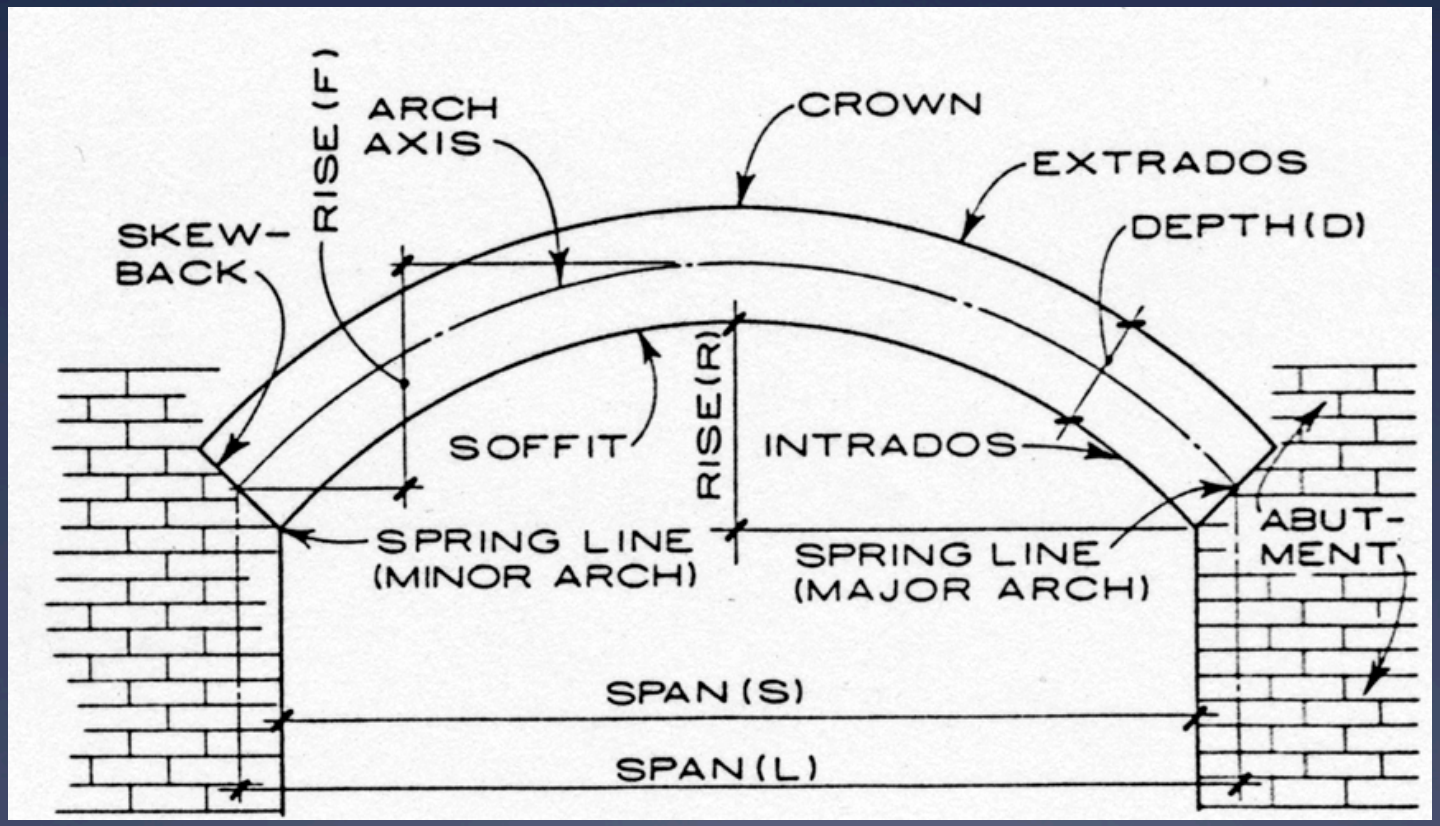
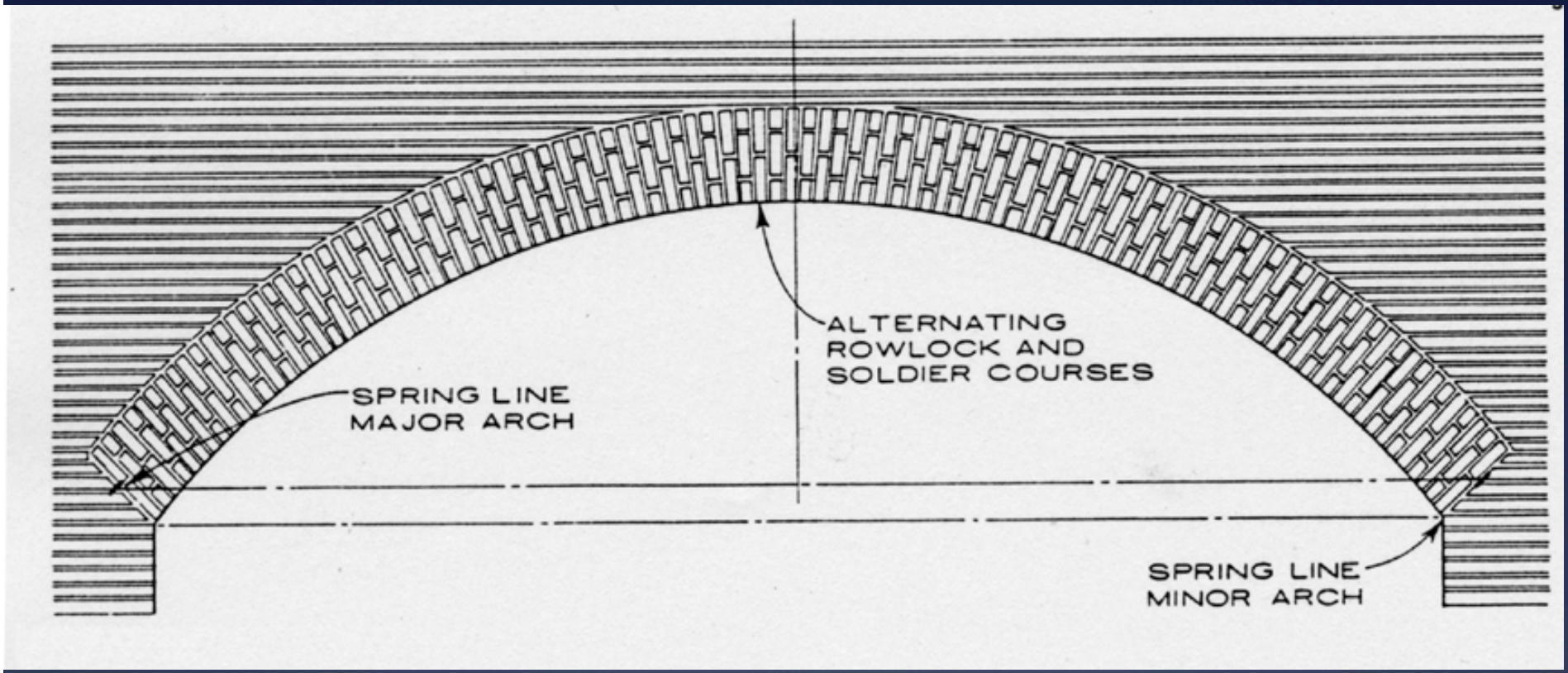
Fort Wayne Performing Arts Center

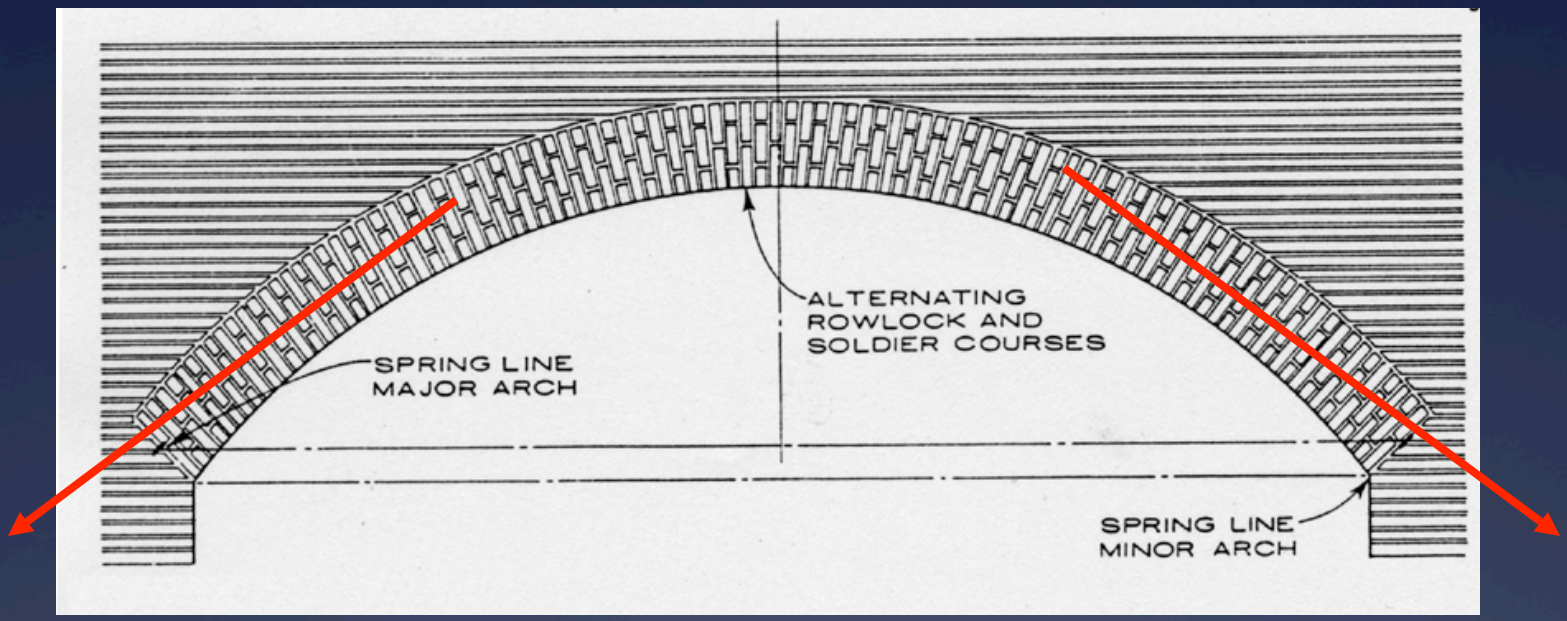
- Arches…and efflourescense



The performing arts center was built in the late 1960’s. Like many projects it had program much larger than it’s budget.

