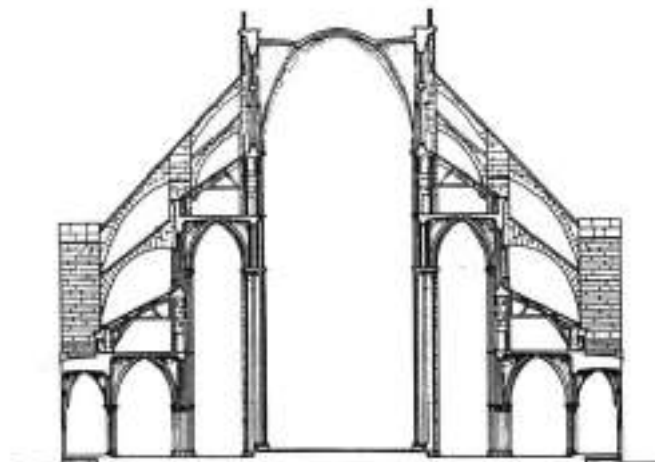
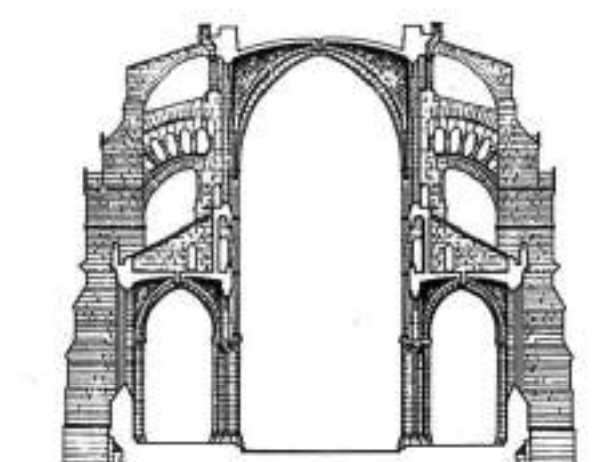


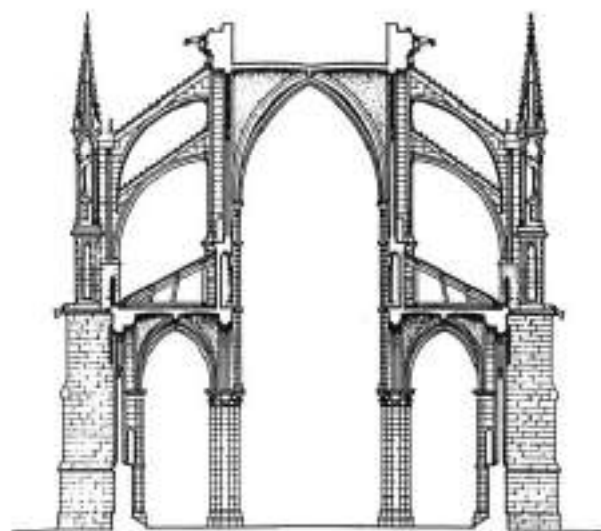
NÔTRE-DAME (1180-)



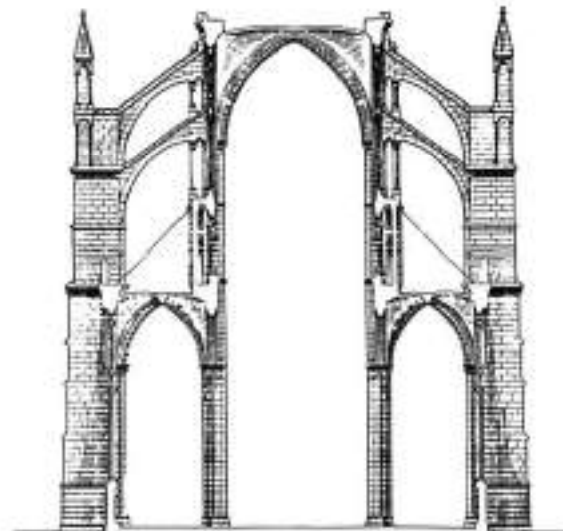
BOURGES (1195-)



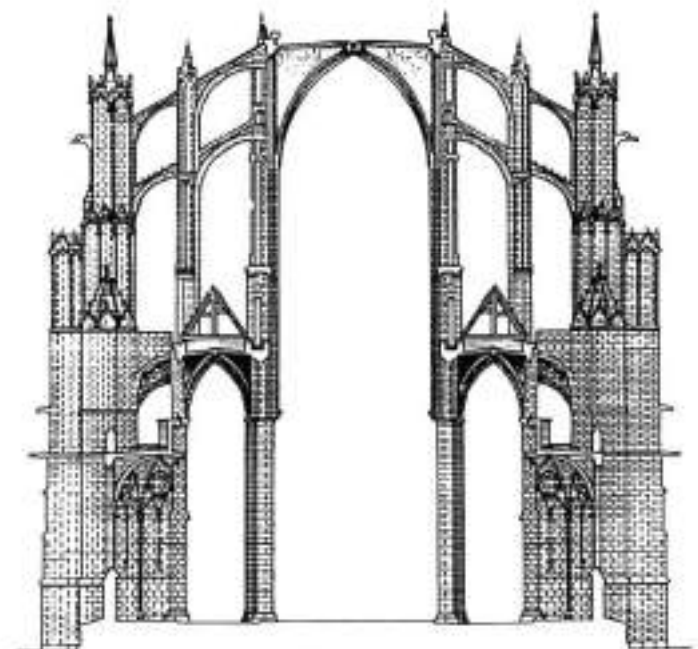
CHARTRES (1194-)



REIMS (1210-)



AMIENS (1220-)

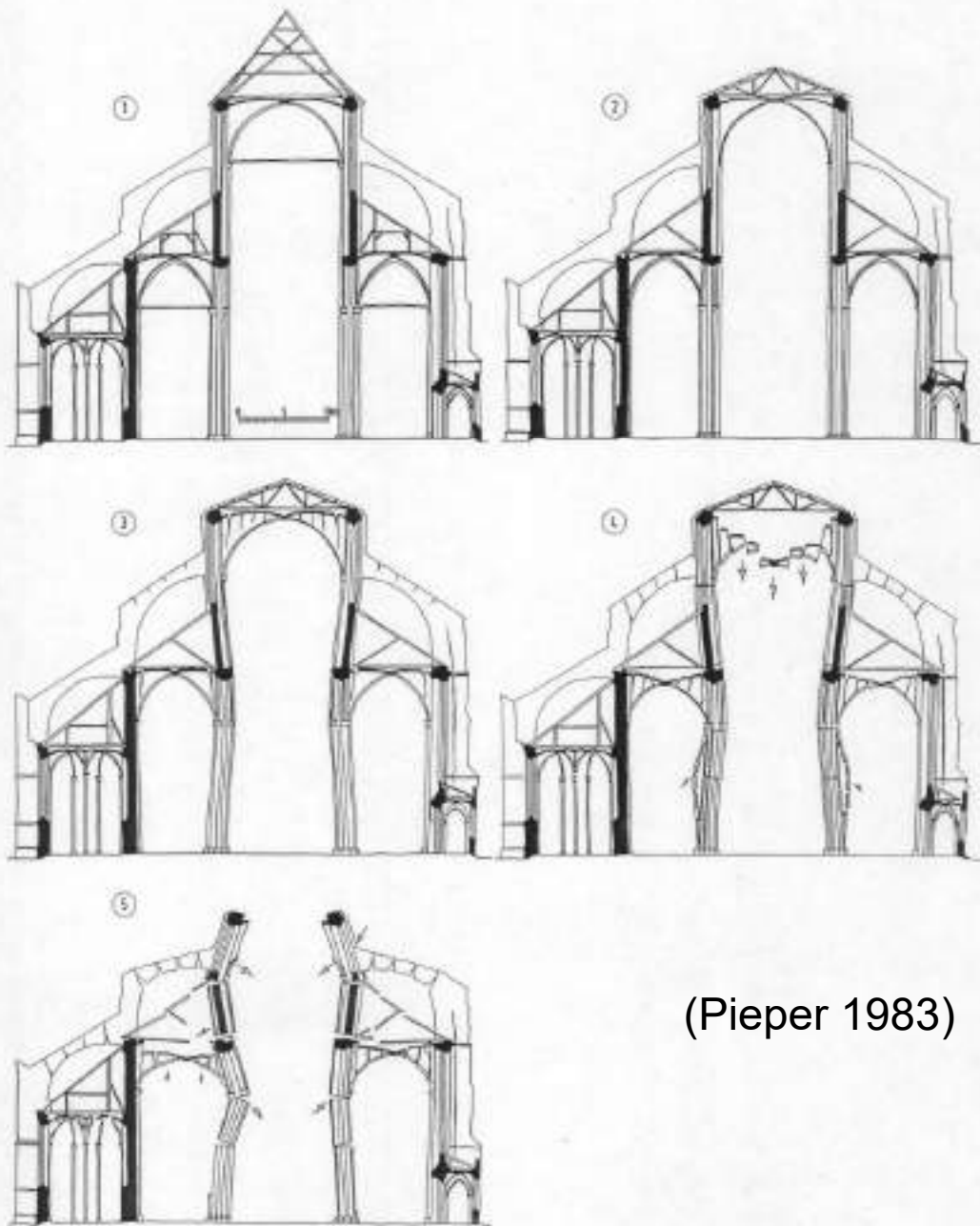


BEAUVAIS (1225-)



“El coro de Notre-Dame es una obra maestra del equilibrio llevada al límite; bastaría con quitar una sola piedra para que todo se derrumbara.”

J. Formigé [Articulation de voûtes gothiques]1928

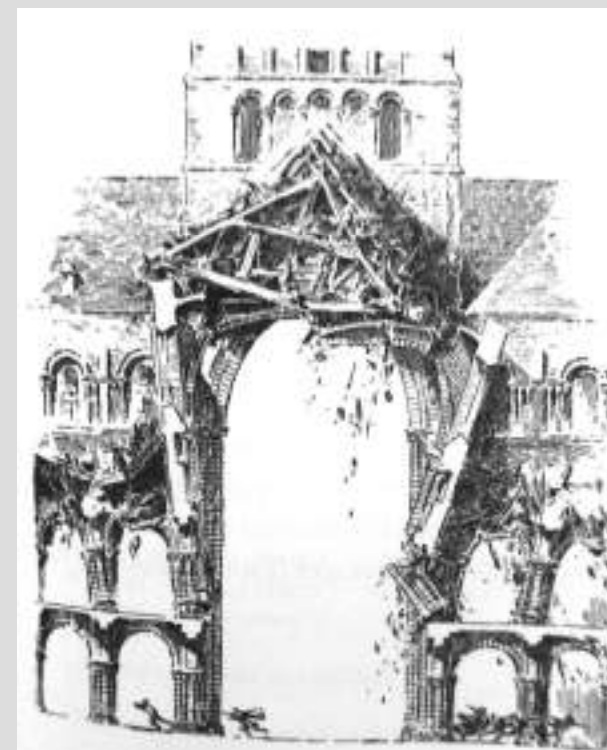


(Pieper 1983)

Colapsos imaginados



Amiens



(Dhuicque 1942)



These exclusive photographs, taken in May, 1921, show how the dome of St. Paul's Cathedral was planned to find its touch, it was leaning. A heavy weight was suspended from the dome and passed through a hole in a brick wall, which kept it steady. The joint braced by the wire supporting this weight was marked and a light punishment was suspended from it (left picture), so that a measurement could be taken of a shift.

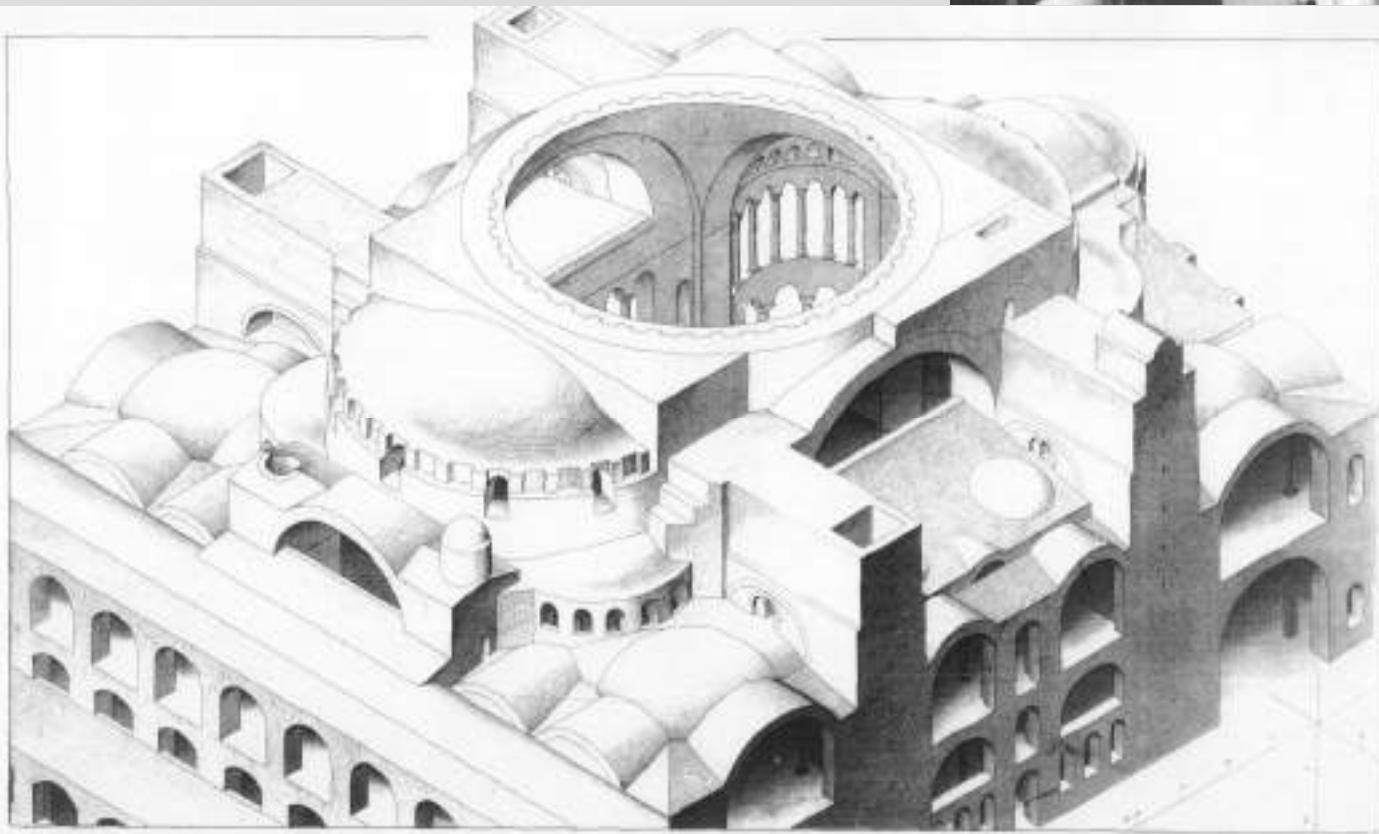
ST. PAUL'S WITH ITS GREAT DOME OFF



Christmas Eve, 1924, the City of London Surveyor's department served a Dangerous Structure Notice on the Dean and Chapter of the Cathedral, saying that the cathedral should be closed immediately to all until the remedial works were over.



ST. PAUL'S ASKEW; DEAN AND CHAPTER WATCHING.



