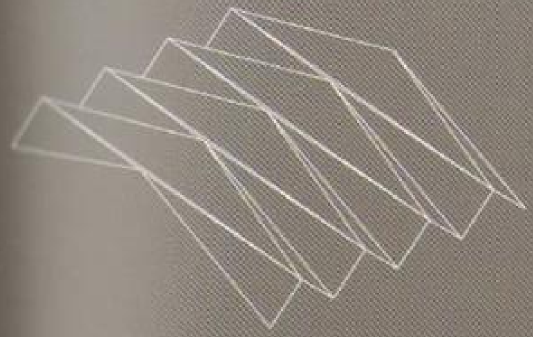
Folded plates distribute loads along the surfaces of a plate and along the seams between the folds, across three dimensions, producing structures composed of surface and linear elements. Folded plates can be made of steel-reinforced concrete, steel plate, or both, in conjunction with, and reinforced by, a linear truss system. This analysis has not specifically addressed resistance to lateral loads. The system of folded plates is subdivided into two primary subsystems: folded plates, and plate and truss folded plates.

Folded plates built of steel-reinforced concrete or steel direct the loads along their surfaces. In addition, the gradual subdivision of reinforced-concrete or steel folded plates increases the overall number of seams which direct the force lines that respond to the bending moments of the structure. When the surface is folded, increasing the depth of each of the folds increases their overall resistance, enabling the surface of the plate to function as a beam.
Folded plate and truss folded plates, built of steel or steel-reinforced concrete surface plates and a linear steel truss, direct the loads along their surfaces and along the lines of the truss. Increasing the depth of their folds similarly increases resistance to bending moments, with the inside of the plate's section cross-braced by a three-dimensional truss.
Both subsystems can produce a gradually changing section that distributes loads in a way which is similar to structural catenaries, arches or domes.

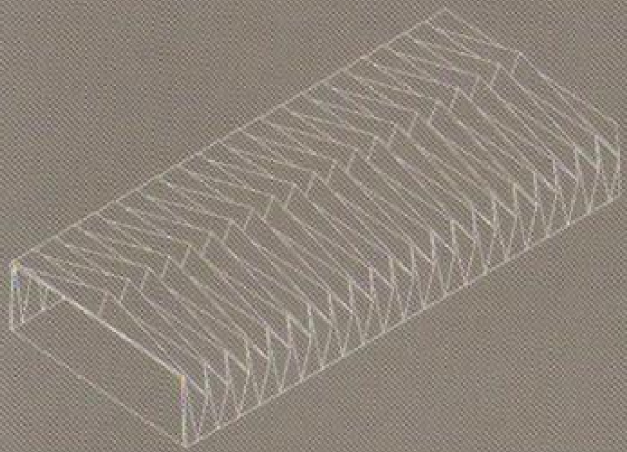


Folded Plate

Folded Plate and Truss

The system of folded plates can tessellate along horizontal or vertical axes of growth, to produce horizontal or vertical forms.

Horizontal tessellation can occur in both of the subsystems, introducing flexibility primarily in section, given that, in all cases, the protogeometry is capable of distributing loads along the horizontal axis. Horizontal tessellation results in shed-like structural forms, with variations in section and plan which are produced by the number of folds in the plate.
Vertical tessellation can occur in folded plates, given that the protogeometry of a folded plate is able to respond to the three-dimensional bending moment which is characteristic of a vertical structure. The vertical tessellation of folded plates can result in structural forms that vary in profile and surface geometry according to the variations in the scale of the folds along the vertical axis of growth.



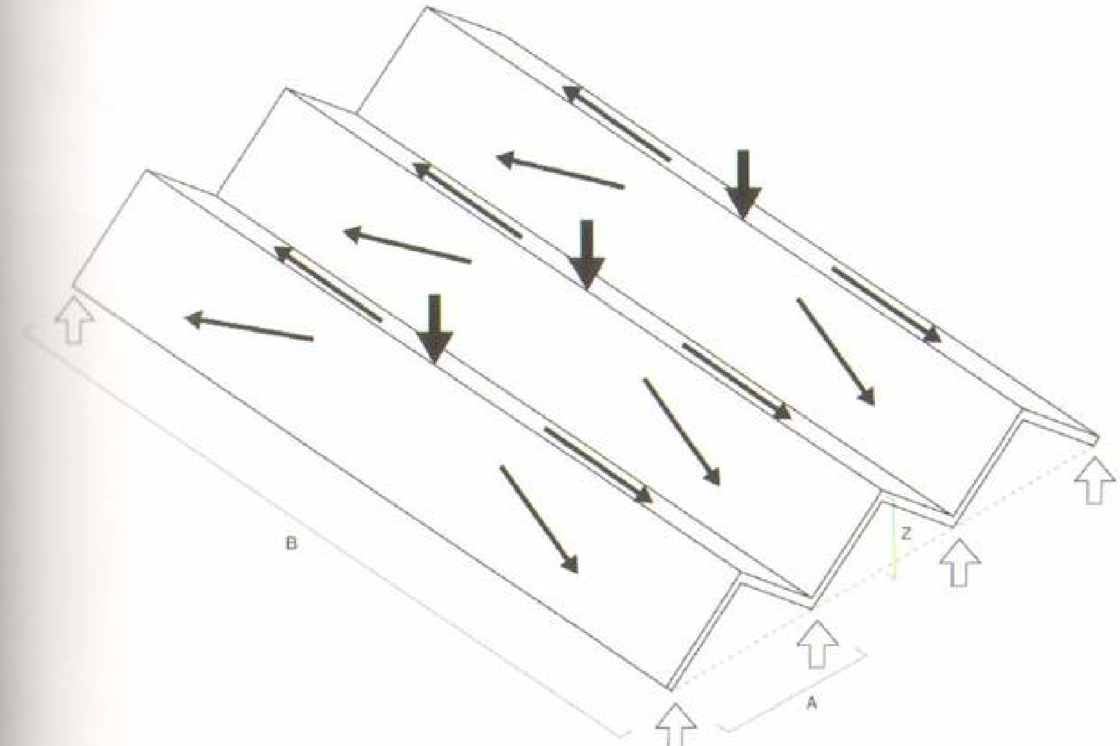
Horizontal Tessellation

Vertical Tessellation

Folded Plate

The base unit of a folded plate is assembled from a thin steel reinforced-concrete or steel surface that is bent to increase its strength and allow it to span like a beam. Folded plates resist the primary bending stresses across their inclined section with peak stress at the ridge and valley of the folds. The depth of the plate's folds is proportional to its resistance to bending. Folded plates can be made of reinforced concrete or steel but they can also be made of a mixture of concrete and lightweight terracotta tiles, in order to reduce the overall weight, or a lightweight polymer mixture of concrete and fibreglass. Scored laminated timber sheets can also be used, resulting in a much lower weight-to-span ratio. This distribution of load through the depth of the steel-reinforced concrete or steel section embeds the folded plate with an affective property of pleating and arching that remains consistent within any space it defines. Folded plates add diffusion to modify or dominate the acoustical affective property of their macro-geometry, which can be focusing (curved) or specular (flat).

Concrete or steel folded plates are flexible in several ways:
Profile: Folded plates can tessellate horizontally and vertically along horizontal or vertical axes of growth to produce structures which are horizontal (sheds) or vertical towers and domes. The protogeometry of folded plates can be flexible in the location of the apexes of the folds, ranging from spanning two supporting walls, to a basic three-sided "portal" section, to a highly folded nave section.
Scale: The rate and scale of the folds can vary, changing the overall subdivision of the section.
Depth: The depth of the folds can also vary according to the scale and rate of subdivision of the overall plate. The deeper the folds, the more structural depth they gain, thus the more resistance they offer to bending moments.
Affect: When the base unit is intertwined with external desires, or when it develops organicity with external factors, its affective properties are multiplied. As a result, in addition to pleating and arching, a folded plate can transmit other optical affects, including flatness, slanting, wrapping, vaulting, corrugation, tubularity, asymmetry, and pinching. The acoustical affects are diffusion and specularity.