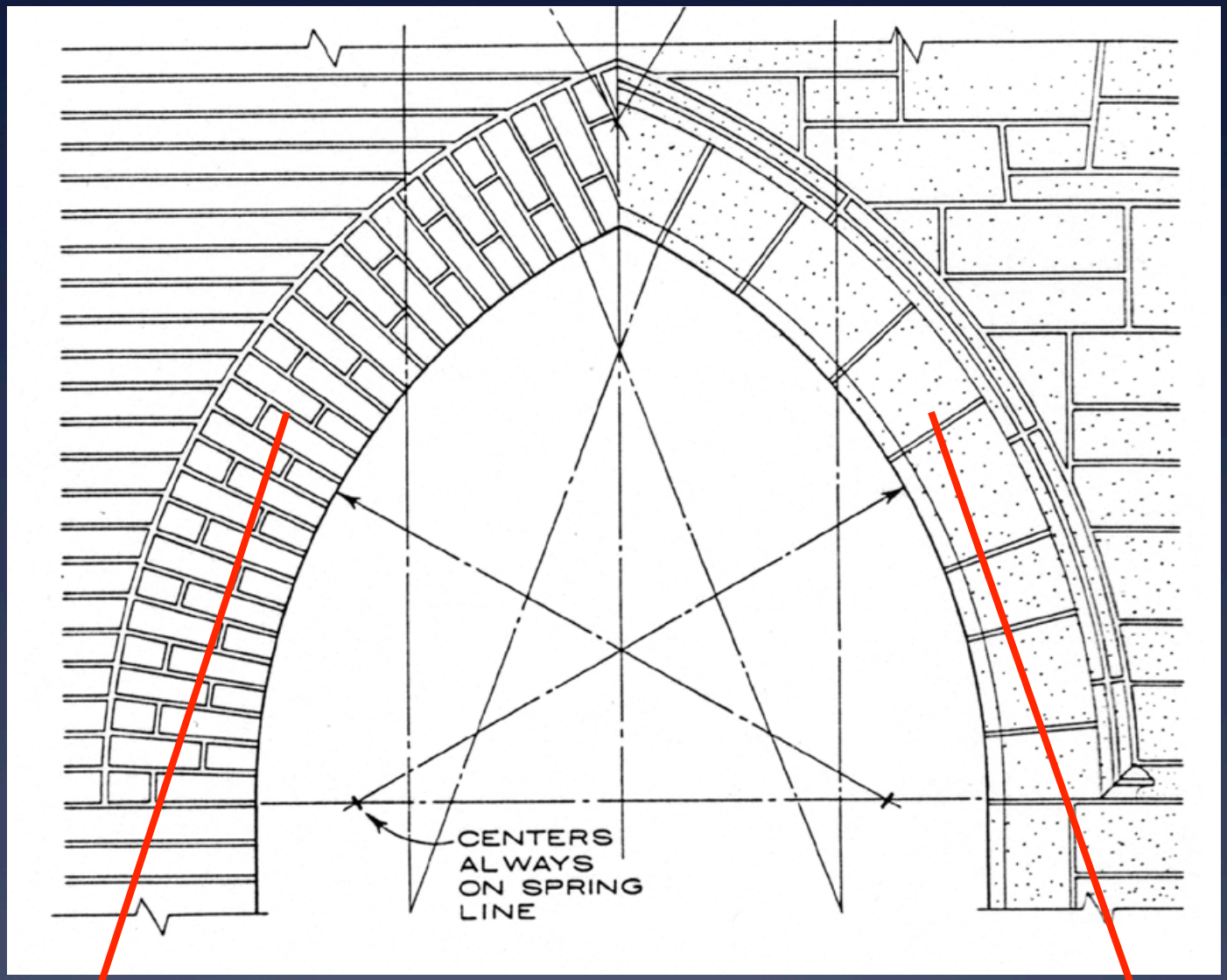


In this project, and in most of Louis Kahns' projects built with brick, the arch is present in some form. Kahn believed the arch was part of the "order" of brick…to use a hidden steel or concrete lintel to support an arch span would be "out of order" with brick and "span"



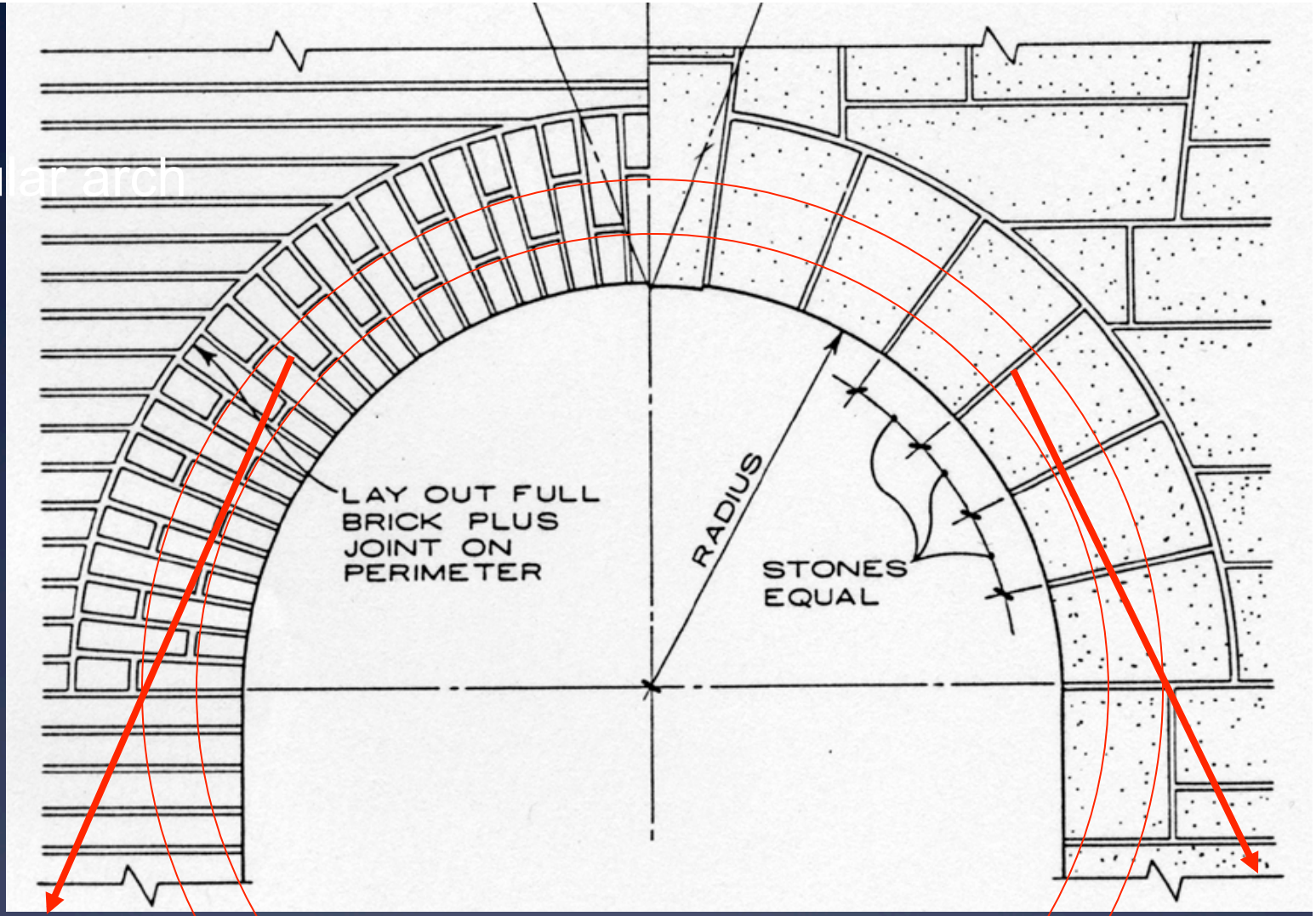
Most arches, particularly this one, constructed out of a segment of a circle…a “segmental” arch put great resultant forces in the wall, the flatter the arch, the more it pushes laterally on the wall from where it “springs.”

Gothic or Pointed arch



The taller the arch, the more vertical is the resultant force on the wall. Which arch is better to place on a column? Why?

Roman or Semi-Circular arch



Arch designers seek to keep the resultant force vector in the middle third of the arch depth

Architects and builders knew the arch was an indeterminant structural problem, the key to stability was keeping the force vectors in the middle 1/3 of the arch. If the vector ended up below the middle 1/3 the arch would collapse inward, above the middle 1/3, it would collapse upward.

This is one step of a graphic method to determine where the resultant vectors from the weight of the arch will reside

From Architects and builders handbook, Harry Parker, editor 18th ed, p. 328

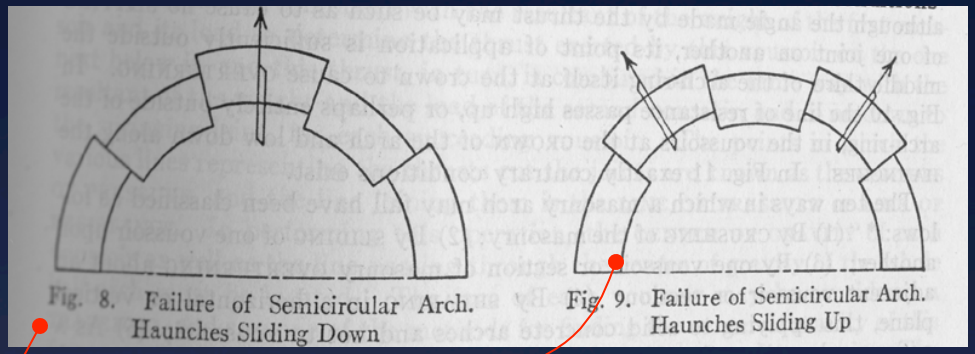
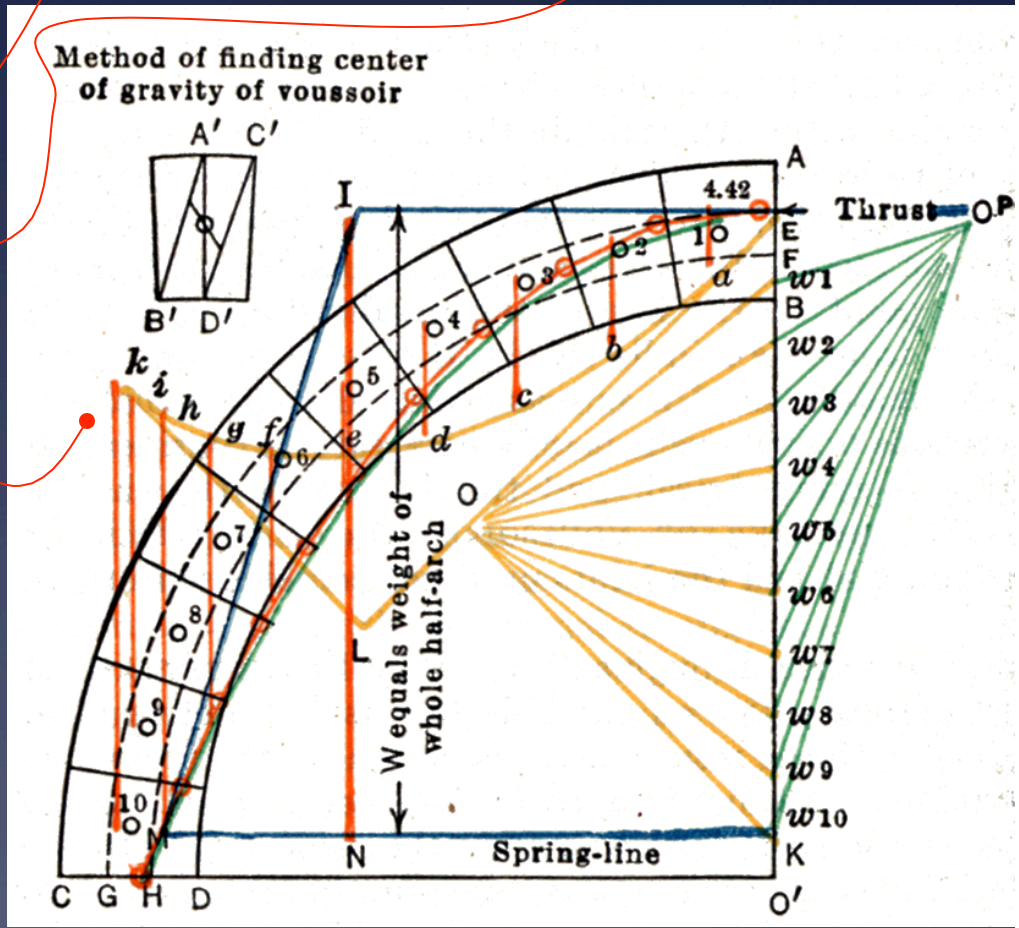