DESIGNED BY A. GARDNER

DESIGNED BY A. GARDNER

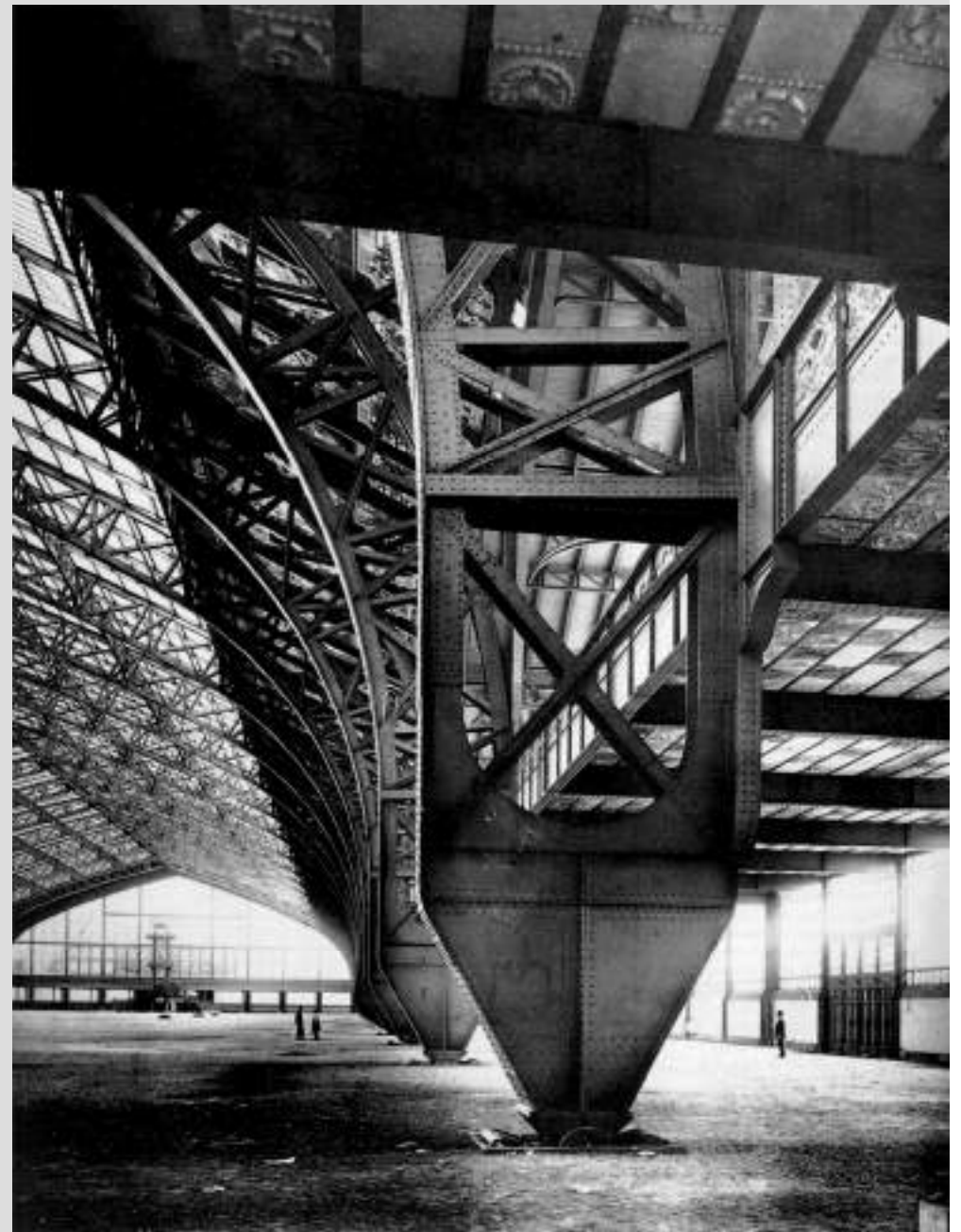
ST. SOPHIE in CONSTANTINOPLE



Templo de Minerva Medica

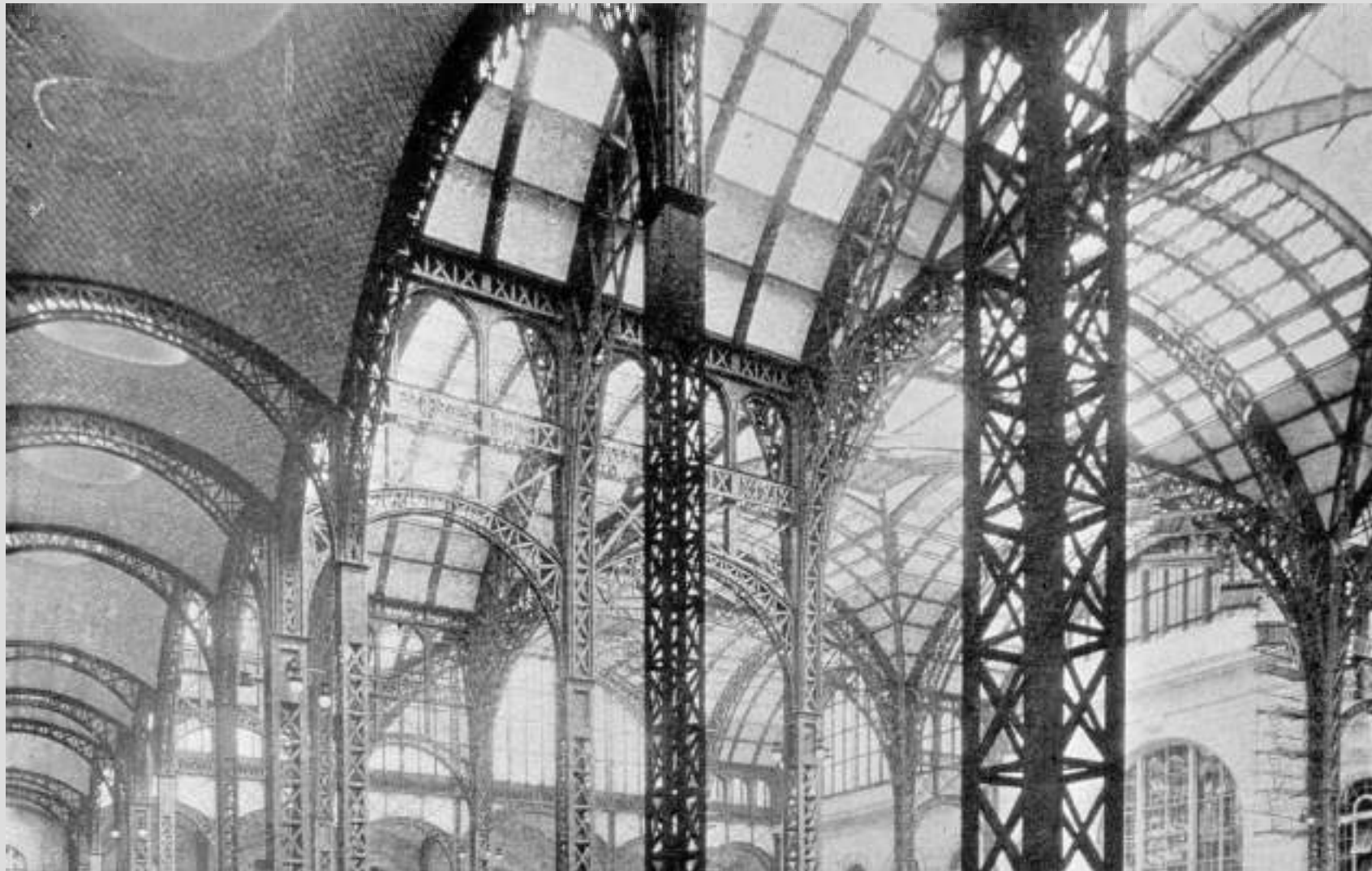


Paris, 1889



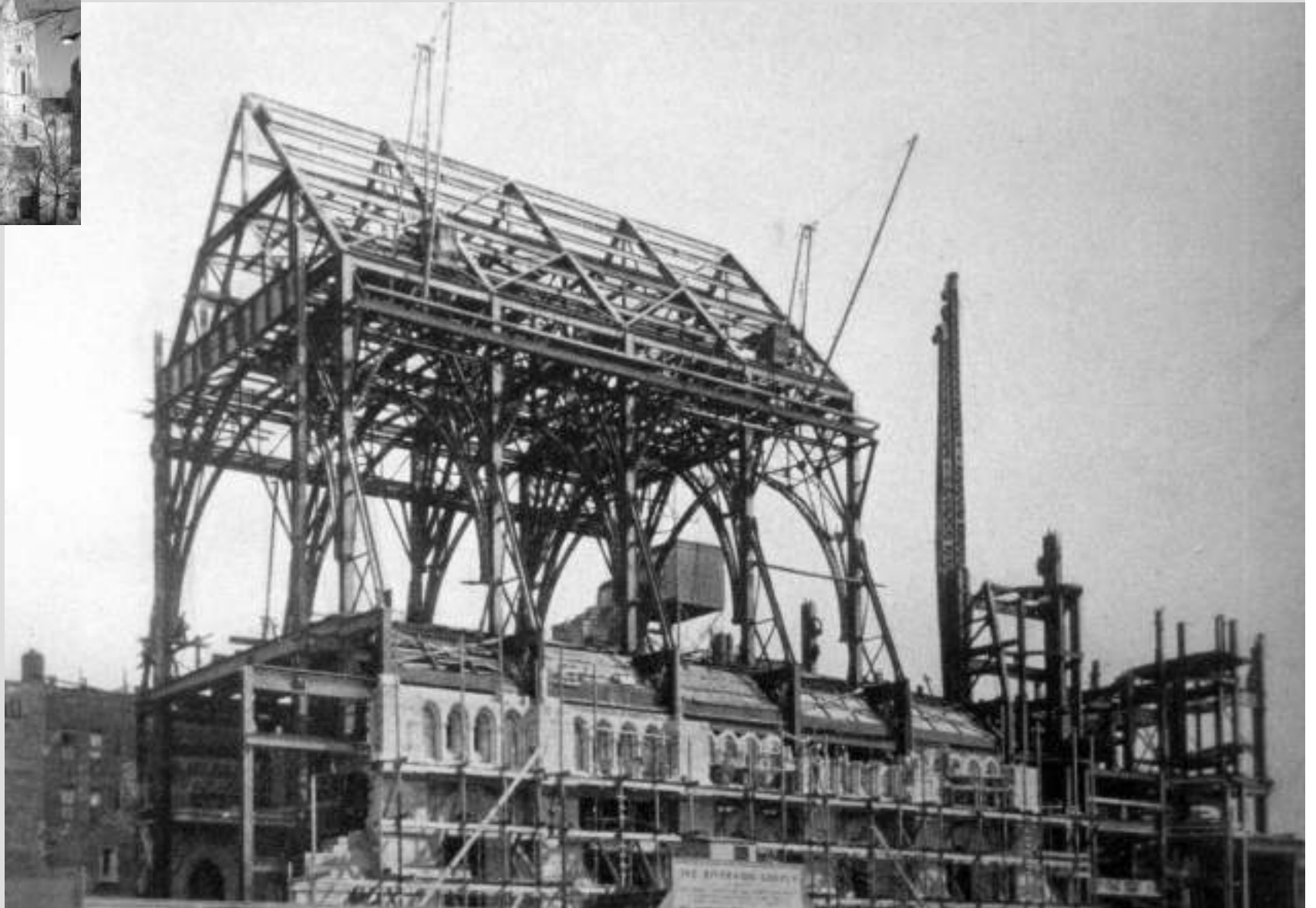


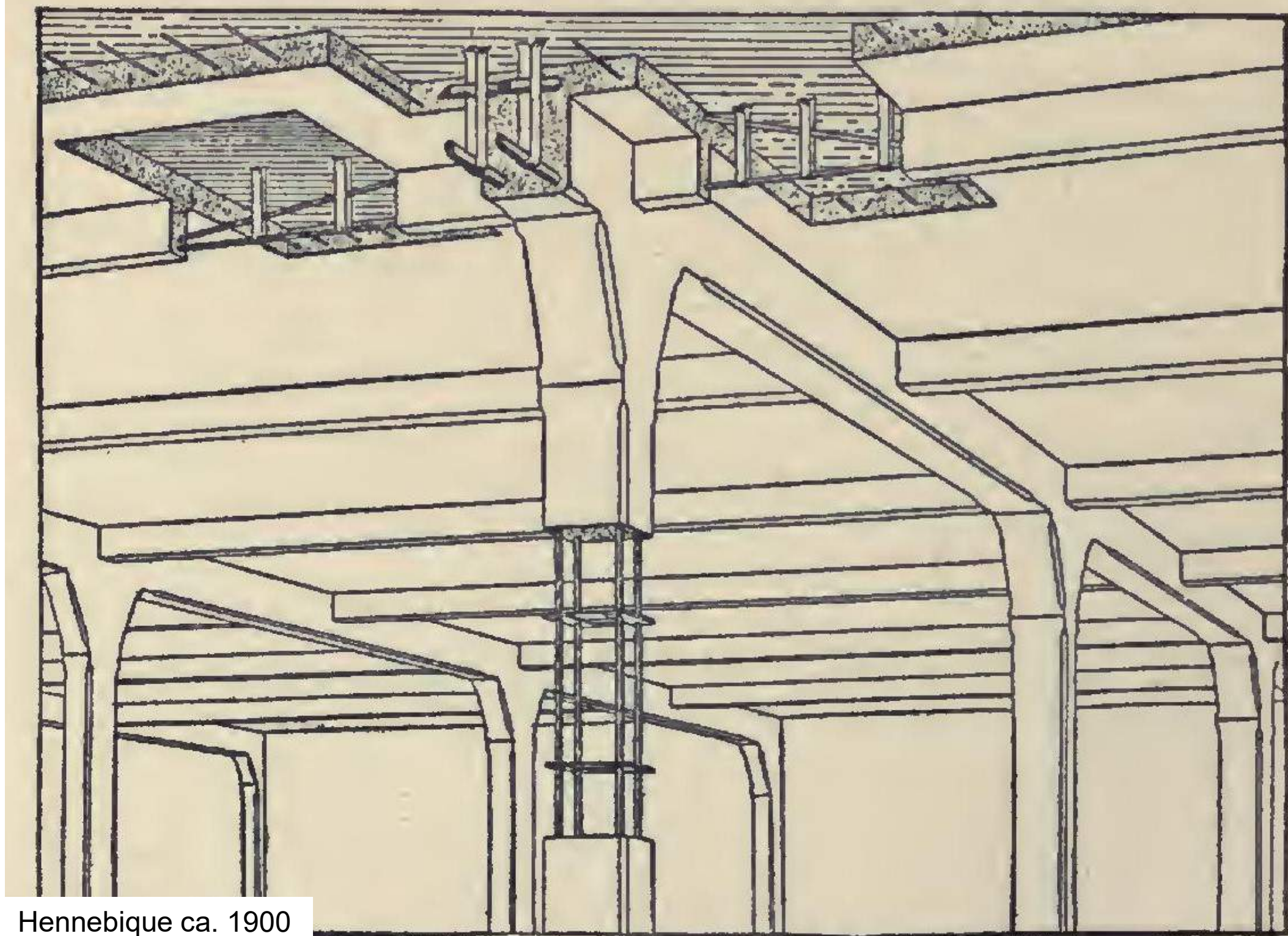
Pennsylvania Station 1910



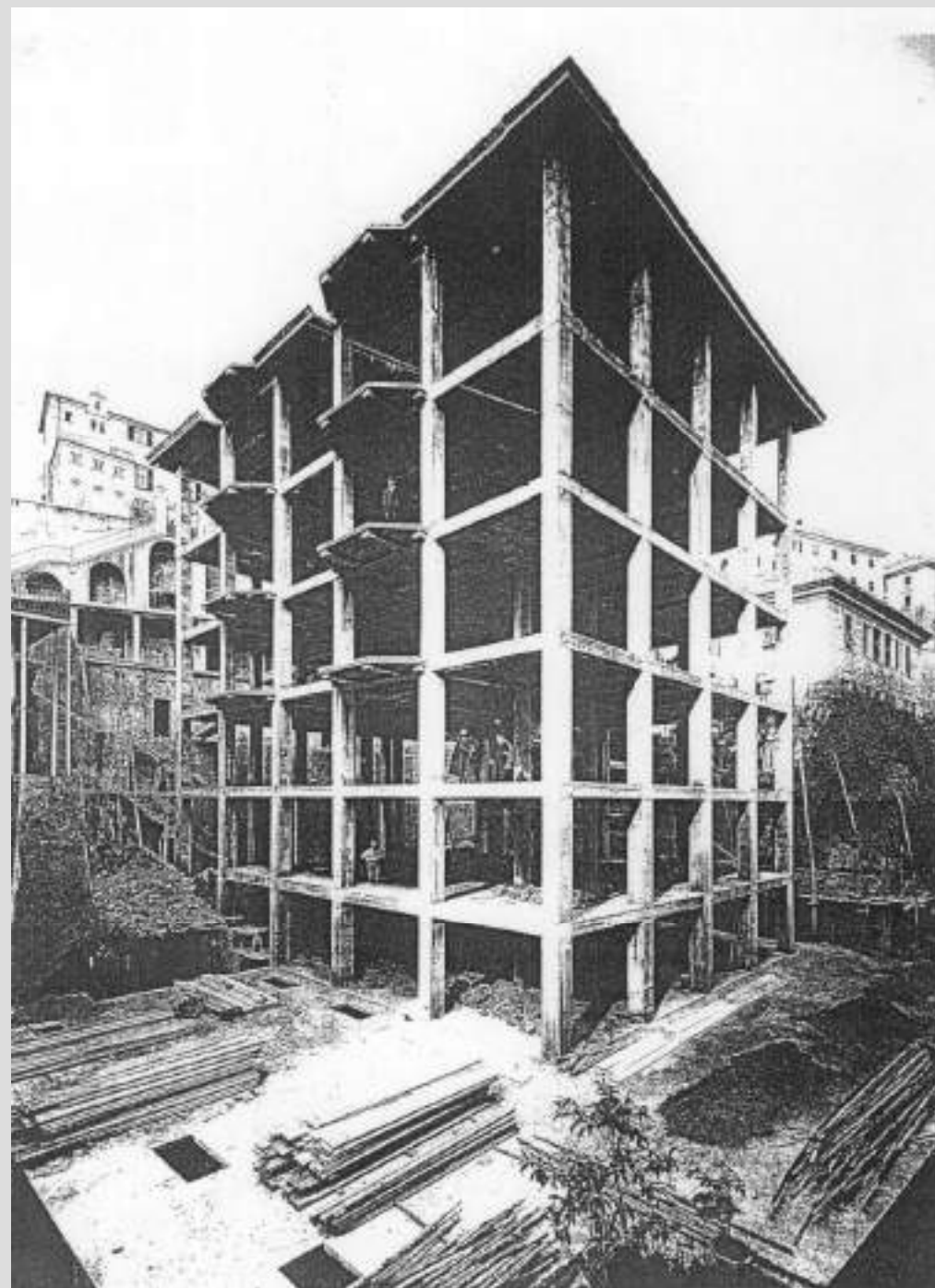
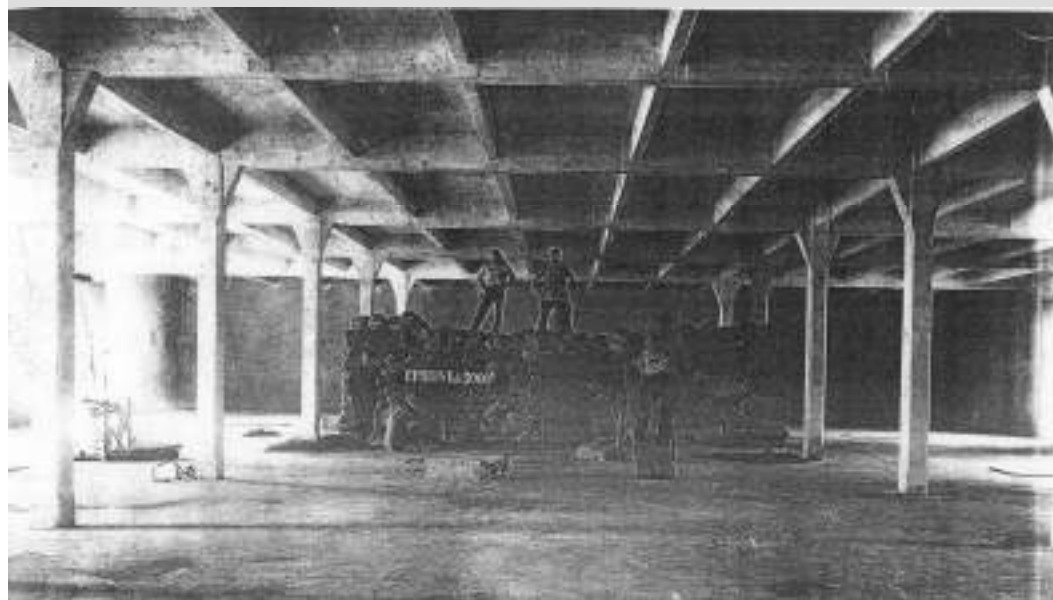
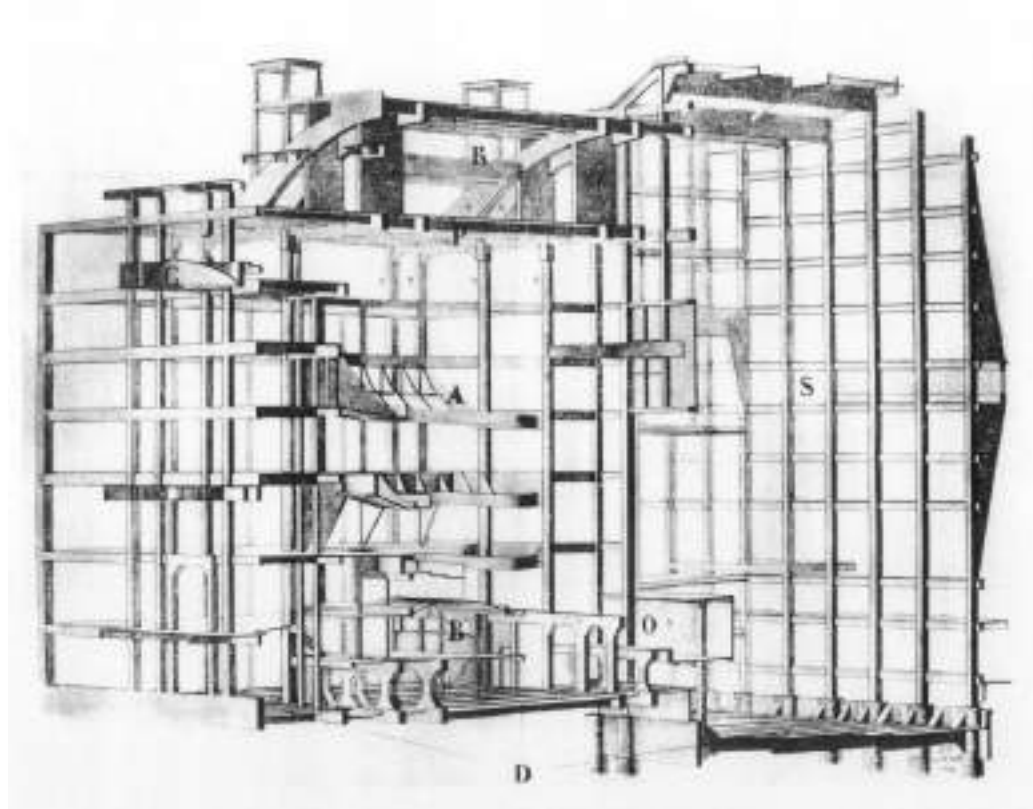


Riverside Church, Nueva York, 1927





Hennebique ca. 1900



1907



López Collado, Gabriel. 1976.

Ruinas en construcciones antiguas. Causas, consolidaciones y traslados.

Madrid: Ministerio de Obras Públicas y Urbanismo.

REFUERZOS DE ARCOS Y BOVEDAS

46. REFUERZOS DE ARCOS CON HORMIGON ARMADO

No sólo debe consistir nuestra intervención al hacer una restauración en sustituir los elementos malos y reponer los desaparecidos, sino también mejorar los que aún hoy se encuentren bien, para conseguir alargar su duración.

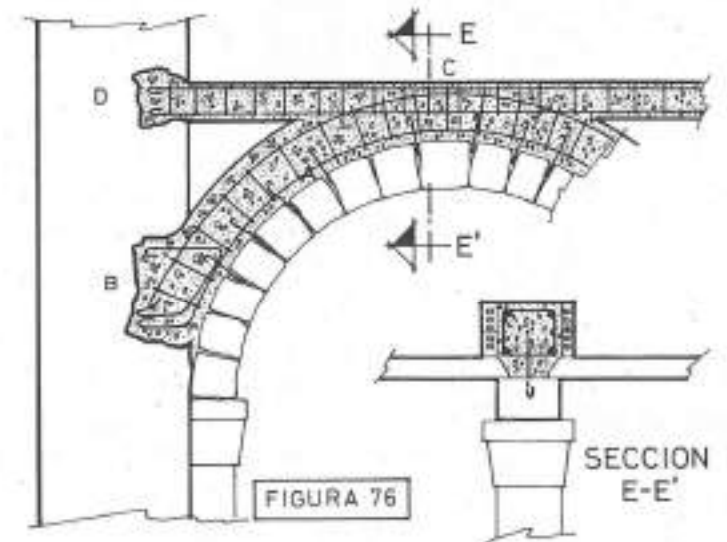


FIGURA 76

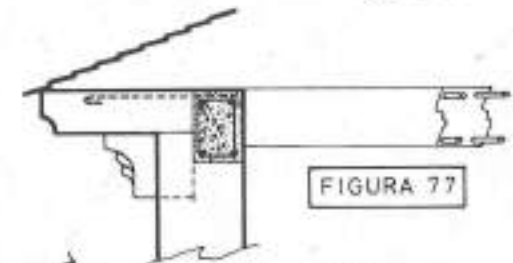


FIGURA 77

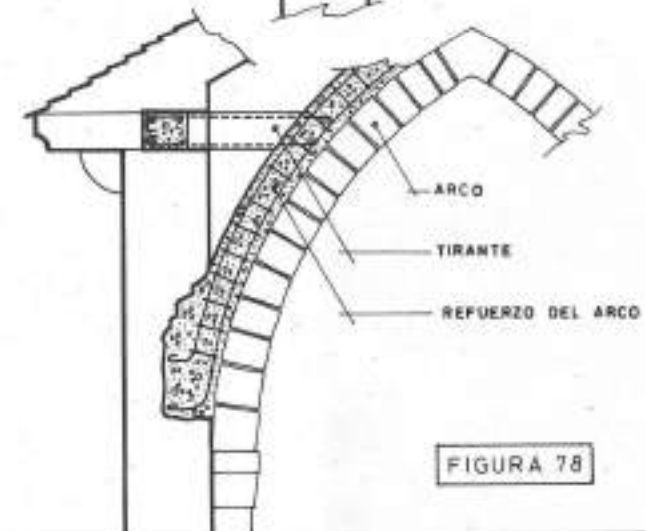
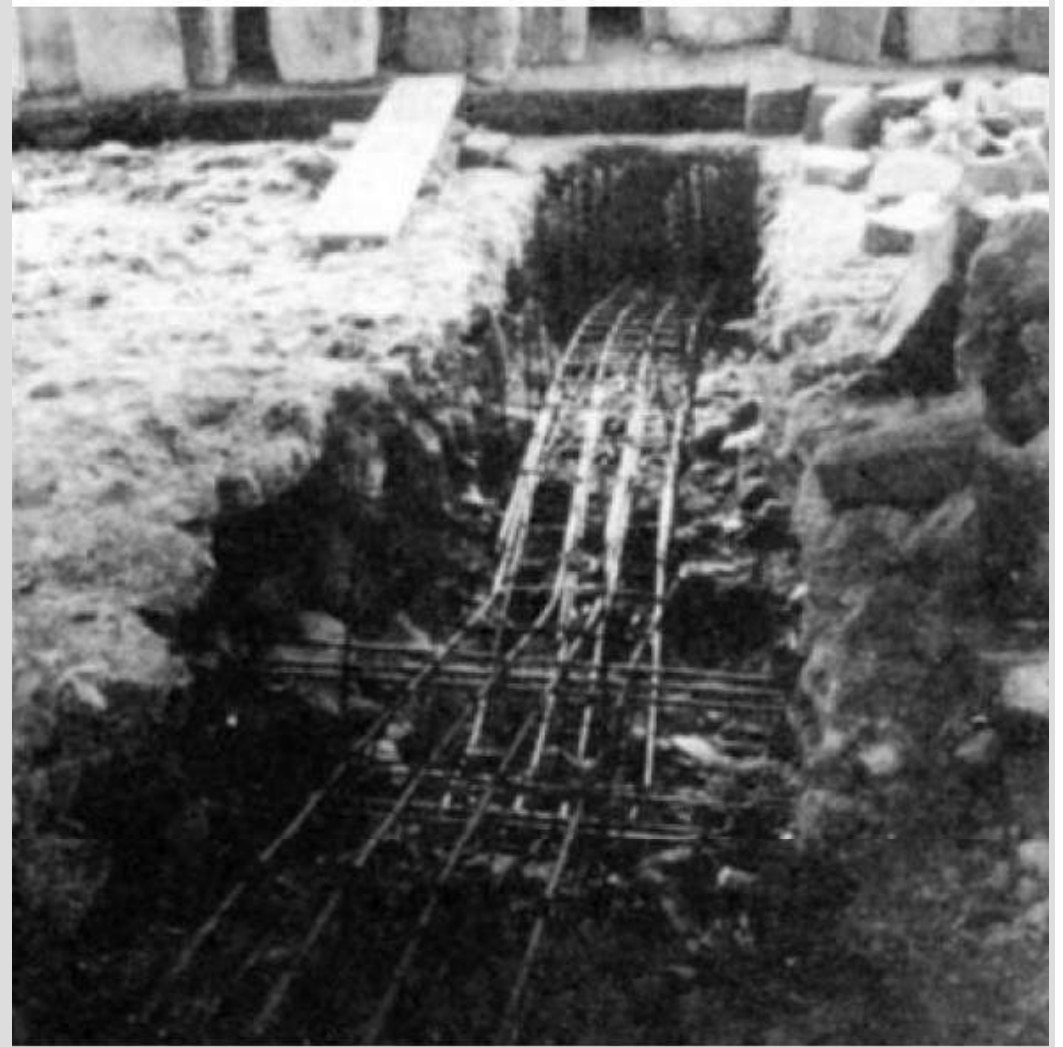
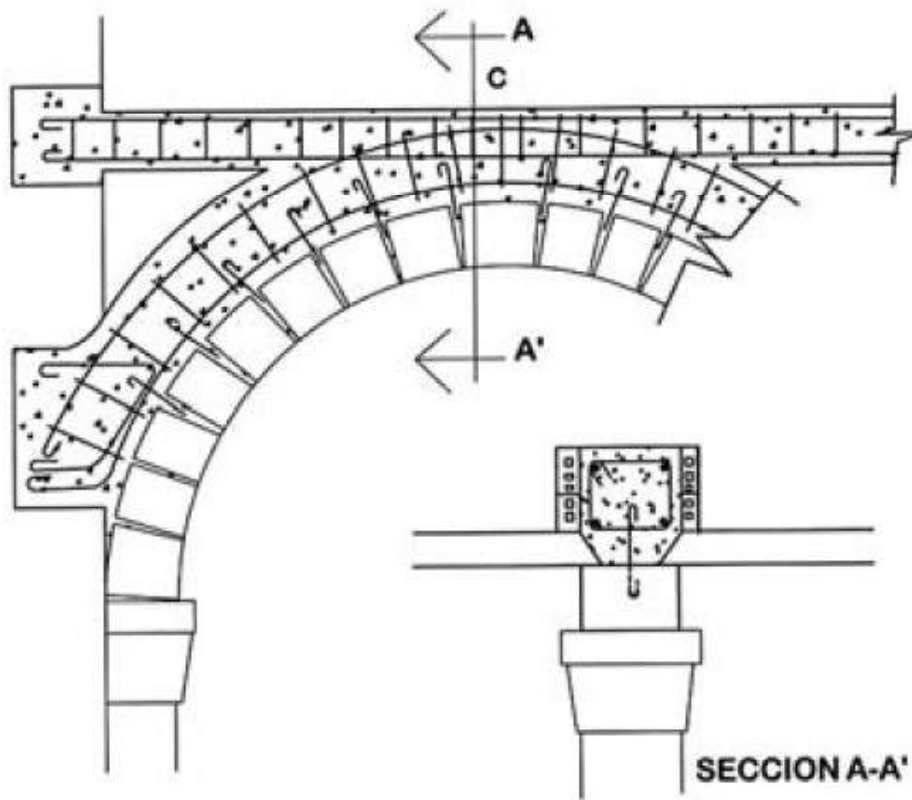
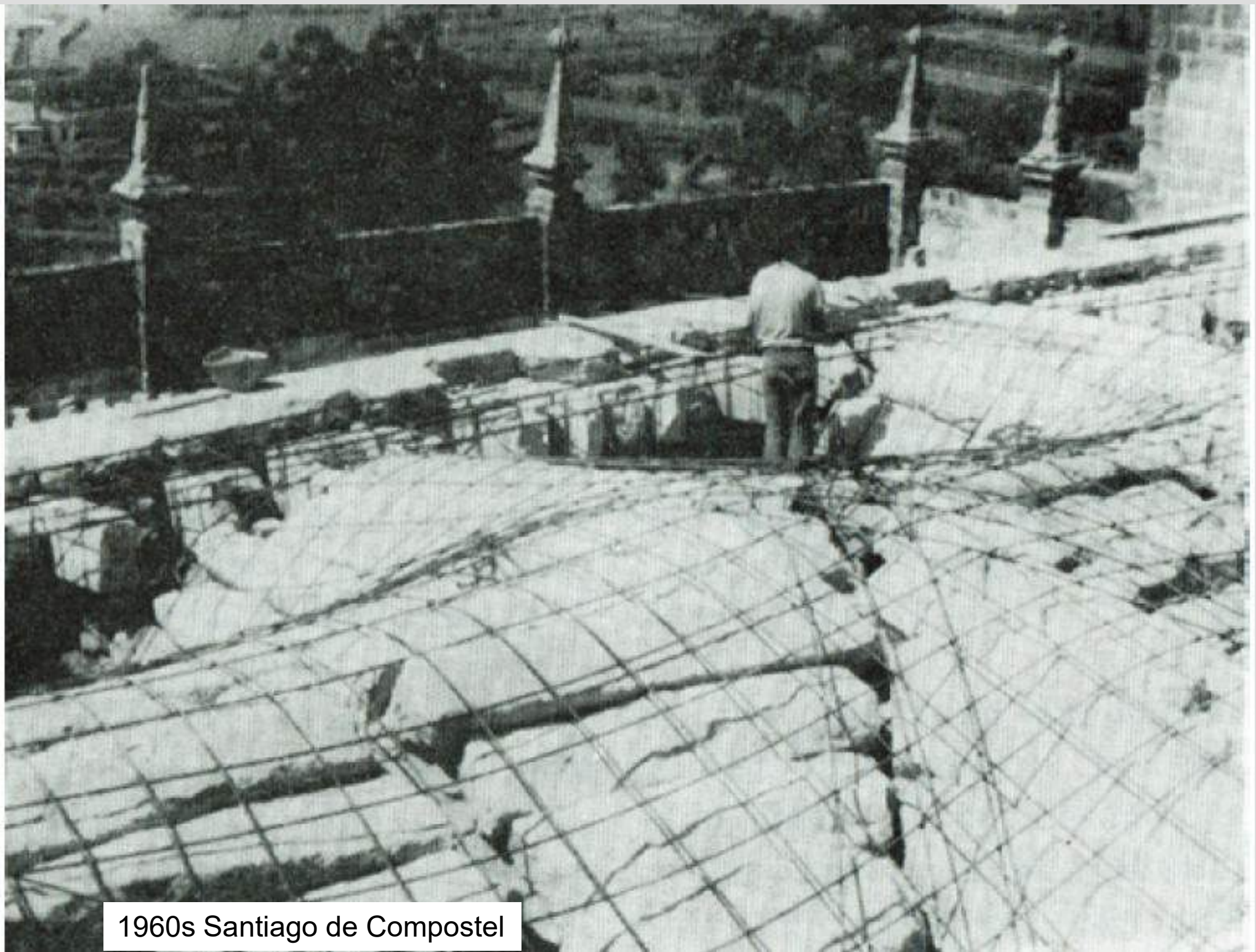


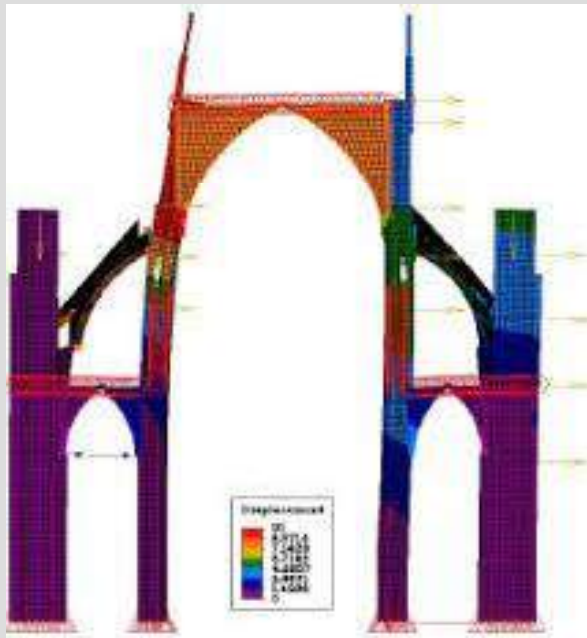
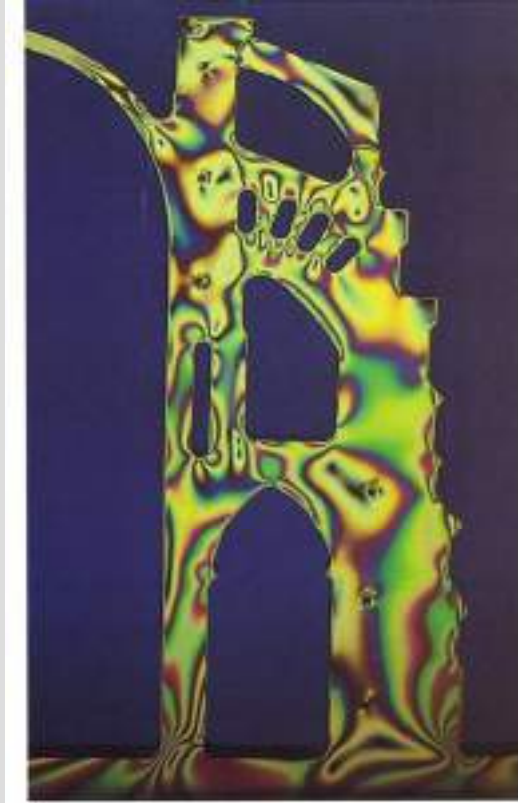
FIGURA 78



(Cathedral of Santiago de Compostela 1960s)



1960s Santiago de Compostel



???