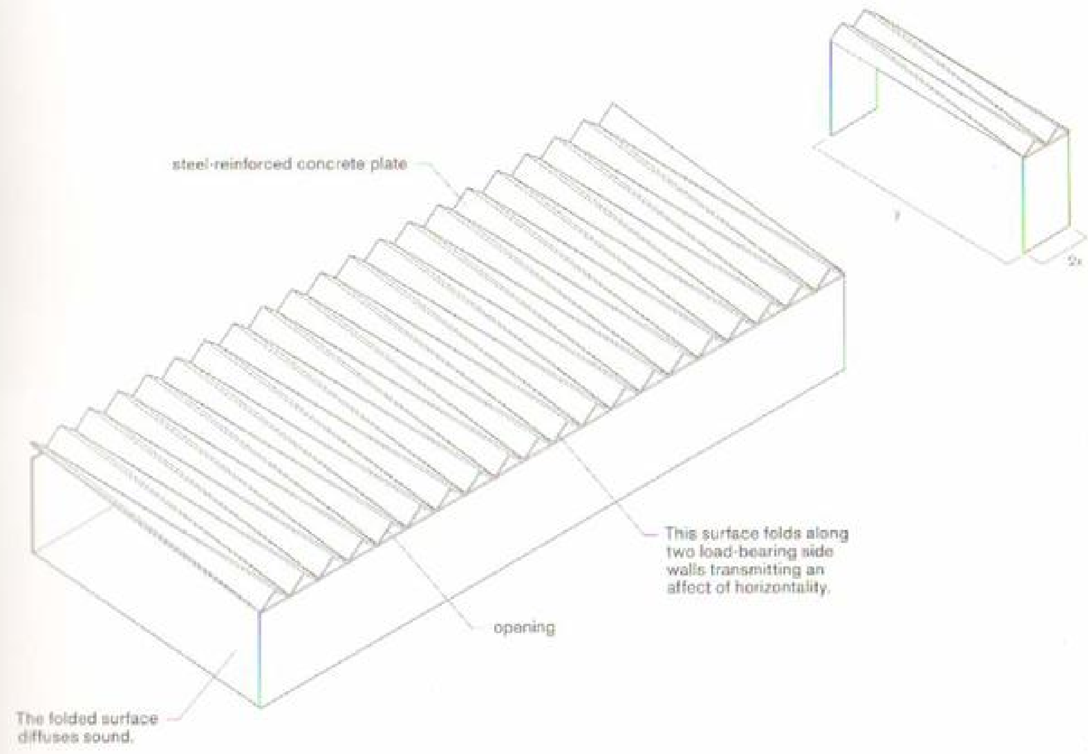


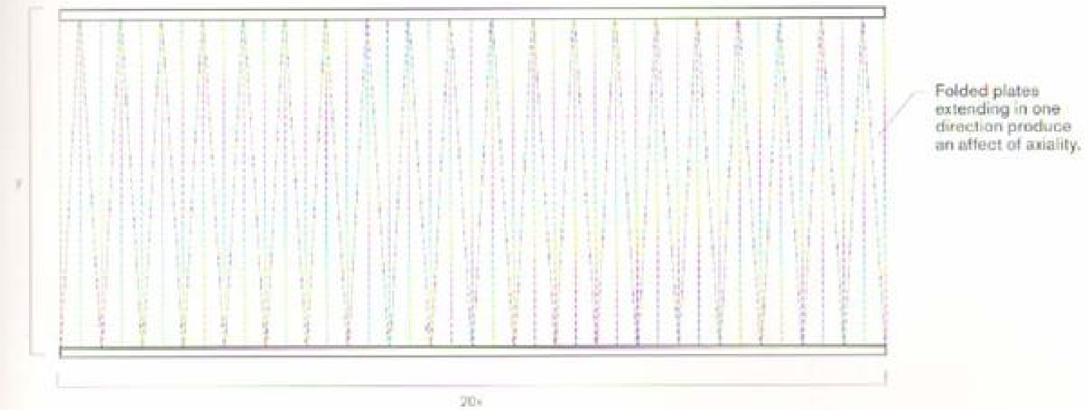
When slope of folds is 22.6-60 degrees:
Z/A = 0.2–0.8
As B increases, Z/A must also increase.

If Z/A is 2 or less the internal bending and shear forces will result in tension in the top of the folds and tension in the bottom at mid span. Similarly, shear stresses will be greatest close to the supports in the plane of the folds. The fold acts like the section of a beam when resisting bending and shear forces.

Horizontality, Pleating, Axiality, Diffusion

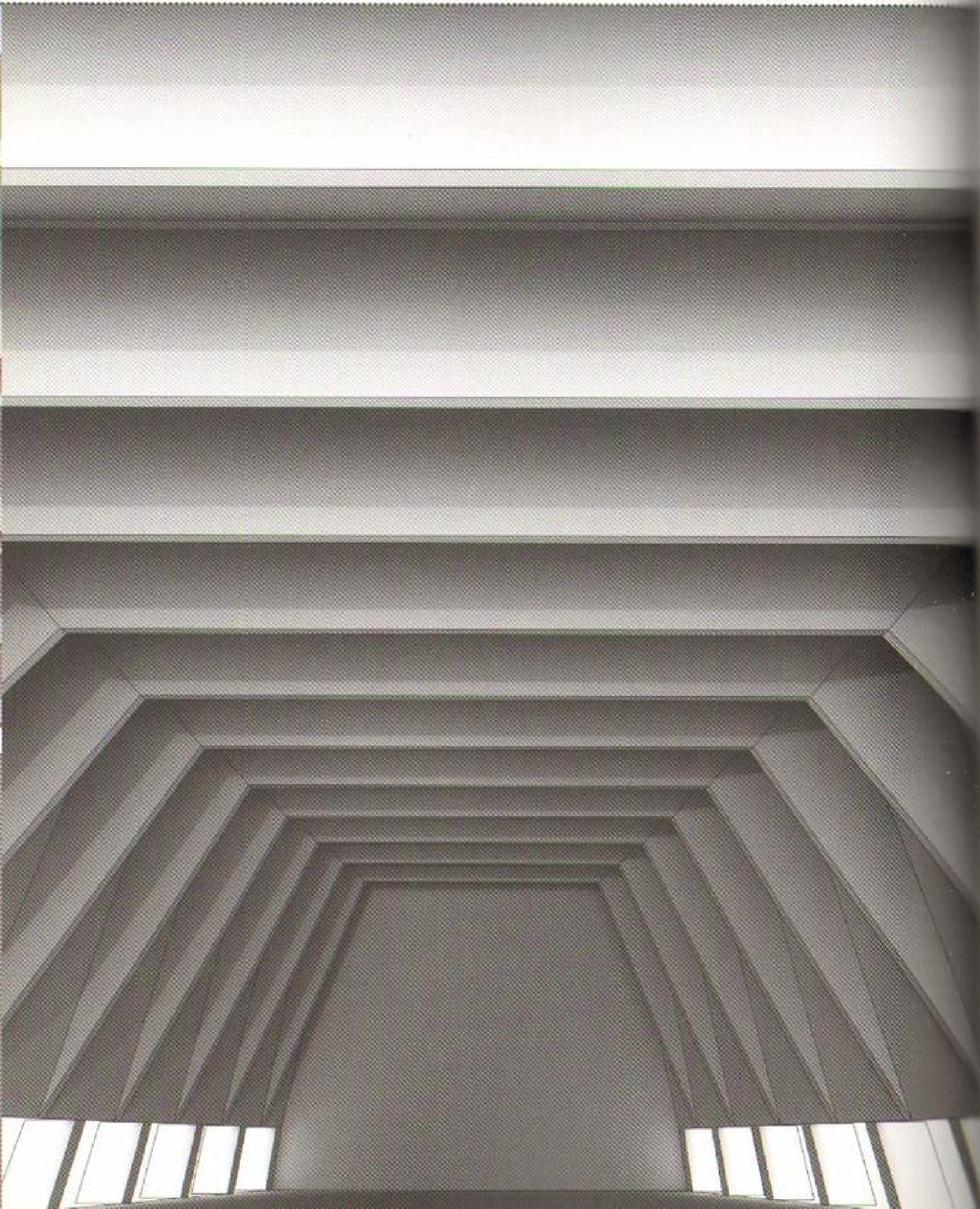
Horizontal / Folded Plate





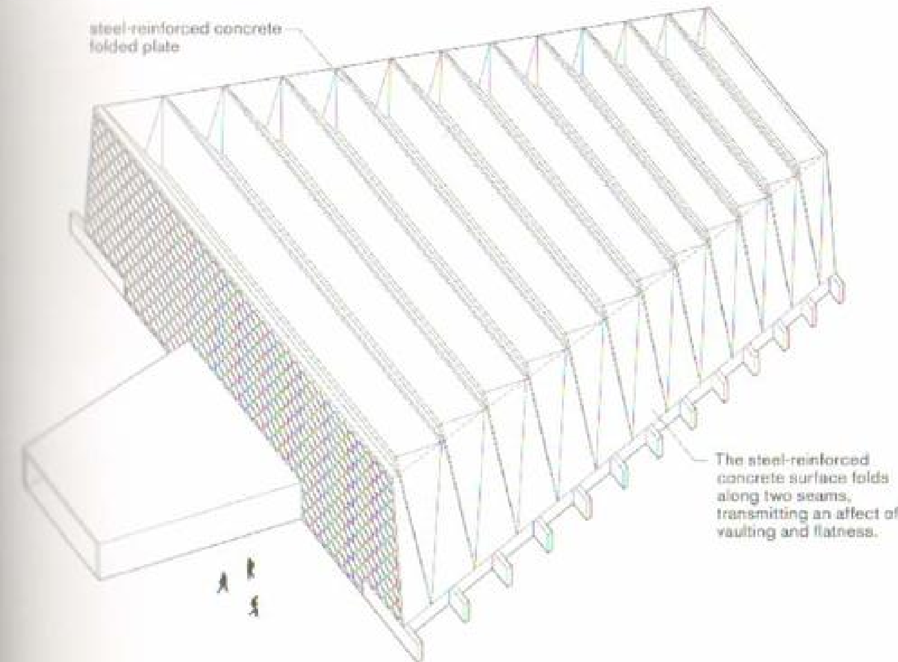
This form is produced by the horizontal tessellation of a folded plate base unit comprising a folded surface that spans two load-bearing walls. The folds give structural strength to the surfaces, allowing them to span like a beam. The overall surface corrugation is determined by the density and depth of the folds. This folded plate assemblage transmits an optical affect of horizontality, pleating and axiality, and an acoustical affect of diffusion.

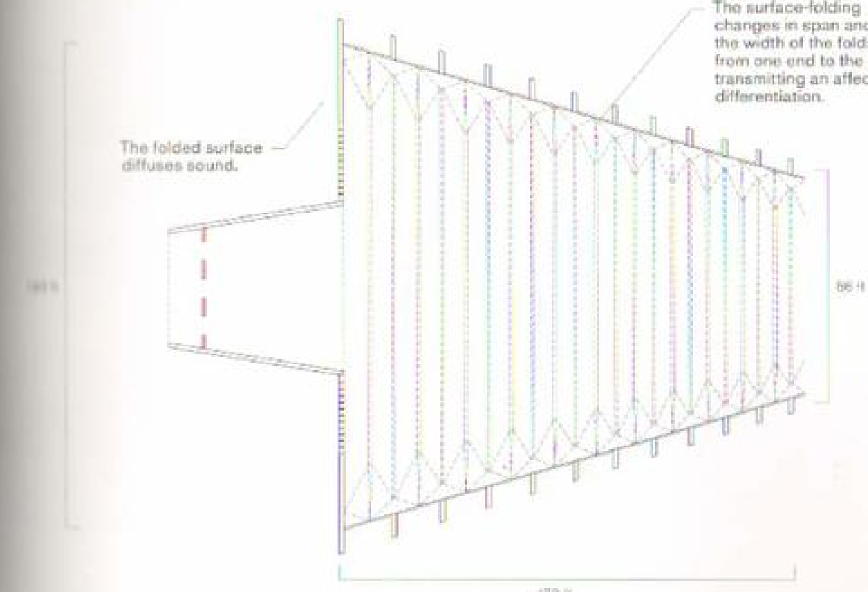
Vaulting, Pleating, Tapering, Differentiation, Diffusion

