

# Lofting

Sailboats, sculptors  
and the defeat of  
the box



What are the spaces that ignite  
imagination?





Do they have a place in architecture?

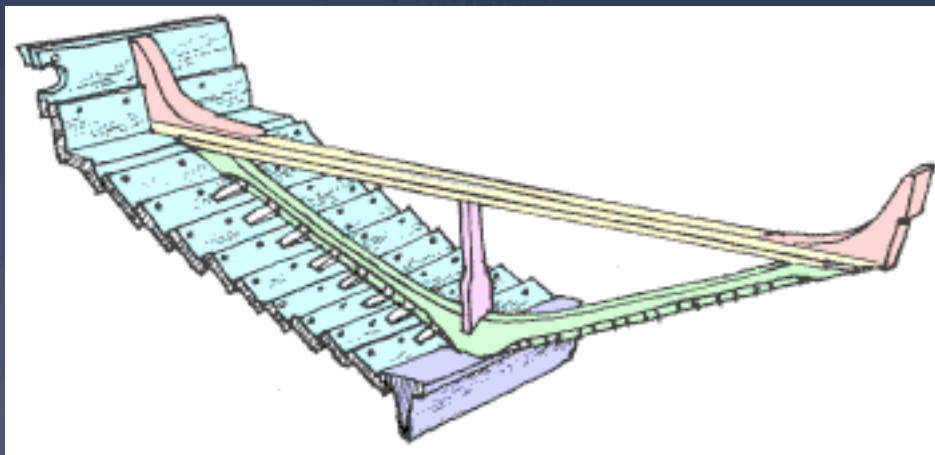
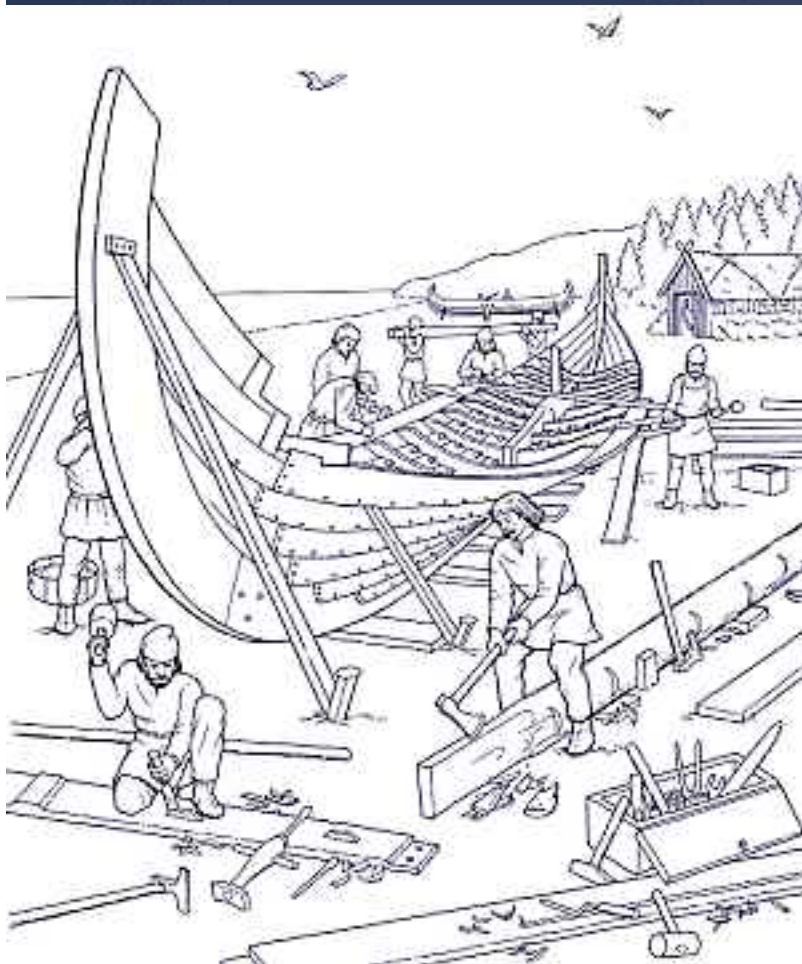


How do we bring these experiences to daily life?

... a process used by boat  
builders for over 5,000 years



## Lofting



George Buehler & Reg Townsend  
Scale: 1/2" = 1' 4/93

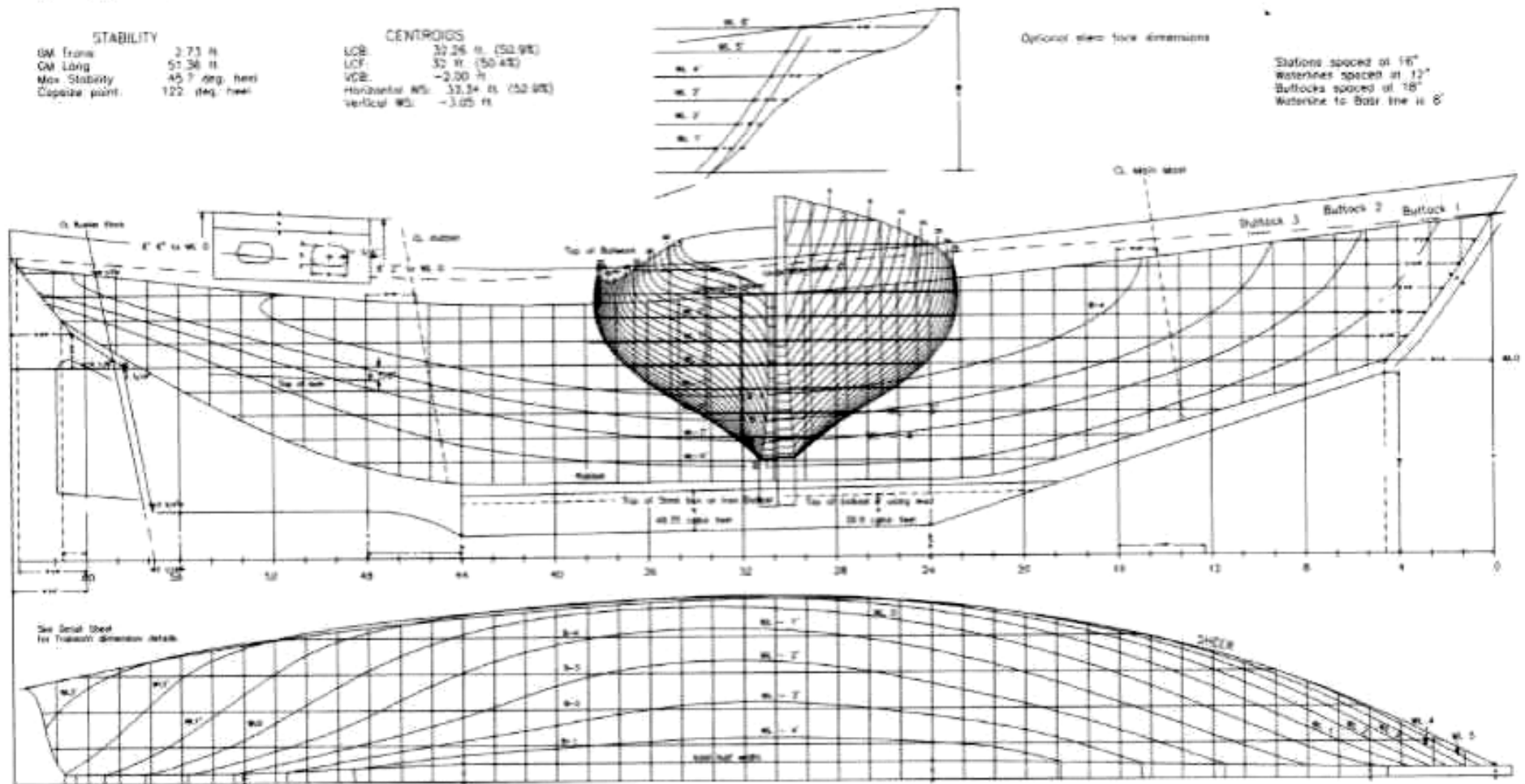
PARTICULARS	RACON	COEFFICIENTS	WATERLINE
LOD: 63' 10-1/8"	Length/Breadth: 3.77	Prismatic: .54	Area: 500 sq. ft.
LBP: 62' 10-9/16"	Length/Depth: 7.68	Block: .231	LCA: 31.96
LWL: 54' 4-9/16"	Breadth/Depth: 2.036	Wetted Surface: 867 sq. ft.	
Beam: 15' 5-5/16"	Deck/Length: .238		
Beam WL: 14' 4-3/4"	Lbs./inch: 2678		
Drift (loaded): 7' 0-3/4"			

STABILITY	
GM Trans:	3.71 ft.
GM Long:	51.36 ft.
Max. Stability:	45.7 deg. heel
Capsize point:	122 deg. heel

CENTROIDS	
LCB:	30.26 ft. (50.9%)
LCF:	32 ft. (50.4%)
VCB:	-3.00 ft.
Horizontal WL:	33.34 ft. (52.9%)
Vertical WL:	-3.05 ft.

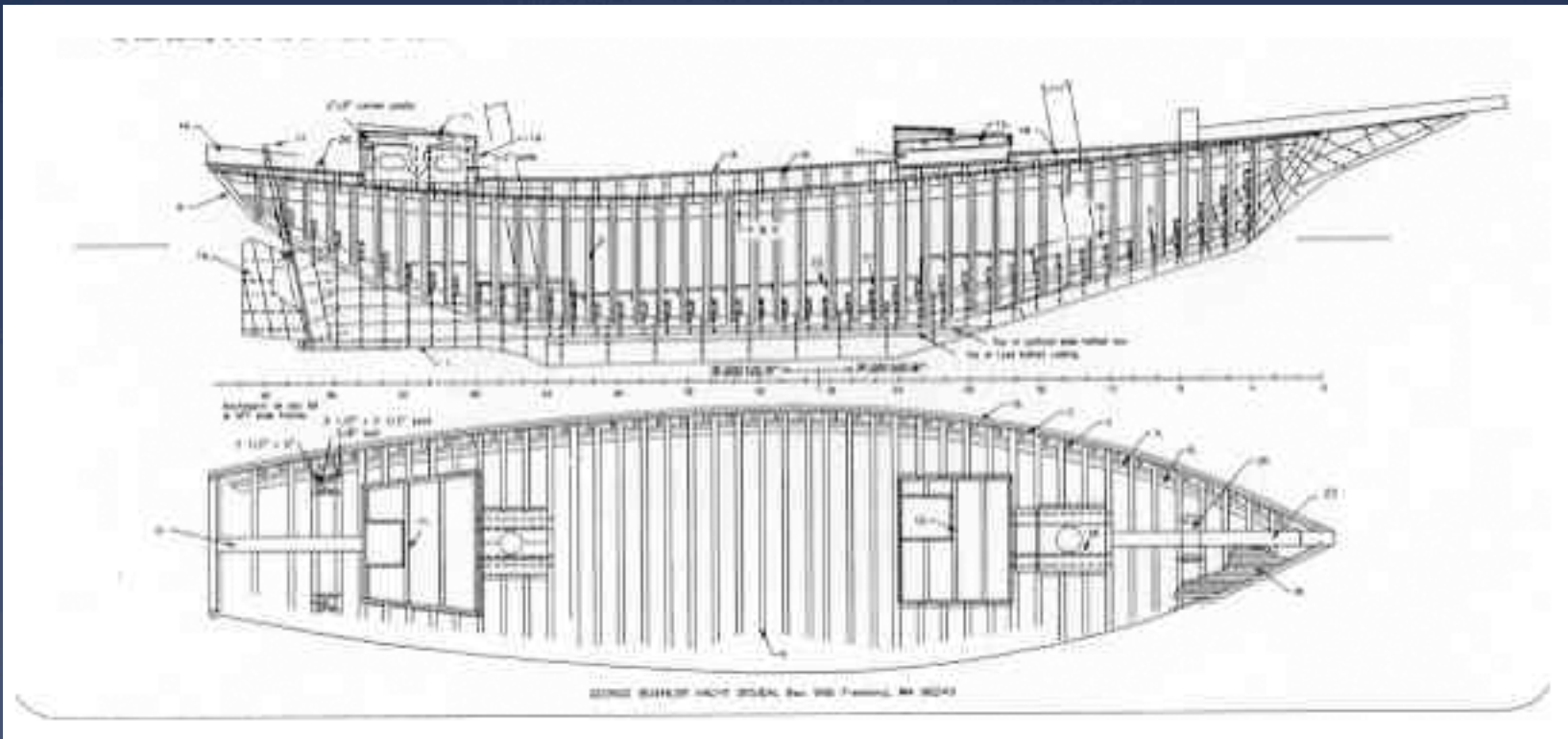
Optional stem face dimensions

Stations spaced at 16"  
Waterlines spaced at 12"  
Butlocks spaced at 18"  
Waterline to Baseline is 8"