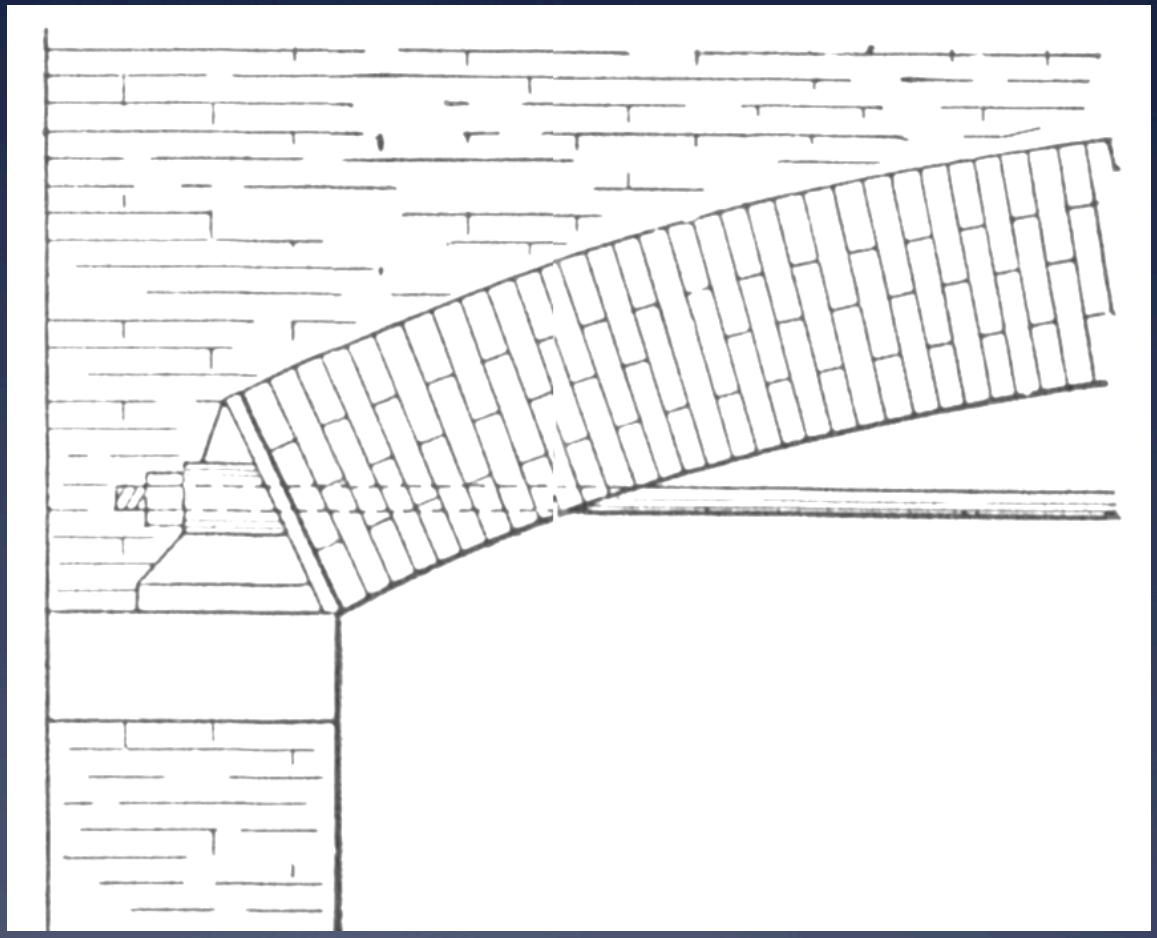
Fig. 8. Failure of Semicircular Arch. Haunches Sliding Down

Fig. 9. Failure of Semicircular Arch. Haunches Sliding Up



To address the thrust produced by the segmental arch, builders would use cast iron end plates and tie rods to accept the tension produced by the arch.

This allowed segmental arches to be placed on columns and near the edges of walls without destroying the wall.



This 7 rowlock deep segmented arch is tied with a concrete tension member to minimize lateral thrust on the adjacent walls.

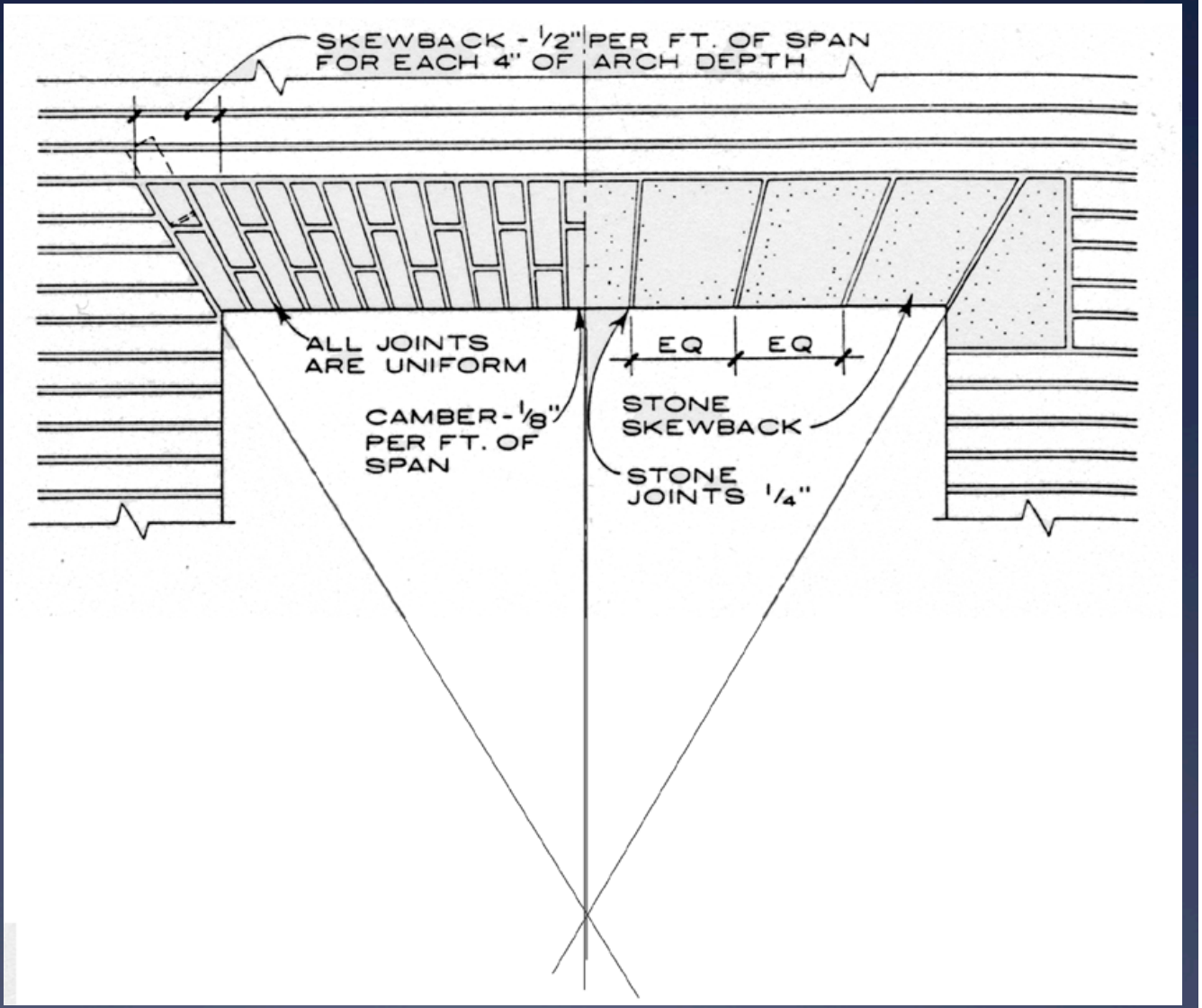
This flat or jack arch and brick masonry surround marks the actors entry to backstage.

Flat or Jack arch

The flat arch or jack arch isn't really flat… the top is flat, but the bottom, the intrados rises 1/8" for every foot of span.

The skewback is calculated as 1/2" per foot of span, per 4" of arch depth, with typical depths ranging from 8 to 16 inches

The jack arch puts the most lateral thrust into the adjacent brick walls



Triangular joints a “rough” arch
If the bricks were triangular and the mortar joints rectangular, this would be a “gauged” arch…a more refined arch

Each passage through concrete block is refined with brick masonry and a red oak door frame.

The white powder on the surface at the arches is efflorescence - salts dissolved out of the brick and mortar, which moved down the wall (following gravity) until the salt water hit an interruption in the wall (the arch.) The water soaked in the arch, evaporated through the arch face, leaving the salt deposits behind

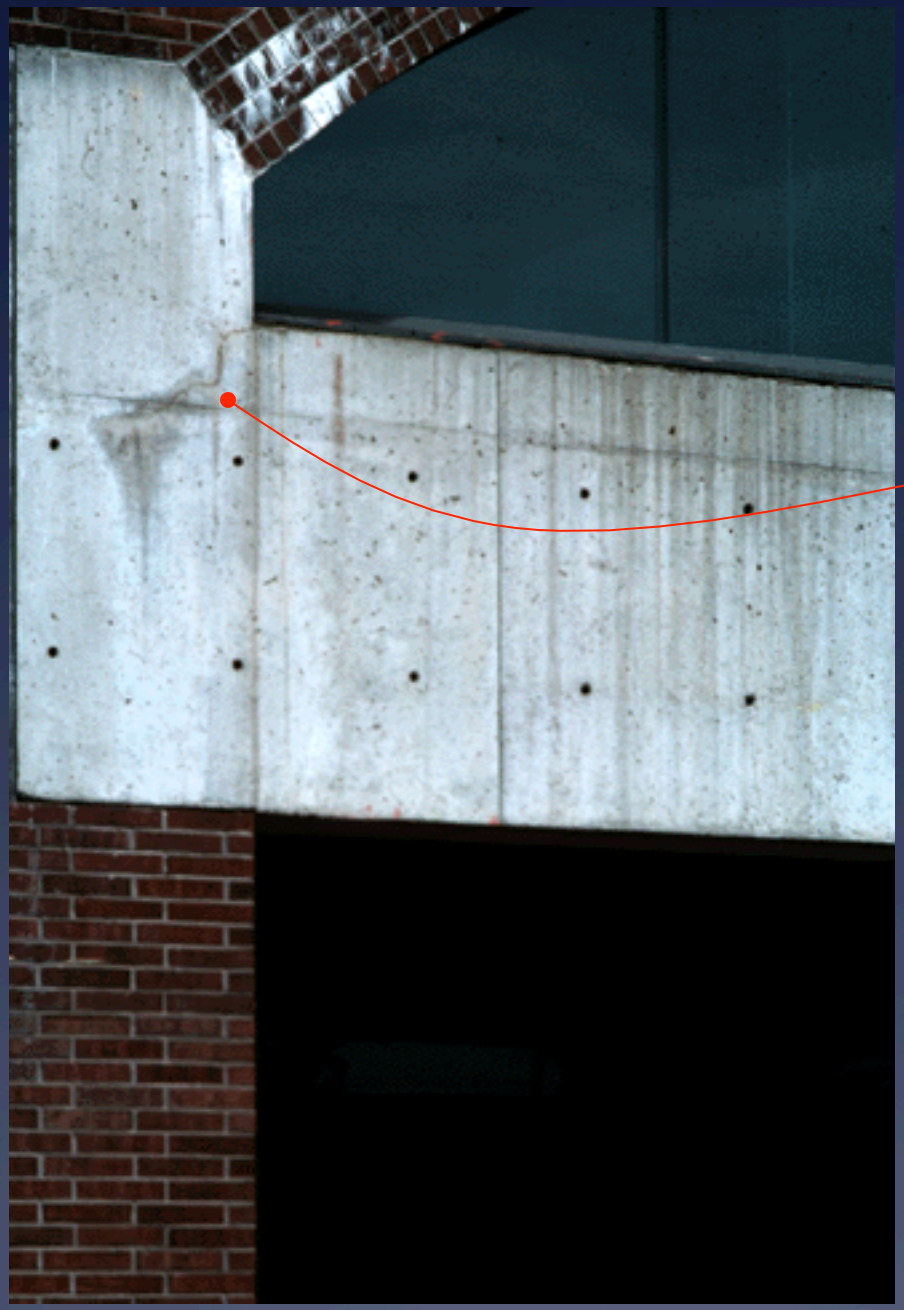
Usually, efflorescence is a sign of a leak.

The leak is usually in a joint or material change above where the salt is found

Water leaking from parapet coping above.

Soaked bricks froze and the faces spalled off.

No end dam at the flashing under this slate sill.