2018 L'Aquila

Estructuras de Mampostería

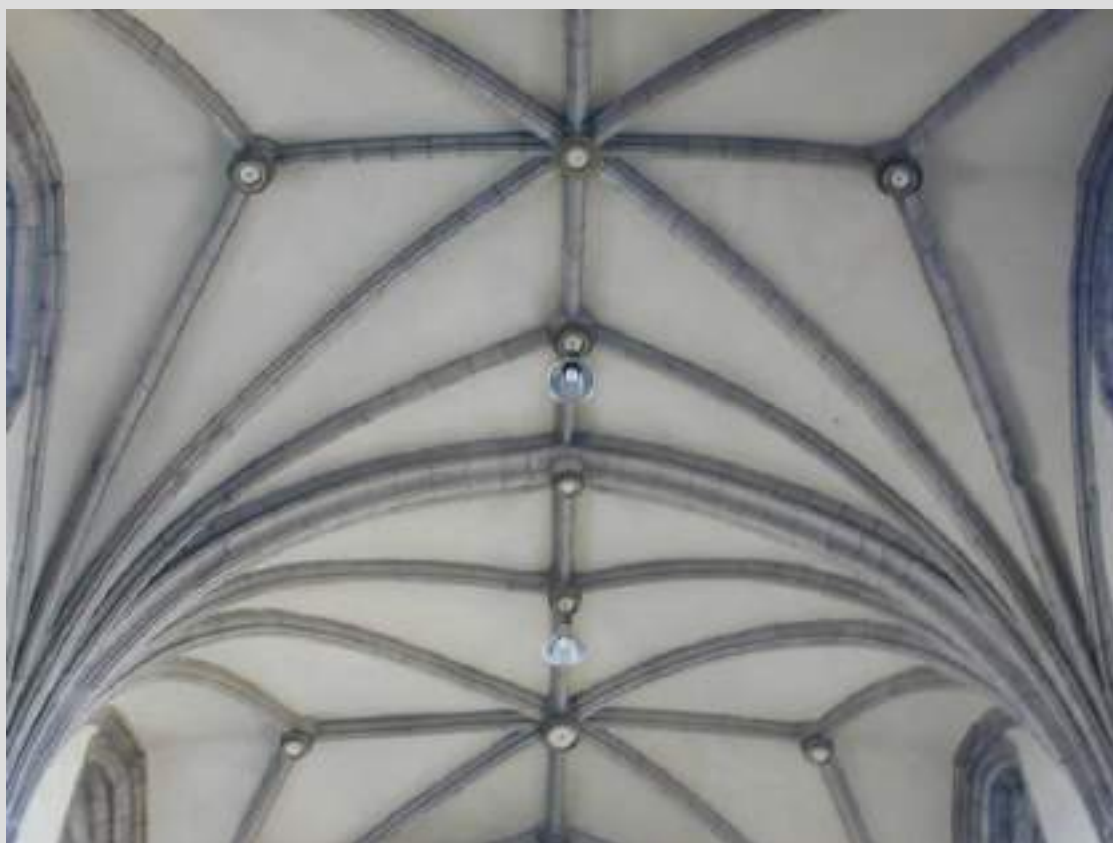


Puente de Navea, Ourense





Iglesia parroquial de Melgar de Fernamental, Burgos



Convento del Rosario
(Oviedo)



Collapse of an oval dome in “La Mantería”, Zaragoza



Convento de Santo Domingo, A Coruña



Lonja de Palma de Mallorca



Ruinas del Convento de Santo Domingo, Pontevedra

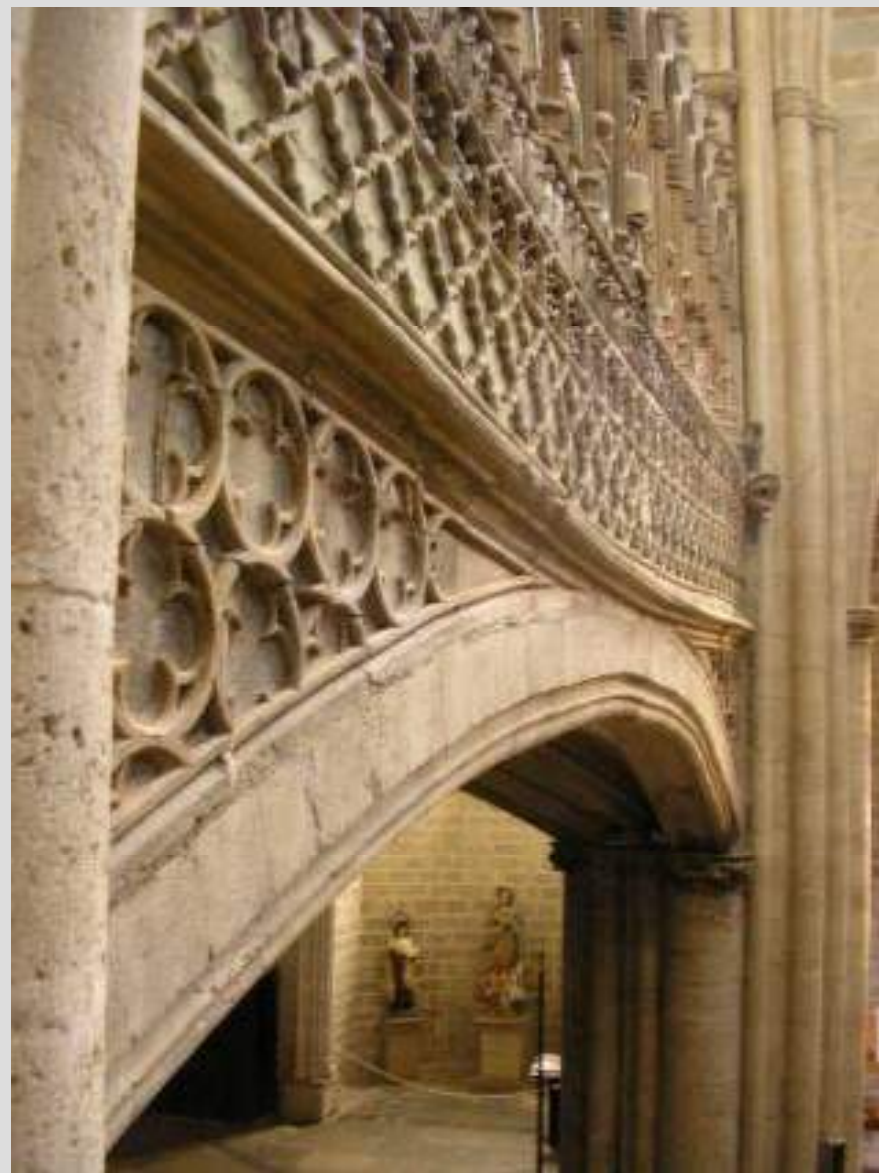


Bóveda de cañón muy deformada, Guimarei, Lugo



Cupulinos de la Torre del Reloj
Catedral of Santiago de Compostela





Coro alto, Morella, Castellón



Ruinas del
Monasterio
de Melón,
Galicia





Puebla



Nuestra Señora de los Ángeles, Ciudad de México





DEEP IMPACT
In Golcuk, a mosque stood firmly, even as poorly built structures fell

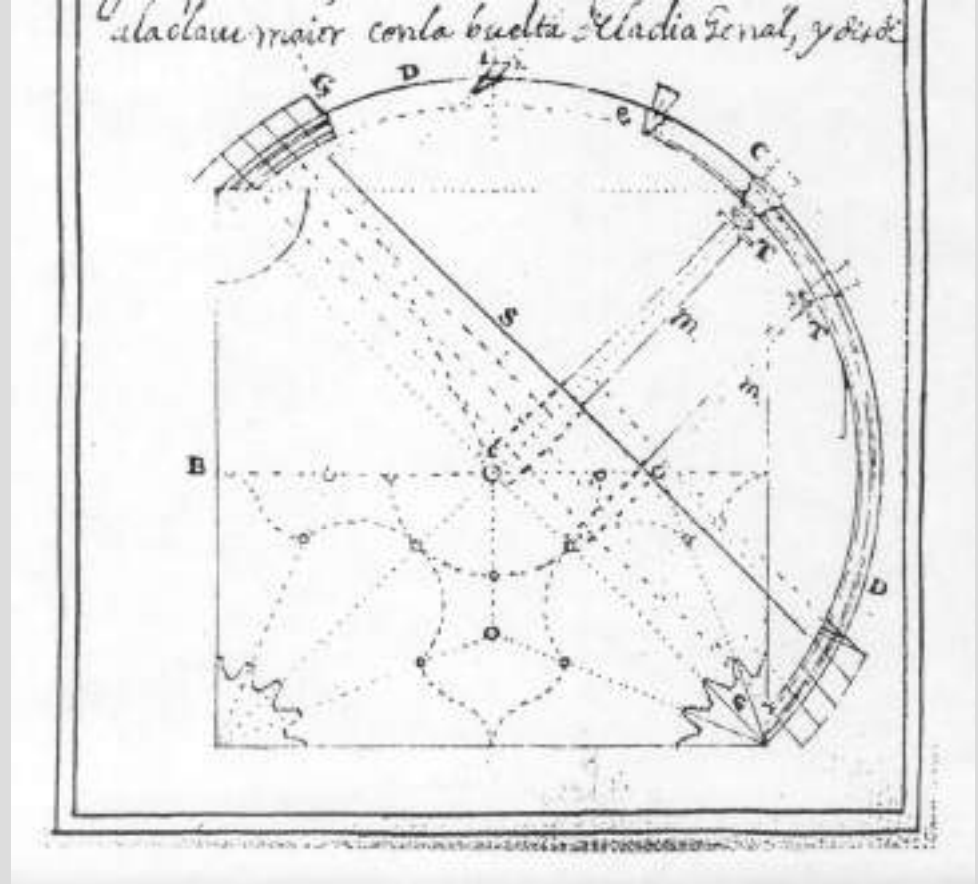
Terremoto de 1999, Turquía



Nuestra Señora del Loreto, Ciudad de México



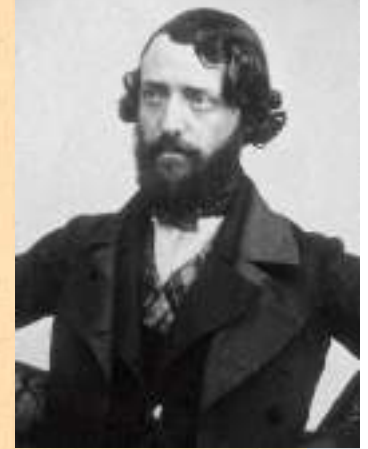
Nuestra Señora de la Antigua, Valladolid
Refuerzo propuesto por Rodrigo Gil de Hontañón 1571



“...pondré a la buelta vna demostracion, en que se entienda esto cuando me sea posible, aunque estas cosas, **podran ser difiçiles de comprehender faltando en quien las procura la experiencia, la practica, la profesion de la cantería, y la execucion, o el aberse allado presente a algunos çierres de cruçeria**, para haçerse capaz en el asiento de ella.”

Rodrigo Gil de Hontañón
Tratado, ca. 1550

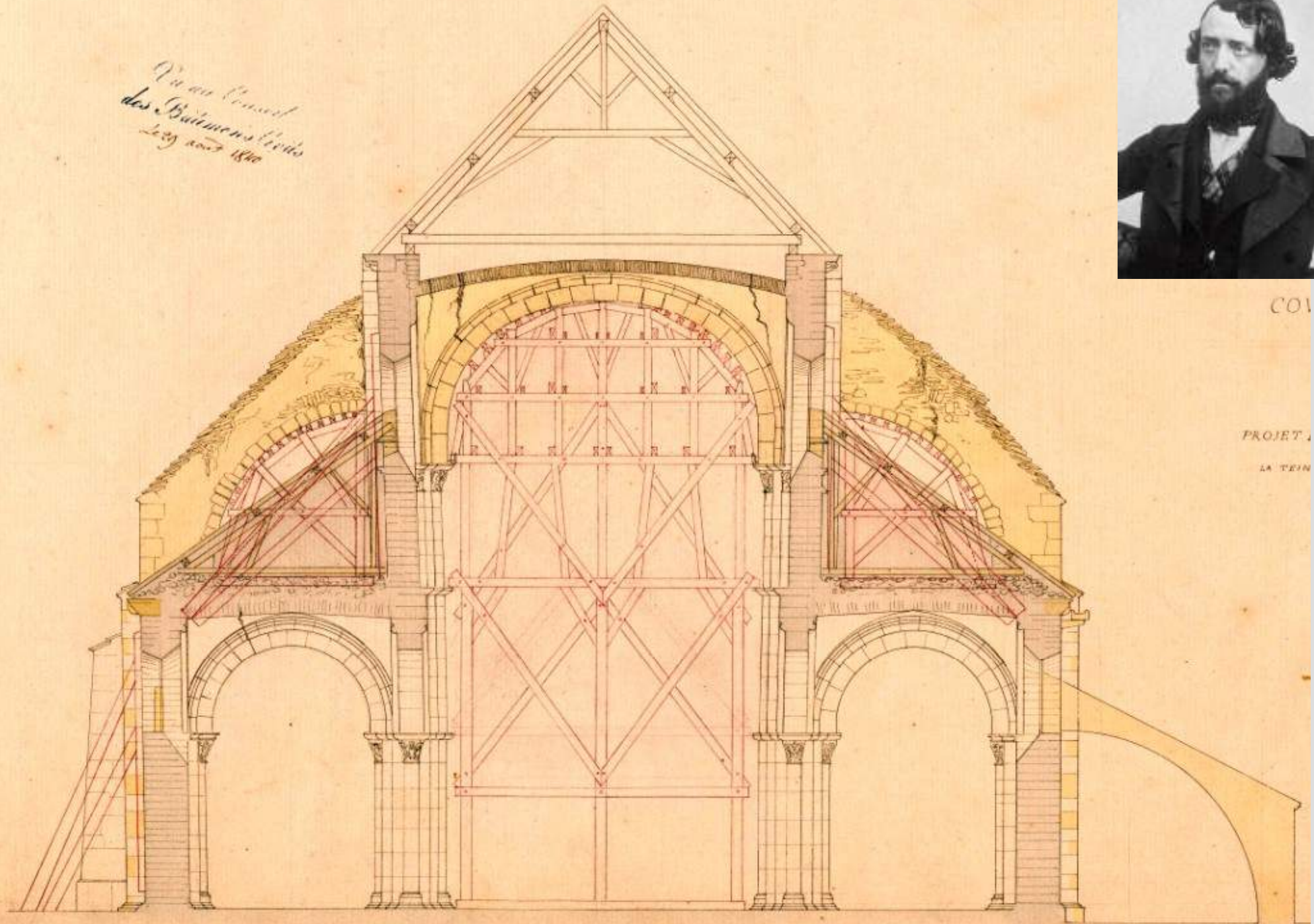
*Plan au Niveau
des Batiments de la
Légende 1840*



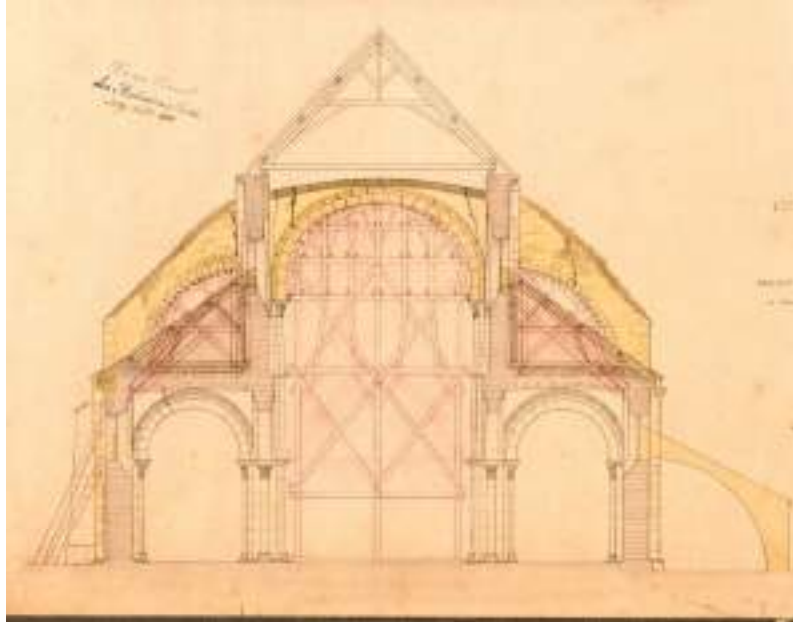
COU

PROJET

LA TEIN

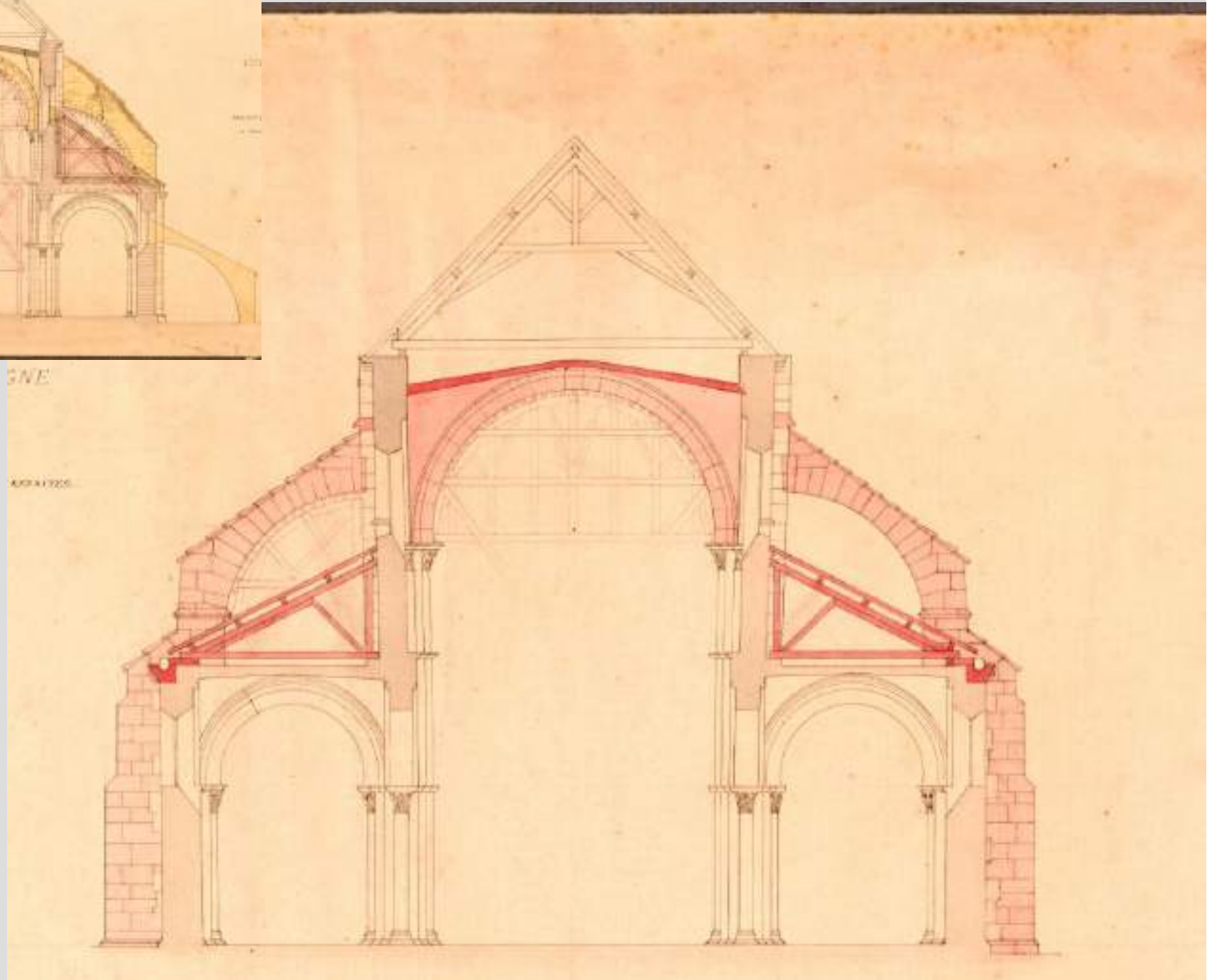


Basílica de Vézelay. Estado en 1840. Viollet-le-Duc

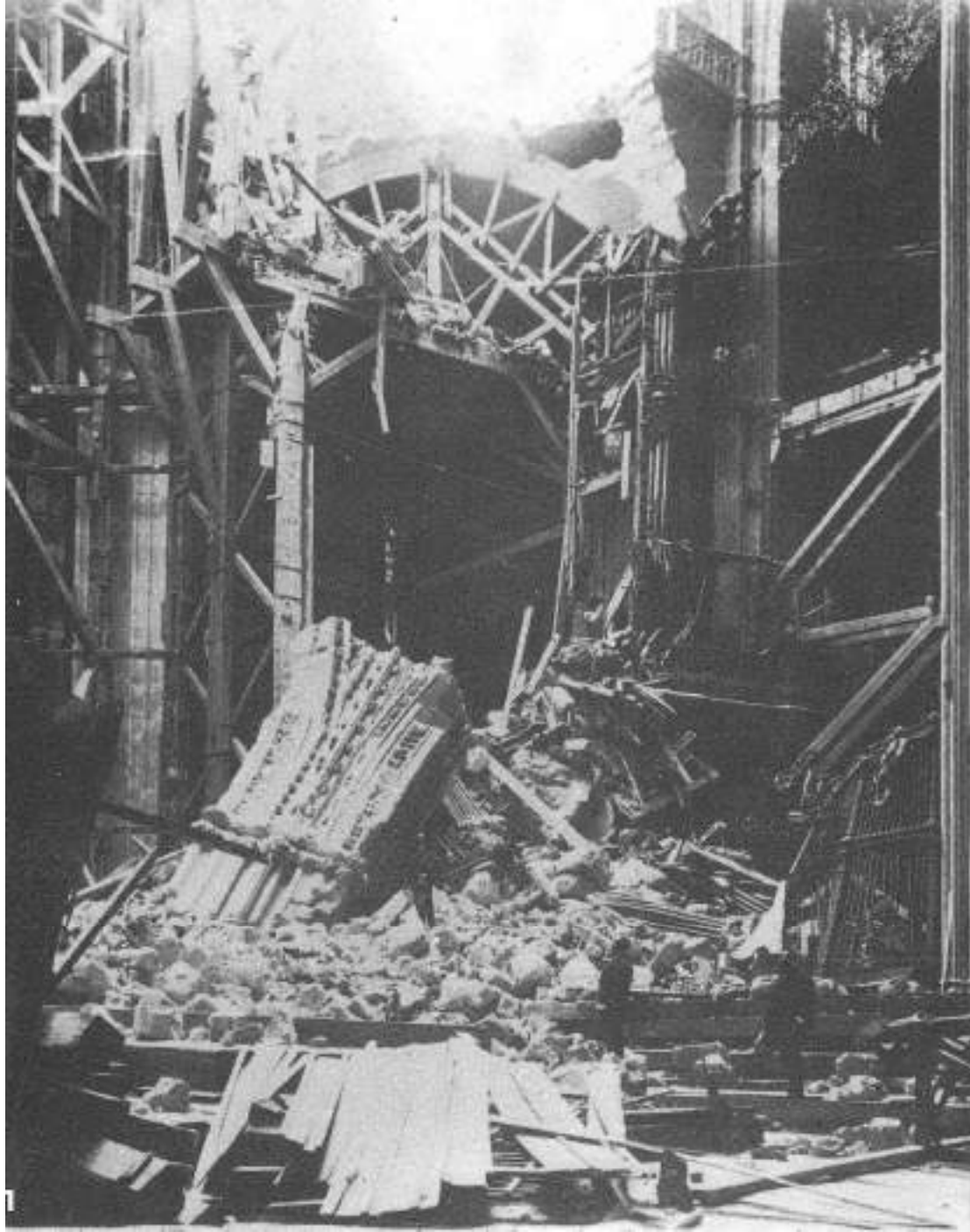


3NE

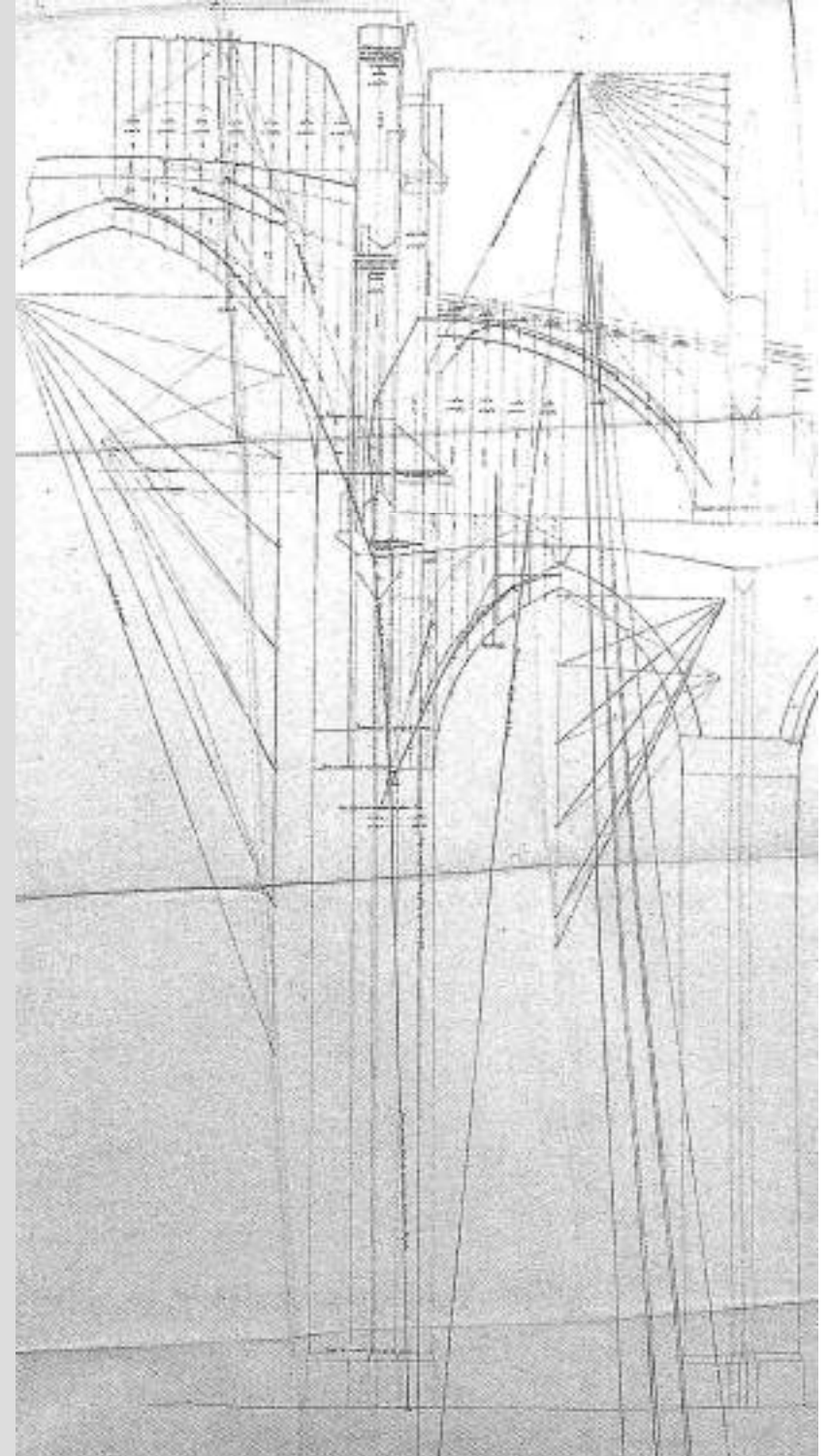
AUT. 1825



Basílica de Vézelay. Estado restaurado. Viollet-le-Duc

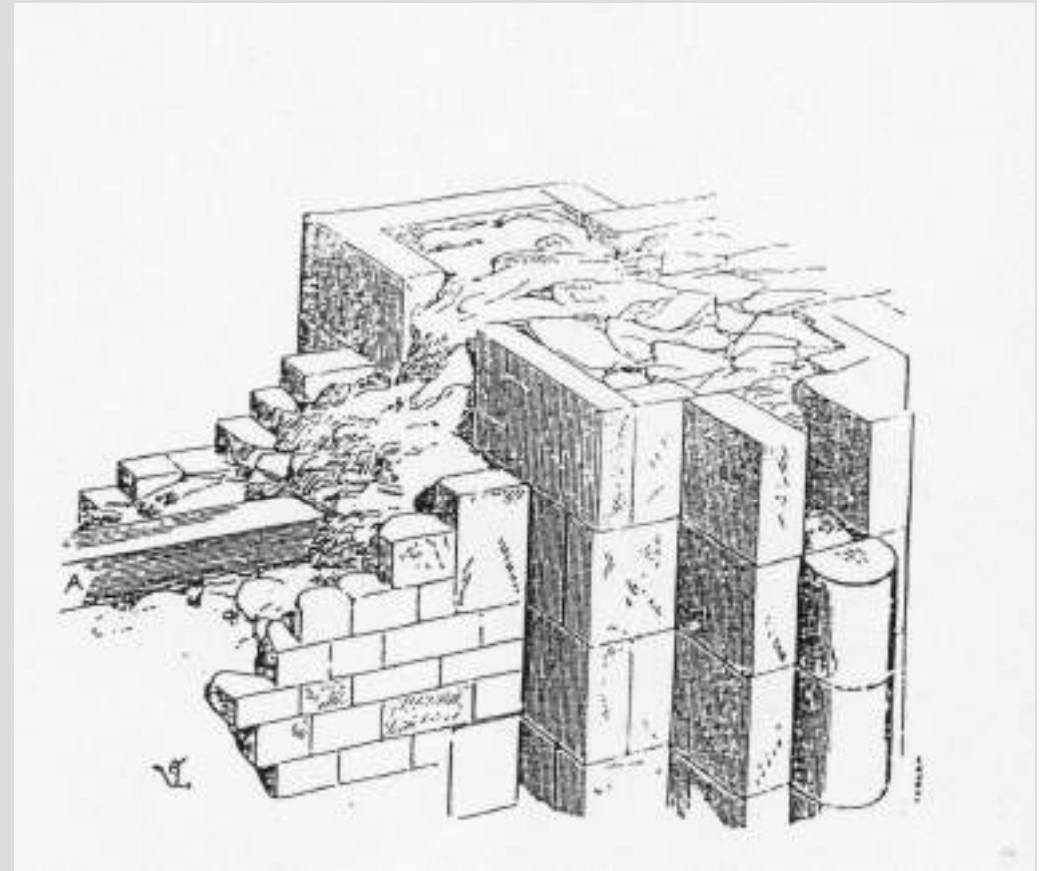
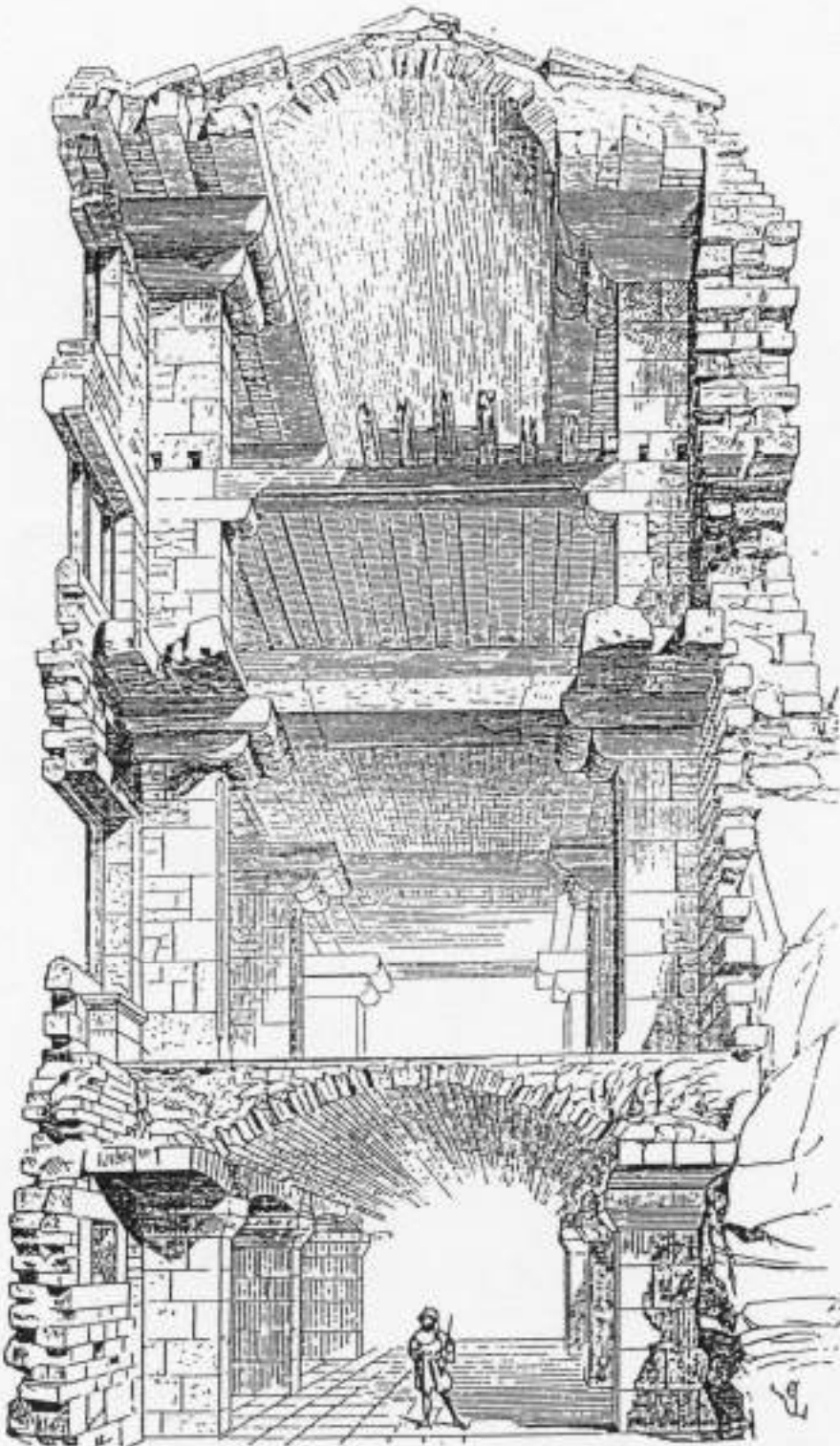