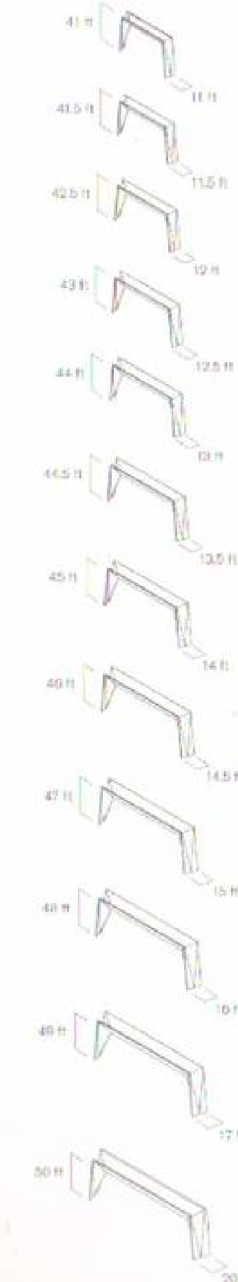


Horizontal / Folded Plate

ST. JOHN'S ABBEY | M. BREUER, P.L. NERVI | COLLEGEVILLE (MN), USA | 1961



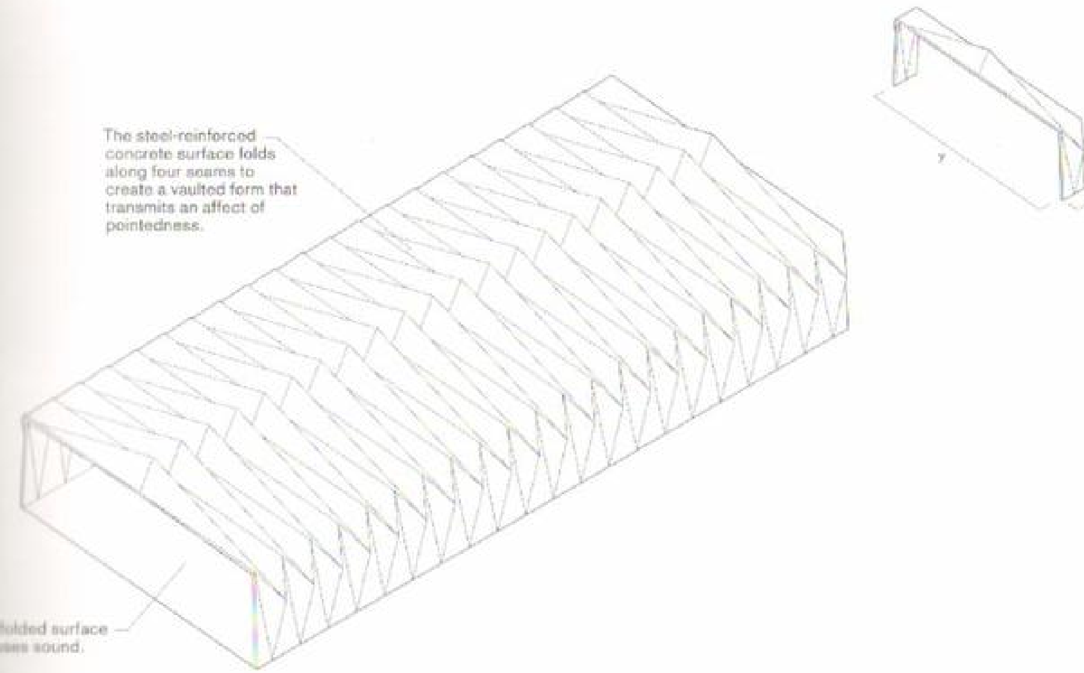


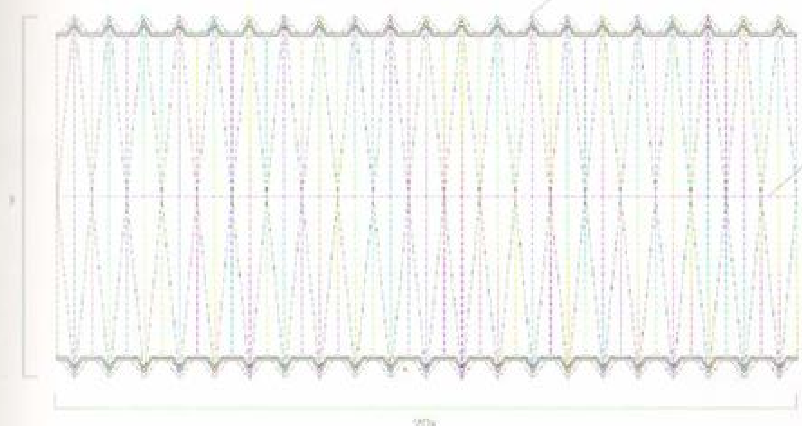


St. John's Abbey is produced by the horizontal tessellation of a folded plate base unit, a surface folded to create a portal section. The density and depth of the repeating folds determines the overall surface corrugation of the resulting form. In addition, the folds give structural strength to the surfaces, allowing them to span like a beam and adding rigidity between the surfaces of the upper and side walls. This assemblage transmits an optical affect of vaulting, pleating, tapering and differentiation, and an acoustical affect of diffusion.

Vaulting, Pointedness, Pleating, Diffusion

Horizontal / Folded Plate

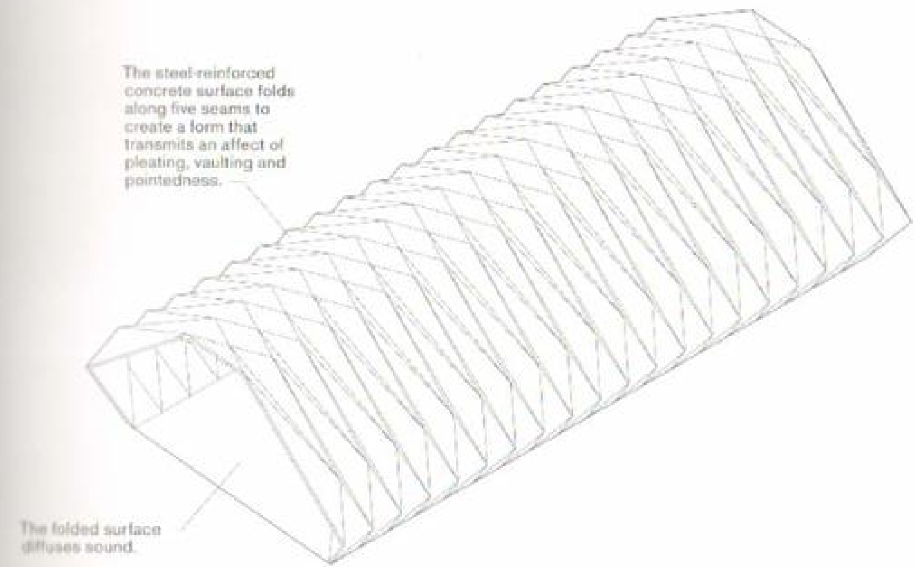


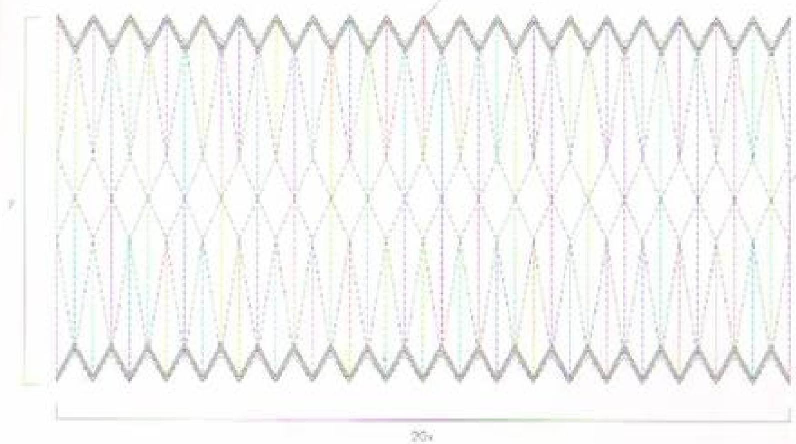


This form is produced by the horizontal tessellation of a folded plate base unit, a surface folded to produce a portal section. The density and depth of the repeating folds determine the overall surface corrugation of the resulting form. In addition, the folds give structural strength to the surfaces, allowing them to span like a beam and adding rigidity between the two upper planes and the surfaces of the side walls. This assemblage transmits an optical affect of vaulting, pointedness and pleating, and an acoustical affect of diffusion.

