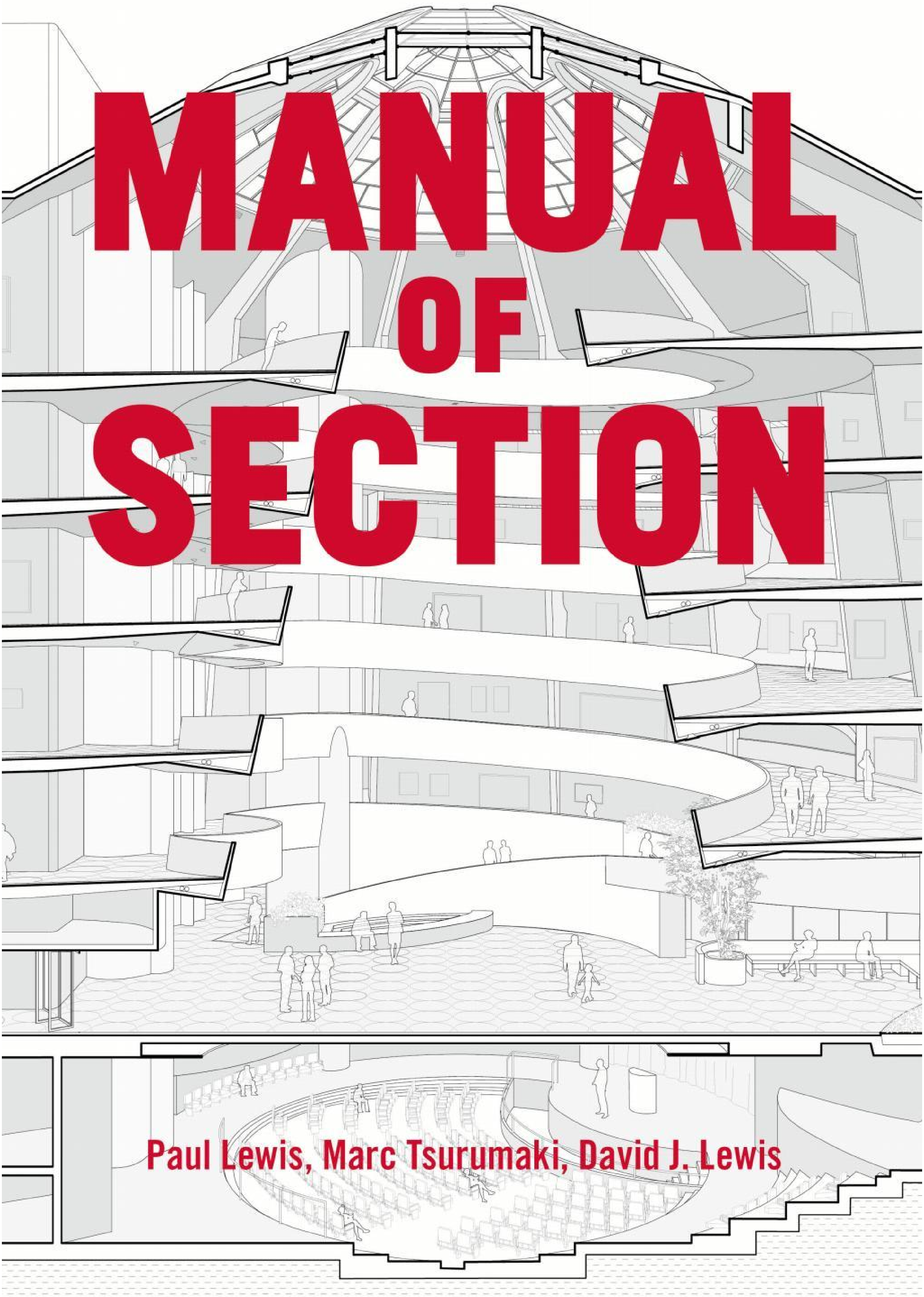
MANUAL OF SECTION



Paul Lewis, Marc Tsurumaki, David J. Lewis

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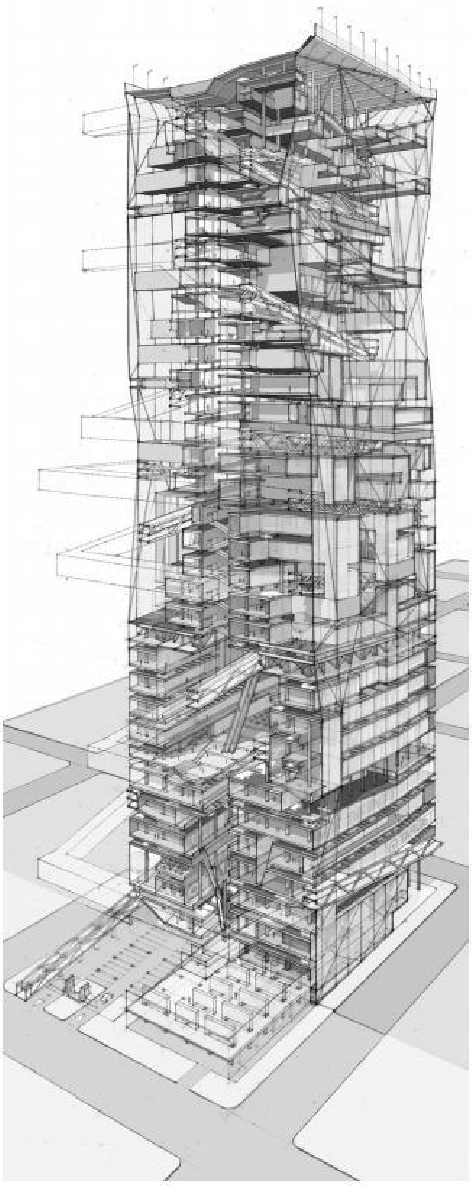
PAUL LEWIS, MARC TSURUMAKI, DAVID J. LEWIS

Princeton Architectural Press, New York

ESSAYS

SECTIONS

APPENDIX



LTL Architects, Park Tower, 2004

The Vertical Cut

INTRODUCTION

This book presents the means for understanding the complex and important role that section plays in architectural design and practice. Discussion and debate of a particular building's section are common in the study and practice of architecture. Yet there is no shared framework for the determination or evaluation of section. What are the different types of section, and what do they do? How does one produce those sections? Why would one choose to use one configuration of section over another? This book explores these questions and provides a conceptual, material, and instrumental framework for understanding section as a means to create architecture.

Our work has been motivated by the belief that the architectural section is key to architectural innovation. Given the environmental and material challenges that frame architectural practice in the twenty-first century, the section provides a rich and underexplored opportunity for inventively reimagining the intersection of structural, thermal, and functional forces. Moreover, the section is the site where space, form, and material intersect with human experience, establishing most clearly the relationship of the body to the building as well as the interplay between architecture and its context.

As practitioners and educators, we are invested equally in section as a type of representation and as a projective tool for spatial and material invention. We offer with this book a clear heuristic structure for a more robust discourse around the architectural section, to establish a shared basis for dialogue toward explorative and experimental architecture. Newly generated section perspectives of sixty-three significant built projects, organized into seven distinct types, provide students, architects, and other readers with a foundation for further cultivation of the section.

WHAT IS A SECTION?

We begin with the seemingly obvious question "What is a section?" In reference to architectural drawing, the term *section* typically describes a cut through the body of a building, perpendicular to the horizon line. A section drawing is one that shows a vertical cut transecting, typically along a primary axis, an object or building. The section reveals simultaneously its interior and exterior profiles, the interior space, and the material, membrane, or wall that separates interior from exterior, providing a view of the object that is not usually seen. This representational technique takes various forms and graphic conceits, each developed to illustrate different forms of architectural knowledge, from building sections that use solid fill or poche to emphasize the profile of the form, to construction details that depict materials through lines and graphic conventions. In an orthographic section the interior is also described through interior elevations of the primary architectural surfaces, while the combination of a section with a perspective describes in depth the interior as a space, using the techniques of perspectival projection.

Because the section begins with the visualization of that which will not be directly seen, it remains abstracted from the dominant way of understanding architecture through photographs and renderings. Sections provide a unique form of knowledge, one that by necessity shifts the emphasis from image to performance, from surface to the intersection of structure and materiality that comprises the tectonic logic of architecture. At the same time, section demonstrates the exchange among multiple aspects of embodied experience and architectural space, making explicit the intersection of scale and proportion, sight and view, touch and reach that is rendered visible in the vertical dimension (as opposed to from top down). In a section, the interior elevations of walls and surfaces are revealed, combining—for examination and exploration—structure and ornament, envelope and interior.

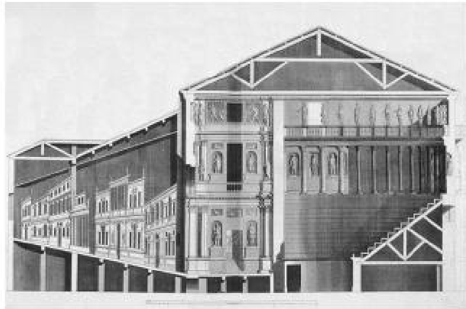
Plans and sections are similar representational conventions and offer an important point of comparison. Both depict a relationship that is not directly perceivable by the human eye, between a building's mass and the space. Both describe cuts—the one horizontal, the other vertical. The horizontal division of a plan cuts primarily through walls, not floors. Sections, on the other hand, are capable of showing cuts through both walls and floors and organize space in alignment with the size and scale of the standing human figure. Plans are typically argued to be the locus of design agency, with sections understood as a means to manifest the effects of the plan through structure and enclosure. In comparison to plan types, which are distinguished by their spatial consequences, section types are usually identified by the scale of their cut: site sections, building sections, wall sections, detail sections. Wall and detail sections foreground technical concerns, using graphic conventions of line, hatch, and tone, and depict material systems and tectonics. Site sections emphasize a built form's massing and its relationship with its environment and decrease the role of internal space. But it is in the building section that a number of crucial issues are at play, including the formal, social, organizational, political, spatial, structural, thermal, and technical.

CONTEMPORARY DISCOURSE ON SECTION

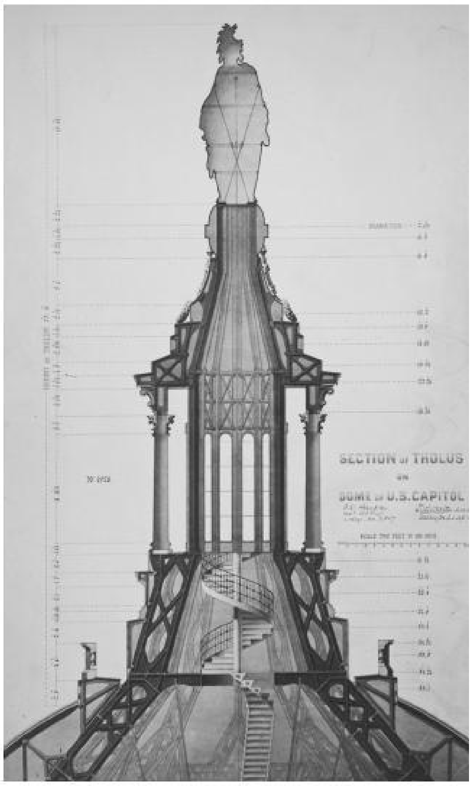
The section is not limited to its status as a representational technique. Today sections are used expansively to illustrate, test, and explore architectural designs. The section illuminates the interplay between a building's structure and the space framed between foundation and roof. Gravitational loads of structure trace vertically down through a building, with wind loads registering laterally against the side of a building's section. The material investment and spatial invention necessary to creatively resist these loads is best explored and depicted through the architectural section.

As questions of energy and ecology have become increasingly important to architectural design, the section will take on a more prominent role. Thermal forces work in section. Cold air is heavier and settles, while hot air rises. The sun rises and falls against the horizon. The vertical calibration of space is essential for inventing and creating architecture to engage environmental performance. Architects need to calibrate overhangs and apertures to produce

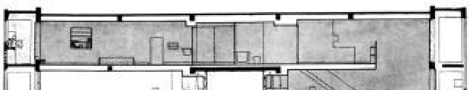
Revealing Cuts



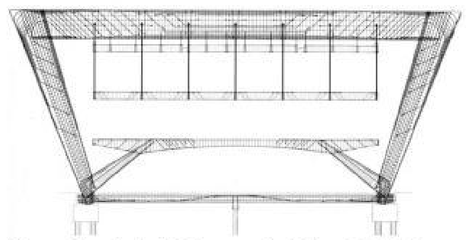
Ottavio Bertotti Scamozzi after Andrea Palladio, Teatro Olimpico, 1796



Thomas Ustick Walter, US Capitol Dome, 1859

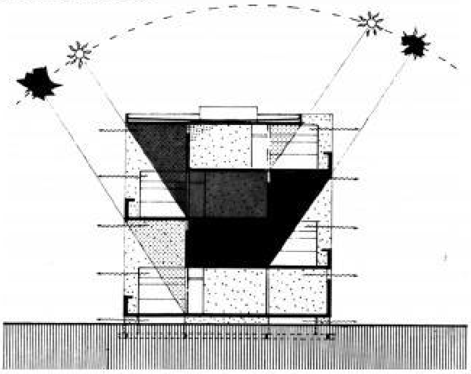


Le Corbusier, Unité d'Habitation, 1952

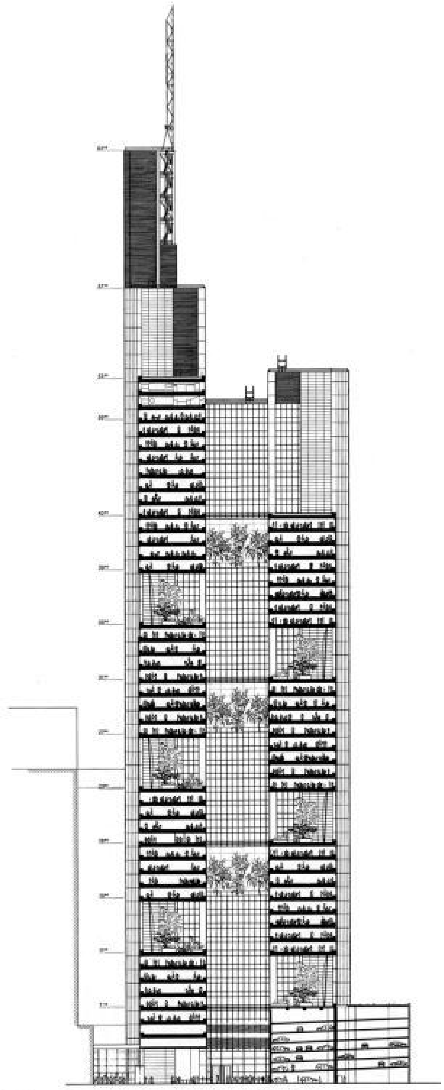


Affonso Eduardo Reidy, Museum for Modern Art, 1967

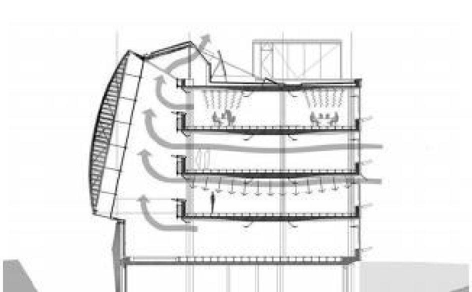
Thermal Sections



Candilis Josic Woods, Shading Diagram, 1968



Foster + Partners, Commerzbank Headquarters, 1997



Bucholz McEvoy Architects, Limerick County Council, 2003

the optimal solar radiation; interiors should be configured to maximize convection-driven air movement; roof pitches need to be set to ensure the efficiency of solar panels; wall thickness must be dictated by insulation calculations; and so on. Often driven by a desire to meet sustainable certification criteria, architects and engineers use section drawings to illustrate adherence to conventions of thermal performance, with arrays of arrows illustrating thermodynamic forces. This emphasis on thermal efficiency foregrounds the opportunities of the section, but paradoxically constrains the spatial and experiential potential of the section by aligning sectional innovation to only functional obligations.

Yet, despite the importance of section as a drawing type and as a key method for optimizing spatial qualities, structural design, and thermal performance, there is a relative paucity of critical writings or discourse on section. A well-established body of writing exists on the history and impact of the plan, but there is no single book on the history, development, and use of the section within the practice of architecture. Only a few essays on section have been published, with the two most often cited written more than twenty-five years ago: Wolfgang Lotz's "The Rendering of the Interior in Architectural Drawings of the Renaissance"[1] and Jacques Guillerme and Hélène Vérin's "The Archaeology of Section."[2] Interestingly, both essays have parallel motives beyond cultivating and describing the architectural section itself.

This lack of direct attention may very well come from the ambiguous position that section occupies. It is often understood as a reductive drawing type, produced at the end of the design process to depict structural and material conditions in service of the construction contract, rather than as a means for the investigation of architectural form. While we are interested in the representational conditions of section, we argue that thinking and designing through section requires the building of a discourse about section, recognizing it as a site for invention.

HEURISTIC STRUCTURE FOR SECTIONS

The initial challenge in creating meaningful and accessible discussions of the section is the absence of a language that would provide a shared frame of reference. To address this void, we have devised a category system based on seven distinct section types: Extrusion, Stack, Shear, Shape, Hole, Incline, and Nest. The vast majority of sectional relationships can be described by one of these categories or several in combination. These types are intentionally reductive in order to make recognition simple; they are rarely found in pure form. Indeed, upon close inspection, no project perfectly demonstrates only one type of section, as all tend to have aspects of two or more. But where a dominant type of section prevails, that designation is given.

Our purpose is not to present these types as a new kind of Platonic ideal to be pursued in isolation. The fact that a building's section may exemplify one of these types does not automatically denote a particular significance or meaning. Rather, respectful of the potential of architecture, we provide these types as a heuristic frame for building a discourse about section at the intersection of material, cultural, and natural systems. Our objective is to learn more about the ways in which section types or combinations of types might be used and how this understanding could serve the discipline of architecture. As we argue, each type of section lends itself to distinct capacities, from the cultivation of a shared sense of space to the facilitation of thermal performance, from the establishment of spatial hierarchies to the enhancement of the interplay of exterior and interior.

The following terms and definitions will be explained in the subsequent essay in greater detail:

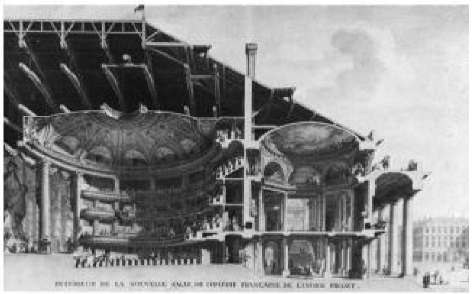
Extrusion: the direct extrusion of a plan to a height sufficient for the intended use
Stack: the layering of floors directly on top of one another—an extruded section, repeated with or without variations
Shape: the deformation of one or more of the primary horizontal surfaces of a building to sculpt space
Shear: the use of a rift or cut along either the horizontal or vertical axis of a building to generate sectional difference
Hole: the deployment of any number or scale of penetrations through a slab, exchanging lost floor area for benefits in section
Incline: the manipulation of the angle of an occupiable horizontal plane, which tilts the plan into section
Nest: the creation of sectional consequences through an interplay or overlap of legible volumes

Sixty-three one-point-perspective section drawings of built projects form the central portion of this book. We selected these projects because they represent a range of approaches to section, forming a body of work useful for further study, development, and inquiry. Certain projects illustrate one of the section types in a clear and demonstrative way. Other projects exhibit complex and creative approaches to section, often incorporating two or more types in a wide range of new formations that transcend the limits of a particular type in isolation.

