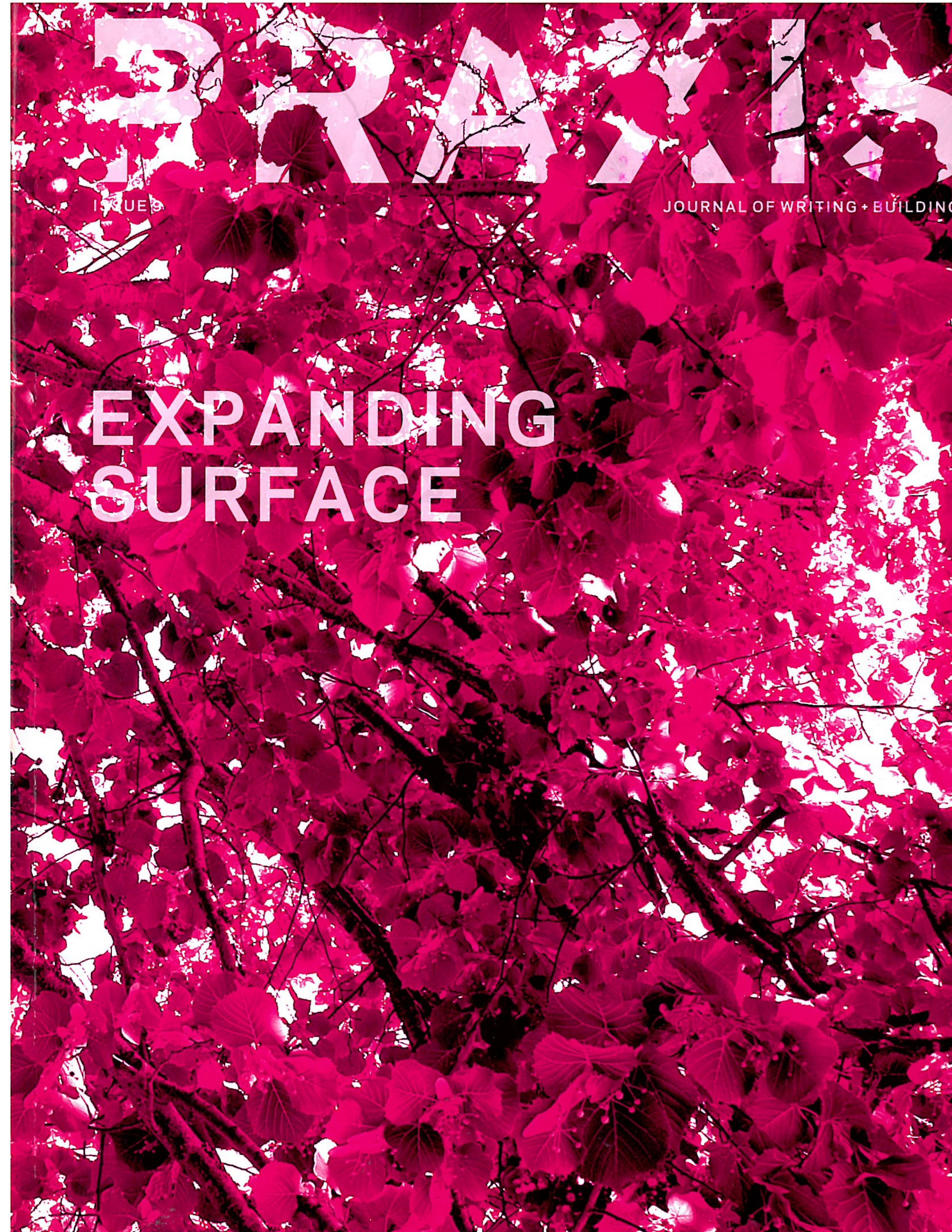
PRAXIS

ISSUE 9

JOURNAL OF WRITING + BUILDING

EXPANDING SURFACE



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PO Box 3633
Columbus OH 43210-0633
t 614.292.8349
f 614.292.7106

www.praxisjournal.net
mail@praxisjournal.net

ISSN 1526-2065
ISBN 0-9703140-9-4
Printed in the United States
by Garrity Printing

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PRAXIS 9 **EXPANDING SURFACE**

Translations: deYoung Museum and the Walker Art Center byHerzog & de Meuron

1

1

1: The tree canopy surrounding the deYoung site. A series of images, including the one above, was used to generate potential patterns of perforation and embossing for the copper panel skin.

1: Images of cracked ice blocks, including above and to right on the following page, were used as references during material investigations for the Walker Museum's aluminum mesh skin.

In 1999, Herzog and de Meuron were awarded the commission to design the new deYoung Museum in San Francisco's Golden Gate Park. Inspired in part by the project's bucolic site, the architects chose to explore a broad definition of the 'natural' as an approach to the design of the project in particular the façade, as the surface that mediates between the park and the institution. Beyond the desire for a relationship with the site, Herzog and de Meuron's pursuit of the natural was related to the deYoung's extensive collection of African and Oceanic art. The initial design proposals literally immersed the art in the site in a series of pavilions surrounded by gardens. Although the pavilion plan, as well as other initial considerations, were eventually abandoned, an interest in the natural and natural processes were primary design considerations from the outset

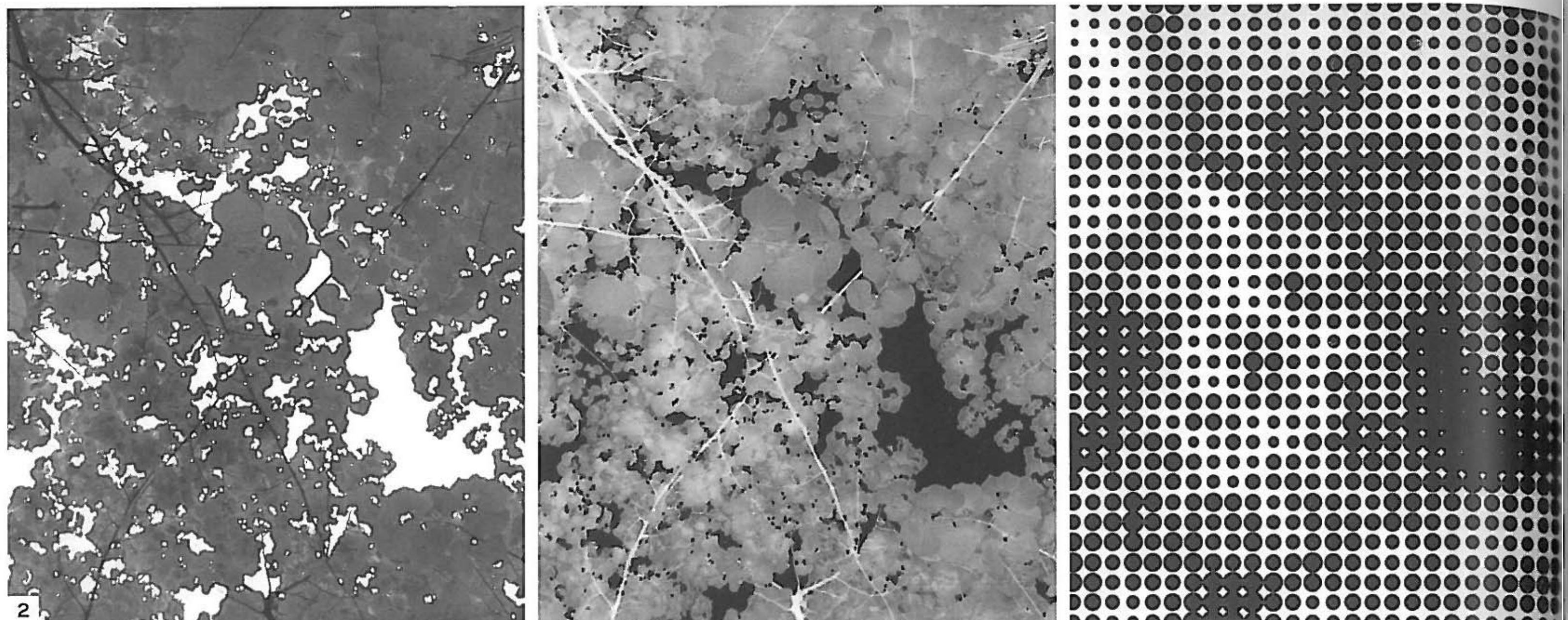
Notions of the natural have clear ramifications for material selection. Herzog and de Meuron, however, also sought to design an effect based on a natural phenomenon—the dappled light that filters through a canopy of trees. Having quickly chosen copper as the façade material (because it transforms over time with exposure to the elements), two main threads of design investigation for the building skin ensued. First,a series of material explorations tested the deformation of the copper through various perforation and embossing geometries. Then, for more than a year, Herzog and de Meuron's office—in collaboration with the Kansas City-based metal fabrication company A. Zahner and associate architects Fong&Chan of San Francisco—tested various options to refine the pattern and density of the deformations to achieve the desired effect. They began with a photograph of a tree canopy, digitally manipulated it to abstract the image into a pattern, and then mapped the pattern onto the copper panels as perforations and dimples. The articulation of the surface became a way to incorporate the natural by reproducing the effect of the tree canopy's light and shadow.

The images presented here, in roughly chronological order, tell the story of the processes behind the design, fabrication, and installation of the deYoung Museum's copper skin. What unfolds is a process of translation through which an initial concept, first captured in a two dimensional image, becomes a 3-dimensional building surface.

Conceptual design for the addition to the Walker Museum in Minneapolis also began in 1999, almost simultaneously with the deYoung project. Herzog and de Meuron were interested in designing an addition that would visually contrast with the solidity of the existing brick building. Their goal was to create the appearance of a thin second skin that wrapped the program in a transparent, light, and reflective surface. John Cook, project architect from the Minneapolis office of HGA (associate architects for the project), recalls how concept design discussions repeatedly revolved around the qualities and beauty of ice. Early in the design process, an employee of Herzog and de Meuron took up temporary residence in the HGA office for the sole purpose of exploring the properties of ice: building a series of wood frames in the office backyard, filling them with water, and waiting for them to freeze. He photographed the solid ice blocks, and then smashed them into pieces in order to document the resulting fractures and their effects on light transmittance and reflectance.

This photographic documentation instigated two threads of further investigation that ultimately informed the design of the Walker's skin. The desire to create the illusion of a thin, translucent wrapper for the building volume led to morphological studies of the relationship between cuts made in a folded surface and the resultant openings in the unfolded surface. Both folds and openings in the final building skin directly correspond to the formal language developed in these studies. In addition, the ice images were used as references during a lengthy investigation dedicated to finding a material that embodied its visual properties, leading to the selection of aluminum mesh.

The images presented herein reveal a roughly chronological look at the processes behind the design, fabrication, and installation of the Walker Museum's aluminum mesh skin. What unfolds is a process of translation through which an initial concept—first explored in the ice block experiments and folded paper models—becomes a 3-dimensional building surface. **—ALAYNA FRASER**



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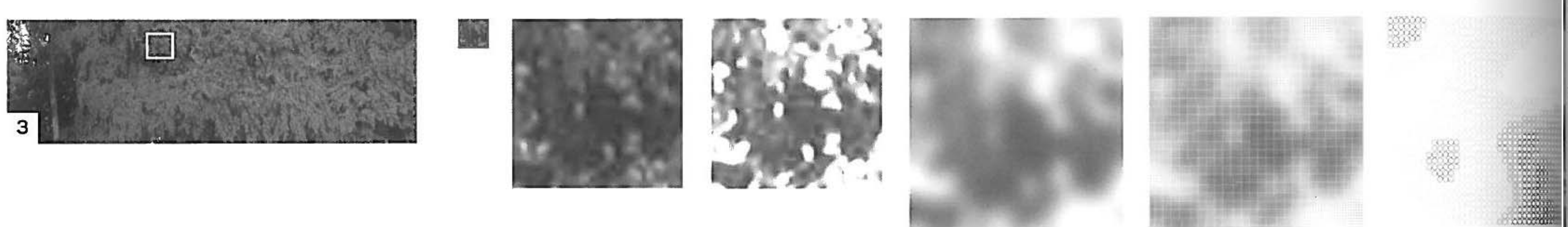

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STEP 1

Image
scale image size 7.14x
change resolution to 300 pix/inch

STEP 2

Contrast
set contrast to +50%
set brightness to +55%

STEP 3

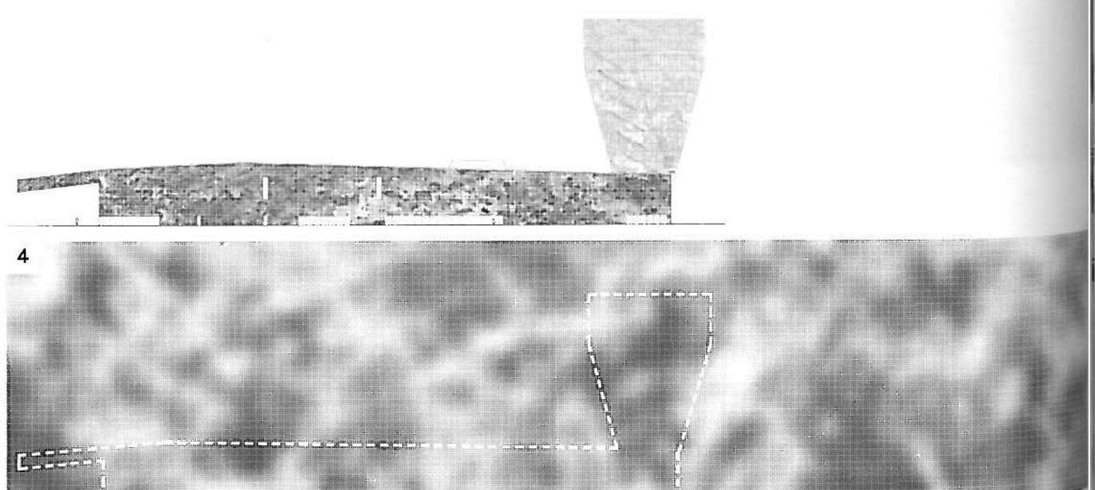
Blur
blur with gaussian blur , radius 30 pixels
scale image 125% (@ 300 pixels/inch)

STEP 4

Raster
use color raster filter (8 pixels - 1 dot)
Phase 1: 90°, Phase 2: 90°
Phase 3: 90°, Phase 4. 90°

STEP 5

Emboss
Translate raster image in AutoCAD file
(by a routine)
Dense areas become darker circles.



