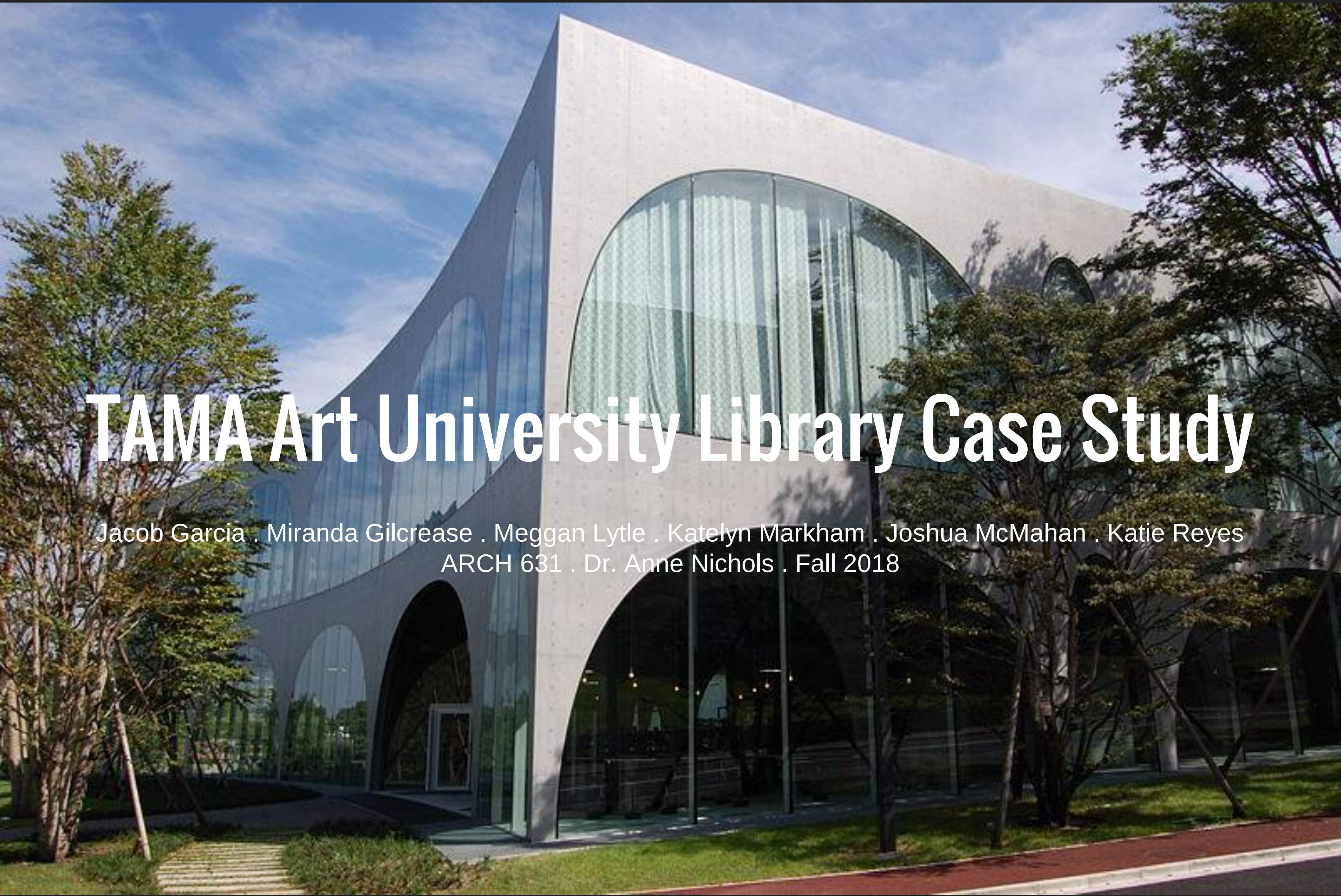


TAMA Art University Library Case Study

Jacob Garcia . Miranda Gilcrease . Meggan Lytle . Katelyn Markham . Joshua McMahan . Katie Reyes

ARCH 631 . Dr. Anne Nichols . Fall 2018

https://sumally.com/p/362137

Architect Toyo Ito

1941
Born in Seoul Metropolitan City

1965-69
The University of Tokyo, Department of Architecture

1971
Started his studio, Urban Robot (URBOT) in Tokyo

1979
Changed its name to Toyo Ito & Associates, Architects

2013
Pritzker Architecture Prize

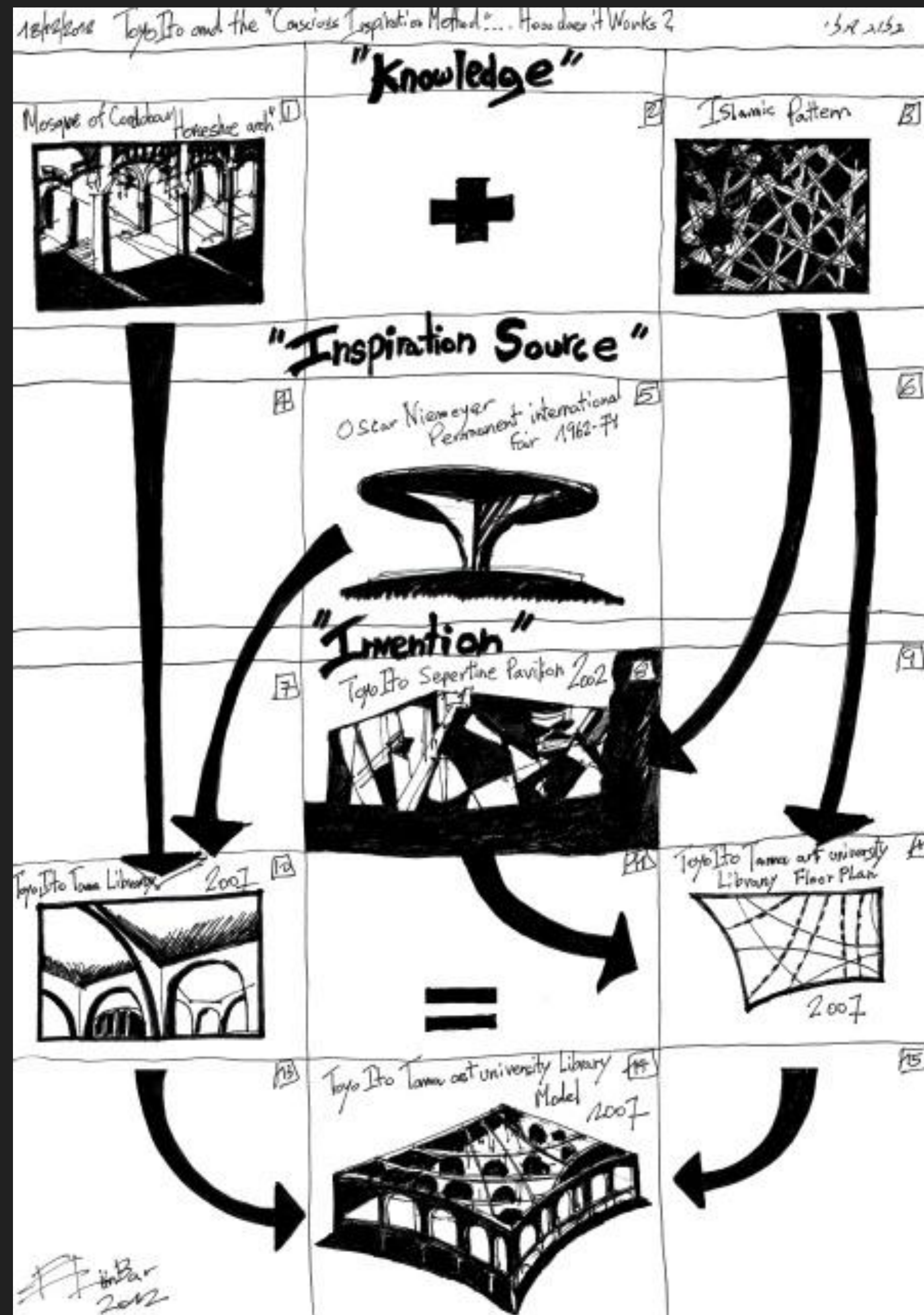
Project Data

- Location
  - Hachioji, Tokyo, Japan
- Period
  - 2004.4 – 2007.2
- Site Area
  - 159,184.87m2
- Building Area
  - 2,224.59m2
- Total Floor Area
  - 5,639.46m2
- Structural Engineer: Mutsuro Sasaki

https://en.wikiarquitectura.com/building/tama-art-university-library/

Design Concept

- Reflect the surrounding nature.
- Interpretation of a geological cave.
- Large glass windows and “random” arches - continuous views
- Inspiration - The Mosque of Cordoba, as well as islamic patterns
- Arches derived from bezier curve



https://archidialog.com/tag/tama-art-university-library/

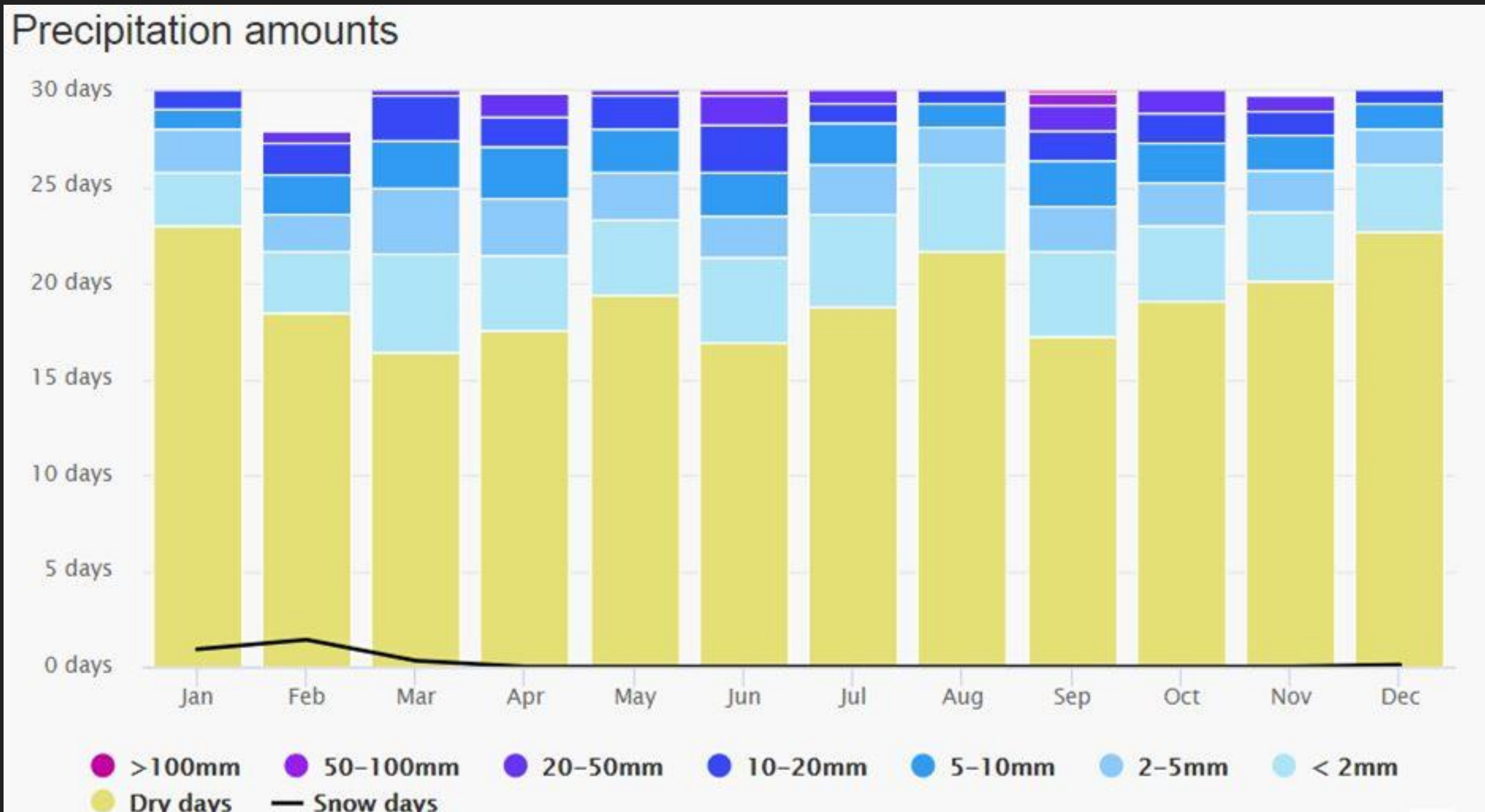
Design Features

- The arches- differ heights and spans
- Arches -represent the stalactites of caves, appearing as if in chaos.
- Design reflects various visual perspectives.
- The design - “emergent” grid, which is made of curved lines, 166 arches, and 56 intersecting points.