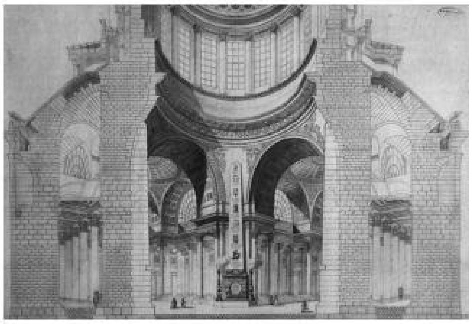
All projects date from the turn of the twentieth century or later, a time frame chosen because of its historical alignment with the proliferation of standardized and industrialized methods of building. These methods typically have given rise to repetitive stacked sections, placing a new imperative on the section as a site of investigation and invention. We included only projects that have been built, to ensure that there would be sufficient documentary evidence to show the tectonic logic of the section and to verify that the complexity of the section did not come at the expense of constructability.

Although many existing publications analyze and assess these sixty-three projects, most do so by seeking to break each project into a series of discrete, easily digestible points. This reductive approach suggests that the comprehension of a building's complexity can be best achieved through categorizing concepts in isolation. Our approach is the opposite. We aim through a single, detailed drawing to demonstrate the range of intertwined issues that make architecture compelling. The section perspective intentionally

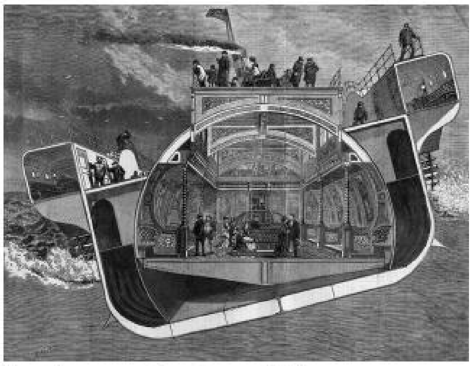
Section Perspectives



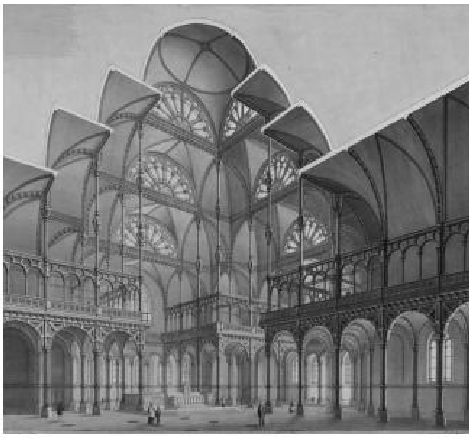
Charles de Wailly, Comédie-Française, 1770



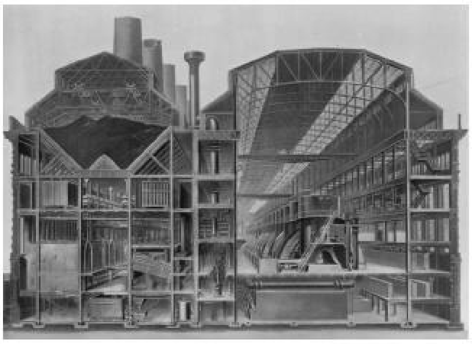
Jacques-Germain Soufflot, Pantheon, drawing by Alexandre-Théodore Brongniart, ca. 1796



Henry Bessemer, saloon steamer, 1874

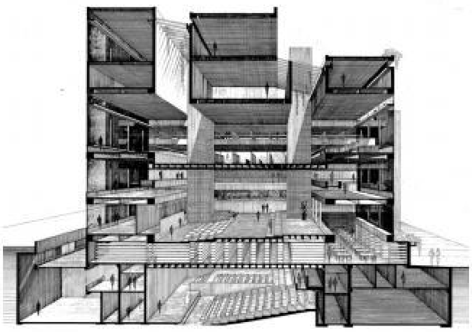


Louis-Auguste Boileau, system of interlocking arches, drawn by Tiburce-Sylvain Royol, ca. 1886

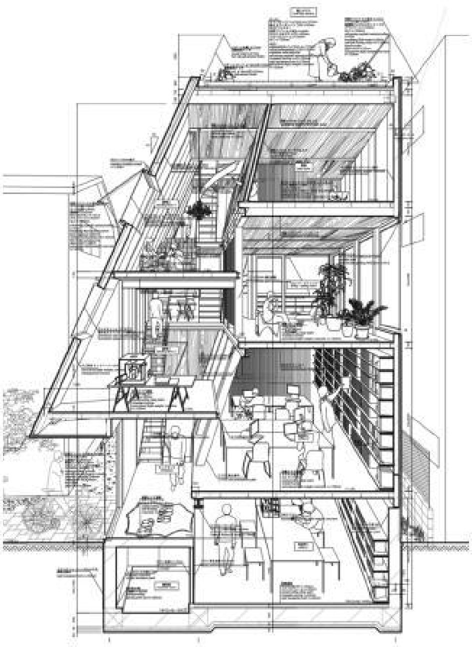


McKim, Mead & White, Interborough Rapid Transit Powerhouse, 1904

Jacques Hermant, Société Générale, 1912



Paul Rudolph, Yale Art and Architecture Building, 1963



Atelier Bow-Wow, Bow-Wow House, 2005

combines the objective, measurable information of the section with the subjective visual logic of the perspective. As such, the drawings created for this book delineate facts and evidence while enticing the viewer into a rich spatial experience. The drawings are both abstract and immersive, analytical and illustrative. They build upon a history of this representational technique that includes such varied sources as the meticulous drawings of the École des Beaux-Arts; the analytical, technical drawings of the industrial era; Paul Rudolph's line rendering of complex spectacles; and Atelier Bow-Wow's hybrid mix of detailed construction drawings with outlines of interior activity.

Representing each project through a single section perspective with a standardized view allows comparison among and across projects. To create each drawing, we built a digital model and established a section cut true to the orientation of the page, not in oblique or perspective. We then set a single vanishing point, adjusting the perspective lens to bring interior or exterior surfaces into view, thus establishing a visual correspondence between the cut plane and the vertical surfaces that compose the projects. From each model, we exported a two-dimensional line drawing, which we adjusted and developed in a vector-based line program. The completed drawings follow the conventions of sectional drawings, where, for instance, the outside cut line that separates the edge of a solid surface and the open air or space beyond is marked by the thickest line, while lighter lines are used to illustrate secondary material distinctions within a cut solid or to describe the details of a surface viewed beyond the cutting plane.

These drawings differ from drawings of archaeological ruins, where the deterioration of a structure reveals its section to the observing eye. Since we cannot, of course, cut directly into built works, our representations depend on interpreting other drawings and images to create an accurate assessment of material conditions. These other drawings are themselves often approximations of construction yet to happen, thus raising compelling questions about historical accuracy and the construction of knowledge. The work of this book is based on photographs, drawings, descriptions, and, where possible, original archival construction drawings and/or digital files obtained directly from architects' firms. The drawings in this book are as precise as practicable, given available representations and the impossibility of absolute precision that is inherent to the section as a representational technique.

In addition to creating the sixty-three section perspectives, we have selected historically significant or otherwise compelling section drawings from throughout the history of architecture. These section images, which accompany the book's essays, include some unbuilt works in order to show the wide range of possibilities for using section to illustrate and generate architectural form. A chapter on the use of section as a generative tool for the work of our office, LTL Architects, complements the sixty-three projects. This work illustrates additional explorations in combining section and perspective, ones in which the section cut itself is put into perspective, as well as speculative projects, in which section is the generator for spatial and programmatic interplay.

Types and Performance of Section

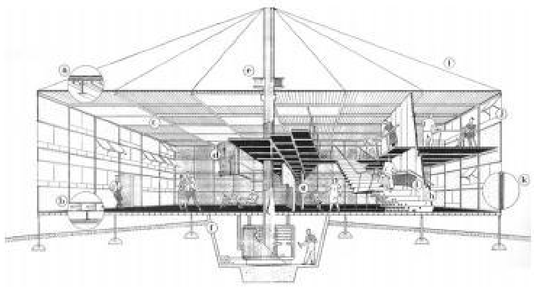
Extrusion, Stack, Shear, Shape, Hole, Incline, and Nest are separate and primary methods for operating in section. For the sake of clarity, they are presented as distinct modes, but they rarely operate in isolation. Buildings exhibiting the most complex and intricate sections contain all manner of combinations. Nevertheless, the distinctions among the types provide a means to articulate how an architectural section is produced and to understand its effects.

EXTRUSION

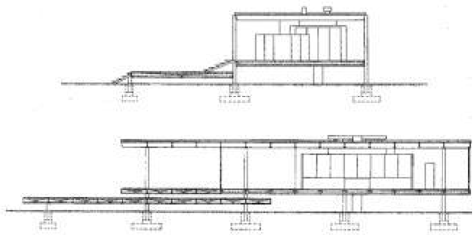
The extrusion of a plan up to a height sufficient for the intended activity is the most basic form of section. An extruded section has little to no variation in the vertical axis. The vast majority of buildings are based on this efficiency, including most one-story office buildings, retail structures, big-box stores, factories, single-story houses, and apartments. Usually built with flat concrete slabs and rectilinear steel or wood frames, it produces the maximum usable square footage in relation to overall building volume. Elaboration of more complex sectional qualities is anathema to this model of efficiency. More complicated sections have the consequence of reducing valuable square footage of real estate. In extruded sections space is activated largely through plan and, to a lesser degree, elevation. It is a banal base against which other developments or types of section can be understood. This type of section usually lacks distinctive qualities, although in cases where an extrusion fails to meet typical models of efficiency, it can produce intriguing effects, including claustrophobia or agoraphobia. One can find examples of extrusions that are extremely low—for example, the half-floor sections found in Spike Jonze's film *Being John Malkovich*—or extremely high, such as the vast interior space of the Palace of Labor by Pier Luigi Nervi. In extruded sections, the ceiling is often the site of design investment, for reasons of structural articulation and the sheer extent of this surface.

Given that a straight extrusion is rarely remarkable, only a few of the buildings in this book are based solely on extrusion. A key condition of the extruded section is the role of the structure that separates the floor from the ceiling or roof. The Glass House by Philip Johnson places extraordinary emphasis on steel columns that rise from regular locations on the plan. The glass walls in effect turn the elevation into the section. The one anomaly of the system is the combined bathing area and fireplace, joined together to hide all the house's plumbing and heating systems behind the extruded figure of a brick cylinder, to preserve the clarity of the sectional diagram. While Johnson places the columns within the window wall external to the inhabitable space, Junya Ishigami does nearly the opposite with the Kanagawa Institute of Technology Workshop, dispersing or aggregating its columns to fill and frame the space as a field for different and adjustable uses. For Ishigami,

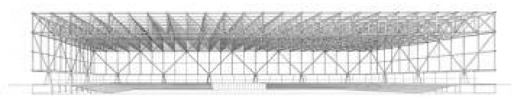
Extrusion Sections



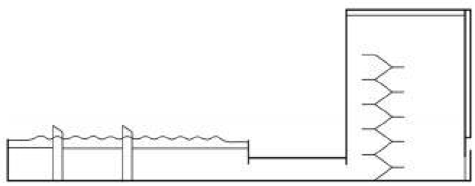
Ralph Rapson and Eero Saarinen, Demountable Space, 1942



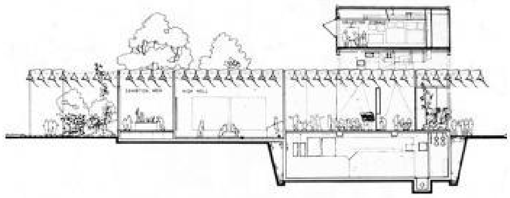
Ludwig Mies van der Rohe, Farnsworth House, 1951



Ludwig Mies van der Rohe, Chicago Convention Center, 1954

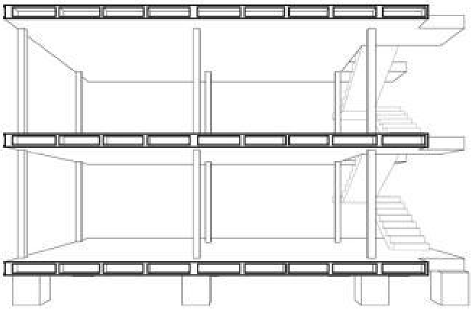


Arne Jacobsen, National Bank of Denmark, 1978



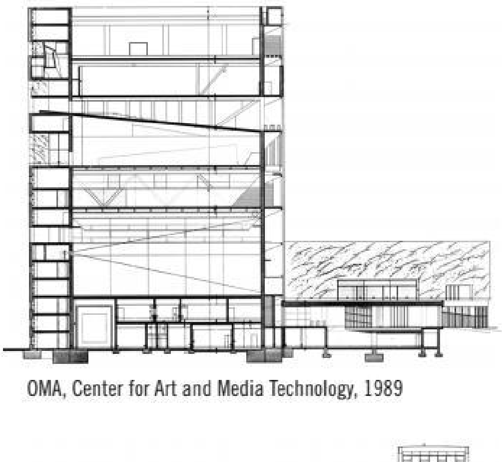
Renzo Piano, the Menil Collection museum, 1986

Stack Sections

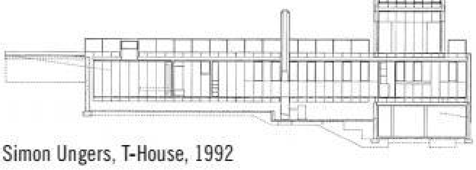


Le Corbusier, Maison Dom-ino, 1914

Antonin Raymond and Ladislav Rado, prototype for a department store, 1948



OMA, Center for Art and Media Technology, 1989



Simon Ungers, T-House, 1992

the extruded section heightens the distinction between the solid concrete base encasing and cantilevering the multiple thin columns and the highly articulated steel ceiling, whose pattern turns the structural diagram into ornament. While the two previous examples work within conventional extruded ceiling heights, in the Palace of Labor in Turin, Pier Luigi Nervi used the massive scale of mushroomlike columns to aggrandize an exhibition hall. Sixteen repetitive structural units define a 70-ft-high space. Although justified by pragmatics of construction speed and efficiency, the excessively tall space, animated by a grid of robust, tapered columns, transforms an extruded section into spectacle.

STACK

Stack is the placing of two or more floors or spaces on top of one another, with little connection among the individual stories. Stacking increases the real estate value of a property by expanding the square footage and usable capacity of a building without increasing its footprint. Financial gain is a basic motivation for the use of stacked section in architecture. Repetitive stacks are similar to extruded sections and can be deployed ad nauseam until limited by code, cost, or structural stability. Alternatively, stack can be created by placing very different floor types and shapes on top of one another. By itself, stacking does not produce interior effects. In office buildings or apartments, for example, each floor can be added with little or no consequence to the previous floors, beyond the impact on the quantity of vertical services required. It is precisely the ease of this accumulation that thwarts any sectional variations; its efficiency is based on the homogeneity of the section. It costs less to build the same floor than to introduce variations; all the expertise of Taylorism remains intact, from drawings to formwork to sequence of construction.

In buildings with single programs the extrusion rarely varies from floor to floor. Yet architects have exploited differences in the height of that extrusion on different stacked floors to allow for programmatic variation. A well-known example is Starrett & Van Vleck's Downtown Athletic Club, which comprises thirty-five levels with nineteen unique floor-to-floor heights, ranging from 6 ft (1.8 m) for a "bedroom utility" to a 23-ft-6-in (7.2 m) "gymnasium." Rem Koolhaas's influential analysis of the building in *Delirious New York* explicates the "culture of congestion" enacted within the building, where each of its "superimposed platforms" sponsors distinct uses, spaces, and experiences. The power of the building is derived from the sectional autonomy of each floor; the stacked section creates a form of seduction. "Each of the Club's floors is a separate installment of an infinitely unpredictable intrigue that extols the complete surrender to the definitive instability of life in the metropolis."[3] Critical to this reading is the fact that the Downtown Athletic Club's section cannot be experienced optically or synchronically. Rather, it is through the diachronic mechanism of the elevator that the narrative of programmatic and sectional disjunction unfolds. The Downtown Athletic Club is a peculiar project in that the fit between program and section is so precisely aligned, as gymnasiums, swimming pools, and handball and squash courts all require specific ceiling heights, and the relatively small footprint of the building allows each of these programs to inhabit its own floor.[4]

Whereas the Downtown Athletic Club conceals the variations of its section behind a muted facade, floor-to-floor variations in a stacked section have been used as the very image of other buildings: for example, MVRDV's Expo 2000 Netherlands Pavilion. Deploying the same logic used to create multilayered cakes, MVRDV juxtaposes completely different architectural spaces, from columnar halls filled with trees to a cast-concrete grotto, all topped by a trussed roof marked by wind turbines. Each floor is unique and varies substantially, demonstrating through the section an accumulation of different ways architecture engages environmental systems. Connection among the different stacked floors is made only through staircases and a bank of elevators clipped onto the exterior of the structure, reinforcing the independence of each zone.

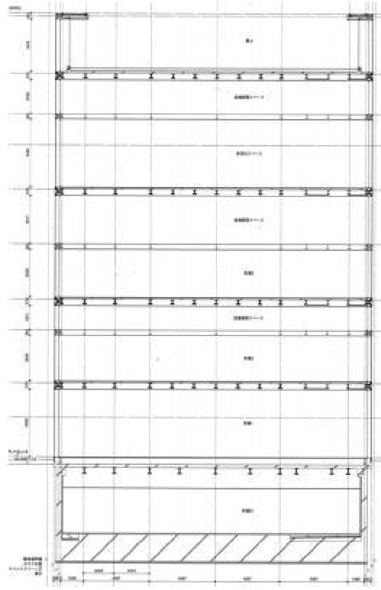
Since stack is based on multiples, an alternate approach takes advantage of repetition, varying only floor heights to create difference. By adjusting the floor height while keeping the profile of each floor the same, SANAA created a distinctive building for the Dior flagship store, its seductiveness a product of the elegance of the architectural operation. In contrast, the individual galleries of Peter Zumthor's Kunsthaus Bregenz are treated as separate volumes, staggered and stacked with the same space between each floor. Services and lighting occupy the stacked spaces between the galleries, with the entire ensemble nested within a double-skin glass shell.

Ludwig Mies van der Rohe's work at S. R. Crown Hall at IIT disguises the stacked section behind a singular architectural form. In truth, the monumental exposed structural beams that mark the profile of the building only support the ceiling of the main floor. A more utilitarian lower floor sits below, half-sunken into the ground and supported by load-bearing walls. The exterior curtain wall, marked by continuous vertical steel members, cloaks the section's stacking, reinforcing the impression of a singular spatial volume.

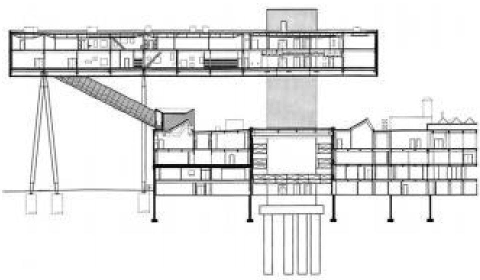
The stacked section limits the thermodynamic movement of air and water. In order for these systems to serve a building, they must be pumped, pushed, and ducted vertically beyond a single floor. Louis I. Kahn's design for the Salk Institute exploits this isolating condition to full effect. To accommodate the extensive mechanical services needed for research labs and ensure that those spaces would be column-free, Kahn layered on top of each laboratory a full floor dedicated to systems threaded through an open Vierendeel truss system. Three successive pairings of lab and service zone make up the stacked section.