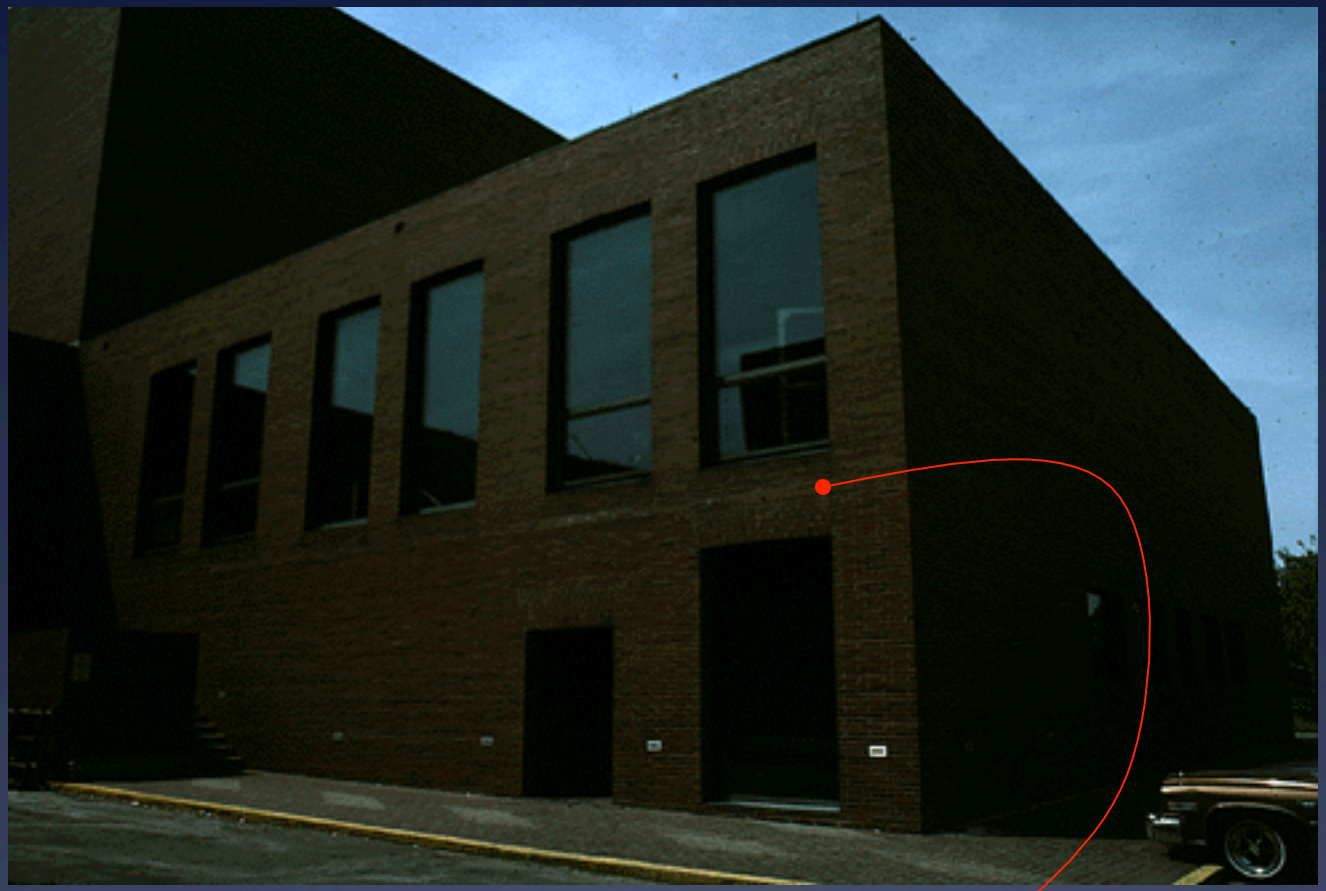
Water can even destroy large concrete elements.

Here, the lack of an end dam for the sill flashing has loaded the concrete with water, contributing to the crack.

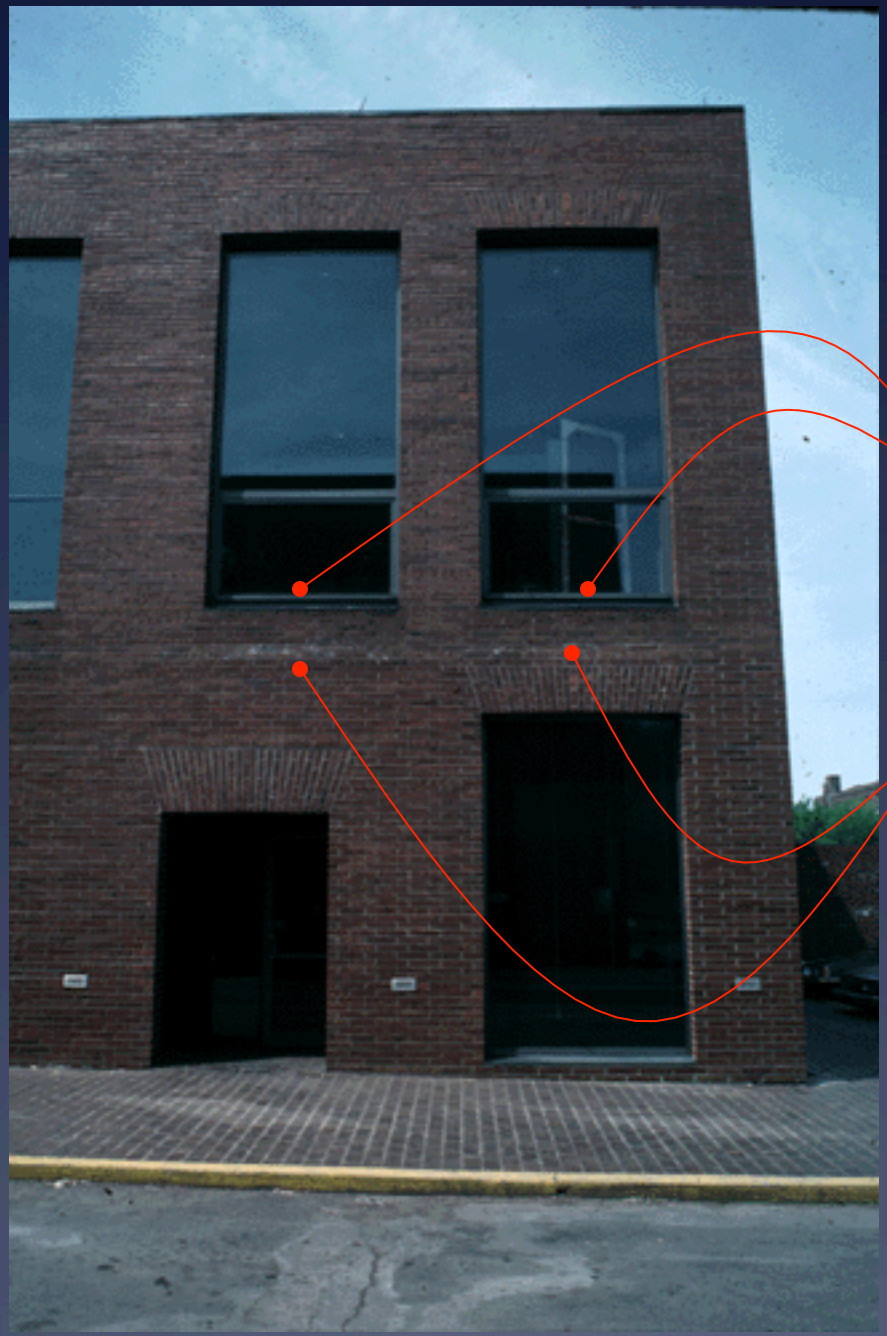
Years later, the arch was dis-assembled by removing and replacing alternating bricks (similar to underpinning.) As is often the case, finding matching bricks was almost impossible. The flashing was installed correctly and it looks like no leaks!

Setting the windows at the back edge of the wall instead of over the cavity increases the presence of the walls mass.

This requires that sill flashing and material be of the highest quality as it leaves a deep, low sloped sill to catch water and snow.



A floor bearing in a masonry wall can be an interruption to the free drainage of the wall. This faint white line indicates the sills above have leaked, the water has moved within the masonry downward, piling up at the floor where it evaporates out, leaving the salts on the brick surface.



Leak is likely here

Efflorescence at the top of the floor slab bearing on the masonry wall.

If not repair quickly the leaks fill the masonry with water. The freezing and thawing of winter and spring can blow the face off the brick

Go to the deteriorated location and look up to find the leak

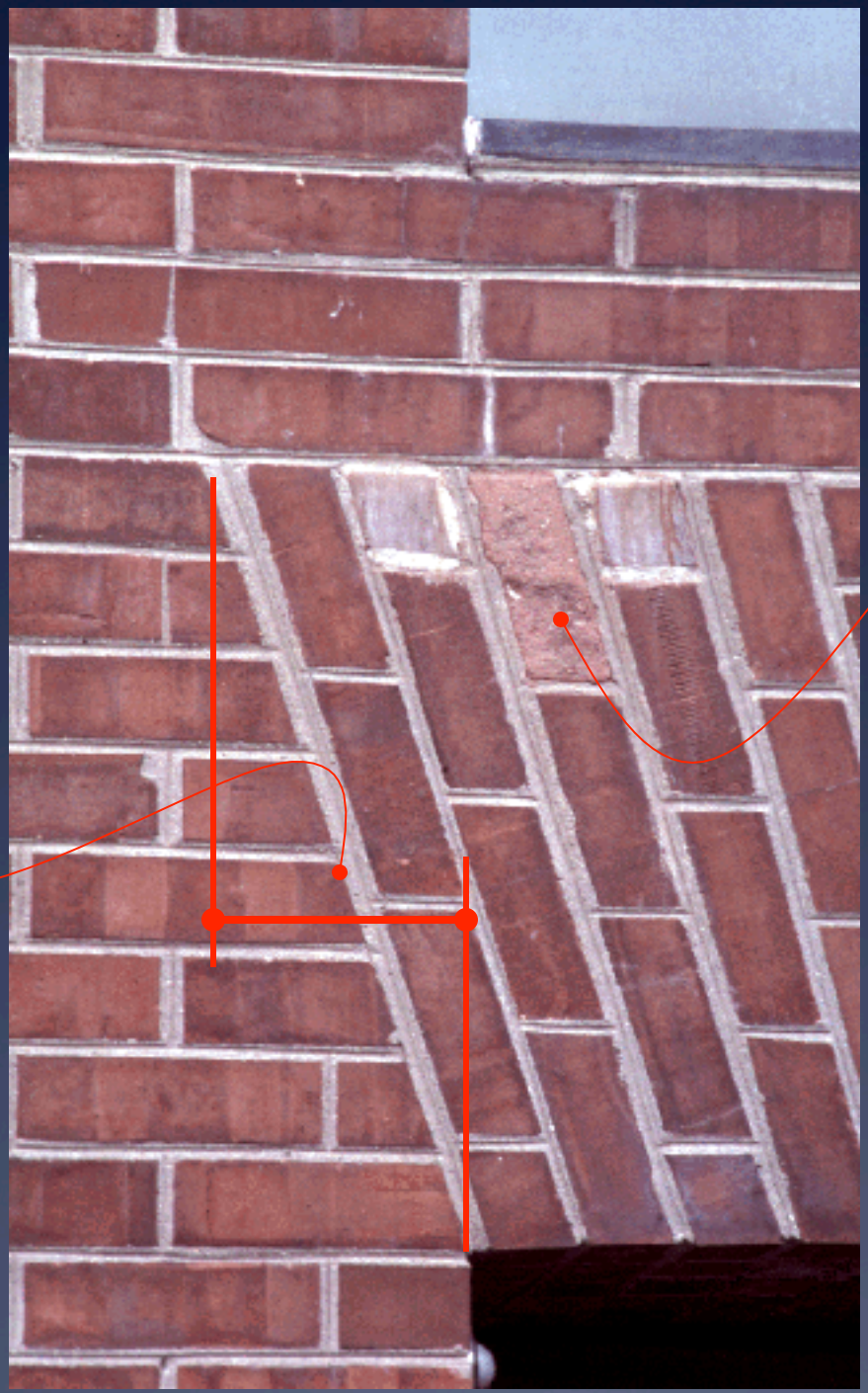
Slight rise on the bottom of the arch 1/8” per foot of span

The deterioration is mostly cosmetic, but because these arches bear load, the weakening brick has to be replaced.

The slate coping at the parapet has been removed, new flashing installed below the coping and the slate replaced.