Catedral de Sevilla. Colapso del crucero 1888



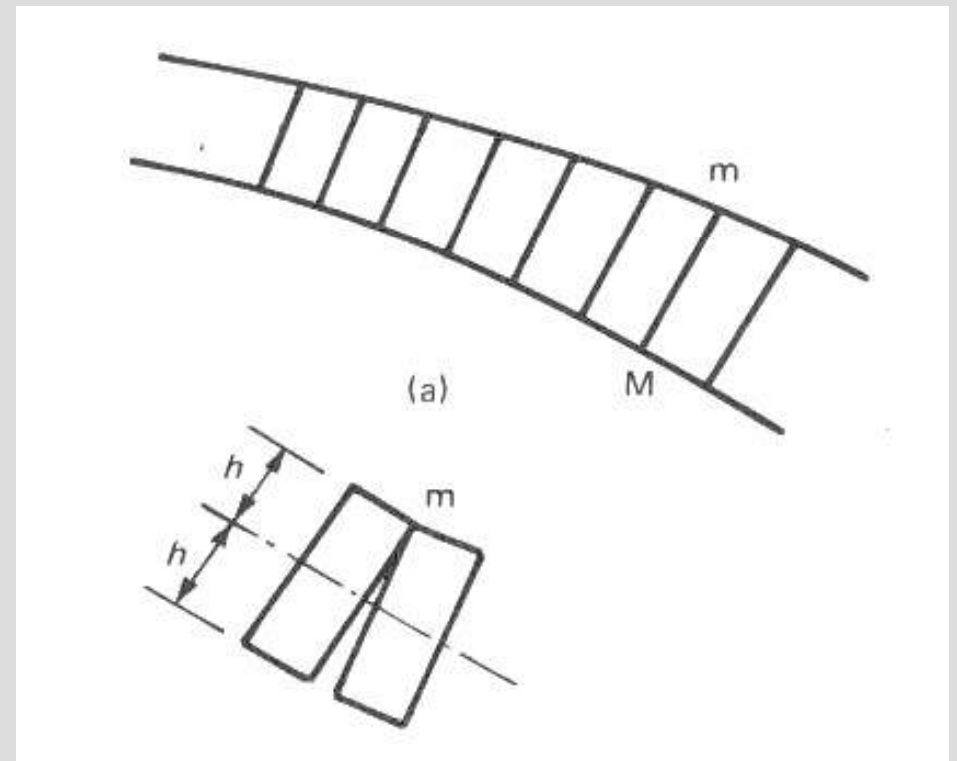
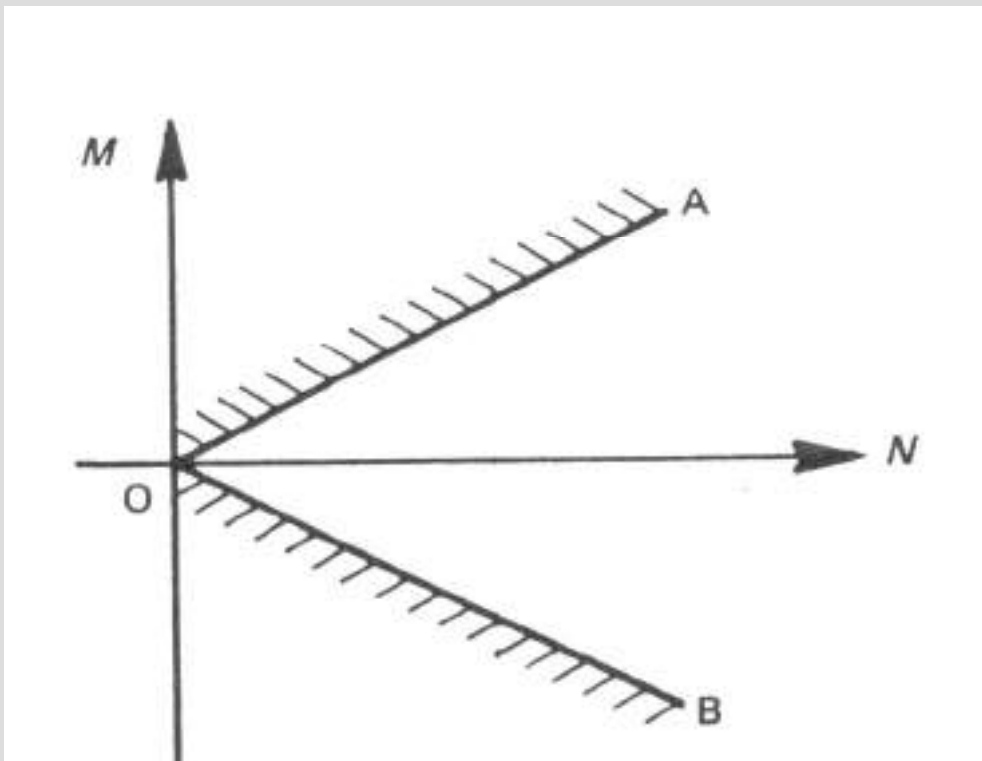
Análisis estático Fernández Casanova ca. 1890

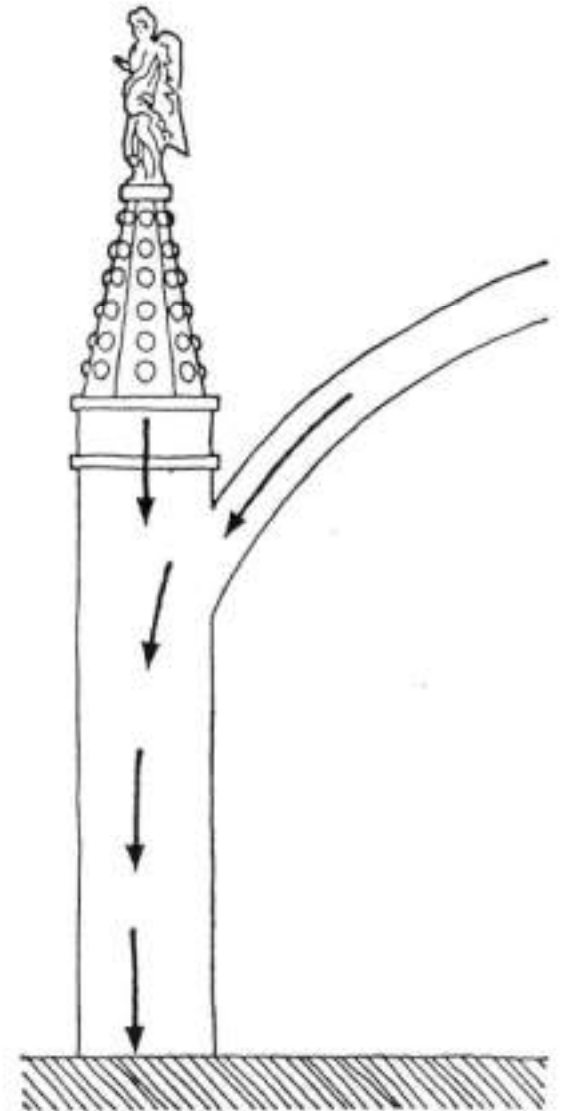
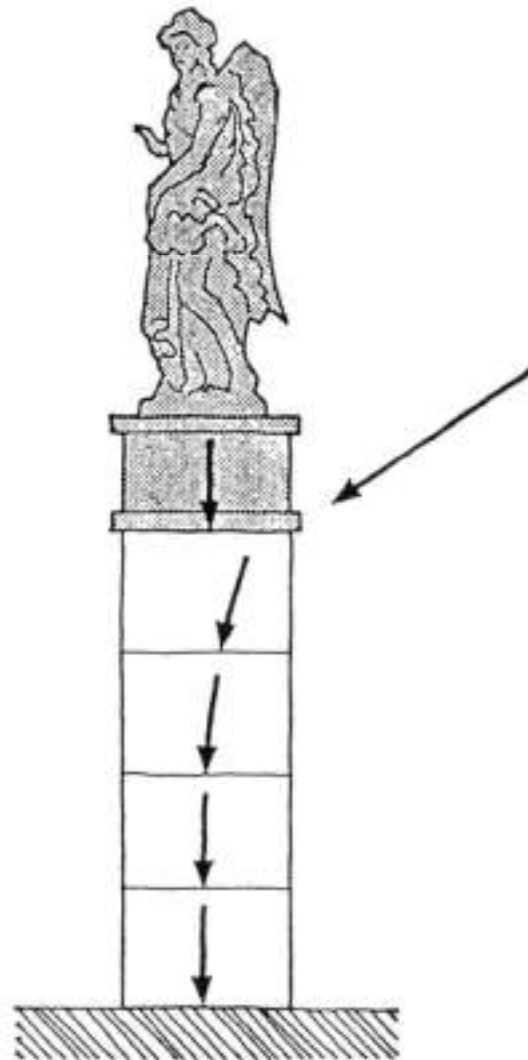
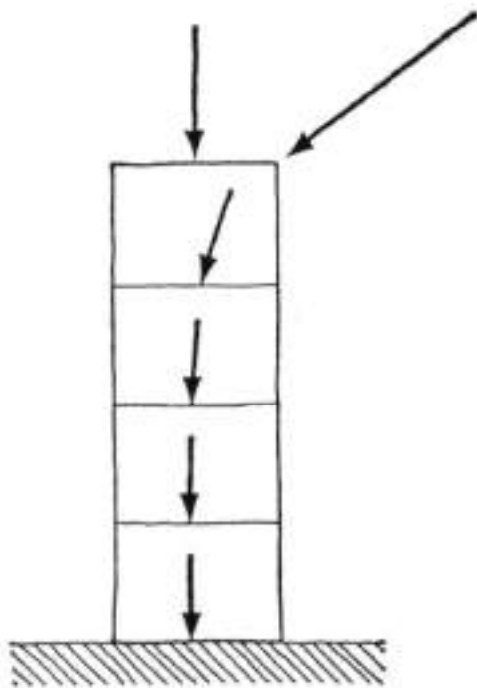
El material Mampostería



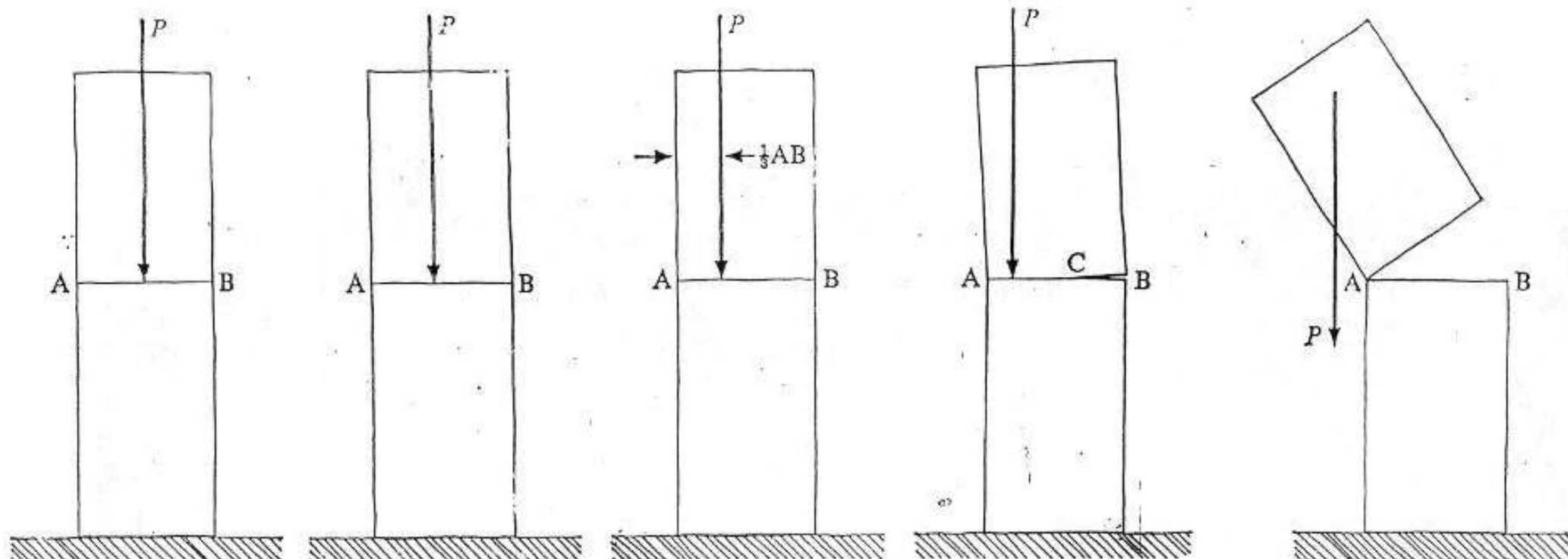
Principios del Análisis Límite de las Mamposterías (Heyman)

- 1) Resistencia a compresión infinita
- 2) Zero tensile strength
- 3) Deslizamiento imposible



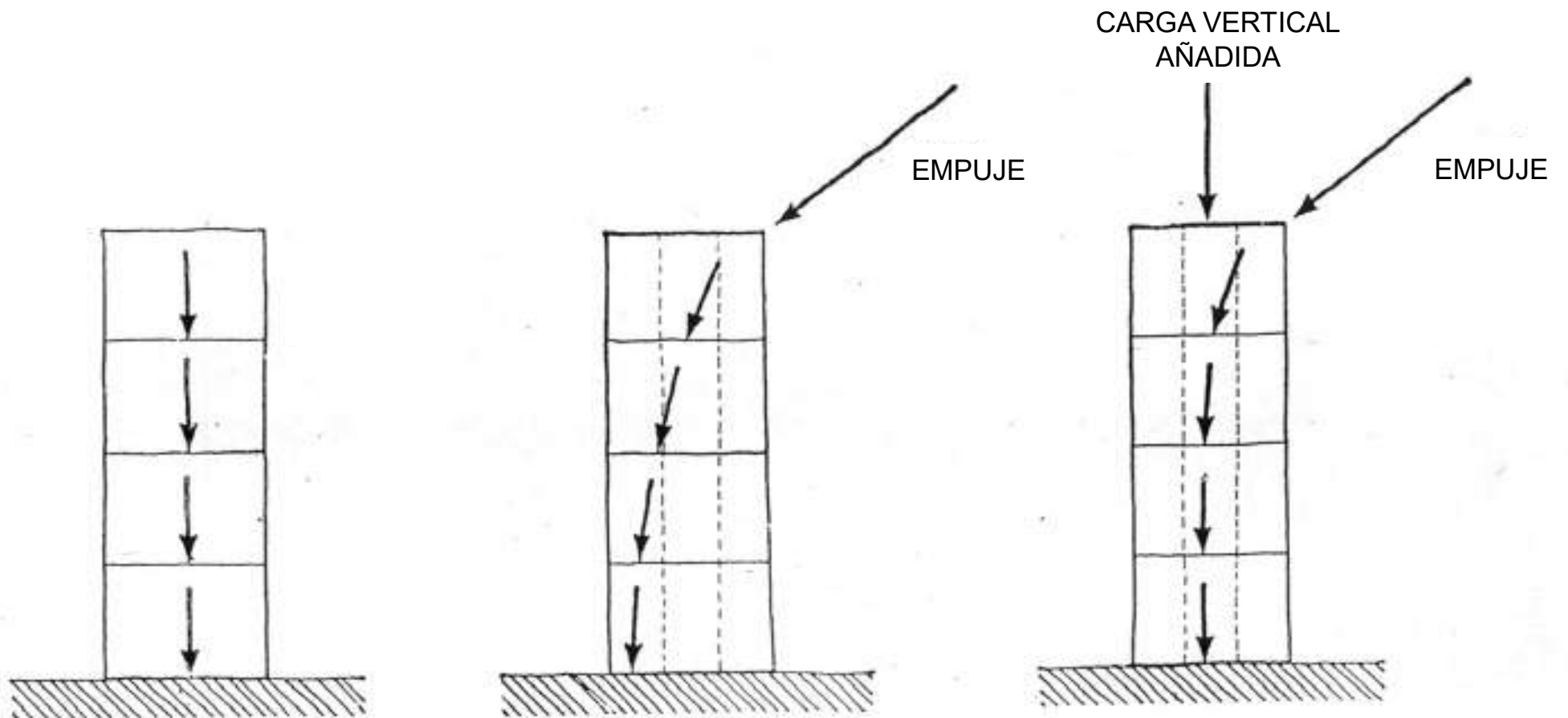


(Gordon 1999)

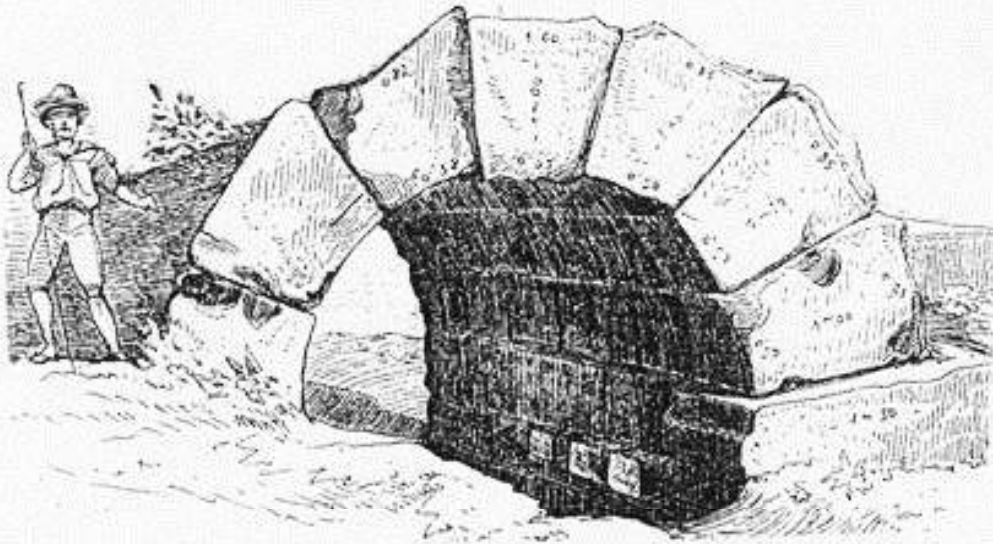


(Gordon 1999)

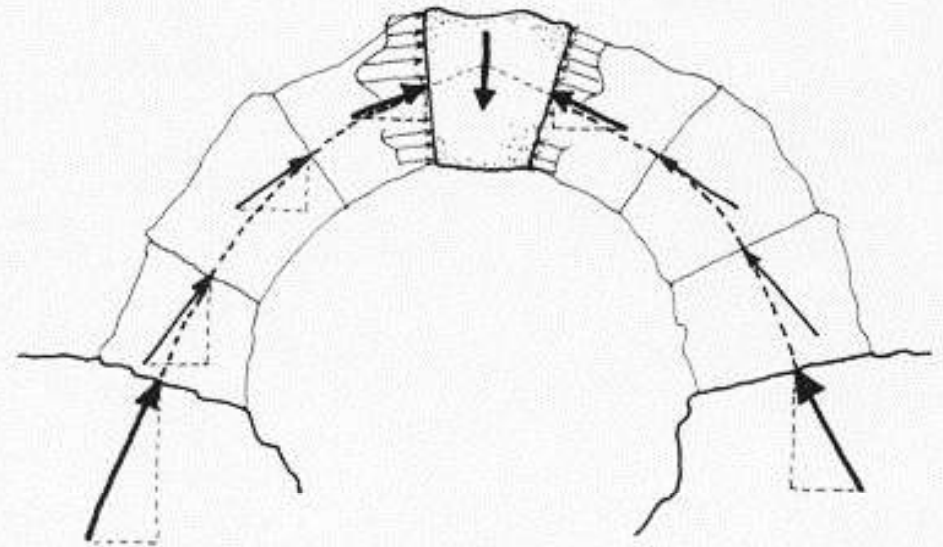
Equilibrio a compresión: Líneas de empujes



Equilibrio de arcos



(a)



(b)

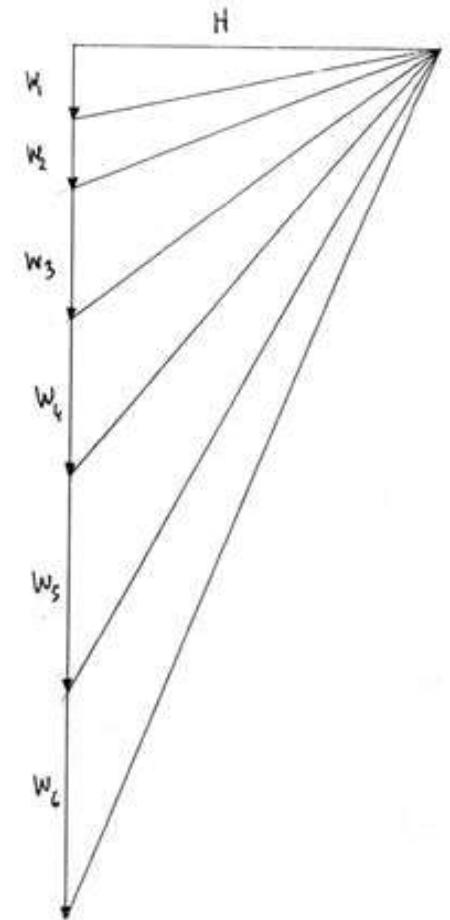
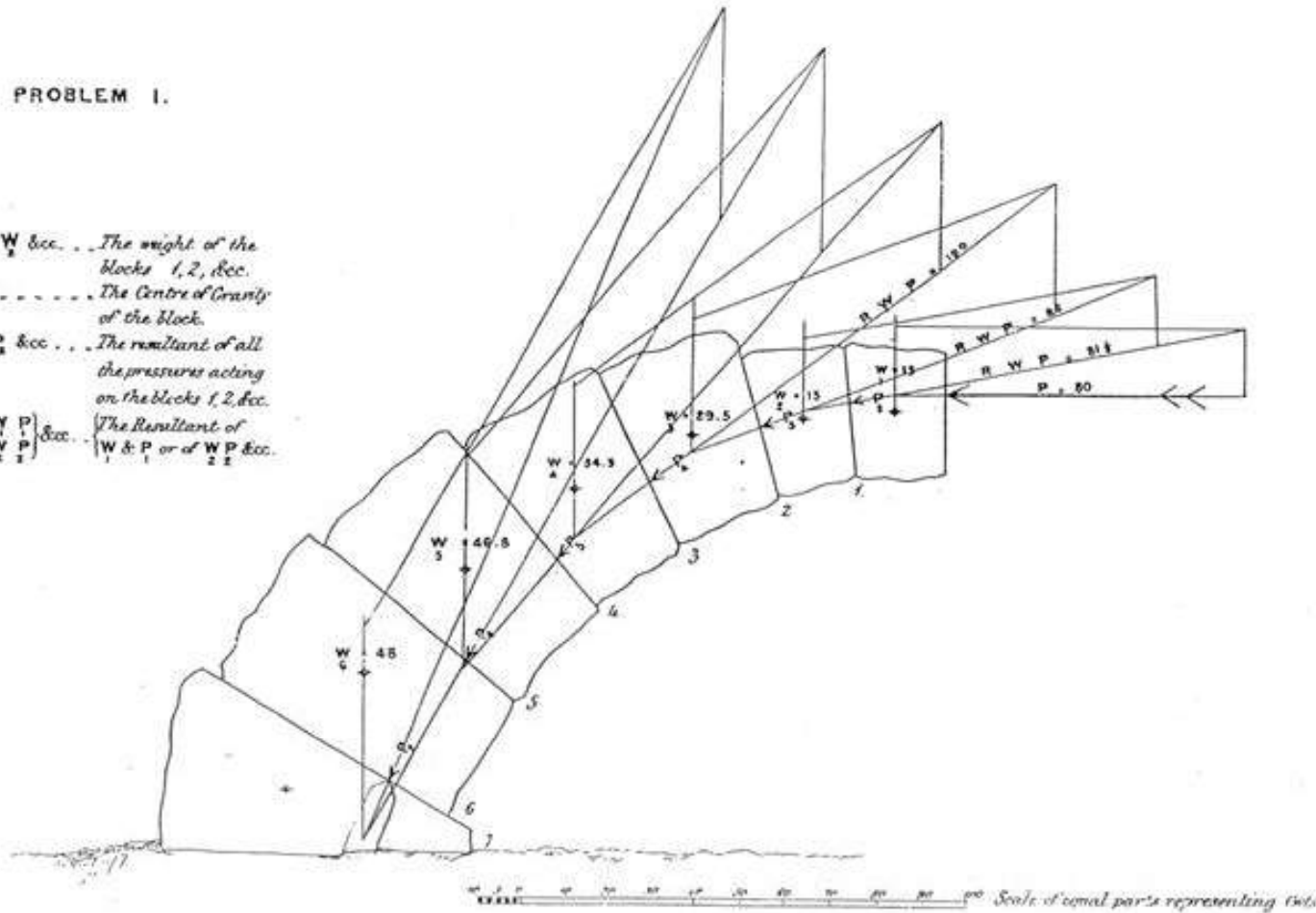
“El arco nunca duerme” Proverbio árabe

STABILITY OF ARCHES.