https://leec737.wordpress.com/2014/02/26/tama-art-university-library/

http://shomei-tanteidan.org/en/wlj/tama-art-university-library/

Site Data



https://www.meteoblue.com/en/weather/forecast/modelclimate/tokyo_japan_1850147

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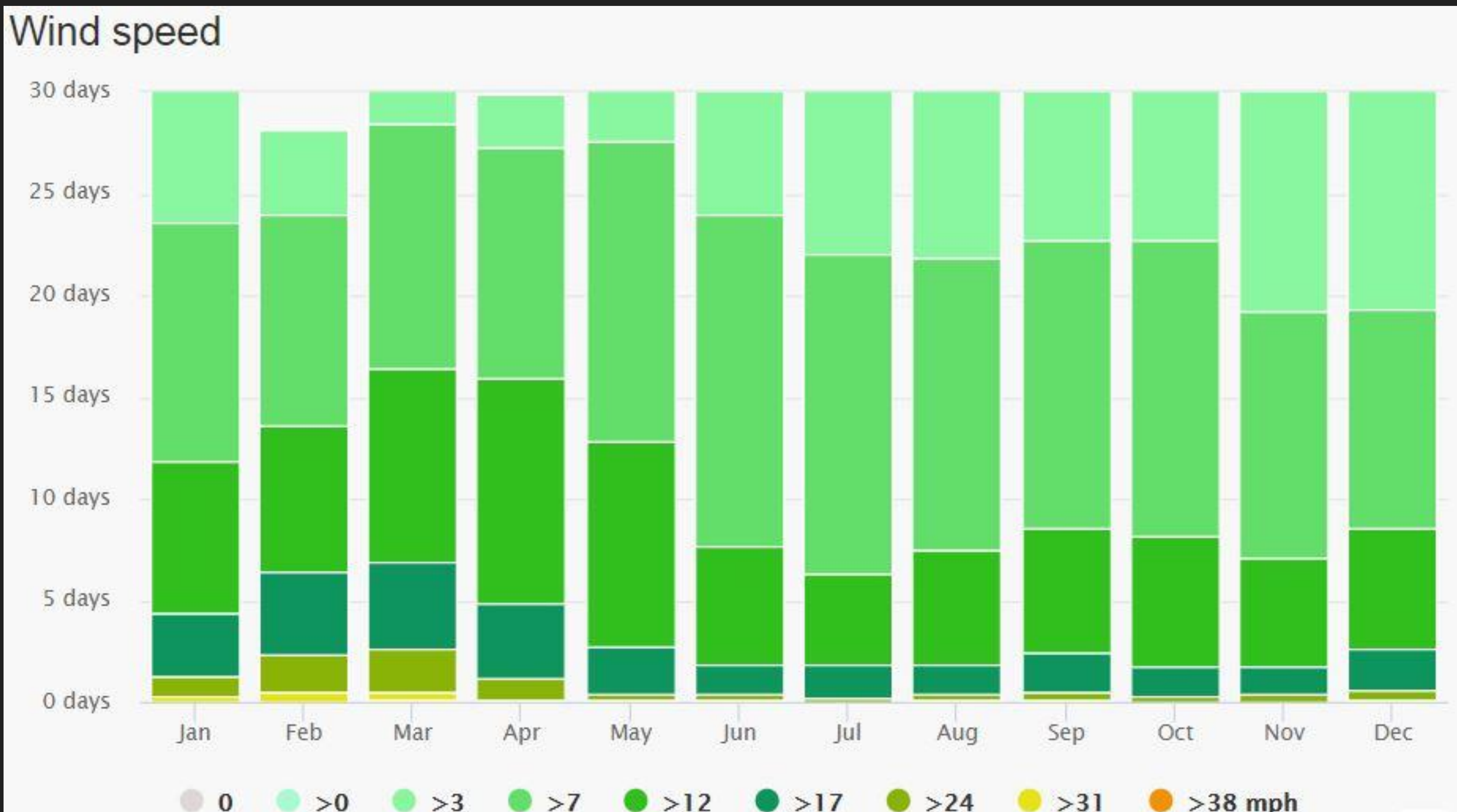

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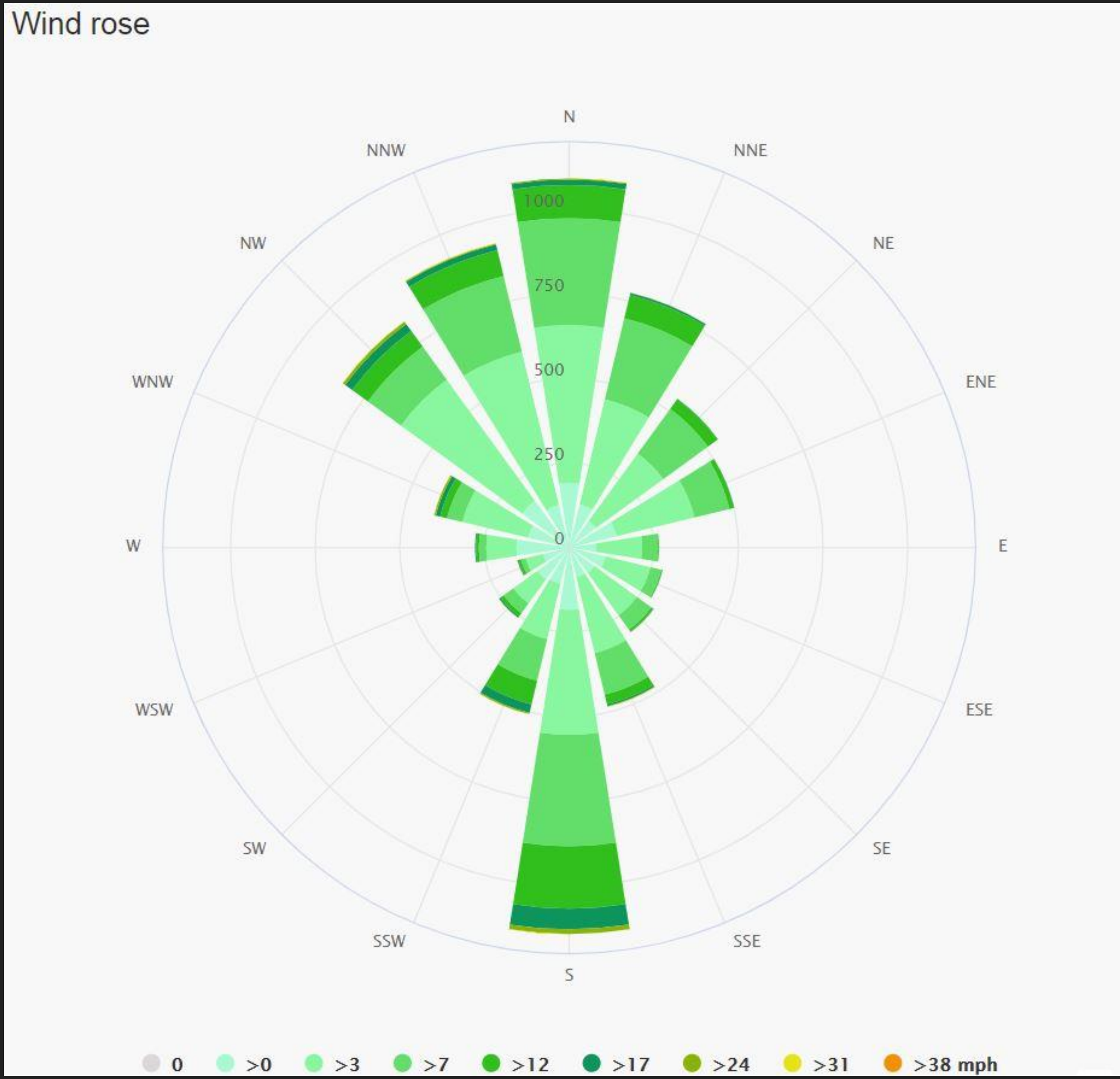

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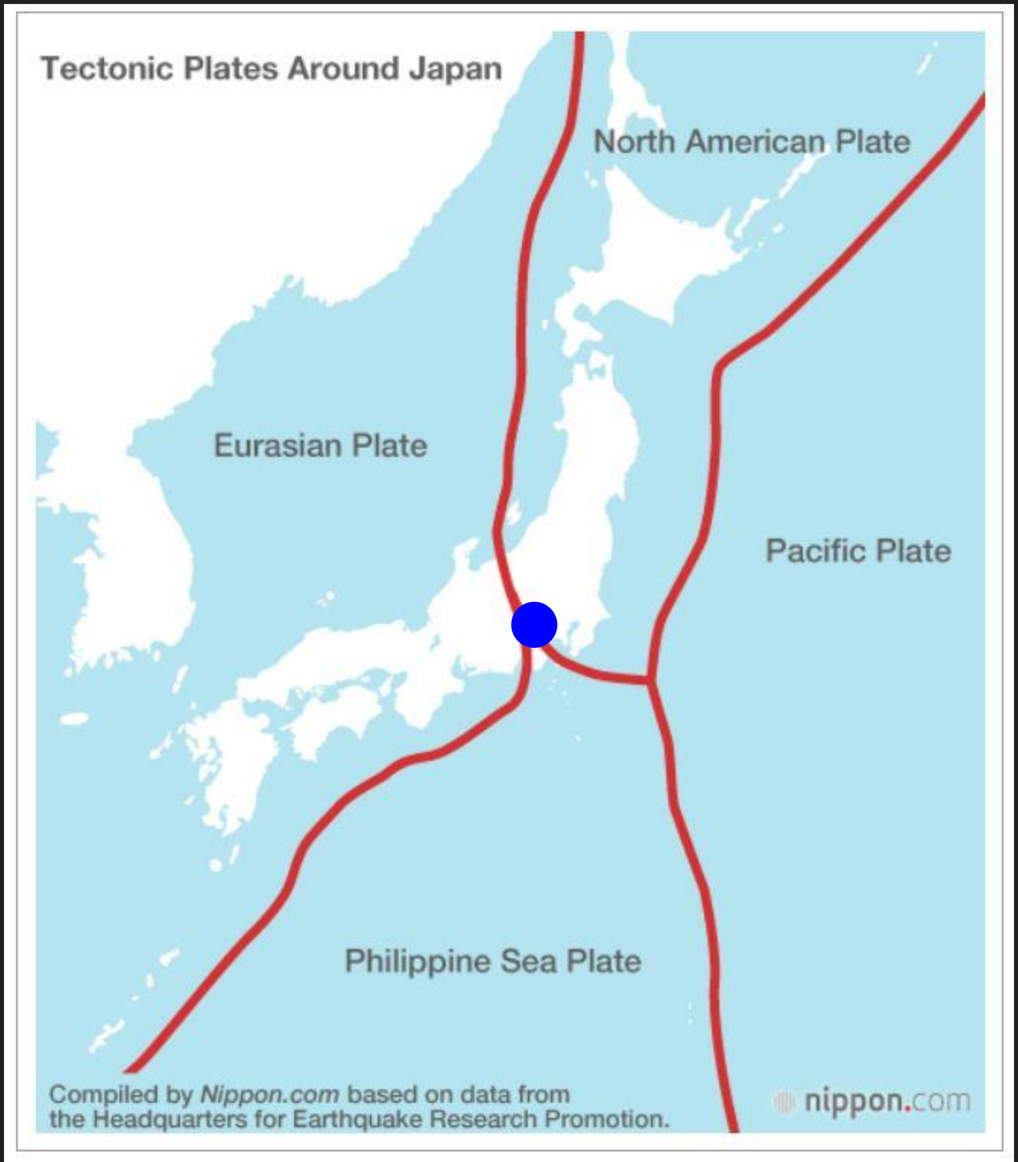
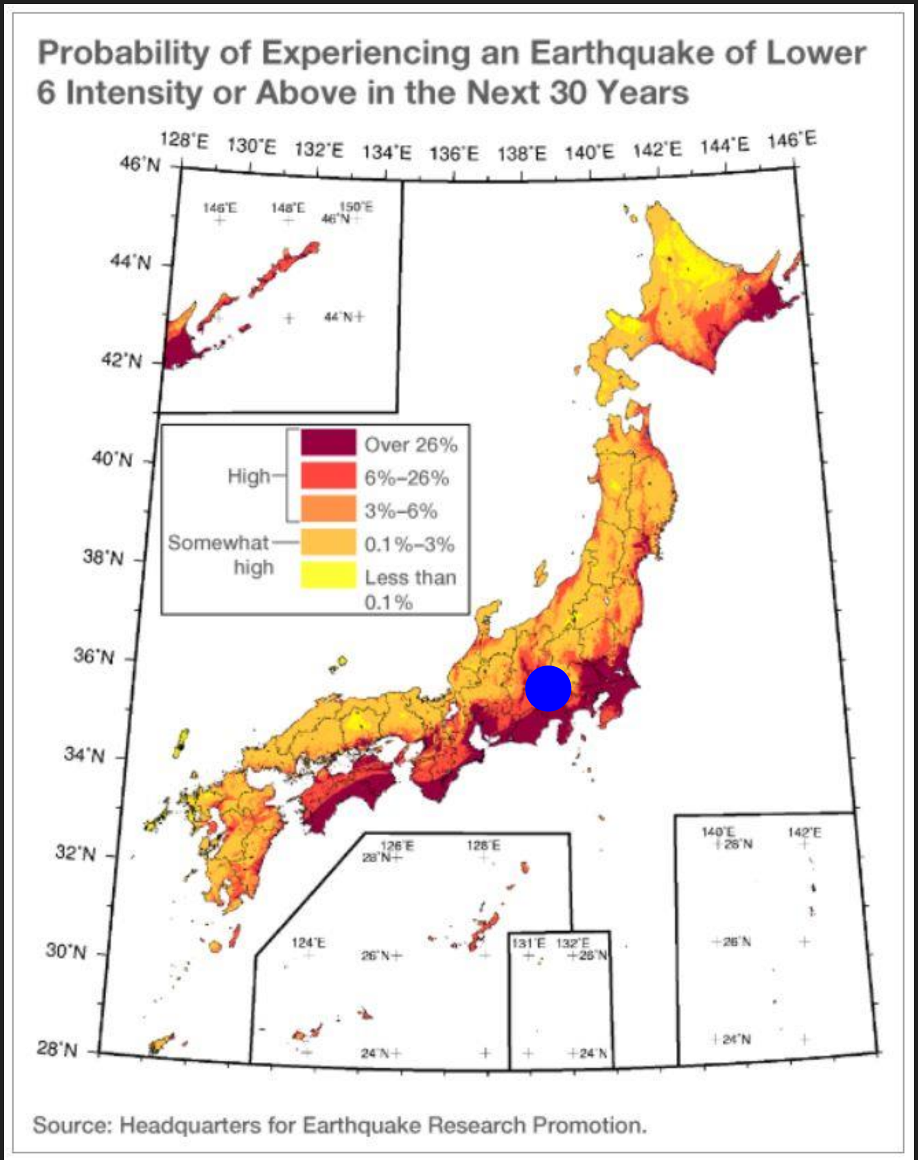


