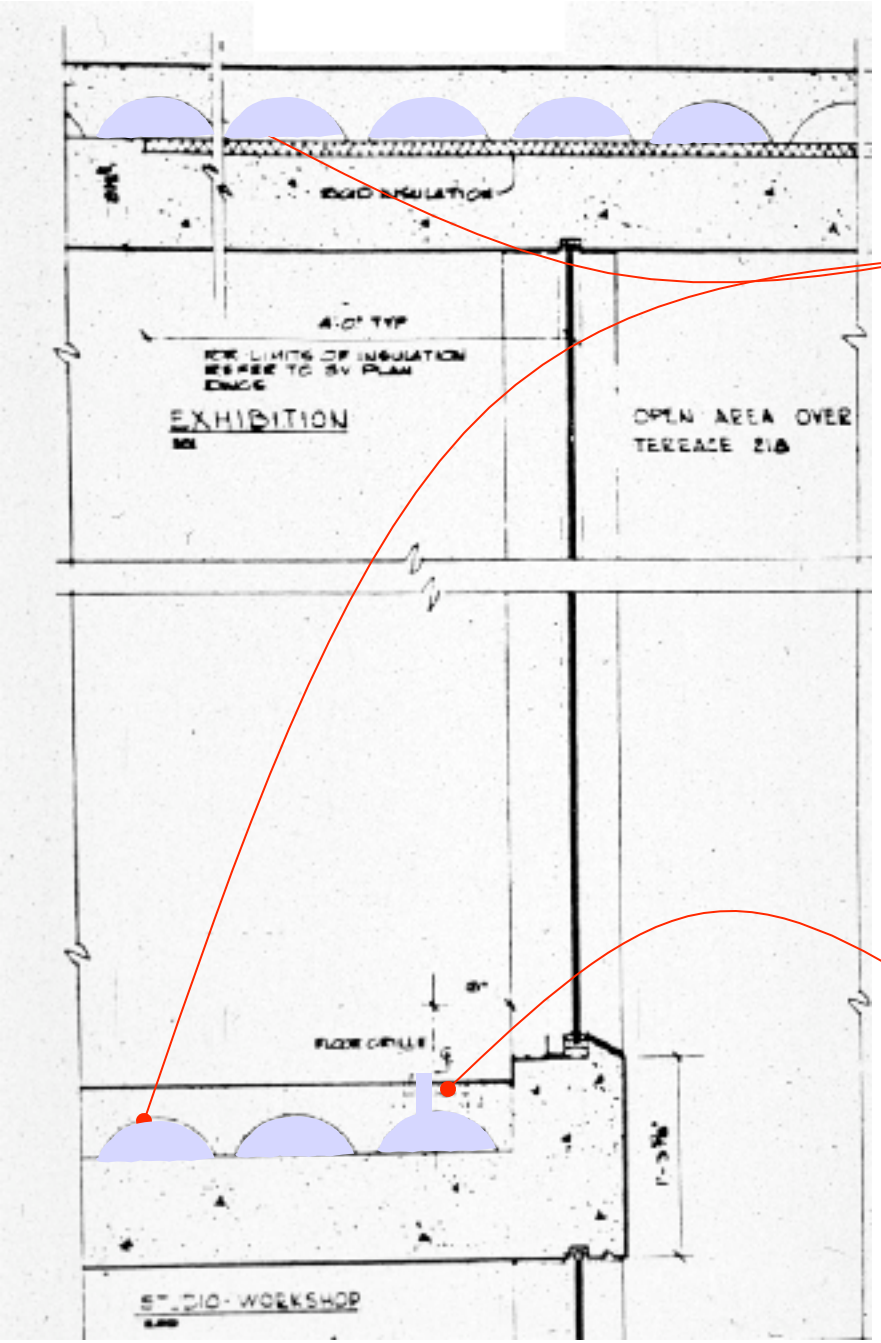
Usually shear heads never go above the slab because … ***people would trip on them!***

But Corbu's clarity of vision about the piloti and slab was also challenging the mechanical engineers…. He would accept ***no ductwork*** visible in the space!

Problem + Problem = solution!

The structural and mechanical engineers were in different firms, not in direct communication, they could only see their own problem…Corbu!

Sert's architects ***combined*** both problems and found the solution!



Air filled floors

Supply air would be carried through a network of small voids beneath a floor slab poured ***on top*** of the structural slab!