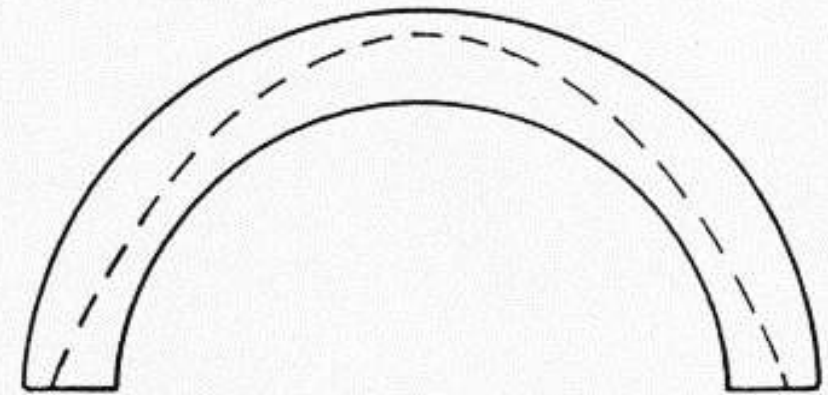
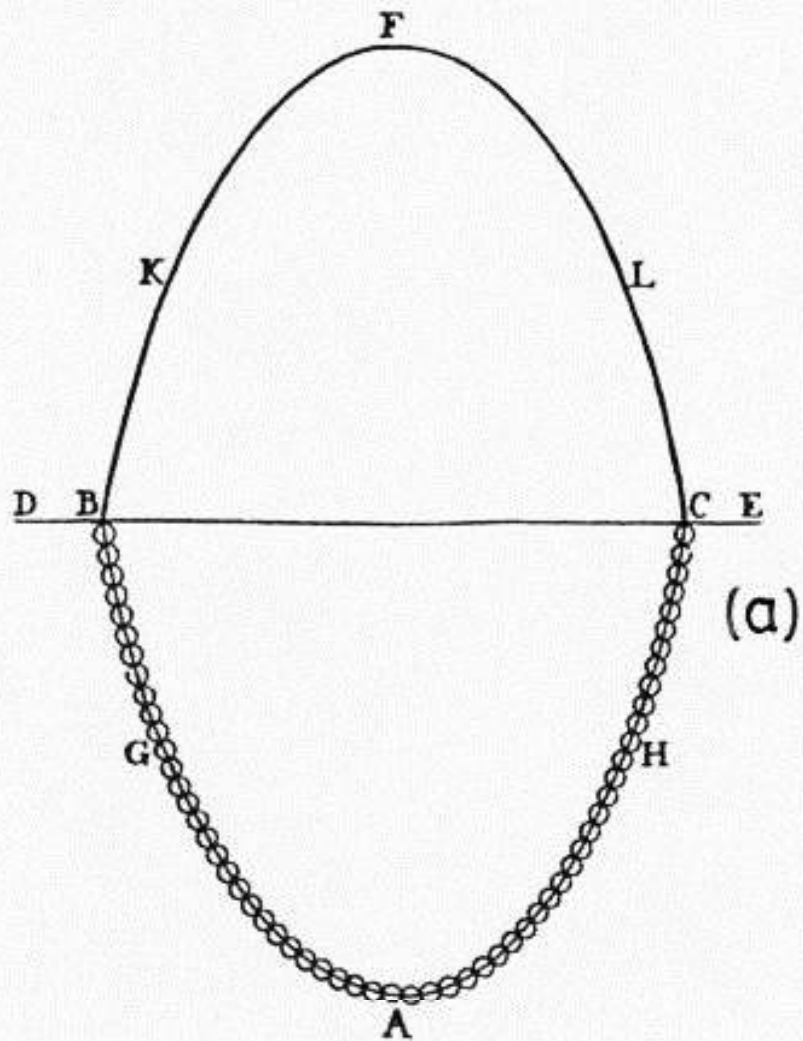
PLA

PROBLEM I.

- W, W_1 &c. . . The weight of the blocks 1, 2, &c.
 $+ \dots$. . . The Centre of Gravity of the block.
 P, P_1 &c. . . The resultant of all the pressures acting on the blocks 1, 2, &c.
 R, W, P } &c. . . The Resultant of W & P or of W, P &c.
 R, W, P } &c. . . The Resultant of W, P or of W, P &c.

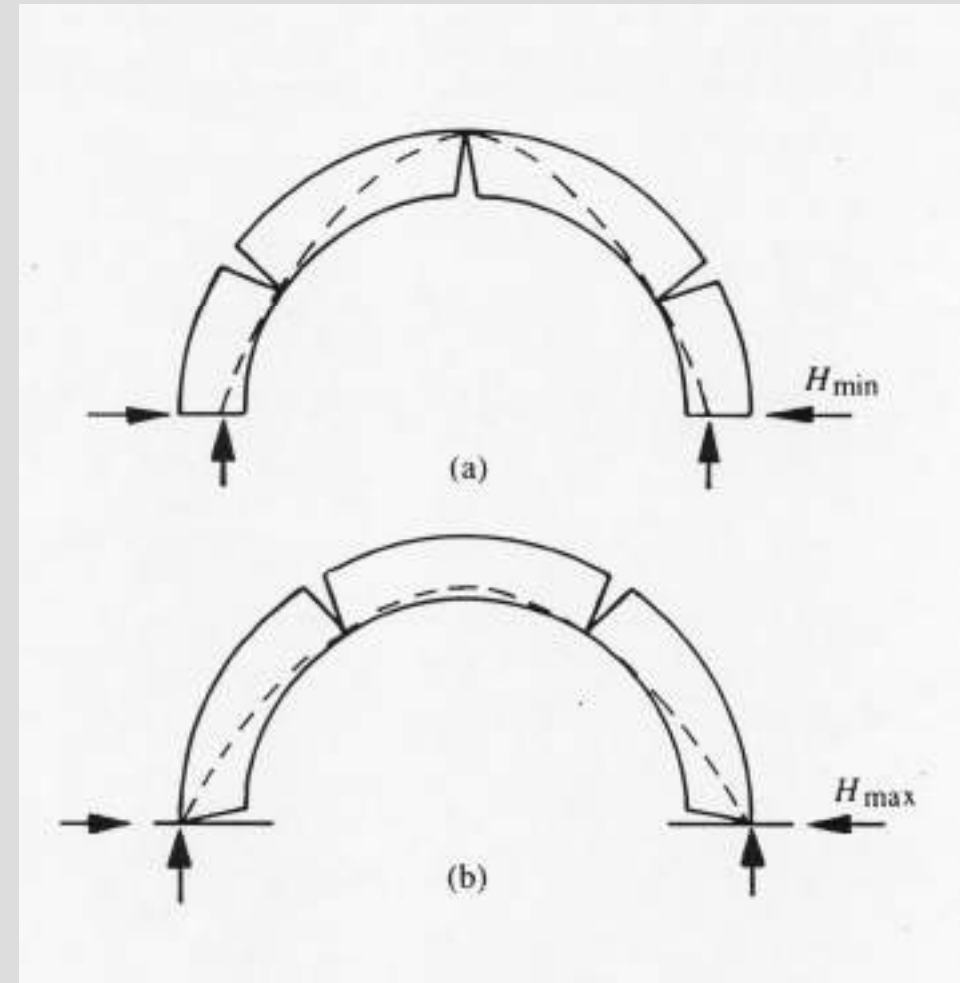
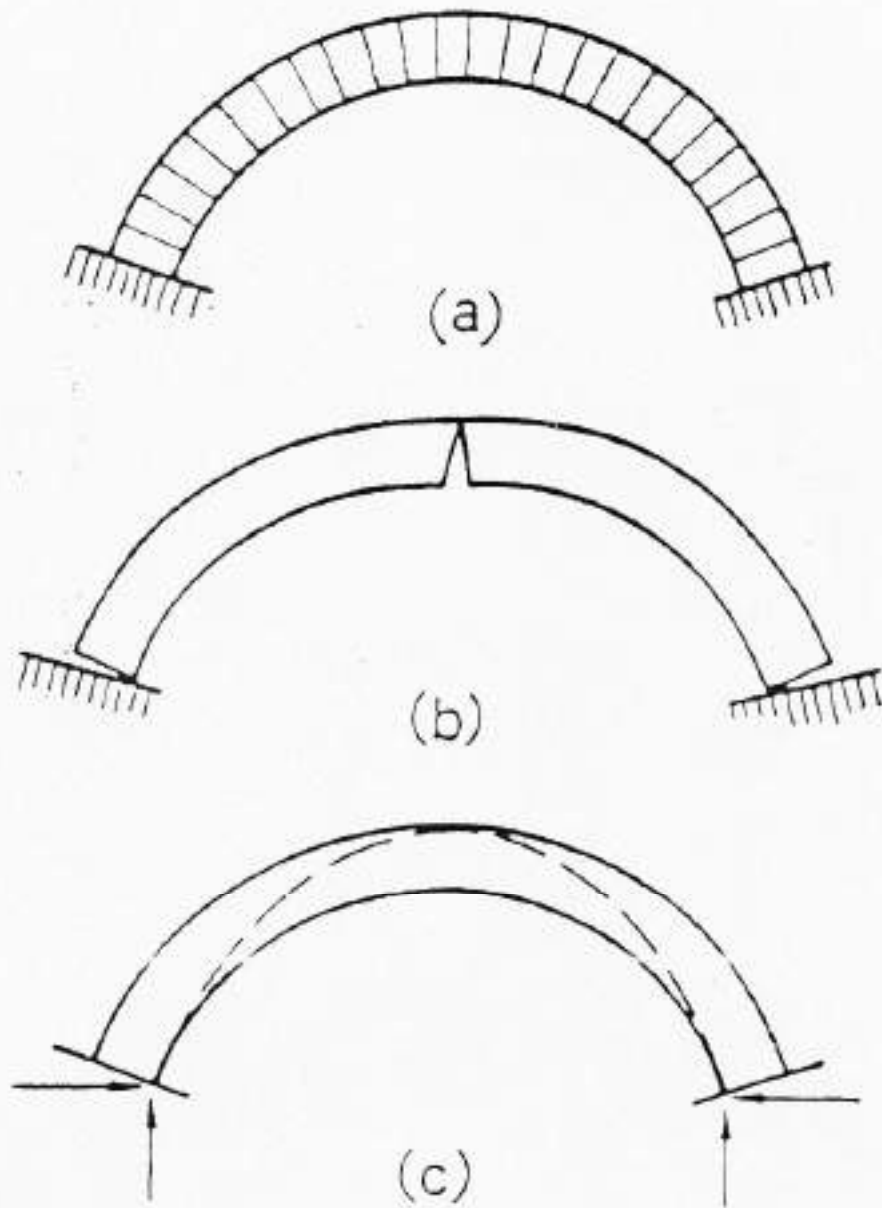


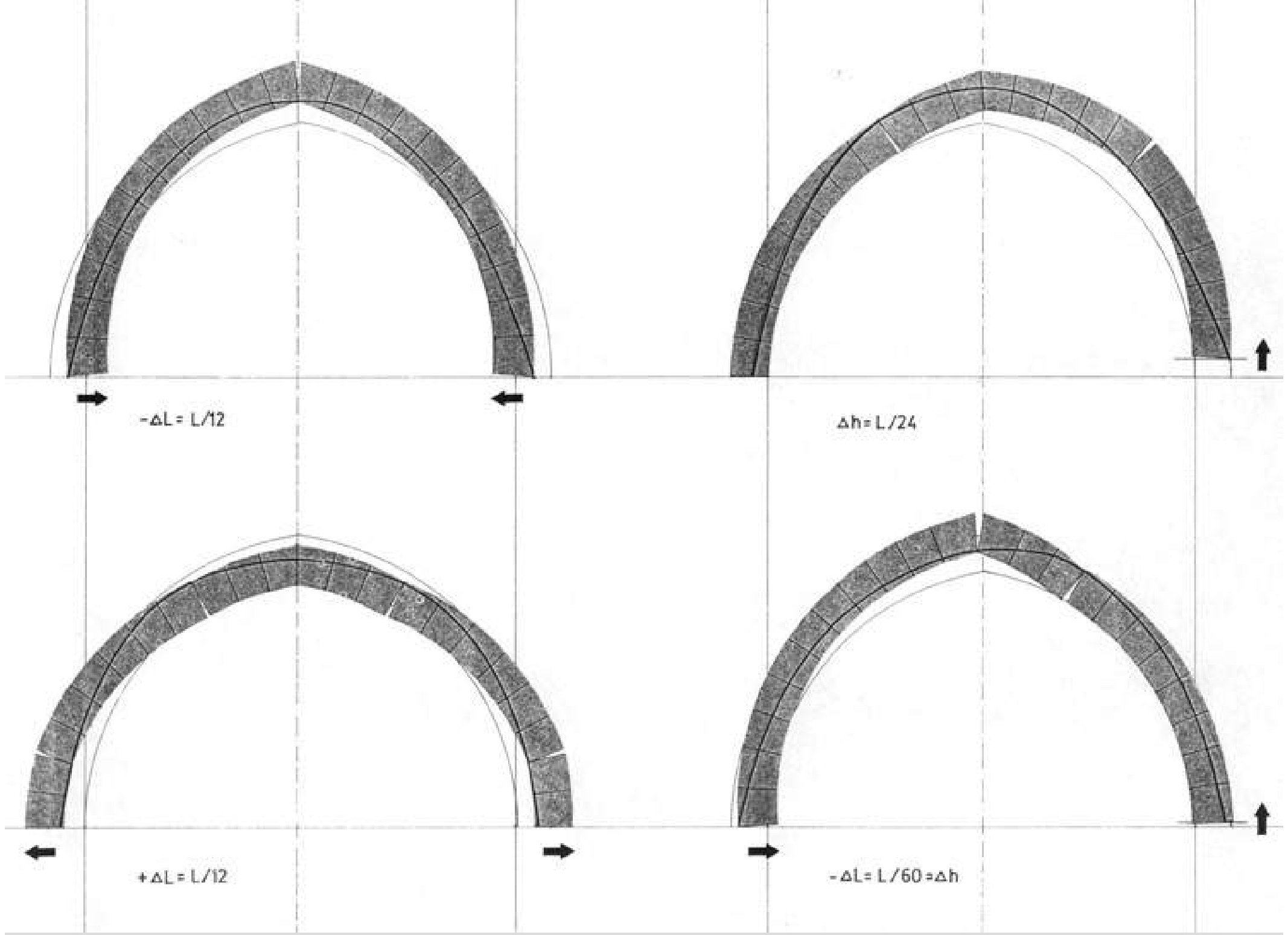
“El arco es una fortaleza formada por dos debilidades” Leonardo da Vinci

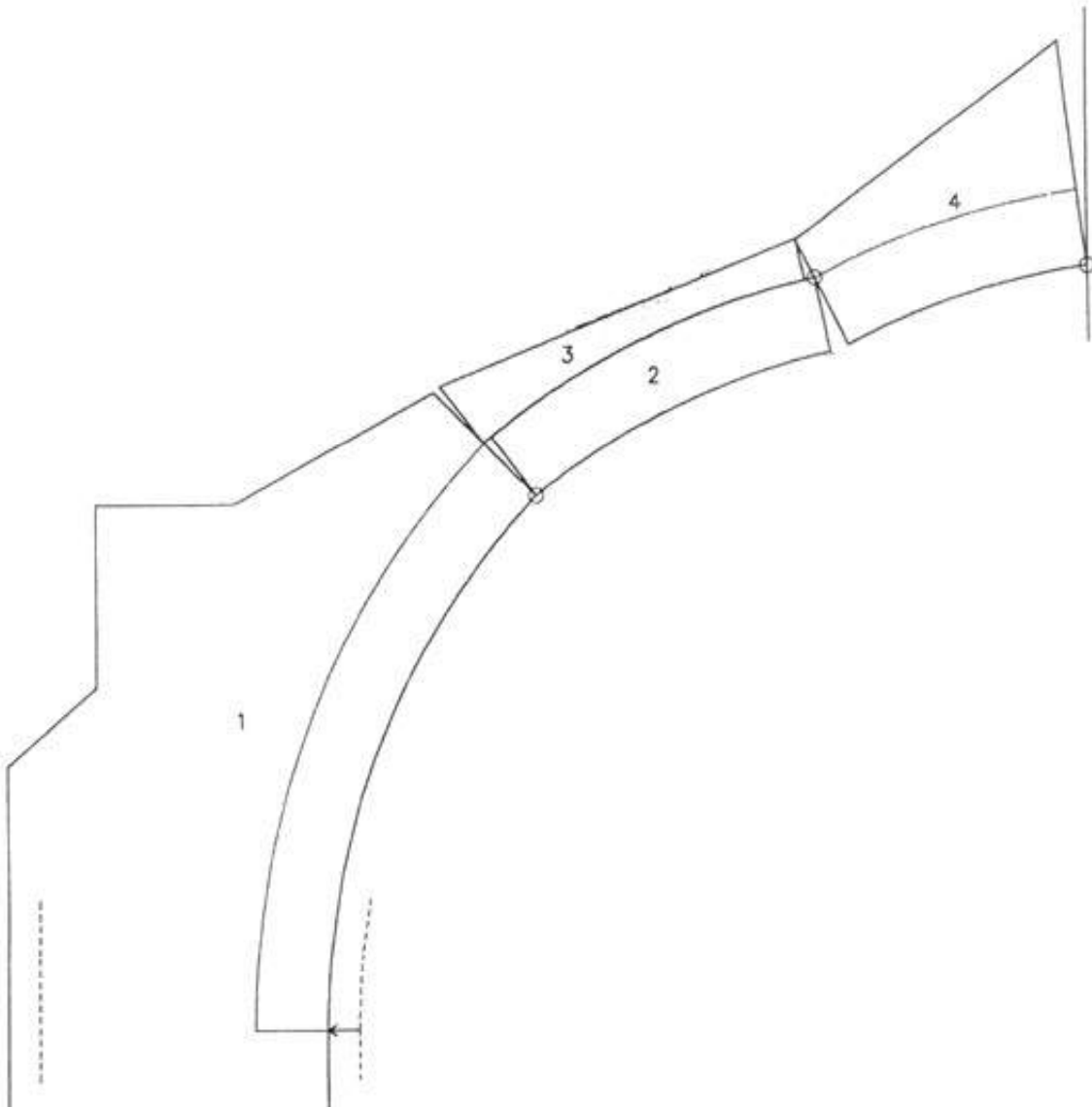


“Como cuelga el hilo flexible, así, pero invertido, se sostendrá el arco rígido”
Robert Hooke (1675)

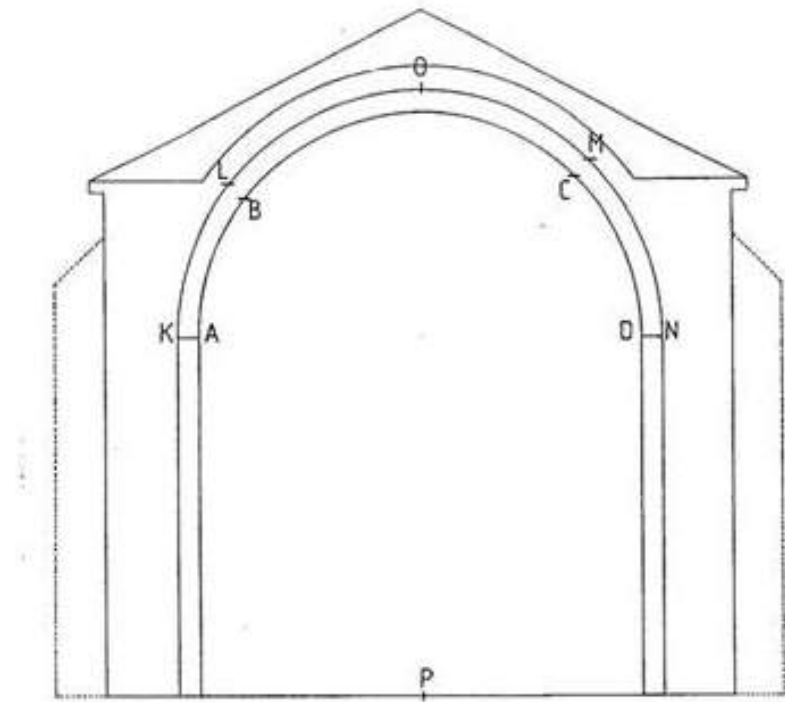
Grietas y plasticidad



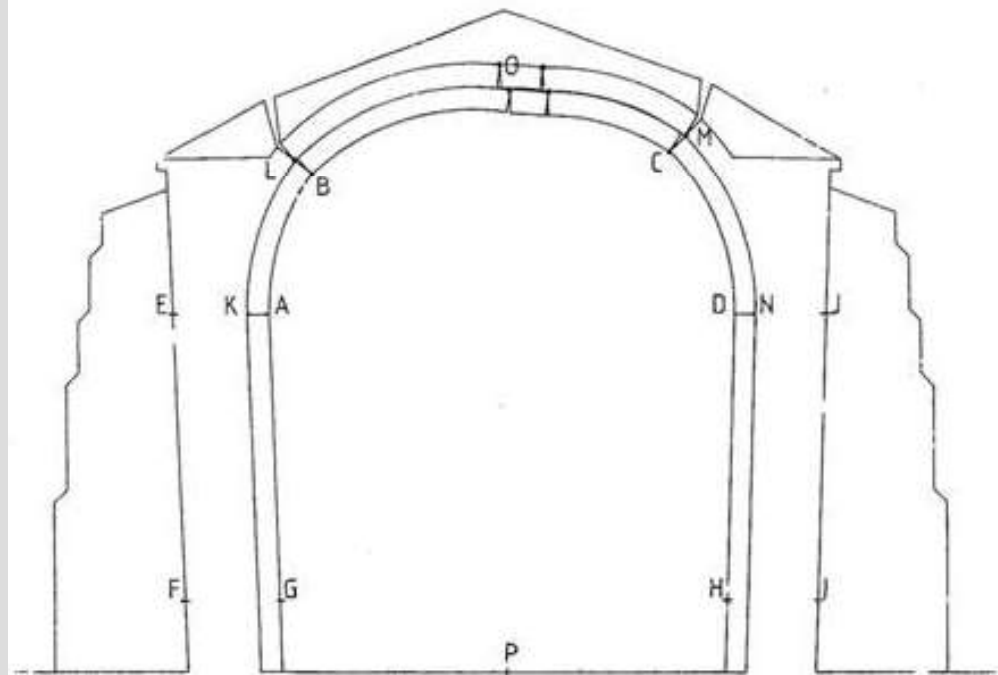




(Smars 2000)

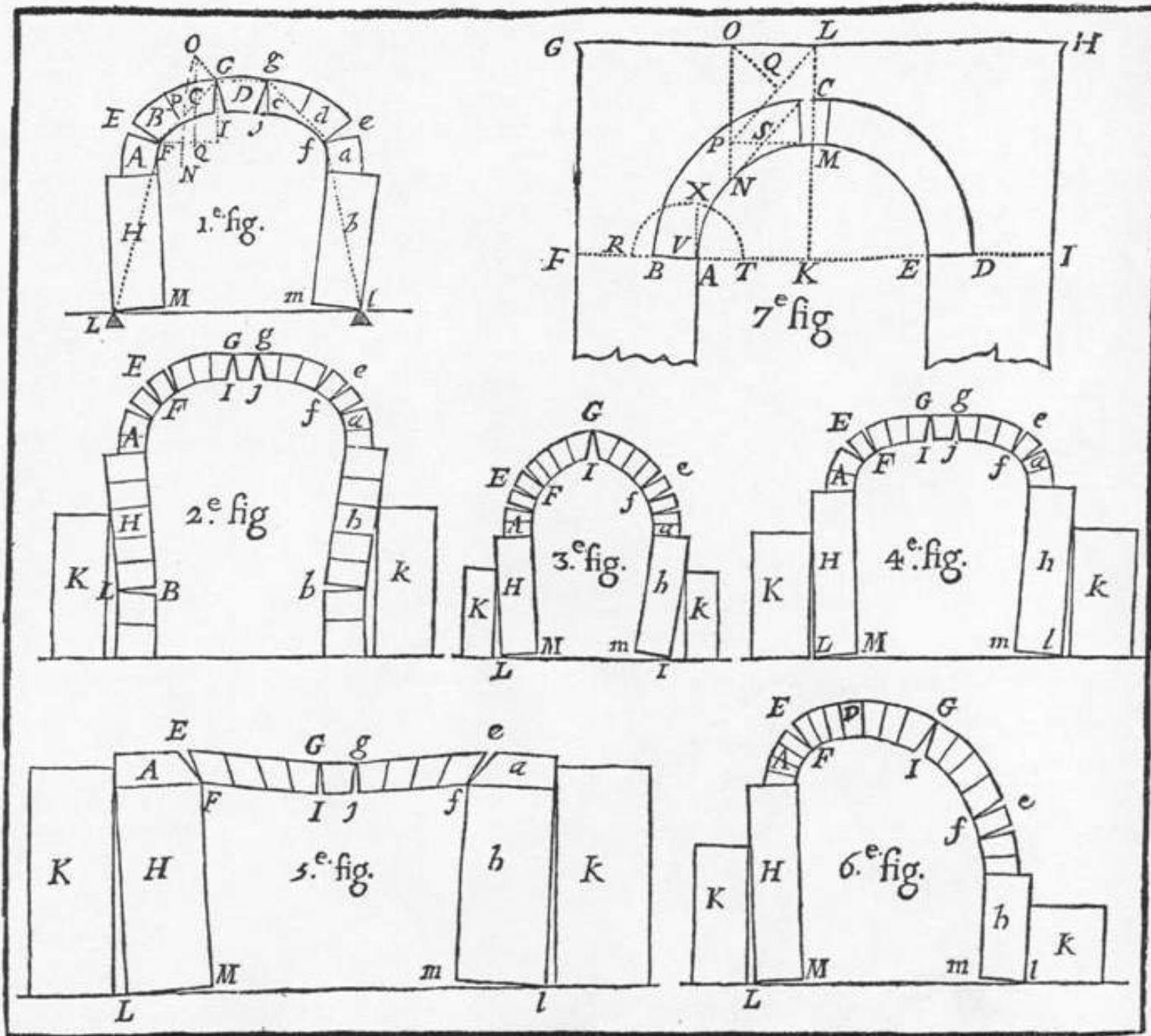


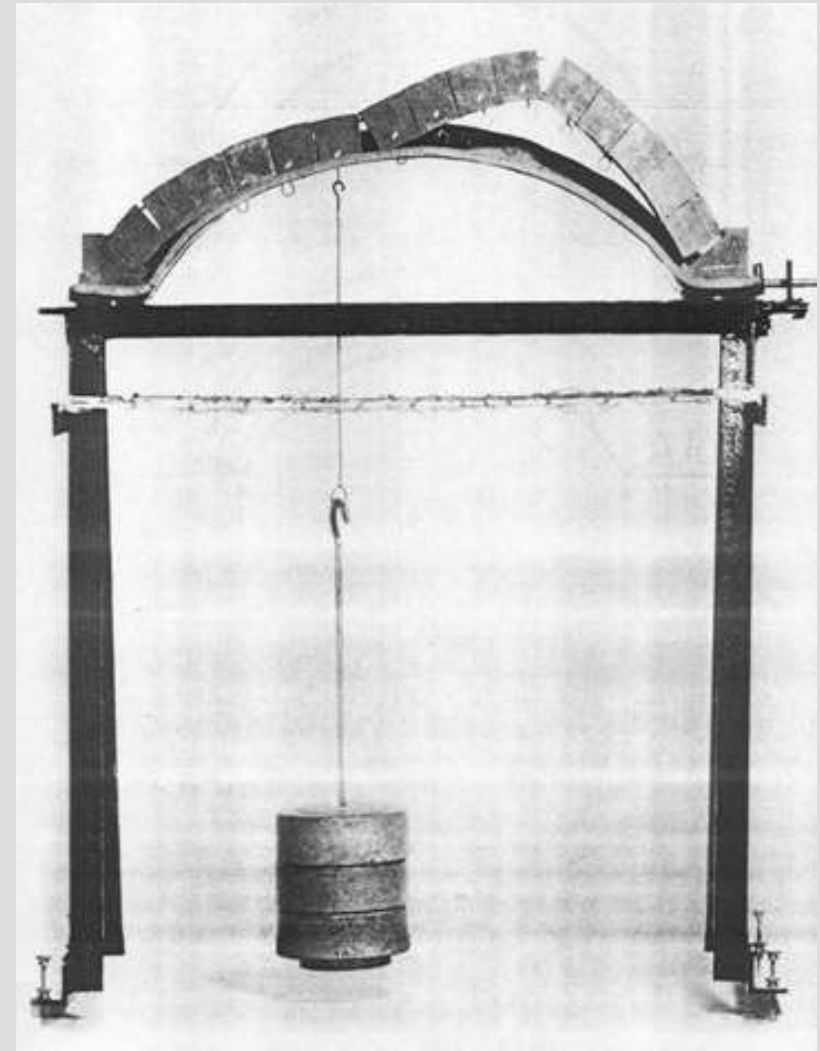
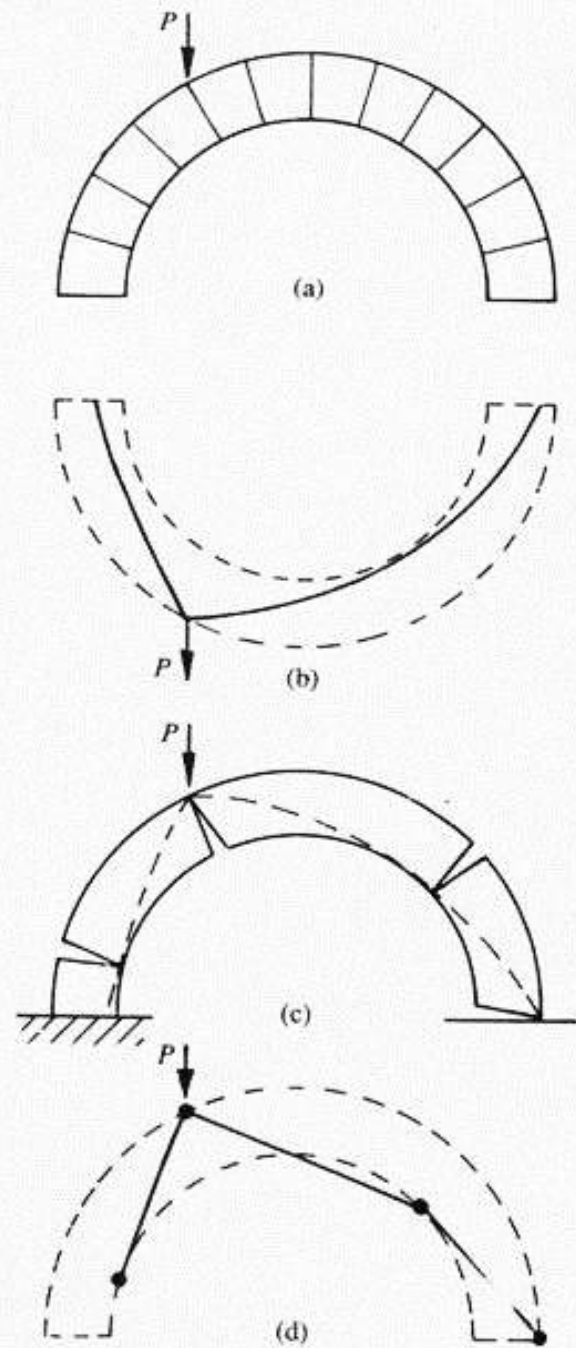
0 1 m