Pleating, Vaulting, Pointedness, Folding, Diffusion

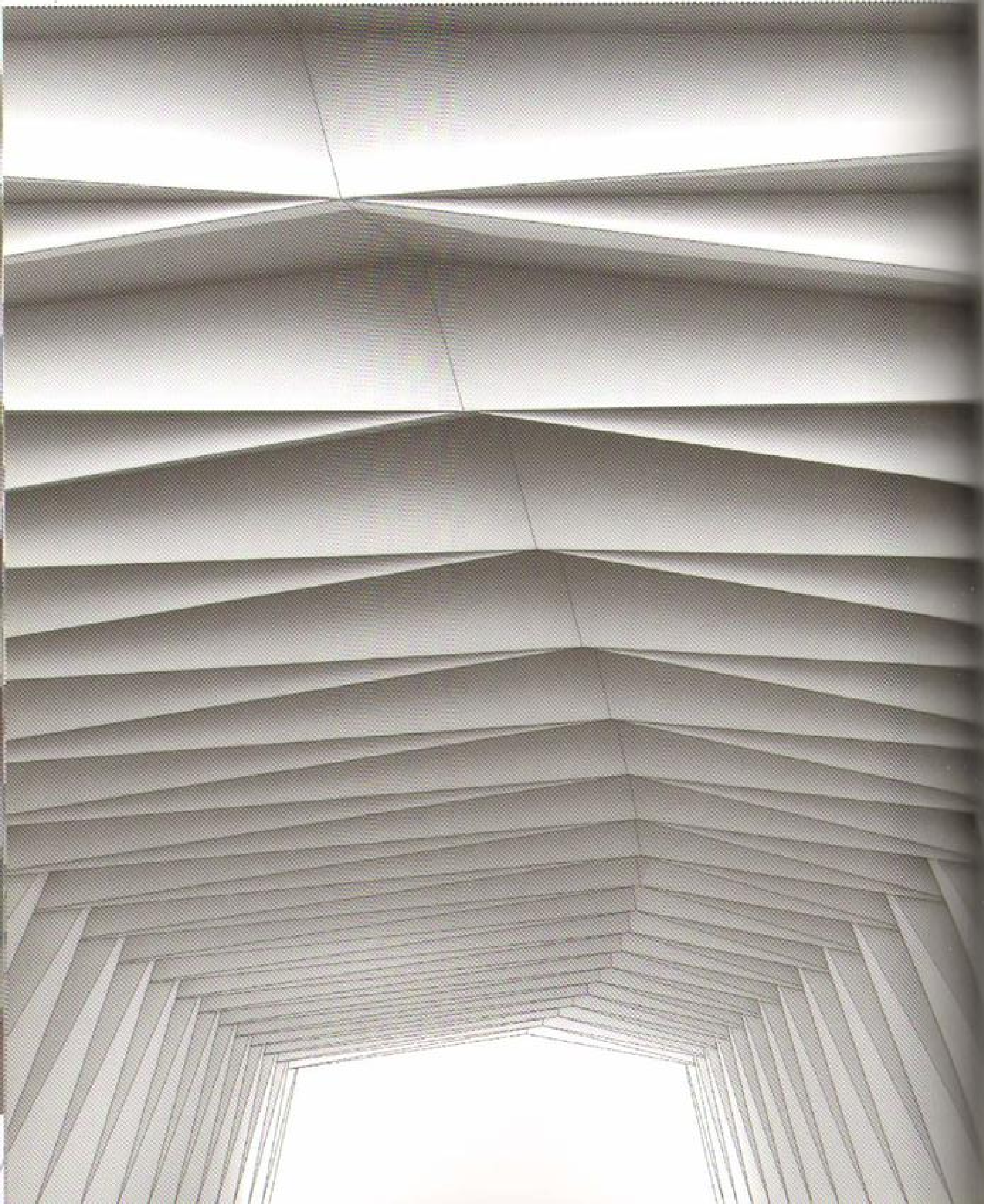
Horizontal / Folded Plate



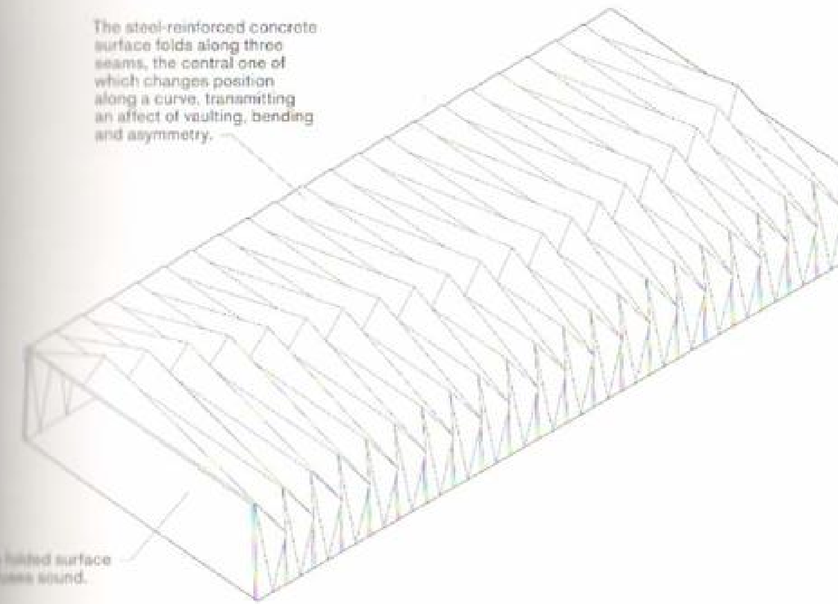


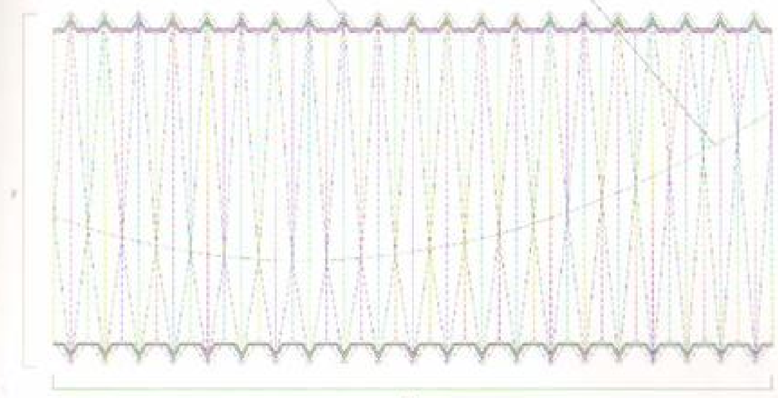
This form is produced by the horizontal tessellation of a folded plate base unit, a surface folded to produce a portal section. The surfaces bend to produce an apex at the centre, a ridge in section, and the side walls, which bend outwards, establishing rigidity and continuity between the top and side planes of the envelope. The resulting section approximates to a barrel vault. The folds give structural strength to the surfaces, allowing them to span like an arch and adding rigidity between the upper planes and the surfaces of the side walls. This assemblage transmits an optical affect of pleating, vaulting, pointedness and folding, and an acoustical affect of diffusion.

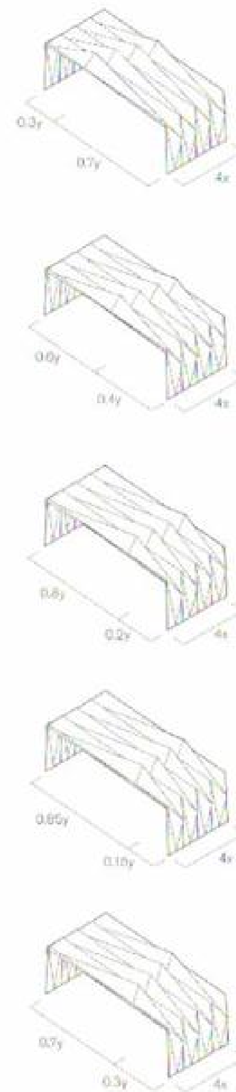
Pleating, Vaulting, Asymmetry, Bending, Diffusion



Horizontal / Folded Plate



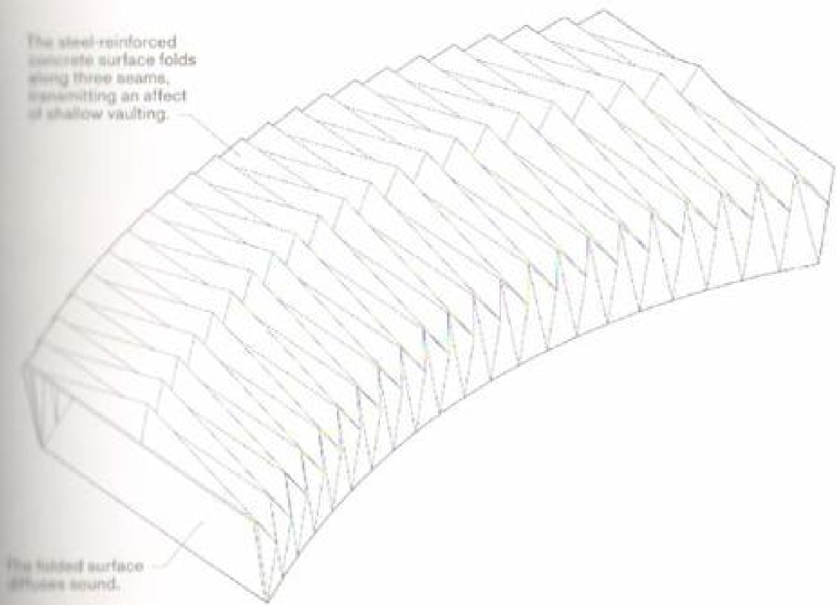


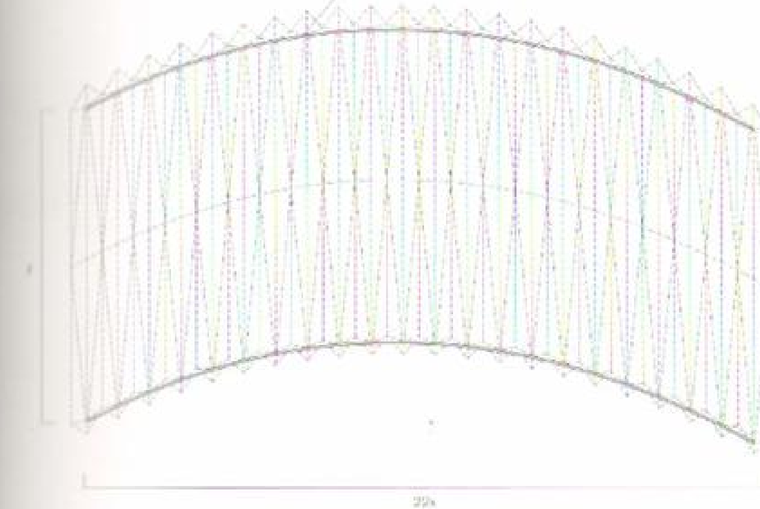


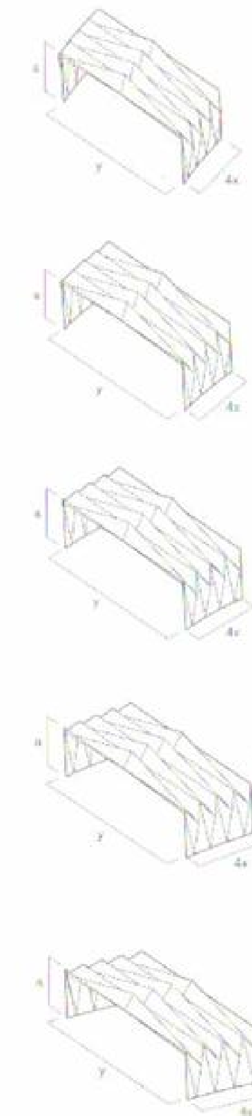
This form is produced by the horizontal tessellation of a folded plate base unit, a surface folded to produce a portal section with a gradually changing apex. The surfaces bend to produce a central apex, which follows a curve in plan, establishing rigidity and continuity between the top and side planes of the envelope. The density and depth of the repeating folds determine the overall surface corrugation of the resulting form. In addition, the folds give structural strength to the surfaces, allowing them to span like beams and adding rigidity between the upper planes and the surfaces of the side walls. This assemblage transmits an optical affect of pleating, vaulting, asymmetry and bending, and an acoustical affect of diffusion.