https://www.nippon.com/en/features/h00234/

Site Data



https://www.nippon.com/en/features/h00234/

Site Data

Probability of an Intensity 6 or Stronger Earthquake in Prefectural Capitals

Tokyo Metropolitan Area	Chiba, Chiba Prefecture	85%
	Yokohama, Kanagawa Prefecture	82%
	Mito, Ibaraki Prefecture	81%
	Saitama, Saitama Prefecture	55%
	Tokyo	48%
Tōkai Area	Shizuoka, Shizuoka Prefecture	70%
	Tsu, Mie Prefecture	64%
	Nagoya, Aichi Prefecture	46%
Kansai Area	Nara, Nara Prefecture	61%
	Wakayama, Wakayama Prefecture	58%
	Osaka, Osaka Prefecture	56%
	Kobe, Hyōgo Prefecture	45%

https://www.nippon.com/en/features/h00234/

Seismic Scale

Scale	Quake Perception and Amount of Damage
0	Imperceptible to people.
1	Felt slightly by some people.
2	Felt by many people sitting still in buildings.
3	Felt by most people in buildings.
4	Most people are startled. Hanging objects such as lights swing significantly. Unstable ornaments may fall.
5 Lower	Many people are frightened and feel the need to hold onto something stable. Dishes in cupboards and items on bookshelves may fall. Unsecured furniture may move.
5 Upper	Many people find it difficult to walk without holding onto something. Unsecured furniture may topple over. Unreinforced concrete-block walls may collapse.
6 Lower	It is difficult to remain standing. Doors may become wedged shut. Wall tiles and windows may sustain damage and fall. Wooden houses with low earthquake resistance may lean.
6 Upper	It is impossible to move without crawling. People may be thrown through the air. Most unsecured furniture moves, and is more likely to topple over. Large cracks may form, and large landslides may occur.
7	Many reinforced-concrete buildings with low earthquake resistance collapse.

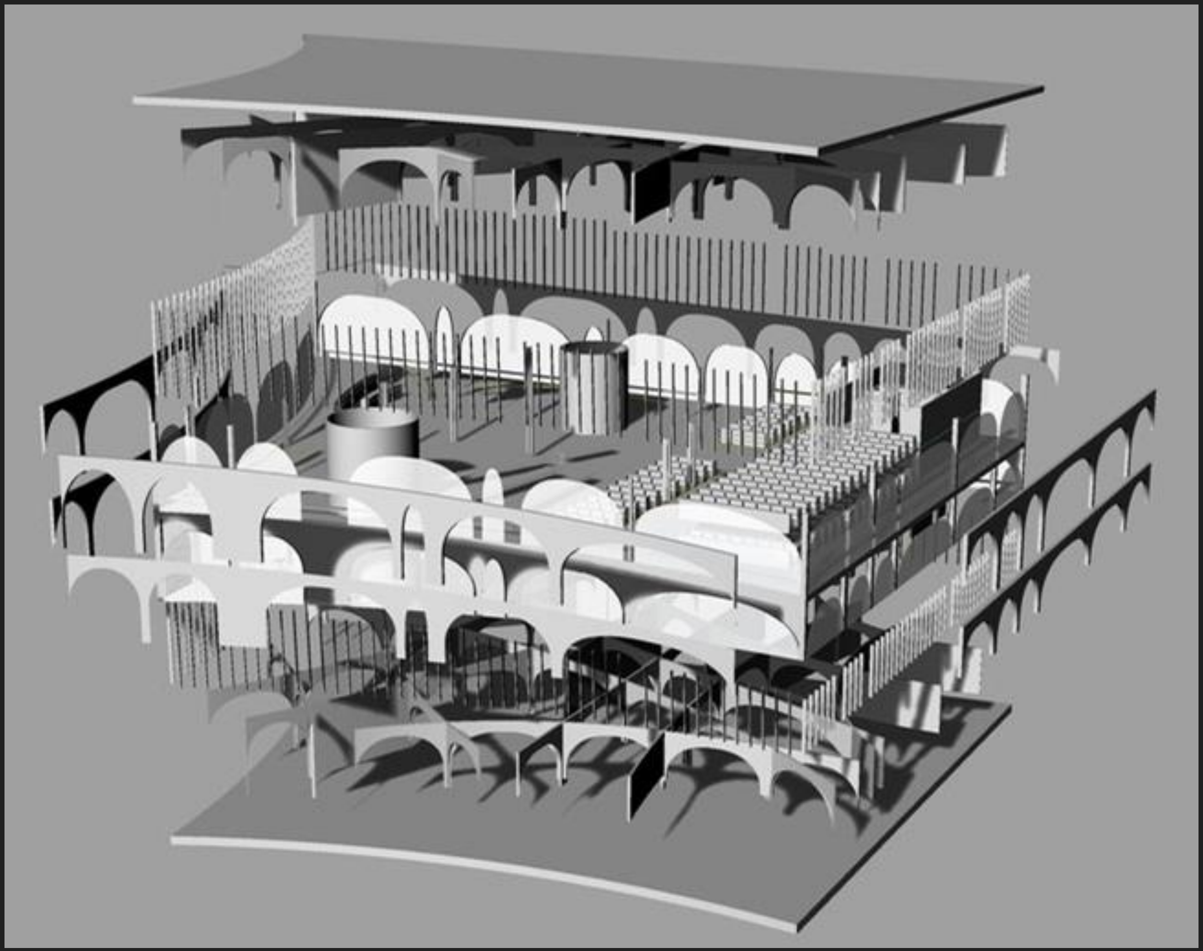
https://www.nippon.com/en/features/h00234/

Seismic Scale Illustration

https://www.jma.go.jp/jma/en/Activities/earthquake.html

The Structure

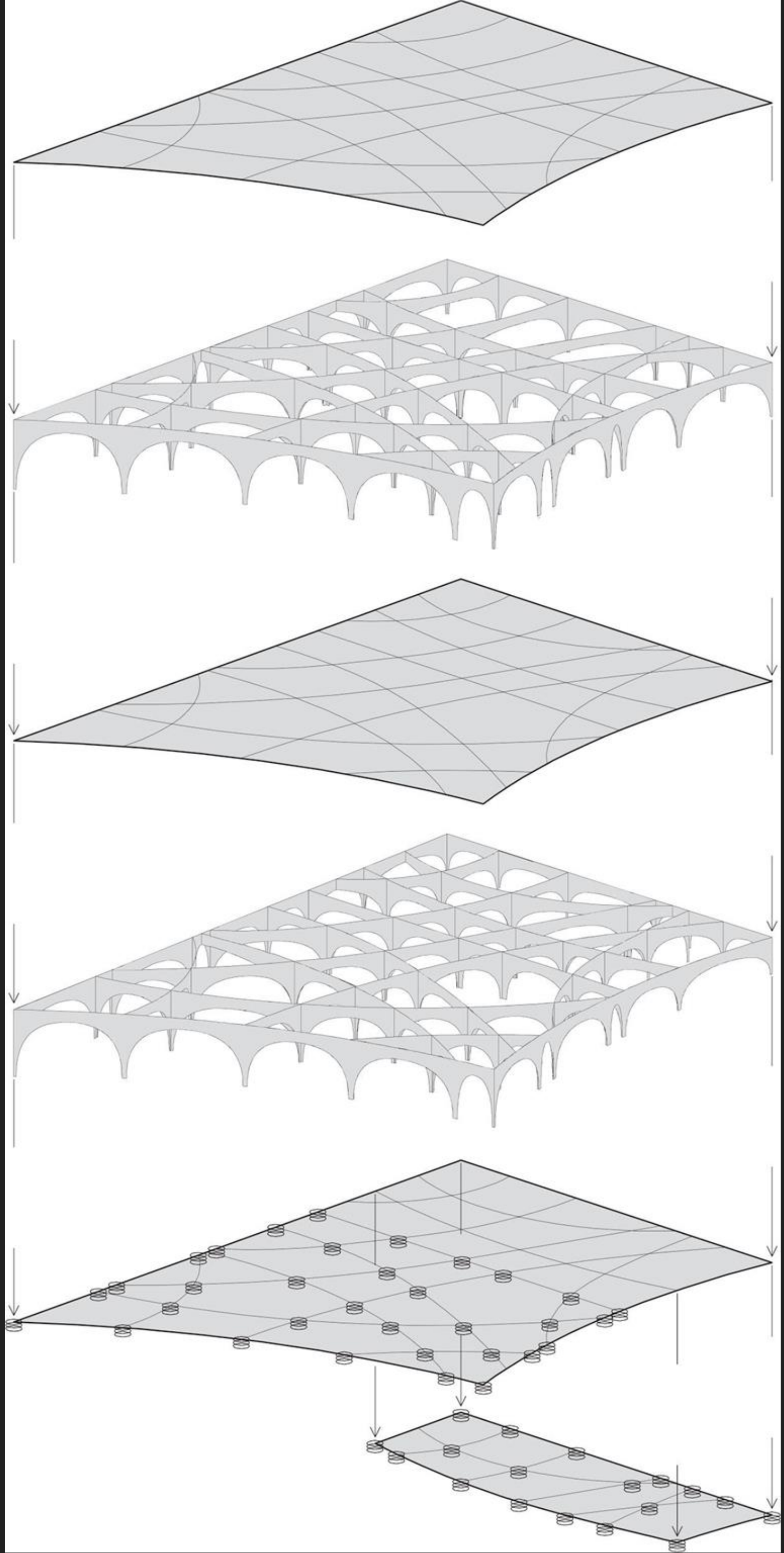
- The main structural system is a combination of steel arches and reinforced concrete.
- The arches are made out of 12mm steel plates that have been covered with concrete (~8in).
- “Emergent grid” floor plan
- Arch intersections form a cross shape
    - aid for seismic (lateral stability)