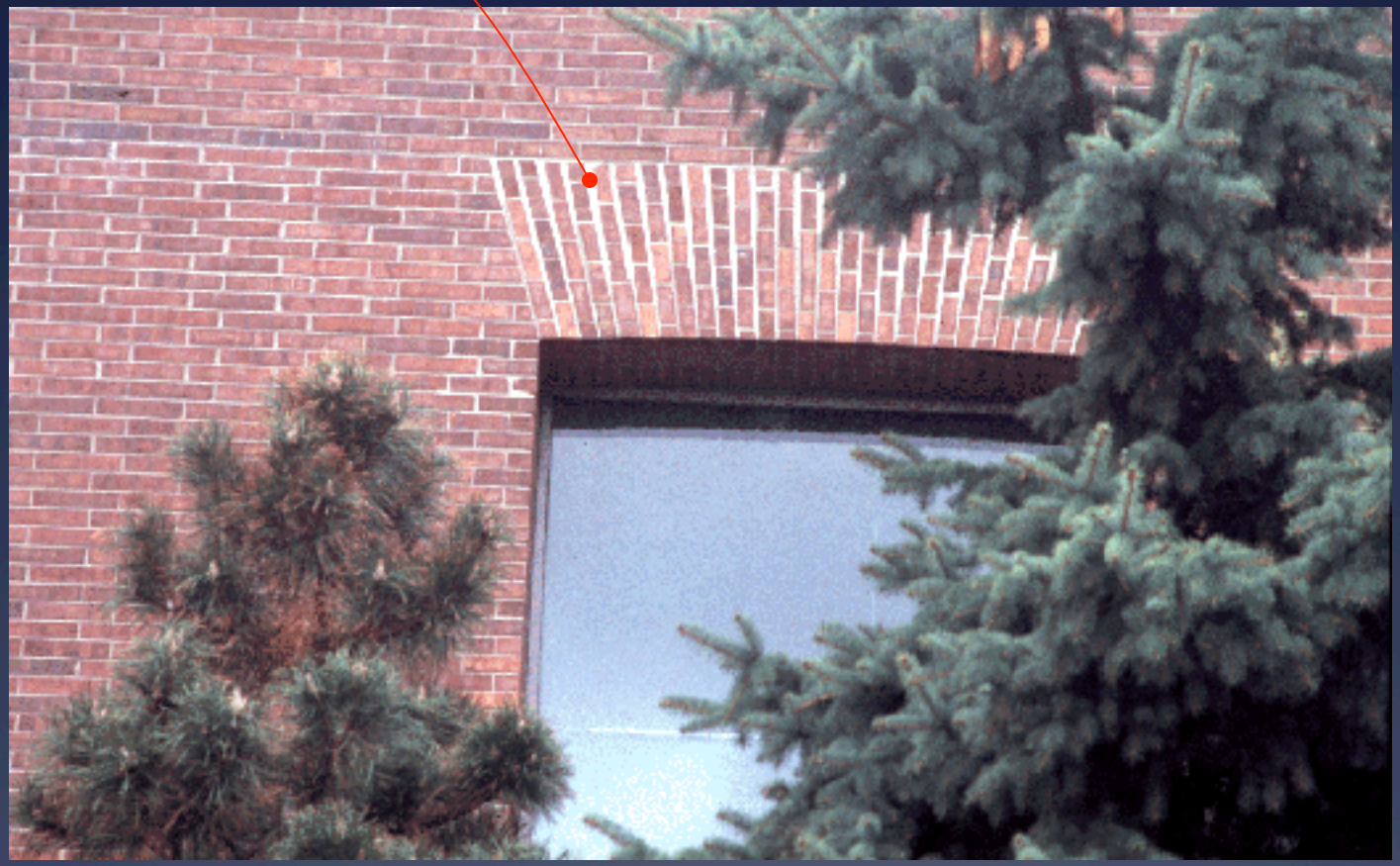
The bricks in the arch have to be cut out one at a time and new brick toothed in.

Skewback 1/2” per foot of span per 4” of arch depth



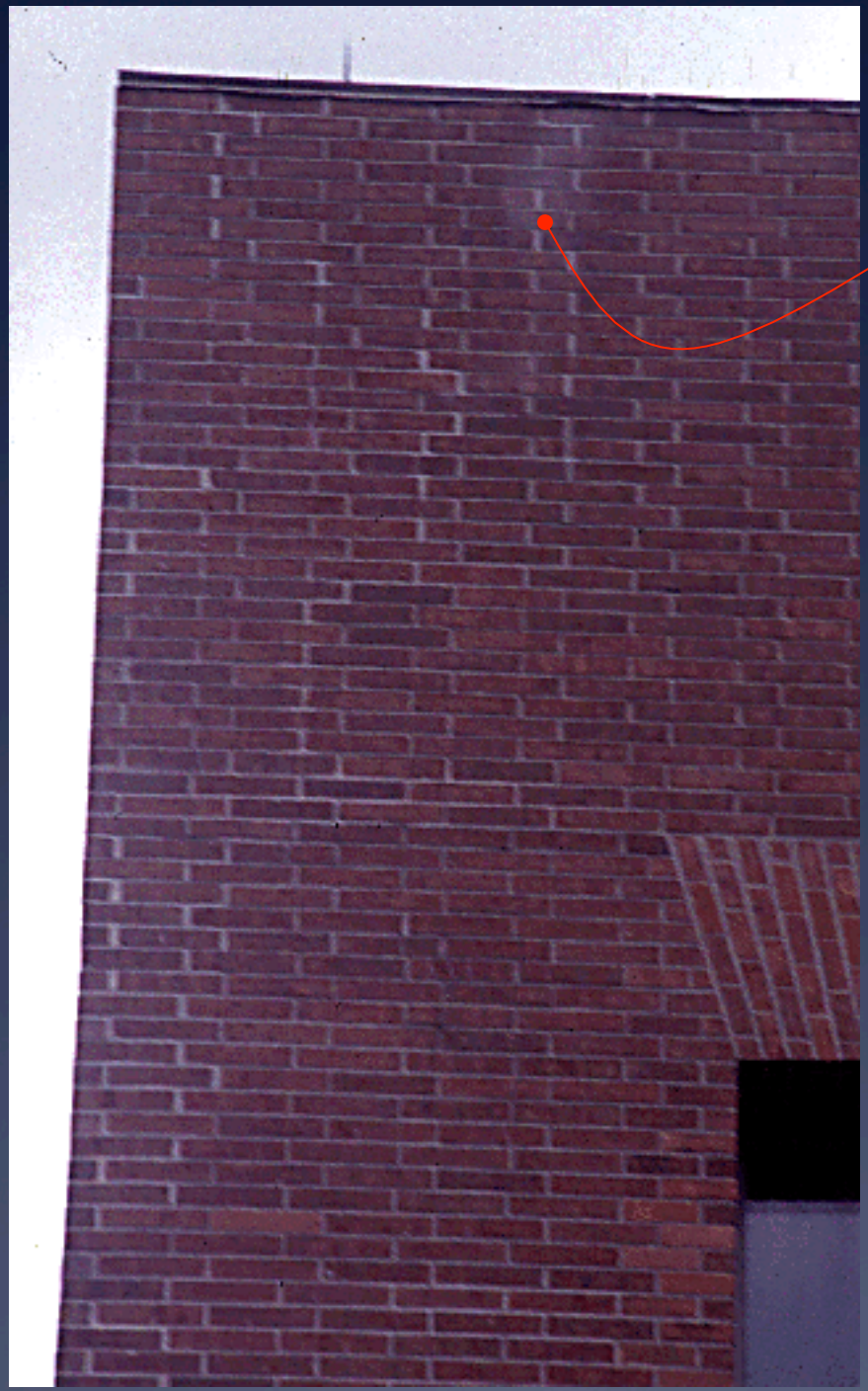
To save on costs of restoration, some patching material was painted over the brick.

Not very satisfactory in appearance.



In some places, the cut out and replacement process left wide, unsightly joints.

After all the work of removing the slate, reflashing below and re-installing it. Some well intentioned electrician drilled a hole through the slate, through the flashing to install a lightning rod.



Where is this leak coming from?

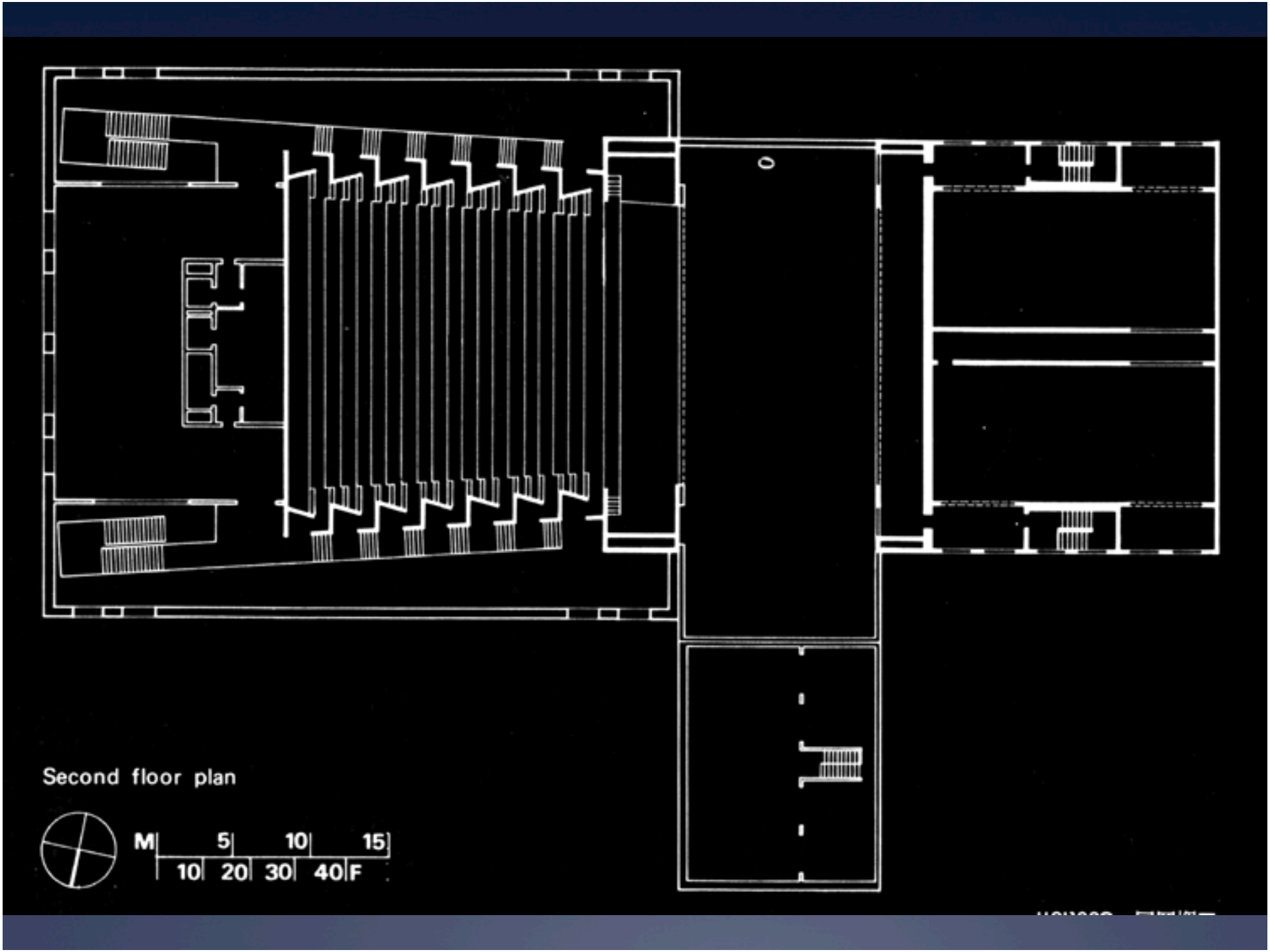
The worst case for the masonry was where it was exposed to moisture from both sides. What does the cooling tower behind this arch produce? How often?