GEORGE BUEHLER YACHT DESIGN, Box 966 Freeland, WA 98249

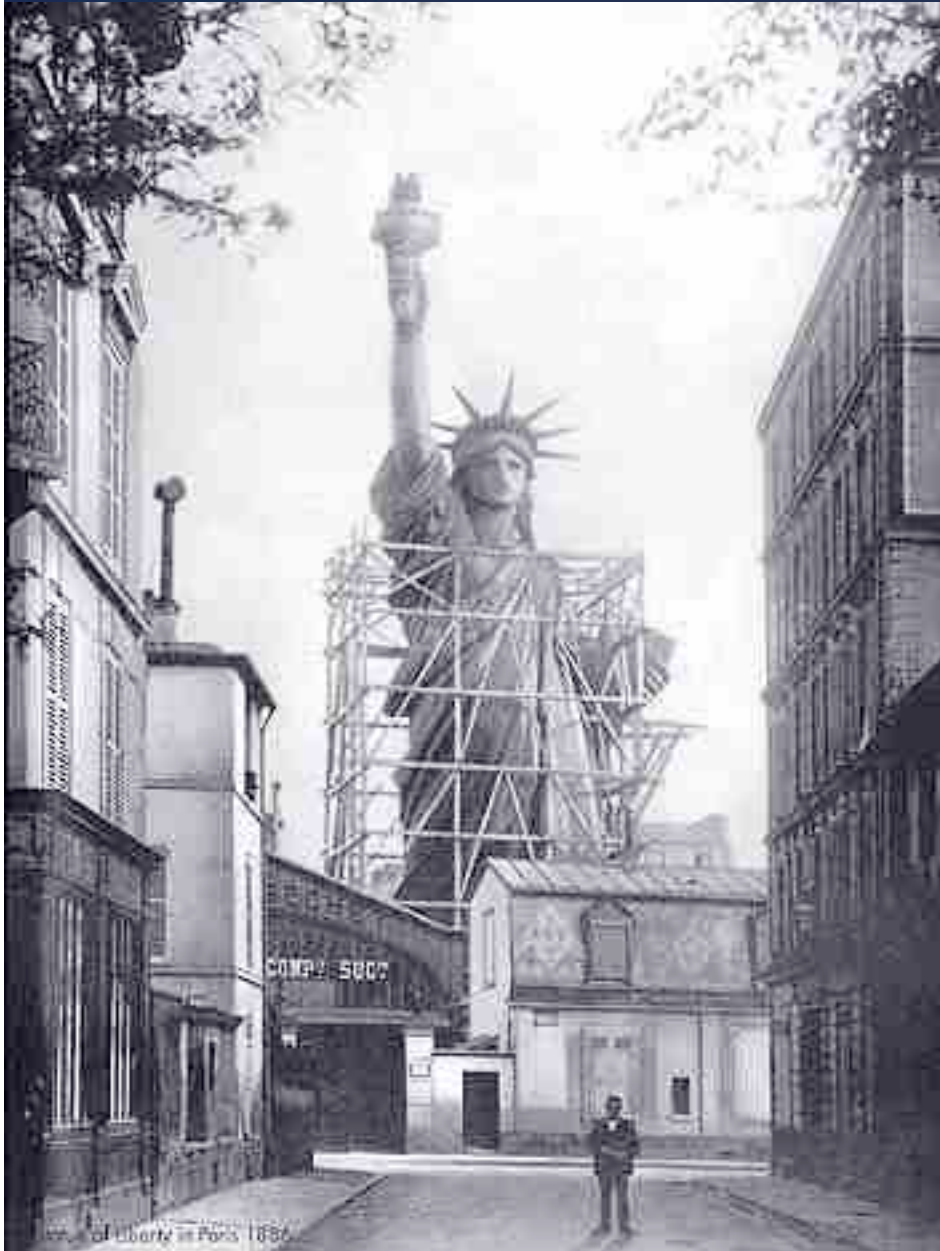
Form of the hull translated into lines with overlaid grid and contour lines



Forms translate to lines  
Lines translate to structural ribs  
Planking skins ribs making surface



... a process used by sculptors  
for over 1,000 years



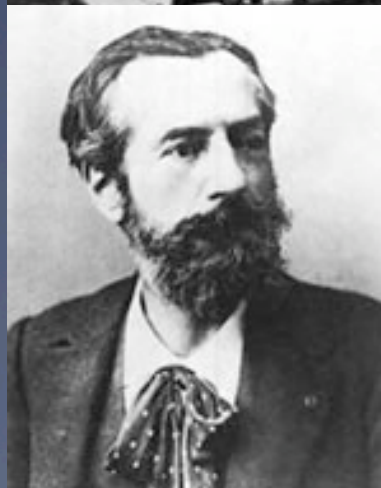
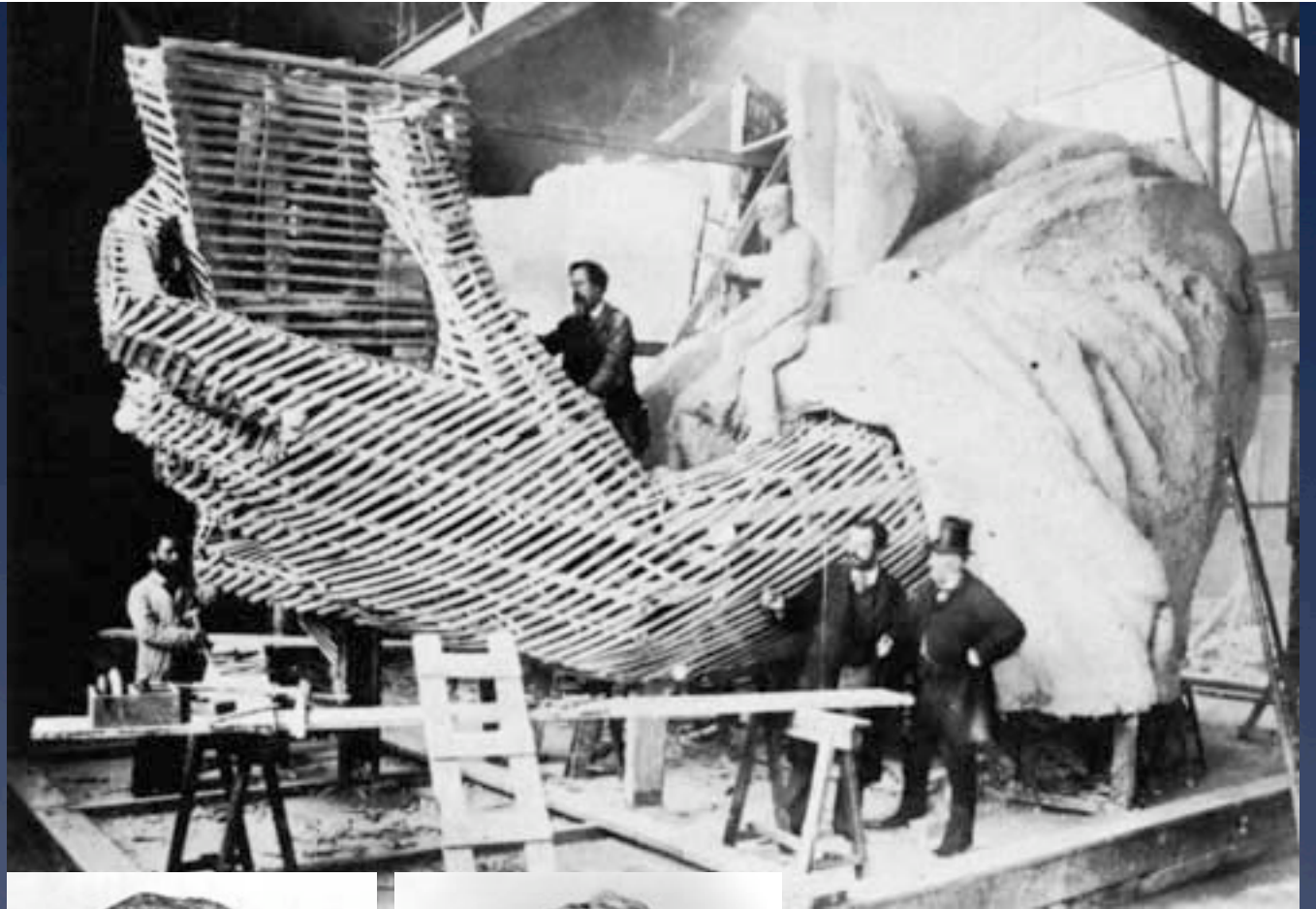
Adapting boat building for art:

Sculptor uses grid to scale up from model to monument

- 4 foot model
- 9.3 foot model
- 36 foot model (cut into parts to scale up 4 times) 151 feet tall

Formwork in process

Building a wood  
armature to carry a  
plaster model (full-  
size) to form copper  
over