http://www.celestelayne.com/blog/2018/1/15/tama-art-university-library

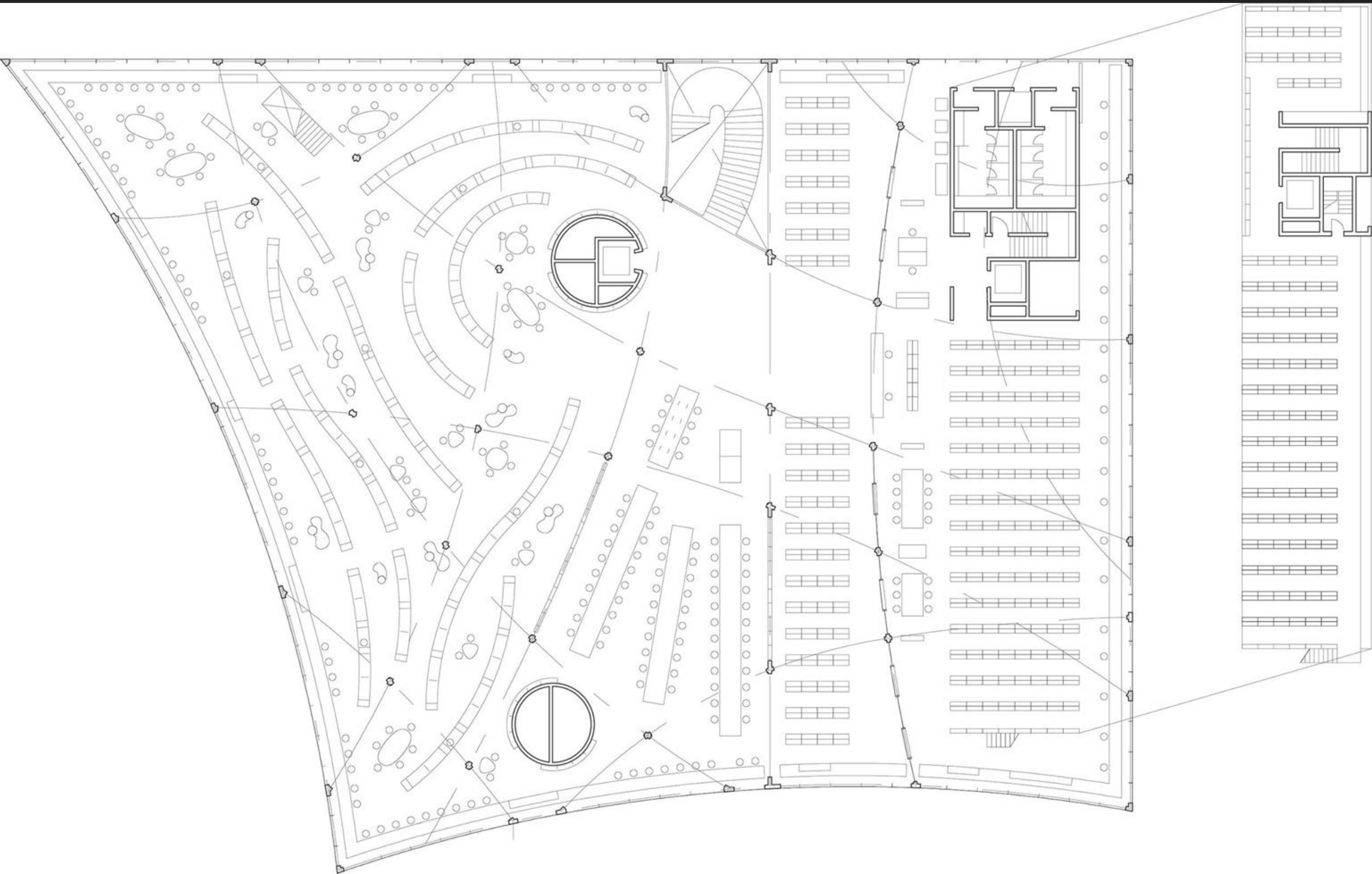
Arches

- Arches on top floor align with bottom floor arches.
- Continuous arches give lateral support to the framing system.
- The “emergent grid” of arches provides diaphragm cross bracing
- Concrete serves as fireproofing and “deflection suppression” for steel arches.
- Composite arch is 200 mm thick concrete (in spans) .
- Composite arch is 400 mm thick at intersection points.

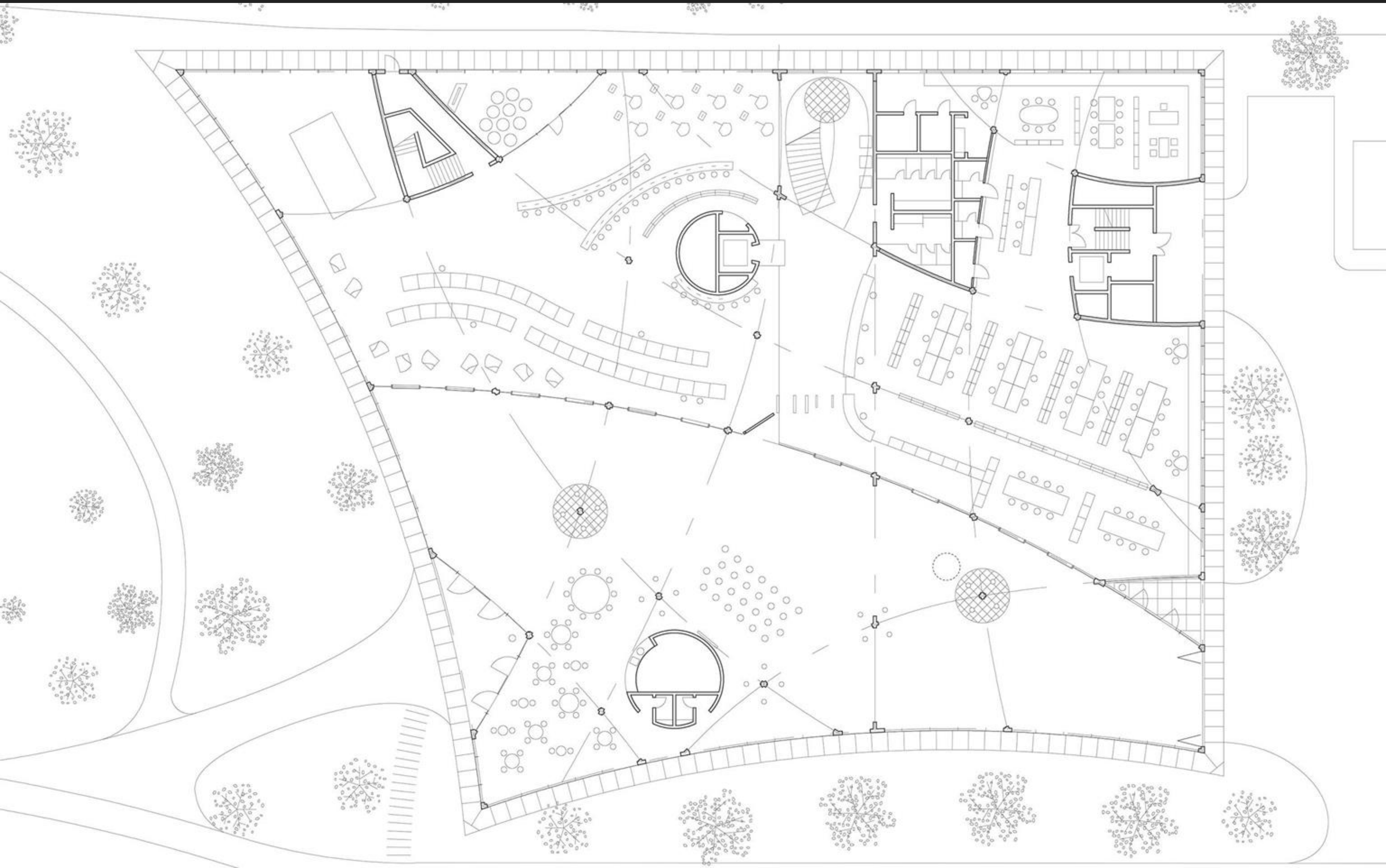


https://divisare.com/projects/322210-toyo-ito-associates-rasmus-hjortshoj-tama-art-university-library