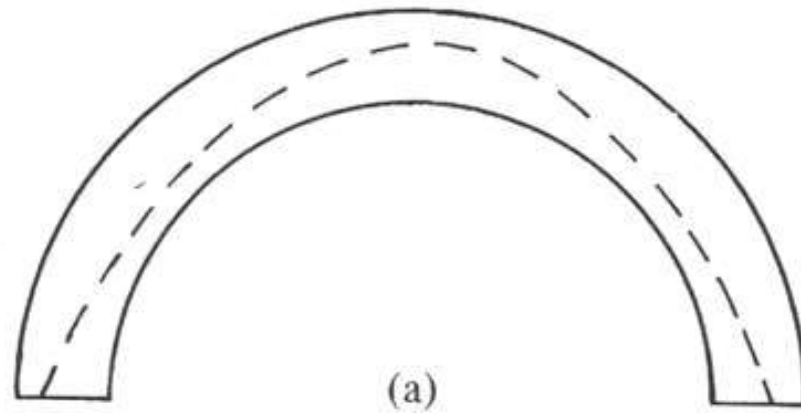
(Huerta, López 1996)

Colapso de arcos



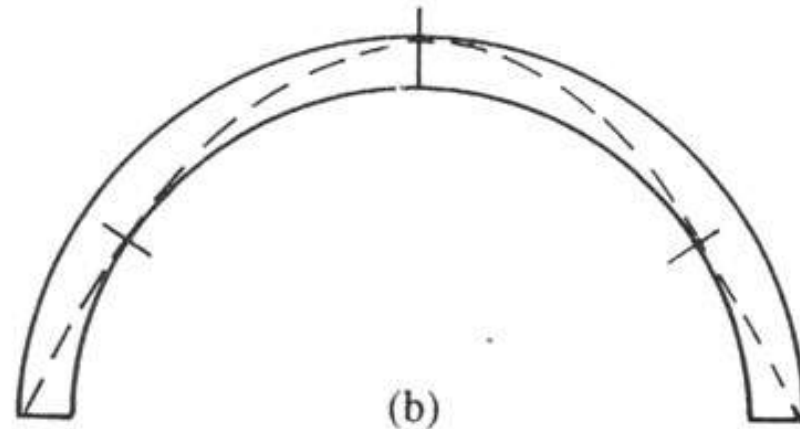


Seguridad geométrica



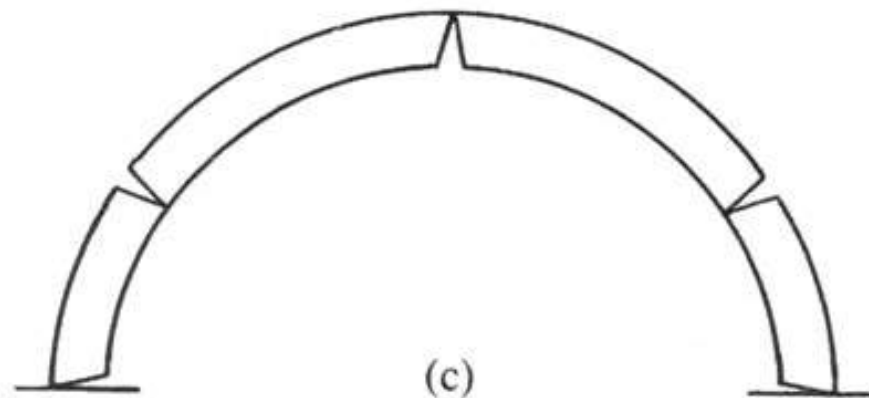
(a)

Arco real



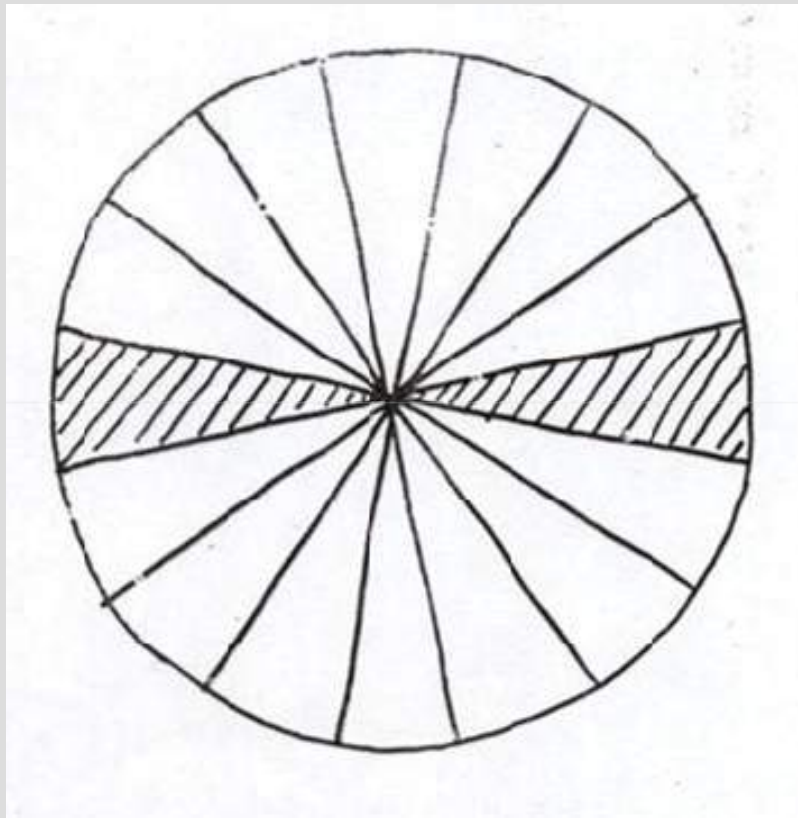
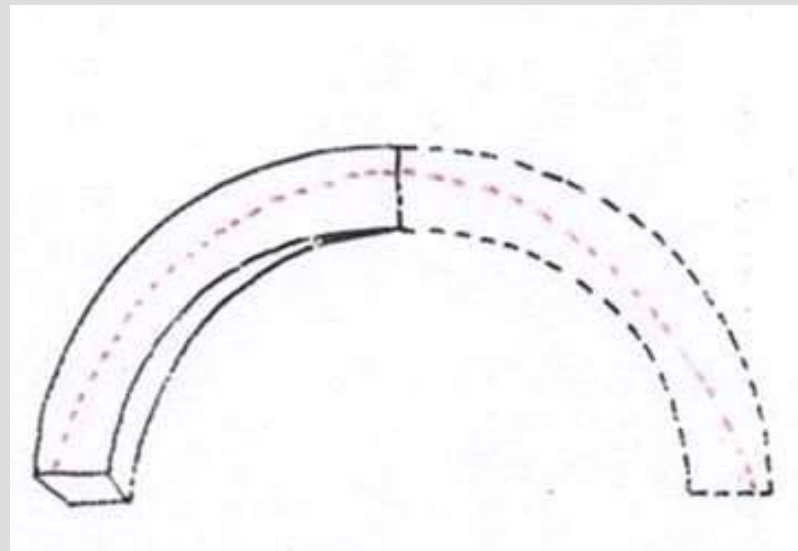
(b)

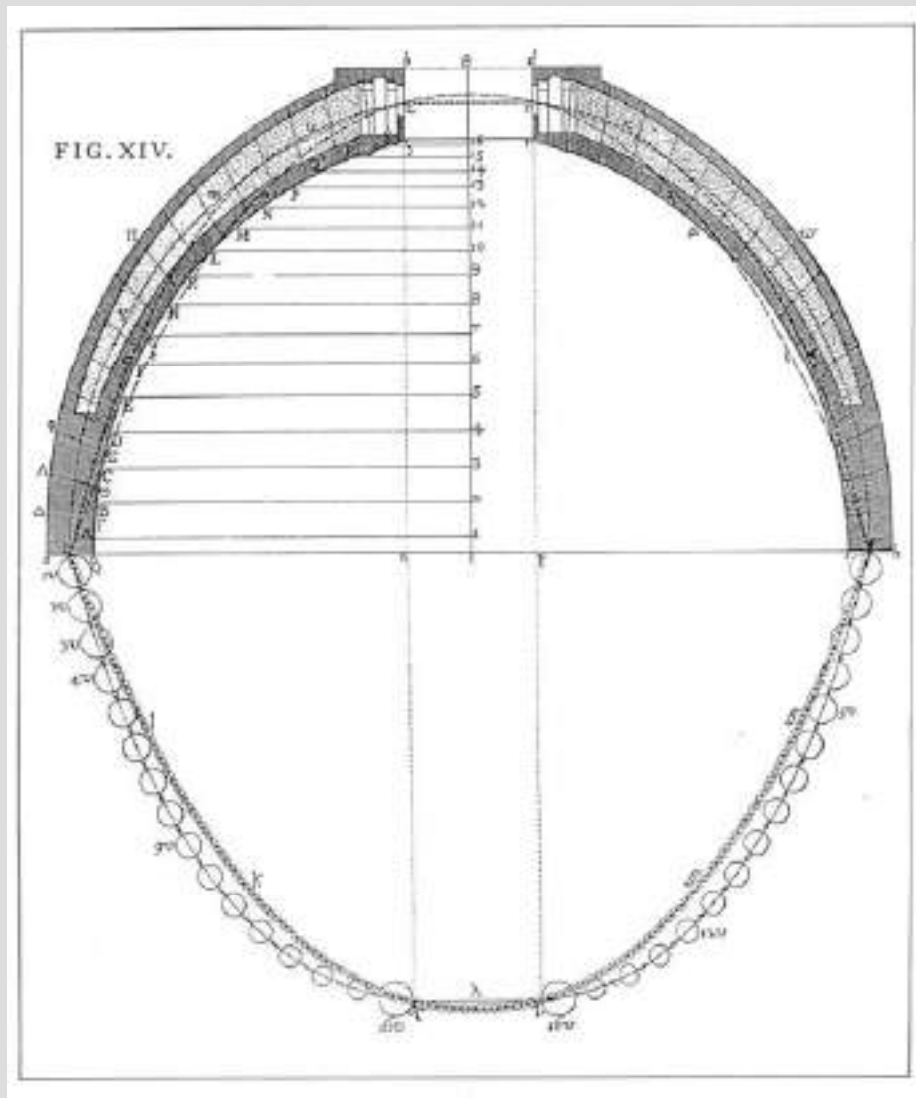
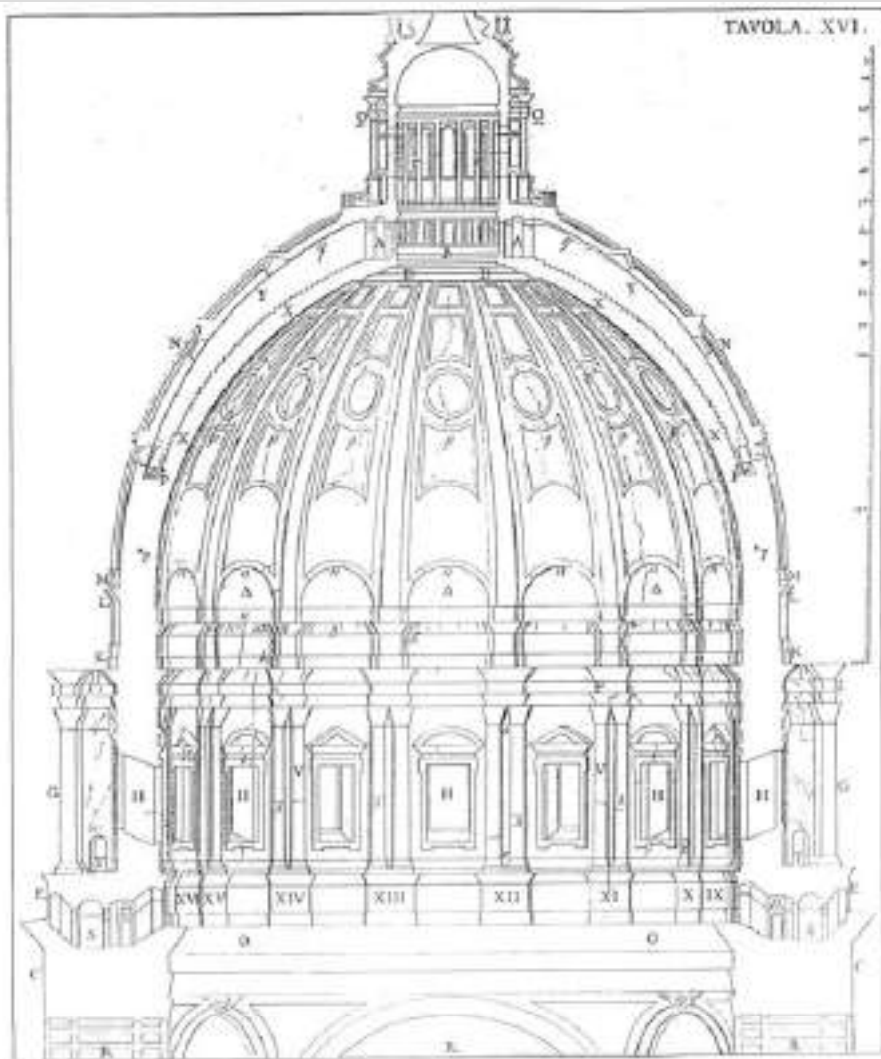
Arco límite

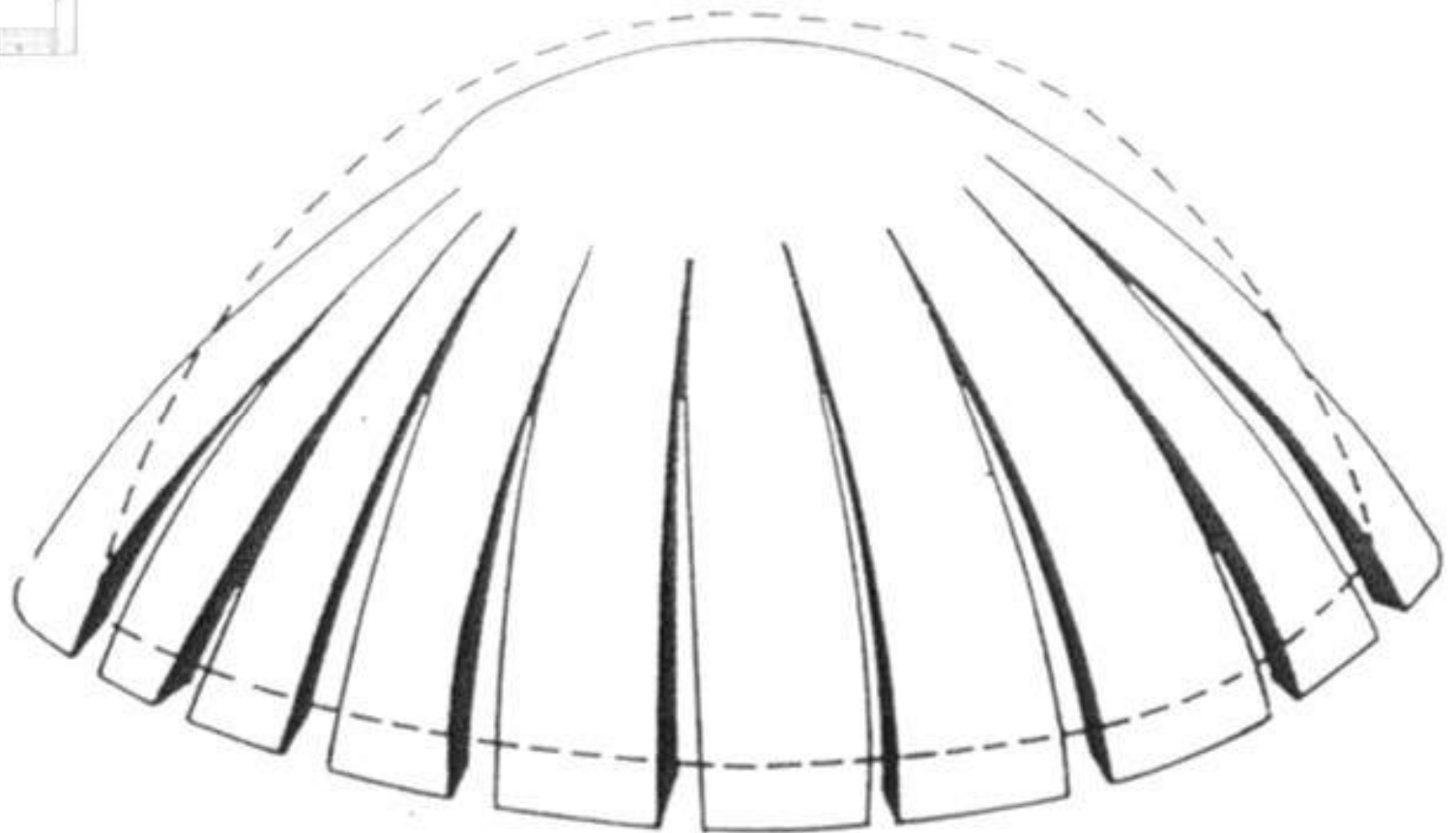
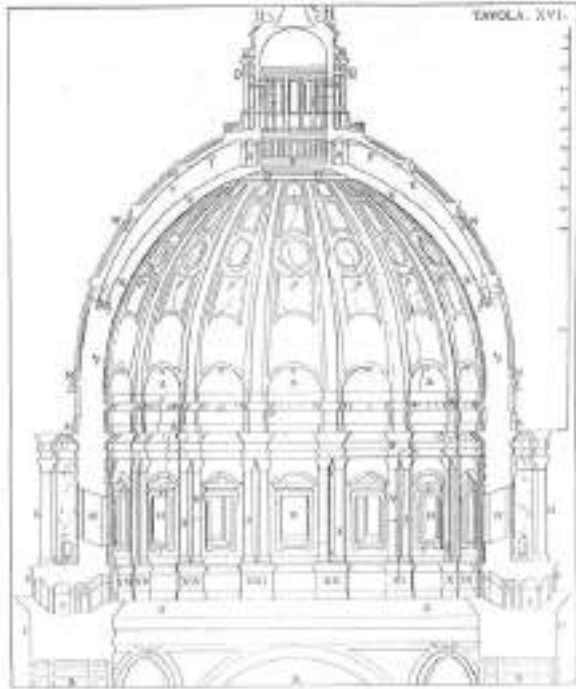


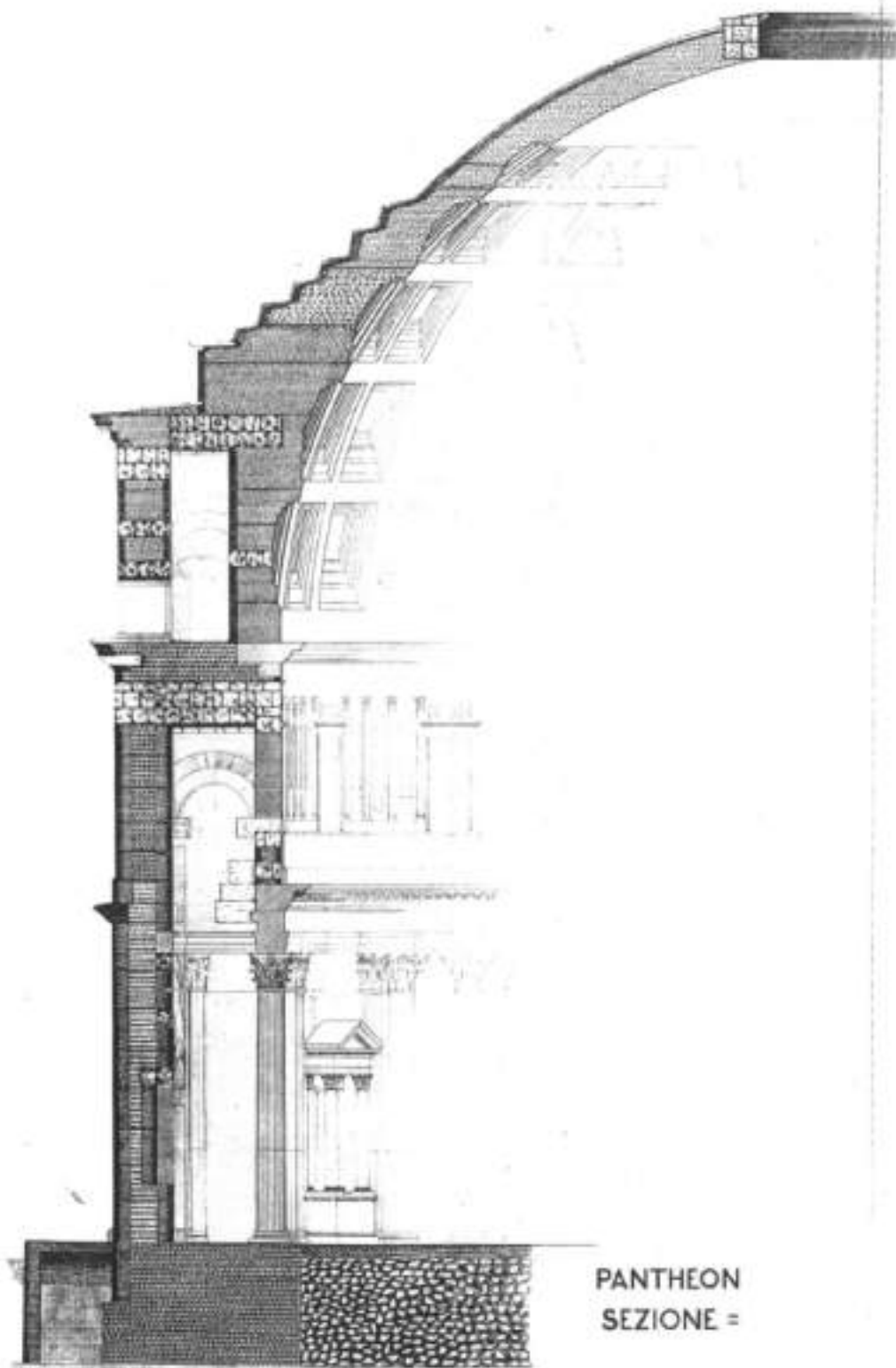
(c)

(Heyman 1995)