Frédéric Bartholdi

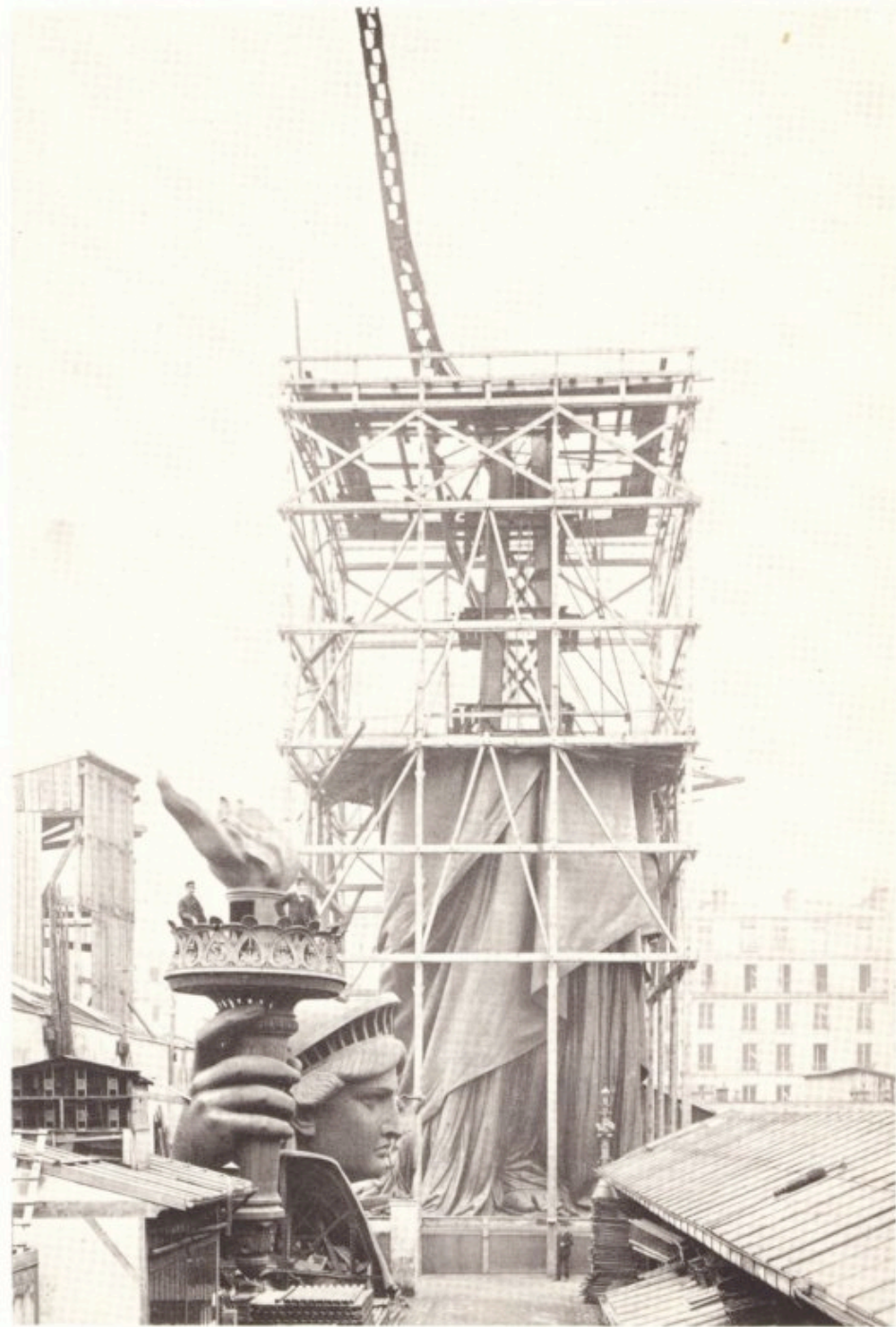
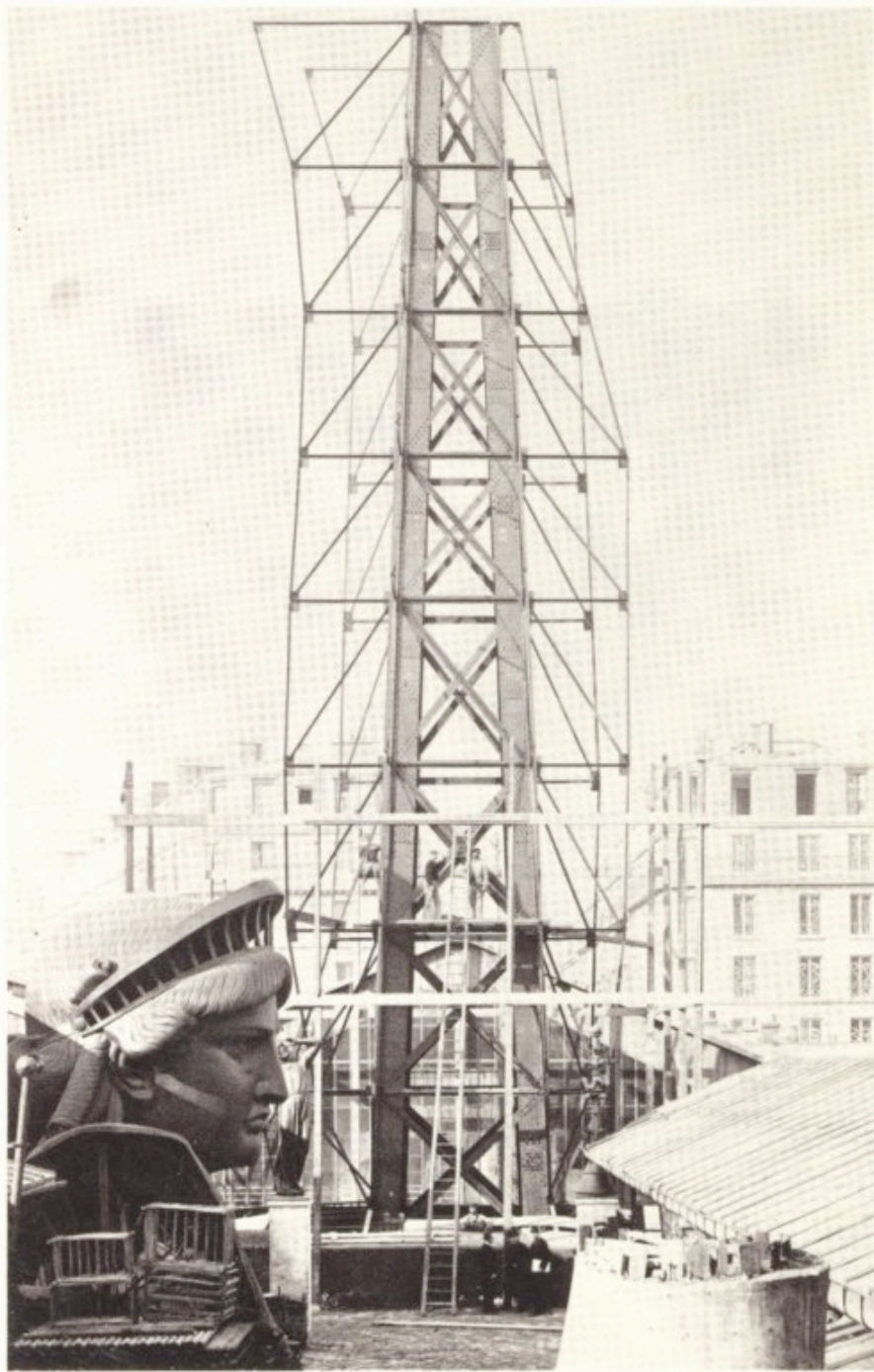


Gustave Eiffel

Bartholdi & Eiffel,  
partners in the art  
and science of  
Liberty













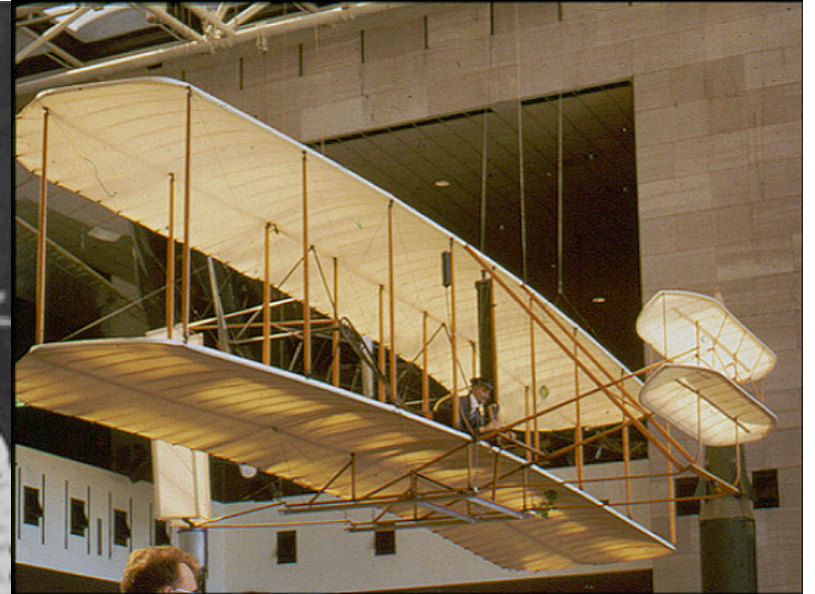
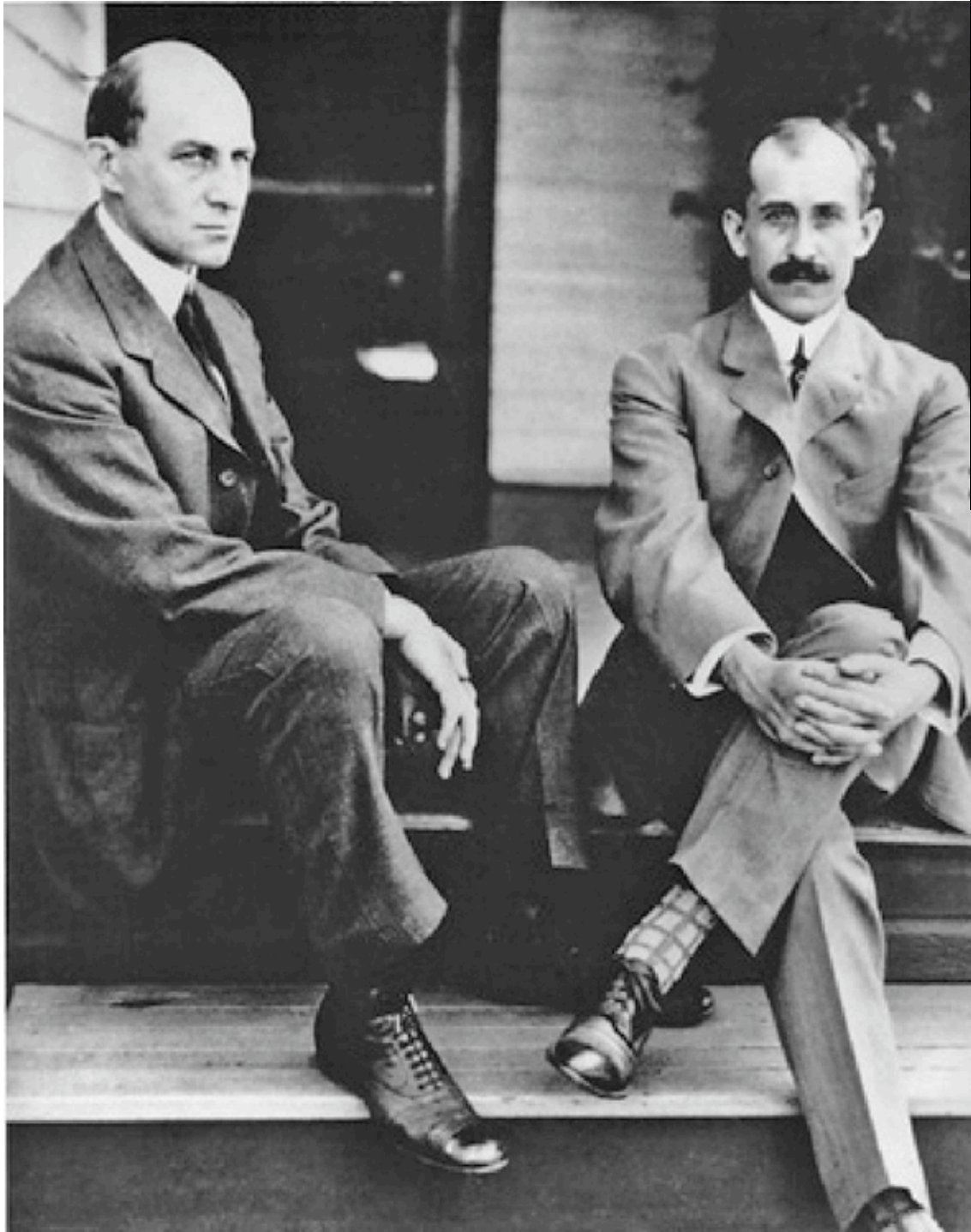
Between the expressive skin and  
rational structure...a space of  
adjustment