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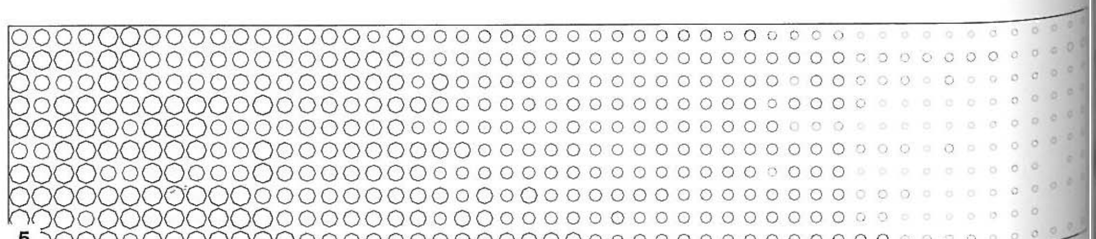

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2: This series of three images is a small sampling of the numerous techniques explored in order to translate the tree canopy photographs into a pattern which would determine the location, shape, size, and density of deformations in the copper panels. Eventually these studies in photo manipulation resulted in a rigorous, ordered, and formulized set of steps that produced the desired outcome.

3: These images demonstrate the five image translation steps finally used. The process begins by taking a selected portion of the original tree canopy photo and performing a set of relatively simple Photoshop manipulations. These steps include: (1) scaling the image size 7.14x and changing the resolution to 300 pixels/inch, (2) setting image contrast to +50%, brightness to +55%, (3) applying a gaussian blur filter, (4) applying a color raster filter, 8 pixels = 1 dot, (5) and translating the raster image into an AutoCAD file, using a routine, which turns dark areas into dense circles. This final step in the image transformation process was completed by an algorithmically based computer program that first translated the density of light and dark pixels in an image into a matrix—a grid with equal spacing of dots—with varying radiuses. The program then further transformed the matrix into a pattern of convex and concave indentations or perforations. The radius of perforations and depth of embossing depend on the initial density of dark pixels in the image: (the darker a portion of the image, due to shadow or branches, the greater the indentation depth and/or perforation radius). Indentations were assigned four levels of depth to communicate these differences in light and darkness values while perforations were assigned eight radius sizes. During this process, an employee of A.Zahner was asked to develop a proprietary piece of software, now called "ZAPLA" (Zahner Automated Panel Layout Algorithm). The program was designed specifically for the above mentioned process. Over the course of a year this software was further refined such that the entire image translation process was largely automated. Herzog and de Meuron manipulated the relative contrast of 'input' images and the program output AutoCAD files that, without further translations, were read by A.Zahner's fabrication equipment. These output files included all necessary fabrication information to make each panel. Due to the complexity of the files, the architects were able to view the results but never actually manipulated them.

4: The final result of the translation process was the production of a pattern for an entire elevation of the building that was then broken down into individual panels.

5: Sample panel, 12'x2'-5".

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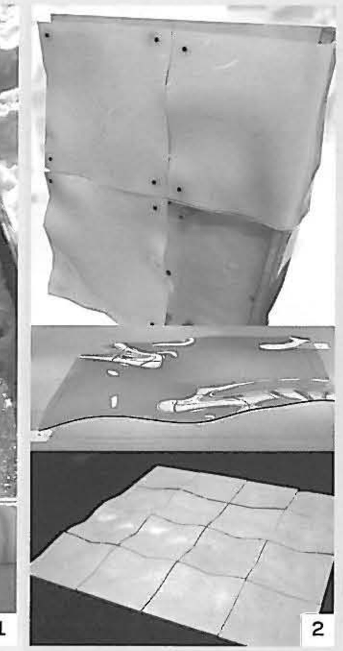

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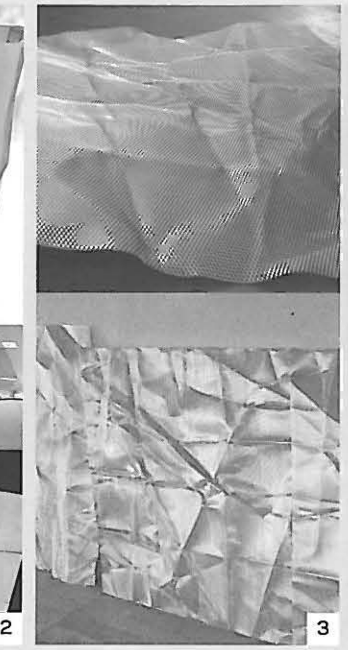

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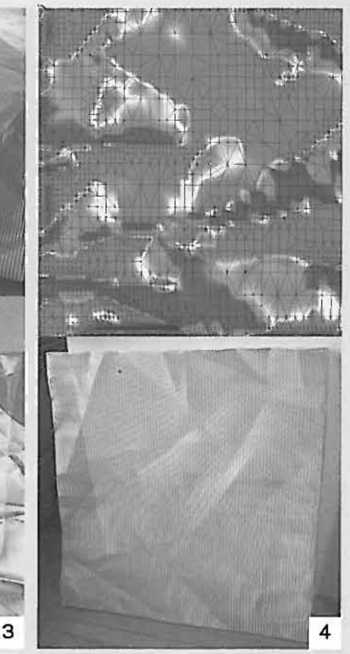

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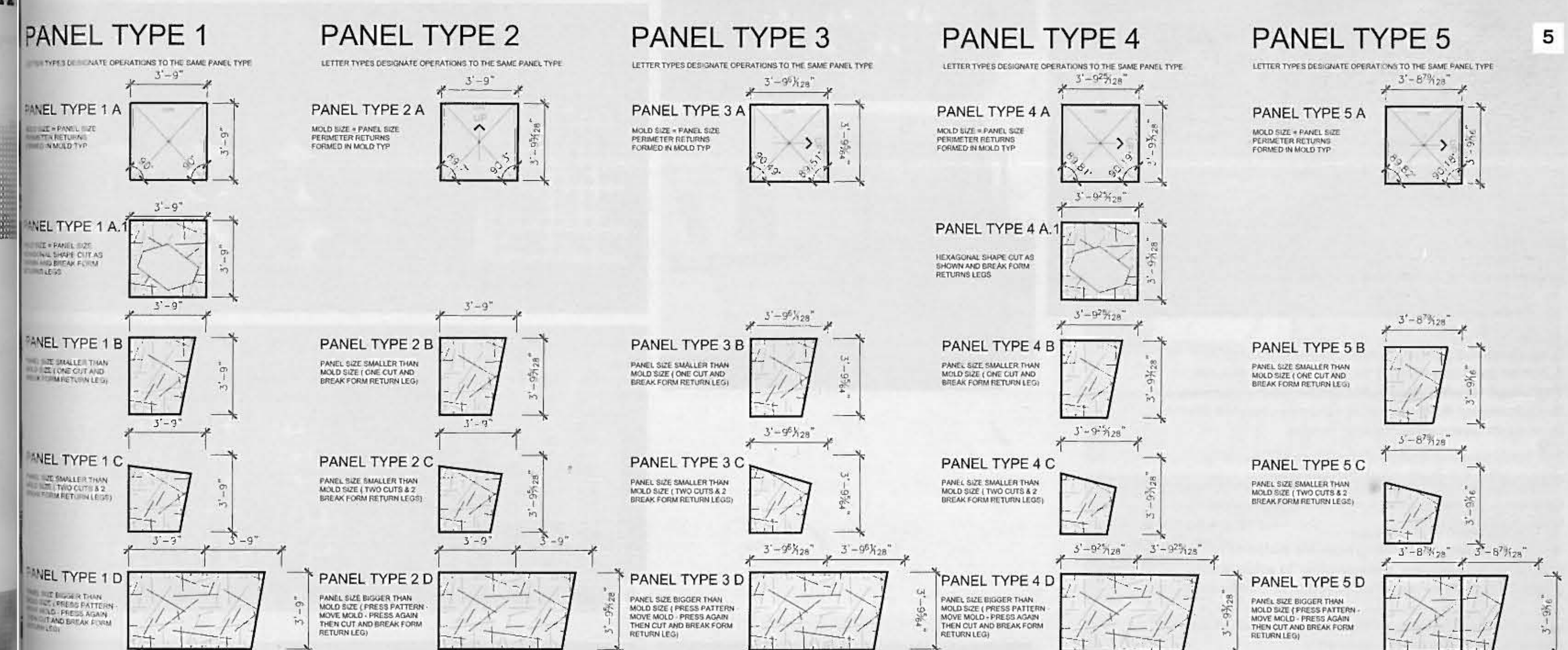

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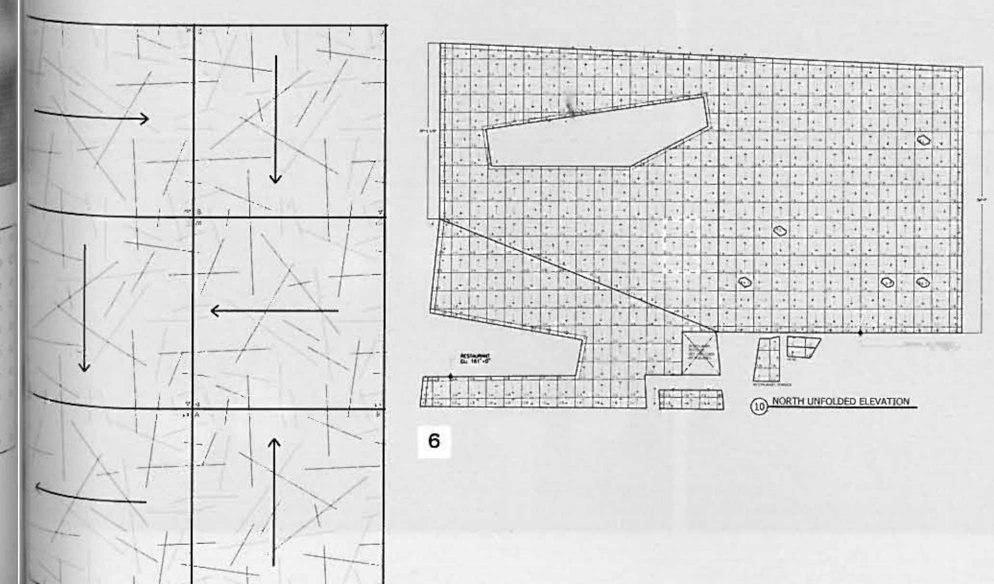

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2: Early material studies for the Walker skin began with an exploration of slumped glass and slumped polycarbonate. These materials were thoroughly tested and ultimately rejected on the basis of both cost concerns and unsatisfactory effects (it proved too difficult to control the reflective and transparent qualities of the final product after slumping). After discarding these options, there was a shift to studying more solid materials, including copper, teflon coated fiberglass, and even stucco. None of these could be stretched or formed to create the desired shape and effect.

3: After exhausting other options, a lengthy exploration into various metals, mesh weaves and densities, and folding patterns ensued. The budget could only support the fabrication of a single panel designed so that when tiled would create the illusion of a varied surface. A single wooden frame, with identical edge profiles, was created to test a variety of folding patterns that, when abutted, would create continuous folds across multiple panels, regardless of the panel orientation.

4 Top: Once an acceptable study panel had been created, HGA hired Permastalisa to first digitize and then rationalize the geometry through manipulation of the panel surface in Catia. Bottom: Final test panel created based on Catia model refinements.

