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

[Link to website](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
Design Features

- The arches differ in 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/
Site Data

Site Data

Wind speed

Site Data

Site Data

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

Probability of Experiencing an Earthquake of Lower 6 Intensity or Above in the Next 30 Years

Source: Headquarters for Earthquake Research Promotion.

https://www.nippon.com/en/features/h00234/
### Probability of an Intensity 6 or Stronger Earthquake in Prefectural Capitals

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

https://www.nippon.com/en/features/h00234/
<table>
<thead>
<tr>
<th>Scale</th>
<th>Quake Perception and Amount of Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Imperceptible to people.</td>
</tr>
<tr>
<td>1</td>
<td>Felt slightly by some people.</td>
</tr>
<tr>
<td>2</td>
<td>Felt by many people sitting still in buildings.</td>
</tr>
<tr>
<td>3</td>
<td>Felt by most people in buildings.</td>
</tr>
<tr>
<td>4</td>
<td>Most people are startled. Hanging objects such as lights swing significantly. Unstable ornaments may fall.</td>
</tr>
<tr>
<td>5 Lower</td>
<td>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.</td>
</tr>
<tr>
<td>5 Upper</td>
<td>Many people find it difficult to walk without holding onto something. Unsecured furniture may topple over. Unreinforced concrete-block walls may collapse.</td>
</tr>
<tr>
<td>6 Lower</td>
<td>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.</td>
</tr>
<tr>
<td>6 Upper</td>
<td>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.</td>
</tr>
<tr>
<td>7</td>
<td>Many reinforced-concrete buildings with low earthquake resistance collapse.</td>
</tr>
</tbody>
</table>
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.
Second Floor Plan
First Floor Plan
Basement Plan
Detail Section
Construction

1. 45mm precast concrete
   25mm thermal insulation
   bituminous roof seal
   hollow core floor slab, 300mm reinforced concrete
   hydrophobic coating on underside
2. external wall, reinforced concrete, with crack-reducing reinforcement coated with silicone resin, hydrophobic coating on inner surface
3. steel arch: 6mm web
   22/65mm flange
4. perimeter joint, permanently elastic seal
5. aluminium window profile
6. curved solar glazing
7. 15mm laminated safety glass
8. steel post, painted white
9. 500/600/10mm carpet tiles on raised floor
10. reinforced concrete, upper layer smoothed with 100mm granolithic aggregate

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

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

Construction of Tadao Ando’s Tama Art University Library. It looks like very thin concrete walls, but they are supported by a steel framework.
Construction
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”.
- 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.

https://libopac.tamabi.ac.jp/drupal/?q=hachioji/feature/structure
Design for Seismic loading

Seismic Dampening Devices

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

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

$1.2D + 1.6L$
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


Tama Art University Library, https://libopac.tamabi.ac.jp/drupal/?q=hachijoji/feature/structure

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


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

https://www.archdaily.com/22711/tama-art-university-library-toyo-ito-by-iwan-baan