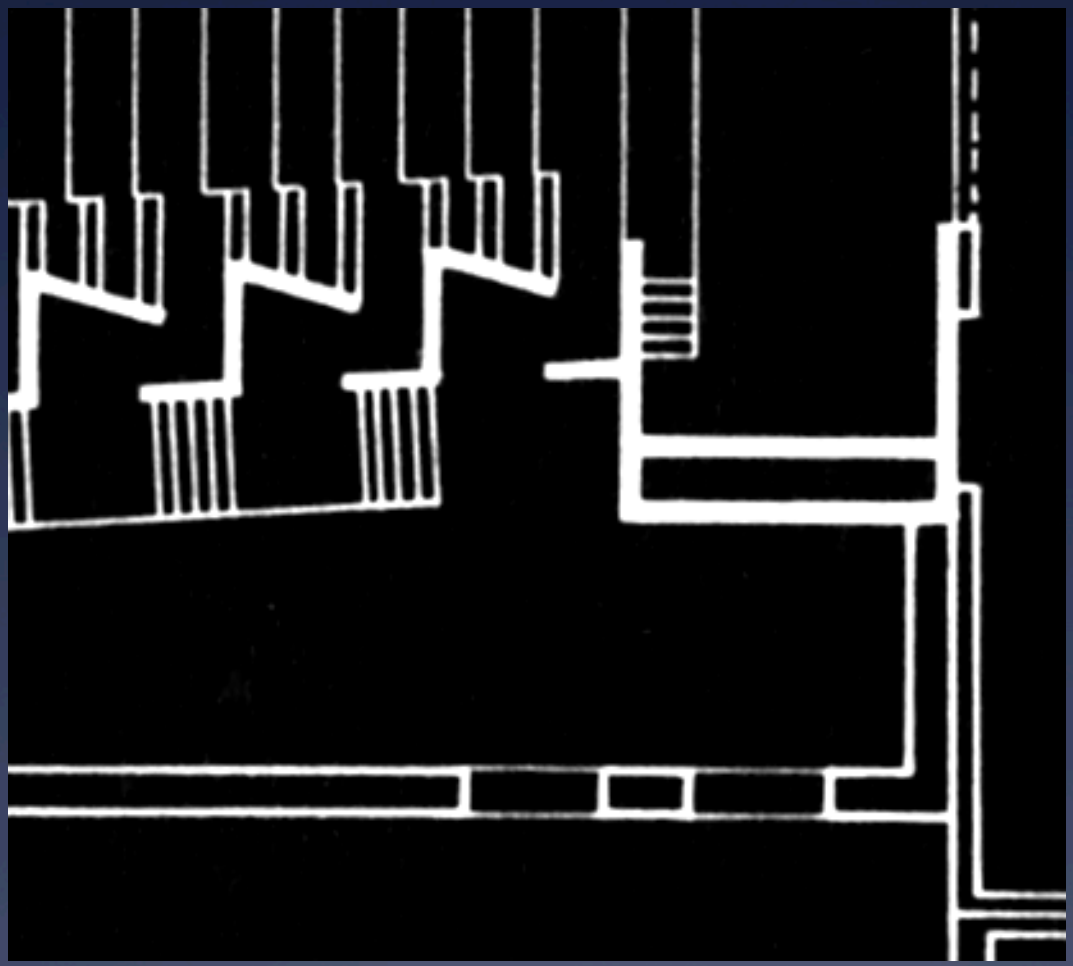
This arch was deemed too badly damaged, and out of sight so it was covered up with cement stucco. How is the stucco doing?

The corners of the cooling tower enclosure were patched with some not-very-close-to-matching brick….

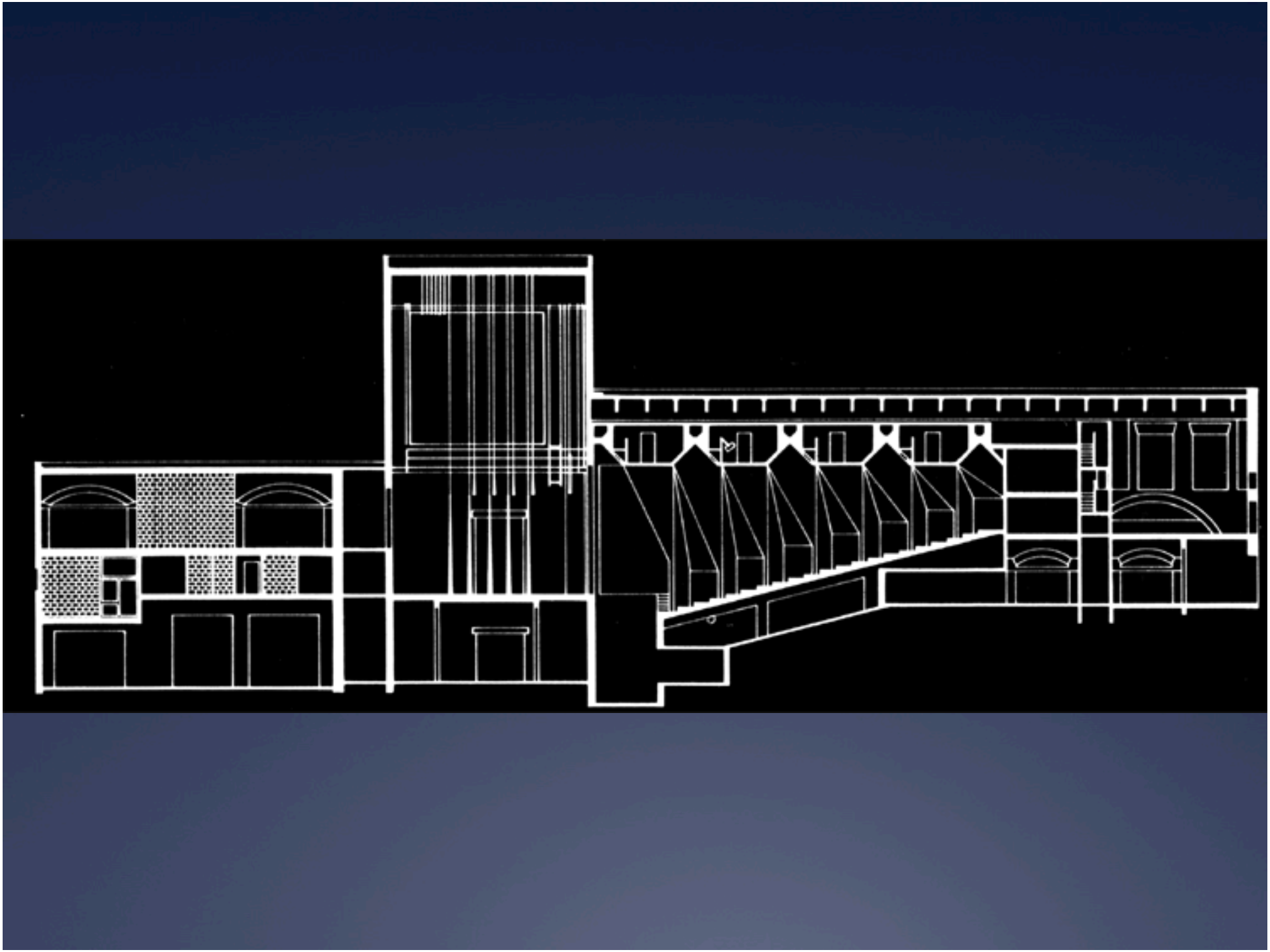
Or bondo, or patching compound.

Damage like this is pretty hard to repair to original condition.


Second floor plan
M 5 10 15
10 20 30 40 F




EXIT



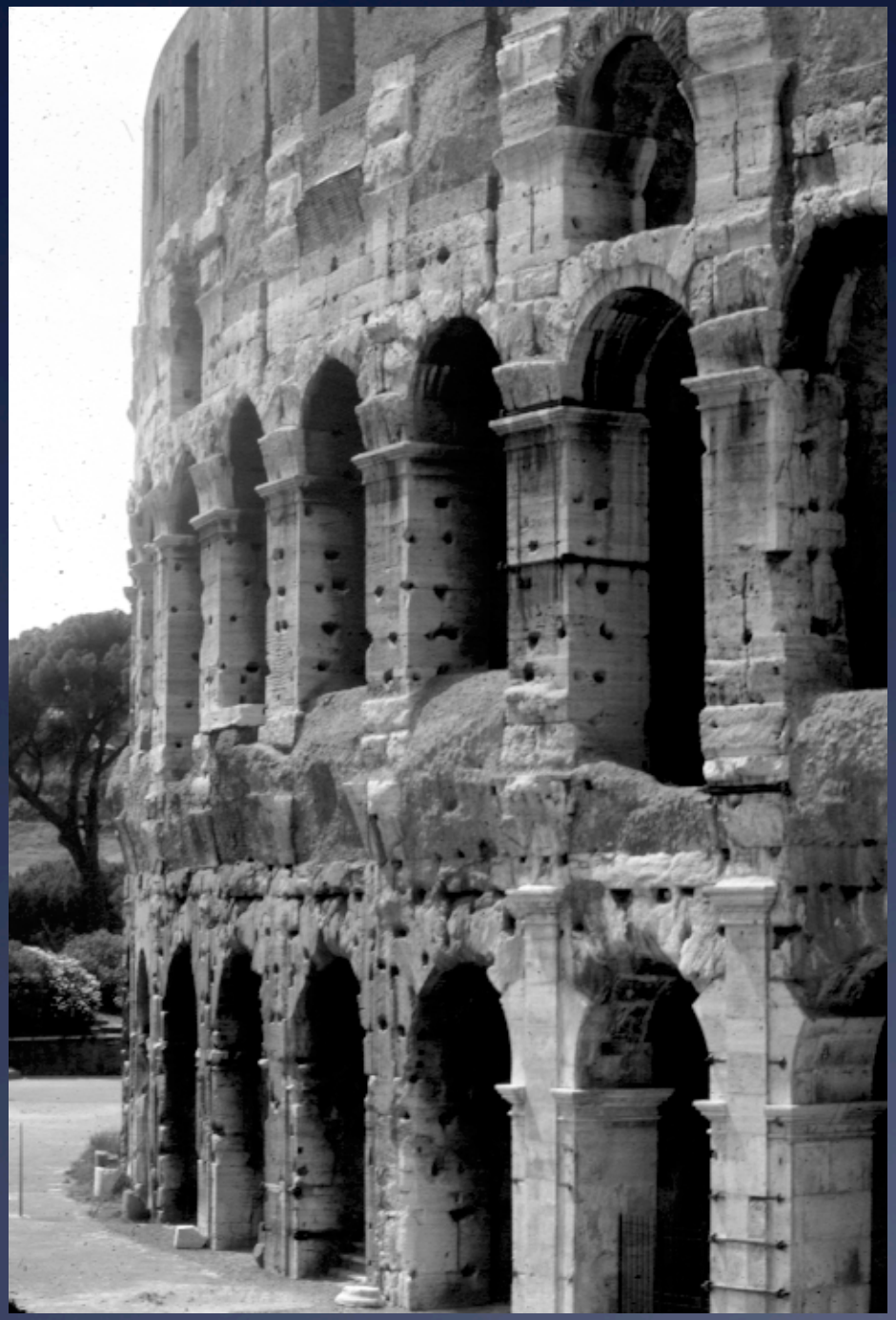
The Romans have been considered masters of masonry. The ruins of aqueducts, walls, theatres continue to teach us lessons about masonry and it’s architecture.

When the empire was rapidly expanding, material and skilled labor shortages were common.