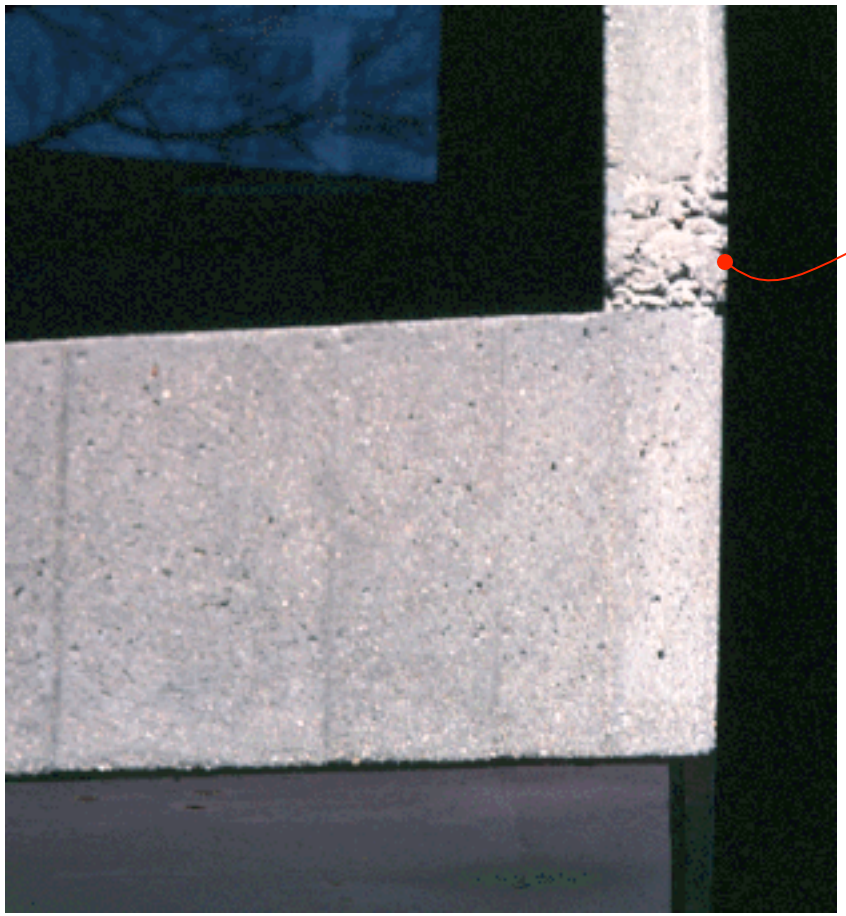
This ***Air Floor*** would cover up the shear heads so no tripping, no projections below the slab, no ducts… everybodies concerns are addressed.

The Air Floor product was ‘+’ shaped plastic vaults set on the floor slab and connected to supply air ducts in the walls.