SHAPE

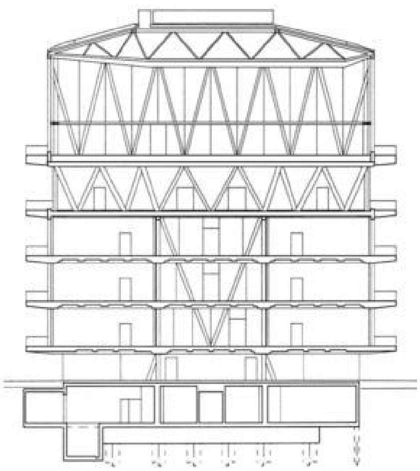
Shaping is the sculpting of space through the deformation of a continuous horizontal surface or surfaces. This adds a particular volume or form to the section and can occur in a floor or a ceiling or both. Shapes can exhibit an extremely wide range of topologies.[5] The ceiling is a more common location for this modulation



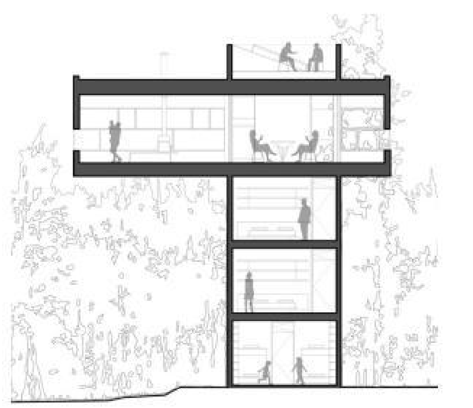
SANAA, Christian Dior Omotesando, 2003



Will Alsop, Ontario College of Art and Design, 2004

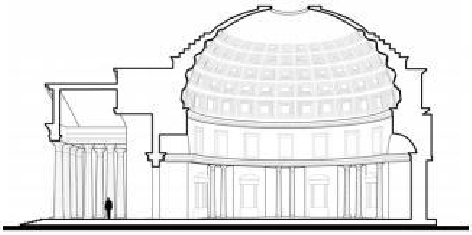


Christian Kerez, school in Leutschenbach, 2009

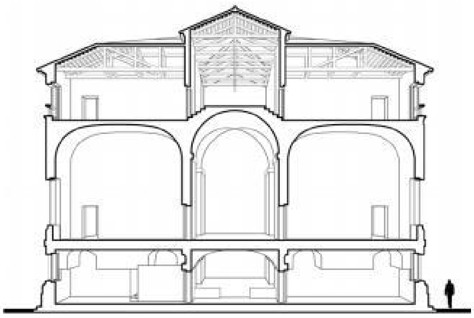


GLUCK+, Tower House, 2012

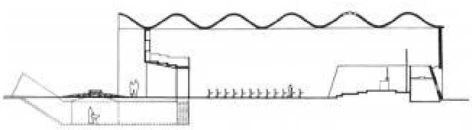
Shape Sections



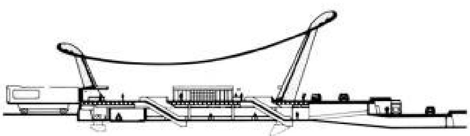
Pantheon, AD 128



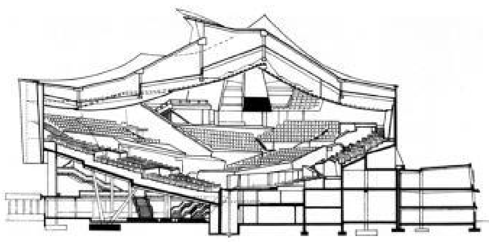
Andrea Palladio, Villa Foscari, 1560



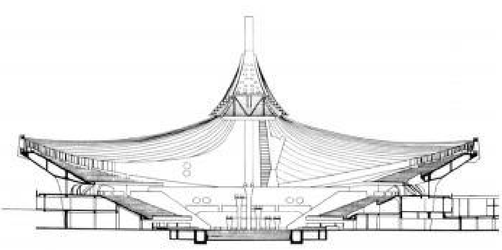
Eladio Dieste, Church of Christ the Worker, 1952



Eero Saarinen, Dulles Airport, 1962



Hans Scharoun, Berlin Philharmonic Concert Hall, 1963



Kenzo Tange, Yoyogi National Gymnasium, 1964

than the floor, as variations in a ceiling do not affect a plan's efficacy. Load-bearing masonry cathedrals, covered stadiums, igloos, and tents all have shaped sections. Buildings with shaped sections frequently exhibit a close fit between their structure and their section, often incorporating vaults, shells, domes, and tensile membranes, with the shaping of the roof aligning with gravitational load paths and structural spans. Much of the work of Félix Candela demonstrates quite clearly the intersection of structural forces and shape in section, as in his design for Los Manantiales Restaurant, consisting of a thin-shell concrete roof cast into hyperbolic-paraboloid forms. The project is in essence a physical manifestation of a structural diagram. Marcel Breuer's Hunter College Library is another example of a structural form, in this case assembling a flowering column module into a repetitive shaped section. Using more conventional framing, Rudolph M. Schindler's Bennati Cabin is constructed from two-by studs organized into triangles, forming an early example of an A-frame house. The shape is structurally efficient, permitting a large living floor below a narrower sleeping loft, with the triangular shape fulfilling local ordinance's request for alpine exterior aesthetics.

The dominance of flat-slab construction in the past century has decreased the frequency of this type of section, as the separation of structure from enclosure, exemplified by Le Corbusier's Maison Dom-ino housing prototype, shifted the articulation of space from section to plan. As Colin Rowe wryly notes about Le Corbusier's Villa Stein in "The Mathematics of the Ideal Villa," "Free plan is exchanged for free section."[6] Shaped section can be found in buildings where an intensification of social space and gathering is needed, including most buildings of collective worship. In churches and synagogues the ceiling can be used to establish a focal point within a unified volume.

The Pantheon and Le Corbusier's Notre Dame du Haut are both sacred buildings with a shaped section, one concave, the other convex. Both use the section to calibrate the play of natural light in the space, and in both the section of the ceiling is aligned with the structure to varying degrees. In a more secular context, Alvar Aalto deployed a complex, sculpted ceiling to reinforce the legibility of different areas within the single open space of his library in Seinäjoki, Finland, as well as to control daylight in the stacks. In addition, Aalto stepped the floor, setting a reading room a half-story down in the middle of the space to provide a sense of privacy while still preserving visibility from the circulation desk above.

A modulated ceiling is frequently limited to a single-story building or to a building's top floor, as the ceiling's other side can be hard to occupy without the introduction of poche, dropped ceilings, or soffits. As such, a desire to manipulate a structure's exterior to protect the interior space from the forces of nature can be a catalyst for using this section type and often informs the shape of the roof. This use of shape is clearly in evidence in Jørn Utzon's double-layered roof system for the Bagsværd Church, where a complex, curvilinear interior ceiling is covered by a simplified rectilinear shed. The section reveals the potential for a loose fit between an exterior shape responding to the obligation of weather enclosure and an interior ceiling that modulates light, sound, and space for sacred purposes. Steven Holl's project Cité de l'Océan et du Surf presents a very different reason for a shaped roof. Here the top of the building is an occupiable outdoor surface, shaped to reflect the waves associated with surfing.

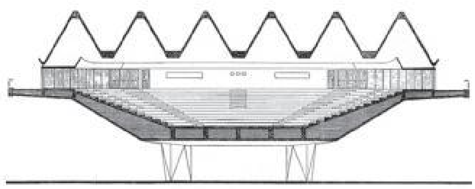
When a shaped section occurs in the floor, causing a disruption to the horizontal plan, it can cluster or choreograph collective programs, particularly those based on stasis. Theaters, auditoriums, and churches frequently use a shaped section in the floor. It is also common for these building types to have adjustments to their ceiling, often for acoustic reasons. While usually described exclusively with regard to its sloped floor, Claude Parent and Paul Virilio's Church of Sainte-Bernadette du Banlay equally displays section deformed by shape, with the roof and floor sculpted and aligned to reinforce the spatial reading of the volume set on an incline. Similarly, the design of SANAA's Rolex Learning Center aligns the shaping of the floor slab and the ceiling slab, but not within a rectilinear envelope. Instead, the space between the underside and the ground is visible and activated. As a hybrid project, the center can be characterized as an unusual combination of an extruded section and a shaped section activated by holes. Similarly, Toyo Ito's Taichung Metropolitan Opera House uses shape in combination with other types of section. However, it is the sculpted concrete forms that dominate, set in contrast to the repetitively stacked floor plates and active in the section, providing the key spaces throughout the project.

It's instructive to note, however, the distinction between the sectional transformations of shaped floors and those of complex topography. In large-scale projects such as the Yokohama Ferry Terminal by Foreign Office Architects or the Olympic Sculpture Park by Weiss/Manfredi, the sectional profile tends toward landscape, with the topography of the landform not oriented necessarily toward the creation of interior architectural space. As these projects expand in size and/or merge into the topographic conditions of the site, their sections are experienced and understood less as shaped surfaces and more as extensions or transformations of landscapes.

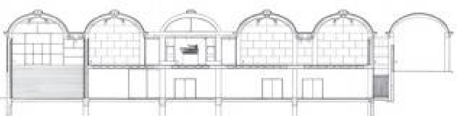
SHEAR

Shear involves a rift or cut parallel to either the horizontal or vertical axis of section. The subdesignations of vertical and horizontal shear are necessary, since each creates completely different sectional operations and effects.

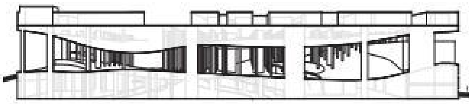
Vertical shear, where floor plates are cut and levels adjusted vertically, means that discontinuity in plan is coupled with new forms of continuity in section. Vertical shear is particularly effective at inducing optical, thermal, or acoustic connections within an extruded or stacked section without significantly compromising the tectonic efficiencies of repetition. This intriguing friction can be used for different purposes. Split-level suburban houses provide greater visual connection and flow between floors than two-story houses. Typically, an entry combined with a kitchen and



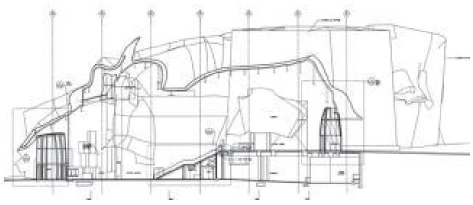
Johannes Hendrik van den Broek, Delft Auditorium, 1966



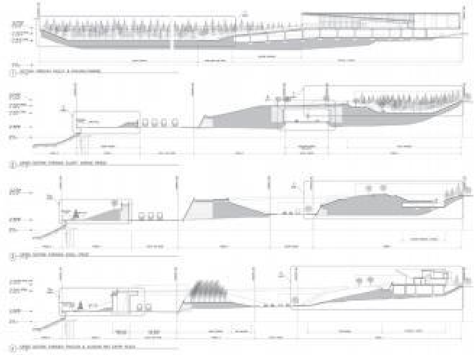
Louis I. Kahn, Kimbell Art Museum, 1972



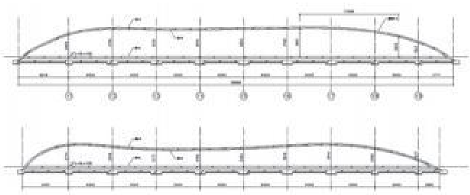
OMA, Agadir Convention Center, 1990



Frank Gehry, Experience Music Project, 2000

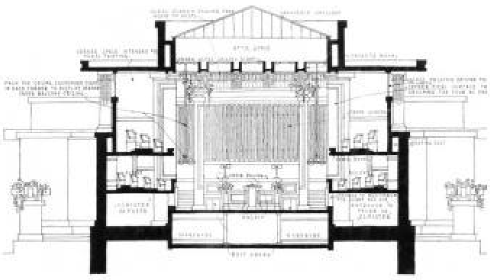


Weiss/Manfredi, Seattle Art Museum: Olympic Sculpture Park, 2007

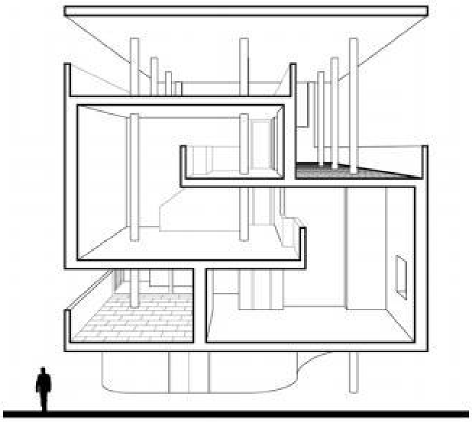


Ryue Nishizawa, Teshima Art Museum, 2010

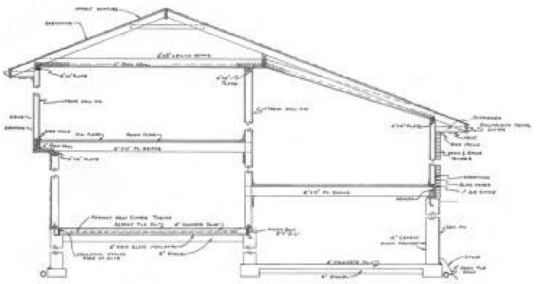
Vertical Shear Sections



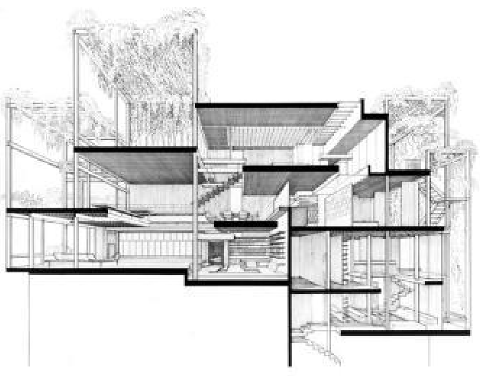
Frank Lloyd Wright, Unity Temple, 1906



Le Corbusier, Villa Baizeau, 1928



A. J. Rynkus, Split-Level House, 1958



Paul Rudolph, Beekman Penthouse Apartment, 1973

dining area is located halfway between a lower-level garage and a more formal living room, with bedrooms above the entry. Rather than simply serving as a connection between discrete floors, the staircase in the split-level house can be argued to be synthetic with the various floors, making the house an extension of the logic of the stair.

In Herman Hertzberger's design for the Apollo Schools, a vertical shear allows for enhanced visual exchange among classrooms and hallways, encouraging theatrical social dynamics while simultaneously allowing the majority of the classroom spaces to be tucked beyond diagonal sight lines. This creates what Hertzberger calls "the right balance between view and seclusion."[7] More extreme juxtapositions between plan and section can be intensified through a vertical shear. Diller Scofidio + Renfro uses vertical shear in Brown University's Granoff Center for the Creative Arts to induce visual dialogue between otherwise disconnected programs, with very little of each program hidden or secluded. This intensification of optical disjunction across programs is registered by a glass wall at the shear line that serves to mitigate sound transmission. Vertical shear can generate intricate relationships between the inside and the outside of a building at the top or bottom of a shear rather than just around the perimeter, because the staggering of levels can carry through the building from the bottom to the top. Vertical shear requires limited change to the footprint or boundary of the exterior walls and is often used to create internal spatial difference for buildings on tight sites.

A horizontal shear maintains continuity in plan and some of the logic of extruded floor plates, but produces spaces through the interplay between setback and cantilever. While a vertical shear directly impacts the interior, a horizontal shear largely affects the exterior. Two other factors affect buildings with horizontal shear. One is the degree to which the shear is applied systematically and regularly to each floor. The other, which is usually directly related to the first, is the degree of similarity among the different floor plates. Henri Sauvage's designs for stepped houses, best exemplified by his apartment building at 13 Rue des Amiraux in Paris, exhibit both a consistently repeated horizontal shear and relatively equal floor plates, producing a series of terraces on the setback side of the shear. In this raked diagram, one side of the building is opened up to the sun and sky, while the other defines a space, cast in shadow, between the cantilevers and the ground. Sauvage placed two raked buildings back to back and filled the underbelly with a swimming pool, effectively creating both private benefits (terraces) and collective benefits (pool) through this one sectional operation. This diagram was highly seductive, particularly for housing, as it injected into the model of the stacked slab tower in the park both superior solar exposure/views and a space rife with collective potential. It efficiently deployed repetition to produce difference. Moreover, it made legible new part-to-whole relationships and allowed for greater continuities between the landscape and the building. Horizontal shear was instrumental in a number of projects and buildings, including Walter Gropius's Wohnberg (1928 proposal), Le Corbusier's Durand Project (1933, Algiers), Paul Rudolph's Lower Manhattan Expressway (1972 proposal), Denys Lasdun's residence halls for University of East Anglia (1962, Norwich, UK) and Christ's College (1966, Cambridge, UK), Ricardo Legorreta's Hotel Camino Real (1981, Mexico City), and more recently BIG/JDS's the Mountain Dwellings. The Mountain brings to fruition one of Sauvage's century-old diagrams, which situates parking beneath a pyramid of sheared housing. The fact that the Mountain contains more parking than needed for the apartments demonstrates that as the amount of the rake or the angle is increased, thereby producing more exterior space for each apartment, an engorged underside can result.

Horizontal shear can create collective social spaces when a sequence of terraces are combined into a single open volume. The Barnard College Diana Center by Weiss/Manfredi cleverly deploys horizontal shear internal to the building mass to open up a series of public lounges stitched together within a multistory academic building, creating visual continuity on the diagonal through the urban campus. Similarly, Neutelings Riedijk's Netherlands Institute for Sound and Vision takes full advantage of the spatial continuity created by horizontal shear, with the orientation of the shear operating at ninety-degree angles below and above grade. The entry lobby is connected visually to a series of stepped levels of the building's subterranean archive. The stacked floors above are sheared in the perpendicular direction, opening up the main space to daylight from the skylight, simultaneously creating a multilevel exhibition volume at the top. The cumulative effect is a ziggurat-shaped void carved from the building mass.

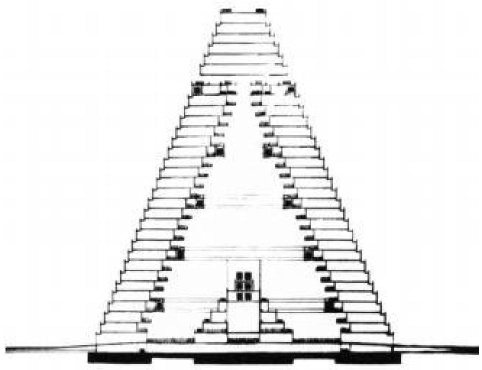
Repetitive horizontal shear on self-similar floor plates produces a combination of staggered exterior spaces, deploying corbeling for stability. The use of horizontal shear in varying amounts creates sectional moments around the full perimeter of a building, often relying on a central core for balance. These moments are more local than a repetitive raked section and can take the form of an accumulation of platforms, balconies, overhangs, and skylights, rather than collective spaces. Frank Lloyd Wright's Fallingwater is a good example of different-size floor slabs that are dispersed to activate sectional effects on the exterior of a building. They twist around the whole of the exterior of the building, producing simultaneous sensations of upward growth and downward cascade, while the interior is compressed, with space pushed horizontally, not vertically.

HOLE

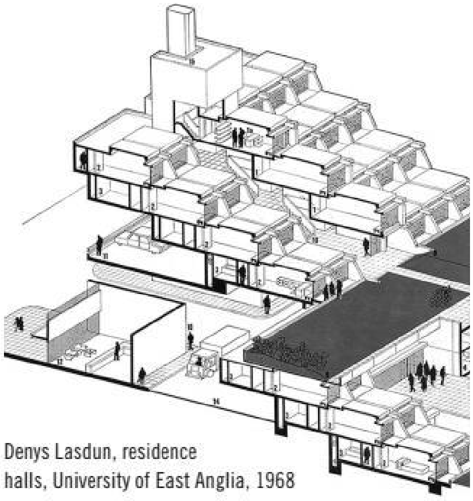
A pragmatic and frequently used sectional device, the hole is a cut or penetration through a slab that exchanges lost floor area for benefits in section. Holes are spatial commodities that can be tactically deployed for vertical effects. They range in scale and quantity from a single small opening between two floors to multiple large atria that organize whole buildings.