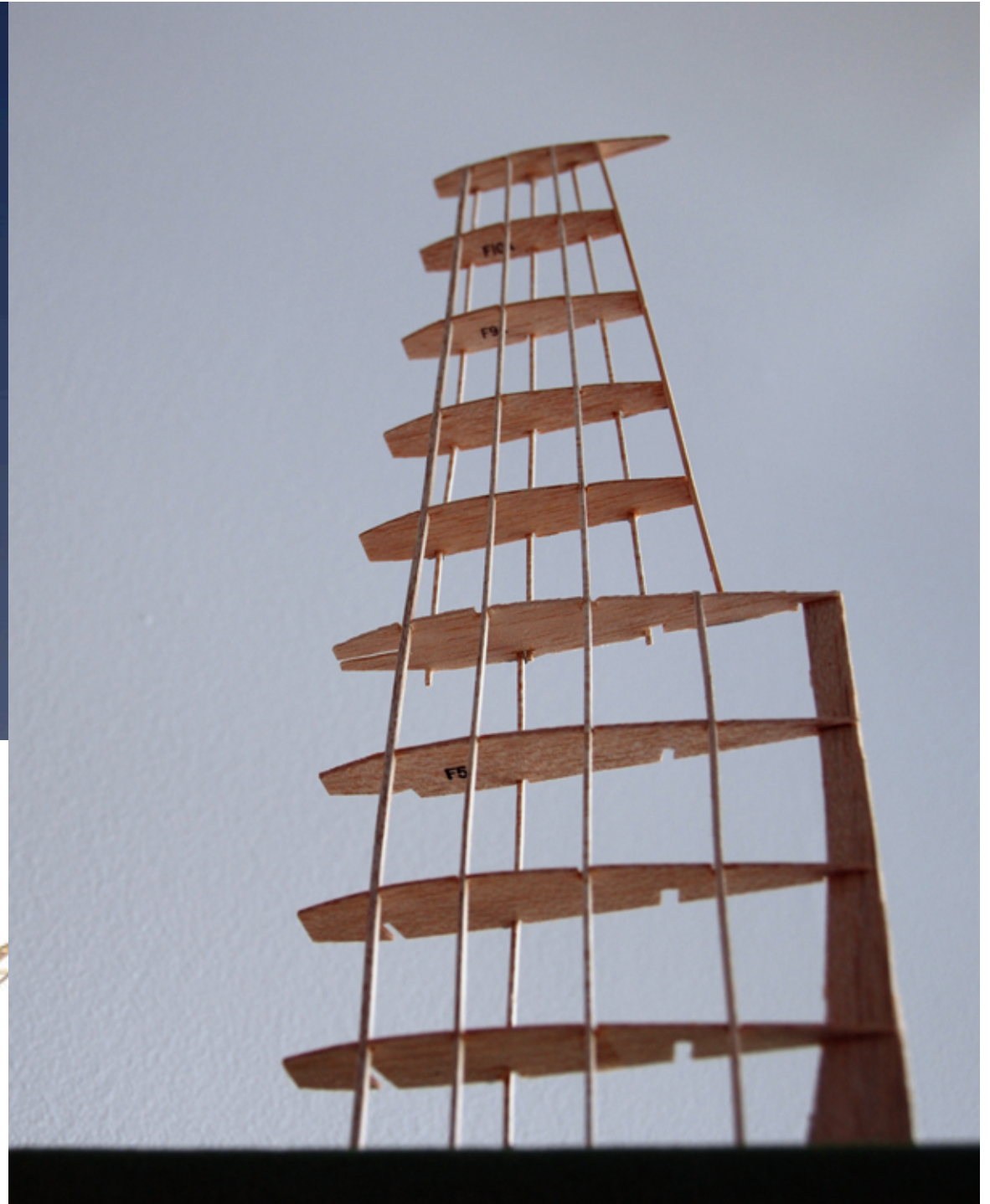


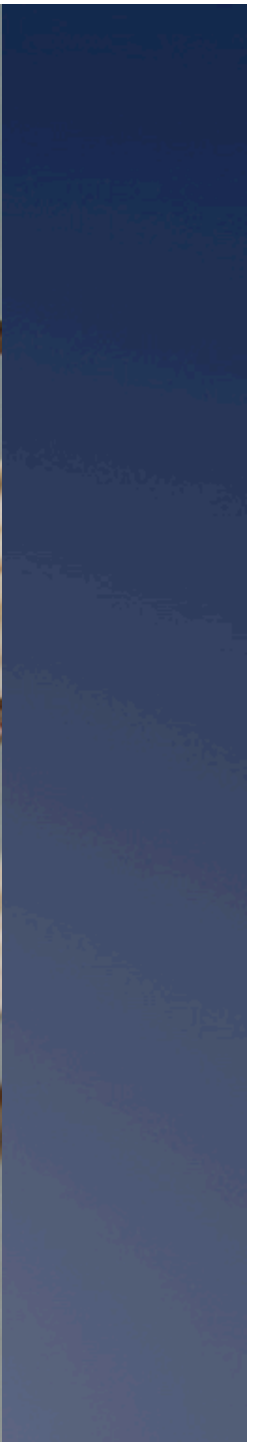
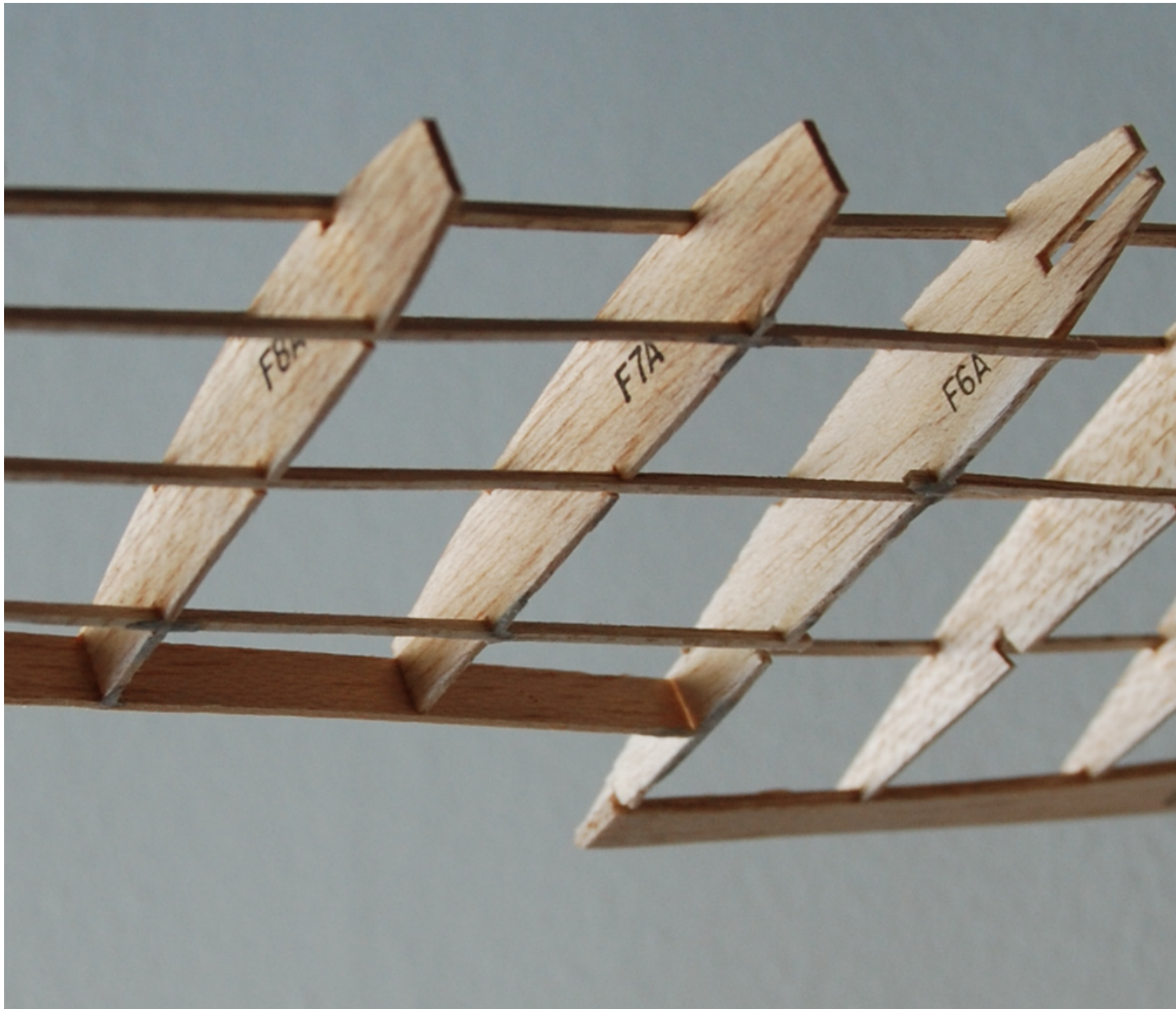


Notable Lofters  
Orville and Wilbur Wright

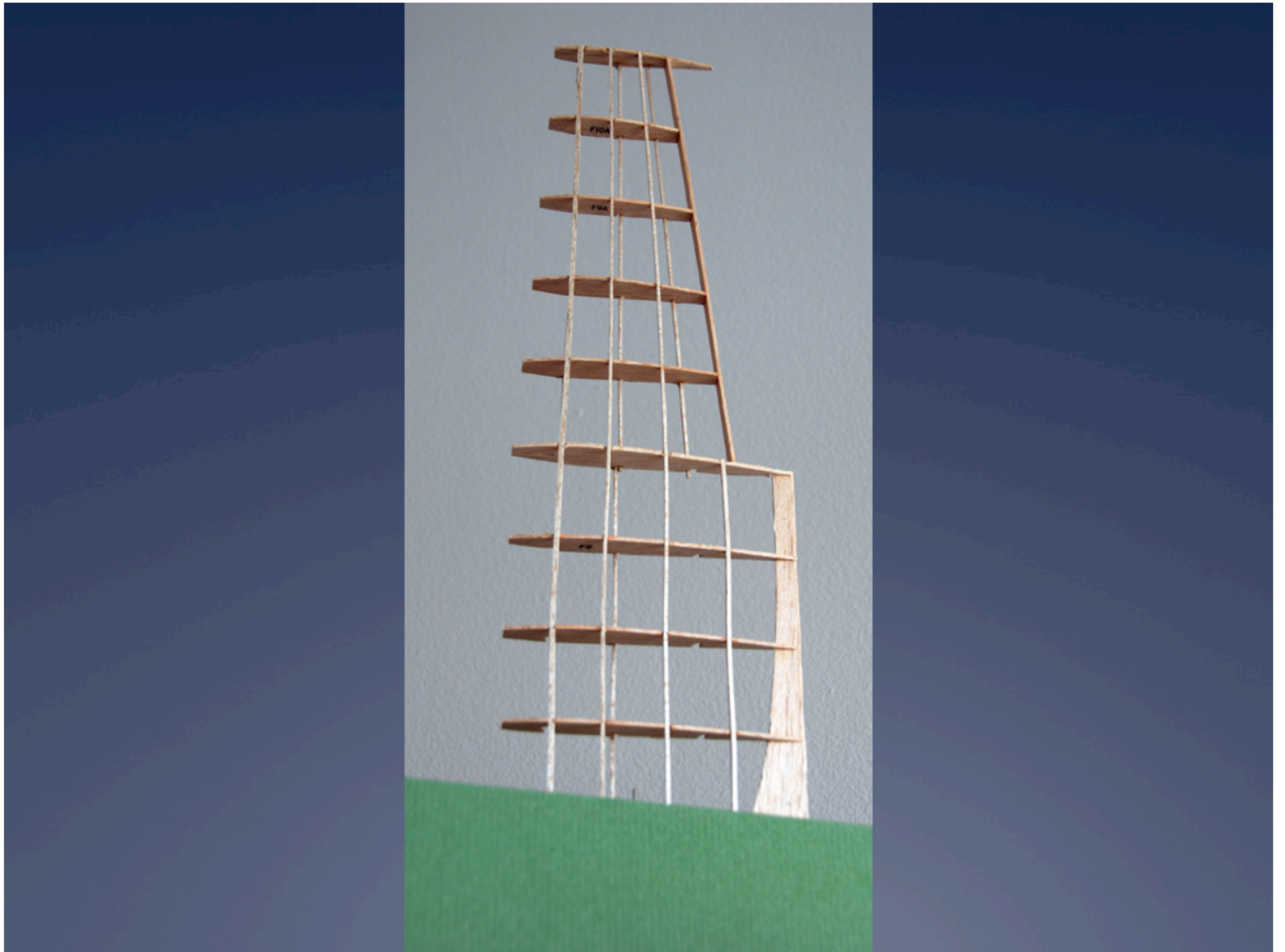


Common technique in aircraft construction, allows complex doubly-curved surfaces to be made from a series of sections swept together with a secondary structure and surface