5: Design of the Walker skin worked outward in scale from the pattern and shape of a single panel to the overall pattern. Five panel types evolved from the single base panel, emerging in response to localized conditions on the building surface. The five types were first organized according to variations in initial panel dimensions (all roughly 3'-9") followed by a further categorization according to increasing degree and complexity of modification required from the original panel (extra cuts, edge folds or both). Ultimately, every panel was fabricated from the same mold.

6: Arrows drawn on each panel in elevation indicate the desired orientation for a typical panel array on the building surface. Panel orientation was determined by software that arrayed the four panel orientations randomly across all unfolded elevation surfaces.


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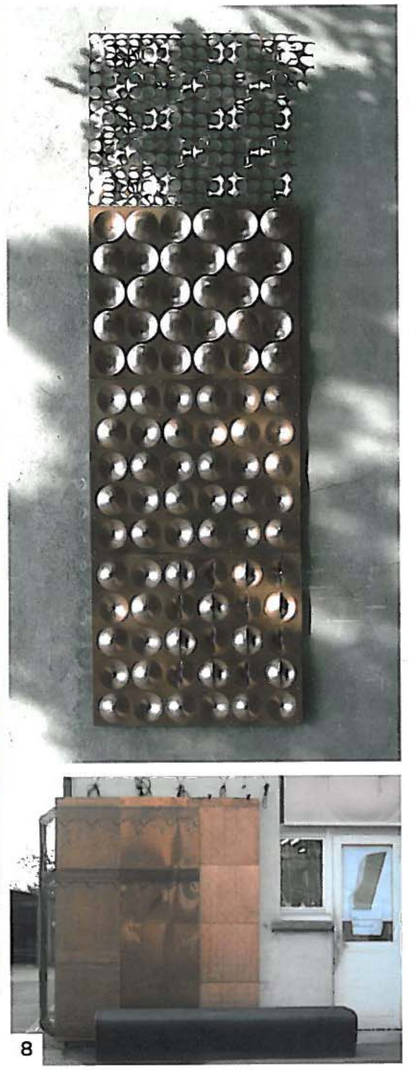
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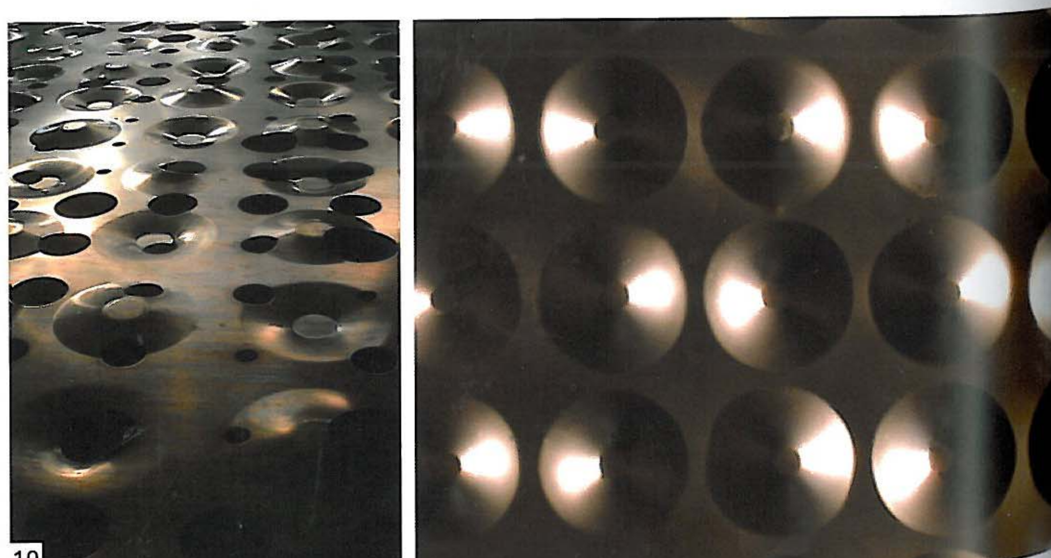
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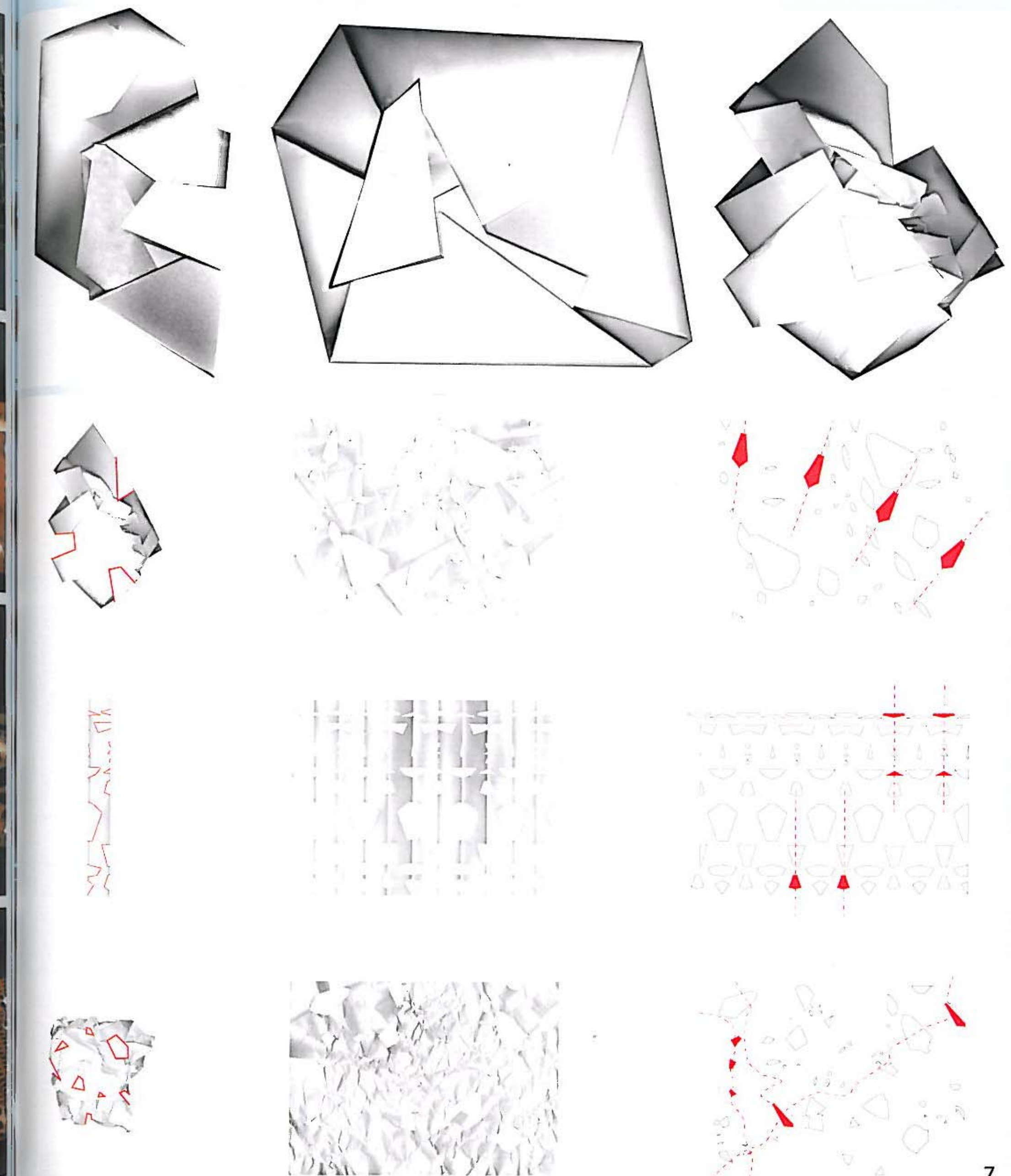
6: An extensive series of mock-ups were created by A.Zahner for design review by Herzog and de Meuron. This image shows a mock-up of panels for the overhang being reviewed for the resultant shadow patterns cast by multiple layers of perforated copper.

7: A study panel of final perforation and embossing shapes after fabrication in A.Zahner's shop.

8: Large scale study panels outside Herzog and de Meuron's Basel office.

9: Early study models testing possible methods for deforming a flat copper panel in order to achieve the desired effect. A variety of perforation and embossing combinations were explored, comparing the change in effect that resulted from different pattern densities, radiuses, and deformation geometry.

10: Study panels of final perforation and embossing patterns in combination on a single panel.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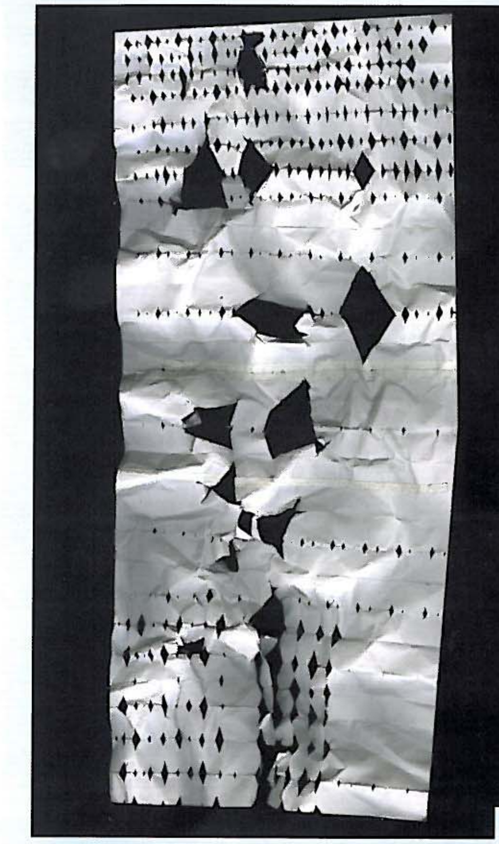
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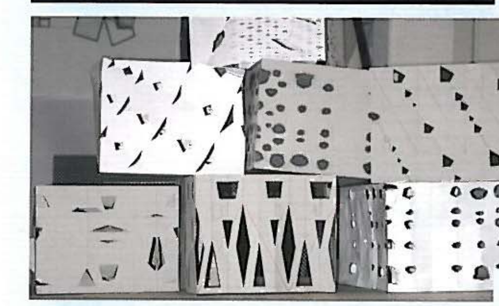
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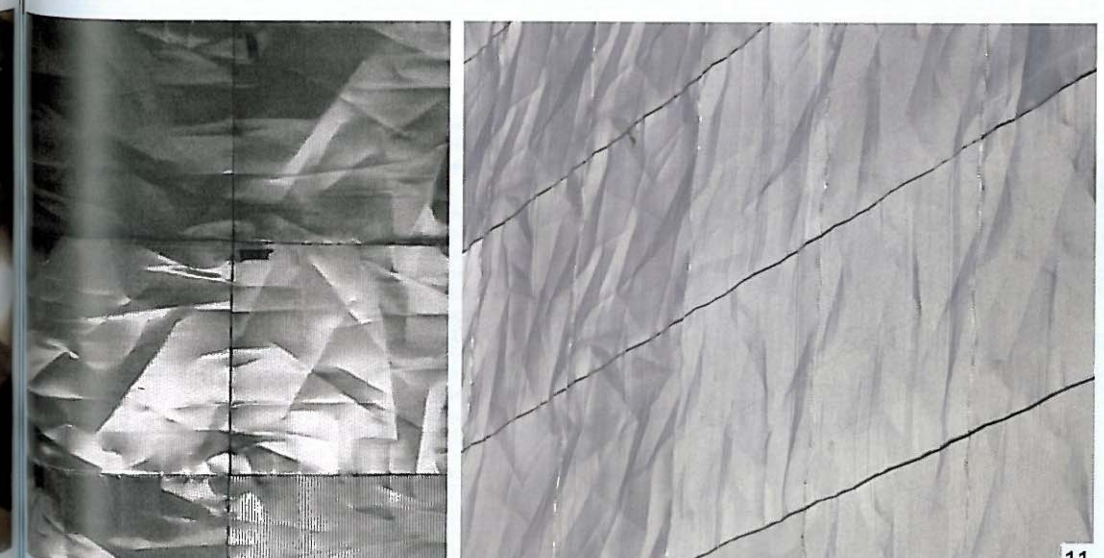
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7 Top: Three samples of folded paper study models used to investigate homologous relationships between cuts made in a folded surface and the resultant openings in the unfolded surface.