Small holes accommodate infrastructural runs, such as risers, ducts, and chase spaces; they are typically not large enough to impact the structural integrity of the floor. The shafts of elevators and fire stairs are used to strengthen an overall structure, with

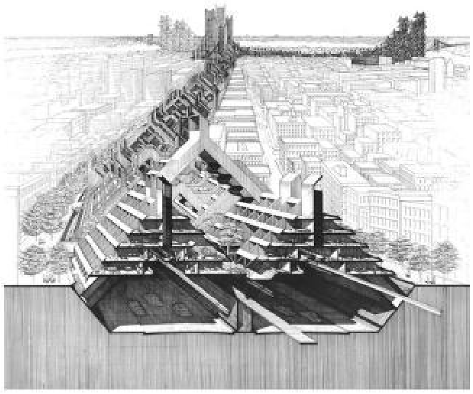
Horizontal Shear Sections



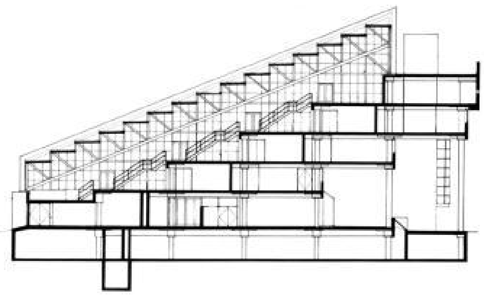
Walter Gropius, Wohnberg proposal, 1928



Denys Lasdun, residence halls, University of East Anglia, 1968

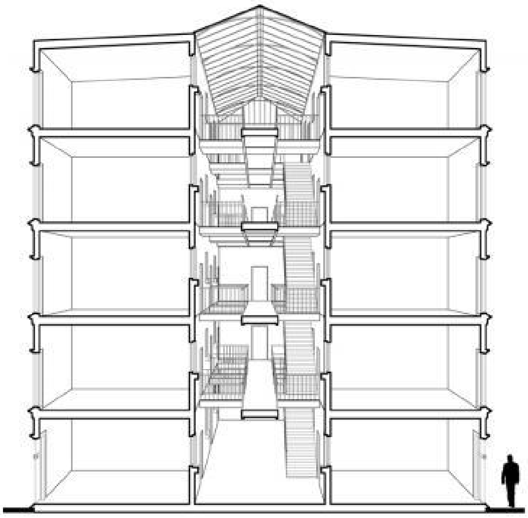


Paul Rudolph, Lower Manhattan Expressway proposal, 1972

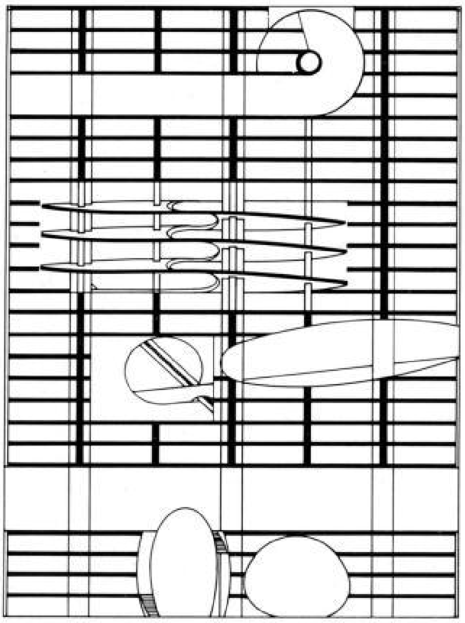


John Andrews, Gund Hall, Harvard Graduate School of Design, 1972

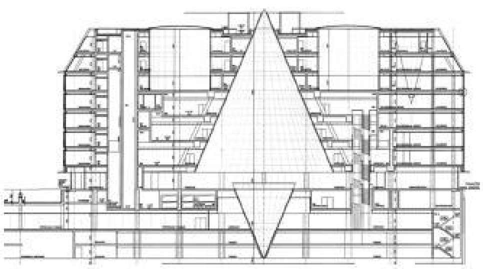
Hole Sections



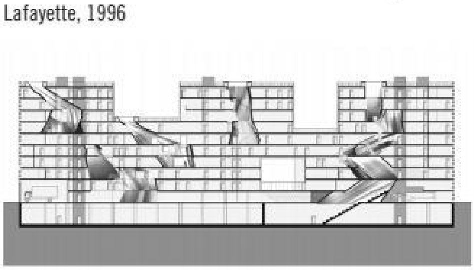
Marie-Gabriel Veugny, la Cité Napoléon, 1853



OMA, Très Grande Bibliothèque, 1989



Jean Nouvel and Emmanuel Cattani & Associates, Galeries Lafayette, 1996



Steven Holl Architects, Simmons Hall, MIT, 2002

solid walls often acting to resist lateral shear forces; they are inserted within vertical holes precisely because these spaces are not expected to produce visual continuity between floors.[8] Small holes through single floor plates can be strategically located based on plan imperatives.

Large holes are more substantial voids in a multistory building, creating spatial continuity among floors. These holes are predicated on some form of visual exchange and allow for light, acoustic, olfactory, and thermal continuity within a building. Holes are a second order of sectional operation, acting on a given single or multilevel stacked section.

A clear and basic manifestation of a hole at the scale of a room is found in Le Corbusier's Maison Citrohan, realized at the 1927 Weissenhofsiedlung exhibition in Stuttgart, Germany. Its central organizing spatial component is the double-height void made by cutting back a substantial portion of the second floor. In addition to allowing exchanges of light, view, and sound, this hole establishes hierarchies between public and private, figure and ground, and part and whole. There is a clarity and simplicity to this two-story section. It does not require a new construction system; it just edits back the given structure. This scale of hole influences the importance and hierarchy of spaces around it, creating, for instance, formal double-height spaces. Lobbies, central meeting areas, interior courtyards, and domestic living rooms all make use of this type of program-specific scaled hole.[9]

Atria amplify the scale of smaller holes, in terms of both width and quantity of floors, and exceed their effect. This increased scale permits the effective distribution of daylight (often from skylights) and movement of air, and heightens the role of the interior. Wright's Larkin Building used the central atrium to organize and focus the program of its offices, allowing sunlight in and assisting with the mechanical distribution of air. Moreover, in this large and sealed building, wisely separated from the din and soot of the neighboring rail yard outside, the atrium replaced the exterior as the building's focus.

At this scale, the atrium is less a cut through floors than a space around which floors are built, a condition Louis I. Kahn made explicit in the articulated structural lining of the atrium of the library at Phillips Exeter Academy. In the asymmetrical Ford Foundation Headquarters by Kevin Roche John Dinkeloo and Associates, the atrium serves as a conditioned, four-season garden, open to sunlight on the south and east sides. Offices on the north and west envelop the atrium, with selective use of horizontal shear to terrace the ground and rooftop enclosure.

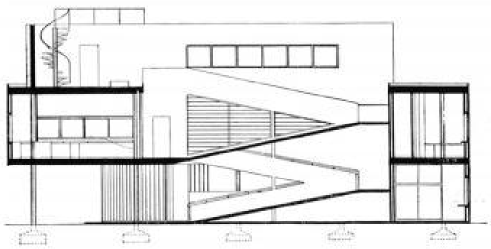
John Portman has pushed the use of the atrium to an extreme, creating hotels that are defined by the radical dichotomy between their conventional exteriors and spectacular interiors. The vast atria of his interiors appear to extend upward infinitely, a sensation heightened by exposed glass elevators accelerating past series of stacked open walkways and balconies. The atrium of Portman's New York Marriott Marquis hotel is framed by thirty-seven stories of rooms, stacked in groups of five floors that illustrate local horizontal shear. The visual pleasure and spectacle of atria account for their frequent use in places of consumption, notably department stores, as exemplified by Galeries Lafayette in Paris of 1912 and Jean Nouvel's design for the same company in Berlin at the end of the twentieth century.

Holes are the key component of Toyo Ito's Sendai Mediatheque, striking an intriguing balance between their implications for the plan and the legibility of the section. The building is organized around thirteen holes, which puncture all seven floor slabs. The holes serve as the locus of circulation; as mechanical shafts; as tubes for the flow of energy, air, light, and sound through the floors; and, paradoxically, as the building's structure. These hollow, inhabitable tubes made through bundled steel columns not only produce the section but become primary plan components, choreographing the program on each floor. In the Sendai Mediatheque, holes ringed by structure animate what would otherwise be a series of repetitive and independent stacked floors.

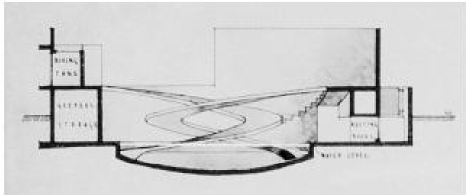
INCLINE

Inclines are sloped floor surfaces, which often connect levels. Inclines change the angle of an occupiable horizontal plane, thus effectively rotating plan into section. Unlike stacks, shears, and holes, inclines blur the distinction between plan and section. With inclines, sectional play does not require the sacrifice of a portion of the plan. Like holes, their specific impact on section is dependent on their scale; they can range from a narrow ramp to a full floor to entire built environments, as envisioned by Claude Parent and Paul Virilio in their oblique urban order. Le Corbusier proposed the *promenade architecturale*, an itinerary through space based on the continuity of the horizontal with ramps. In its first realization in 1923, with Villa La Roche–Jeanneret, a single ramp cuts one level through a gallery. At this scale, the incline is more of an object within a double-height space than a fully formed component of the building's section. This ramp has a stronger impact in plan, where its curve highlights a bulge in the wall. In comparison, the incline in Villa Savoye is much more instrumental in organizing and activating the entire building as a *promenade architecturale*. It connects space in, up, through, and out of the two floor slabs, culminating in a roof garden atop the building. However, the vertical space of section is truncated by the fact that the ramp fills the area that was removed from the floors in order to accommodate it. Moreover, the ramp moves from inside to outside and is spatially disconnected inside the villa, where Le Corbusier relied on the continuity of the wall adjacent to the ramp to register the section. This reading is substantiated by the section drawing for Villa Savoye included in his *Oeuvre complète*, which is from an earlier scheme, in which that wall extended up another floor. Somewhat ironically, a narrow ramp such as the one in Villa Savoye produces more discontinuity than continuity in plan. Even though the ramp is only four feet wide, it requires thirty-two feet to make the connection between the two floors.[10] The incline viewed in the path of travel along the ramp creates continuity of section, but this comes at a price. In order to connect different floors, the incline must also cut into the plan of the villa,

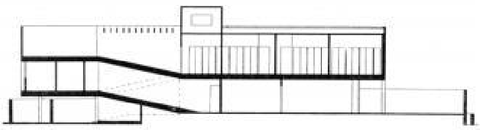
Incline Sections



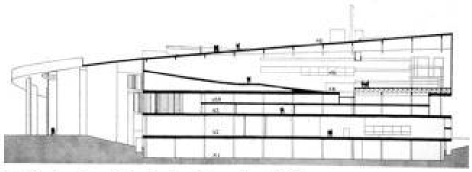
Le Corbusier, Villa Savoye, 1931



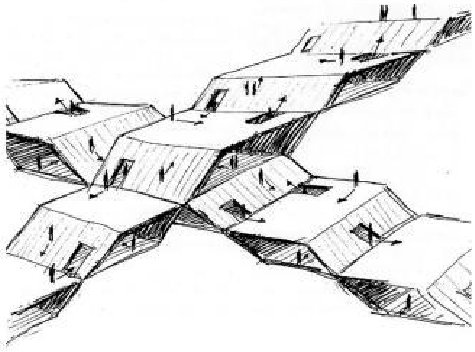
Tecton, Penguin Pool, 1934



Vilanova Artigas, Almeida House, 1949

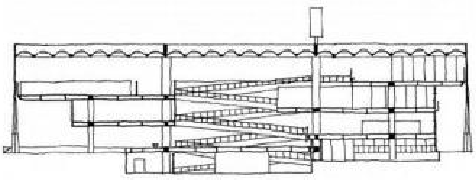


Le Corbusier, Palais des Congrès, 1964

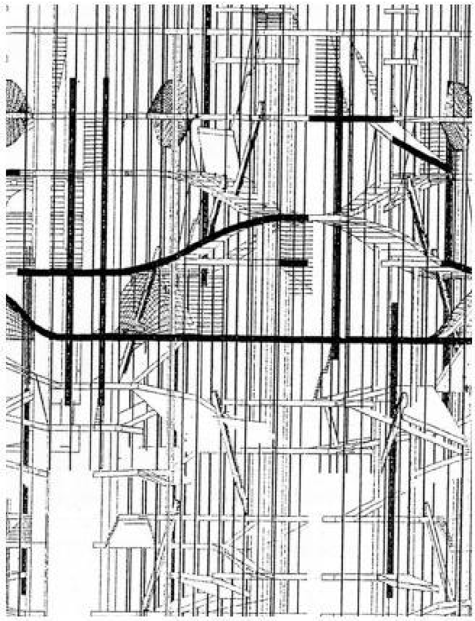


Claude Parent and Paul Virilio, habitable circulation, 1966

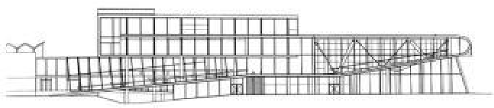
Incline Sections



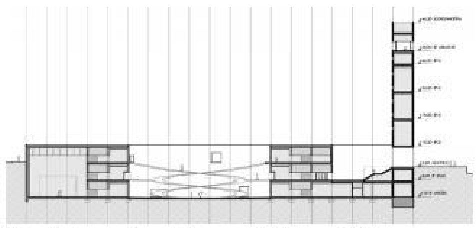
Vilanova Artigas, São Paulo School of Architecture, 1969



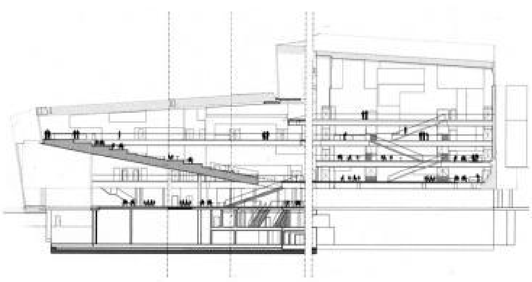
OMA, Jussieu-Two Libraries (detail), 1992



OMA, Educatorium, 1997



Alberto Campo Baeza, Museum of Memory, 2009



Henning Larsen Architects, Harpa, 2011

creating a discontinuity of space. The ramp at the Villa Savoye cuts the plan in two, distinguishing the garage from the entry hall and the exterior terrace from interior bedrooms, while enabling light and views to pass diagonally across the ramp.

This paradox of an incline creating continuity in section only through discontinuity in plan was examined and explored by Frank Lloyd Wright in two different projects. In the V. C. Morris Gift Shop, a narrow ramp is aligned with an atrium, thereby enhancing visual connections across the section and decreasing the disruptions to the space from shear. Movement up and, more important, around this incline adds to the spectacle of shopping. While the incline in Villa Savoye is autonomous, as it splits the column grid and penetrates through all floors, the incline in the Morris Gift Shop appears to be hung from the balustrade of the floor above, allowing the circulation on the ground floor to slide in and around it. Because the Morris Gift Shop was an insertion into an existing building, Wright's play with the incline was constrained, but he explored this theme further in the Solomon R. Guggenheim Museum. In this well-known museum as spiral, Wright fuses an incline and atrium, turning the main gallery floors into a single continuous promenade. (Side galleries and support spaces have flat floors and are located away from the central event.) Since all floors merge into a single surface, the challenge for the viewer is not an issue of sequence or passage but rather starting point. Wright famously insisted that all visitors first entertain an elevator ride to the top, with the downward slope of the incline facilitating a leisurely walk. (Curators have not always followed Wright's commands when designing show sequences.)

Wright's work on the Guggenheim draws parallels to his unbuilt Gordon Strong Automobile Objective and Planetarium project, where a double-helix ramp brings cars up and down. Designs for roads and parking systems have deployed incline as a necessary means of facilitating automobile passage. Ramped parking structures use inclines in two distinct manners: either as connecting pieces among level floors of repetitively stacked parking or as continuously ramped surfaces that merge parking and circulation. The Guggenheim plays on the latter, while Herzog & de Meuron's 1111 Lincoln Road explores the creative possibilities of the former, introducing variations in floor height to transform a parking structure into a social destination, complete with a residence with sheared floor plates on top.

While Wright negotiates the paradox of the ramp creating discontinuity by introducing the central atrium in the Guggenheim, OMA deploys the incline to foster greater programmatic density and to create visual juxtapositions. OMA's Rotterdam Kunsthal is a cut-back incline at the scale of a whole building. The shear between two inclined surfaces is exaggerated and animates programmatic misalignments, with a single incline that is split by a wall of glass into an interior corridor moving up and an exterior path that threads through the center of the building. The outer edges of this incline are pushed to the exterior and are legible as elevations. OMA's unbuilt project for Jussieu (1992) is organized around a continuous incline, which, like the

Guggenheim, eradicates floor-to-floor distinctions. But unlike at the Guggenheim, the width of the incline expands and contracts and, more important, tactically deploys discontinuity within that surface through cuts, folds, and shears, to allow for a multiplicity of programs and spaces on the same continuous surface.

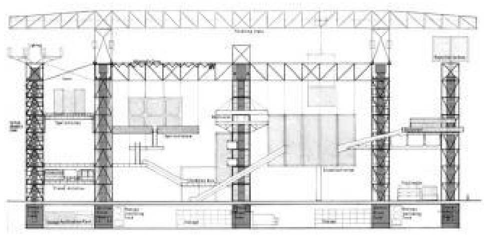
Although one objective of a continuous inclined surface is an activation of the section, the consequence is not necessarily an intriguing vertical space. This is because an inclined surface often folds back on itself, effectively forming a stacked section with unlevel floors. In these projects, vertical extensions of space are produced by editing back or removing parts of the floor, as in the Guggenheim's atrium or the vertical shafts in the Kunsthal or Jussieu.[11] Continuous inclined surfaces often exhibit shear and need holes for visual continuity. This is clearly evident in Henning Larsen's Moesgaard Museum, where the shape of the building is defined by its inclined, sloped green roof. Whereas the incline is obvious on the exterior, it is primarily visually apparent within the interior when viewed through a large hole for the building's oversized staircase.

NEST

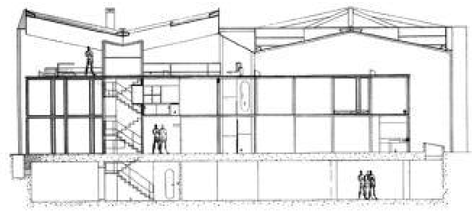
Nests produce sections through interplay or overlap between discrete volumes. Whereas stack, shear, hole, and incline work primarily with flat plates, a nest positions three-dimensional figures or volumes for sectional effect. The early twentieth-century houses of Adolf Loos often demonstrate volumetric nesting, with rooms stacked on various levels to create complex spatial sequences, typically described as *Raumplan*. The spatial, structural, or environmental performance of the nest usually exceeds that of the volumes operating in isolation. Crucial in this approach to section is the functionality of interstitial space and its relationship to the exterior skin. Although the permutations of a nested section are numerous, a handful of examples will help explicate two significant variations.

To create the Center for Arts in La Coruña, Spain, aceboXalonso Studio lodged a series of highly specific performance spaces as distinct but interconnected forms within a box formed by a multilayered skin. The resulting interior is a complicated vertical space that moves around the volumes. The volumes are programmatically specific, whereas the space of the section between is indeterminate, fluid, and undefined. As the performance spaces press up against the exterior, the double skin of the shell is interrupted, thus making visible on the outside the nesting of the volumes in section. MVRDV's Effenaar Cultural Center is based on a more pragmatic approach. Individual rooms, each with its own size and function, are arrayed around the exterior of the building's skin, in effect increasing the thickness of that skin. These generate a doughnut in section, with a main concert hall as the center of the doughnut, thereby linked to all the individual programs in the building. Whereas aceboXalonso begins with a large frame into which smaller programs are nested, MVRDV organizes the nested volumes to create the overall figure, building the whole from individual parts.