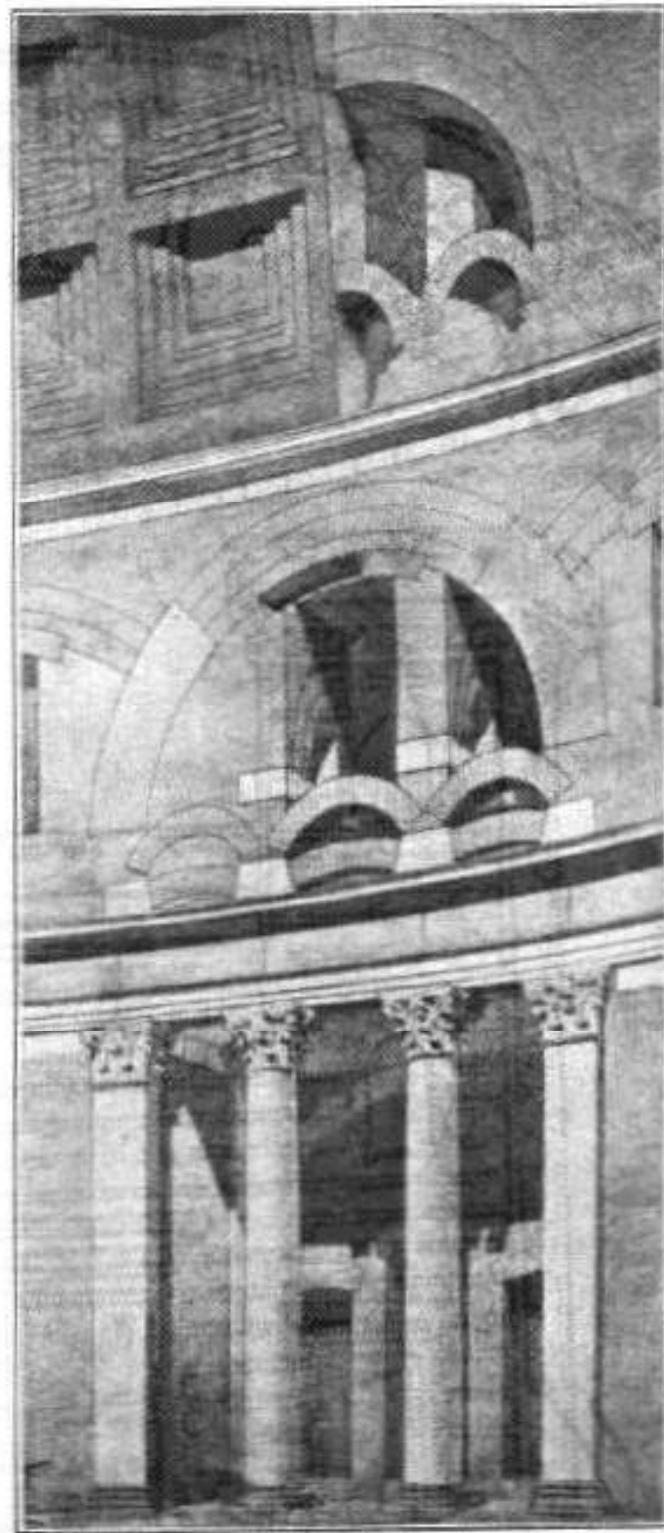


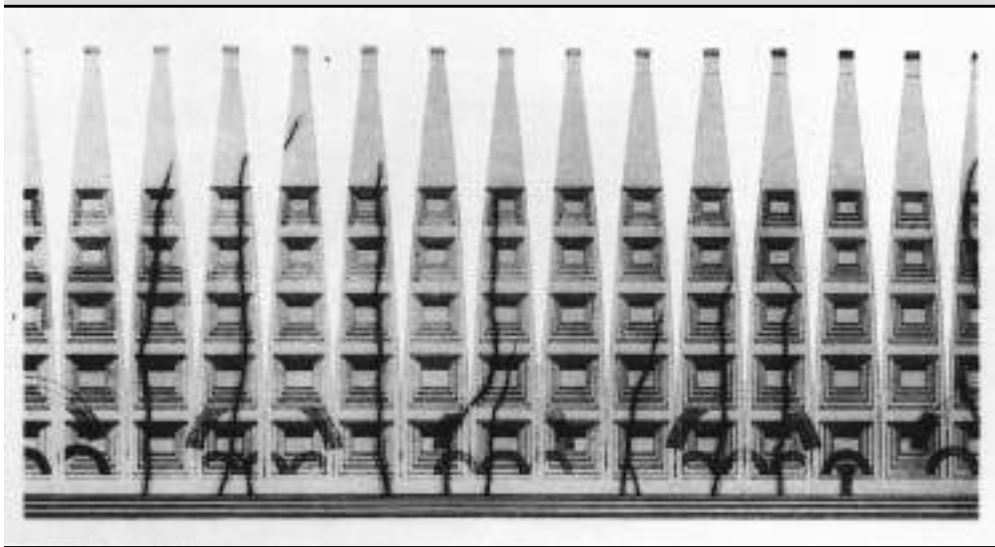


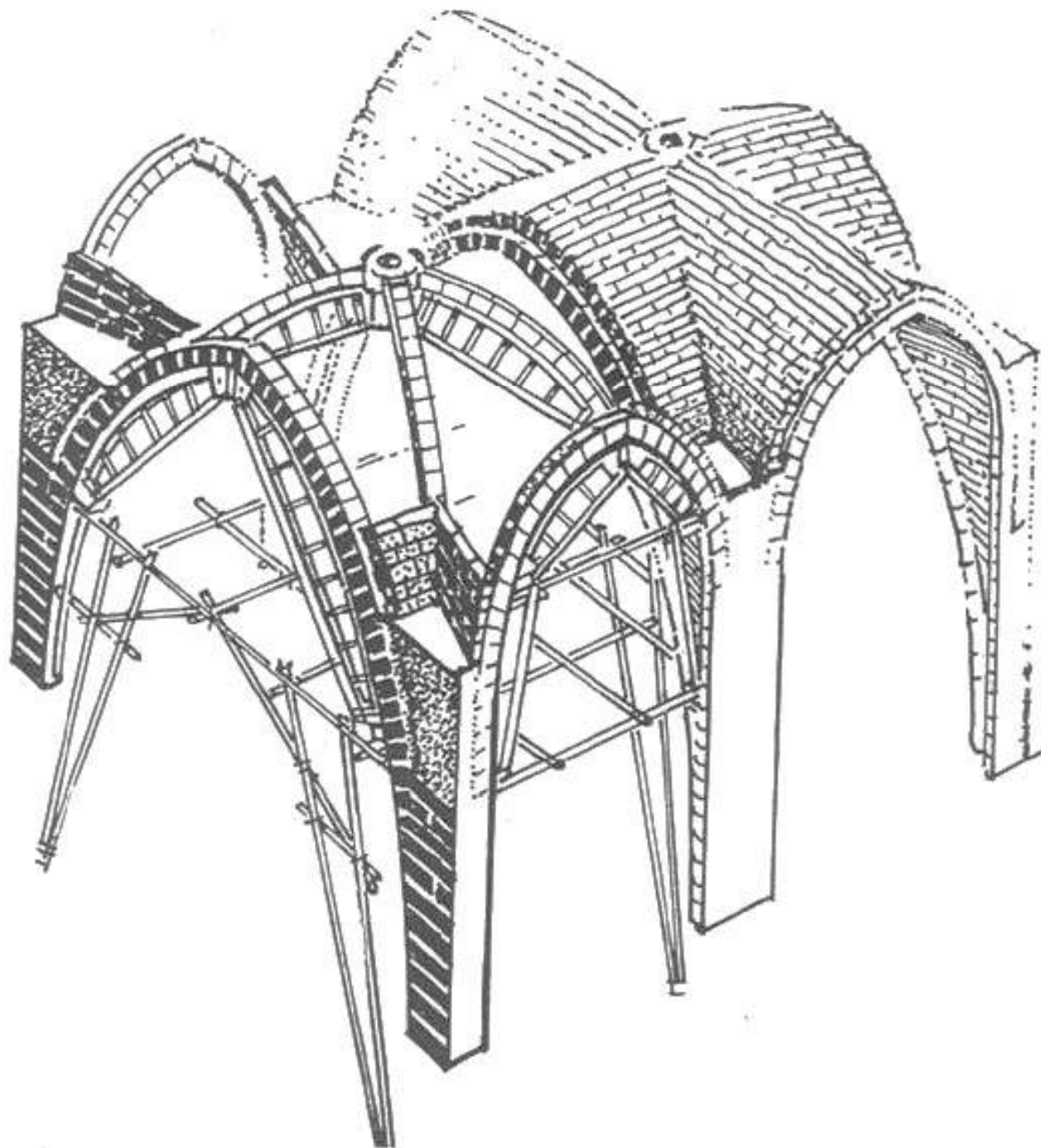


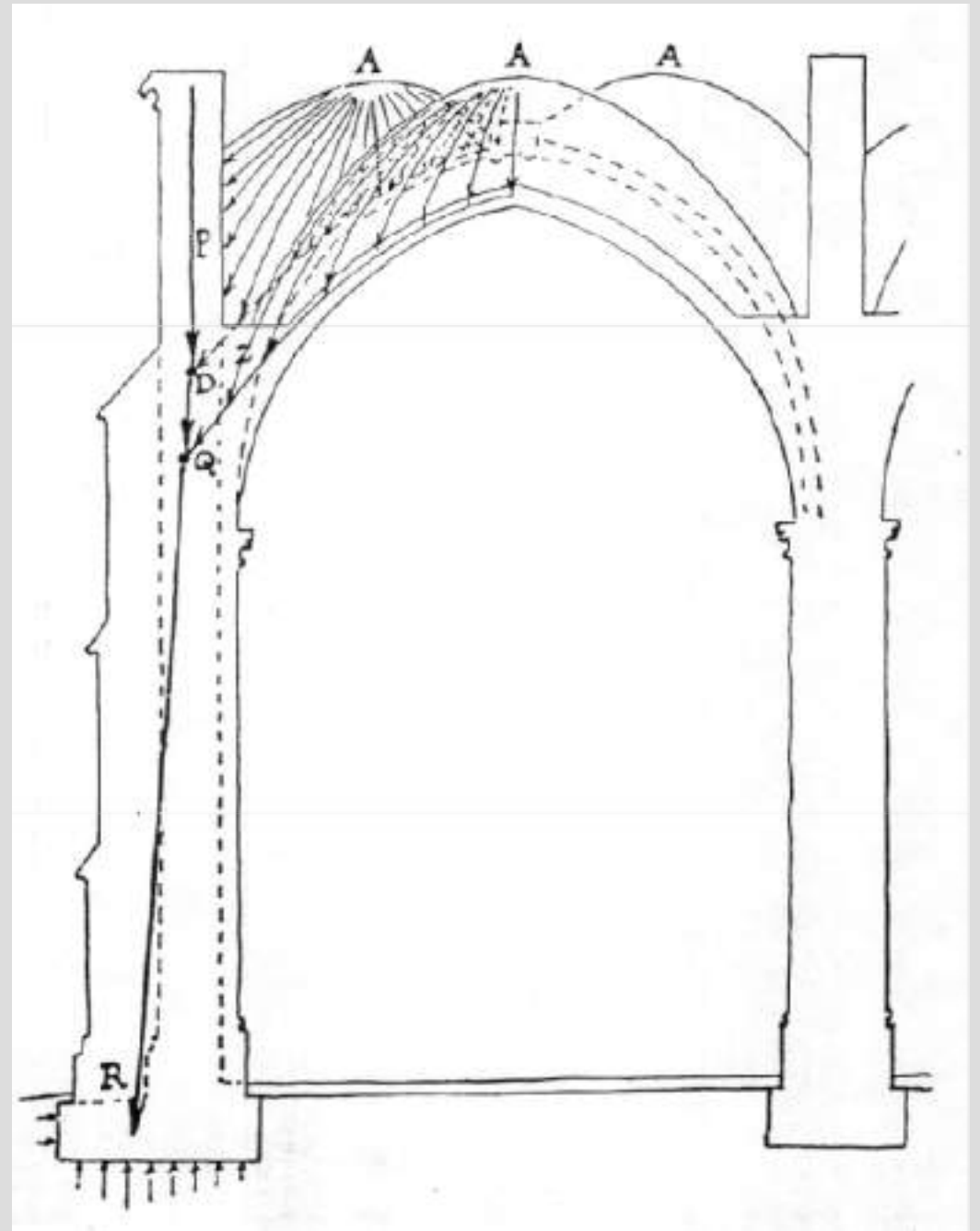
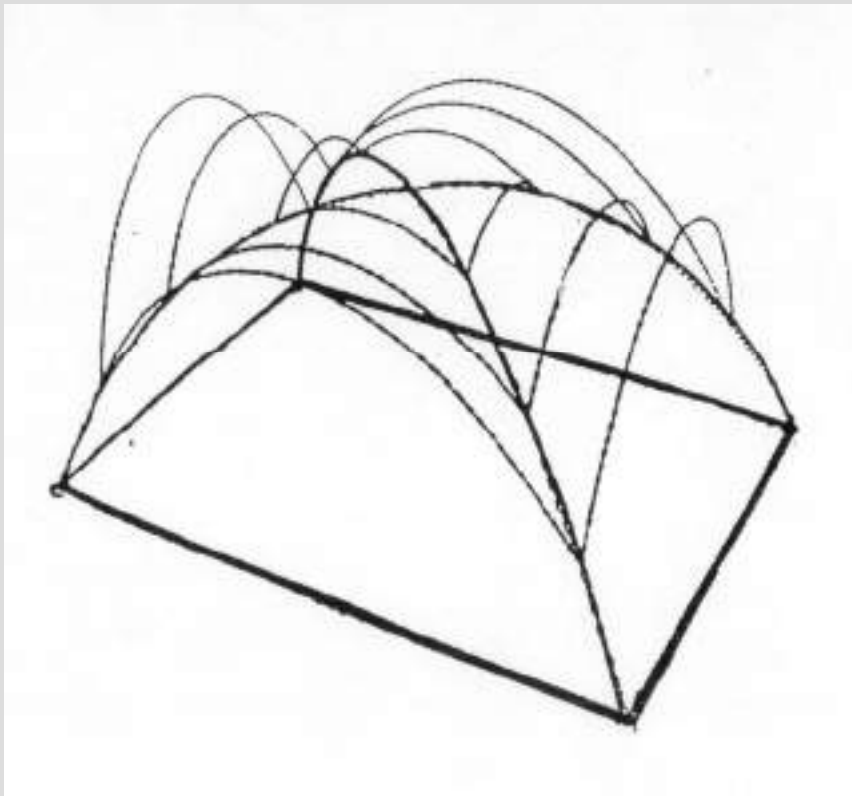
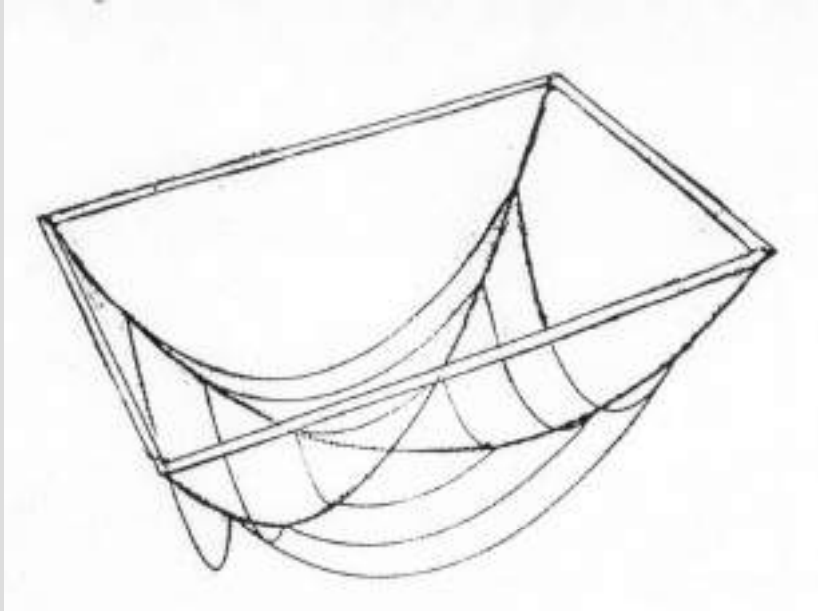


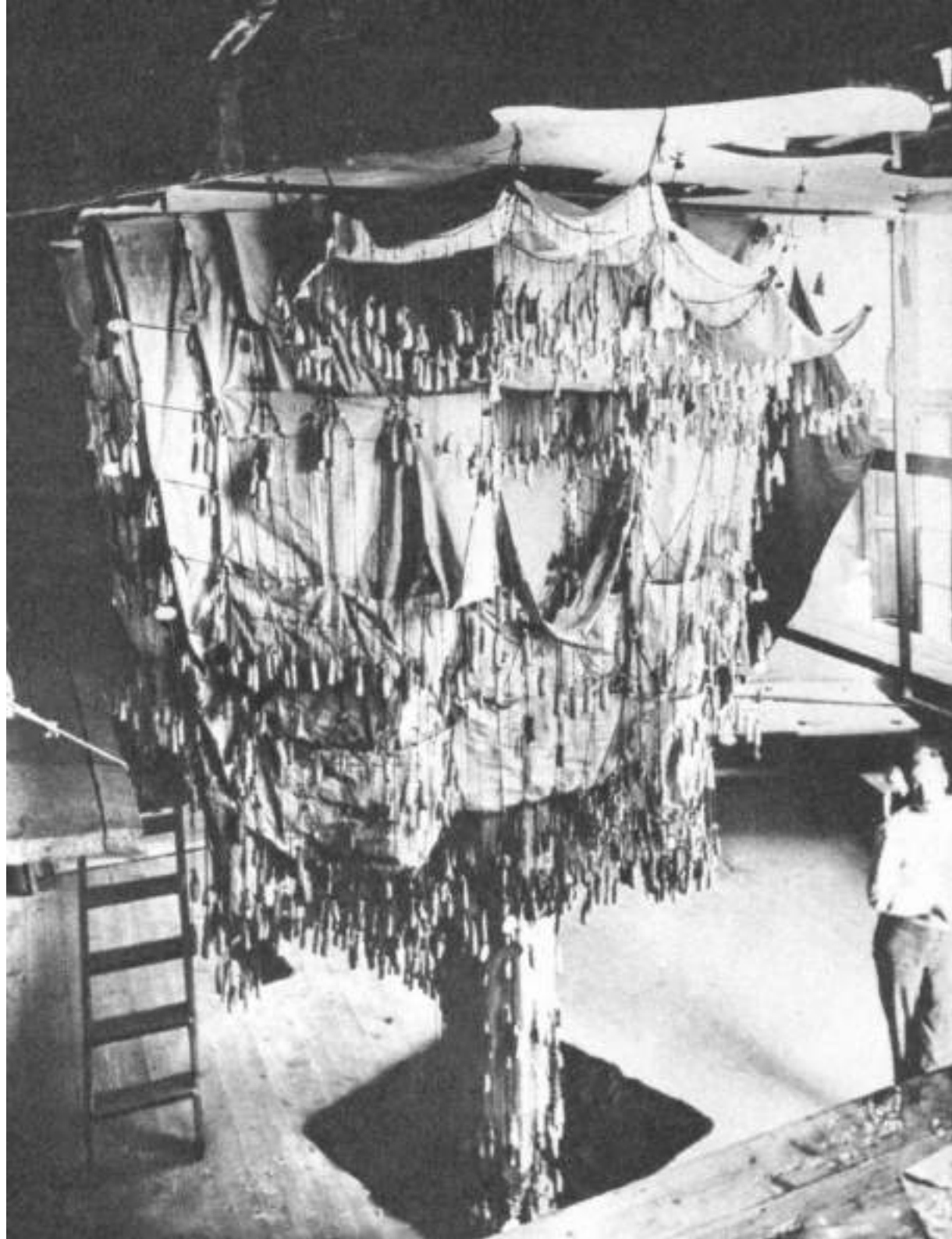
PANTHEON
SEZIONE =

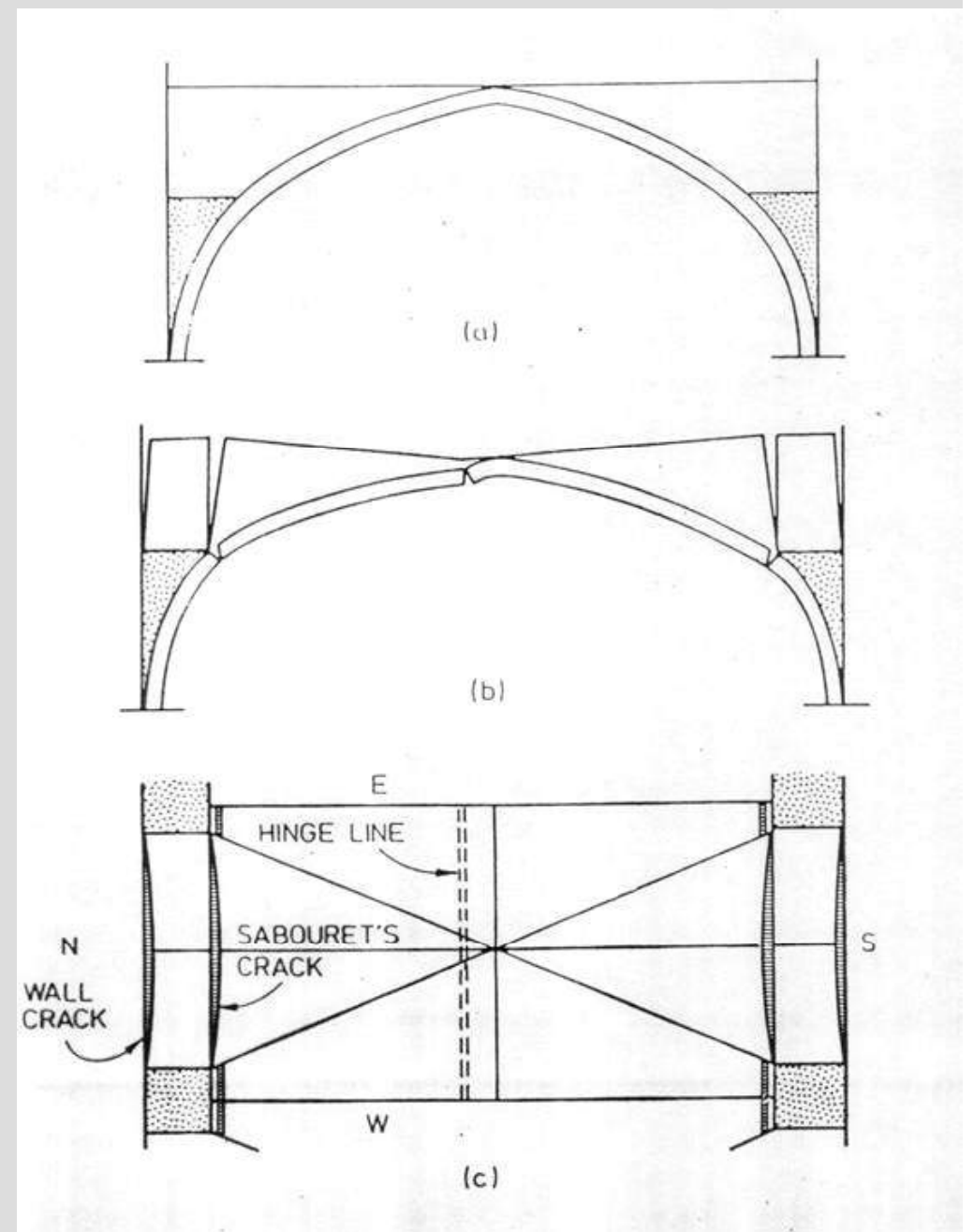
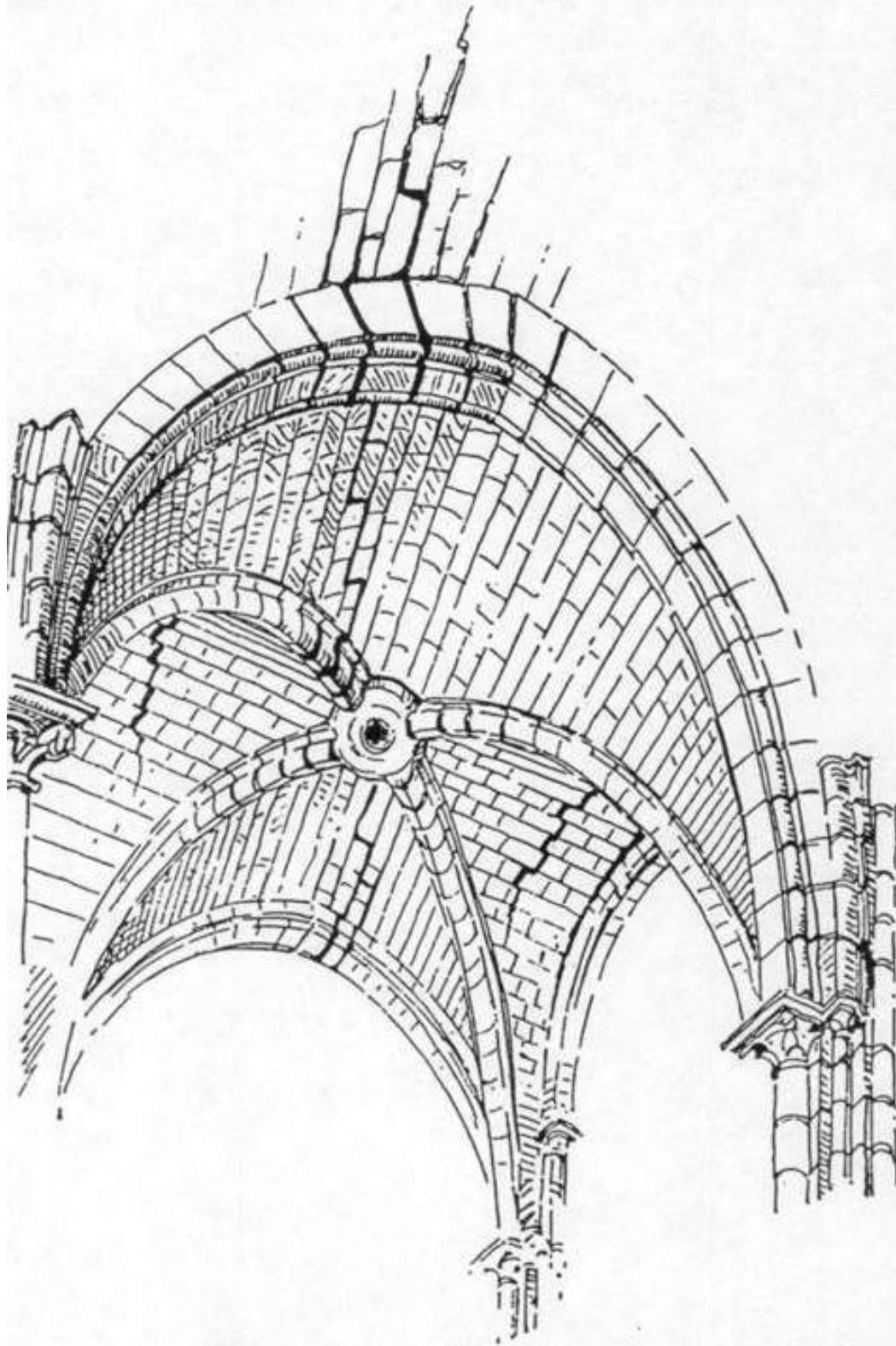




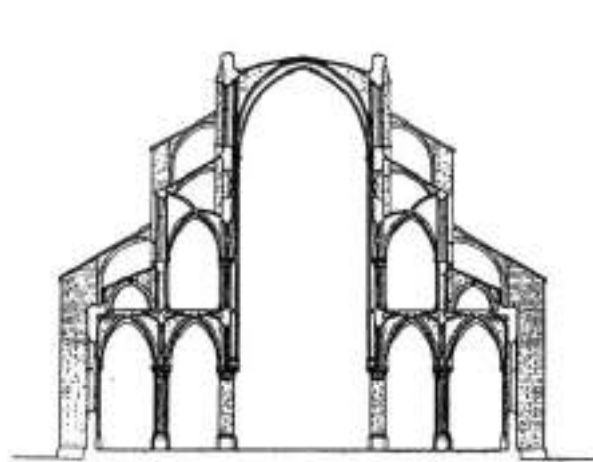




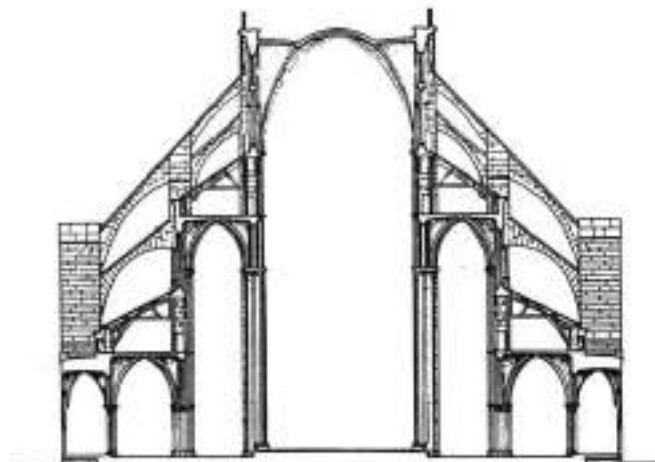




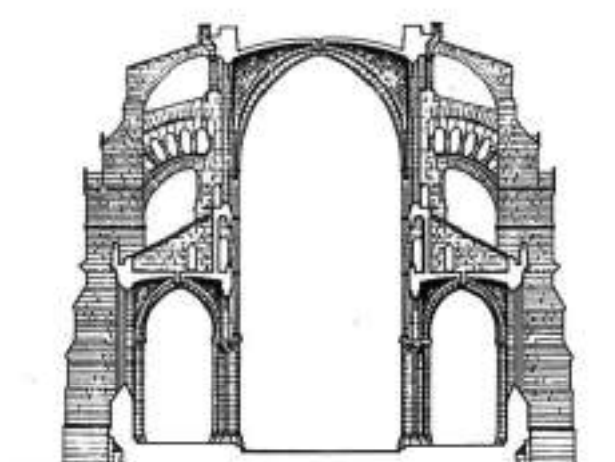
(Heyman 1995)



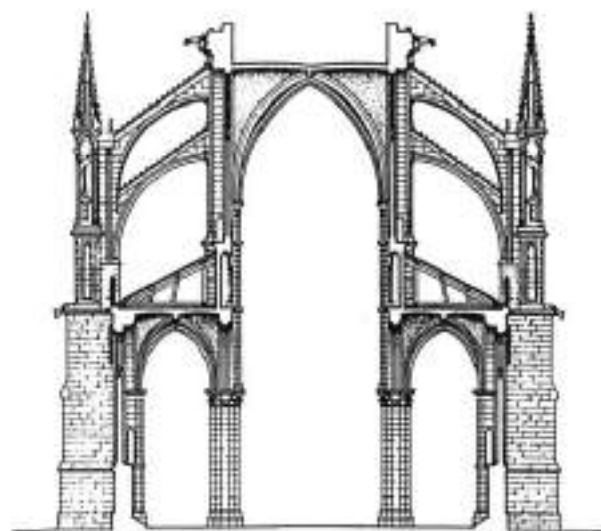
NÔTRE-DAME (1180-)



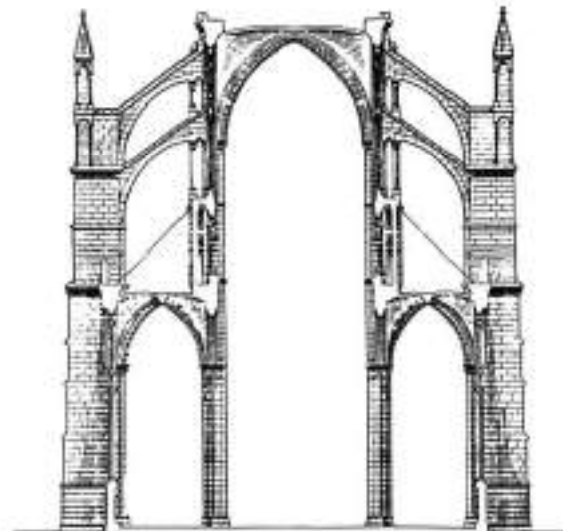
BOURGES (1195-)



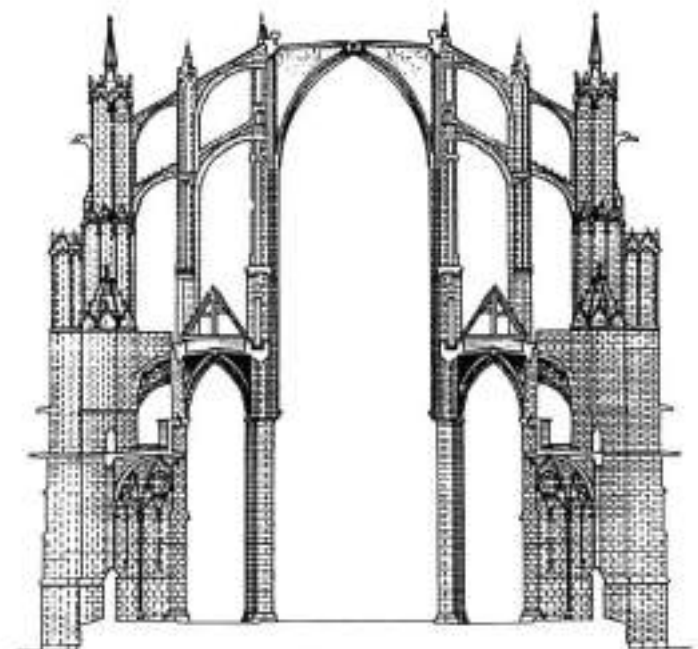
CHARTRES (1194-)