**Hughes H-4 "Spruce Goose"**

Length: 66.6 m

Span: 97.5 m

Height: 24.1 m

**Boeing 747-400**

Length: 70.6 m

Span: 66.4 m

Height: 19.4 m

**Airbus A380-800**

Length: 73.0 m

Span: 79.8 m

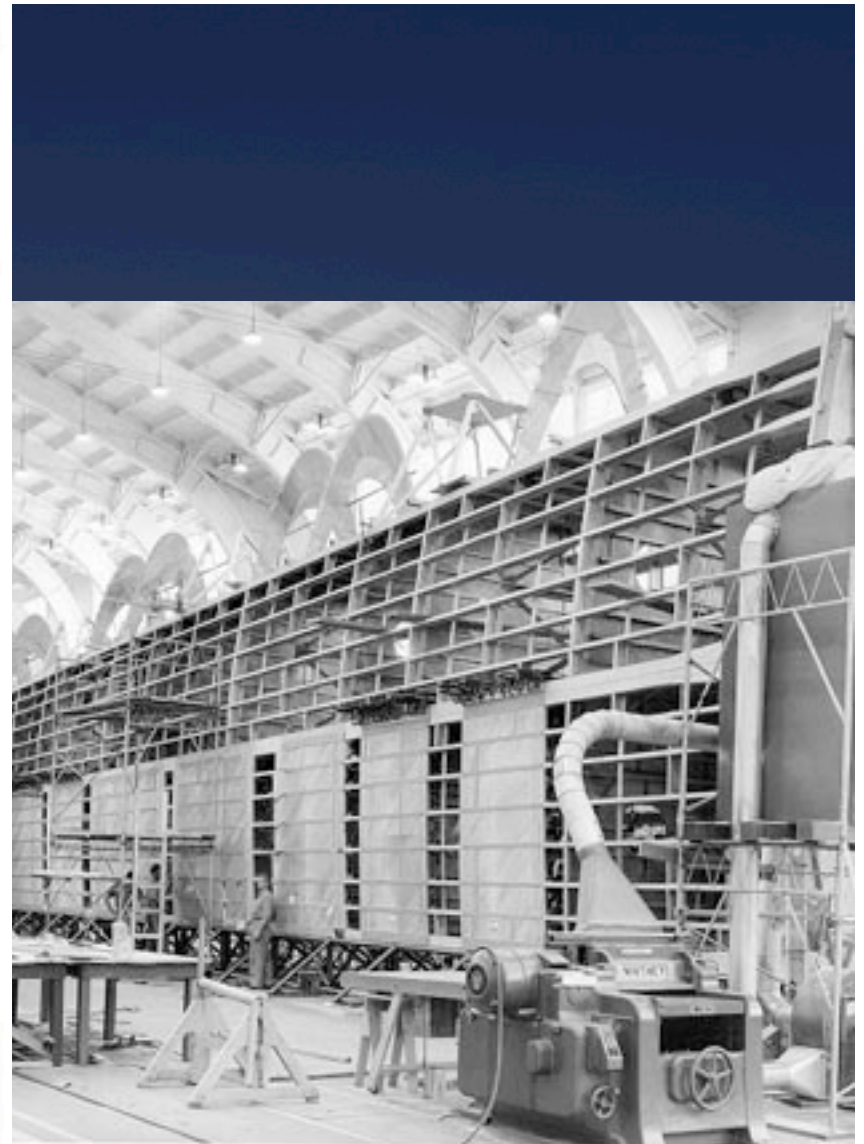
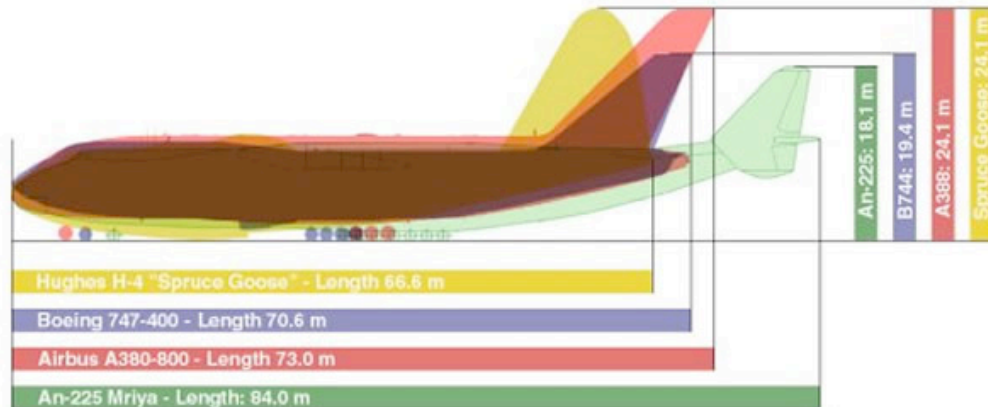
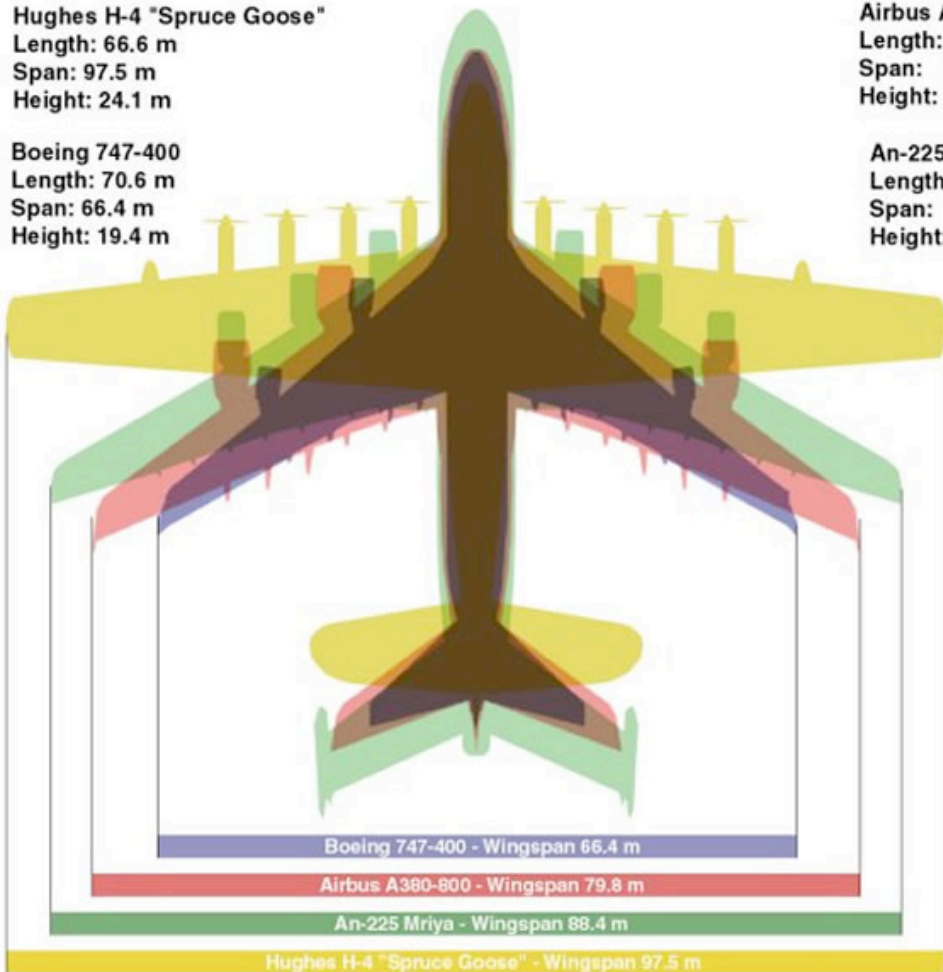
Height: 24.1 m

**An-225 Mriya**

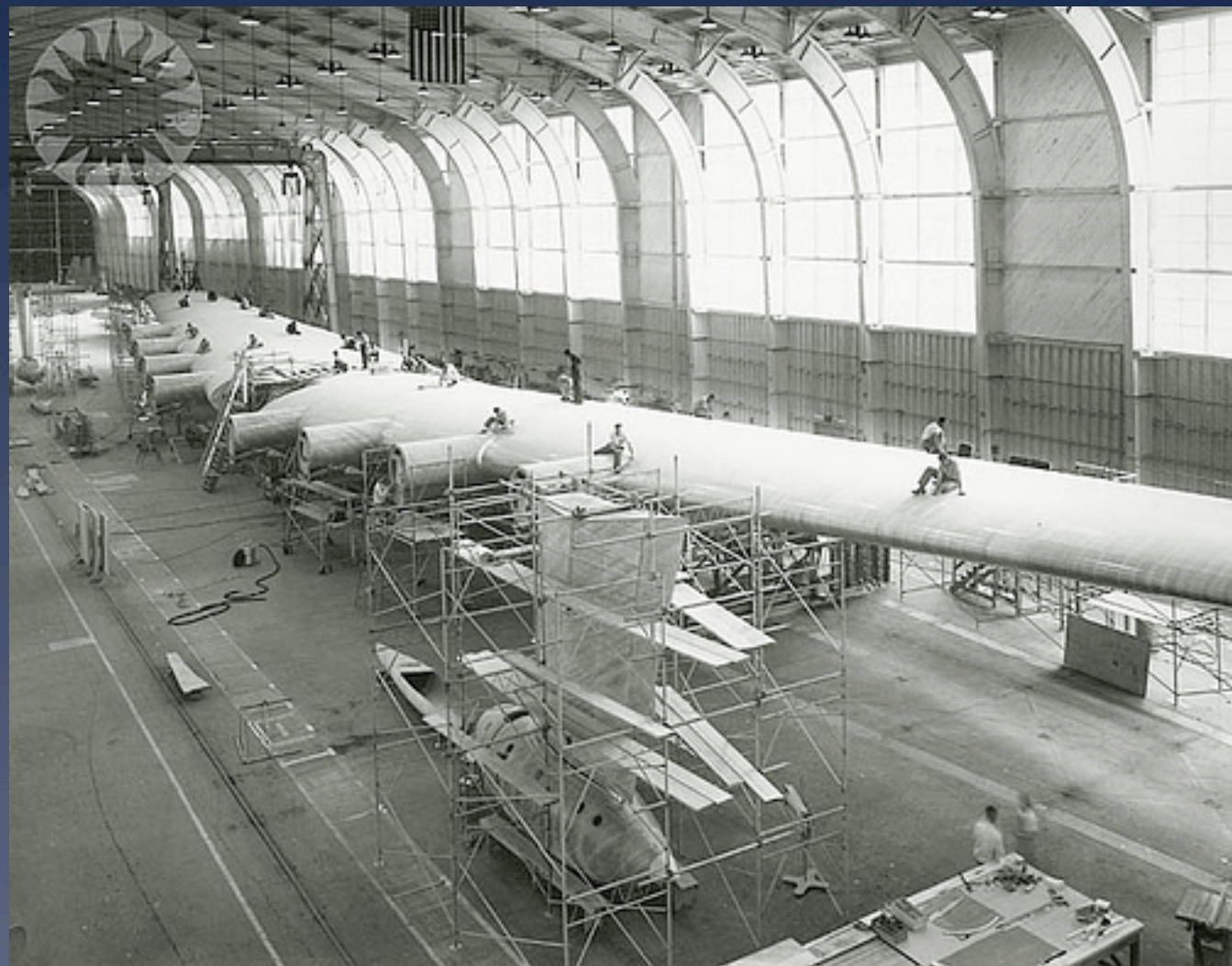
Length: 84.0 m

Span: 88.4 m

Height: 18.1 m



Lofting the largest wood aircraft



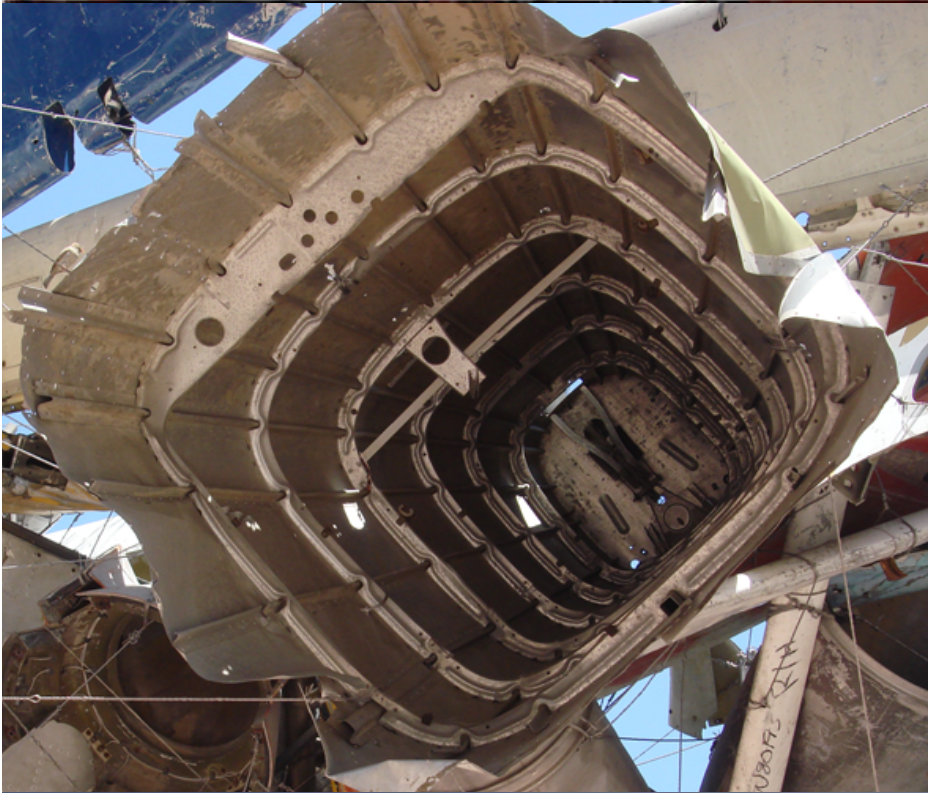




The largest model airplane ever!  
"The Spruce Goose" Howard Hughes

Wingspan 319 feet  
Fuselage 219 feet  
Tailheight 49.5 feet  
400,000 pounds





What kinds of spaces are possible?  
What forms?  
What possibility to integrate structure  
and systems?

... and architects for perhaps  
less than 100 years













# Ronchamp

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

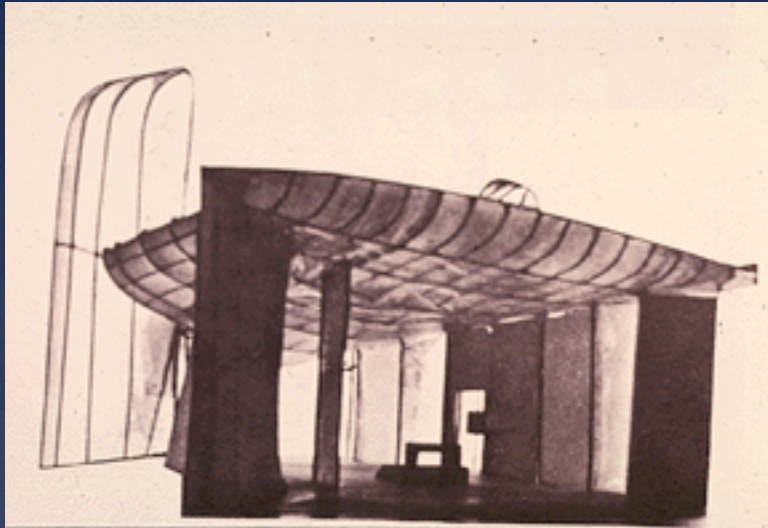
At an early point in the design process the architect and engineer must have an idea of how the concrete will be used as a structure.