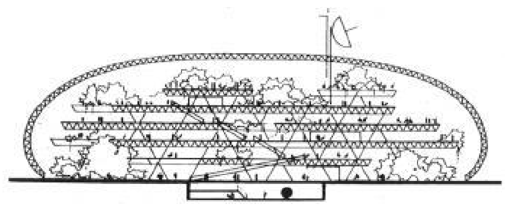
Nest Sections



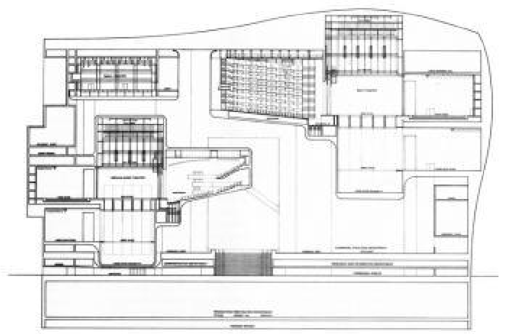
Cedric Price, Fun Palace, 1964



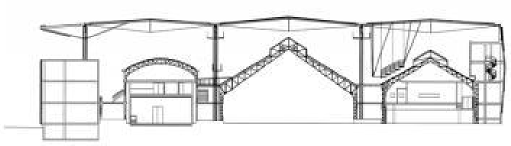
Le Corbusier, Heidi Weber Museum, 1967



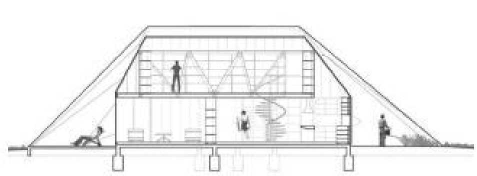
Buckminster Fuller and Norman Foster, Climatroffice, 1971



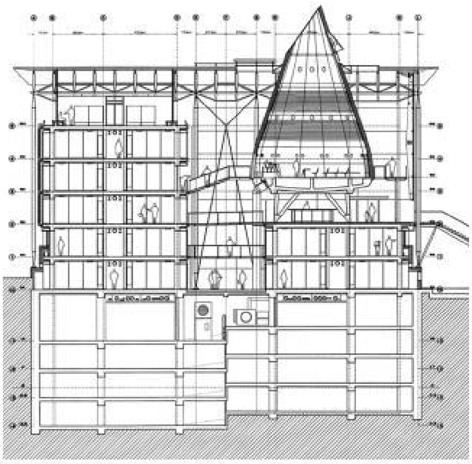
Jean Nouvel and Philippe Starck, Tokyo Opera House, 1986



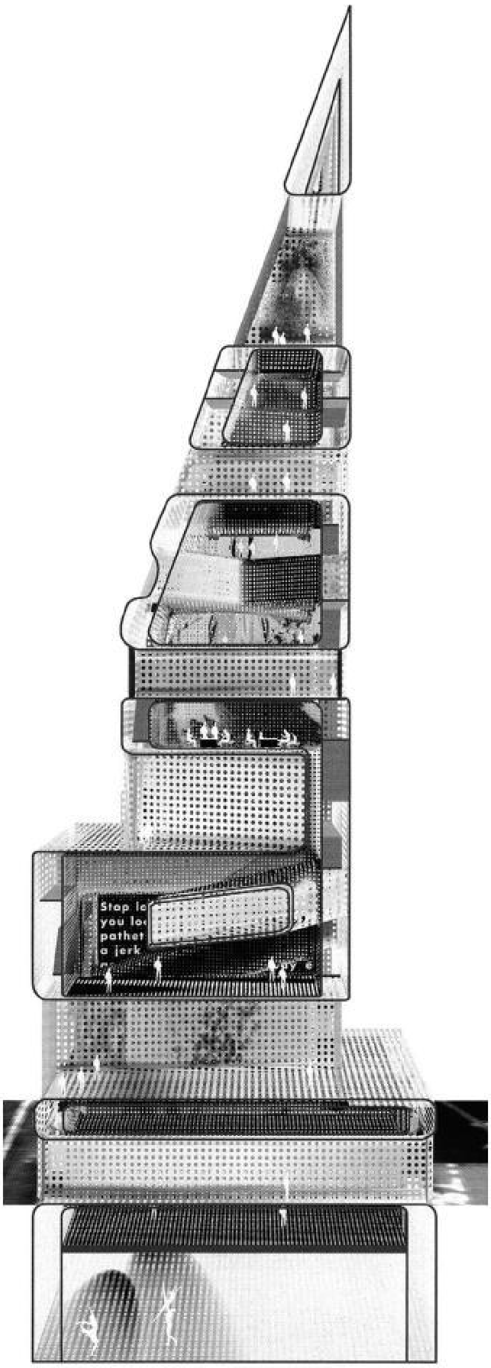
Bernard Tschumi, Le Fresnoy Art Center, 1992



FAR frohn&rojas, Wall House, 2007



Richard Rogers, Bordeaux Law Courts, 1998



MVRDV, Eyebeam Museum of Art and Technology, 2001

Vertical circulation in these and other nested projects is a key design challenge, as stairs run the risk of disrupting the tight set of adjacent volumes. In Loos's designs, stairs are woven in and among nested volumes, becoming at times part of a sequence of the vertical staggering of volumes and at other moments hidden and tucked away, existing in the space between rooms. With the Effenaar Cultural Center, MVRDV simply moved the circulation and fire staircases to the exterior, where they exist as independent spaces attached from outside.

MVRDV's 2001 proposal for the Eyebeam Institute is a more nuanced and intricate approach to nesting. As with Effenaar, individual program pieces are dispersed in section, but here they are separated from one another. The consequence is a complex interstitial void punctuated by the shapes of those program pieces. Moreover, the exterior skin, which doubles as structure, extends around these pieces into the building volume, effectively bridging between pieces and stiffening the exterior structure. Apertures on the exterior of the building replace the structural skin where the interior volumes kiss that skin. The specificity of these nested interiors' programs is visible on the exterior, yet this specificity is occluded from view within the larger building cavity. As with the two previous projects, the interstitial space is programmatically indeterminate, permitting unforeseen activities to be catalyzed by the spatial stimulation of an open and compelling section.

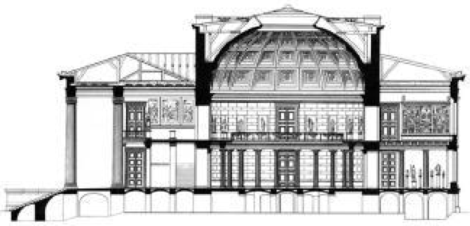
These previous three examples all deploy discrete volumes adjacent to one another to activate an interstitial section. A different category of nesting occurs when discrete volumes are lodged inside one another. Although the logic of this type of nesting would seem to undermine the development of section, this redundancy, when intelligently deployed, can intensify the programmatic relationship between the volumes. It can also produce new models of thermal performance based on a complex relationship between exterior and interior conditioned spaces. A small-scale example of this type is Charles Moore's own house in Orinda, California, from 1962, where the volumes of the sitting area and the shower, each marked by four columns and a skylight, are caught within the overall shell of the small house. These "aedicules" invert both the normal structure of the house and the conventional location of the bath, which here is open to the whole house. These nested volumes become the primary structure of the house, allowing its exterior corners to disappear as sliding doors. Counterintuitively, this nesting sponsors greater openness and connection between the exterior and the most private interior. A different manipulation of the expected logic of nesting is found in the San Paolo Parish Complex in Foligno, Italy, by Fuksas Architects. Large, hollow sleeves structurally connect the two volumes, suspending the inner volume and channeling sunlight into this innermost space, bypassing the outer volume. The contrast in both the volume and illumination of the section add dramatic effect to the church. Nesting is a particularly good sectional device for manipulating and controlling daylight through multiple layered skins, a technique used by Gordon Bunshaft of Skidmore, Owings & Merrill at the Beinecke Library. Here a box of translucent stone protects rare books from the damaging effects of direct sun, while placing them on dramatic display within their own internalized glass vitrine, nested inside the exterior envelope.

An extremely literal example of a nested section is Sou Fujimoto's House N. The three rectangular layers of this house are all white, contain self-similar rectangular framed openings on all five sides, and diminish only slightly in thickness from outer- to innermost. Yet, by locating the thermal enclosure on the middle layer and by pushing the outer skin to the limits of property, Fujimoto conscripts the grounds as the site of a surprisingly complex homogeneity that blurs conventional distinctions between interior and exterior, private and public. Although all the layers look alike, each does different things: the outer defines the precinct of the house; the middle regulates the thermal environment; and the inner distinguishes bedrooms from the living/dining area. Each alone would be too porous, but collectively they regulate privacy and view. Nonetheless, the layers do little to increase the environmental performance of the house, as it is only the middle layer that acts as the thermal barrier. In contrast, the Mont-Cenis Training Center by Jourda Architectes uses sequential nesting to enhance thermal performance. Two unremarkable linear buildings are located under a very large wood shed, which spans beyond the footprints of the inner buildings. Clad in glass and photovoltaic panels, the outer skin uses passive solar and ventilation to modify extremes in weather, producing a temperate thermal layer between the outside and the two inhabited buildings. Neither fully inside nor fully outside, this space is conceptually and functionally akin to the cavity between two panes of glass in a thermal window. Furthermore, nesting makes possible a gradient of thermal conditions directly linked to the complex interplay of space, building materials, and thermodynamic forces in section. Mont-Cenis Training Center is a more refined elaboration of the exterior thermal or climate utopias envisioned by Buckminster Fuller. Whether in his conceptual dome to encapsulate Manhattan or the United States Pavilion at Expo '67 in Montreal, Fuller repeatedly used nested section to generate controlled thermal environments. These large-scale nested sections were the product of his exploration and innovations in space-frame construction systems, which allow for the building of expansive envelopes, facilitating the placement of buildings within buildings.

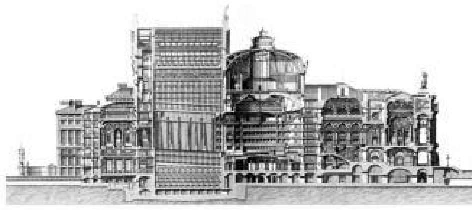
HYBRIDS

Extrusion, Stack, Shape, Shear, Hole, Incline, and Nest are primary methods for operating in section. For the sake of clarity, they have been presented as distinct modes, but they rarely operate in isolation. Hole and Shear, for instance, require the existence of extruded floors or stacked sections to register the action. Shaped sections typically couple with stacked plates to provide sufficient support and service spaces. Indeed, buildings exhibiting the most complex and intricate sections contain all manners of combinations. We have included projects that exemplify innovative combinations of section types, often in creative tension; where no single dominant type is in evidence, we have designated these projects Hybrids.

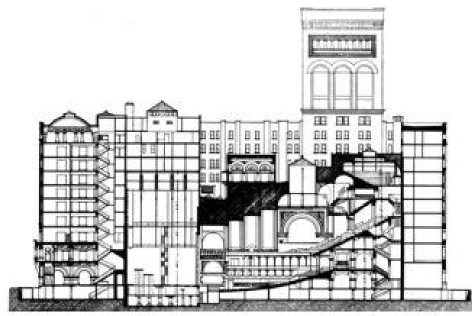
Hybrid Sections



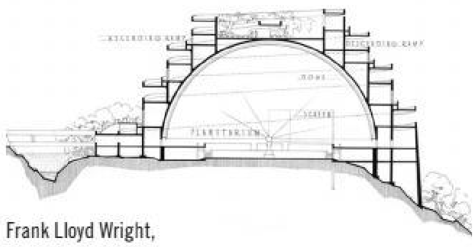
Karl Friedrich Schinkel, Altes Museum, 1830



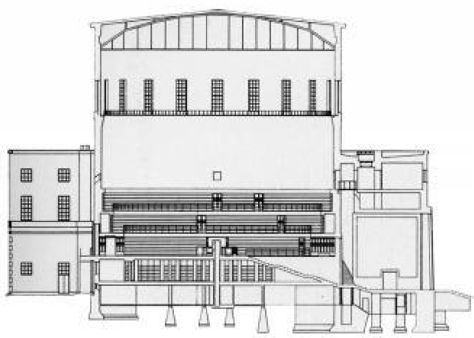
Charles Garnier, Paris Opéra, 1875



Adler & Sullivan, Chicago Auditorium Building, 1889



Frank Lloyd Wright,
Gordon Strong Automobile Objective, 1925



Erik Gunnar Asplund, Stockholm Public Library, 1928

The direct extrusion of a plan to a height
sufficient for the intended use

The layering of floors directly on top of one another; an extruded
section, repeated with or without variations

The deformation of one or more of the primary horizontal
surfaces of a building to sculpt space

The use of a rift or cut along either the horizontal or vertical axis
of a building to generate sectional difference

The deployment of any number or scale of penetrations through
a slab, exchanging lost floor area for benefits in section

The manipulation of the angle of an occupiable horizontal
plane, which tilts the plan into section

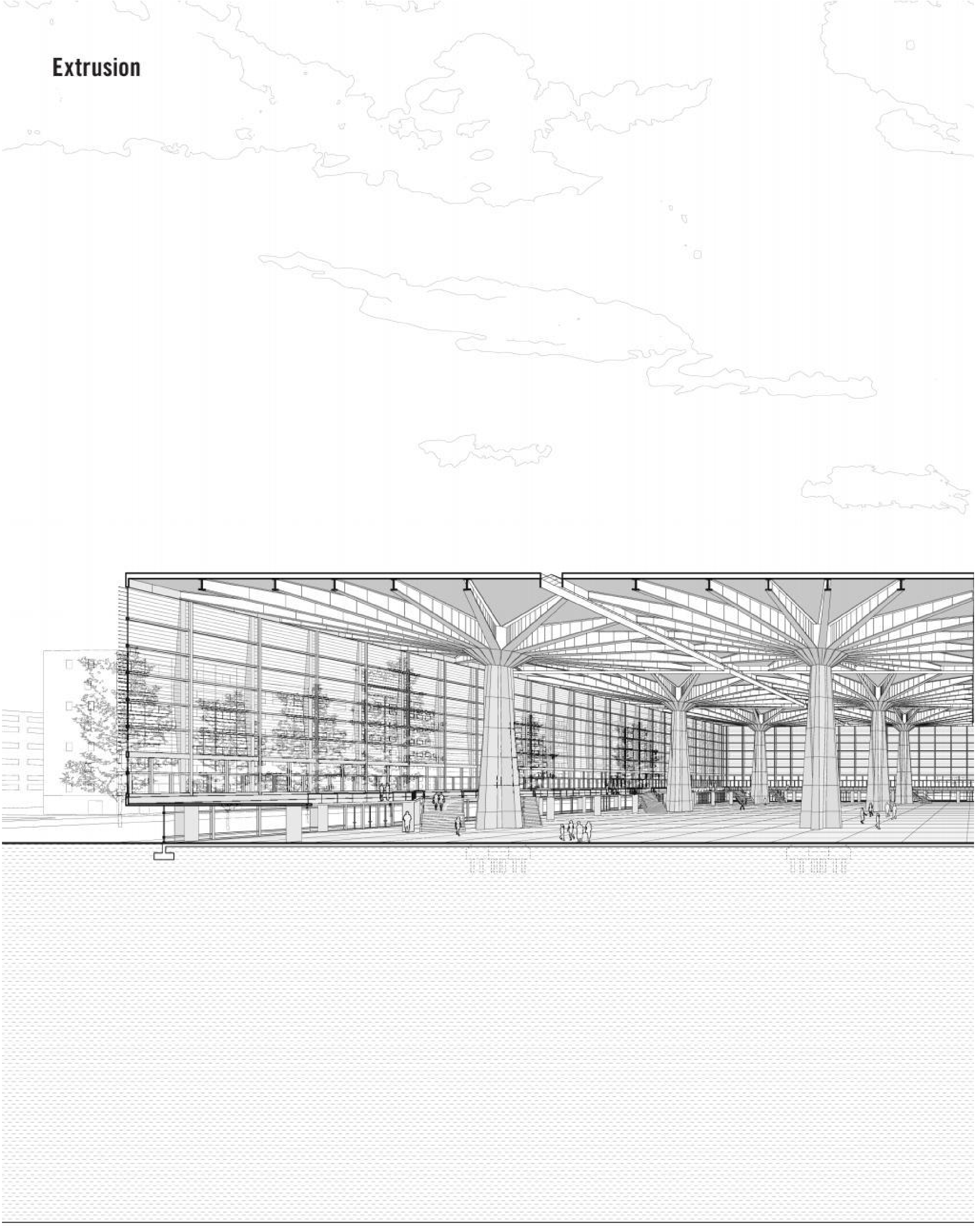
The creation of sectional consequences through
an interplay or overlap of legible volumes

Any combination of Stack, Extrusion, Shape, Shear, Hole, Incline,
and Nest; buildings rarely exhibit section types in isolation

The extrusion of a plan up to a height sufficient for the intended activity is the most basic form of a section. An extruded section has little to no variation in the vertical axis. The vast majority of buildings are based on this efficiency, including strip malls, big-box stores, factories, single-story houses, and the floors of most office, retail, and multistory residential buildings.