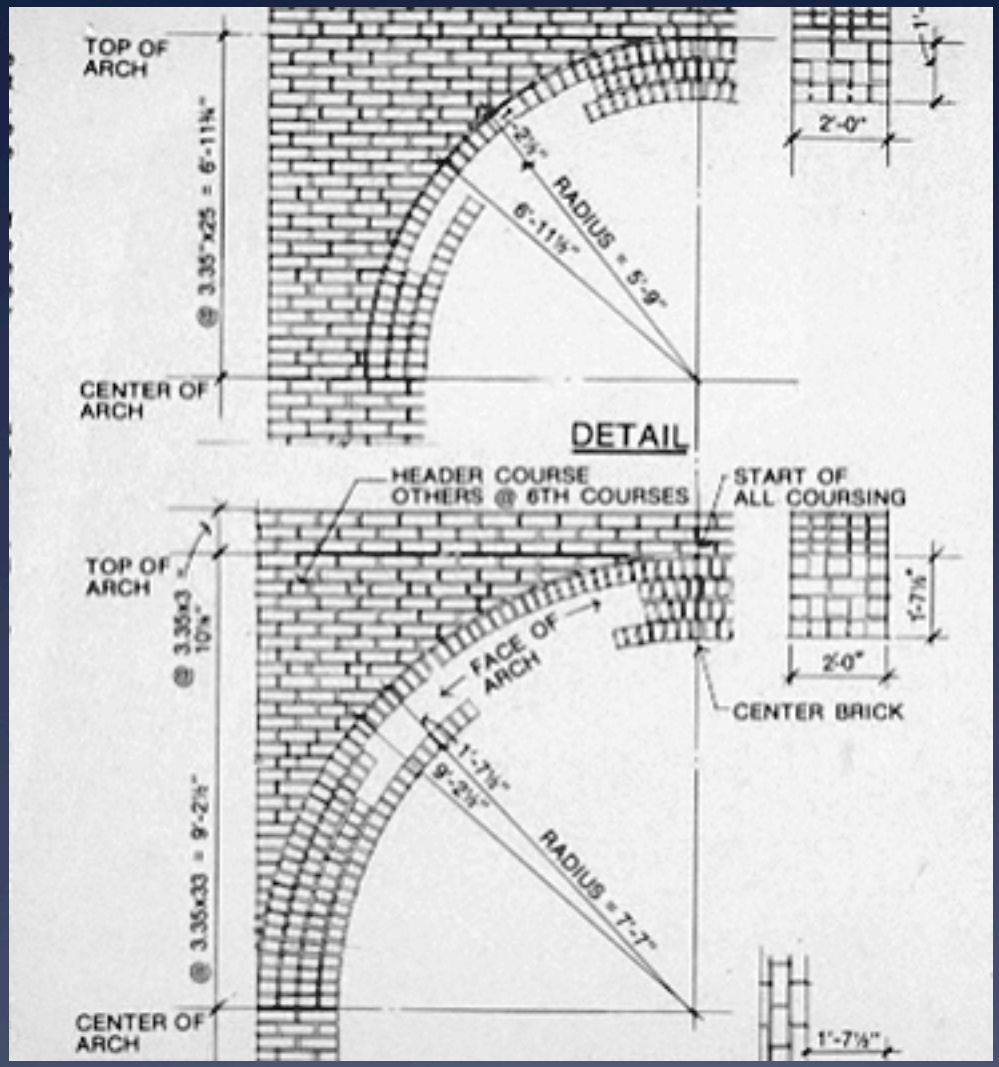
To work around these shortages, the Romans developed new construction methods and materials.

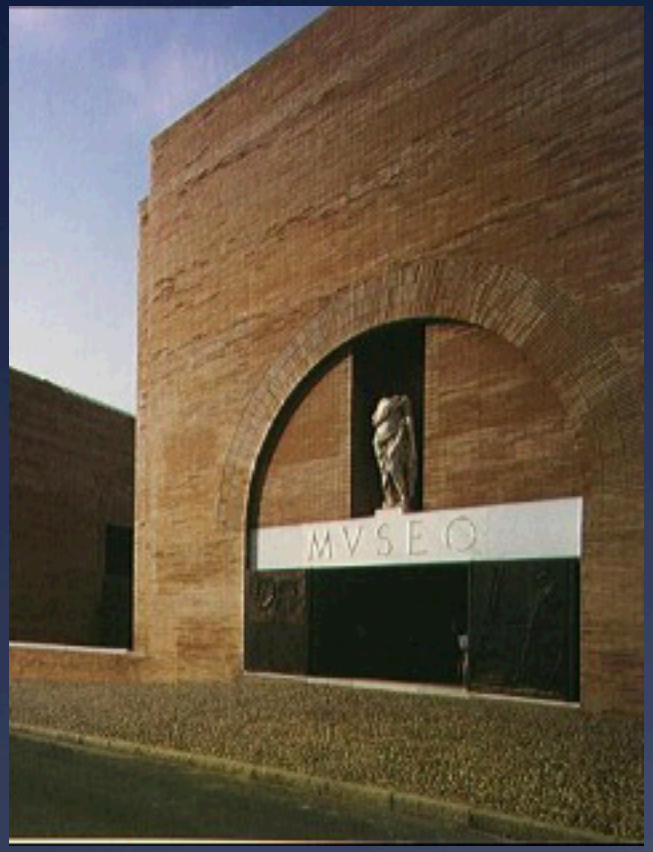
Primary among these was the composite wall. A wall with layers tasked to cladding, formwork, and structure

The colusseum in Niemes is a typical example of Roman masonry.



Roman buildings often had Stone cladding held to the structure with iron or bronze cramps, many removed after the fall of the empire. (precious metal)


TOP OF ARCH
@ 3.35"x25 = 6'-11¼"
CENTER OF ARCH
RADIUS = 5'-9"
6'-11⅛"
2'-0"
DETAIL
HEADER COURSE OTHERS @ 6TH COURSES
START OF ALL COURSING
TOP OF ARCH
@ 3.35x3 = 10¼"
@ 3.35x33 = 9'-2⅛"
FACE OF ARCH
CENTER BRICK
1'-7⅛"
9'-2⅛"
RADIUS = 7'-7"
1'-7⅛"



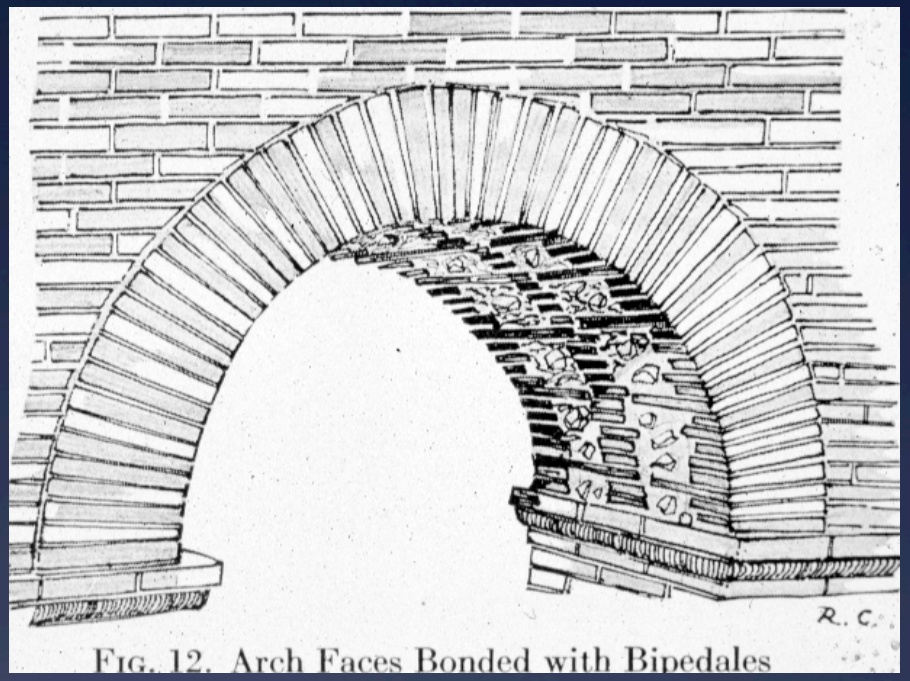


FIG. 12. Arch Faces Bonded with Bipedales

Architect Rafael Moneo updated many traditional Roman construction methods to build the Museum of Roman Antiquities in Merida, Spain.

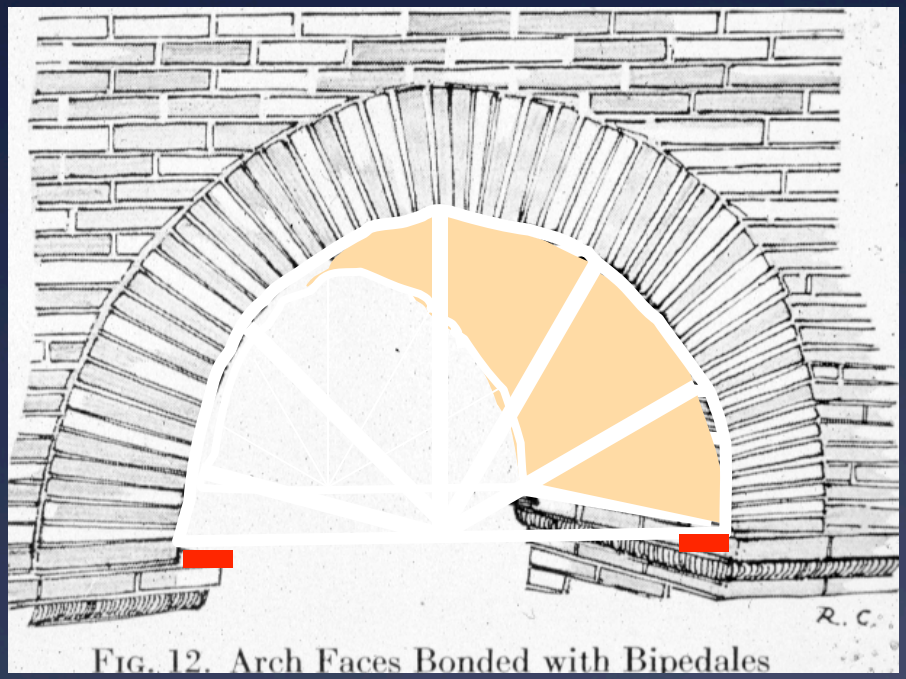
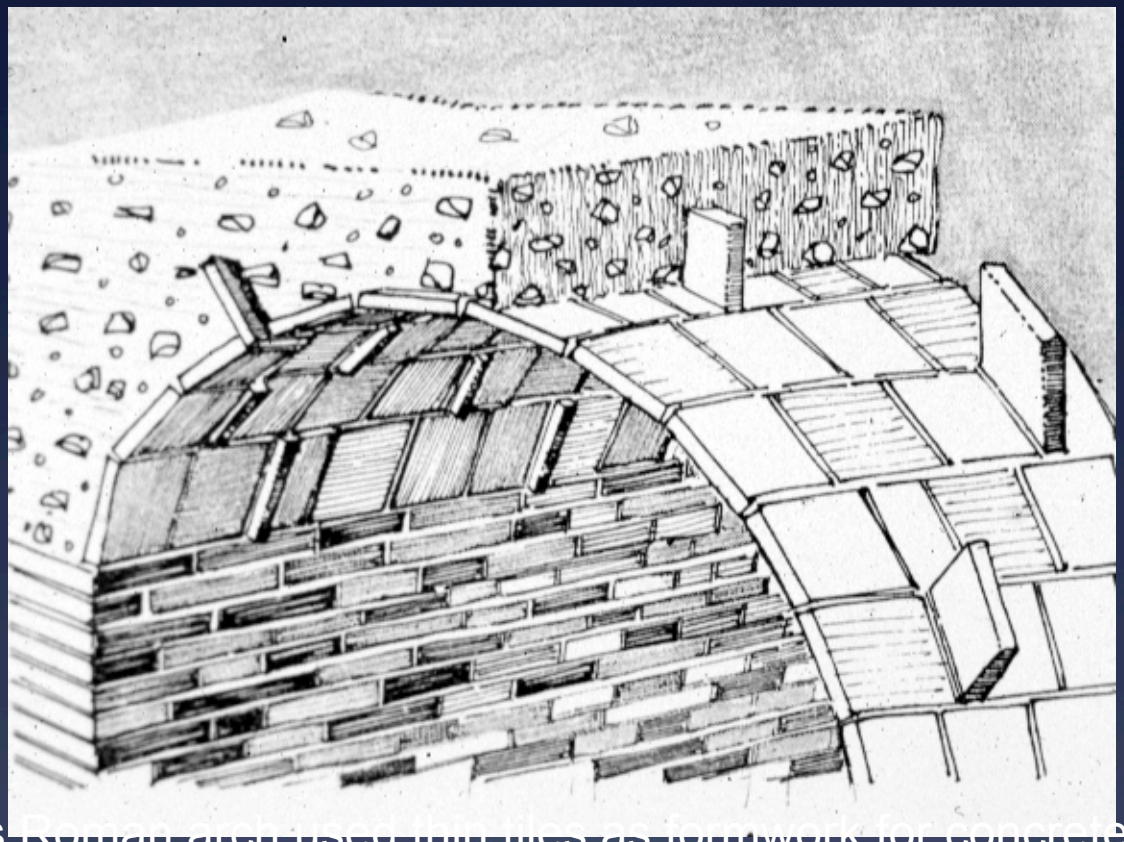


FIG. 12. Arch Faces Bonded with Bipedales

Usually, the roman arch required formwork to put in place. The formwork for arches is still called centering. It is usually made of wood, and is supported by wedges on scaffolding.