Pleating, Vaulting, Bending, Diffusion

Horizontal / Folded Plate



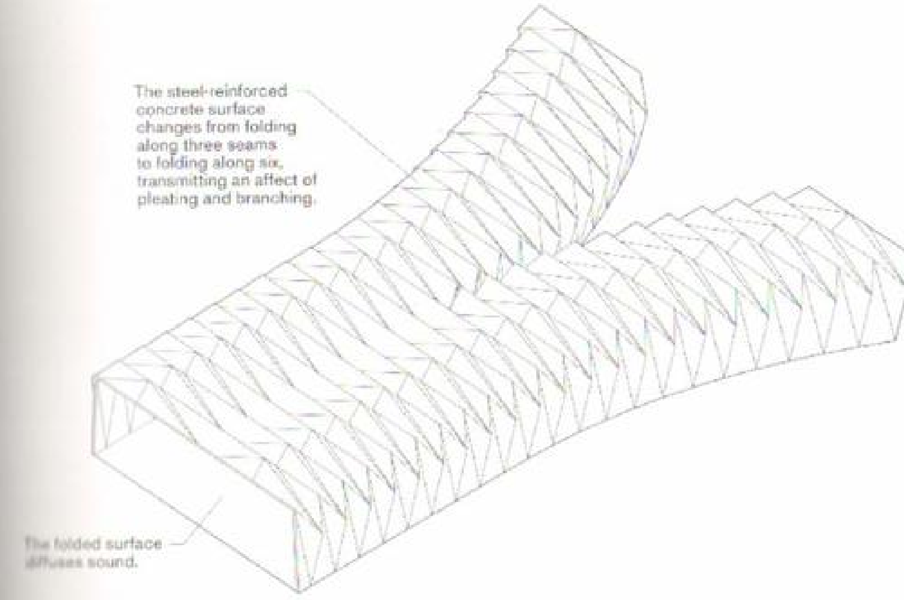


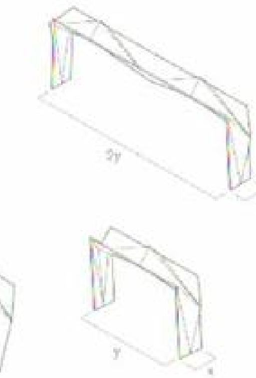


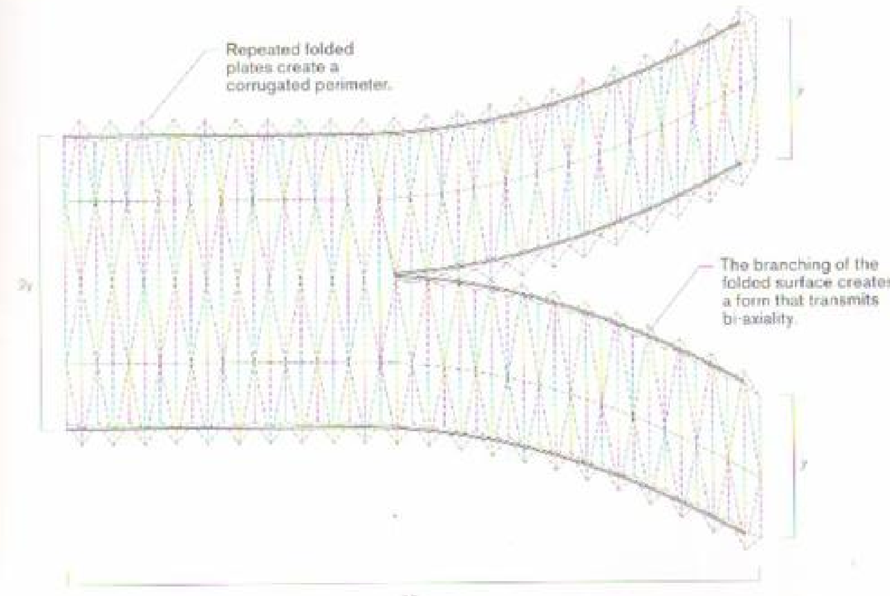
This form is produced by the horizontal tessellation of a folded plate base unit, a surface folded to produce a portal section with a central apex, which is curved in plan. Rigidity is established by the continuity between the top and side planes of the folded surface of the envelope, with both following the curvature of the plan. The folds give structural strength to the surfaces, allowing them to span like beams and adding rigidity between the upper planes and the surfaces of the side walls. This assemblage transmits an optical affect of pleating, vaulting and bending, and an acoustical affect of diffusion.

Pleating, Branching, Vaulting, Bi-axiality, Diffusion

Horizontal / Folded Plate

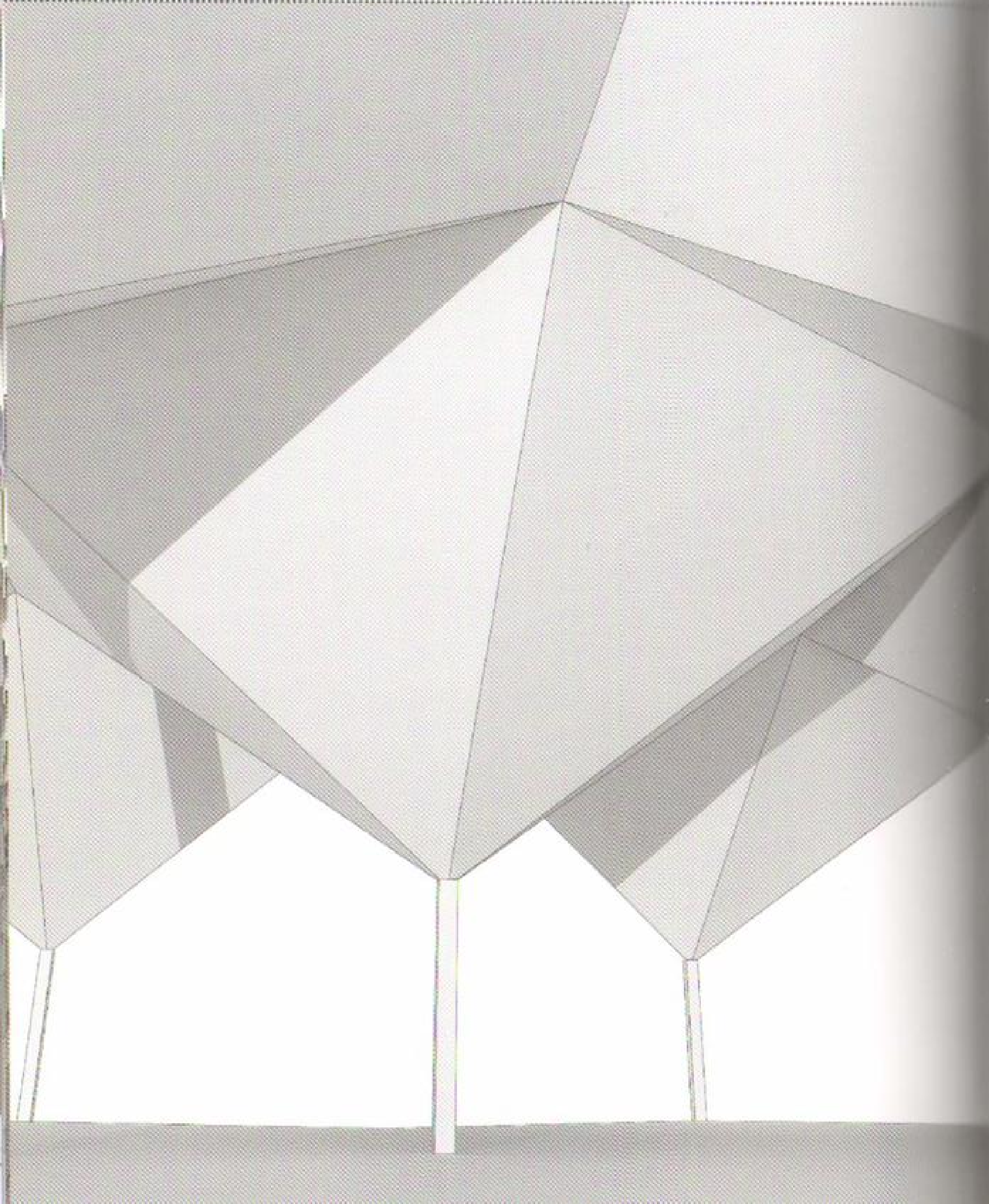




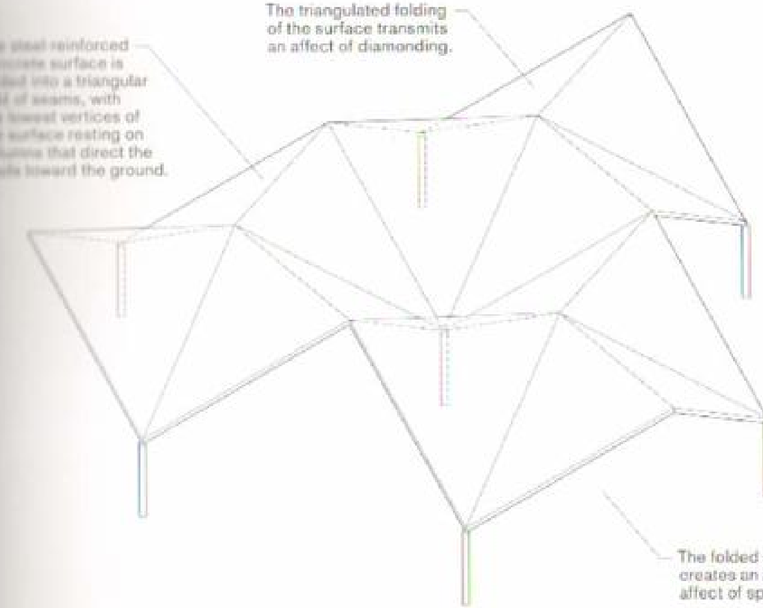


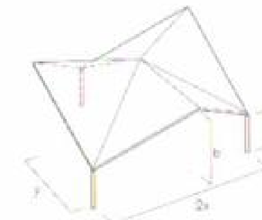
This form is produced by the horizontal tessellation of a folded plate base unit, a surface folded to produce a portal section, curved and bifurcated in plan, with two apexes. The surfaces bend to produce a single bay that branches into two separate bays. Rigidity is established by the folds of the surface as well as the continuity between the top and side planes of the envelope. The overall surface corrugation is determined by the density and depth of the folds. The folds give structural strength to the surfaces, allowing them to span like beams and adding rigidity between the upper planes and the surfaces of the side walls. This assemblage transmits an optical affect of pleating, branching, bi-axiality and vaulting, and an acoustical affect of diffusion.