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





# Ronchamp

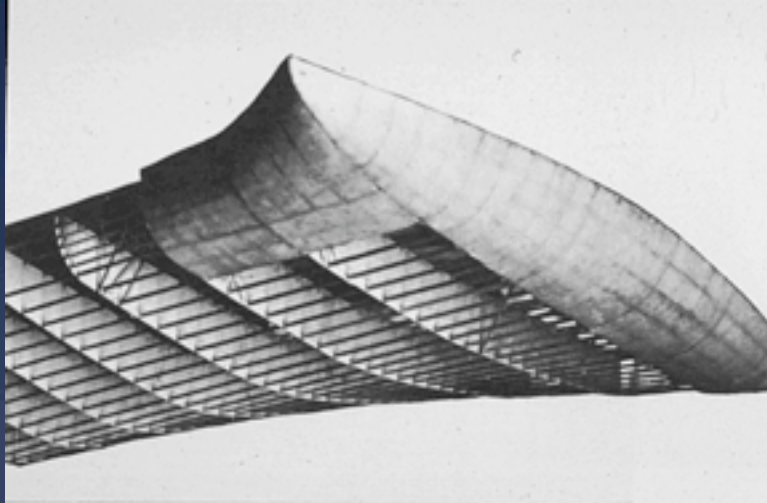


Despondent about the loss **(or theft...if you ask Corbu)** of the United Nations competition, Corbu was walking barefoot on a beach on Long Island when he stepped on a crab shell.

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.

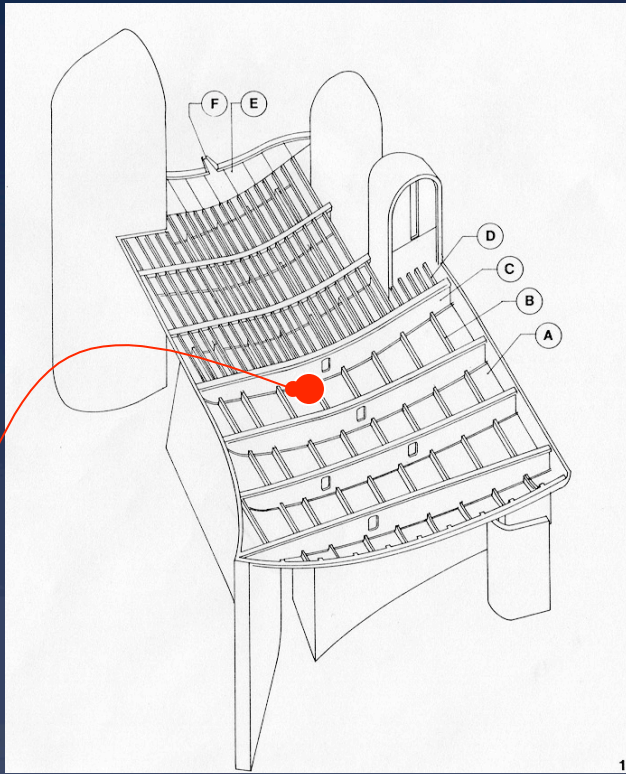
In reality, the roof is a series of parallel concrete beams, cast in concrete, having their bottom chord as part of the ceiling shell slab, and the top chord part of the roof shell slab

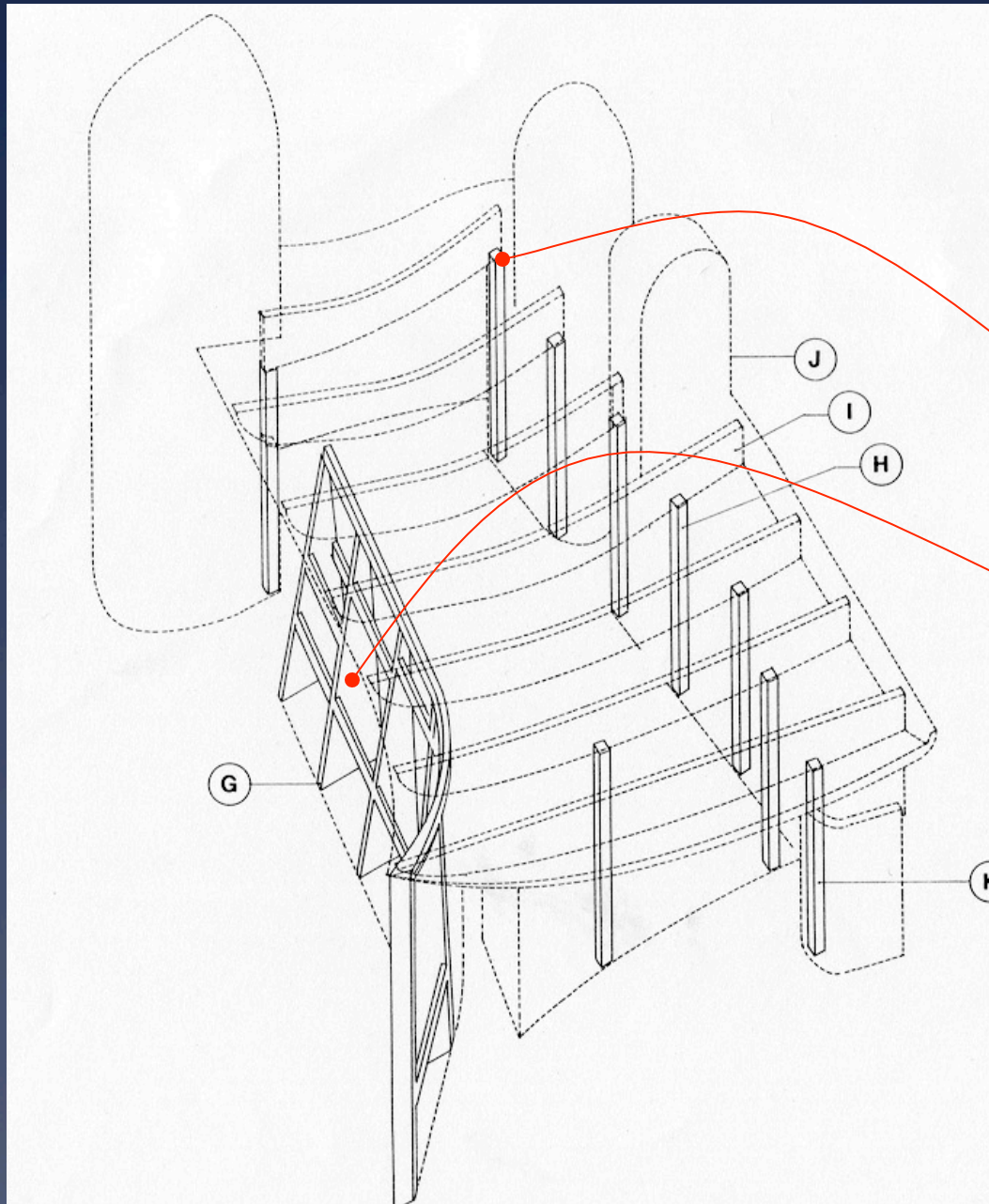


# Ronchamp

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.





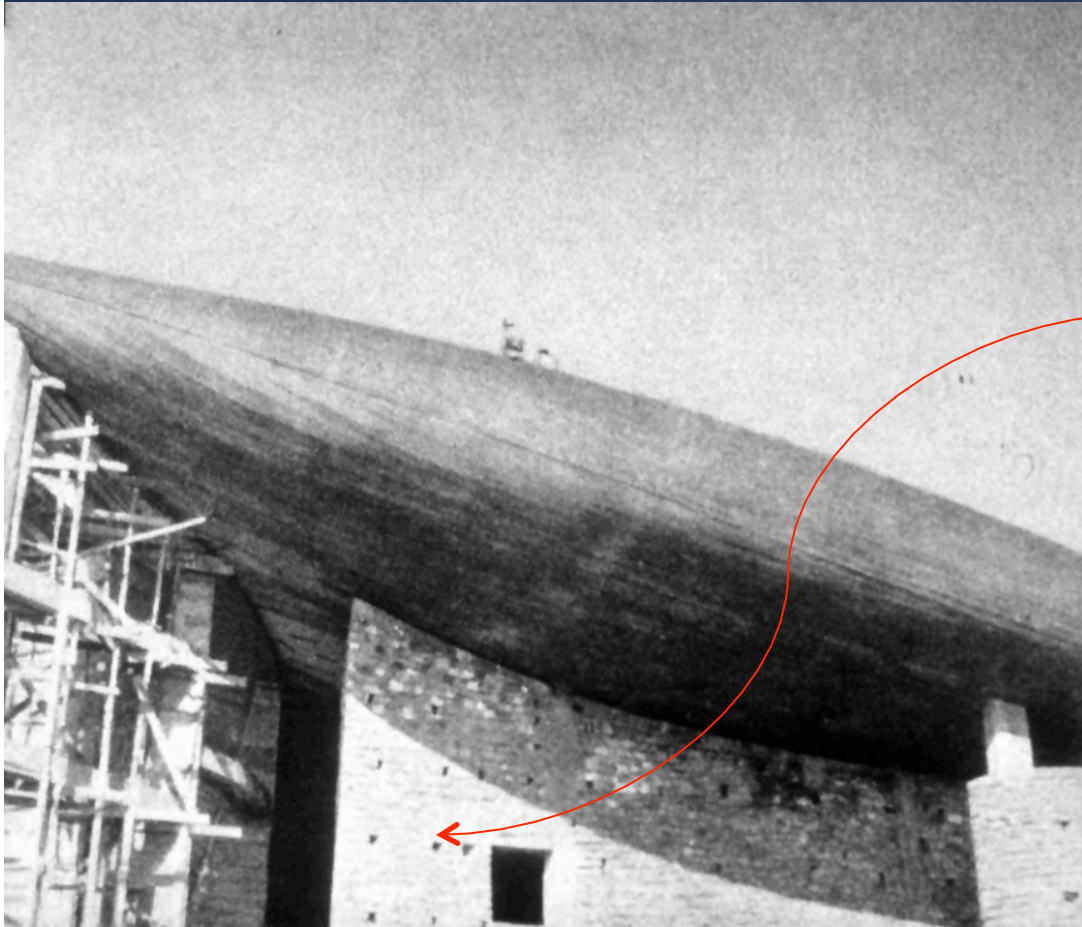
The walls contain two kinds of columns.