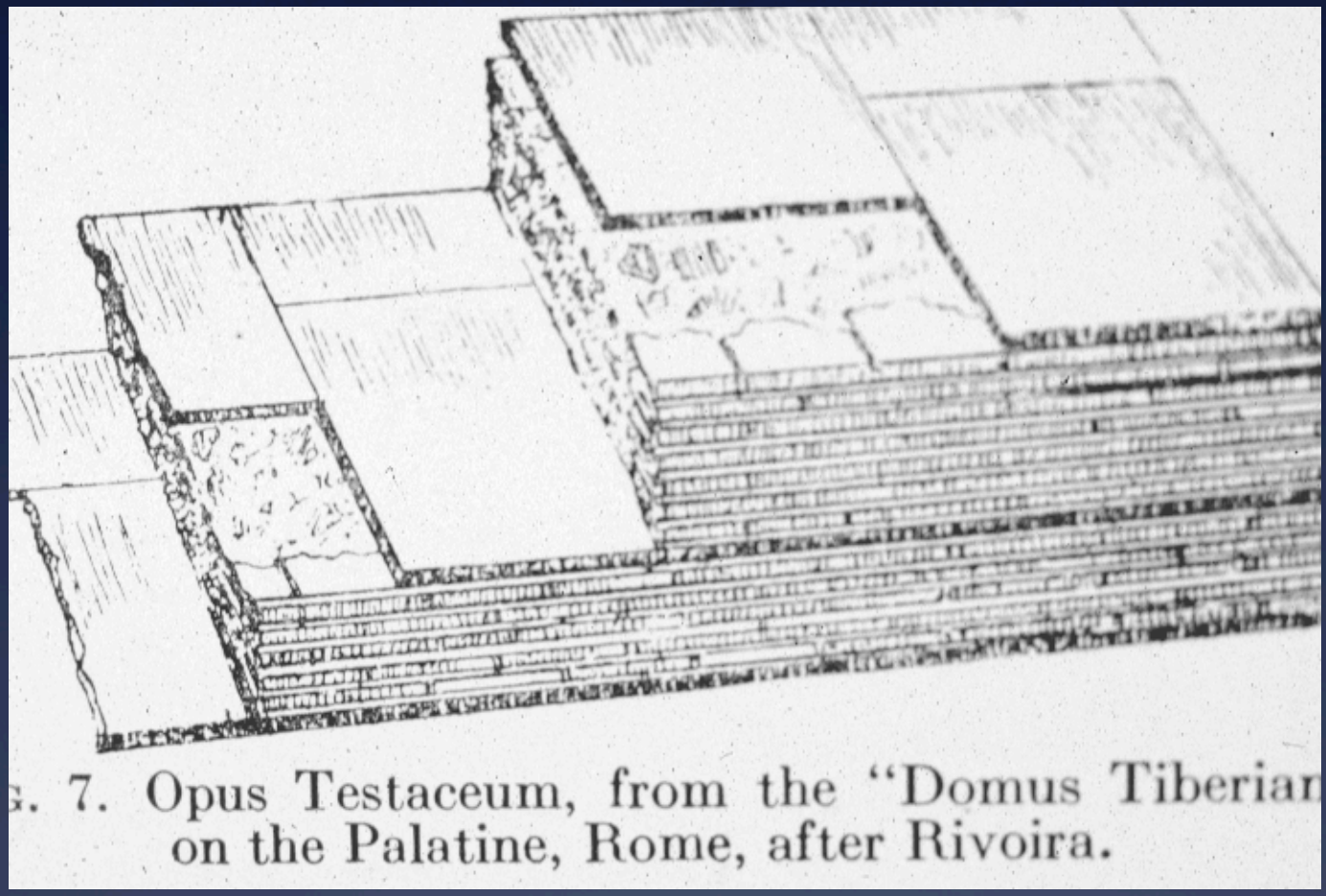
When the arch was done, tradition had it that the designer of the arch would stand below the arch while the masons drove the wedges out of the centering.

Any bad designers would be crushed…interesting way of maintaining the gene pool of arch designers.



This Roman arch used thin tiles as formwork for concrete mass above. The projecting tiles acted as ties, connecting the concrete to the tile.

This is very similar to the 1” thick tile vaults found in subways, and churches built through the 1930’s by the Robert Gustavino Company of New York. Gustavino’s vaults were commonly used for ceilings in large spaces and could span up to 60 feet carrying 400 lbs per s.f.!



g. 7. Opus Testaceum, from the "Domus Tiberian
on the Palatine, Rome, after Rivoira.

As both brick and masons became scarce, Romans developed composite walls where a thin "form" of brick was laid by skilled masons and a coarse fill of concrete and rubble was dumped between by laborers. Every six courses were header courses to tie the wall together.

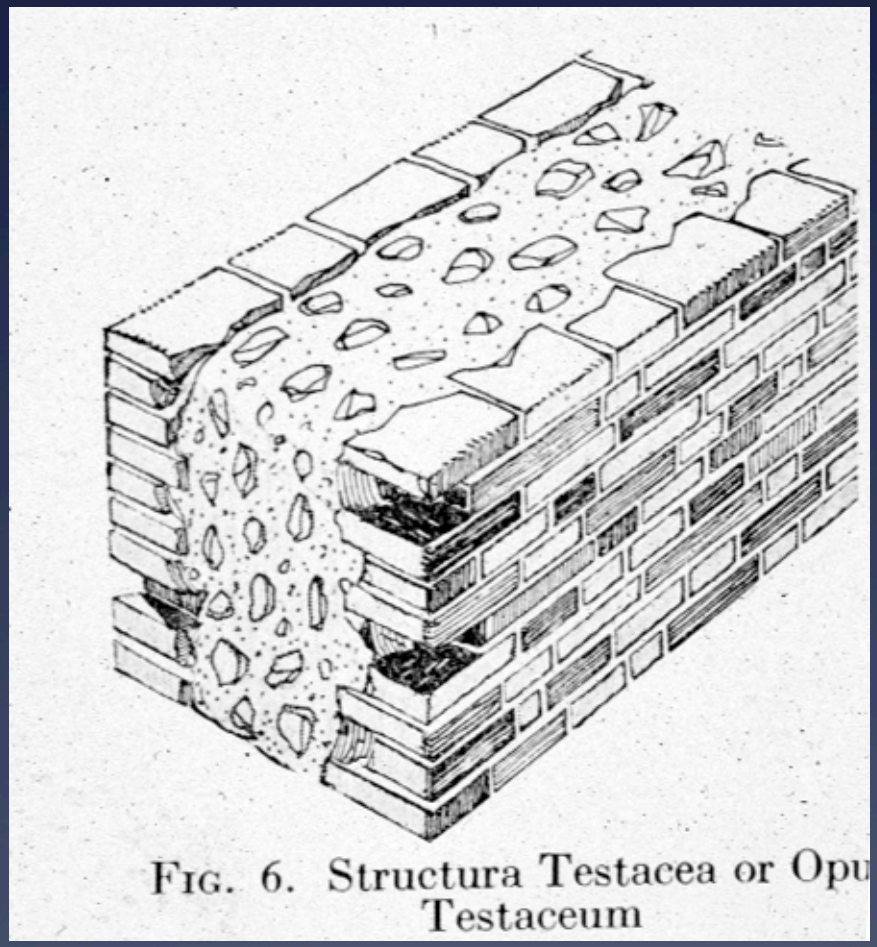
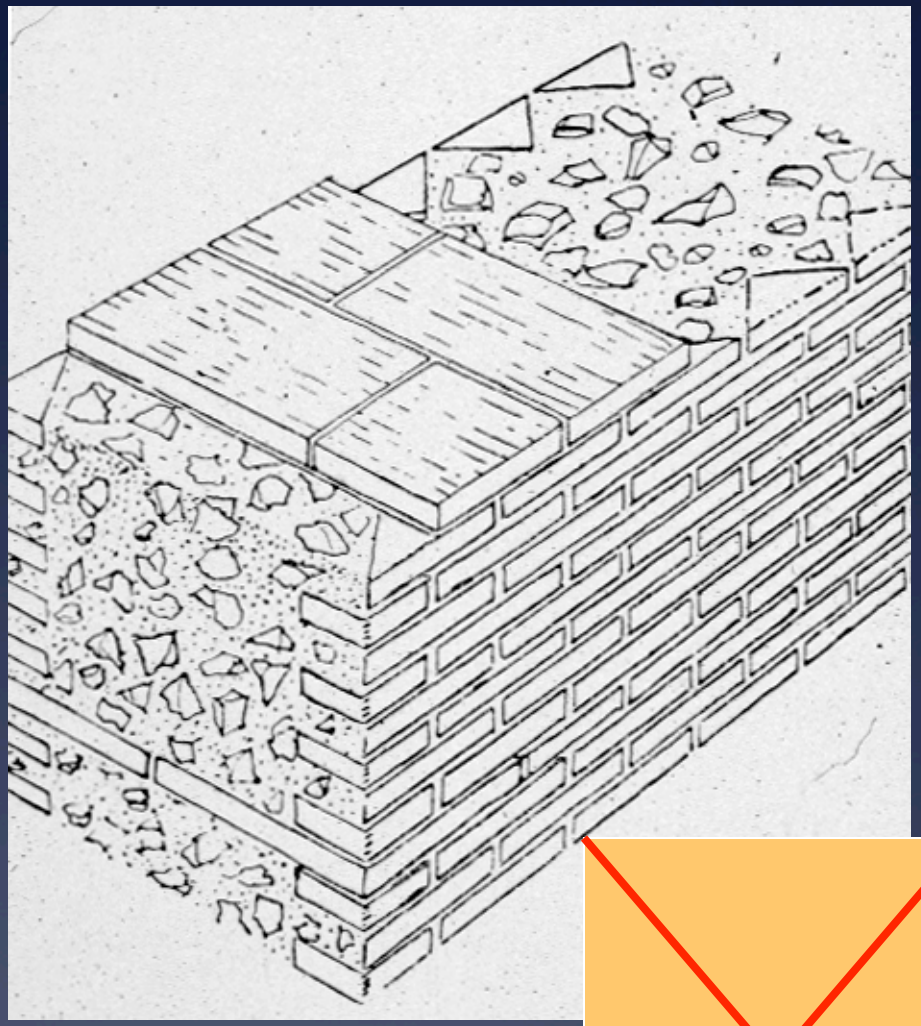
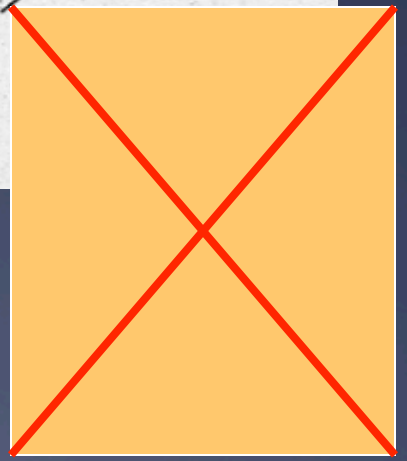
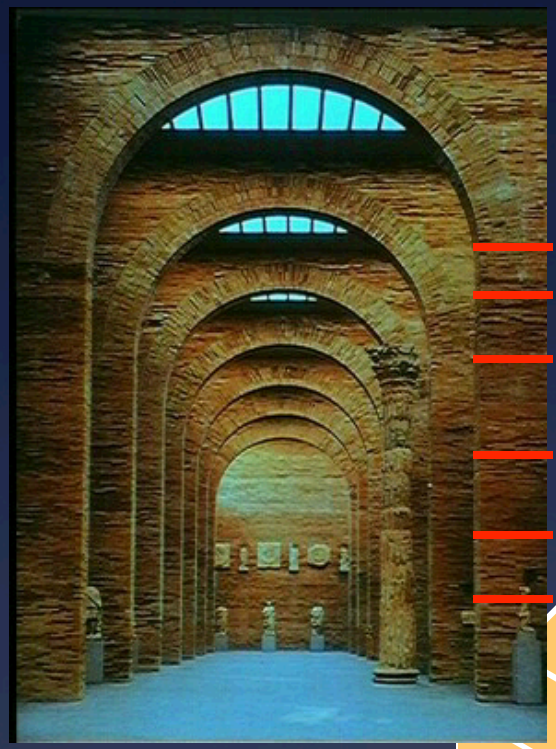


FIG. 6. Structura Testacea or Opu
Testaceum

As the composite method caught on, Romans began producing bricks that were easier to break into face forms. This simple diagonally scored brick could be easily broken into four triangular bricks. The resulting irregularity on the back face of the brick would help the concrete fill bond to the brick.







Moneo uses the brick as formwork for a concrete fill, very similar to the Roman methods