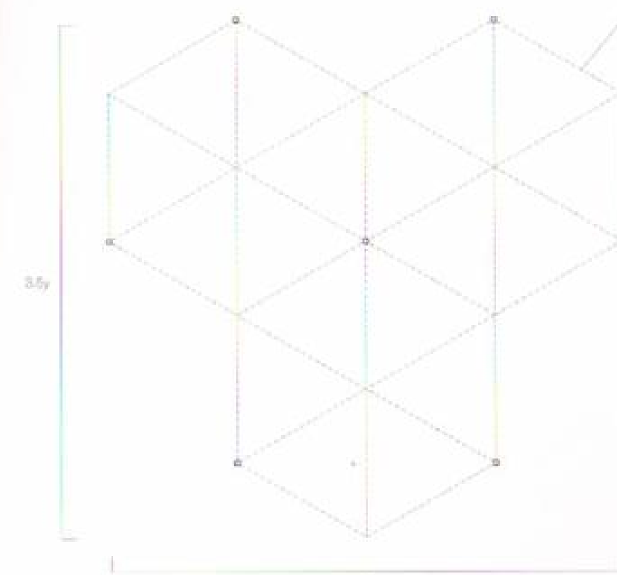
Diamonding, Openness, Specularity



Horizontal / Folded Plate

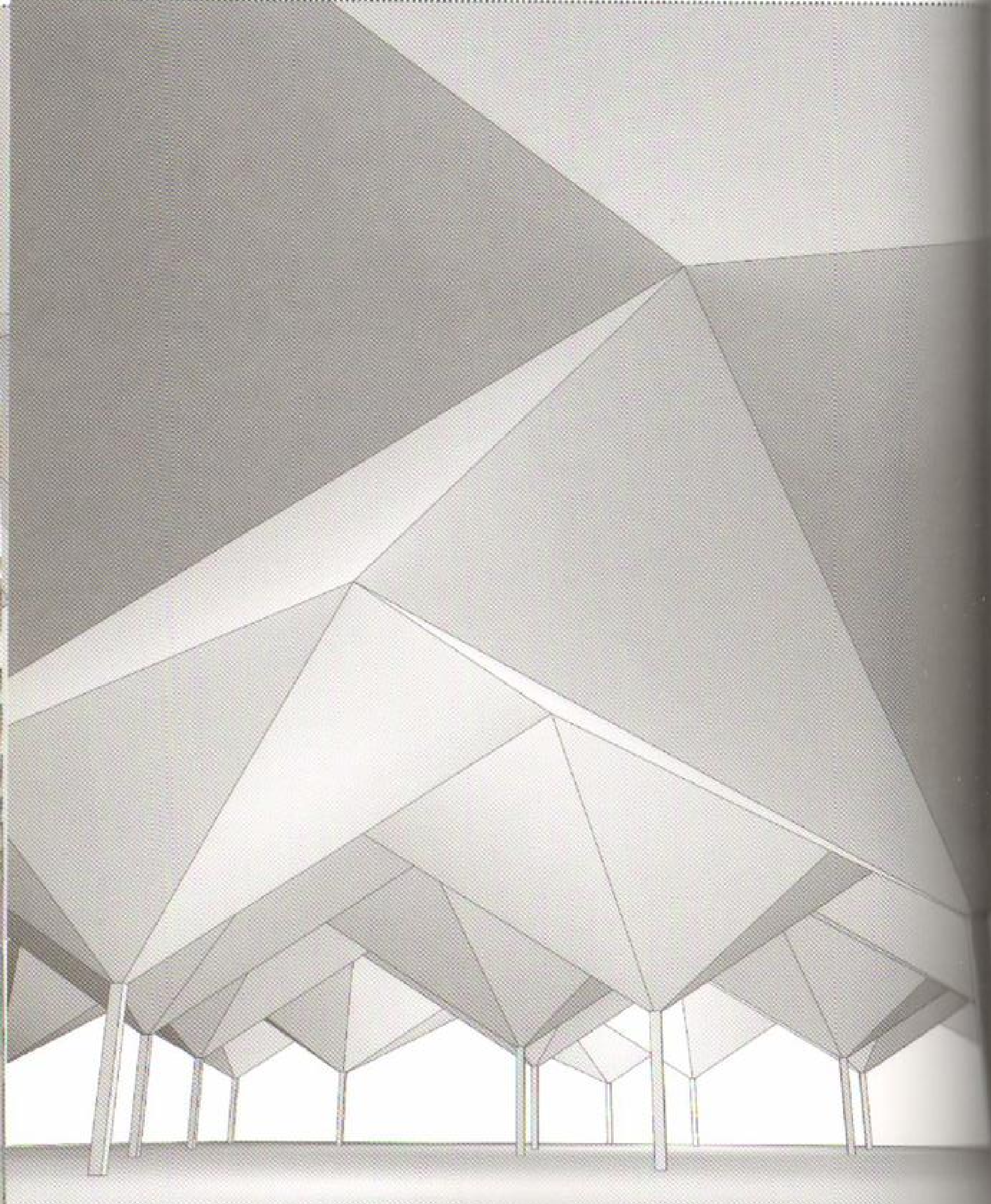




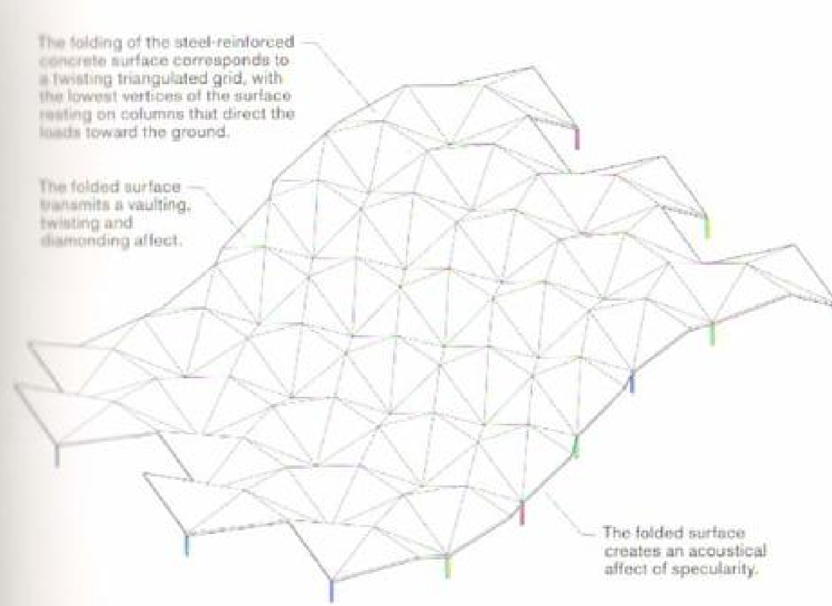


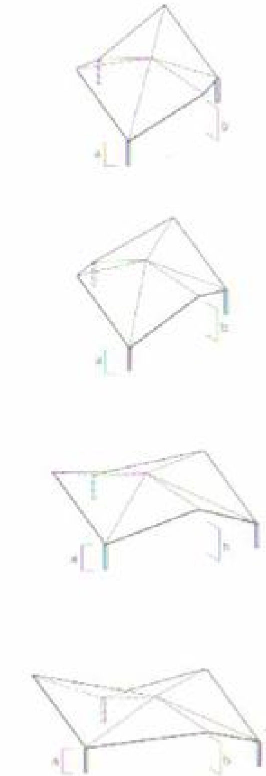
This form is produced by the horizontal tessellation of a folded plate base unit, a folded surface that spans between supporting columns which are set on a triangulated grid. The folded surfaces approximate to the surfaces of a vault, with the folds introducing rigidity. This assemblage transmits an optical affect of diamonding and openness, and an acoustical affect of specularity.