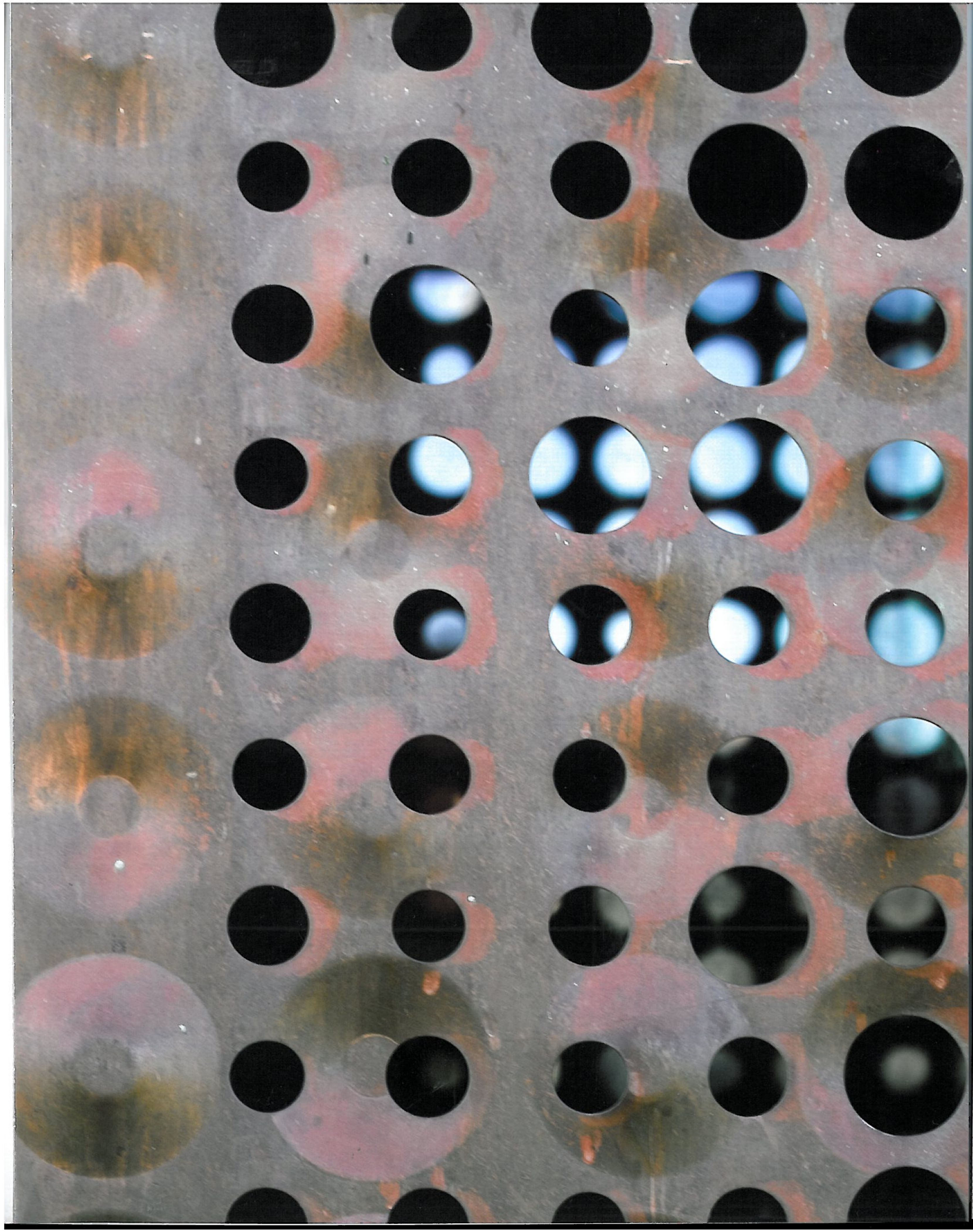
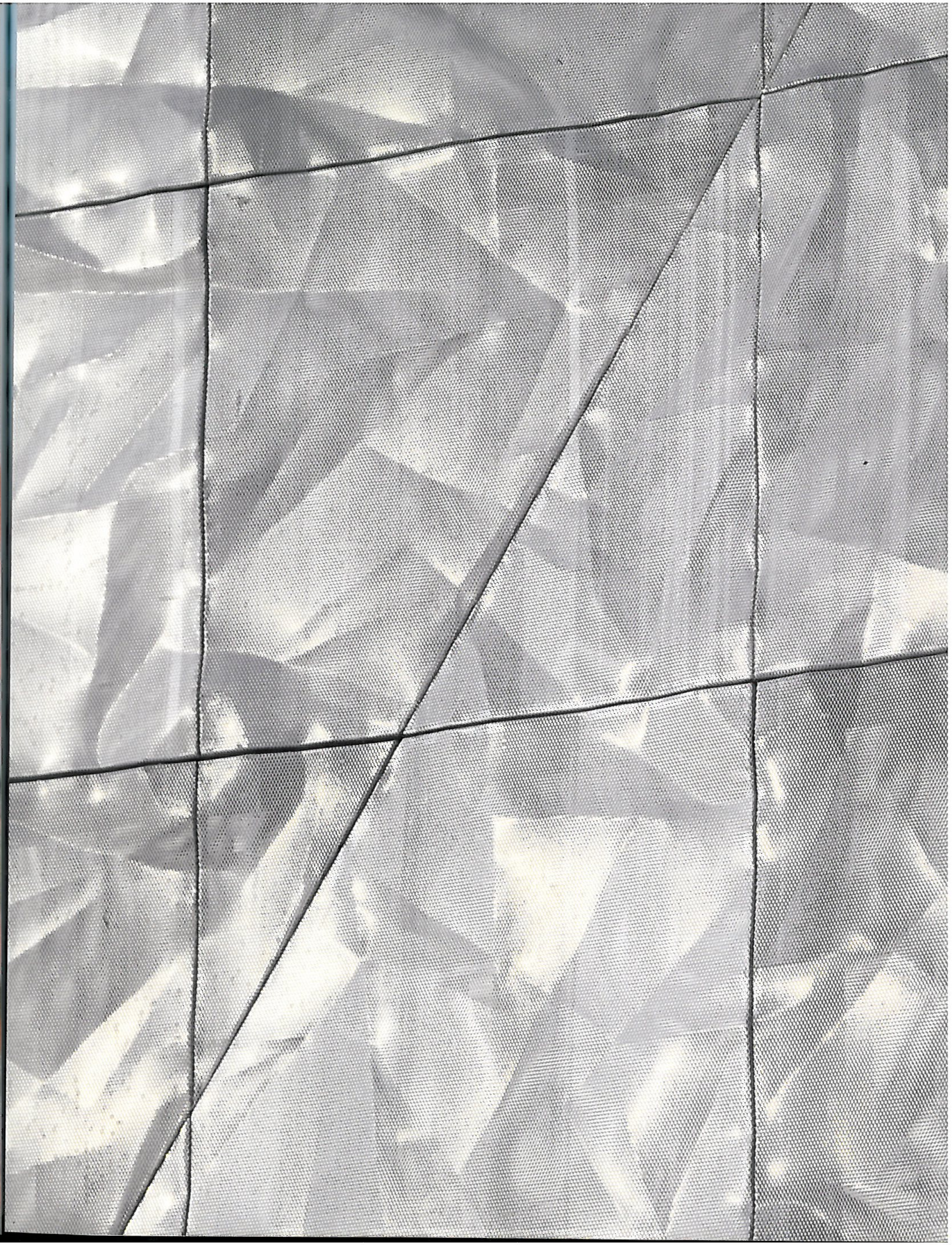
Bottom: Three diagrams of folded paper study models showing the process through which a folded surface was cut (marked in red in left column), unfolded, and diagrammed to illustrate shape patterns of the resultant openings. The family of shapes generated by these studies informed openings in the final building skin.

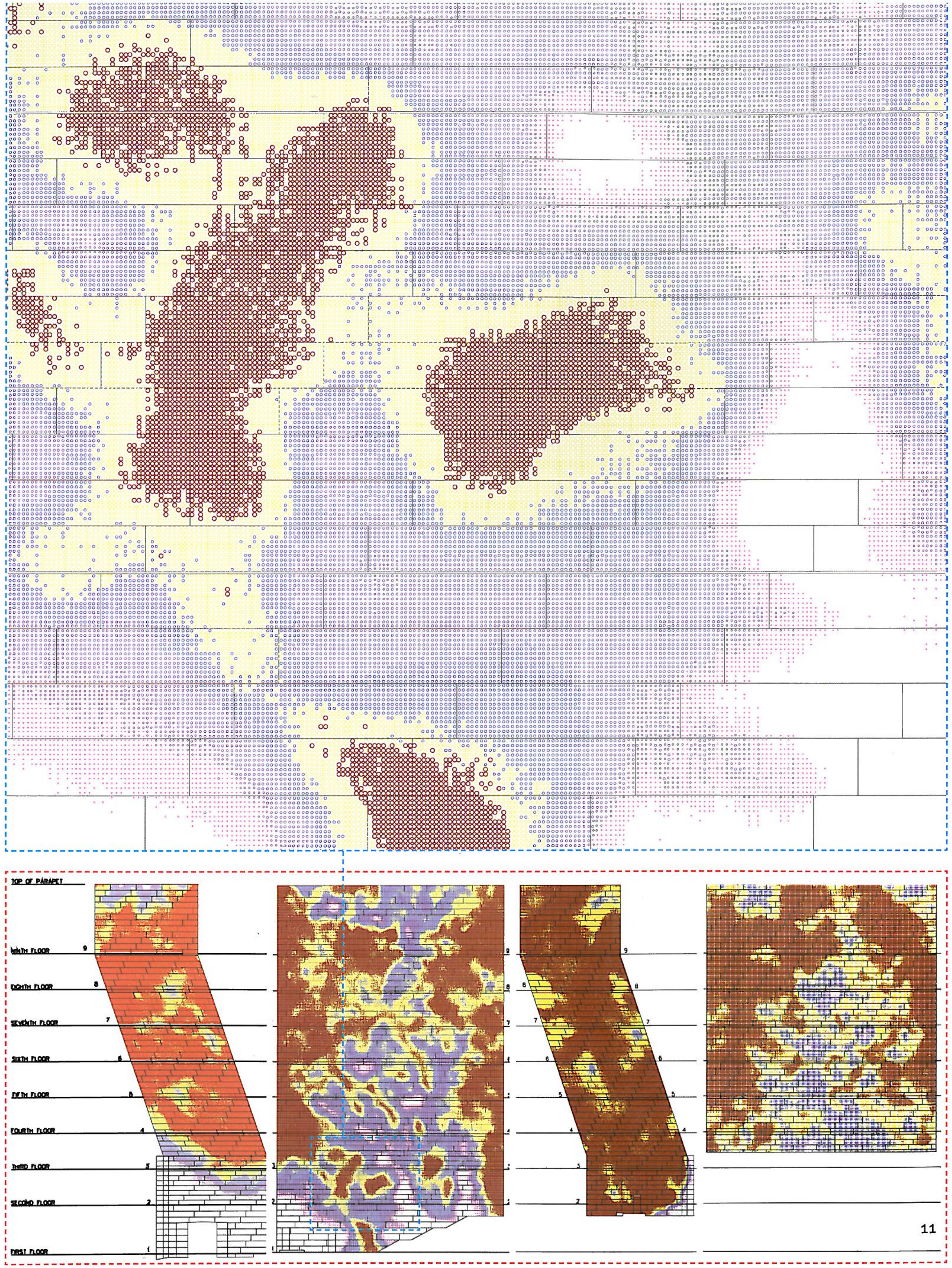
8: Unfolded surface of potential building skin and opening shapes.