Second Floor Plan

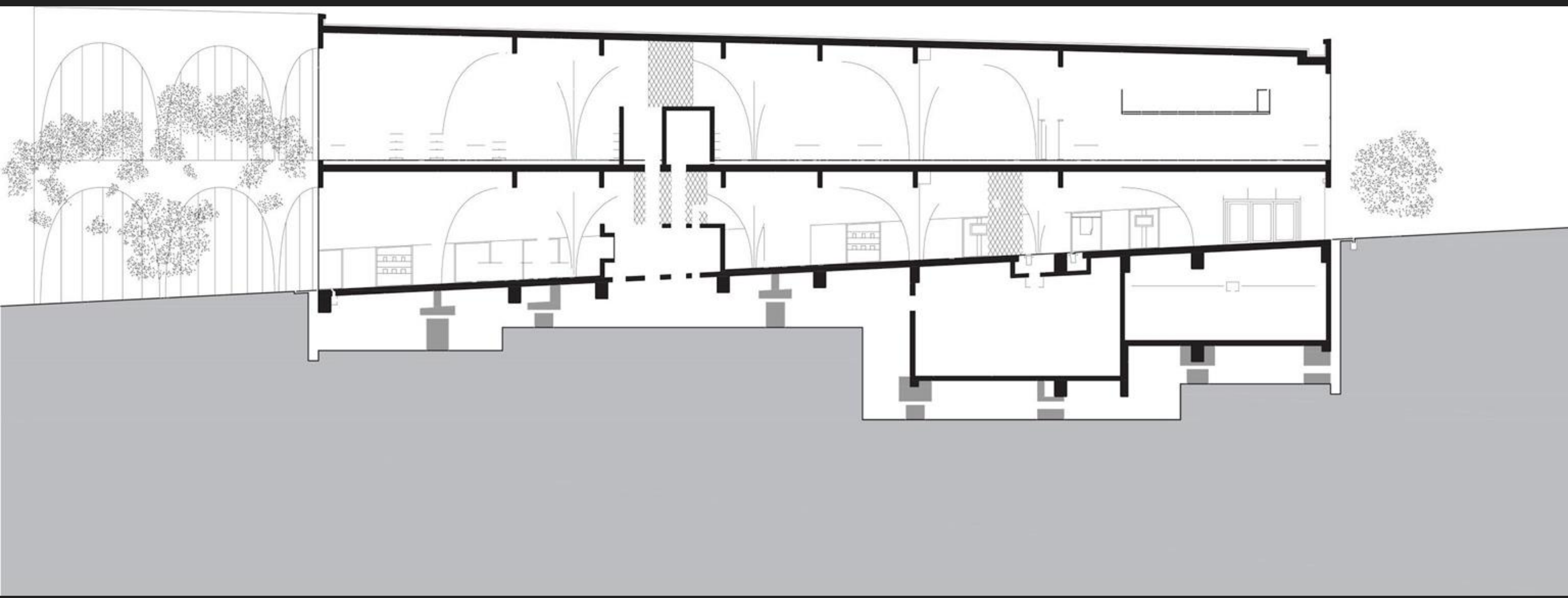


First Floor Plan

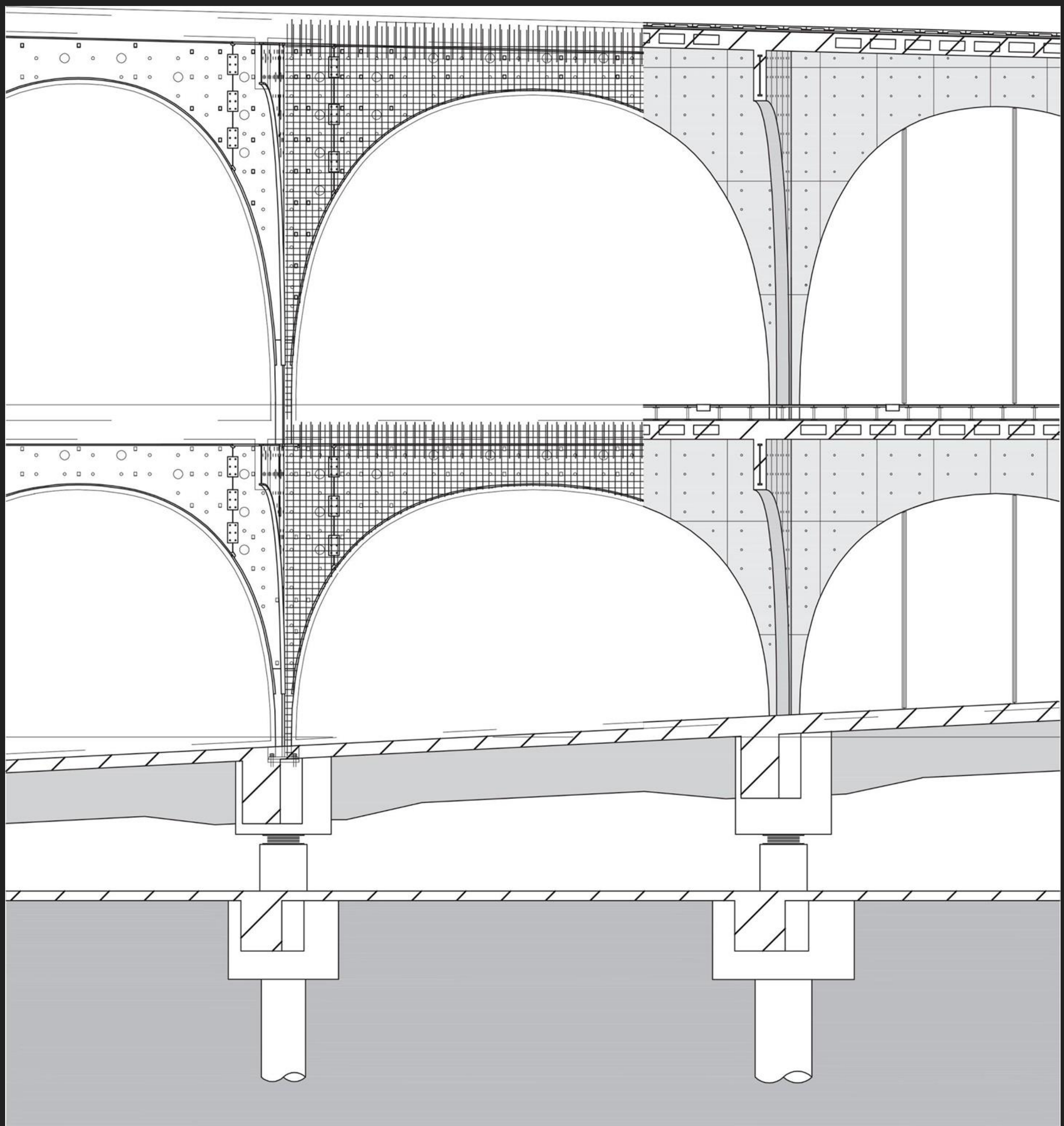


Basement Plan

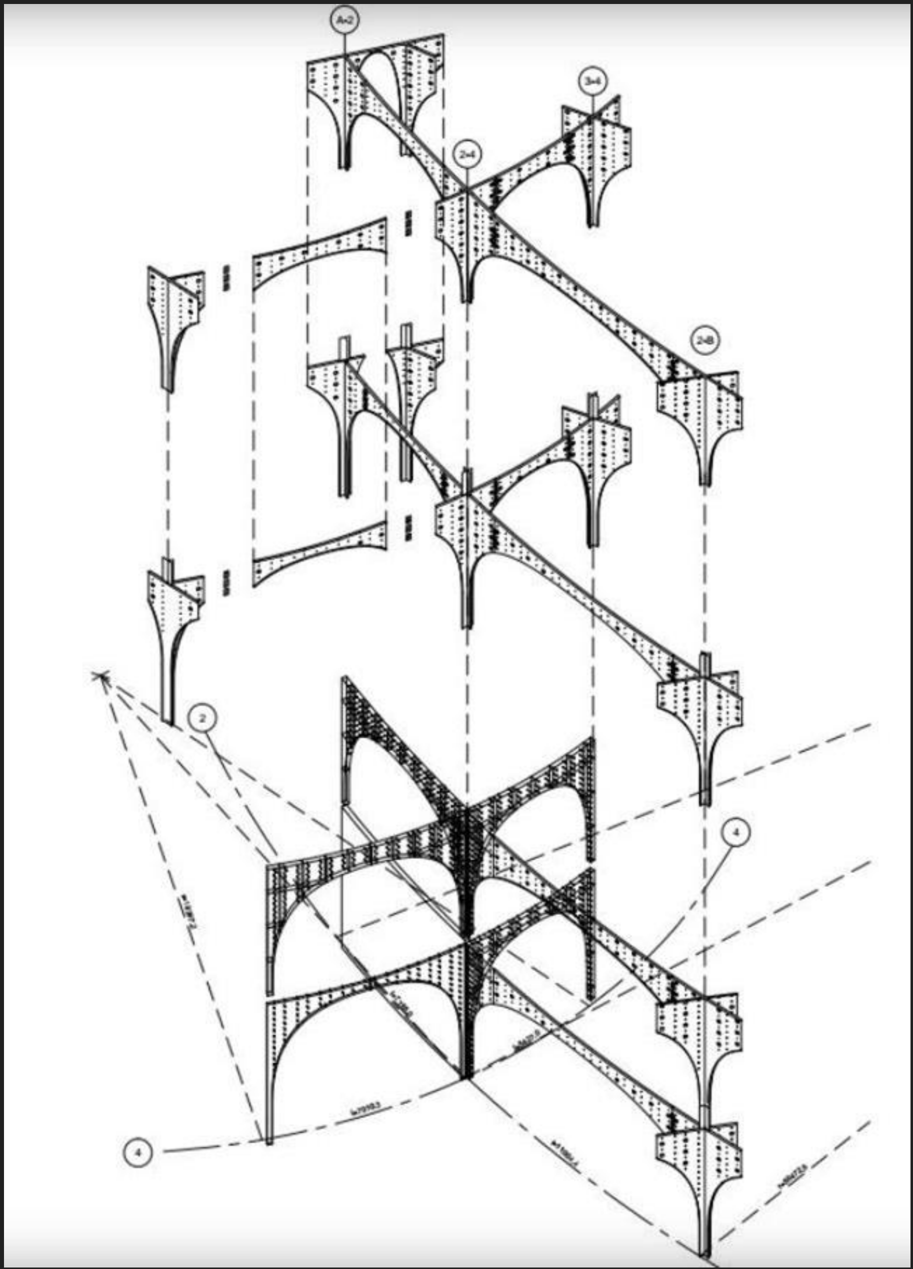
Section



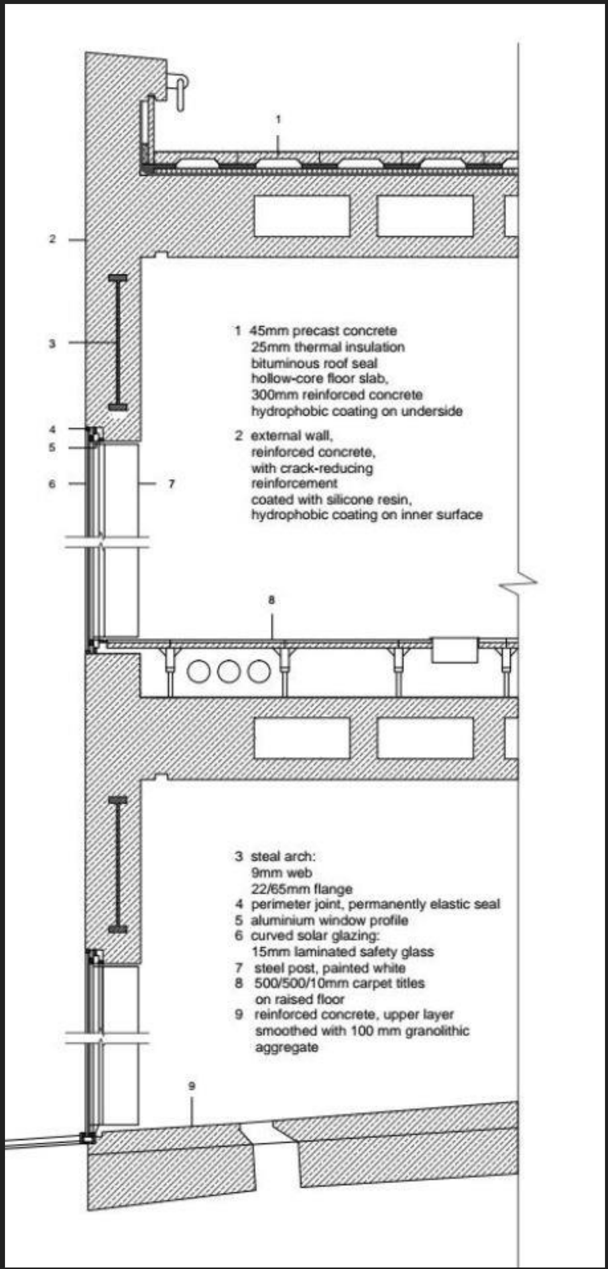
Detail Section



Construction



https://issuu.com/fanwen2/docs/final

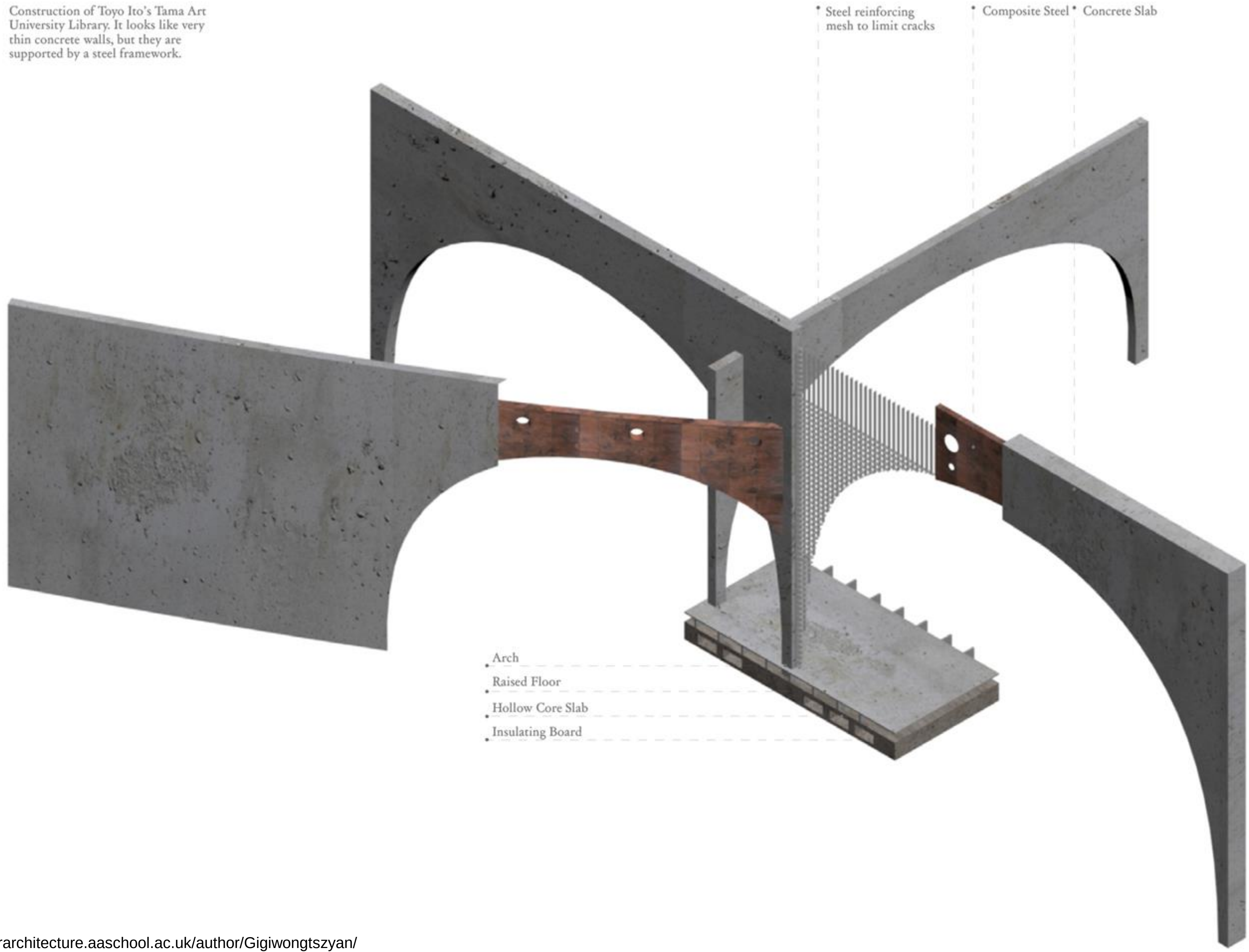


https://issuu.com/fanwen2/docs/final

Construction

https://en.wikiarquitectura.com/building/tama-art-university-library/

Construction

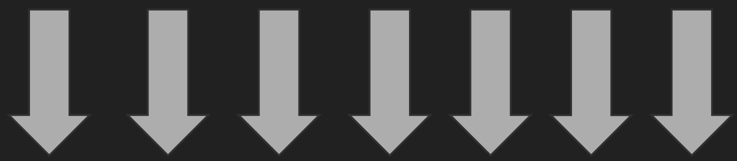


http://toolsforarchitecture.aaschool.ac.uk/author/Gigiwongtszyan/

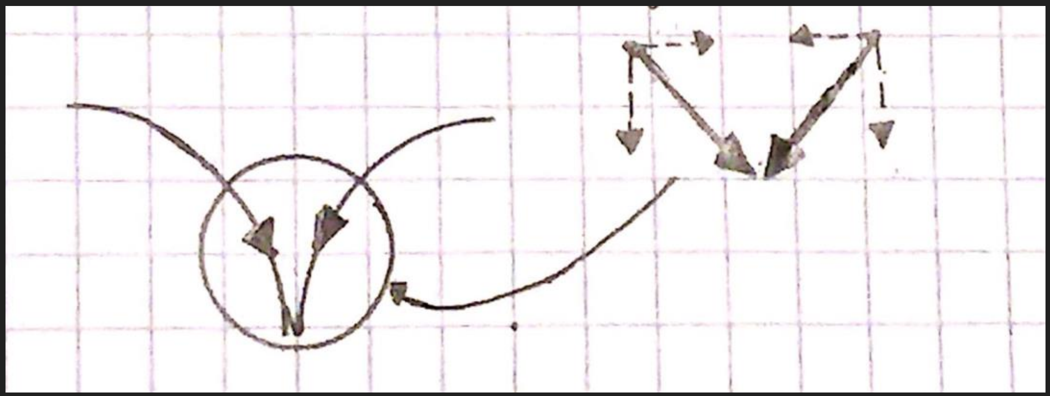
Construction

https://www.archiweb.cz/b/knihovna-tama-art-university

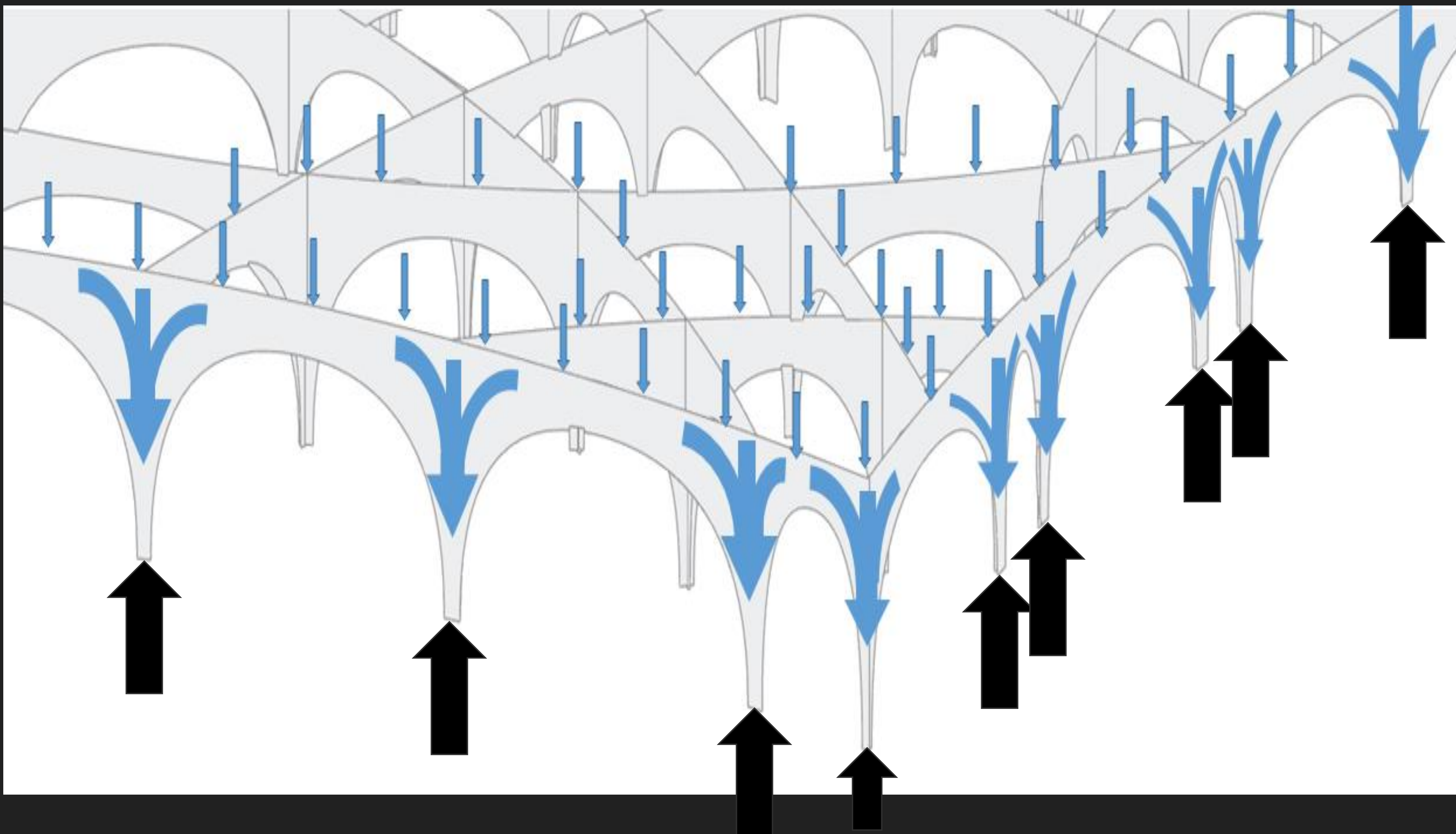
Load Tracing: Gravity



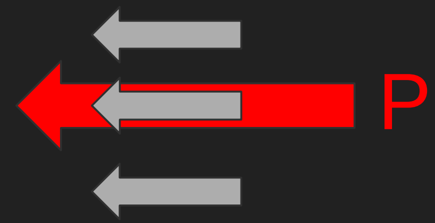
- Gravity loads would be transferred across the horizontal elements of the arches at an angle due to the nature of the structure.
- Since the arches are continuous, the horizontal components of the tangential forces cancel each other out much like a buttress would on a Gothic cathedral.
- The vertical components of the tangential forces flow together, thus increasing the compressive force down through the arch column.
- The vertical loads would then continue down into the foundation of the building.



Gravity Load Tracing

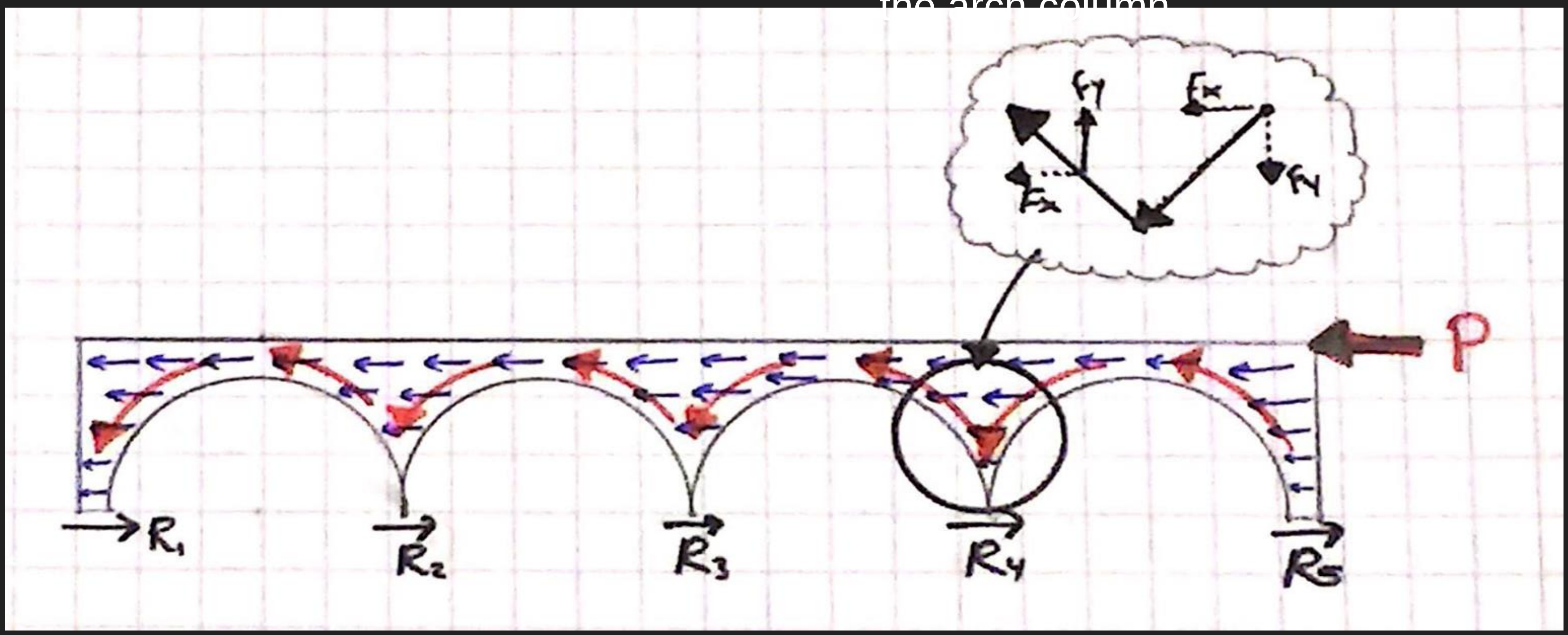


Load Tracing: Lateral Loads



- Lateral loads would be transferred through the plate elements of the composite arches. The load would then trace through the shape of the arch.