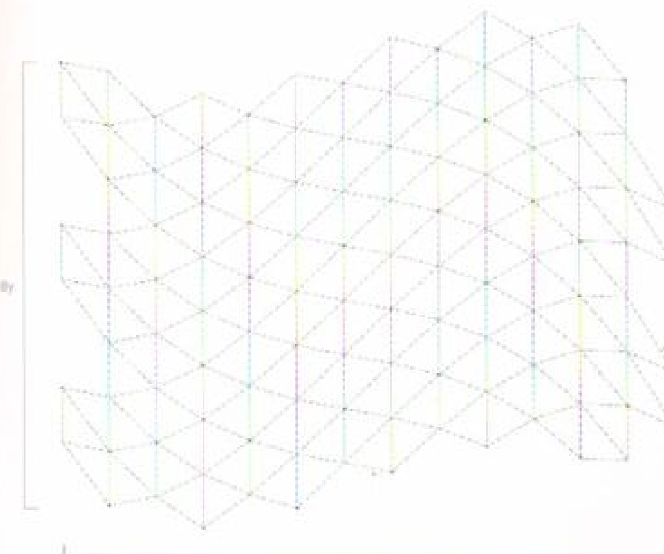
Diamonding, Vaulting, Twisting, Specularity



Horizontal / Folded Plate



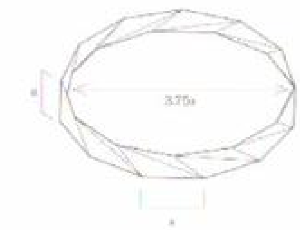


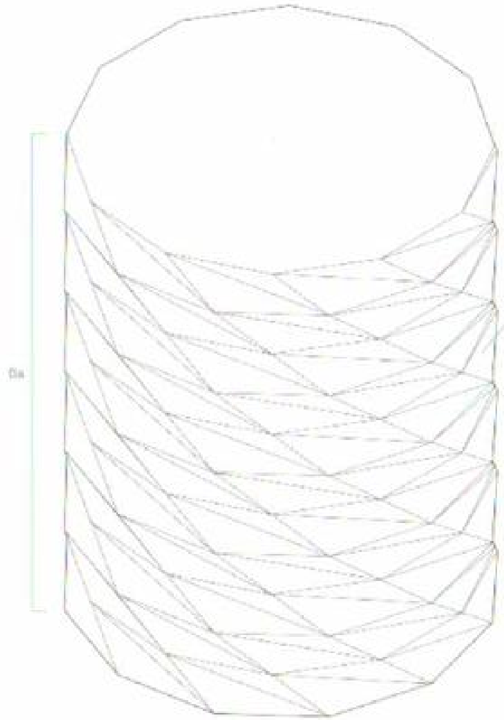


This form is produced by the horizontal tessellation of a folded plate base unit, a folded surface that spans outwards from the faces of a series of supporting columns that follow a triangulated grid which is distributed along a pattern of curves. The folded surfaces spanning between the columns approximate to the surfaces of a vault, with the folds introducing rigidity. This assemblage transmits an optical affect of diamonding, vaulting, and twisting, and an acoustical affect of specularity.

Pleating, Diamonding, Verticality, Diffusion, Focusing

Vertical / Folded Plate



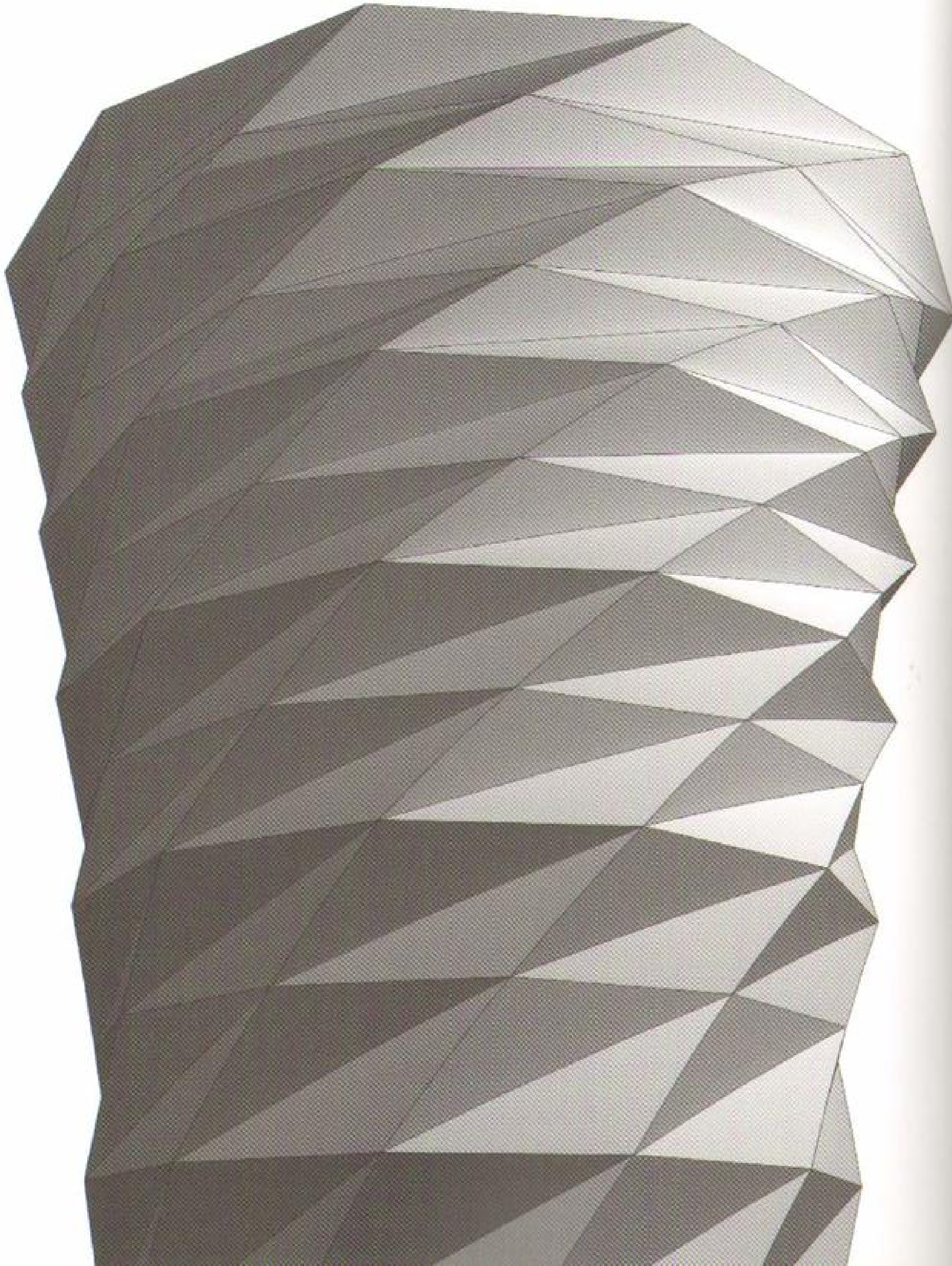


Vertical tessellation of the triangulated folded surface transmits an affect of diamonding and verticality.

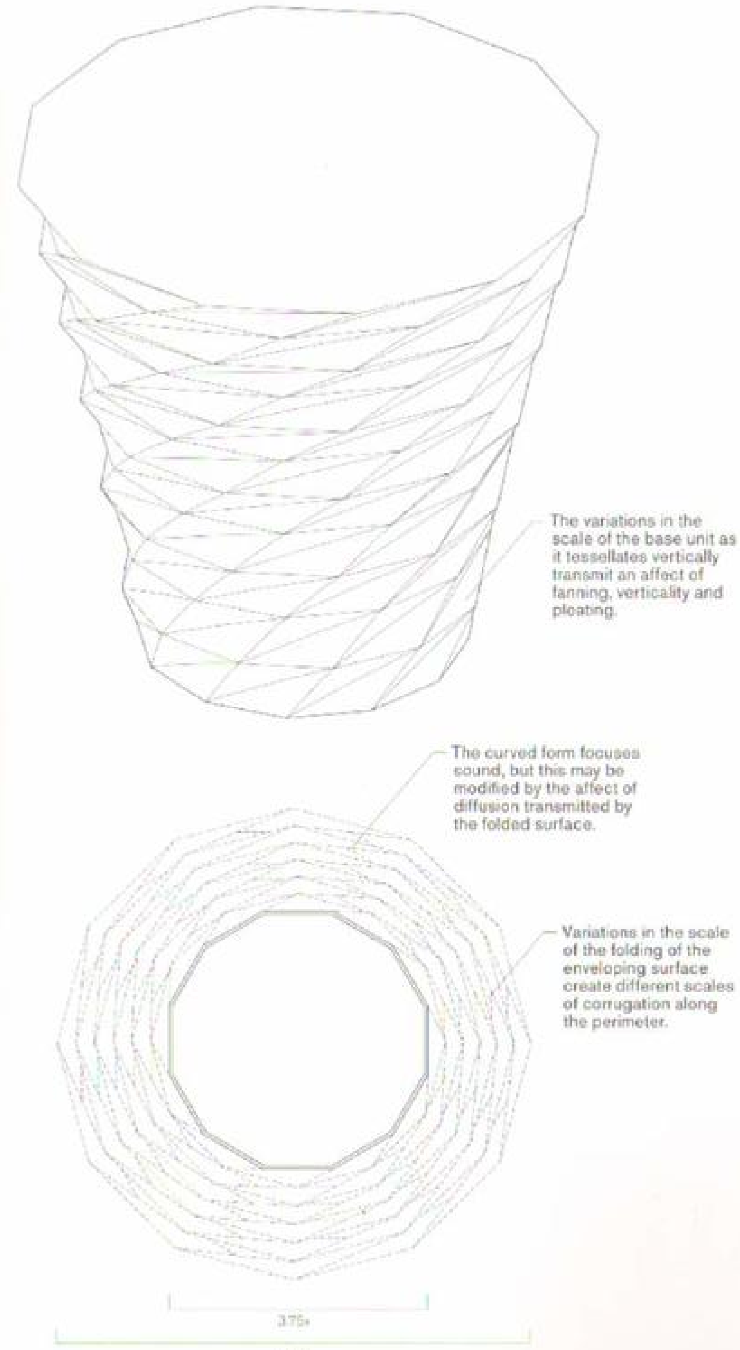
The curved form focuses sound, but this may be modified by the affect of diffusion transmitted by the folded surface.