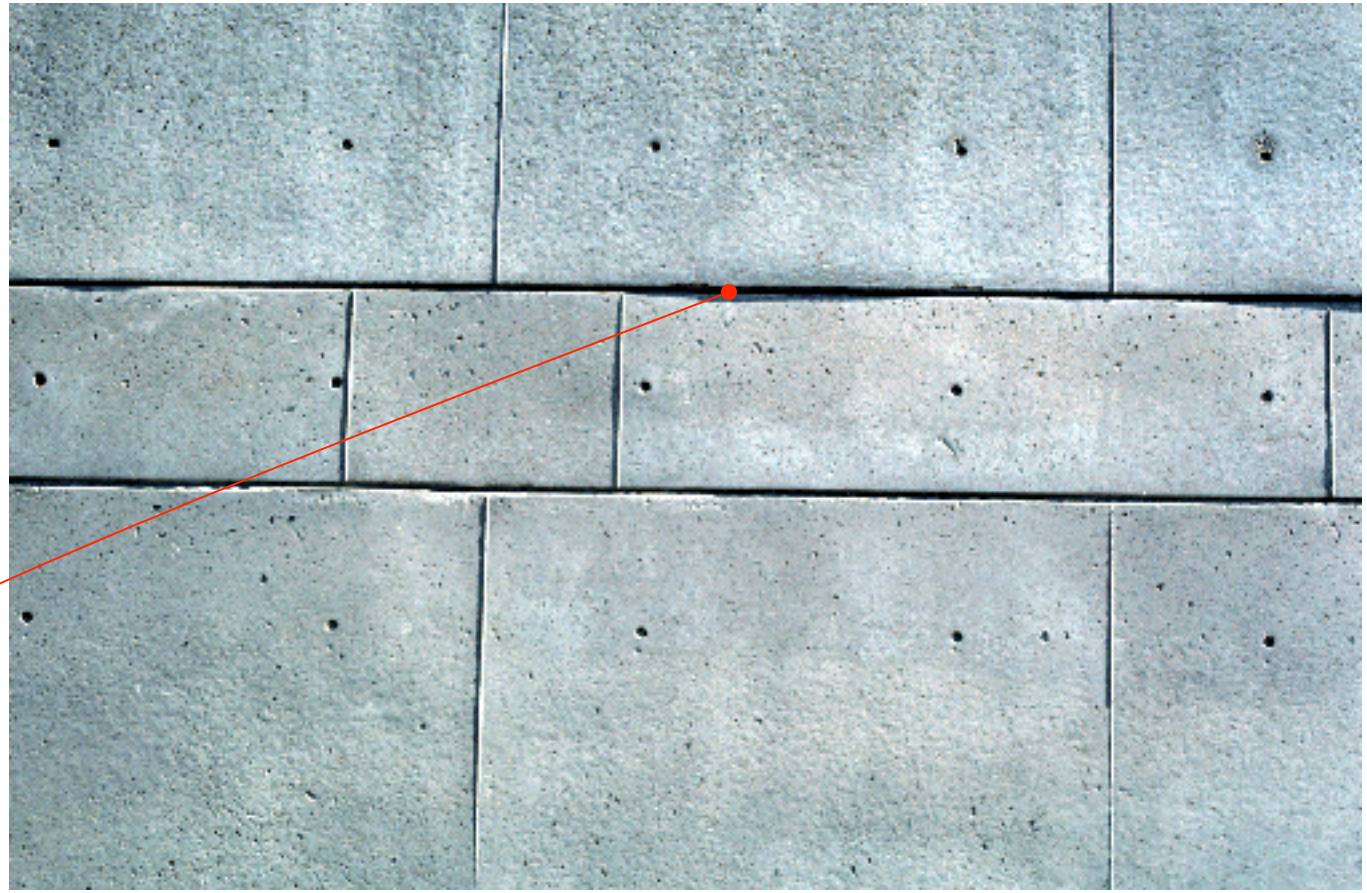
Where supply air was needed for in the room distribution, a slot was cut through the topping into the Air Floor to release supply air.

Traveling in Boston, Corbu thought a higher quality of concrete was possible here than in France. The details of the bris solei and ondulatories challenged the form builders, concrete placers to execute the very tall, very thin vertical elements.

- The quality of the finished project is very high, one of the best concrete buildings in the U.S.
- This due in a large part to the quality of the formwork, built by tradesman from the ship building industry in Boston!
- Who else could build wood structure precisely, without leaks around curves and detailed elements?