- Since the arches are continuous, the vertical components of the tangential forces cancel each other out at the arch columns.
- The horizontal components of the tangential forces flow together, thus increasing the shear force down through the arch column.



Seismic and Wind Considerations

- Exterior glass windows are “perfectly” embedded into the concrete arches.
- Deflection from frame action needs to be minimal to avoid glass breakage.
- Center of mass and center of rigidity need to align to prevent torsion
- Low-rise buildings have a high natural frequency and need to avoid reaching resonance from high frequency earthquakes.

https://arcspace.com/feature/tama-art-university-library/

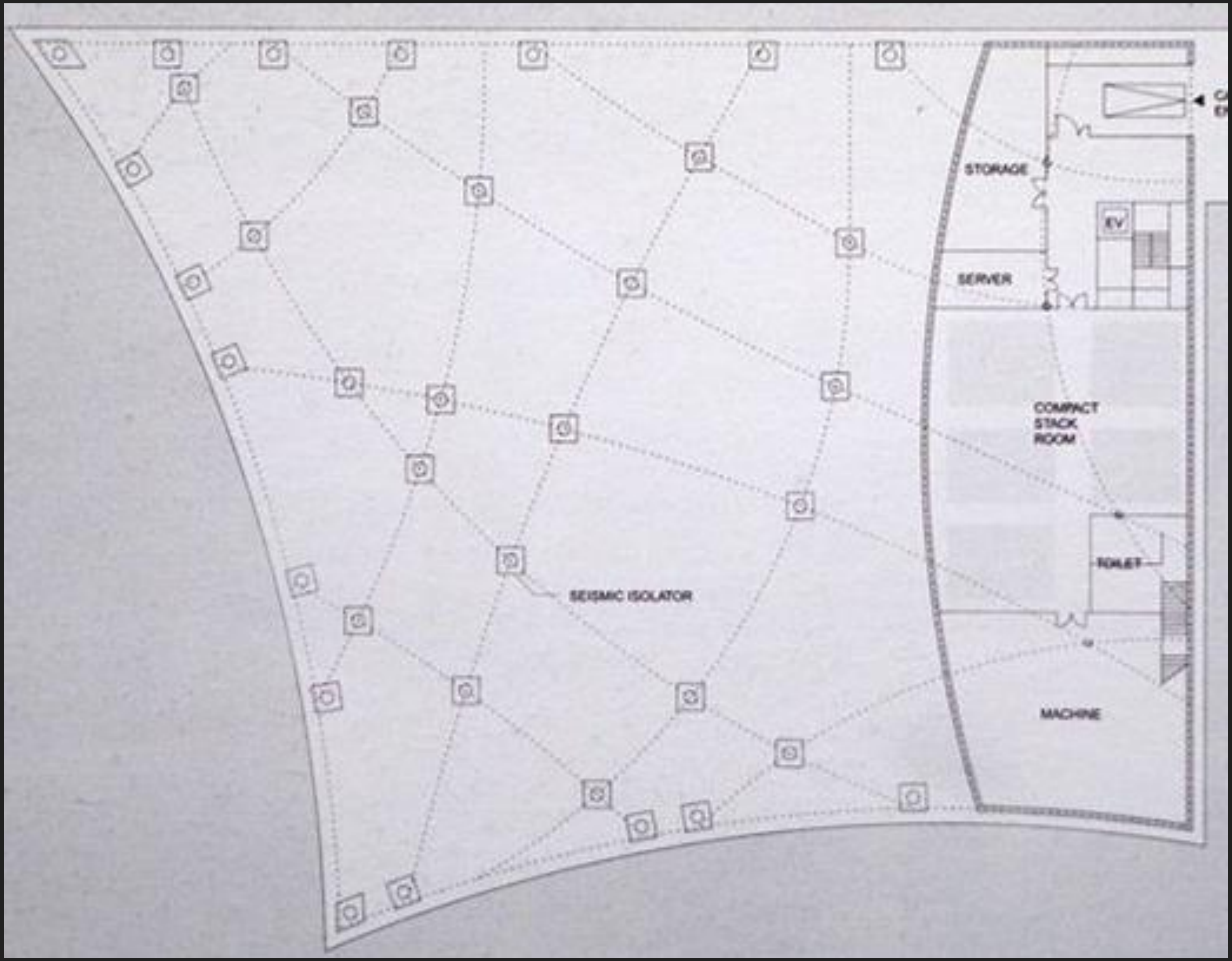
Seismic and Wind Load Solutions

- Due to the redundancy from the rigid frame system, deflection is minimized.
- Arch plan was distributed evenly to maintain the center of mass and center of rigidity, thus preventing torsion.
- A base isolation system reduces building movements by absorbing large lateral forces and allowing the building to “displace slowly up to 50 centimeters”.

https://libopac.tamabi.ac.jp/drupal/?q=hachioji/feature/structure

- Large building plan with many interconnected arches leads to increased overall building stiffness.
- Strong winds are effectively resisted by the rigid frame arch system.
- Rigid connections create a higher redundancy to prevent total collapse with the destruction of a few members.
- Reinforced concrete prevents buckling of the members.