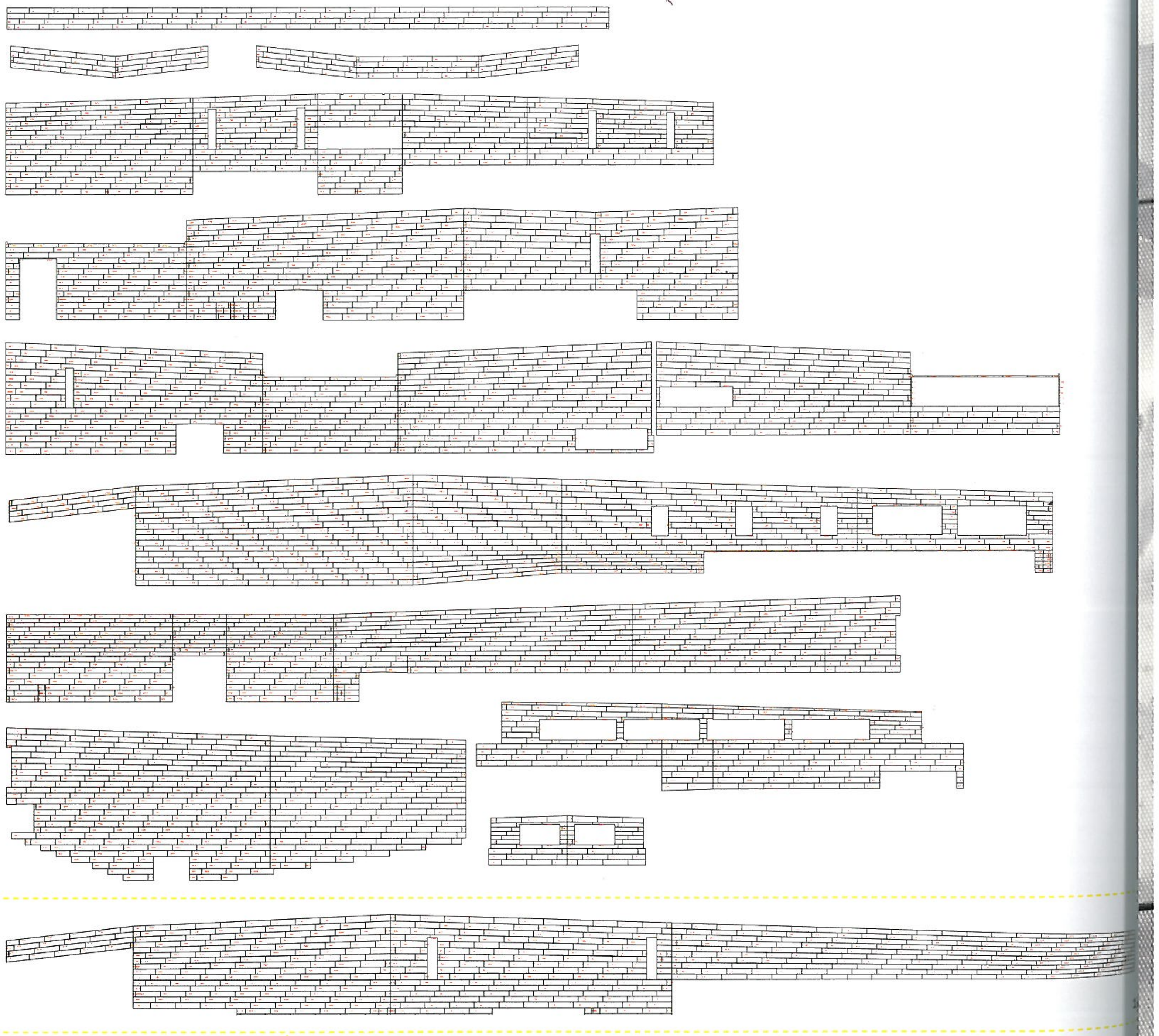
9: Early study models showing various folded paper surfaces wrapping the museum volume. The building skin was conceived as a surface of folded and cut paper.

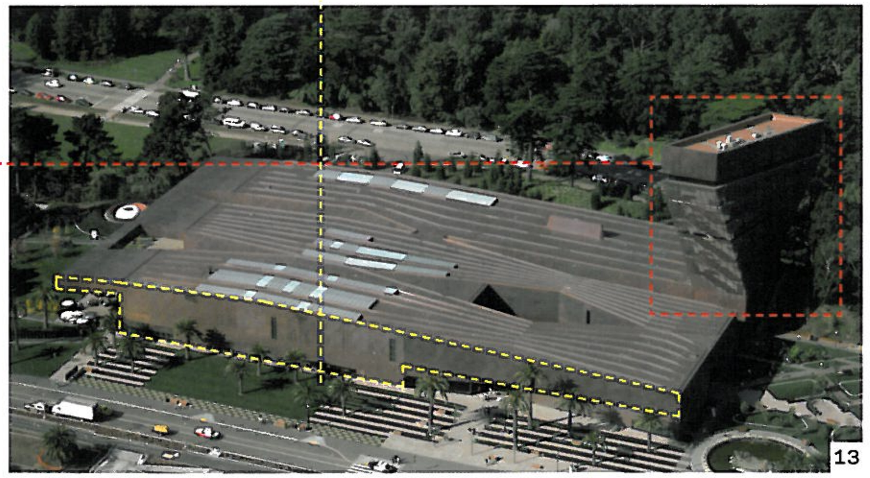
10: Final conceptual study model conveying design intent for an illuminated box wrapped by a thin, perforated surface.

11 left: Multiple test panels randomly arrayed to create the illusion of varying panel patterns; right: Final panel array installed on building.



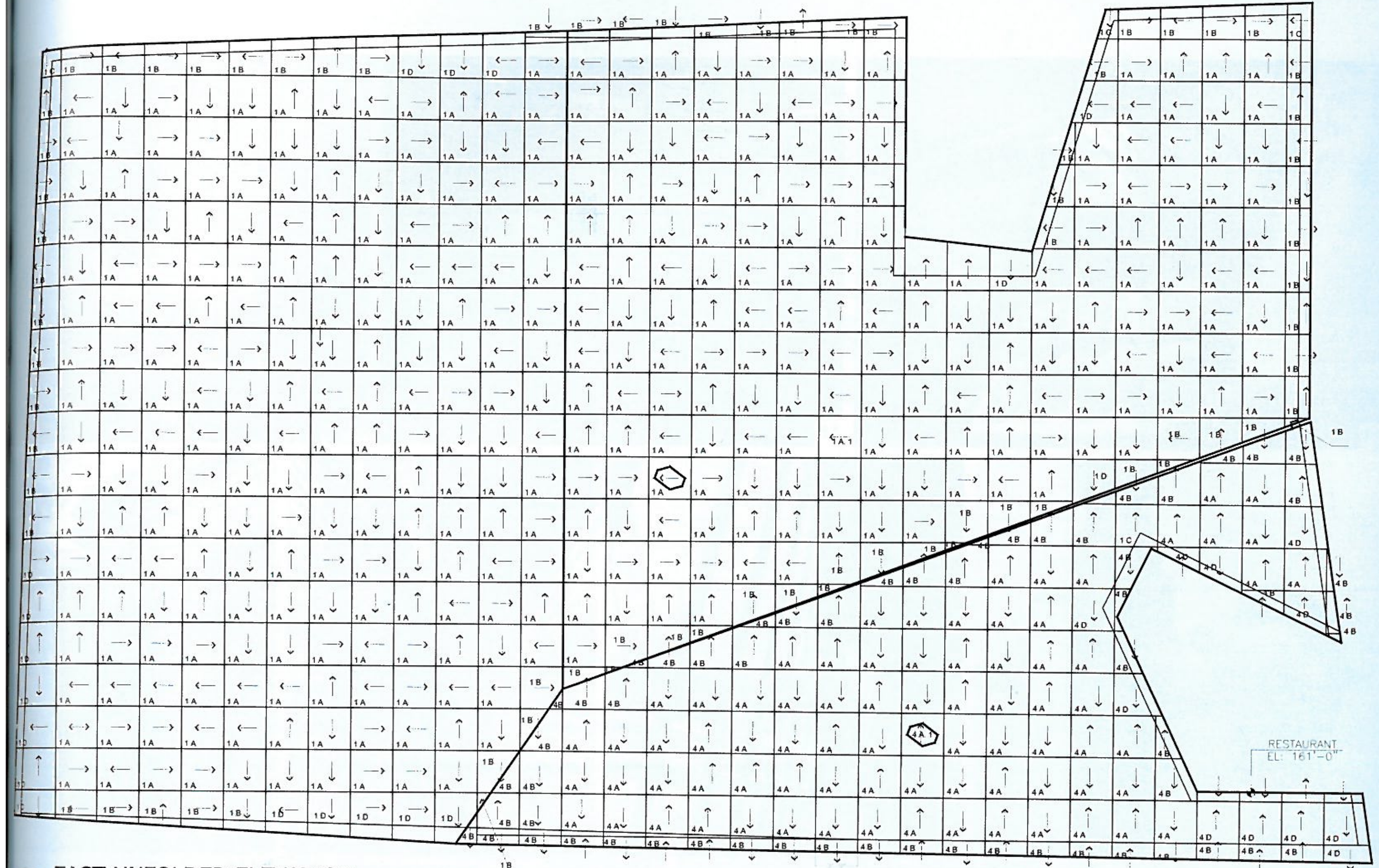


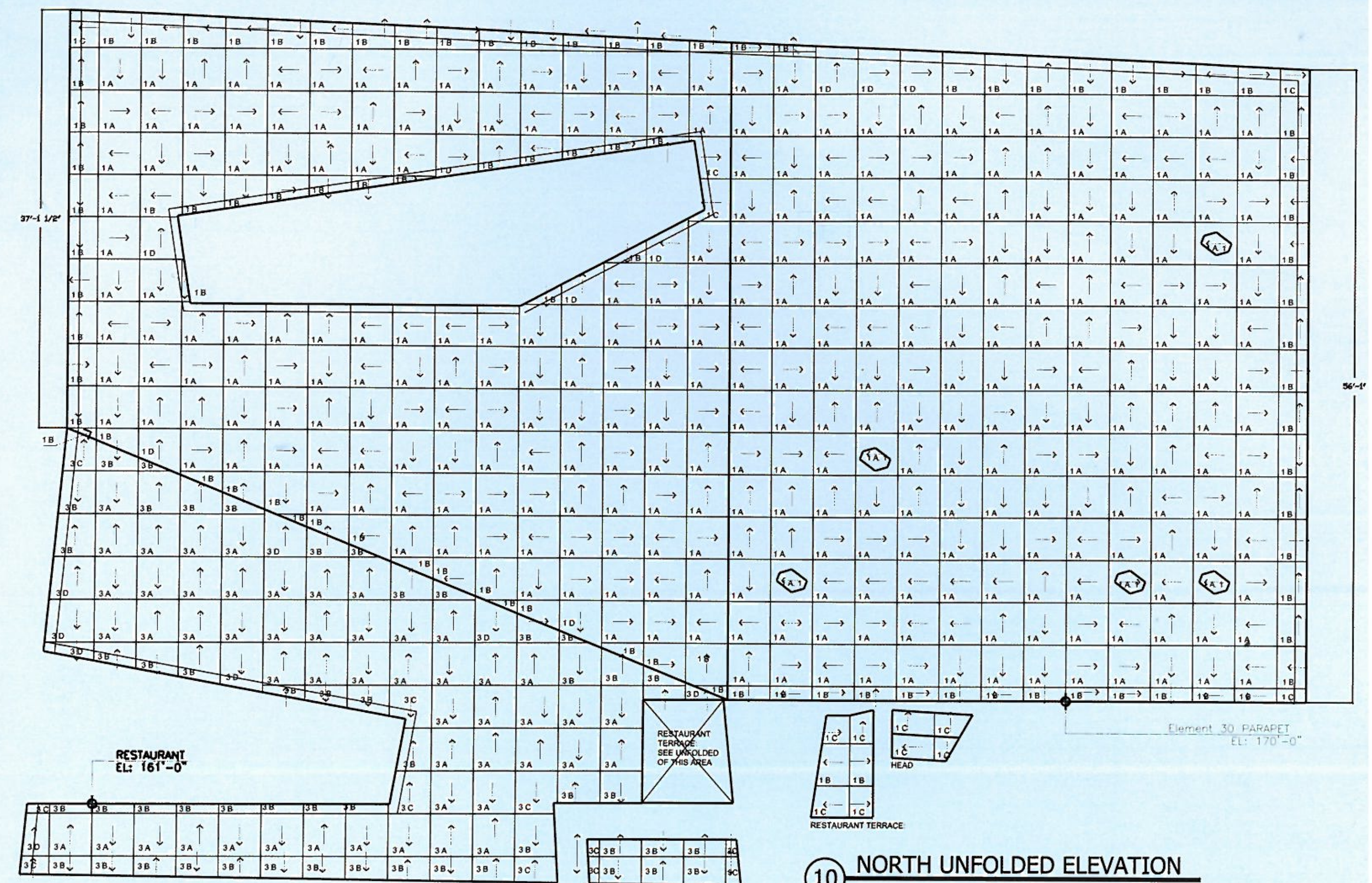


11: Fabrication shop drawings of the tower showing panel divisions and perforation pattern on unfolded tower elevations. The different colors represent different perforation radiuses.

12: The unfolded elevations show the panel division required for fabrication and installation. To best maintain the reading of the full elevation 'image', the panels were inscribed to minimize joints and the need for variations in panel size and shape. Additionally, size considerations were influenced by the copper manufacturing industry to ensure that replacement panels were cut from a standard sheet of copper. The result of these considerations was a laterally shifting grid of 12'x 2.5' rectangular panels for the main building and trapezoidal panels for the torquing tower. 7200 panels out of the total 11,115 panels applied to the building have a unique pattern of embossing and perforation (only panels on the roof have repeating patterns). During the fabrication process each panel was assigned a 16-digit identification number that designated a panel's location, shipping sequence, row number, panel number, modifier (e.g. corner, tapered or window panel) and revision number. In total, 129,000 sq ft of copper was used for the main building, 80,000 sq ft for the roof and 33,218 sq ft for the tower.

13: Aerial photo of finished building referencing unfolded elevations.