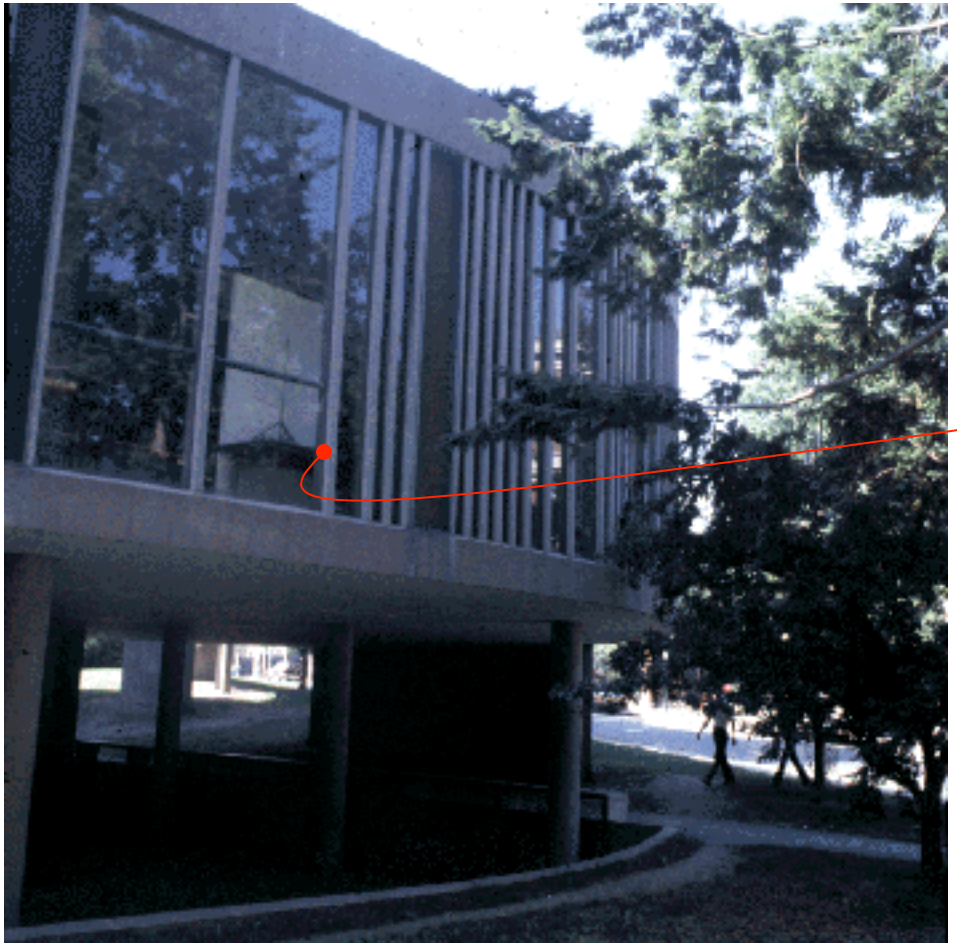


- Not many flaws exist on this project.
- One of the few, this honeycomb at the joint between a floor slab and a vertical face of the bris solei may have been caused by a form leak. Any form leak will allow water and cement paste out of the form, leaving a segregated mix area behind.



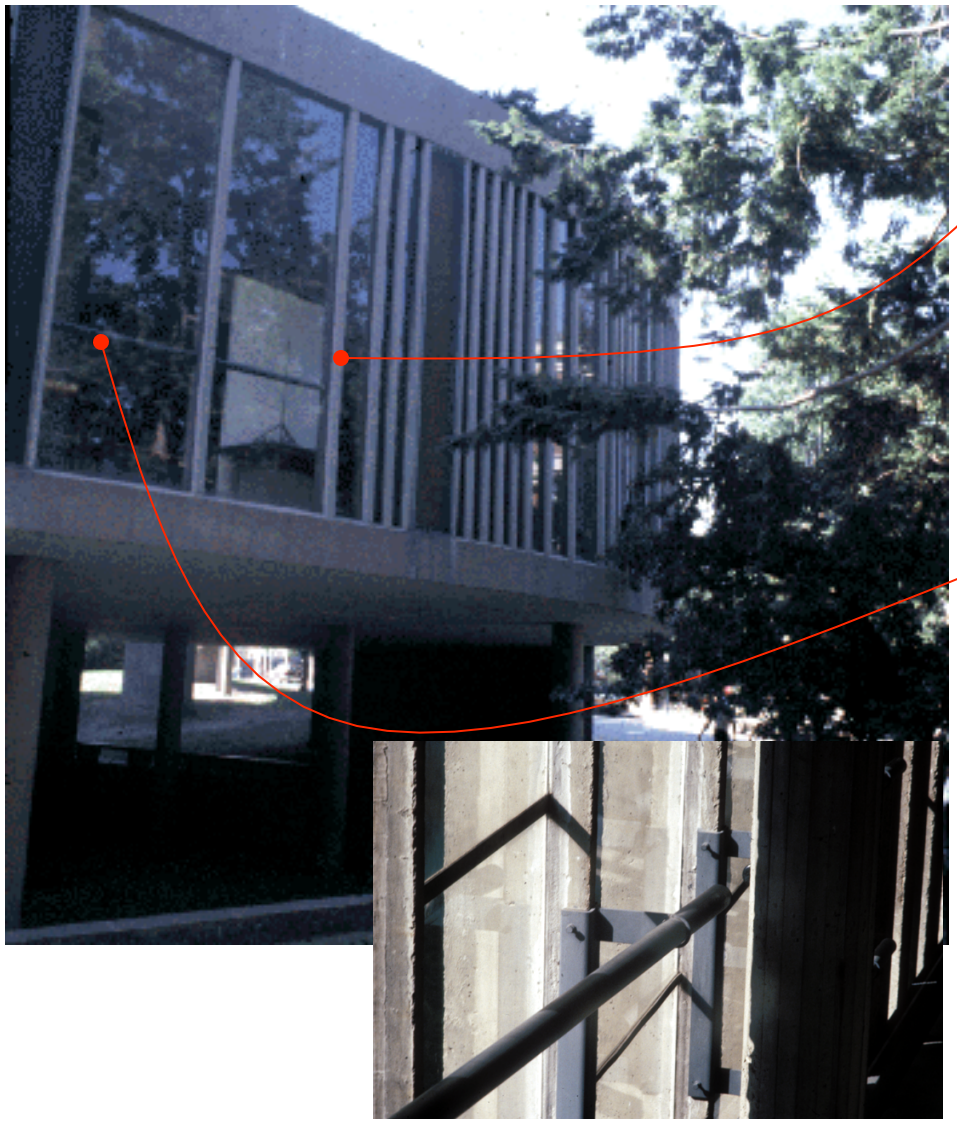
- Here, the wall forms deflected under the load of the concrete, and bowed out at the middle of each form. A little more bracing may have prevented this.