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

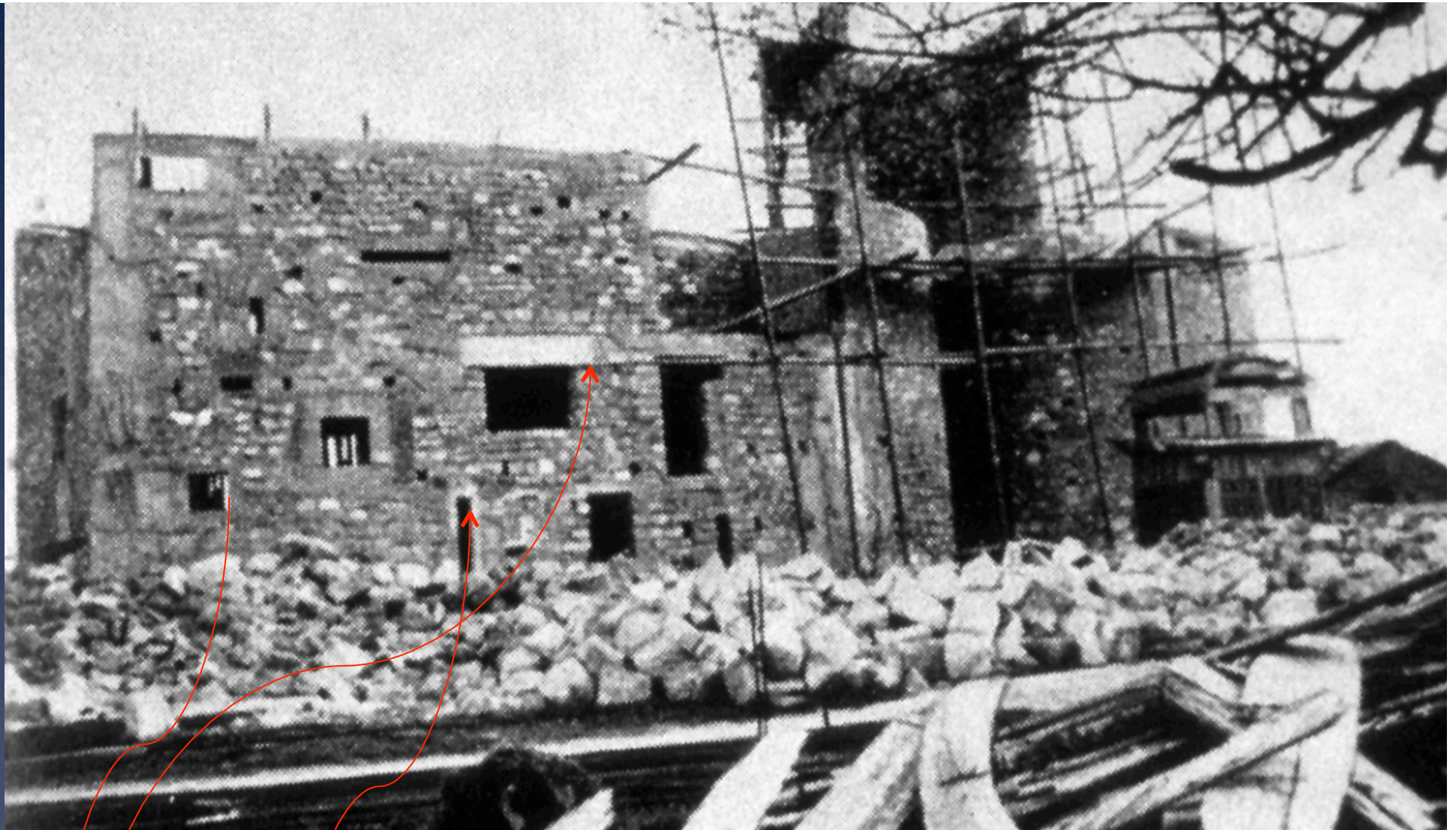






Slicing dark and light

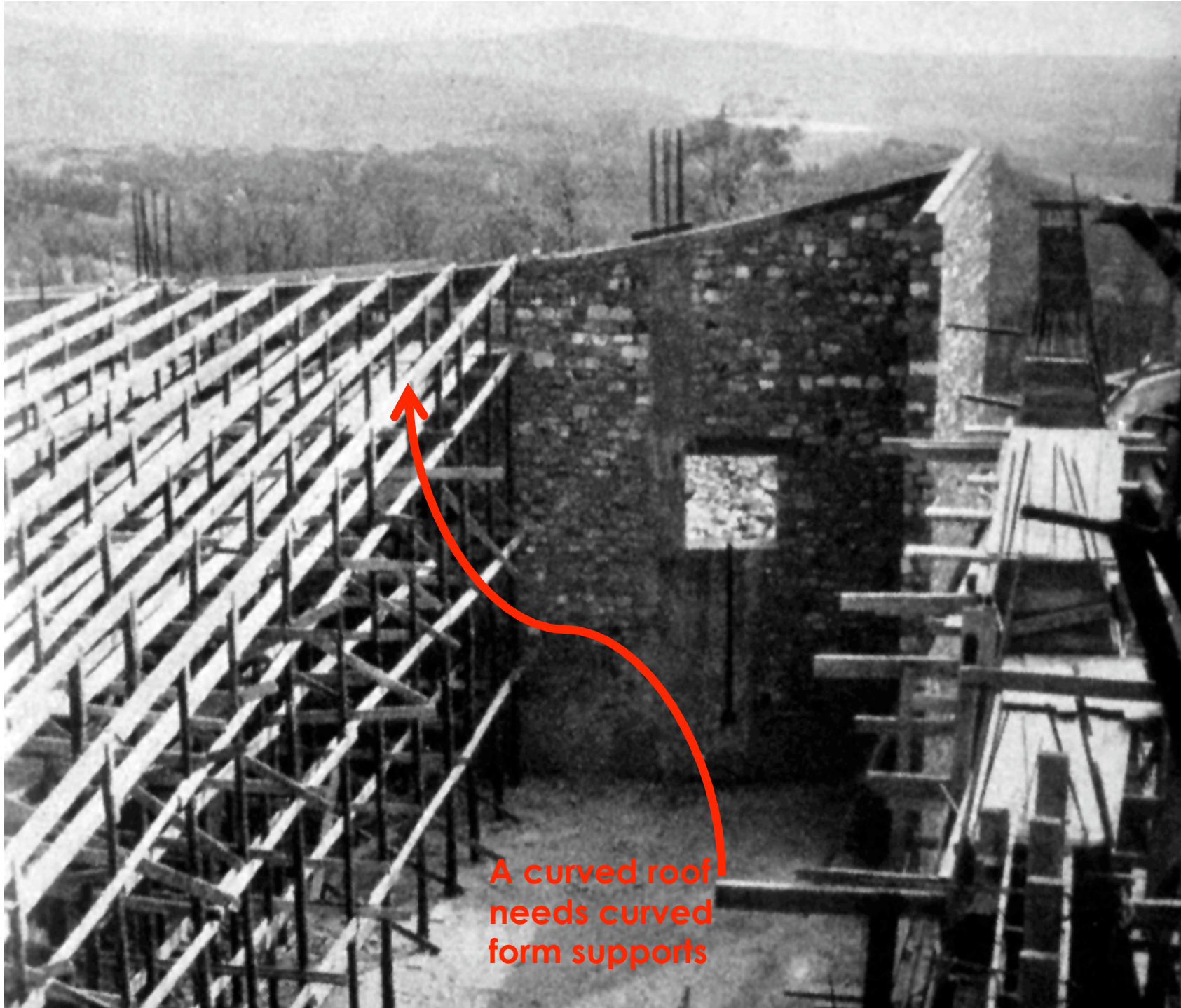




It just looks like a monolithic wall...actually has lots of parts

Lintels  
Jambs  
Frames

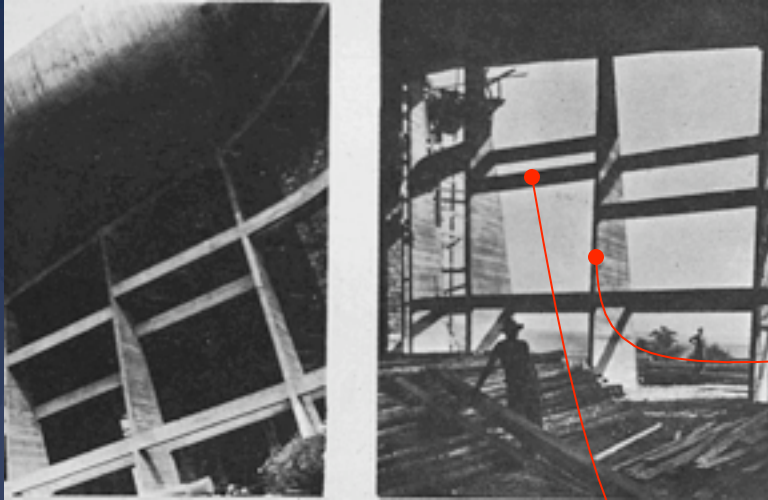




A curved roof  
needs curved  
form supports

# 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



# 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?***

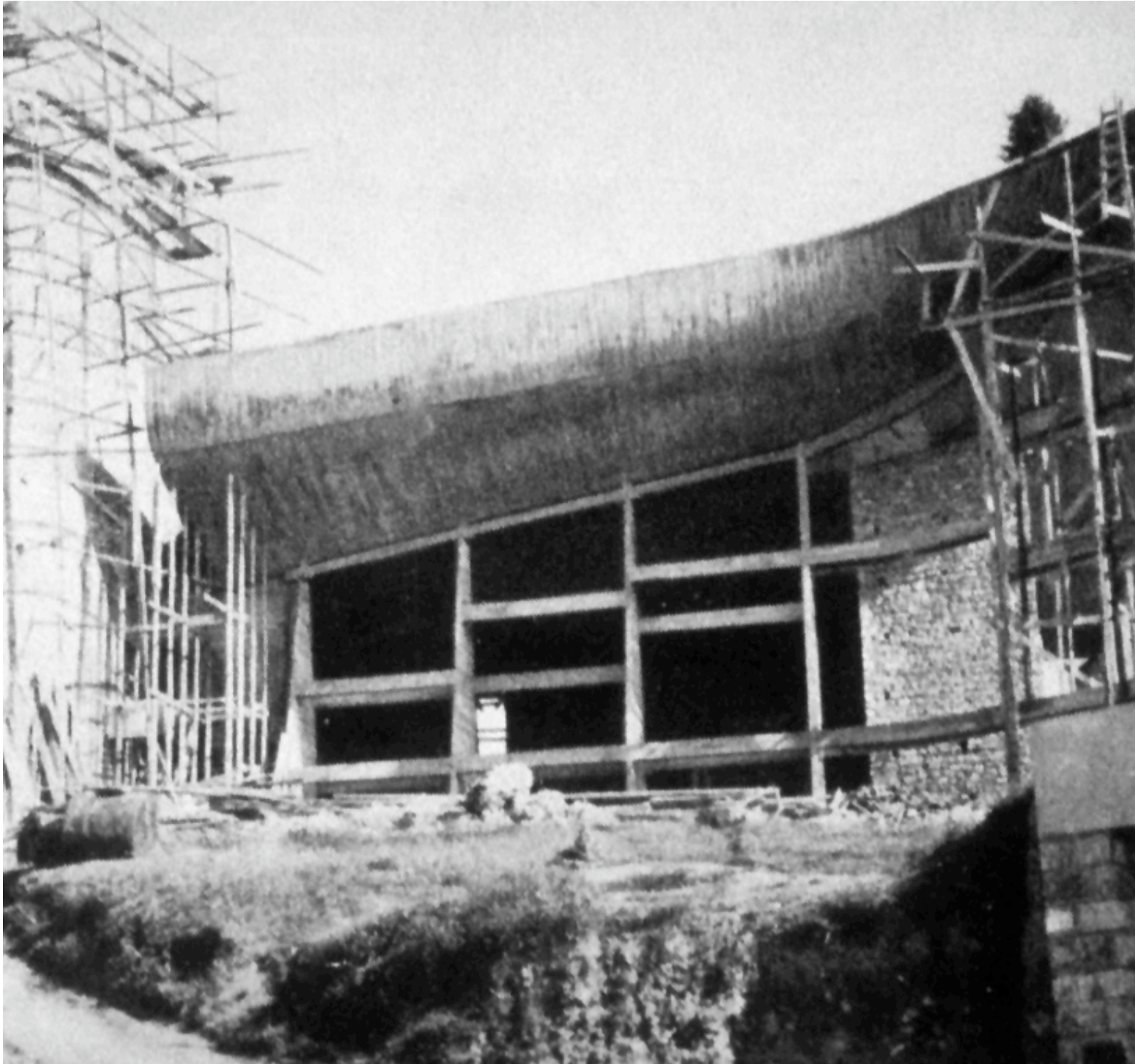
Yet this wall has to carry each of the massive concrete roof trusses.





Art and Pragmatics...the drip





The greatest  
wall in  
architecture  
takes shape











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









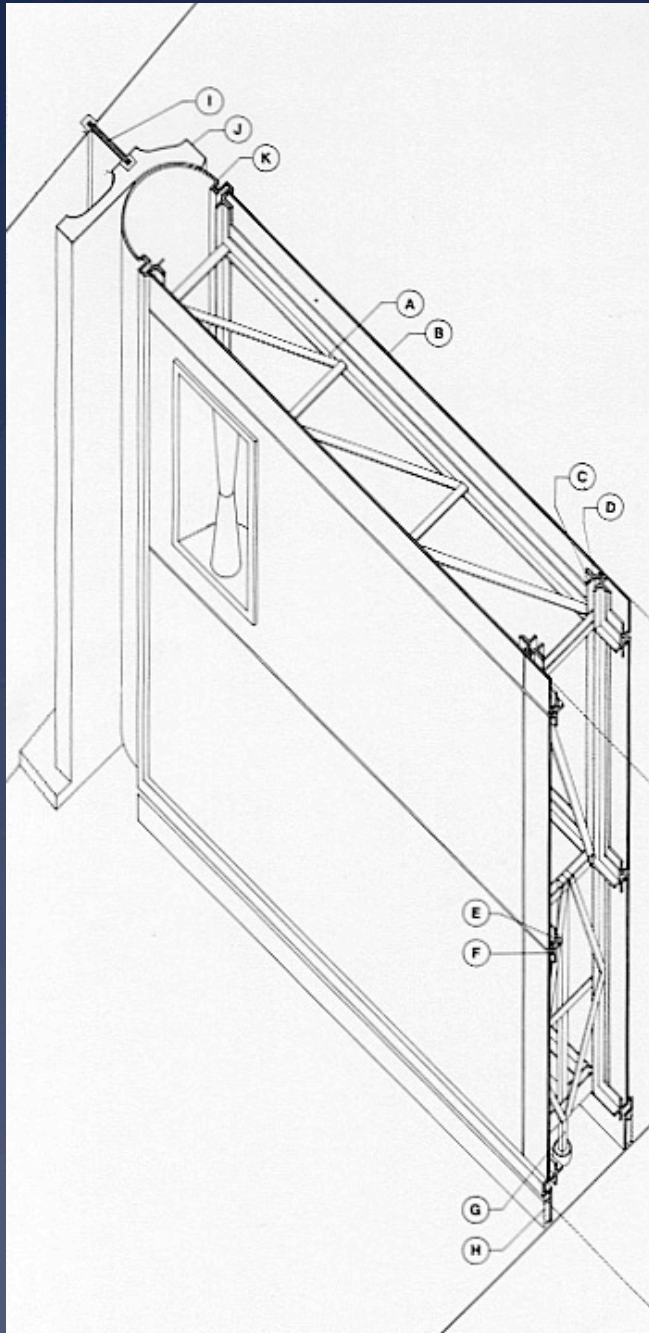
Light falling on a rough surface is  
graded by the surface so we can  
know the falloff





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.