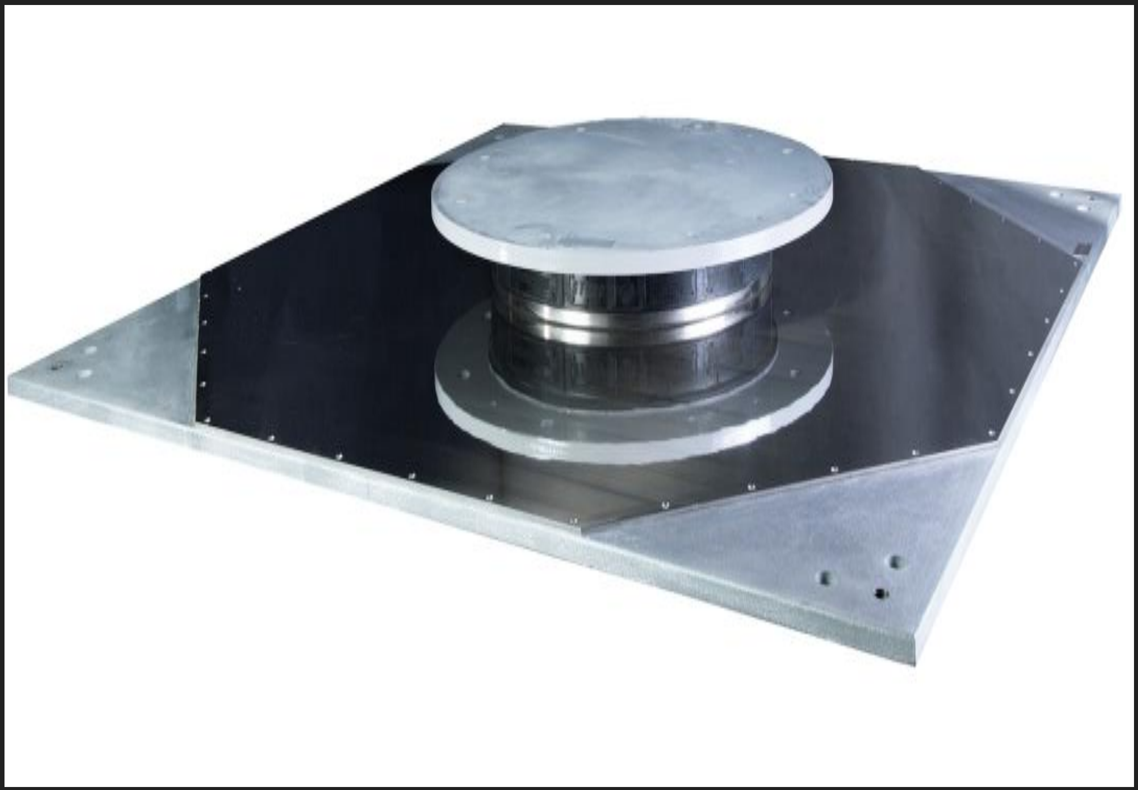
Design for Seismic loading



https://duranvirginia.files.wordpress.com/2013/06/virginia-duran-blog-amazing-libraries-tama-art-university-library-by-toyo-ito-floor-plan.jpg

Seismic Dampening Devices

- Low-friction elastic sliding bearing
- Laminated rubber bearing base isolator



https://www.japanrubberweekly.com/2018/10/bridgestone-develops-new-and-improved-series-of-seismic-isolation-bearings/

Underground seismic isolation system

“Floating Building”

https://libopac.tamabi.ac.jp/drupal/?q=hachioji/feature/operation

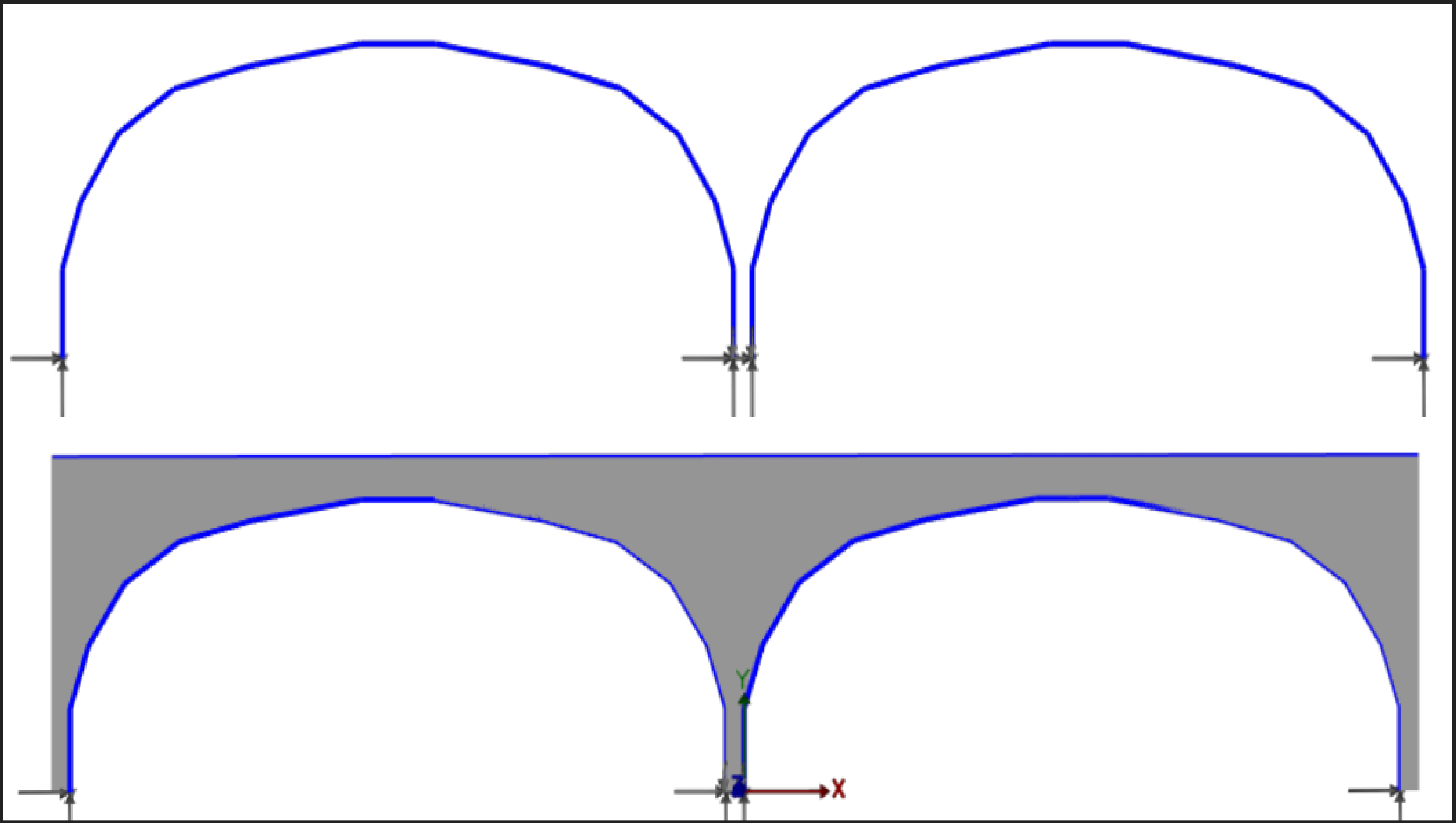
Structural Analysis

- Risk Category (ASCE 7-10): Risk Category II

- Load Combinations (ASCE 7-10): LRFD
    - 1.4*D
    - 1.2*D+1.6*L
    - 0.9*D+1.0*W

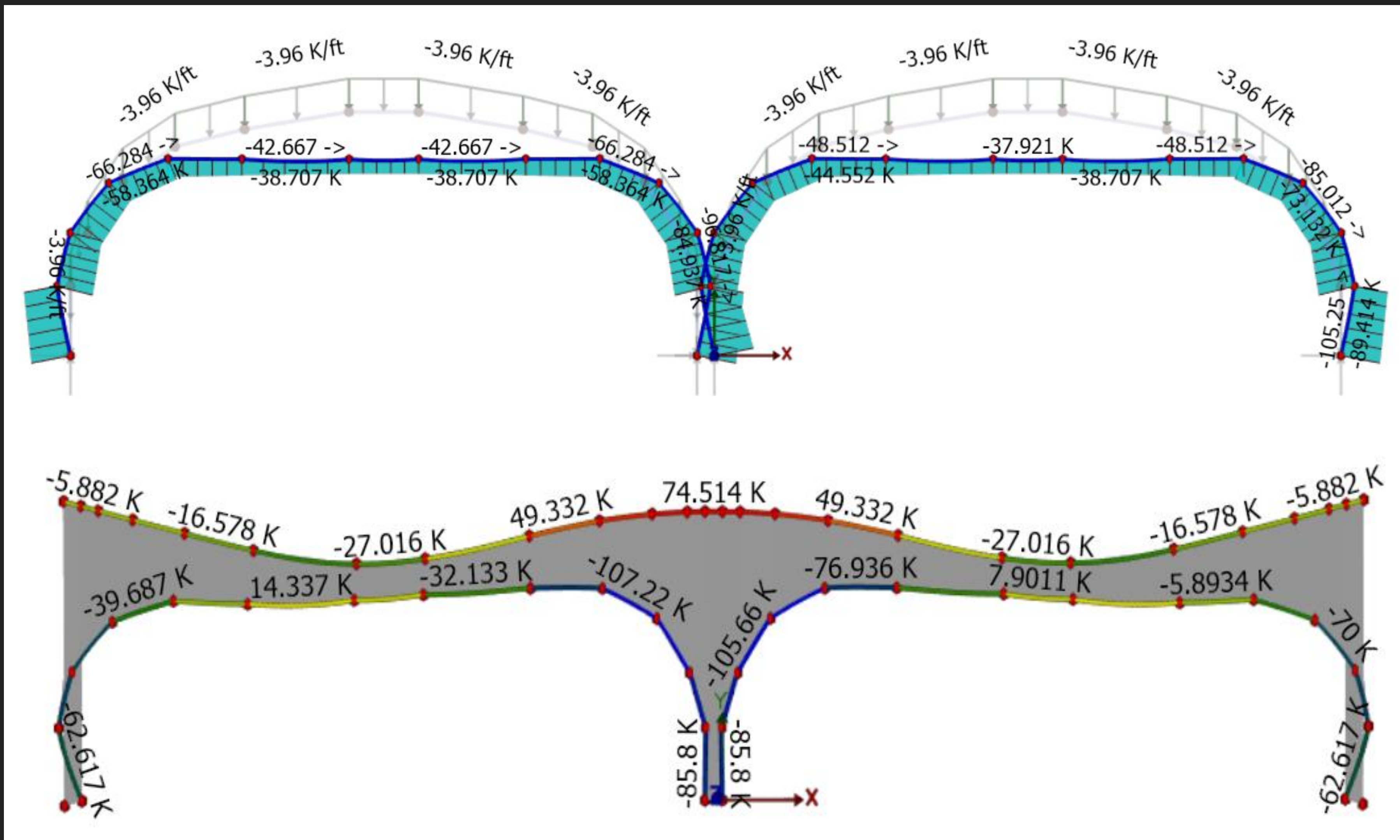
- Minimum Uniformly Distributed Live Loads (ASCE 7-10)
    - Table 1607.1
        - Libraries:
            - Corridors above first floor: 80 psf
            - Reading Rooms: 60 psf
            - Stack Rooms: 150 psf