Concrete Mullions

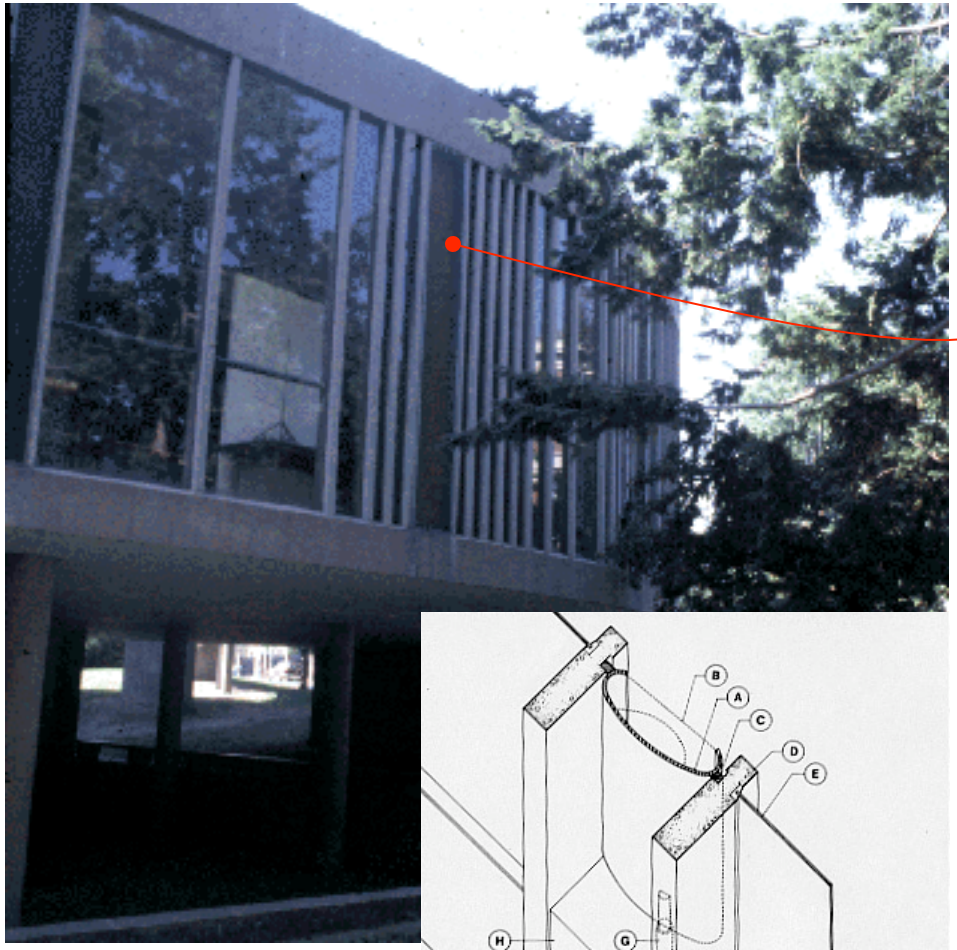


- Corbu used concrete to form the mullions between glazed panels around the curved portions of the plan.
- These ondulatories were precast and set in place as the glazing was installed.

Structural handrails



- In many of Corbu's projects using these ondulatories, the concrete was too thin and began to deflect, breaking the glazing.
- Here, and in other projects, a steel rail has been added to both brace the ondulatories and act as a guard rail, keeping people from walking through the glass!



Ondulatories & Aereatures

The glazing between the ondulatories was not operable in most of LeCorbusier's projects. To provide for ventilation, Corbu designed pivoting opaque panels he called aereatures that could be opened to allow in air, keeping the glazing system a simple, inexpensive, fixed design.