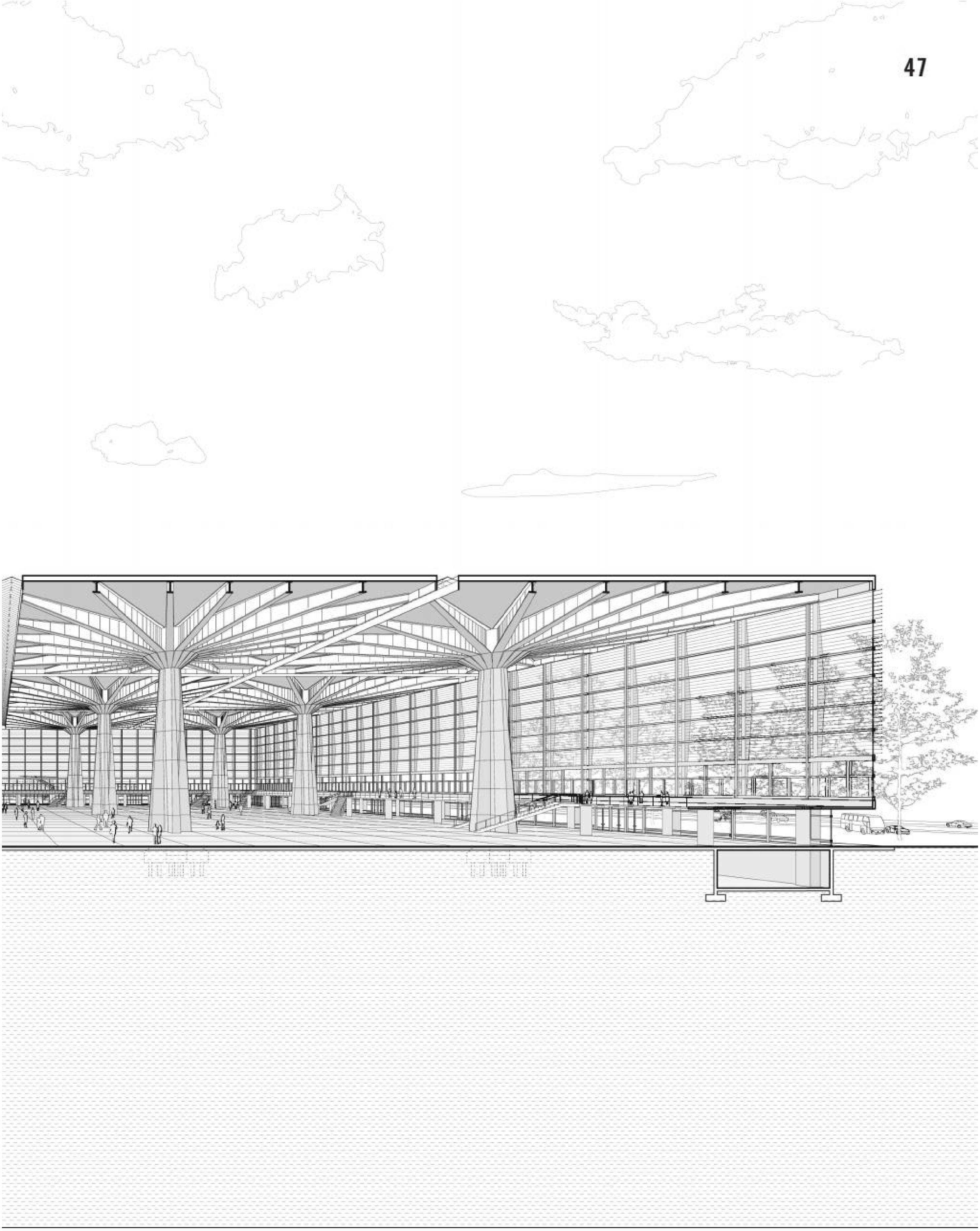
EXTRUSION

Extrusion



Palace of Labor | Turin, Italy

Covering 269,098 sq ft (25,000 sq m), this enormous exhibition hall and training center was designed in part as a response to the expedited construction sequence of a competition. Built in eleven months, the roof was conceived as sixteen individual 82-ft-tall (25 m) mushroomlike forms, each consisting of a 65-ft-7-in (20 m) cast-in-place reinforced-concrete column topped with a 131-ft-3-in (40 m) square steel roof assembly. The accumulation of these units, built one by one, allowed interiors and the glass enclosure to be constructed prior to the completion of the entire roof. The large concrete



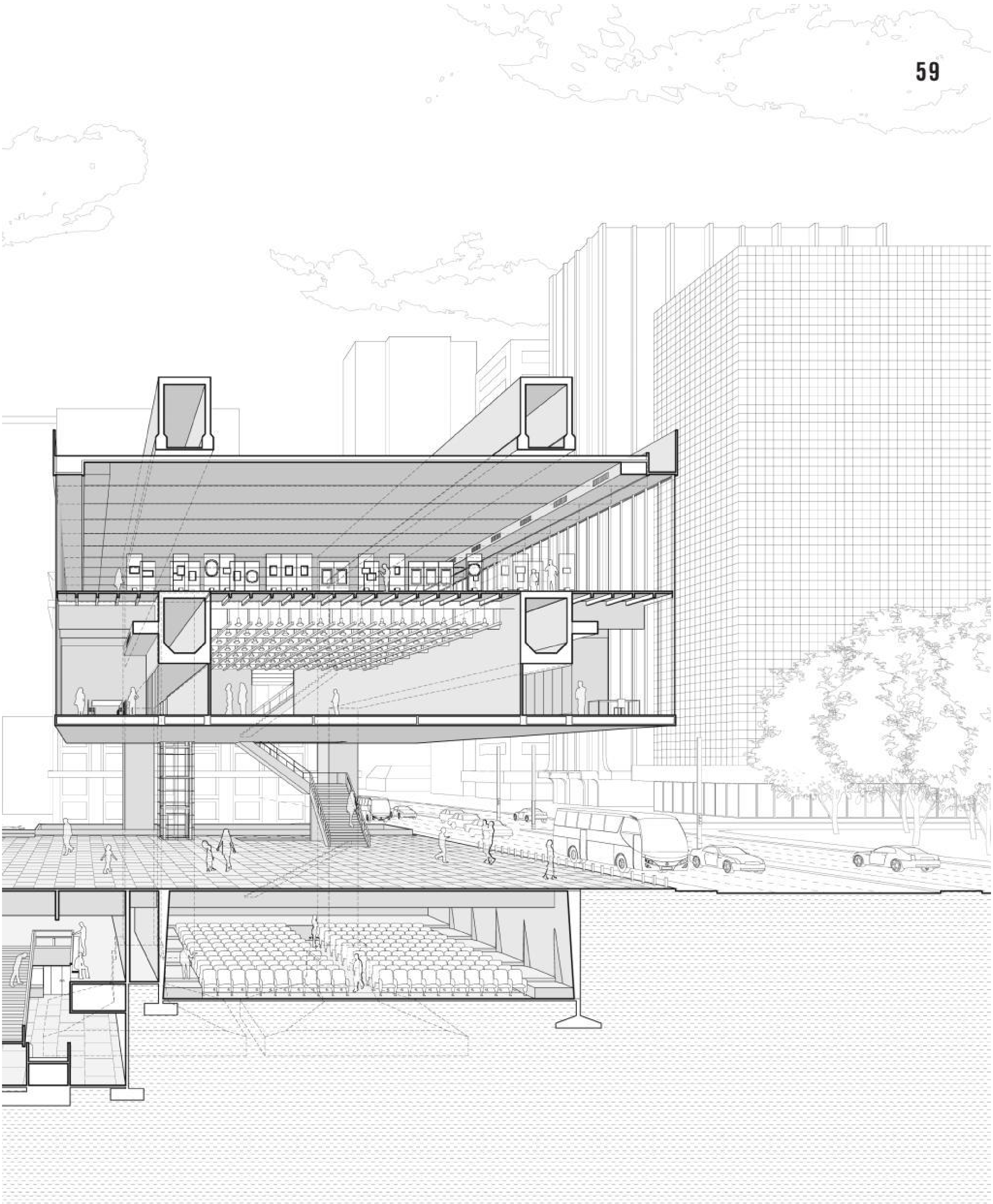
columns taper from a 16-ft-5-in-wide (5 m) cruciform, to a 8-ft-2-in-diameter (2.5 m) circle, to which are anchored twenty radiating steel-beam spokes that support the roof. Continuous glass strips run between the structures, allowing natural light into the space and registering the autonomy of each massive structural unit. A row of external steel ribs spans between a perimeter mezzanine and the roof to stiffen the enclosing glass curtain. The height and scale of this section exceeds conventions and transforms this extruded section into a grand civic space and spectacle.

Stacking increases the real estate value of a property by expanding the square footage and programmatic capacity of a building without increasing its footprint. This is a basic motivation for the creation of section in architecture. A repetitive stack is largely an extruded section, deployed ad nauseam. By itself, stacking does not produce interior effects.

STACK

São Paolo Museum of Art | São Paolo, Brazil

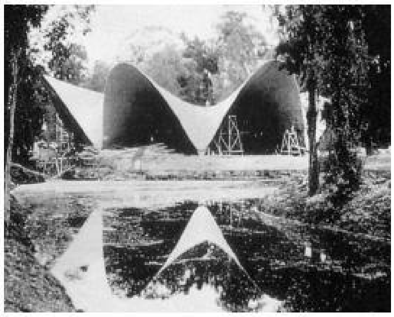
This cultural center comprises three stacked volumetric parts: the first suspended 26 ft 3 in (8 m) in the air, the second submerged below grade, and the third located in between—an exterior belvedere at street level. Two pairs of hollow prestressed 8-ft-2-in–by–11-ft-6-in (2.5 by 3.5 m) concrete frames span the 243-ft (74.1 m) length of the upper volume, suspending two floors. The lower floor contains offices, a library, and a central exhibition space, with circulation corridors located immediately below the concrete beam. On the upper level, the concrete beams



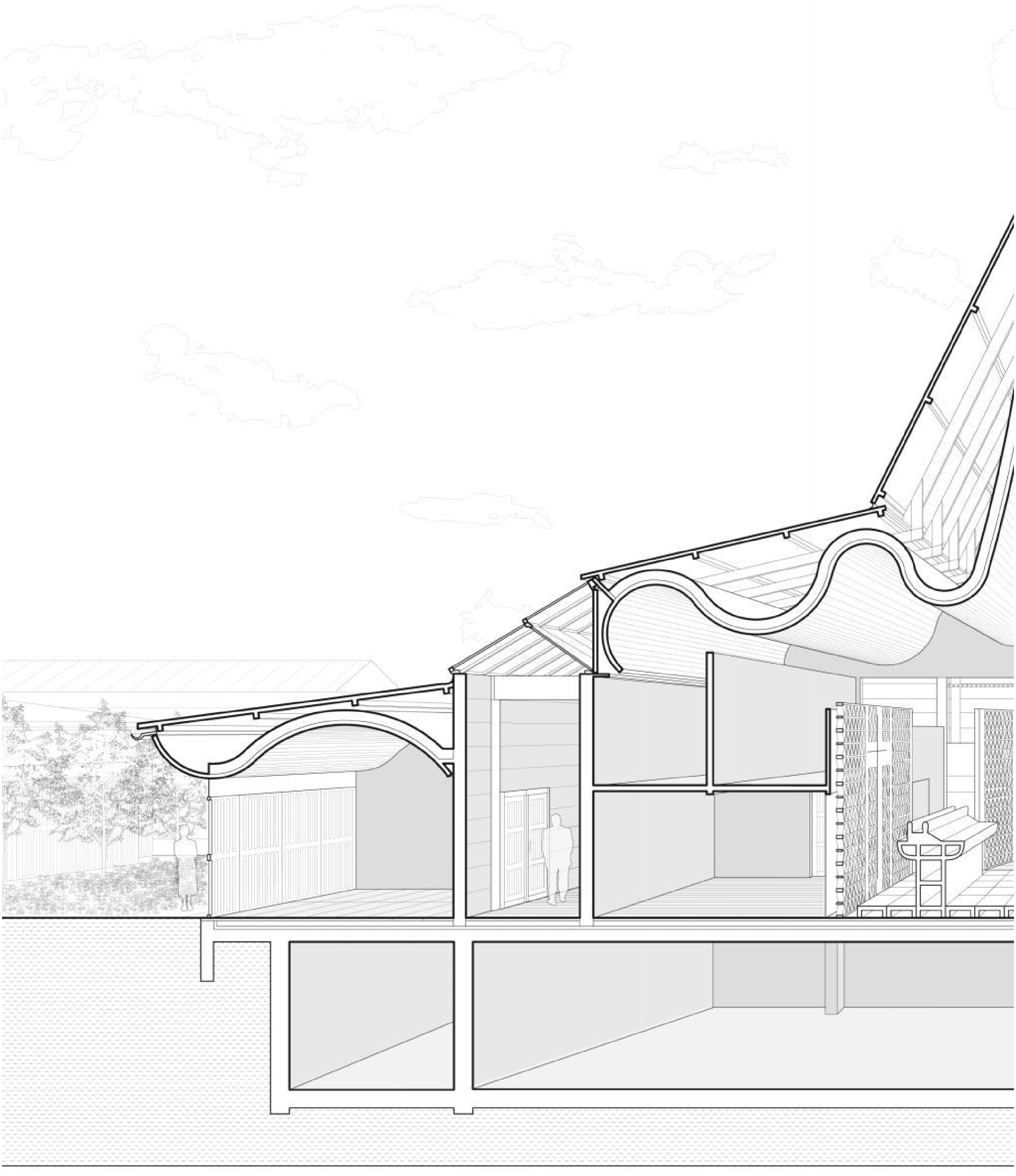
are external, producing an unimpeded exhibition hall enclosed by a curtain wall on all four sides. An external stair and elevator link the suspended volume and the plaza with the below-grade civic hall, auditoriums, theater, library, restaurant, and service spaces. Exploiting the topography of its urban site, this stacked complex is paradoxically both subterranean and floating, camouflaged and monumental, compressed and expansive.

Shaping is a modulation of the flat surface of a section. This adds a particular volume to the section and can occur in a floor or ceiling or both. The ceiling is a more common location for this modulation than the floor, as it does not affect the plan's efficacy. Shaped sections often coordinate large collective programs.

SHAPE

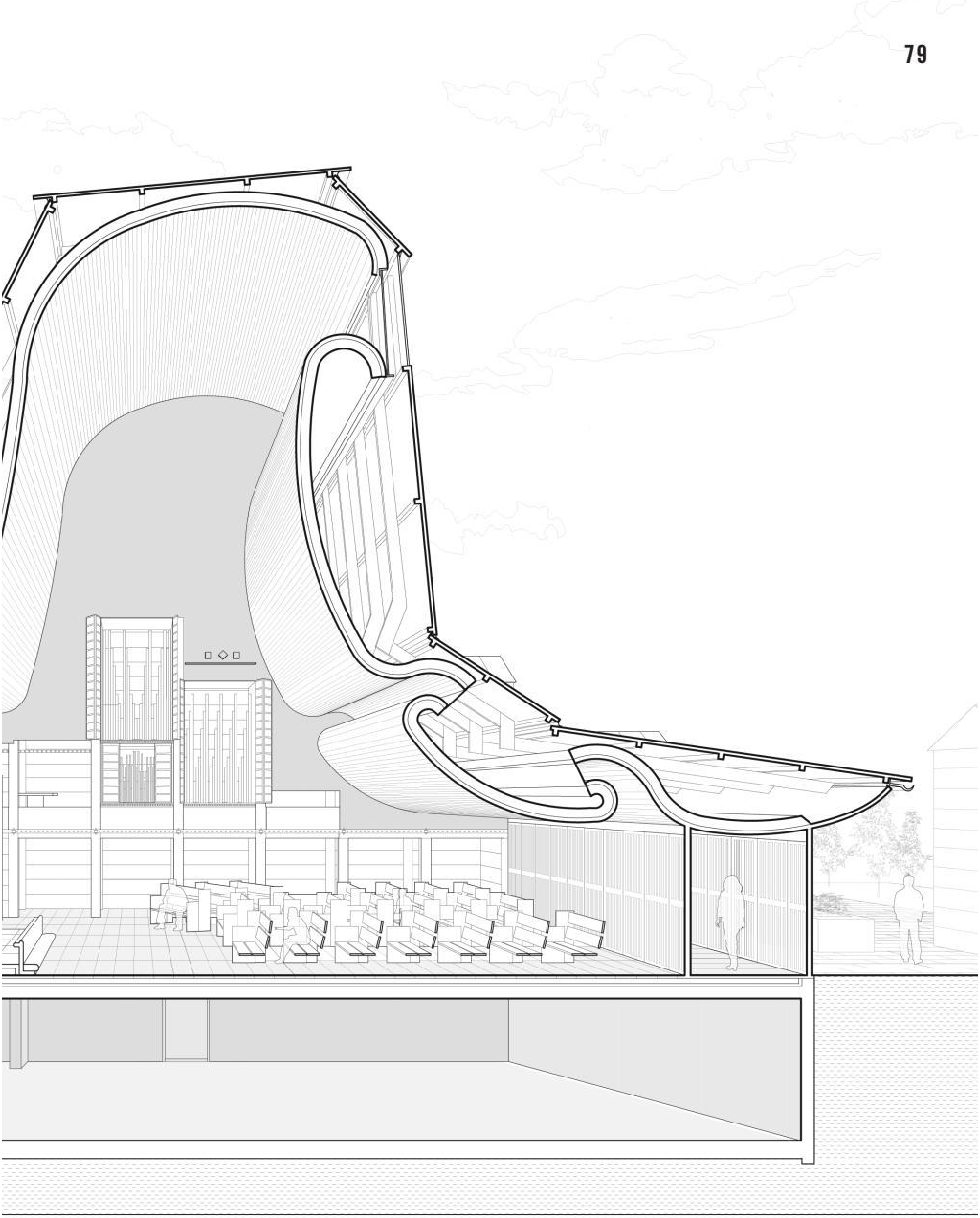


Shape



Bagsværd Church | Copenhagen, Denmark

In plan, the chapel of the Church at Bagsværd is the central space in a rectangular collection of rooms and courtyards, which are framed by perimeter aisles used for circulation throughout the church. Natural light enters primarily through a large skylight located between the two uppermost folds of the curved ceiling, as well as through the glass ceilings of the perimeter aisles. The surface of this ceiling, which is at its lowest above the entry, compressing space over the congregation, vaults skyward toward the altar and accentuates lines of sight beyond the sacristy. A sequence of



Jørn Utzon | 1976

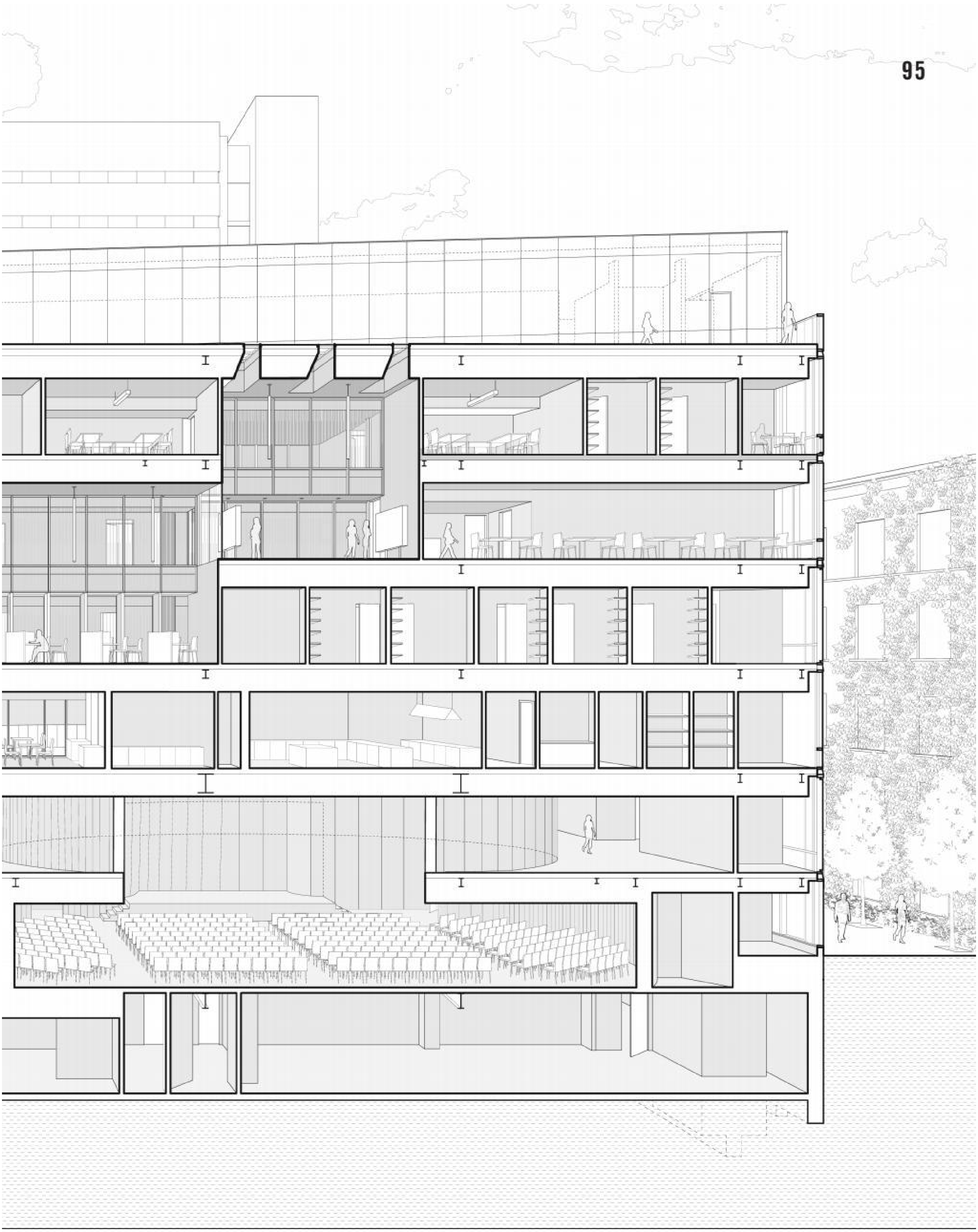
connected arcs evoking layers of clouds forms the sectional geometry of the ceiling. The ceiling is composed of thin board-formed concrete shells, which span 63 ft 8 in (19.4 m) between the two perimeter aisles and support the external metal roof. The structural relationship between the ceiling and roof inverts the typical hierarchy, in which interior surfaces are supported by exterior structure. In this shaped section, the voluminous quality of the interior stands in extreme contrast to the flat surfaces of the exterior massing.