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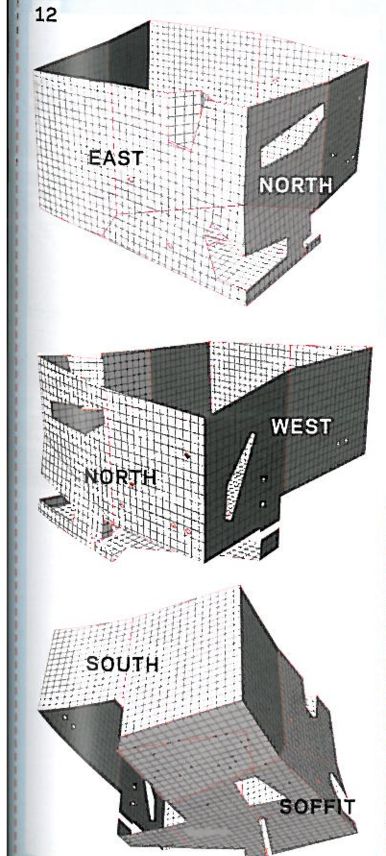
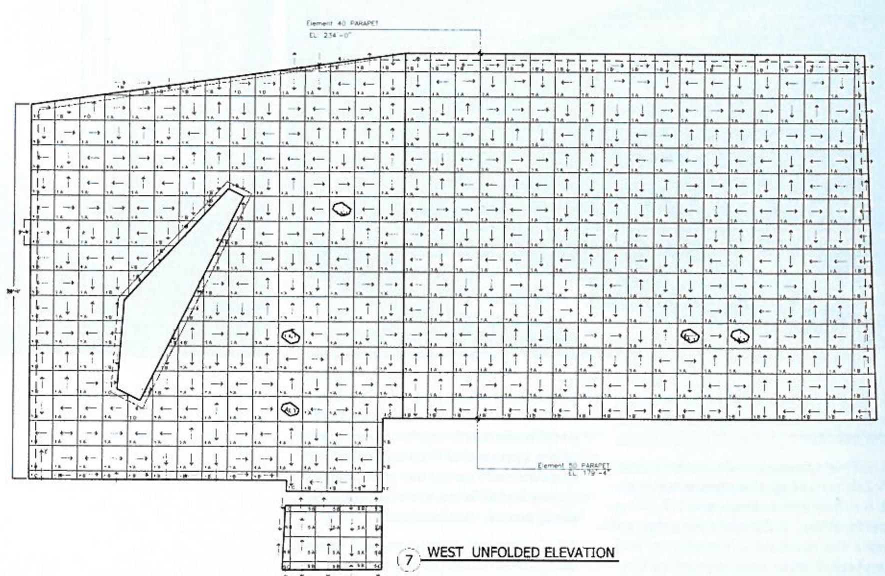


12: 3-D models of the building skin and corresponding unfolded elevations.

13: Night rendering of museum addition and existing facilities as reference for elevation drawings.

14: Unfolded building elevations showing panel orientation pattern for all surfaces covered in the aluminum metal mesh. The building skin has a total of approximately 2900 panels, equaling a total surface area of around 30,000 sq ft.



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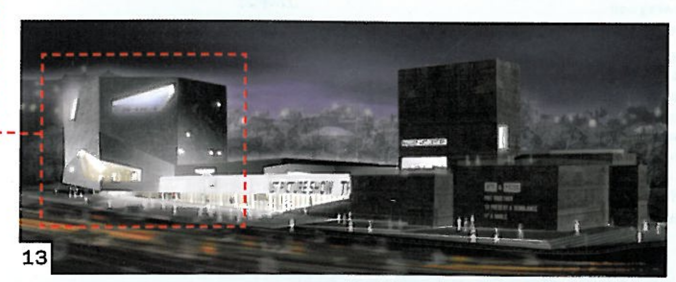

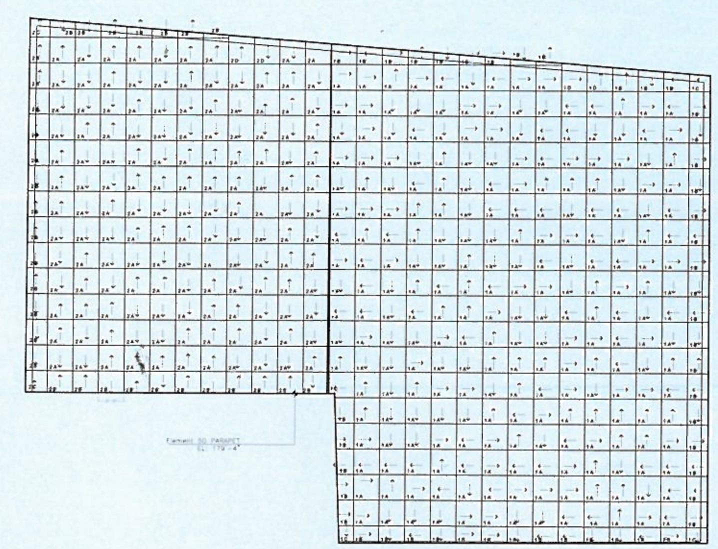

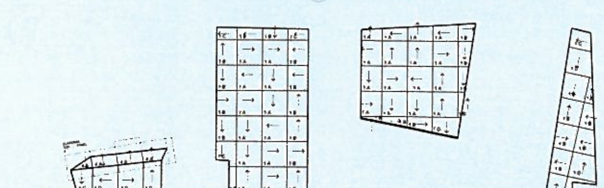

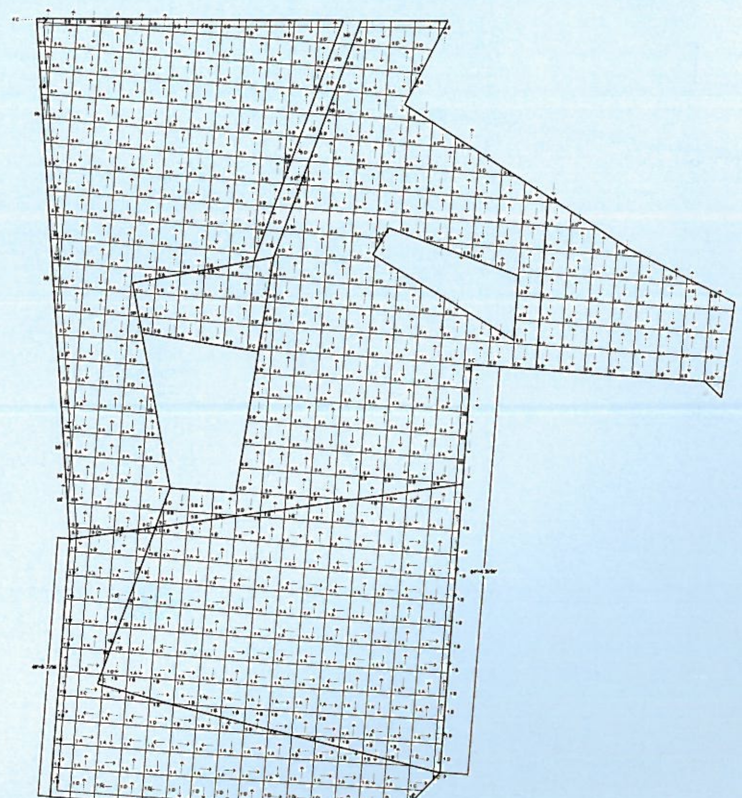

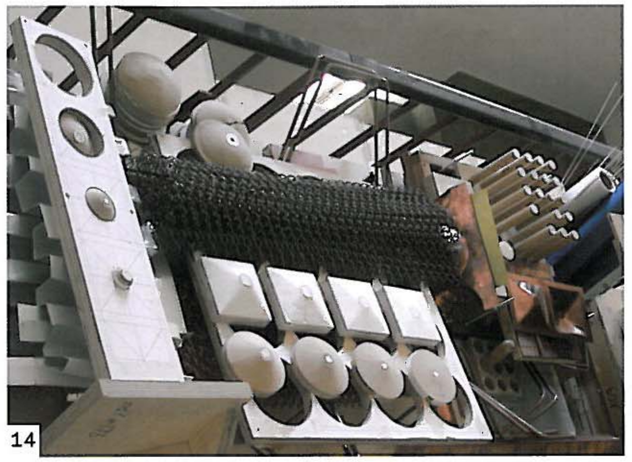
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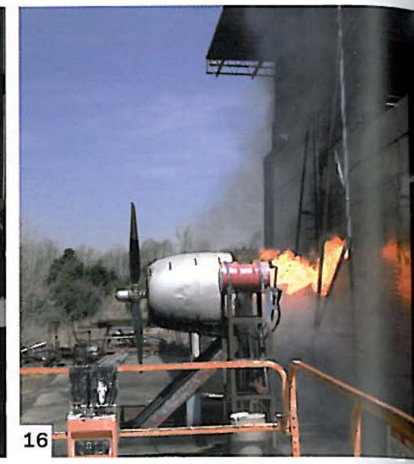
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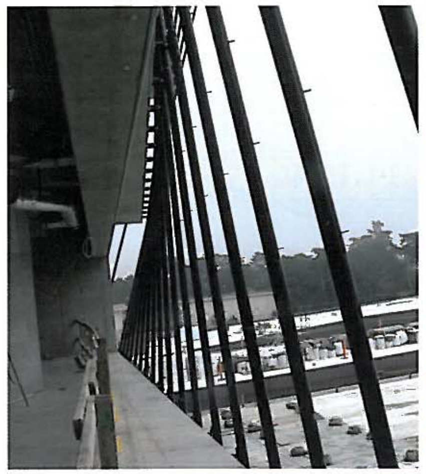



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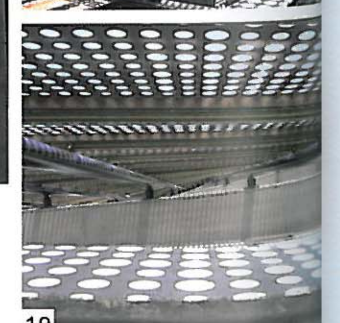
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14: Various tools used in conjunction with A.Zahner machinery to fabricate the panels.

15: Final copper panels under review at A.Zahner's shop; the panels required 1.5 million embossings and 1.7 million perforations. A.Zahner's patented software and machinery, 'metabump,' and 'metaperf' were used to produce the final panels. Only two machines were required to complete each panel: the panels were first cut to size and perforated, then 'bumped' and formed to the desired shape.

16: A fire rating test shown in-progress. Full scale mock-ups of the exterior enclosure, including glass and copper panel systems, were required by code officials. Before final installation was allowed to occur, a host of safety and performance tests for the copper rain screen system were required. The deYoung is the first large installation of copper on any building façade in the US; for this reason there were no precedents to support its performance in this capacity. A.Zahner developed details and mock-ups for each portion of the system and then met with local code officials to explain and demonstrate its performance under rain, fire, wind, and earthquake loads.

17: Construction sequence for tower skin. Construction of the building began in 2002 and took three years to complete.

18: Construction photos showing copper panel installation on base building.

19 top: View inside completed overhang; bottom: View looking down through interstitial space between copper panel and typical exterior wall assembly. The perforated panels afford the ability to integrate and hide ventilation systems on the building exterior, as well as to manipulate the diffusion and intensity of light entering the interior.


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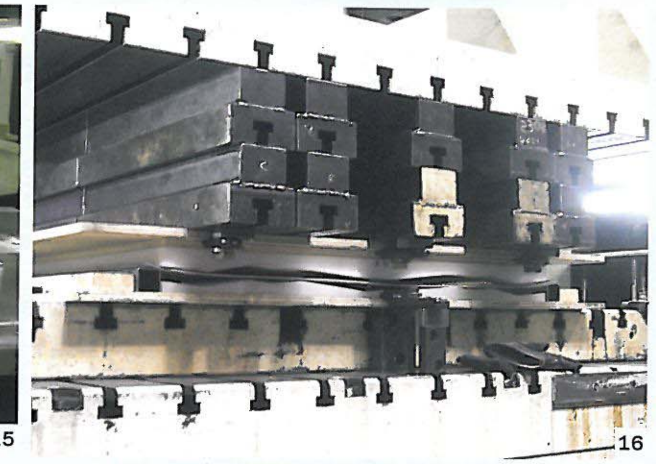
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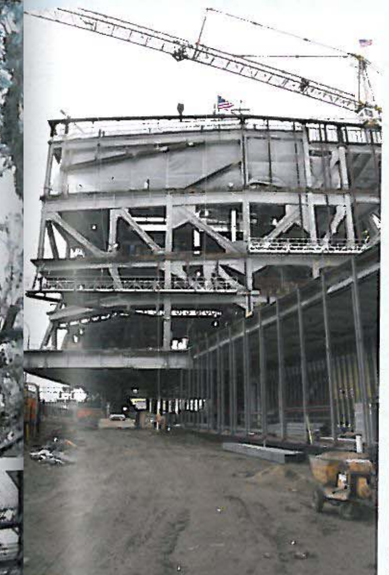

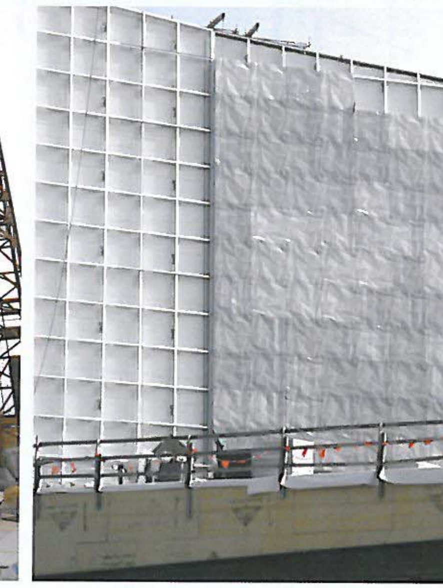
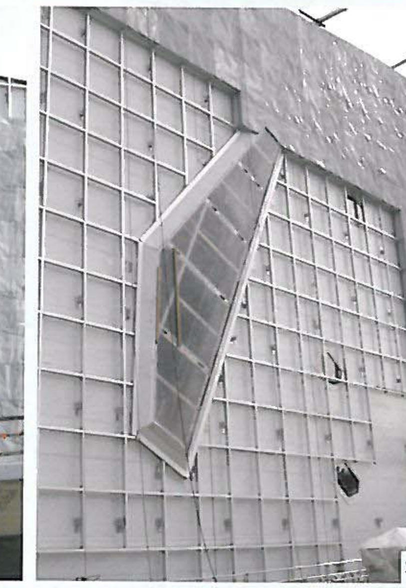
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15: Despite the variety of panel types, all are initially formed from the same mold. The first mold made to fabricate the aluminum mesh panels was routed from solid plastic. This quickly proved inadequate to create the desired crispness of folds in the mesh, so it was replaced with a solid stainless steel mold that was used for the remainder of the fabrication process. Image shows this final mold.