Simplified Arch Systems



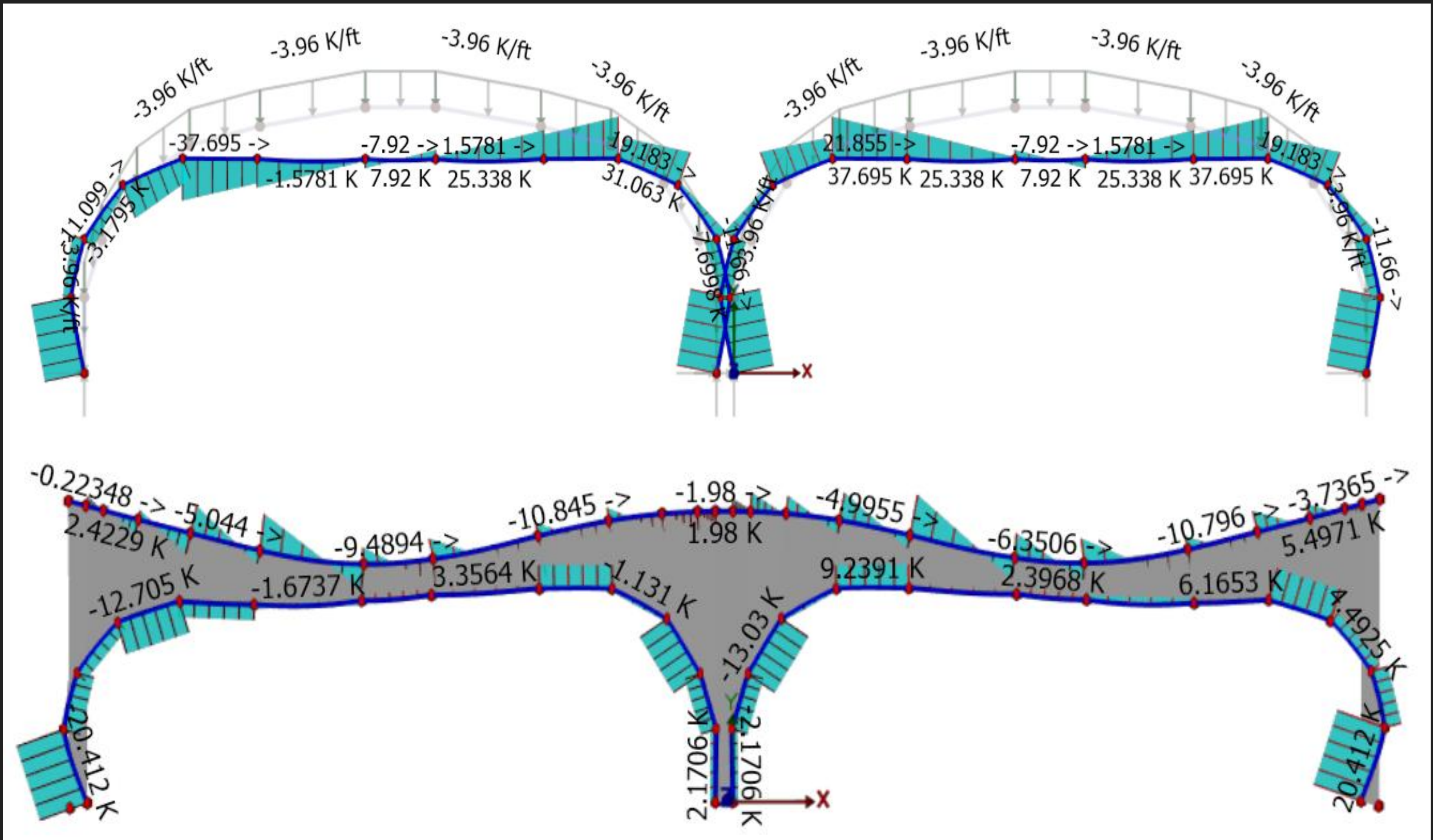
Axial

1.2*D+1.6*L



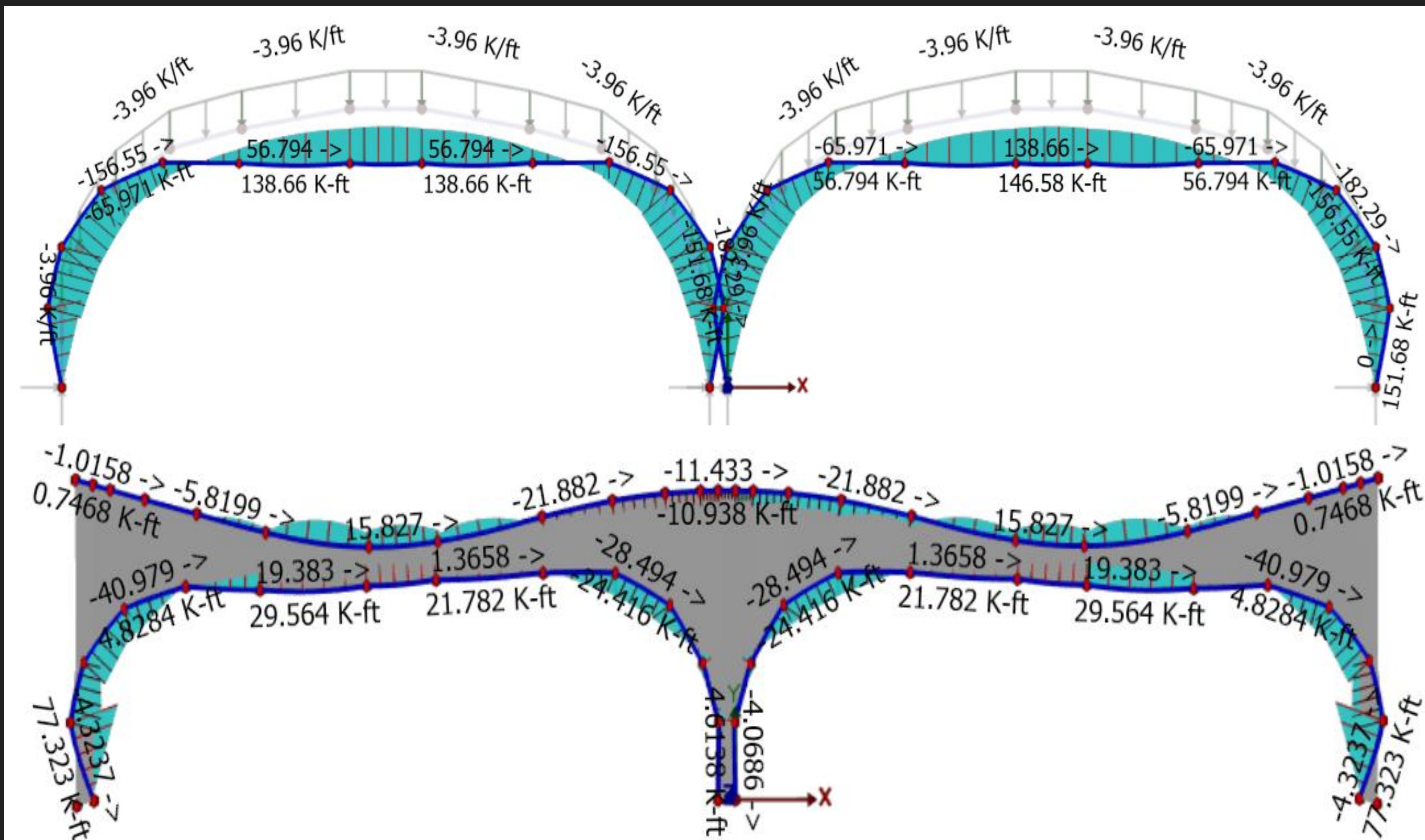
Shear

1.2*D+1.6*L



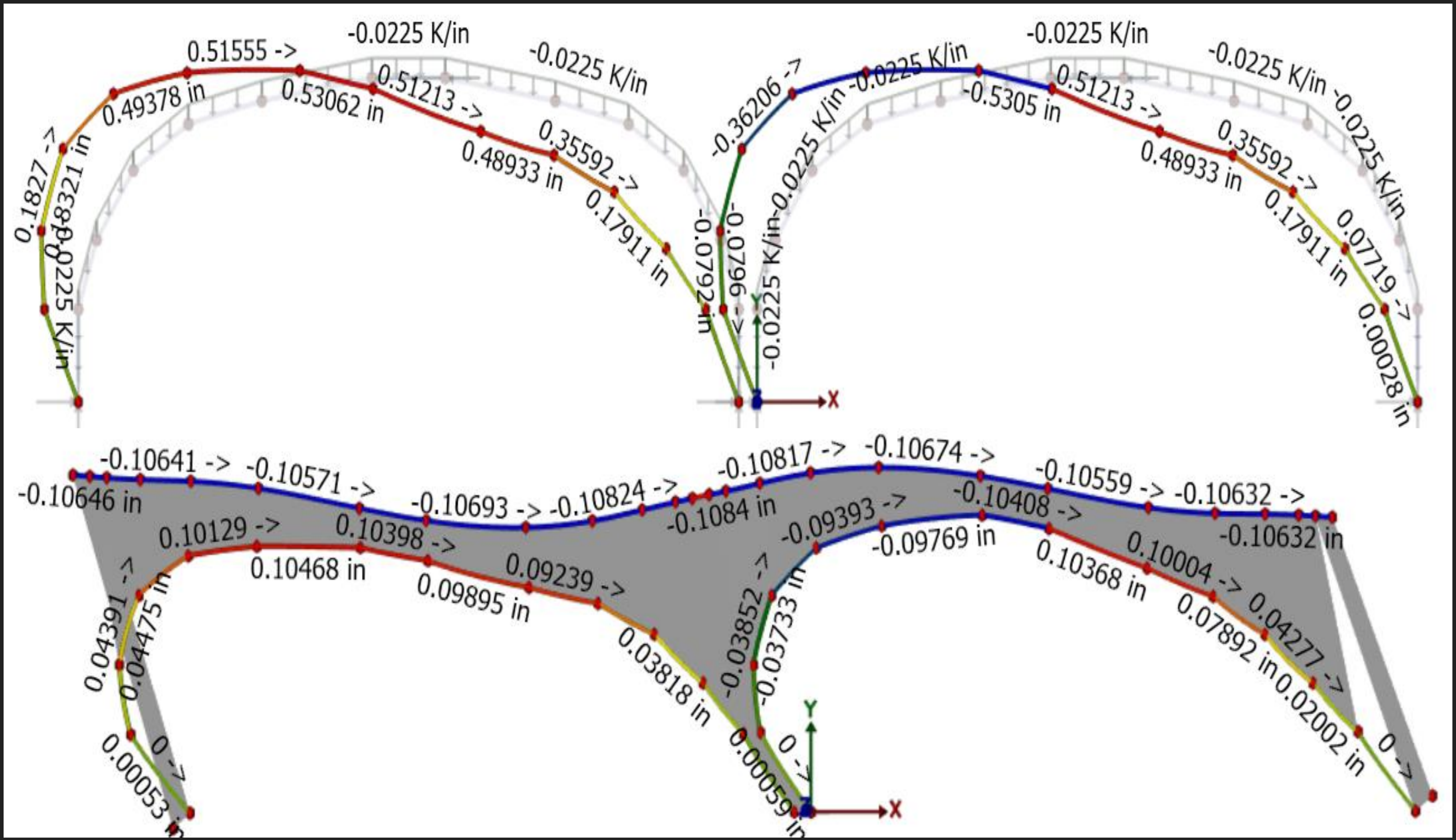
Moment

1.2*D+1.6*L



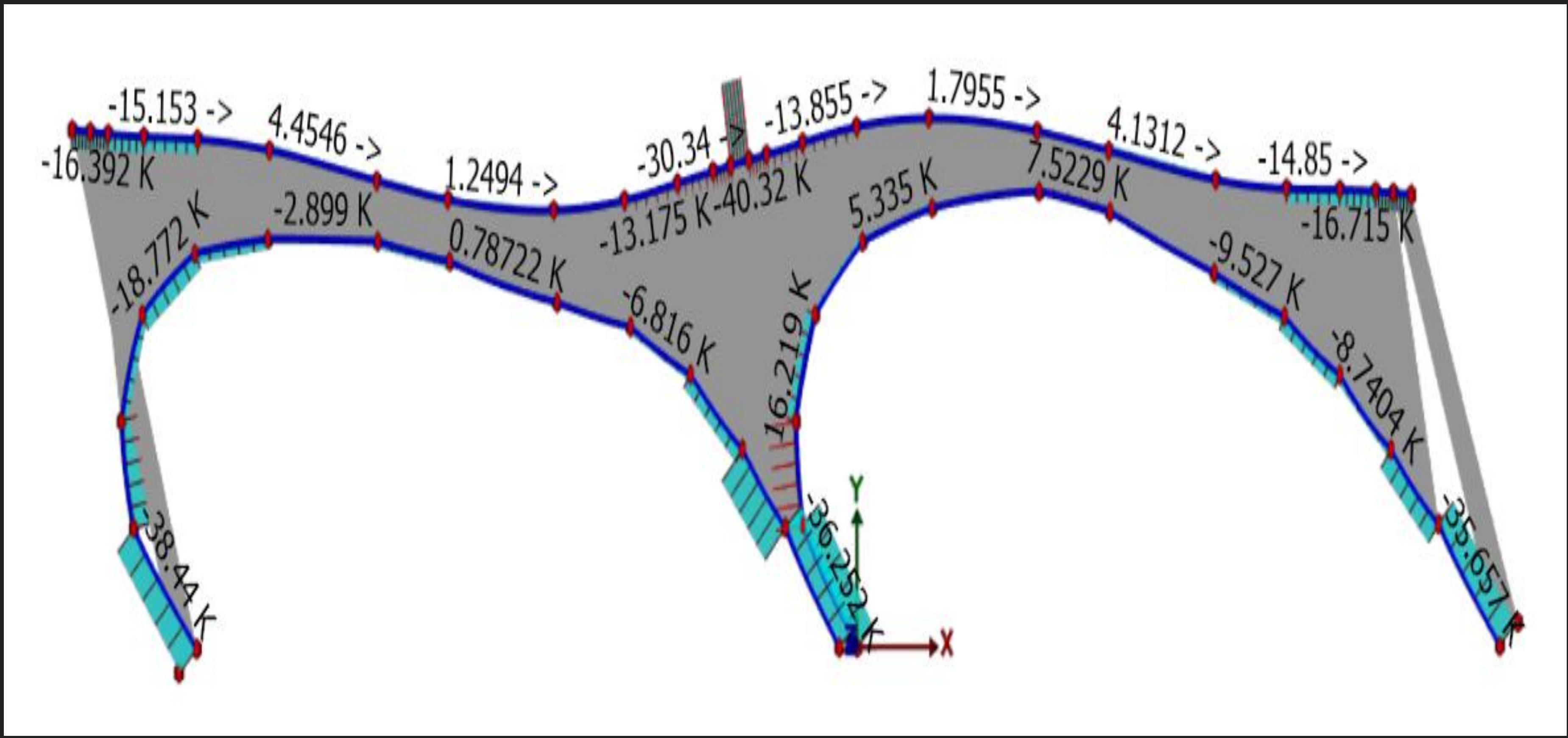
Dx Displacement

0.9*D+1.0*W



Shear

0.9*D+1.0*W



Resources

Schodek, Daniel L., and Martin Bechthold. *Structures. Seventh Edition*. Boston : Pearson, [2014], 2014.

Phillips, David and Yamashita, Megumo. *Detail in Contemporary Concrete Architecture*. London: Laurence King, 2012

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