Shear induces a rift or cut parallel to either the horizontal or vertical axis of section. This type of section is particularly effective at inducing optical, thermal, or acoustic connections within an extruded or stacked section without significantly compromising the tectonic efficiencies of repetition upon which those types are based.

SHEAR

Barnard College Diana Center | New York, New York, USA

Situated parallel to Broadway, this arts center encompasses studios, classrooms, offices, exhibition galleries, a black-box theater, a cafe, a dining room, and a five-hundred-seat circular performance space. Four double-height spaces are stacked diagonally, producing a visually continuous void through the center of the building. This void is registered on the east facade (facing Broadway) through the articulation of custom-fritted glass panels. Separated by clear glass for acoustic reasons and fire mitigation, these volumes each contain a distinct social program and collectively allow



Weiss/Manfredi | 2010

visual links throughout the building as well as to the adjacent campus lawn. Academic programs are distributed around the oblique void, with the largest space—a circular performance hall—located under the horizontal shear. On the side facing west, circulation extends into glass volumes that cantilever outside the building's footprint. This section combines the spatial and optical effects of a hole section with the cumulative consequence of a horizontal shear.

Holes are a pragmatic and frequently used means to produce a section, and range in scale and quantity from a single small opening between two floors to multiple large atria organizing whole buildings. Holes exchange lost floor area for benefits in section. They are a spatial commodity that can be tactically deployed for vertical effects.

HOLE

Phillips Exeter Academy Library | Exeter, New Hampshire, USA

At the heart of the Exeter library is a 70-ft-high (21.3 m) atrium framed on all four sides by concrete structure. Capped by a monumental 16-ft-deep (4.9 m) concrete brace-frame and wrapped in a timber-clad clerestory, this central hole or atrium draws light into the middle of the 111-by-111-ft (33.8 by 33.8 m) square library, illuminating the circulation and reference floor below. Multistory circular holes on each side of the atrium reveal the wood-clad balconies of each floor and the stacks behind the balconies, which extend to the outer edges of the building. At the periphery, 210

Louis I. Kahn | 1972

built-in private carrels merge wooden furniture with the exterior brick skin, creating a synthetic wall section in which materials indicate use. The profile of the concrete floor slab integrates lighting fixtures, mechanical systems, balconies, and staircases while accommodating the sizable structural load of the collection. While this holed section animates a twentieth-century library, brick piers produce a crenellated effect along the perimeter ambulatory, echoing the medieval legacy of libraries.

Inclines are a means of continuing a horizontal surface in section by changing the angle of an occupiable horizontal plane, thus rotating the plane into section. Unlike Stacks, Shears and Holes, Inclines are not based on the distinction between plan and section. With Inclines, section does not require the sacrifice of a portion of the plan.

INCLINE

Villa Savoye 118
Le Corbusier

V. C. Morris Gift Shop 120
Frank Lloyd Wright

The Solomon R. Guggenheim Museum 122
Frank Lloyd Wright

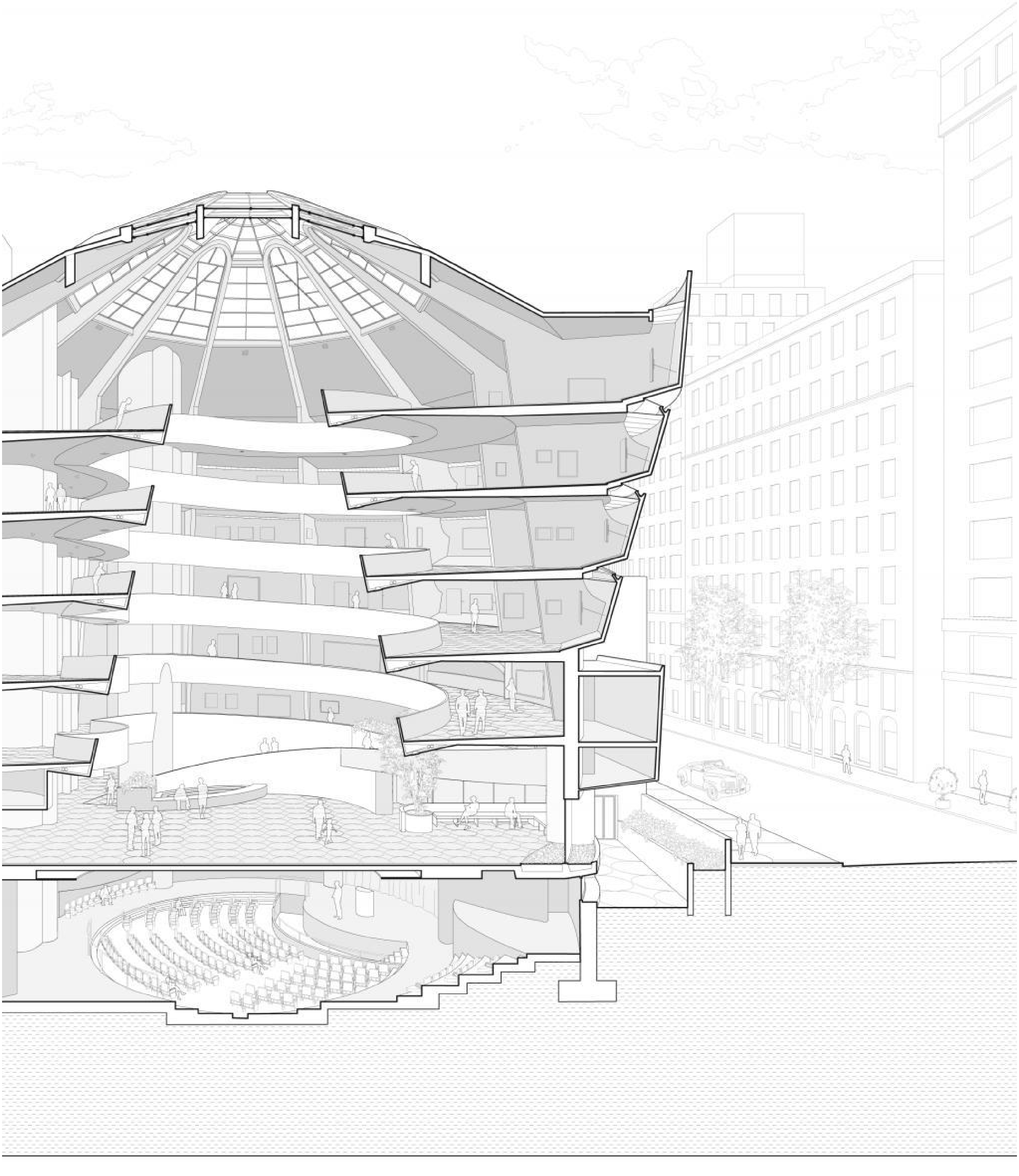
Kunsthal 124
OMA

1111 Lincoln Road 126
Herzog & de Meuron

Moesgaard Museum 128
Henning Larsen Architects

The Solomon R. Guggenheim Museum | New York, New York, USA

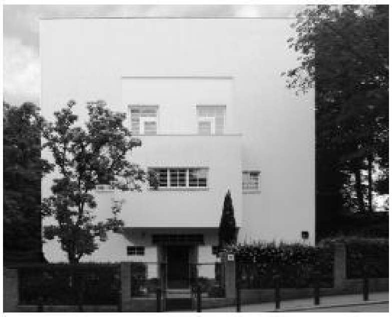
The main gallery of the Guggenheim Museum is an exemplary demonstration of an inclined section defining an entire building. Rising at a 3 percent grade and stretching more than 1/4 mi (0.4 km) in length, the continuous path expands in width as it moves upward, producing a conical void at the center of the museum and an inverted conical form on the exterior. A skylight supported by concrete ribs fills the 92-ft-high (28 m) atrium with daylight, while the continuous perimeter skylight enabled by recessions in the exterior profile was intended to backlight paintings to make them appear to float. The tapered concrete balcony and integral soffit conceal



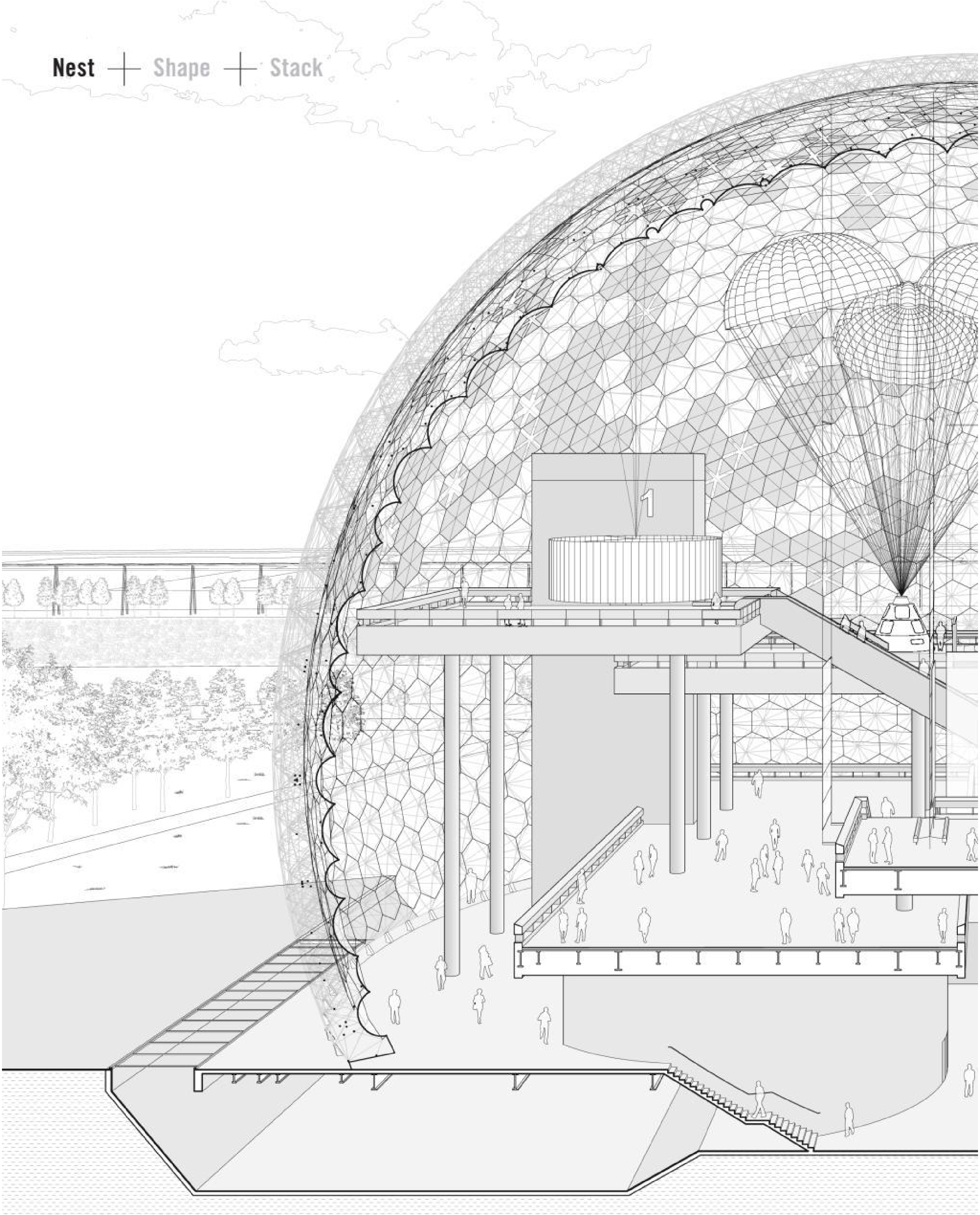
the air supply duct. The primary point of tension between the incline and level floor is at the bottom, where Wright folded the ramp up against itself to form a base. An exterior porte cochere separates the main gallery from the administrative wing. While the administrative wing echoes the circular form of the main gallery, the inclined section is confined to the gallery, as connection among the flat administrative floors is made through a service core, with a small atrium providing limited visible continuity. In the main gallery, the inclined section's physical continuity is complemented by the visual connectivity of the large atrium.

Nests produce sections through interplay or overlap between discrete volumes. While Stack, Shear, Hole, and Incline work primarily with flat plates, a Nest positions three-dimensional figures in specific relationships for sectional consequences. The spatial, structural, or environmental performance of the nest usually exceeds that of the volumes operating in isolation.

NEST

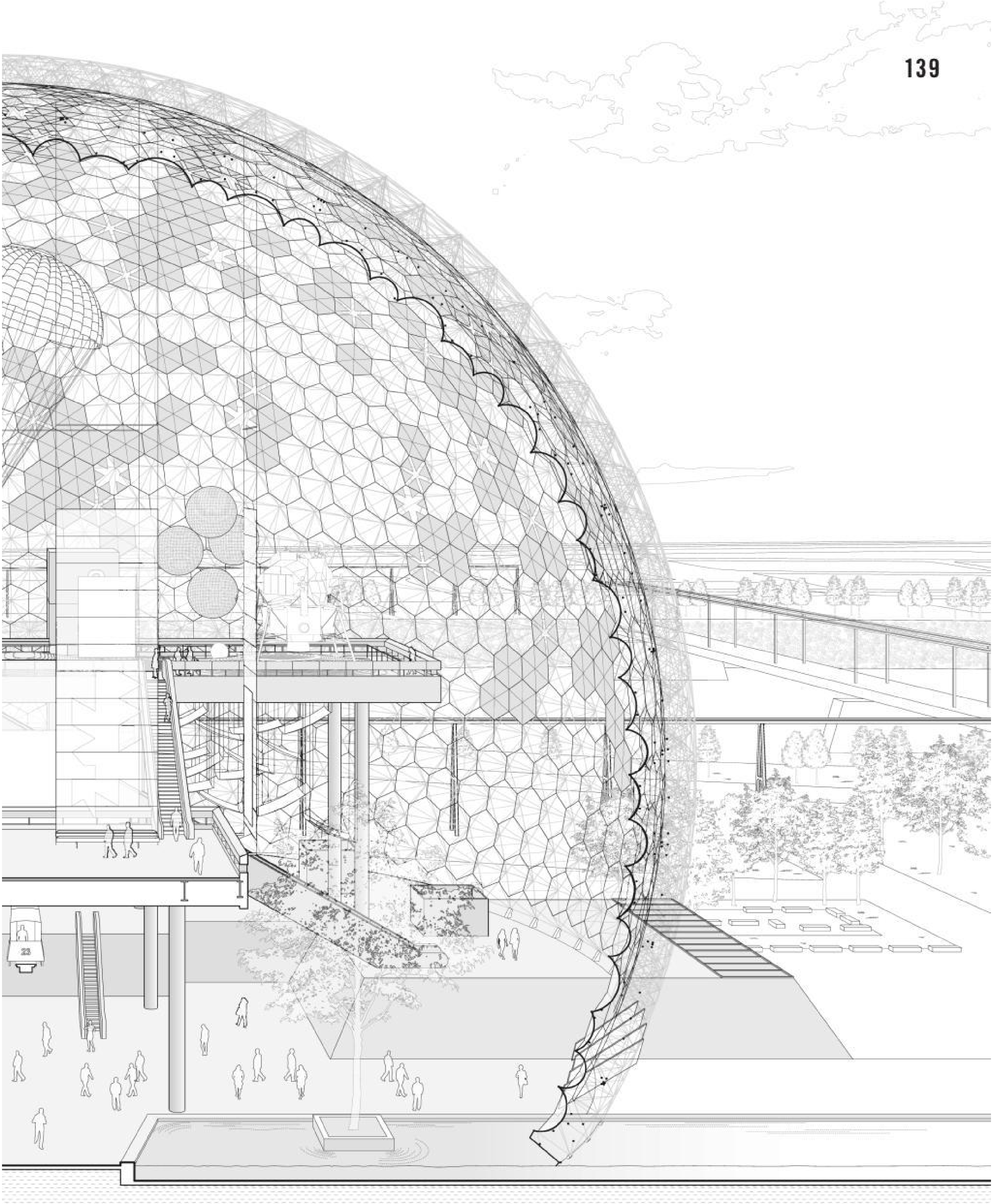



EFFENAAR



United States Pavilion at Expo '67 | Montreal, Canada

This pavilion was commissioned at the height of the Cold War by the United States Information Agency to stand opposite the Soviet Pavilion. The American Pavilion contained a three-hundred-seat theater and multilevel exhibition platforms designed by Cambridge Seven Associates to celebrate the country's cultural and aeronautical achievements. All exhibition spaces were nested inside a geodesic steel-framed dome with a diameter of 250 ft (76.2 m) and a height of 206 ft (62.8 m). A 40-in (101.6 cm) gap separated the outer triangulated surface of the dome from an inner hexagonal surface, which was infilled with 1/4-in-thick (6.4 mm)



transparent acrylic panels. A motorized, self-regulating shading system covered one-third of the panels, working with air-conditioning to create a vast thermal microclimate. Within the interior volume of 6.7 million cu ft (189,722 cu m) were a series of concrete platforms supported by rolled-steel sections and 30-in-diameter (76.2 cm) steel columns. These exhibition trays were accessed via a series of escalators, one of which was 125 ft (38.1 m) long—at the time the longest ever constructed. This unique space was a consequence of the radical difference between the occupiable horizontal platforms and the huge translucent dome.

Extrusion, Stack, Shape, Shear, Hole, Incline, and Nest are primary methods of operating in section. For the sake of clarity, they have been presented as distinct modes, but they rarely operate in isolation. Indeed, buildings exhibiting the most complex and intricate sections contain all manner of combinations and hybrids.