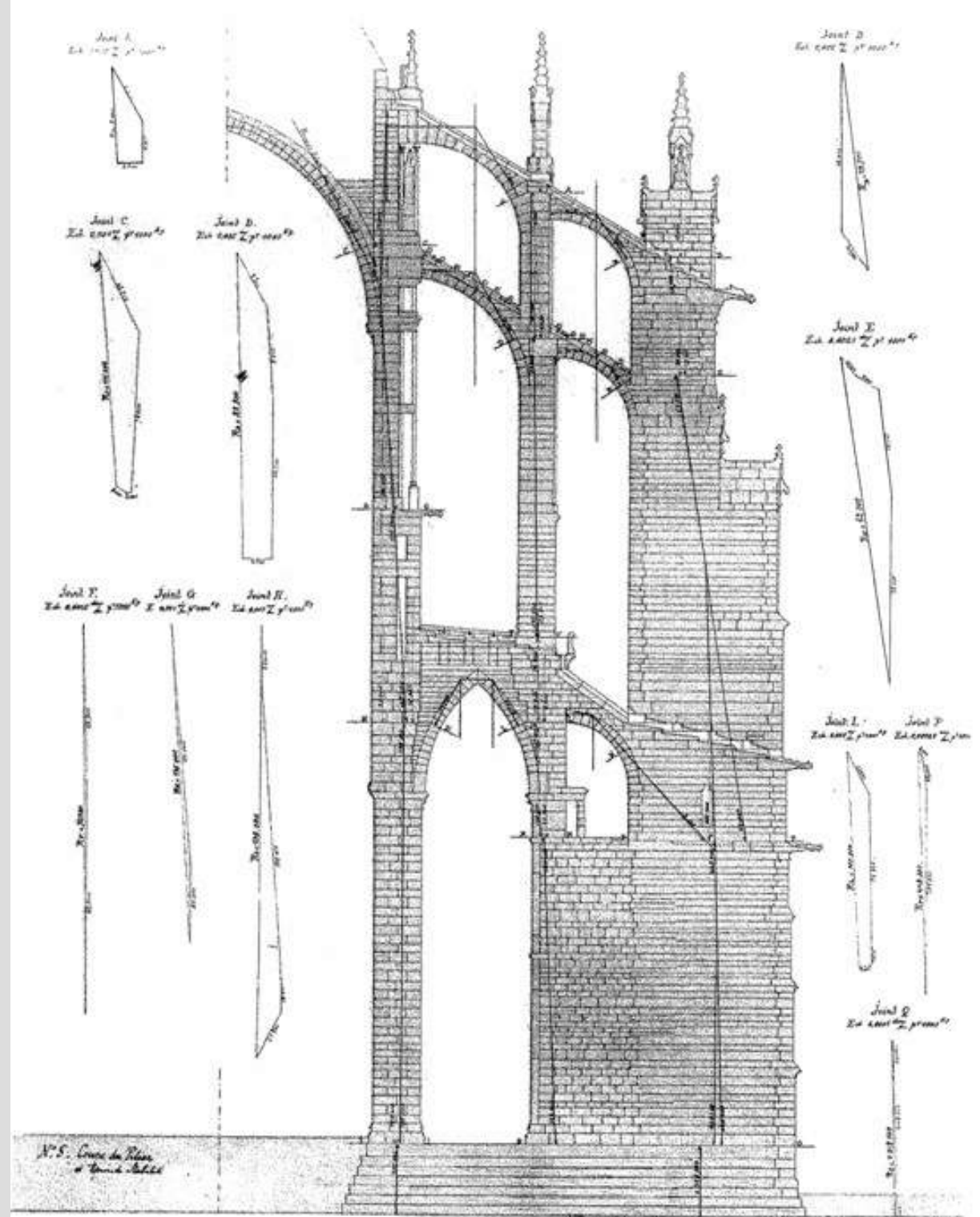
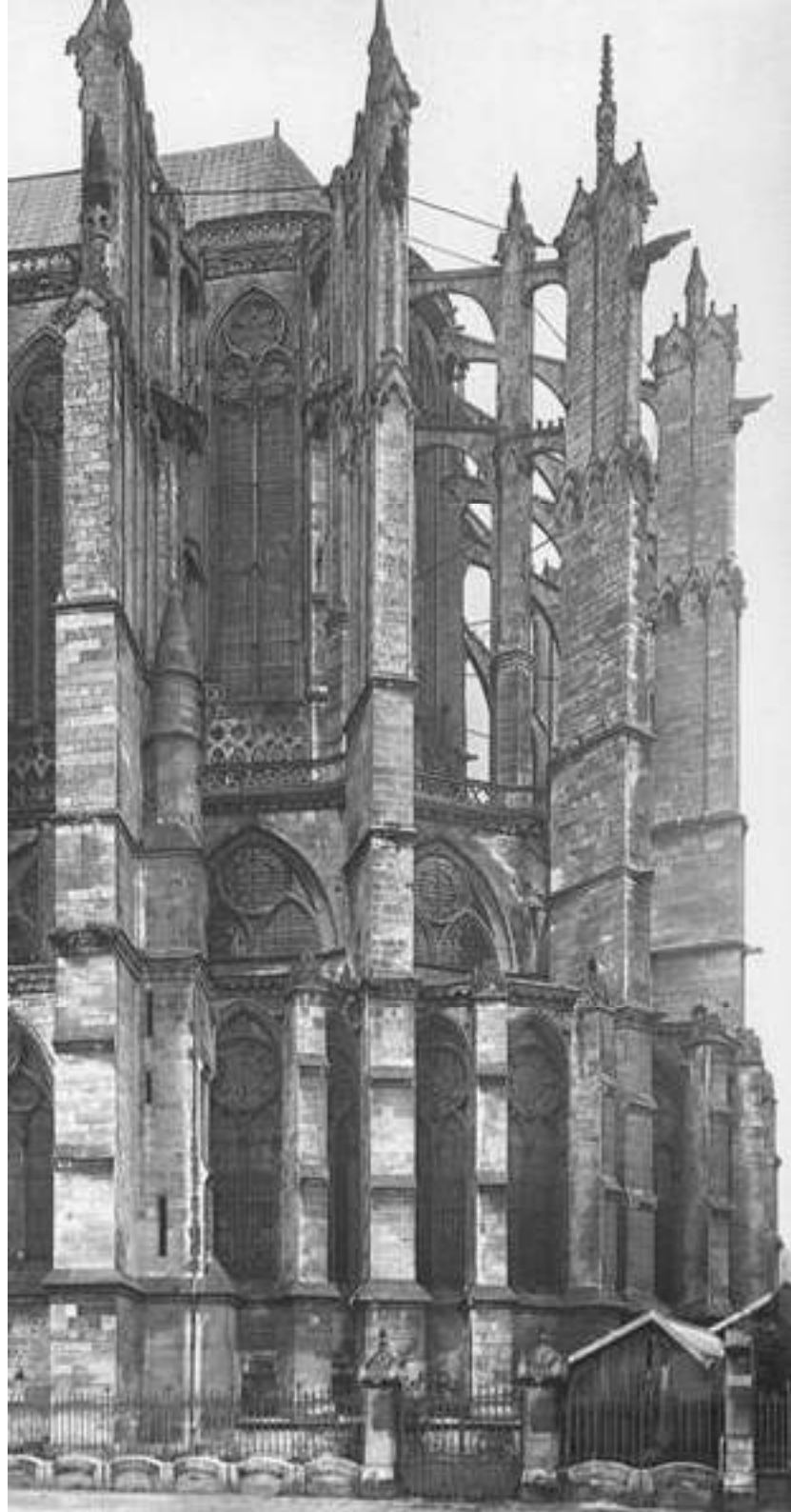
REIMS (1210-)



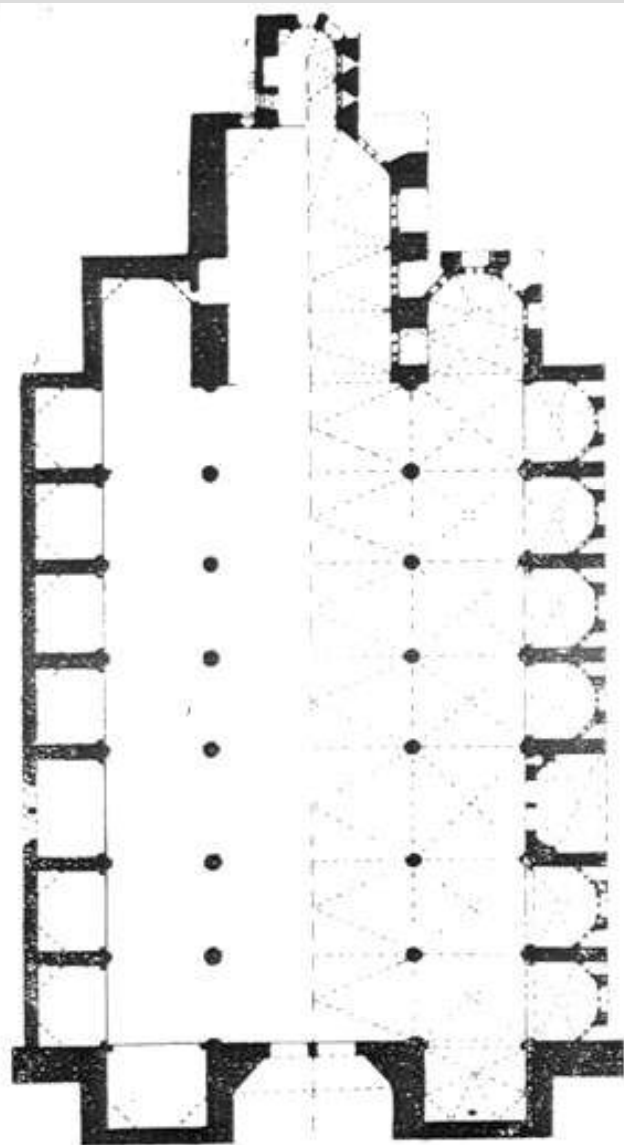
AMIENS (1220-)



BEAUVAIS (1225-)

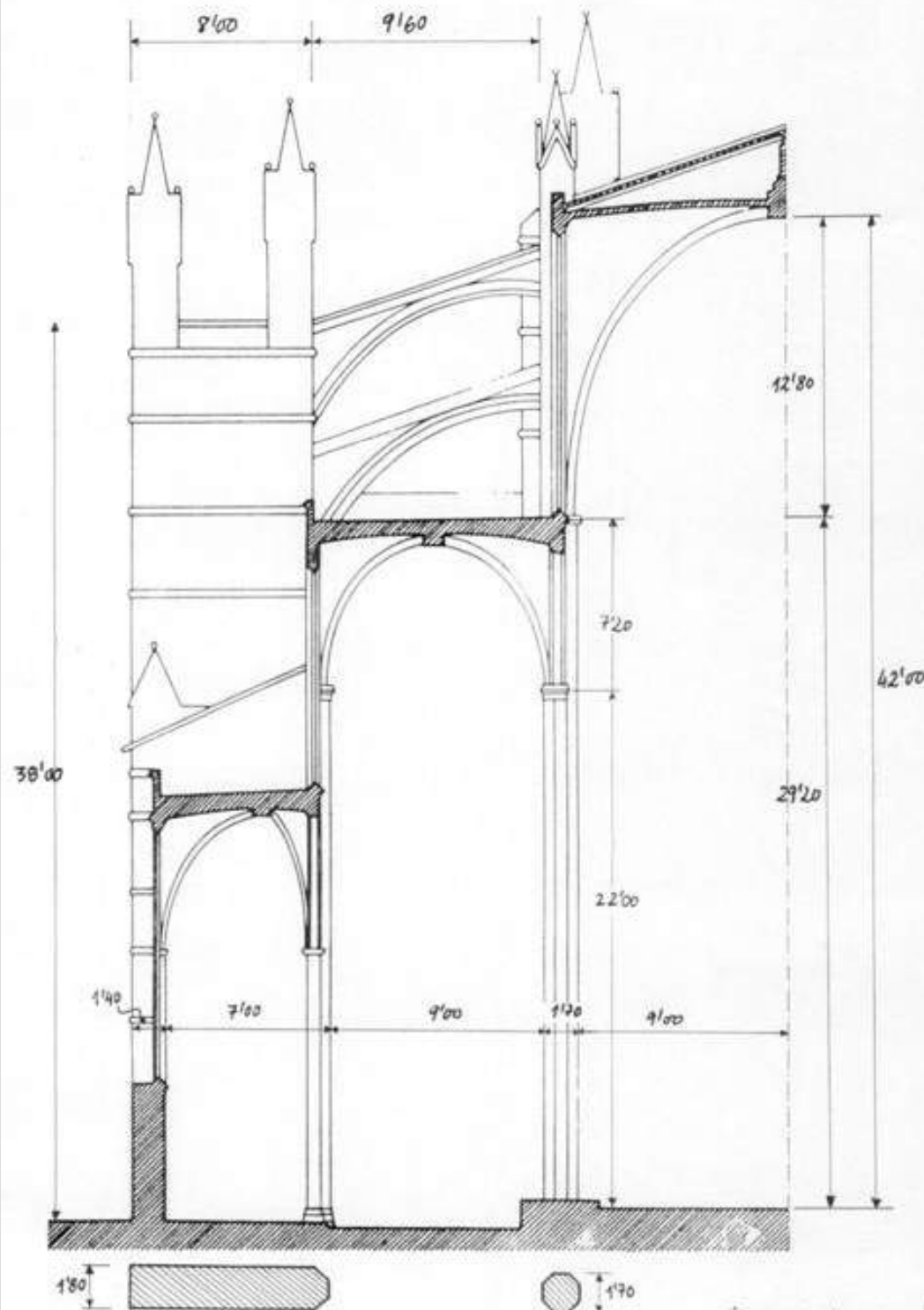


(Benouville 1901)

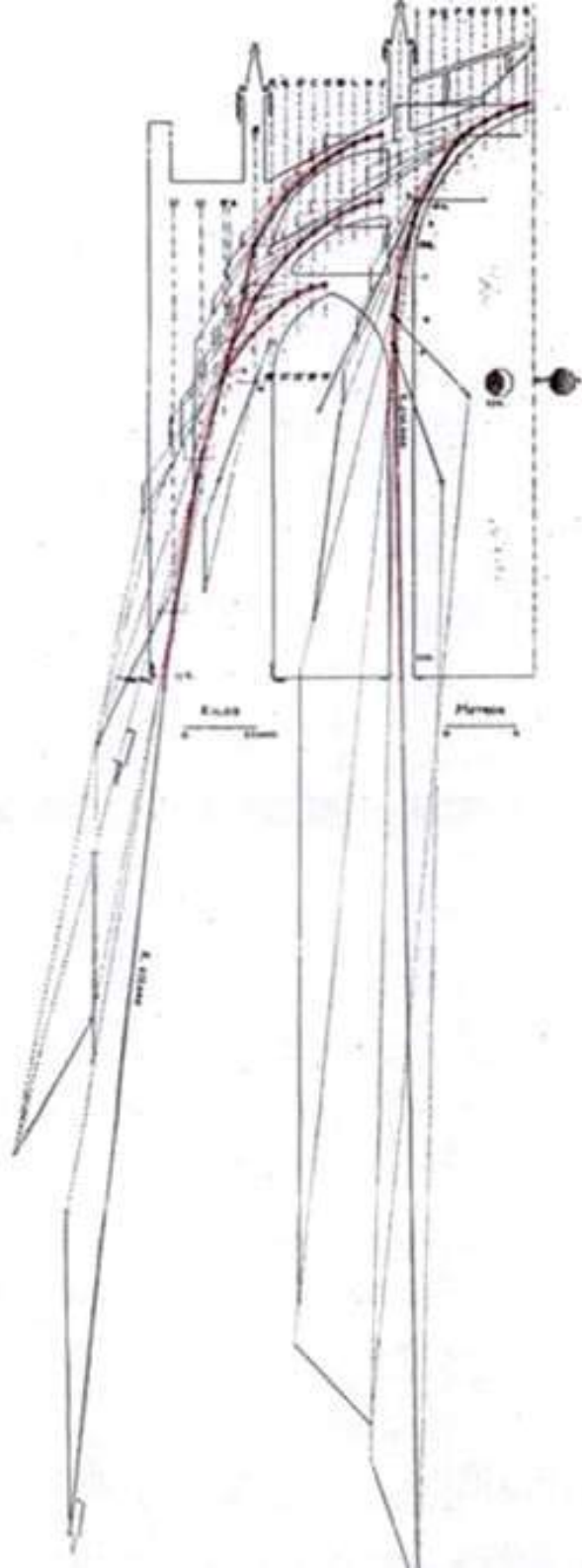


CATEDRAL de MALLORCA
ESQUEMA
de su
PLANTA

(Rubiò Bellver 1912)

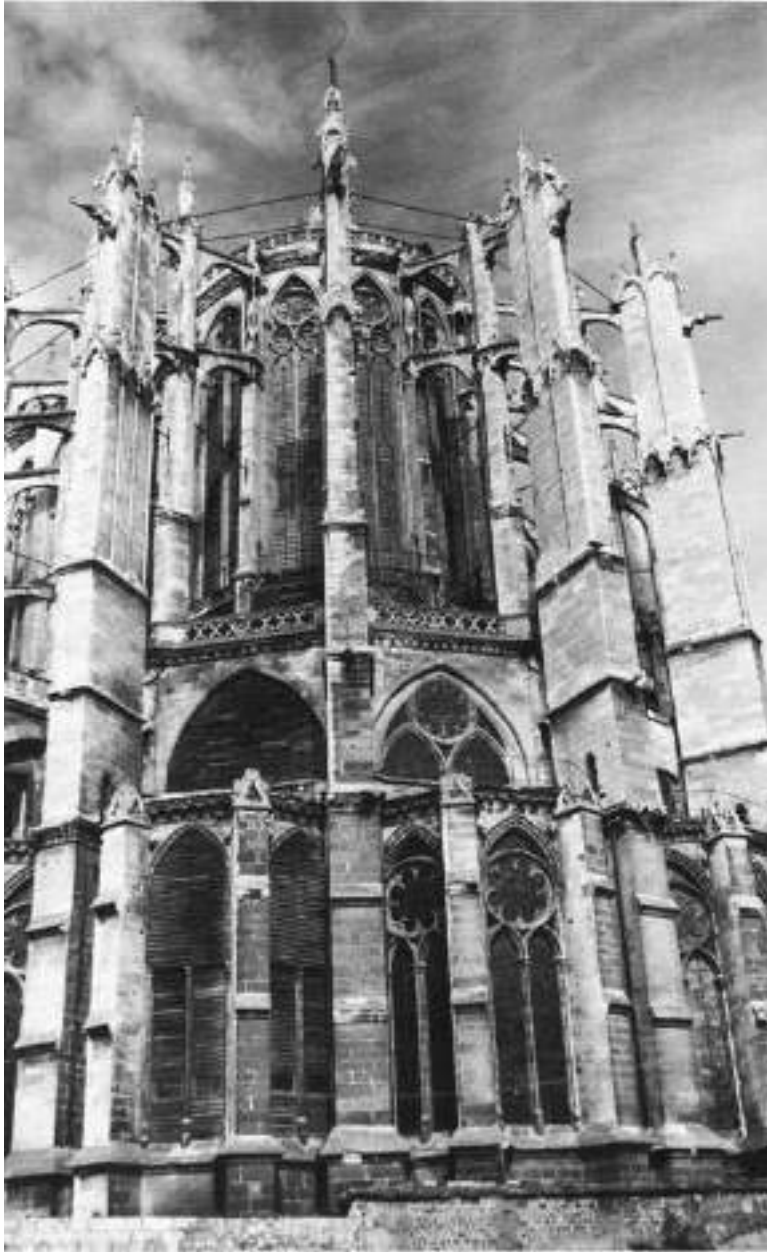


(DOMENGE/SALAS, 1999)



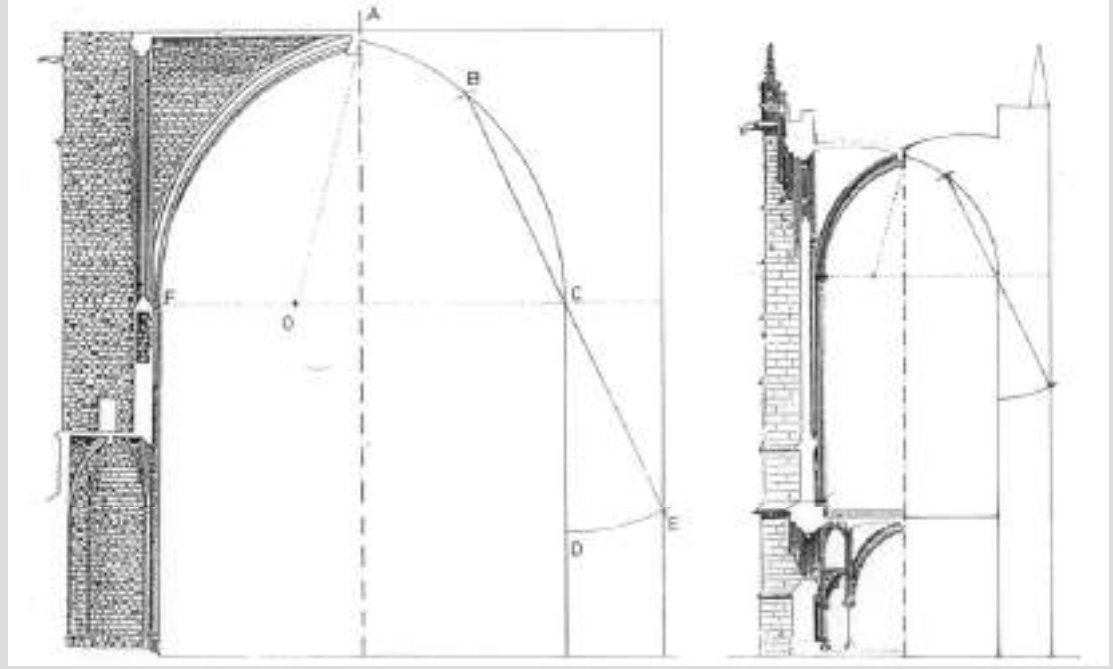
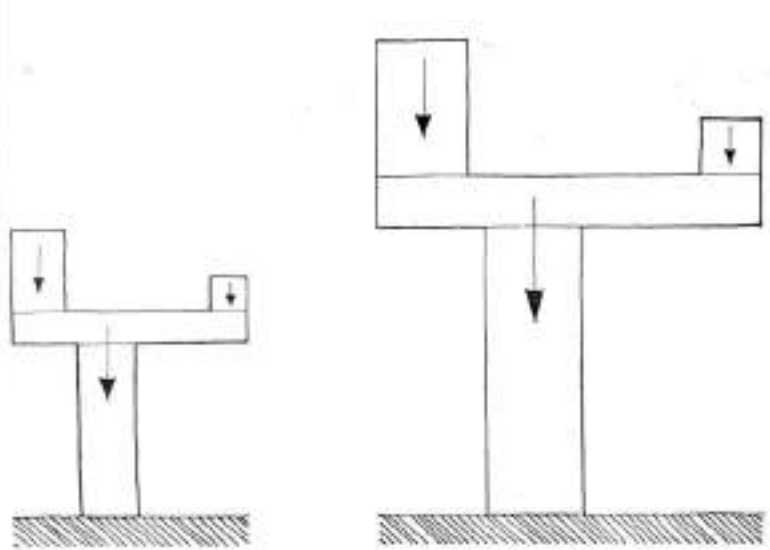


Le squelette cède ou résiste . . . suivant le besoin et la place . . . il semble posséder une vie , car il obéit à des forces contraires et son immobilité n'est obtenu qu'au moyen de l'équilibre de ces forces . . .

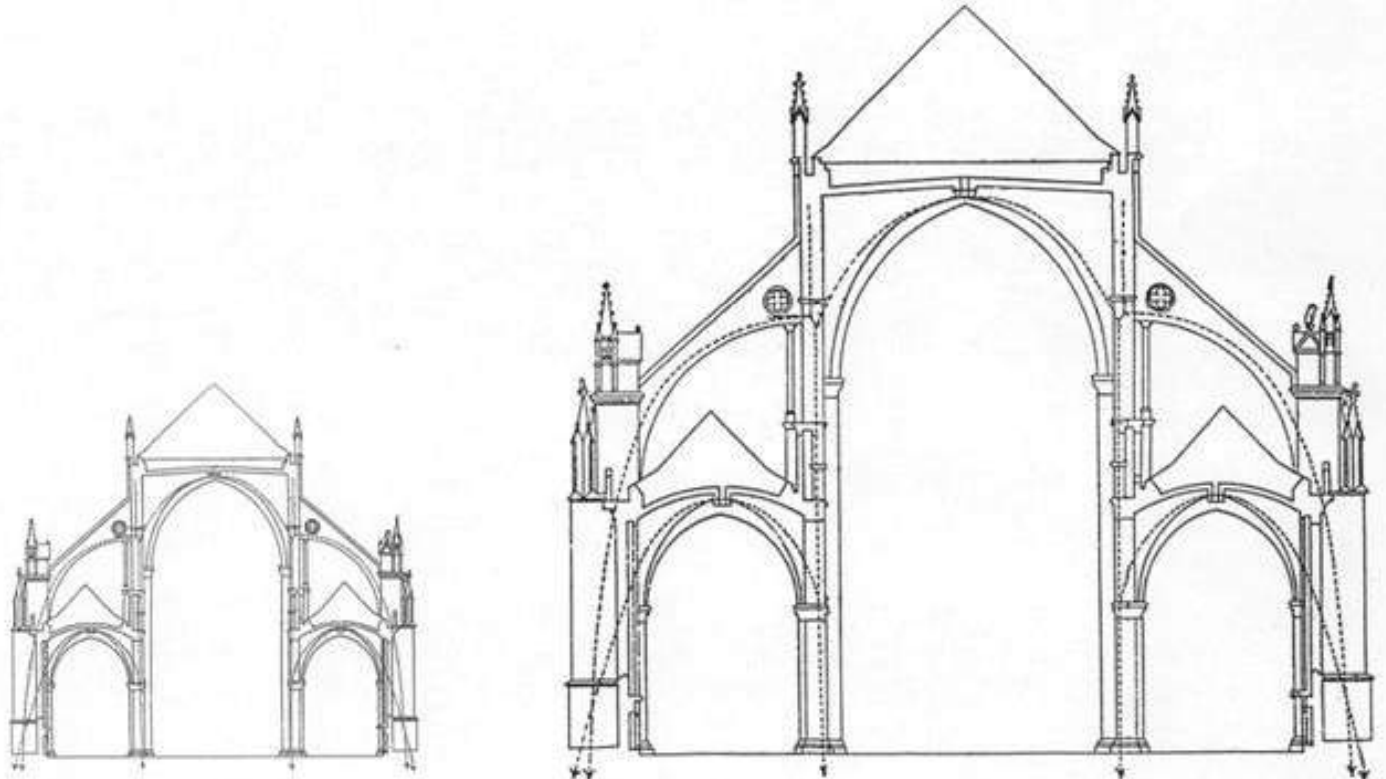


El esqueleto cede o resiste... según la necesidad y el lugar... parece poseer vida, pues obedece a fuerzas opuestas y su inmovilidad se obtiene sólo mediante el equilibrio de estas fuerzas...

Viollet-le-Duc *Dictionnaire*



El equilibrio por la forma
es la esencia de la arquitectura
de mampostería





Ética

(enseña las normas una vida buena)

Enemigos:

Ignorancia

Miedo

Codicia (dinero)

Ética

Ignorancia

Conocimiento

Miedo-Agresividad

Respeto/Cuidado

Codicia

Responsabilidad

Ética y Equilibrio



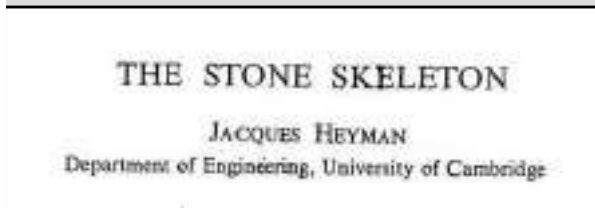
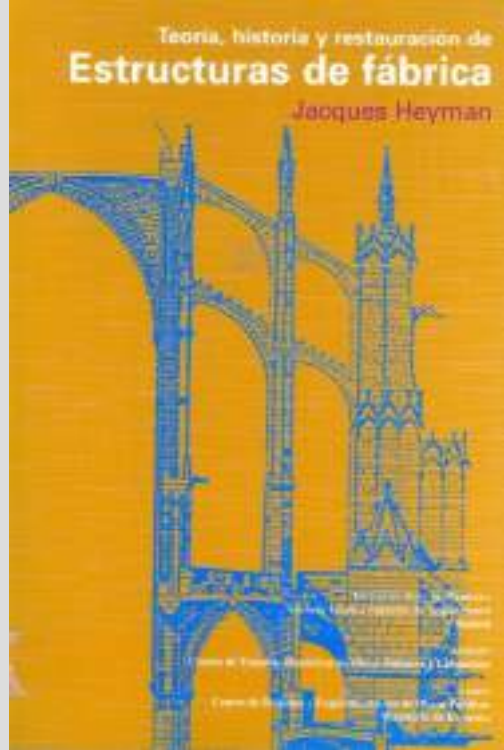
UT. PONDERA LIBRA, SIC ÆDIFICIA ARCHITECTURA.

(Como se pesa en la balanza,
así, se construye la arquitectura)

Gautier 1717 *Traité des ponts*



Jacques Heyman 1925-



Jacques Heyman 1966