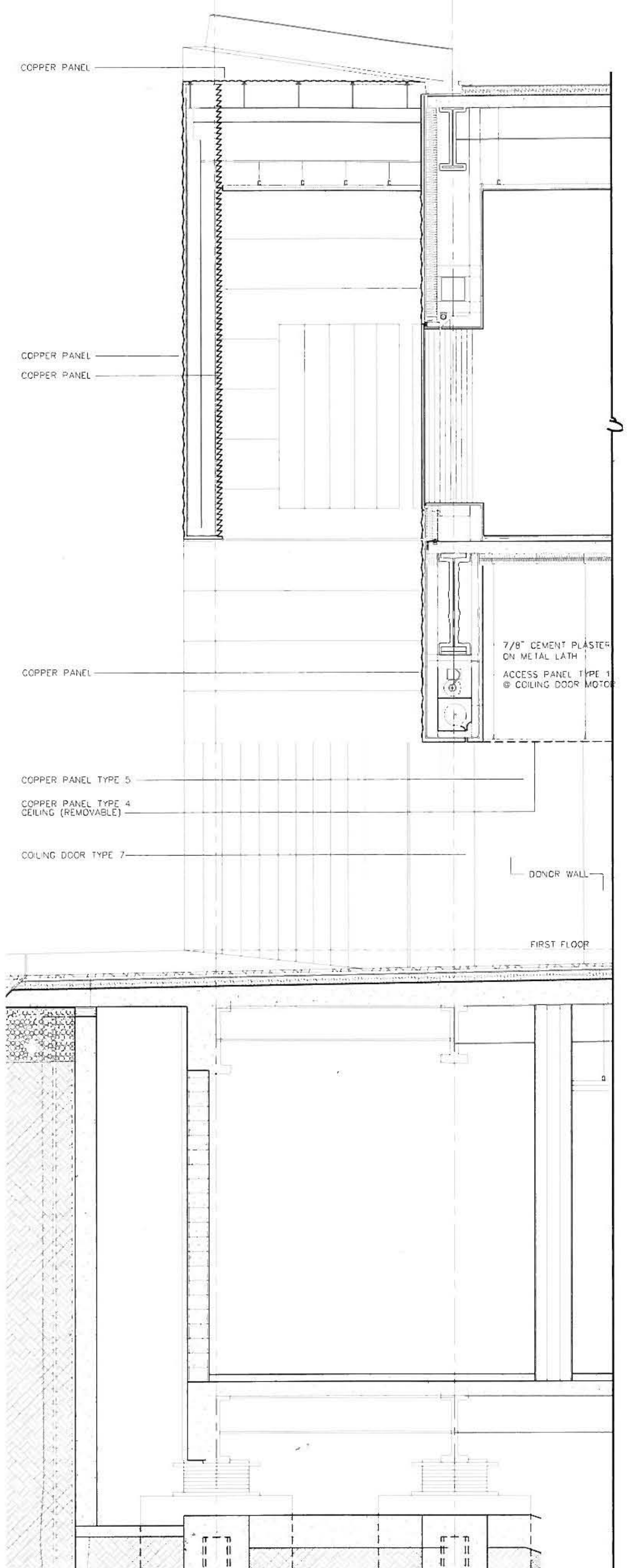
16: Fabrication of mesh panel using plastic mold.

17 top: The Walker Museum addition is the first building in the US to use expanded aluminum mesh as a key component of the material palette. Because the metal panels were a completely new and custom system, a series of code compliance tests were required by local building officials. Performance goals for wind loading and repetitive stress deformation were established based on recommendations from the structural engineers. Initial testing was done in-house, as shown above. In this image, deformation from various loads is recorded by pouring sand in increasing amounts onto the surface of the panel. Wind tests were done in a similarl homemade fashion by strapping a panel to the front end of a truck, attaching a wind and stress gauge to the panel, and then driving the truck down the highway at various speeds. Last minute discoveries of material weaknesses, particularly under repetitive stress loading tests, resulted in a flurry of new testing only weeks before installation. Various alloy combinations and anodizing processes were tested before a suitable combination was found that could withstand the established performance goals; bottom: Completed panels under review for finish quality.

18: Construction sequence photos of north and west elevations.

20: Entry court wall section.

21: Tower wall section. For all system details, A.Zahner employed detailed Pro/ENGINEER and Catia models to finalize the design. Much of the system had to be custom designed and fabricated. All mullion extrusions are custom shapes based on the variety of system tasks required. Mullions on the tower had to be designed to twist in the vertical dimension. Mullions were also designed to take wind loads from the glazing but not act as part of the lateral bracing for the overall structural system. Additionally, the mullions were designed as seismic connections to isolate the glazing from earthquake loads.



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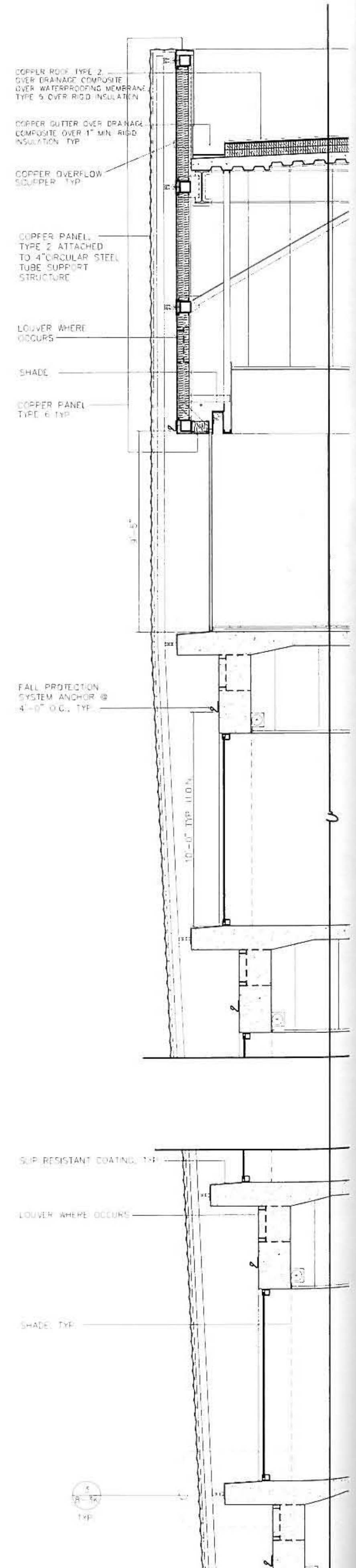

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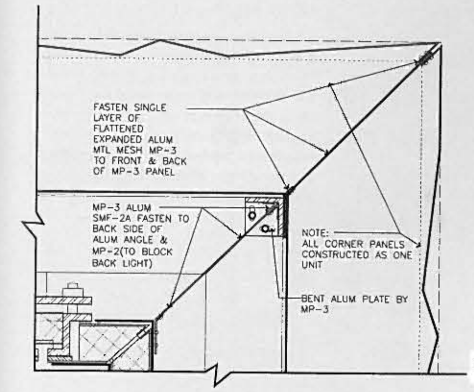

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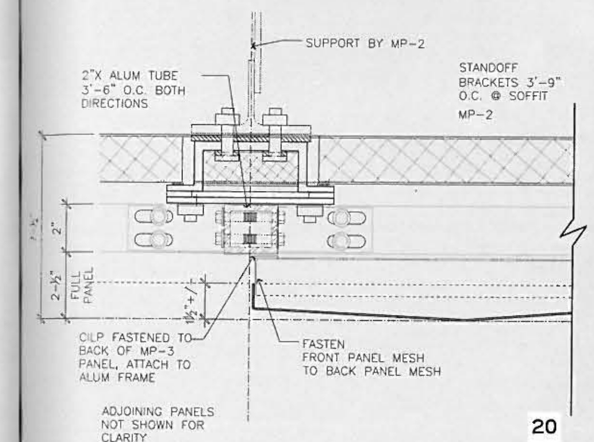

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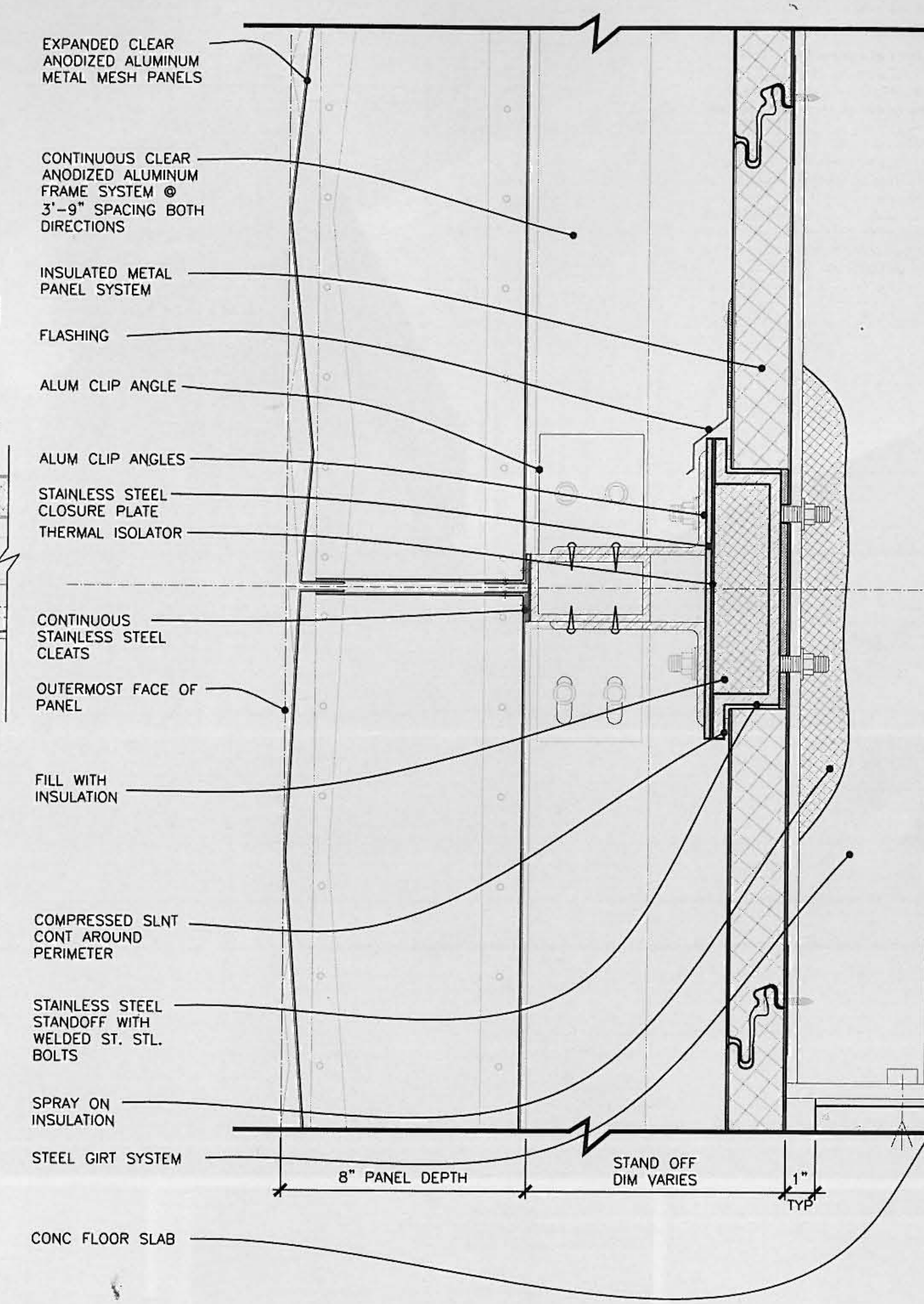
19: Typical corner detail.