HYBRIDS

Yale Art and Architecture Building | New Haven, Connecticut, USA

Designed and constructed during Paul Rudolph's tenure as chair of the architecture department, the iconic Art and Architecture Building arrays 37 unique floor levels around a central core of open, collective spaces anchored by a series of striated-concrete towers. The section, which combines stacked, sheared, and nested forms punctuated by holes, produces a variety of visual and spatial overlaps and intersections, most notably among the expansive central pinup spaces and galleries and the more peripheral and compressed studios and offices. Staggered levels, bridges, and offsets multiply the interactions among

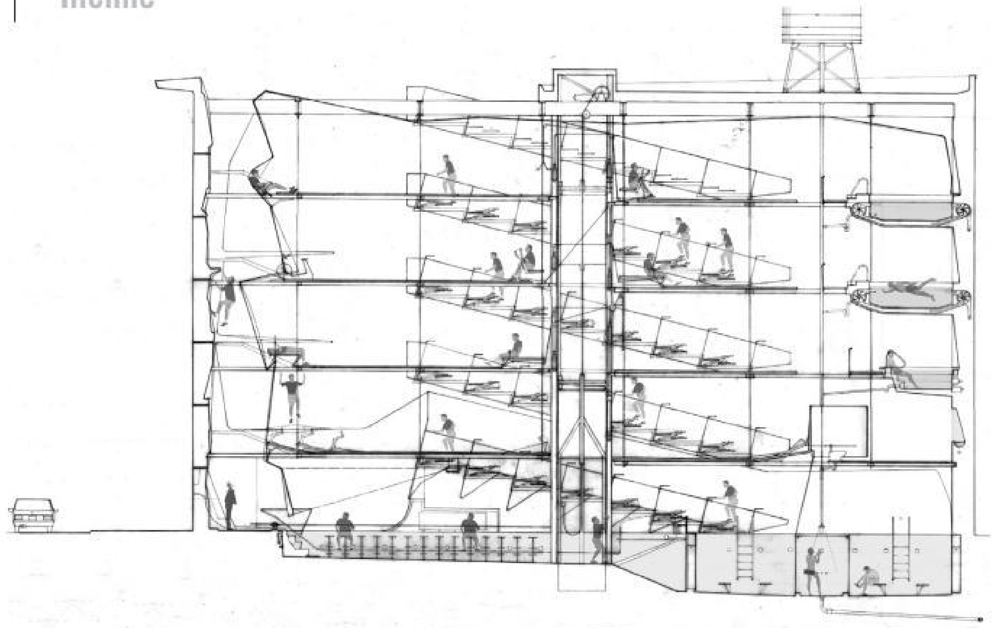
Paul Rudolph | 1963

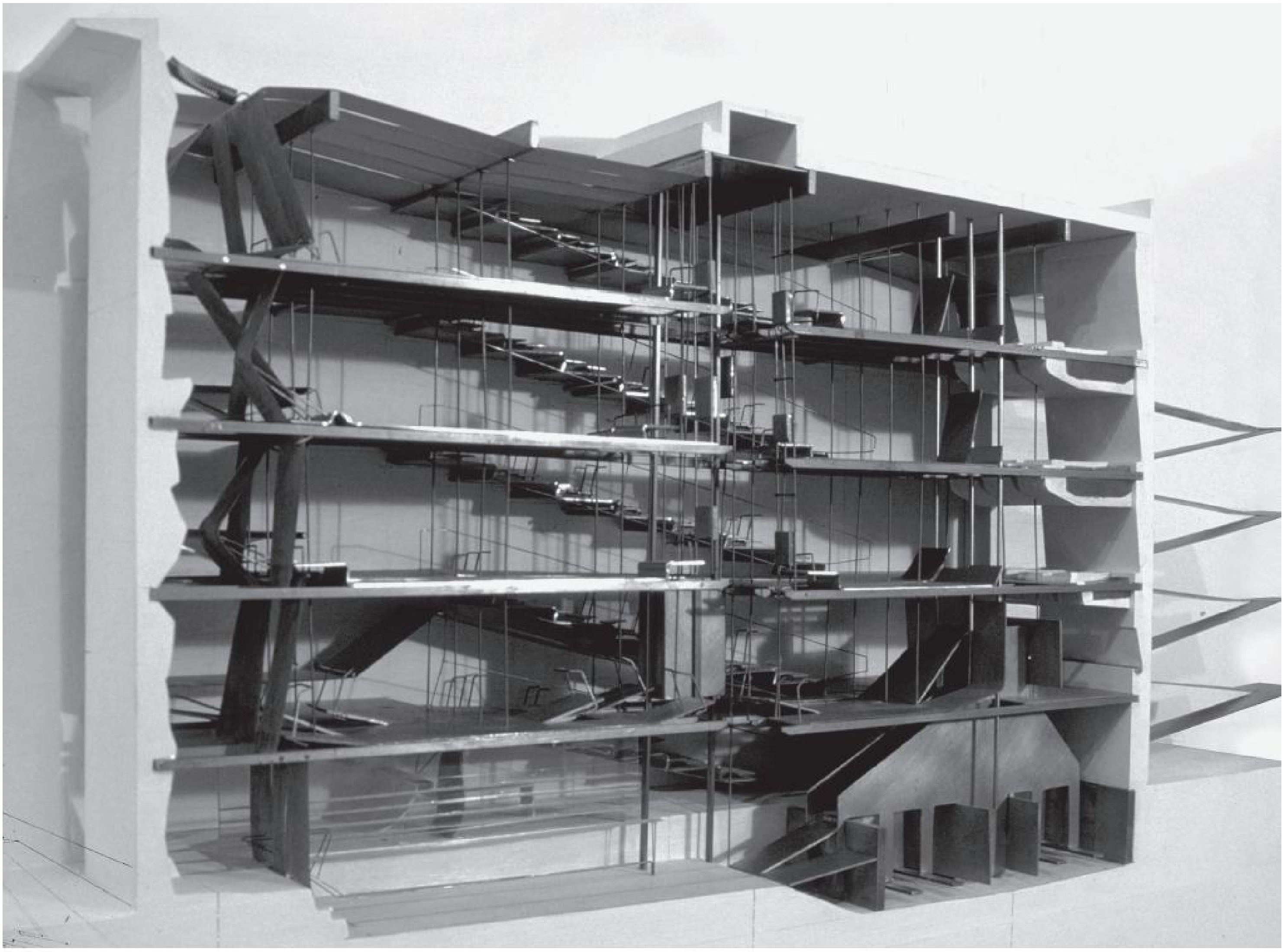
adjacent spaces while allowing for campus views through large, steel-framed glass windows from deep within the interior. Massive piers of heavily textured, bush-hammered concrete provide structural support for horizontal platforms, house mechanical services, and contain vertical circulation. At the upper levels, the play of horizontal planes gives way to enclosed tubelike forms that bridge the vertical masses to enclose the spaces below. Between these volumes a collection of skylights and clerestories admit daylight, enlivening the varied spaces of this complex combination of section types.

In the work of LTL Architects, we foreground the section not only as a representational technique, ripe with the ability to demonstrate structure, interior space, and form, but also as a key locus of design invention. If the plan still absorbs much architectural interest, serving as a means to control function, organization, and movement, we argue that the section is the critical means for engaging social, environmental, and material

LTL IN SECTION

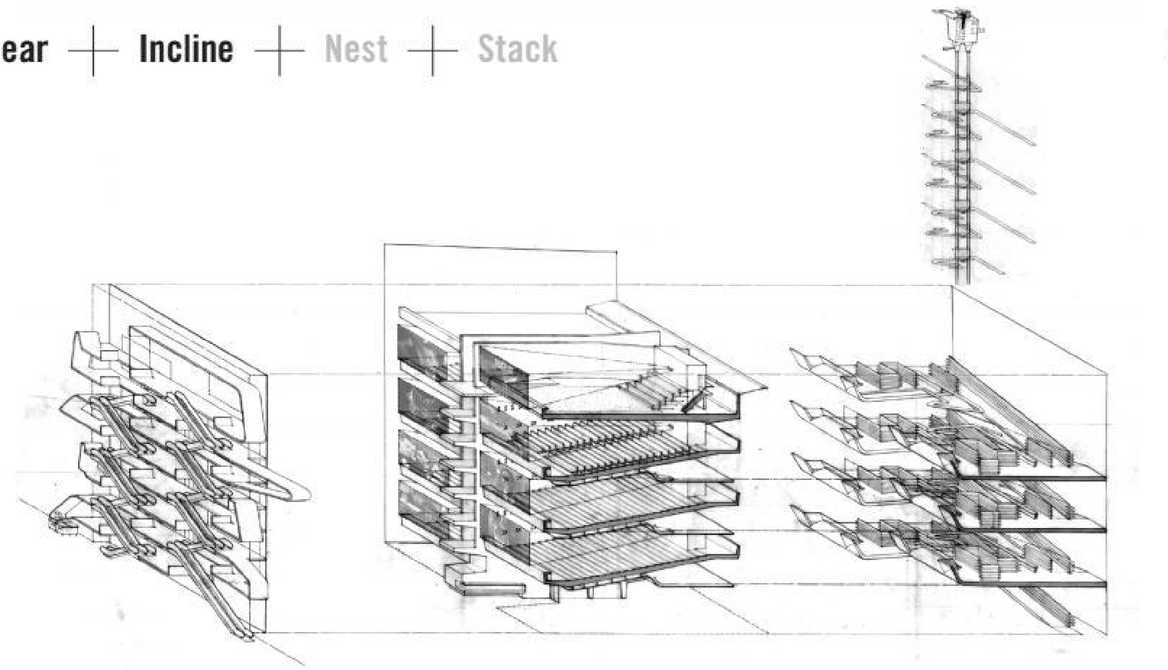
questions. Designing and thinking through section establishes a relationship among architectural form, interior space, and site, where the consequences of scale are tangible and visceral. As a cut into that which cannot be seen, the section embodies and reveals territories for architectural experimentation and exploration.

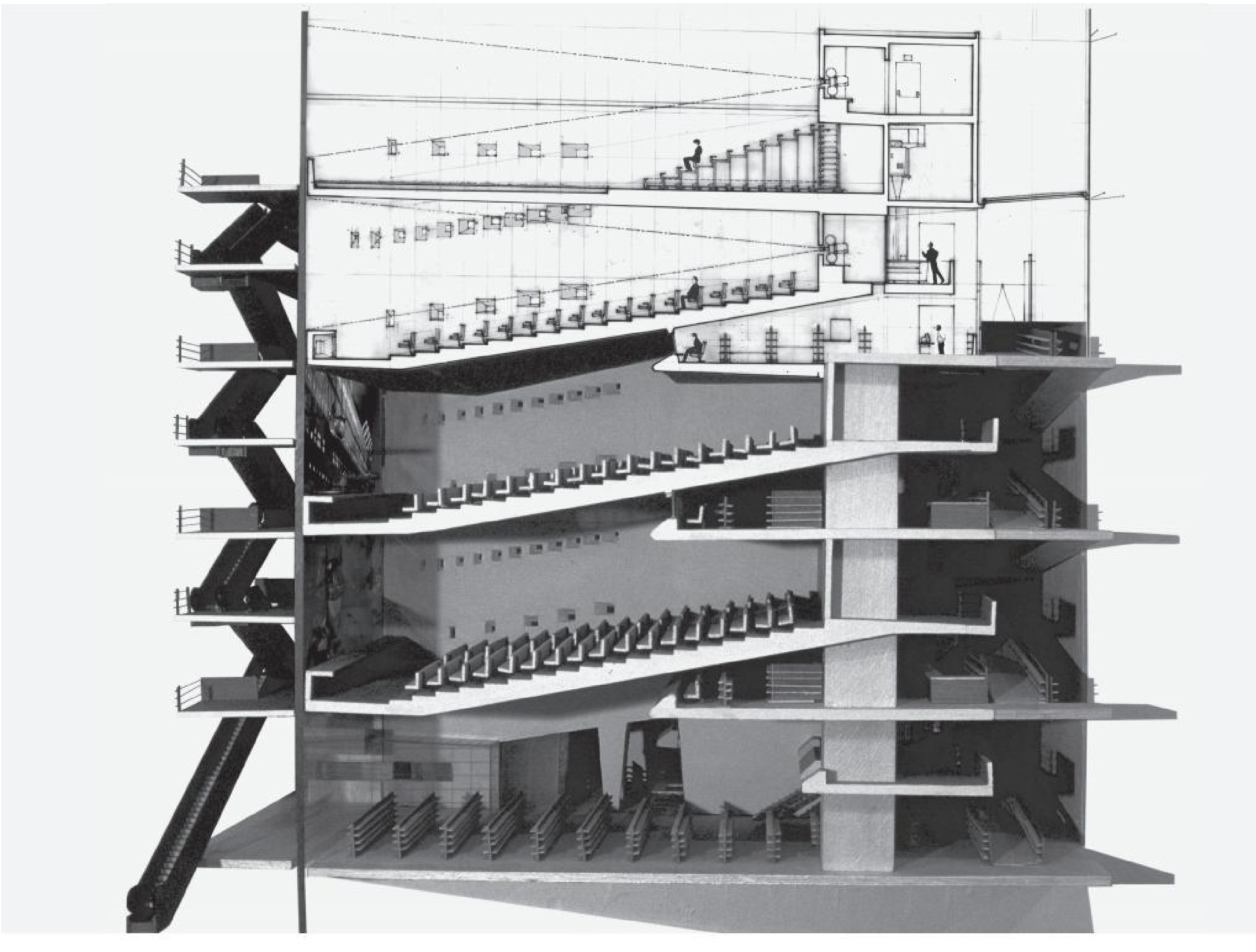




Sport Bars | New York, New York | 1997

This project collapses the distinctions among machines, bodies, and building in an urban health club and sports bar by linking discrete activities in section. Individual exercise machines are sutured into corresponding architectonic systems: the rock-climbing wall is the facade; weather membrane doubles as resistance membrane; elevator counterweights align with weight machines; plumbing lines couple swimming and bathing. By organizing these systems around three vertical shafts or holes that extend into the sports bar below, we offered sedentary patrons views of both televised sporting events and the activities in the gym above.

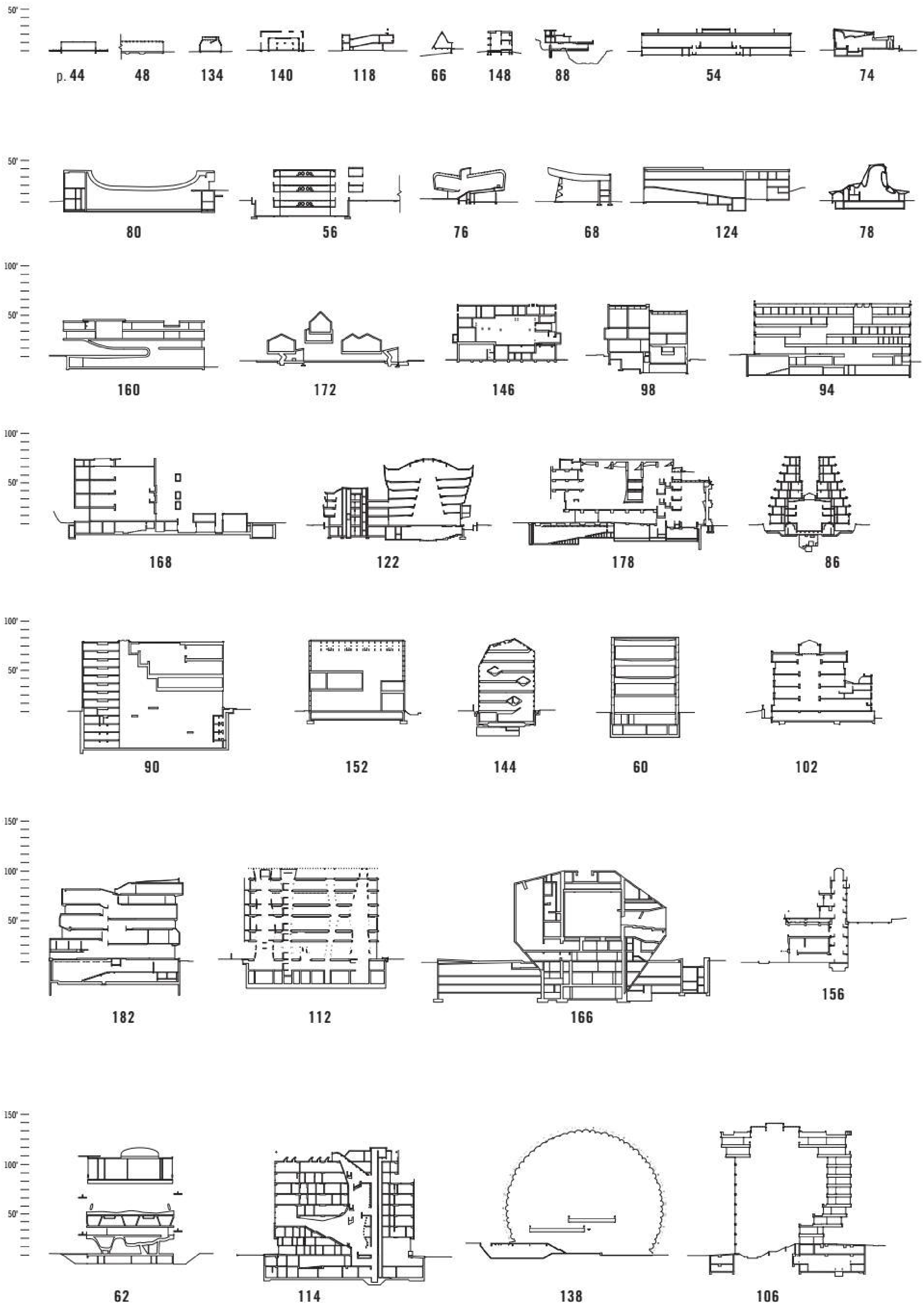


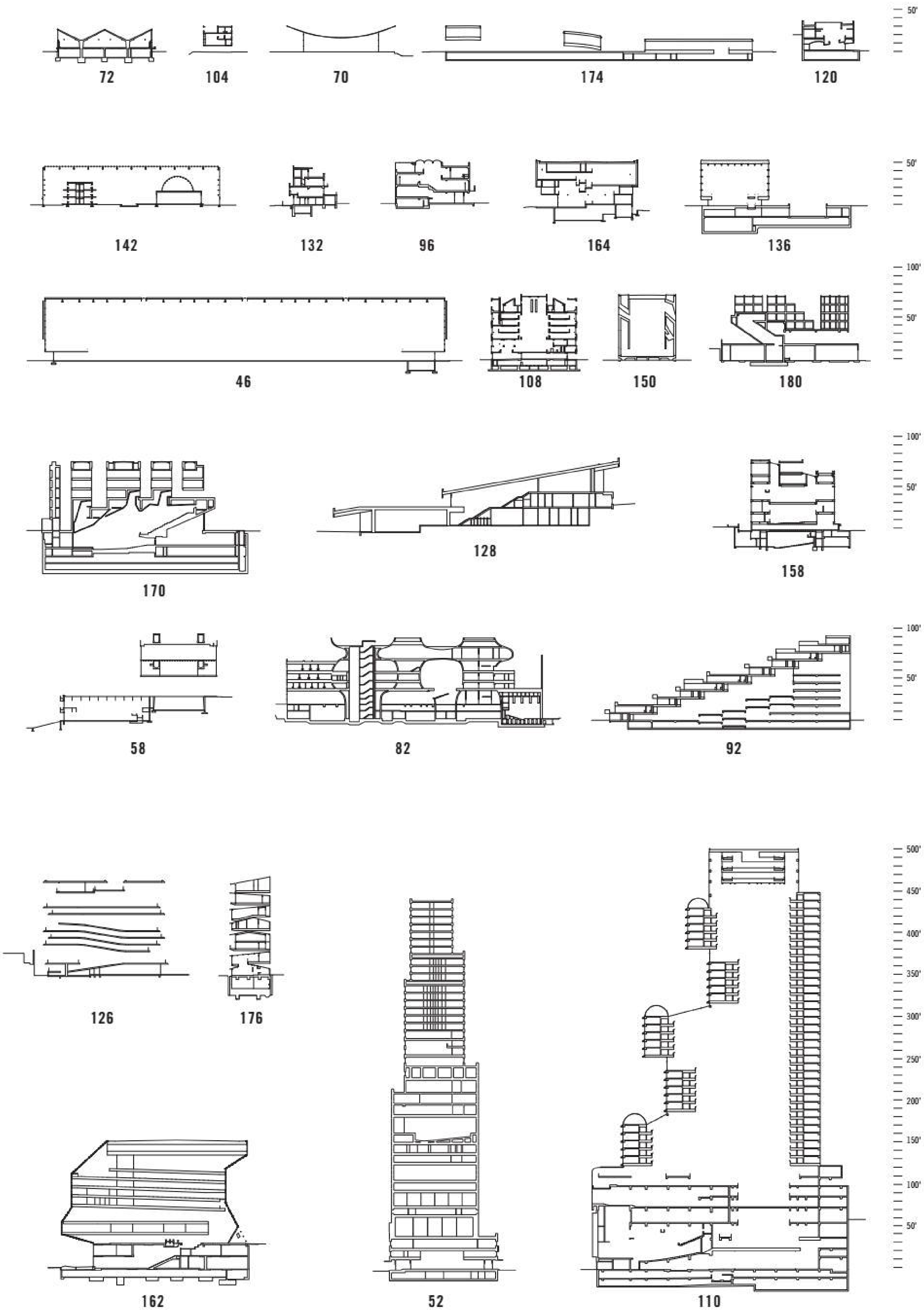


Video Filmplex | New York, New York | 1997

In this speculative project that examines the culture of filmgoing, we highlighted sectional operations in nesting a series of shaped spaces, organized on inclines to enable unusual adjacencies between disparate programs. A video store occupies the interstitial space formed by the sloping of the theater floors. Restrooms are sandwiched between two stacks of theaters, allowing films to be watched even during bathroom breaks. The two stacks are sheared vertically, allowing us to design the facade as a continuous public space, linking the two sides of the Video Filmplex into one complex.

Sections by Height




72
104
70
174
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50'
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164
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158
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50'
58
82
92
100'
50'
126
176
162
52
110
500'
450'
400'
350'
300'
250'
200'
150'
100'
50'