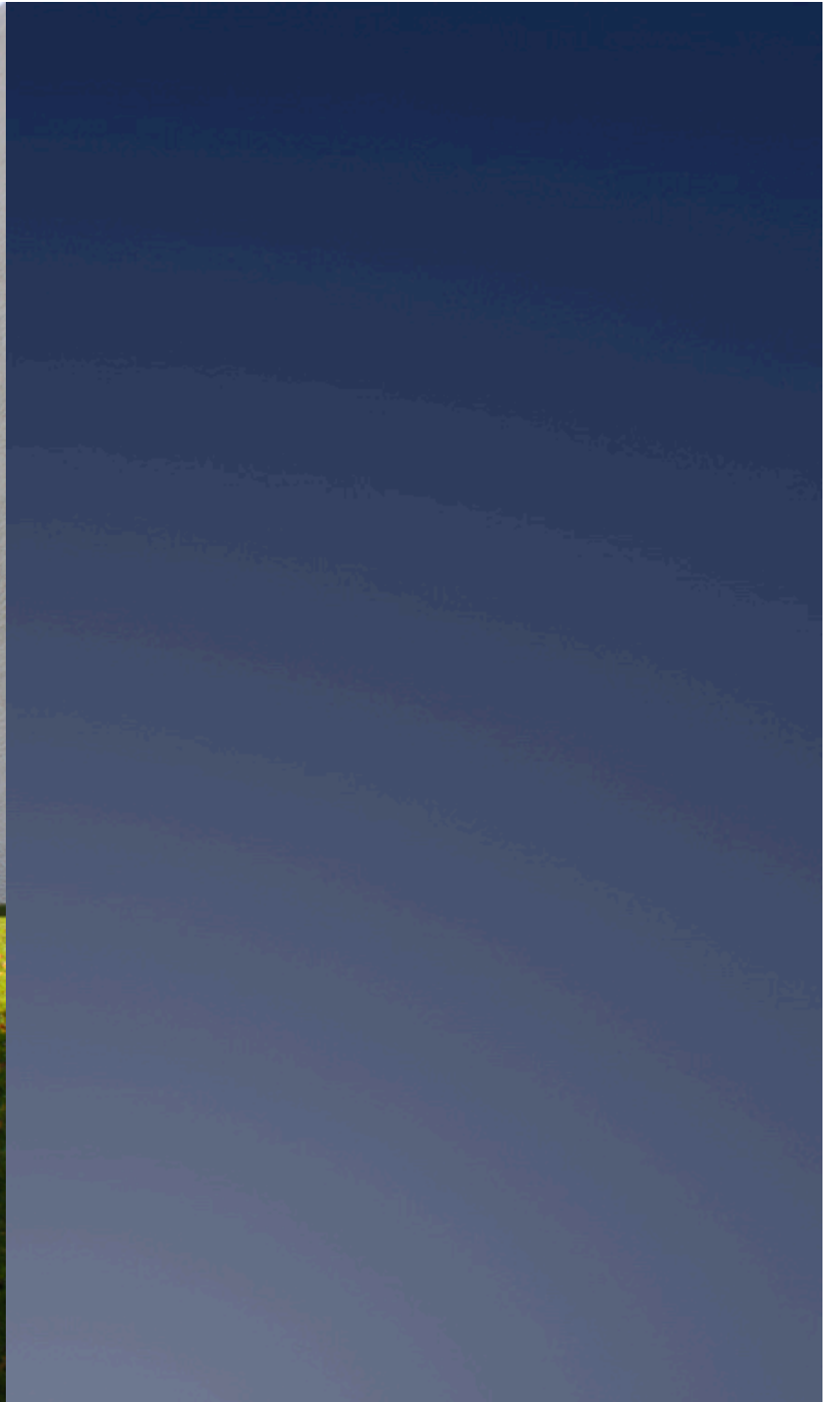


What place does art have  
with architecture?



A door and light to enter the  
upper pulpit









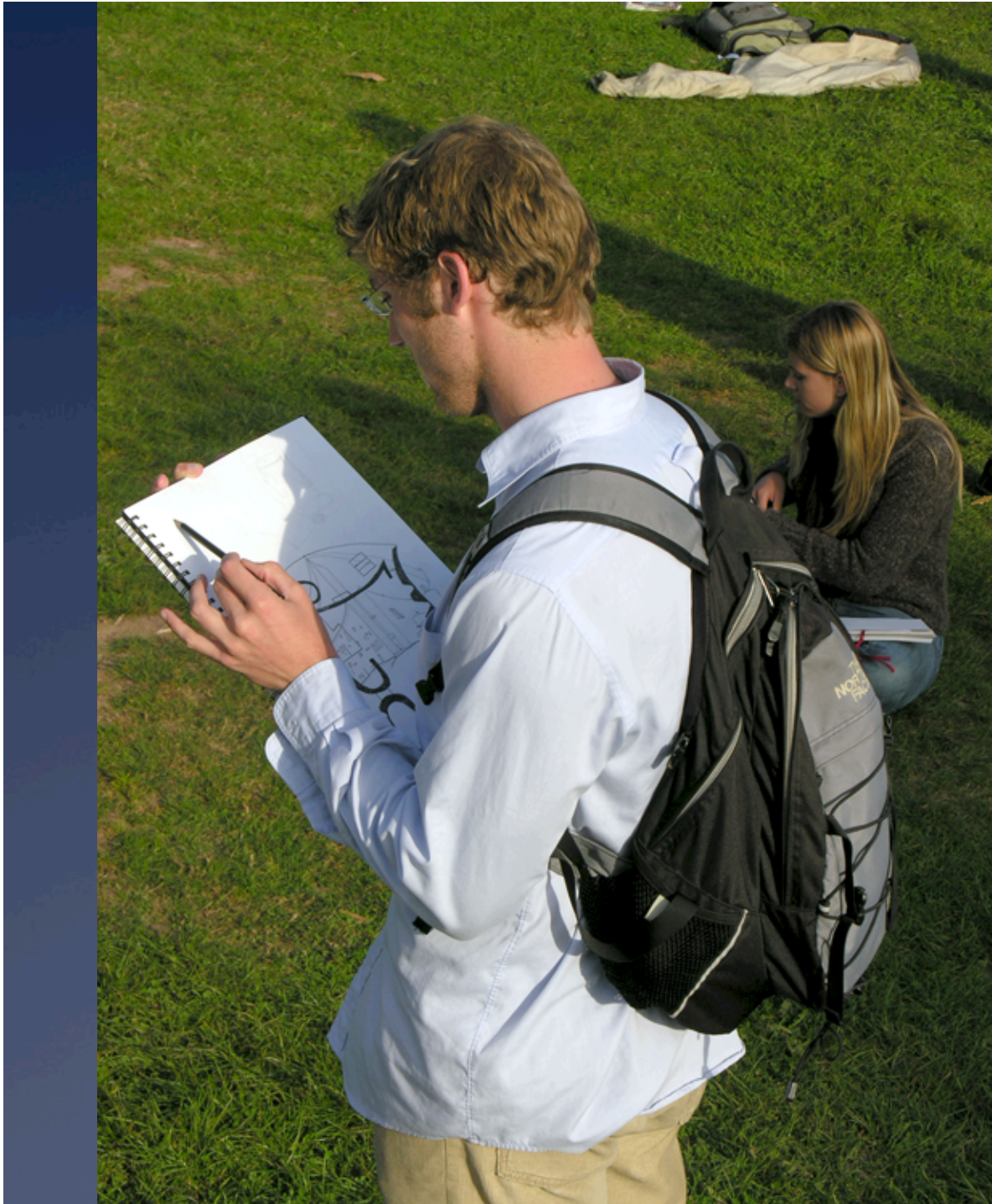
Architecture from pragmatics...sculpted scupper



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

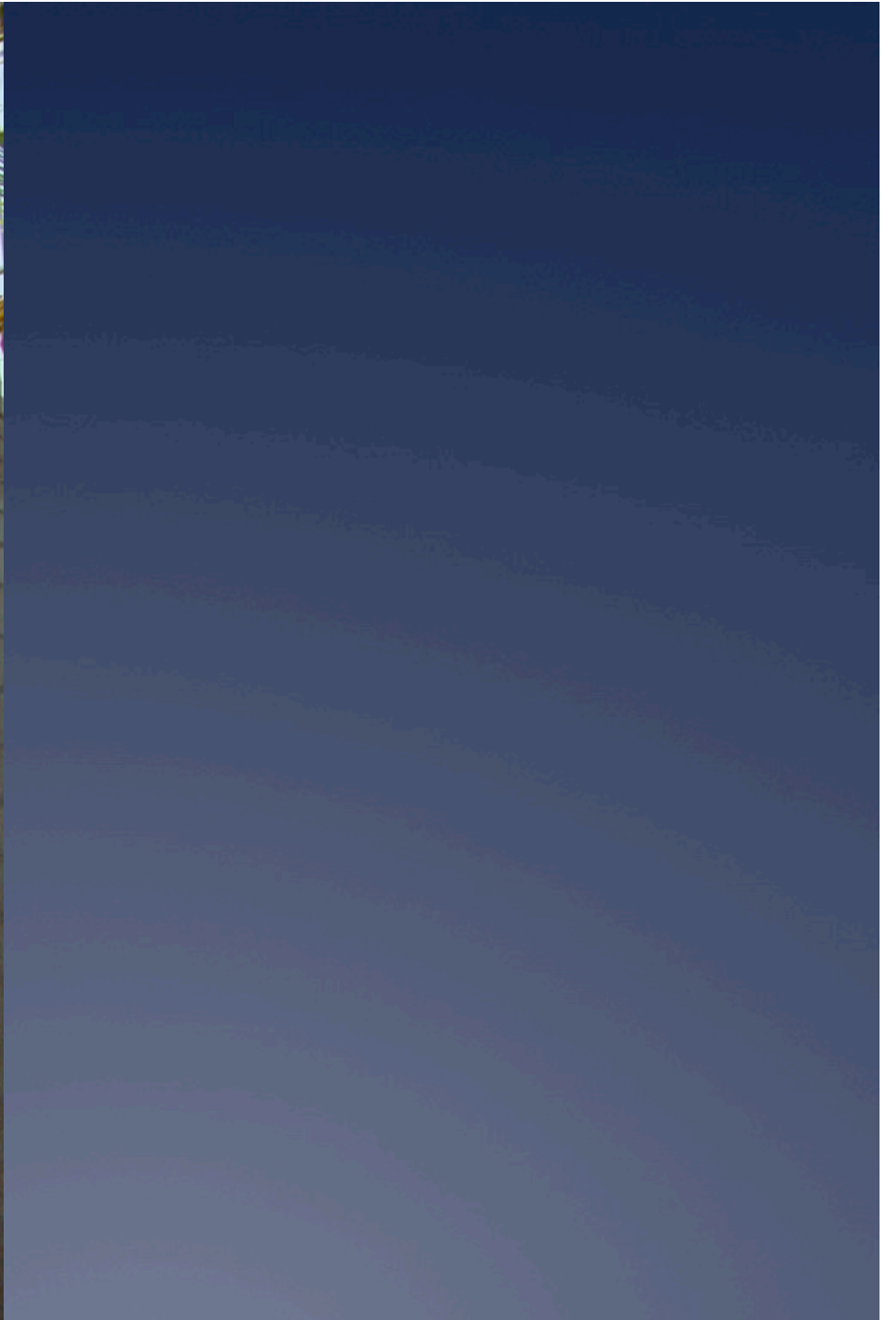


And then there was the fish....



Before Bilbao, before Weismann, before Seattle, there was the fish, many fish really, in Barcelona, Minneapolis, Seattle, Kobe, and Venice each a study of scales, skin, structure...and here, silicone









Separation of skin and structure initiated by Eiffel and Bartoldi for the Statue of Liberty, rendered in wood, steel, glass and silicone sealant by Gehry.