20: Typical soffit detail. The metal mesh system wraps around to cover the soffit of the large overhang, emphasizing the 'wrapper' quality of the system.

21: Typical assembly section detail of mesh panel on steel girt wall system.

22: Axonometric of typical assembly section detail for mesh panel on steel girt wall system.



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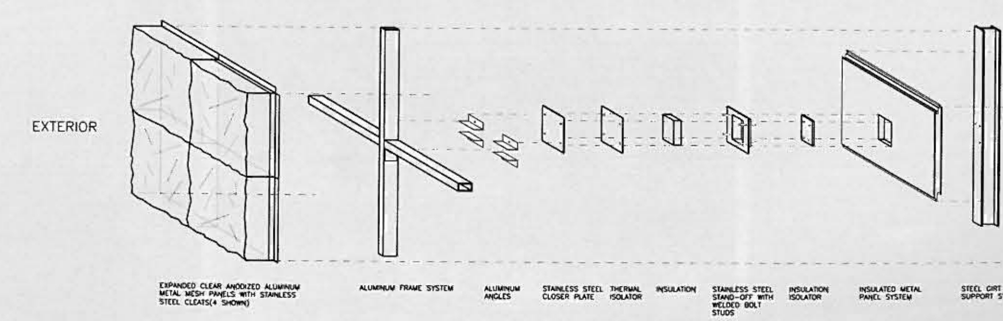

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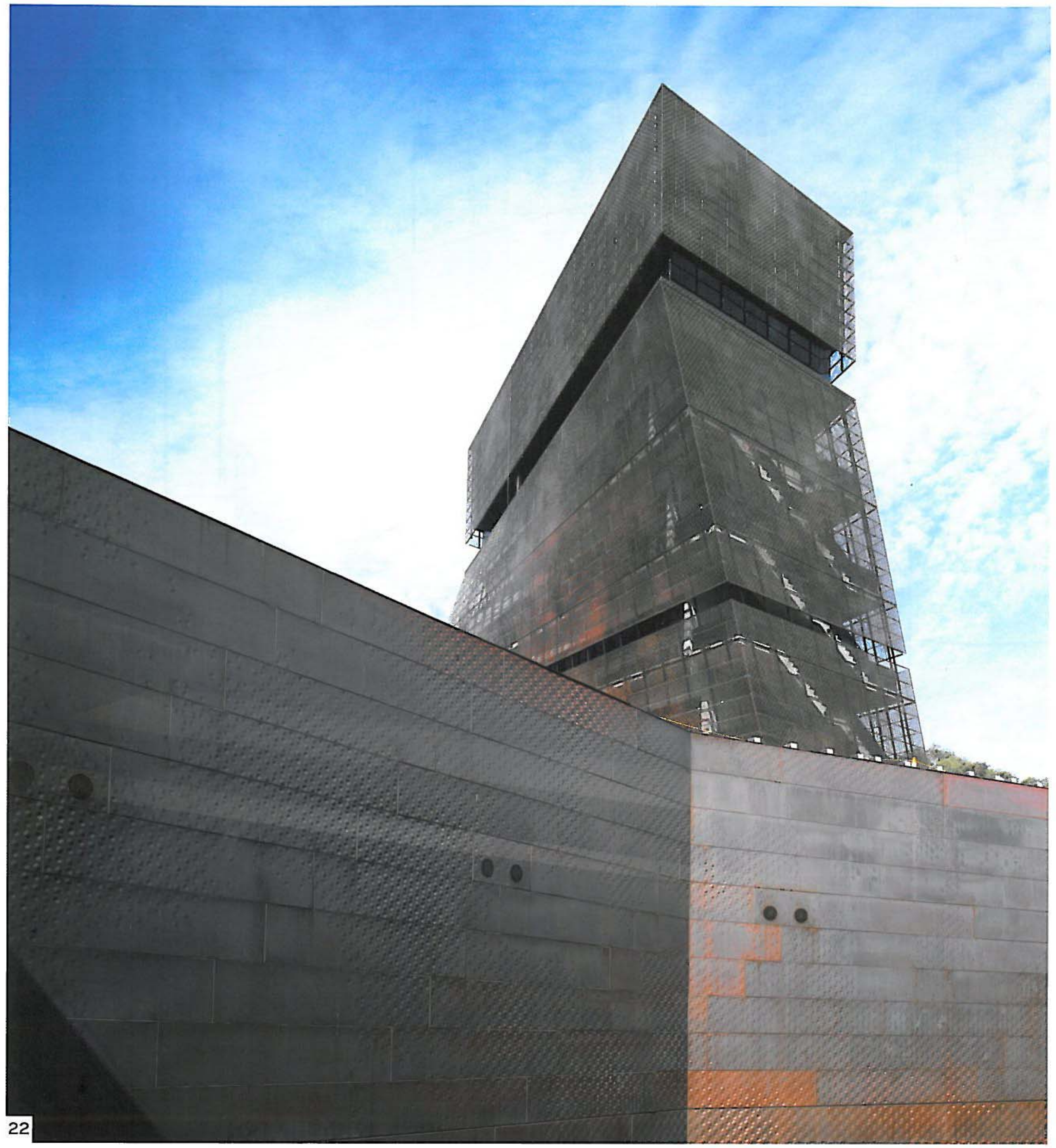

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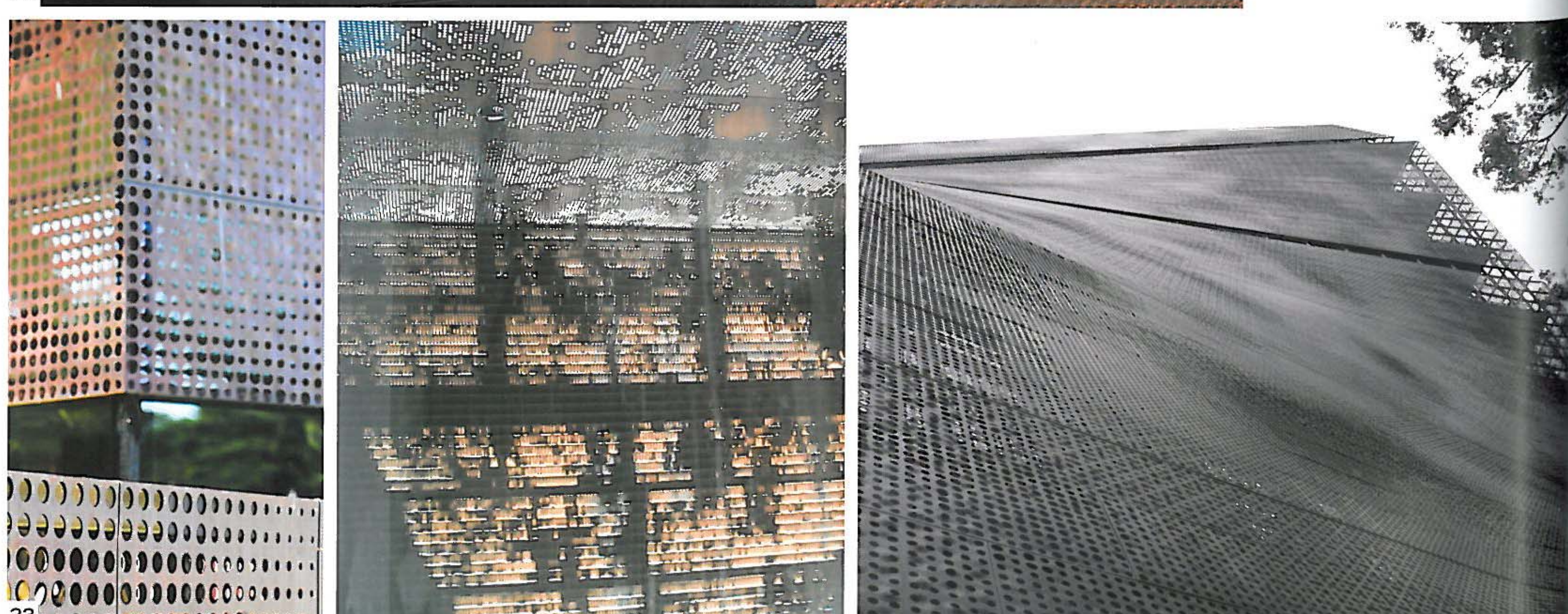
22: Detail photo, taken December 2006, shows effect of patination on copper panels.

23: Various images of the newly completed deYoung building. Despite the relatively small palette of variations in perforation and embossing geometry, the copper skin produces extremely varied effects intended to blur the reading of the building with its natural surroundings. With time, the oxidation process will only exaggerate this.



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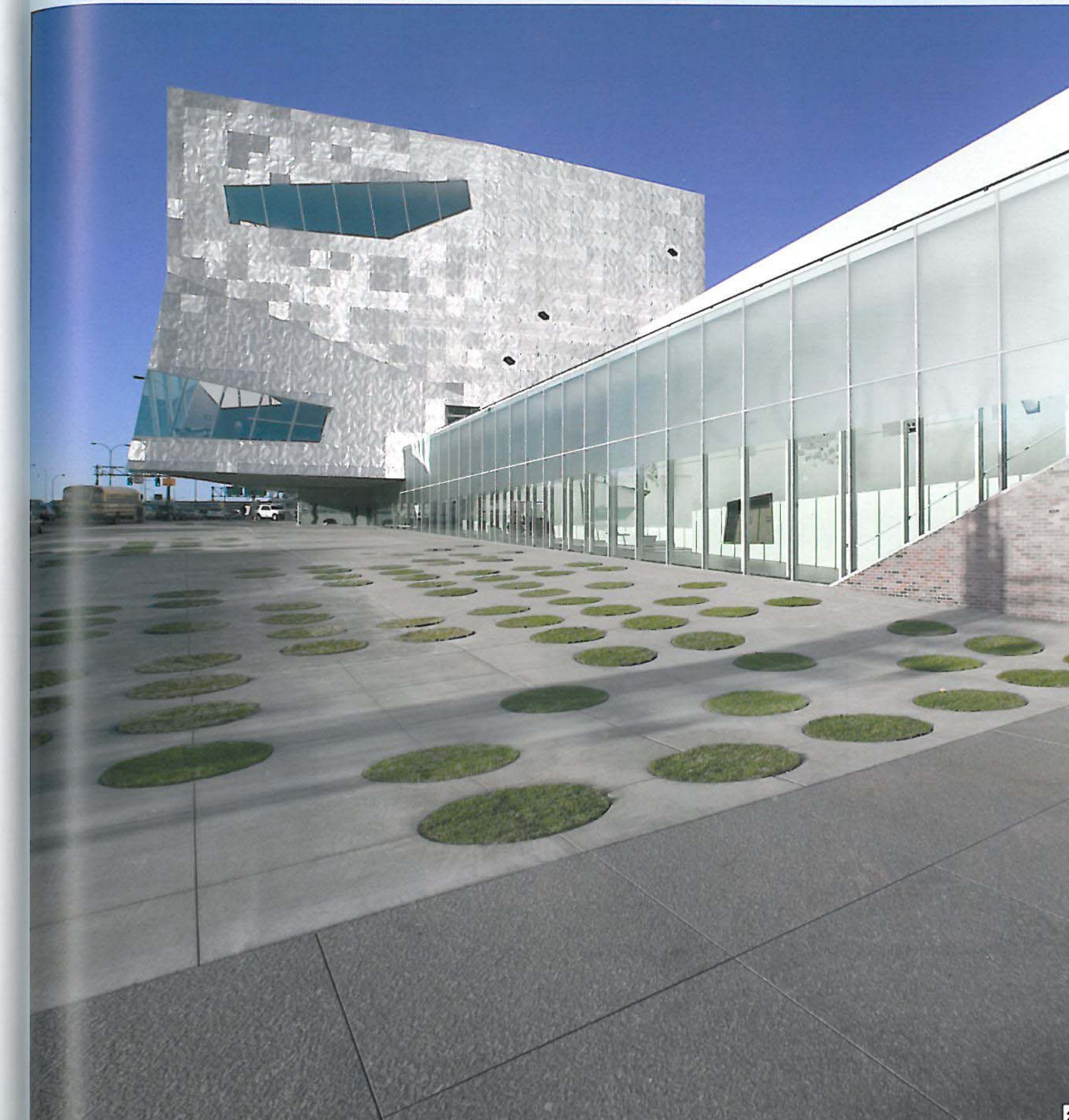

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23: Photo of Walker skin taken December 2006 reveals the continuity of surface and apparent variety created through the single metal mesh panel.

24: Various images of the newly completed building showing the qualities of reflectivity and lightness achieved by the metal mesh surface. Openings in the wrapper occur as punctures in the otherwise uniform surface.

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