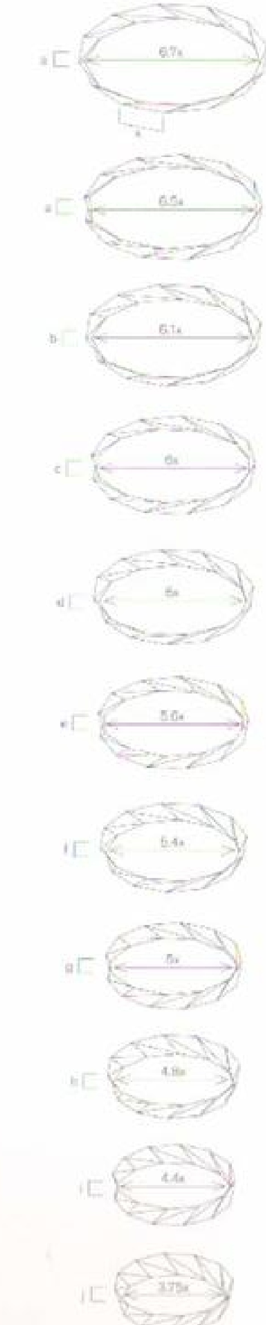
This form is produced by the vertical tessellation of a folded plate base unit, a surface which is folded to produce a horizontal ring. The rings are identical, producing a vertical figure with an extruded profile. This assemblage transmits an optical affect of pleating, diamonding and verticality, and an acoustical affect of diffusion and focusing.

Pleating, Fanning, Verticality, Diffusion, Focusing



Vertical / Folded Plate

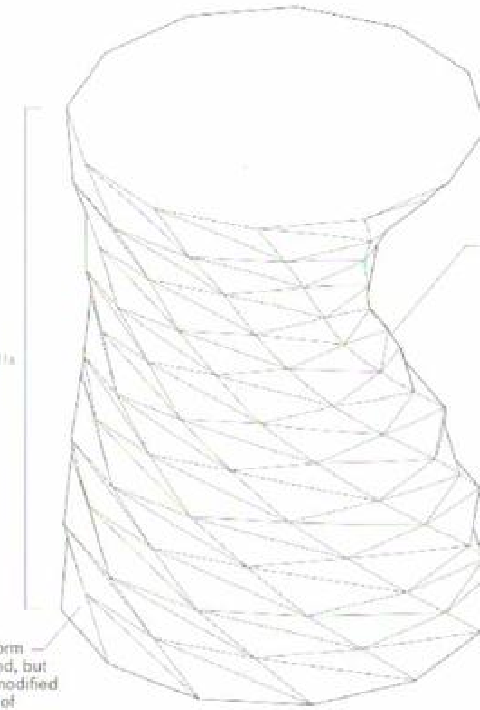




This form is produced by the vertical tessellation of a folded plate base unit, a surface which is folded to create a twelve-sided polygonal ring. The scale of the rings increases as the assemblage becomes taller, creating a profile that becomes wider towards the top. This assemblage transmits an optical affect of pleating, fanning and verticality, and an acoustical affect of diffusion and focusing.

Pleating, Twisting, Verticality, Diffusion, Focusing

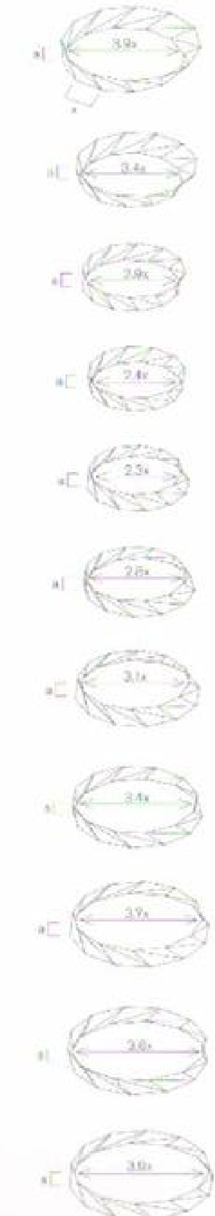
Vertical / Folded Plate



The steel surface folded around a circle creates a ring-shaped base unit that tessellates vertically while varying in scale and folding profile to form eleven different base units which together transmit an affect of twisting, pleating and verticality.

The curved form focuses sound, but this may be modified by the affect of diffusion transmitted by the folded surface.

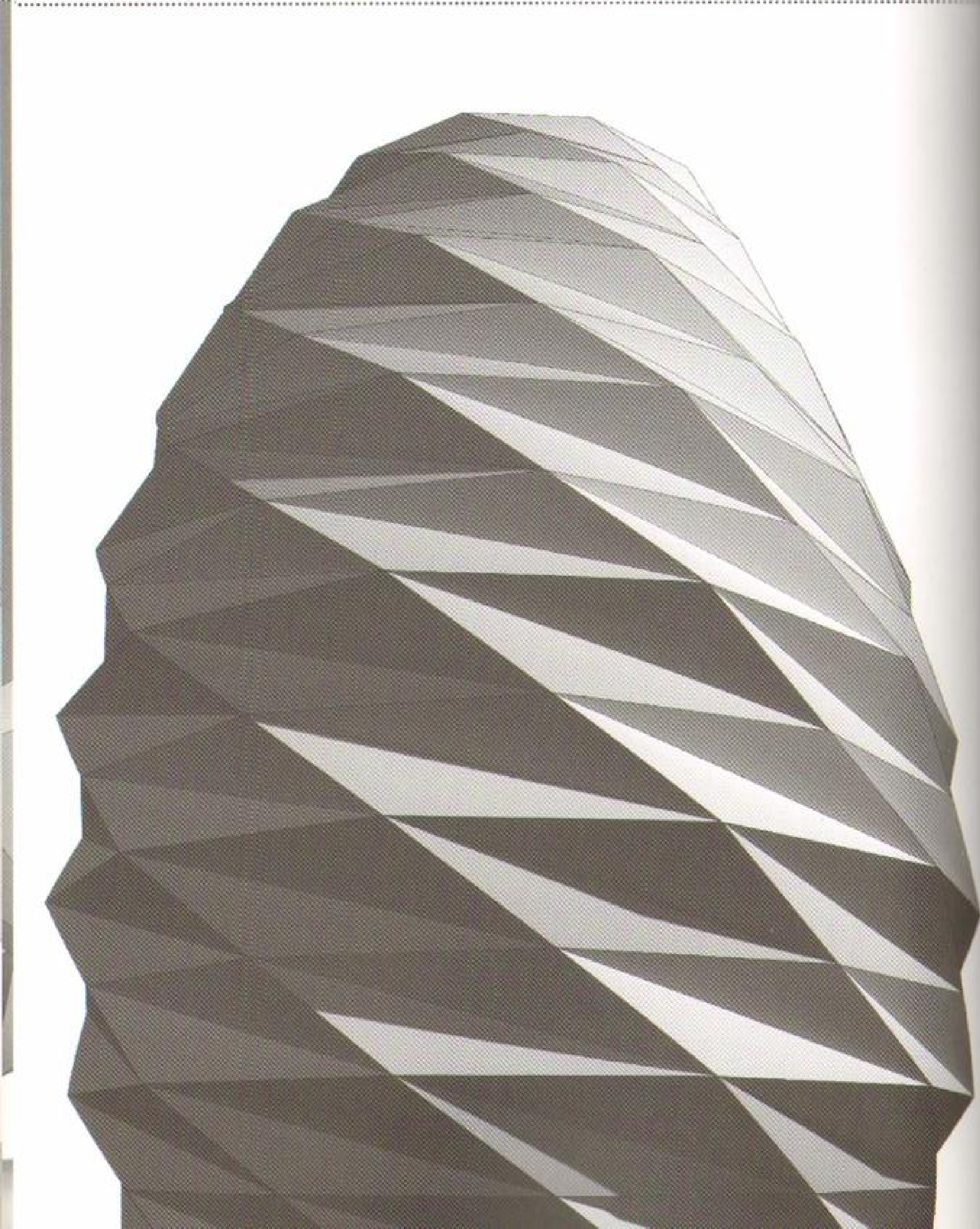
Variations in the folding of the enveloping surface create an asymmetrical, vertically extended space.

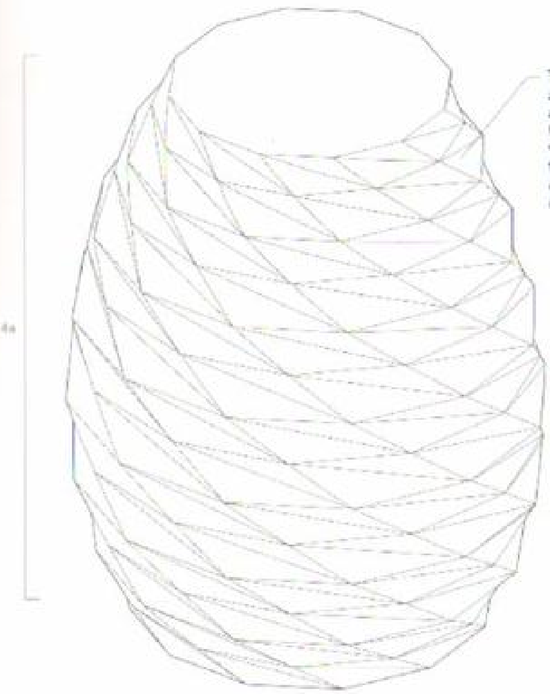


This horizontal form is produced by the vertical tessellation of a folded plat base unit, a folded surface in the form of a twelve-sided polygonal ring. The scale of the rings increases and decreases as the assemblage becomes taller to create eleven differently sized rings and a twisted profile which grows wider at the top and the bottom, but is narrower towards the center. This assemblage transmits an optical affect of folding, twisting and verticality, and an acoustical affect of diffusion and focusing.

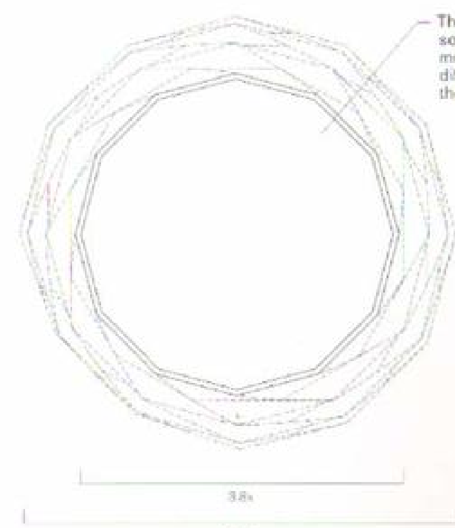
Pleating, Conicality, Diffusion, Focusing

Vertical / Folded Plate





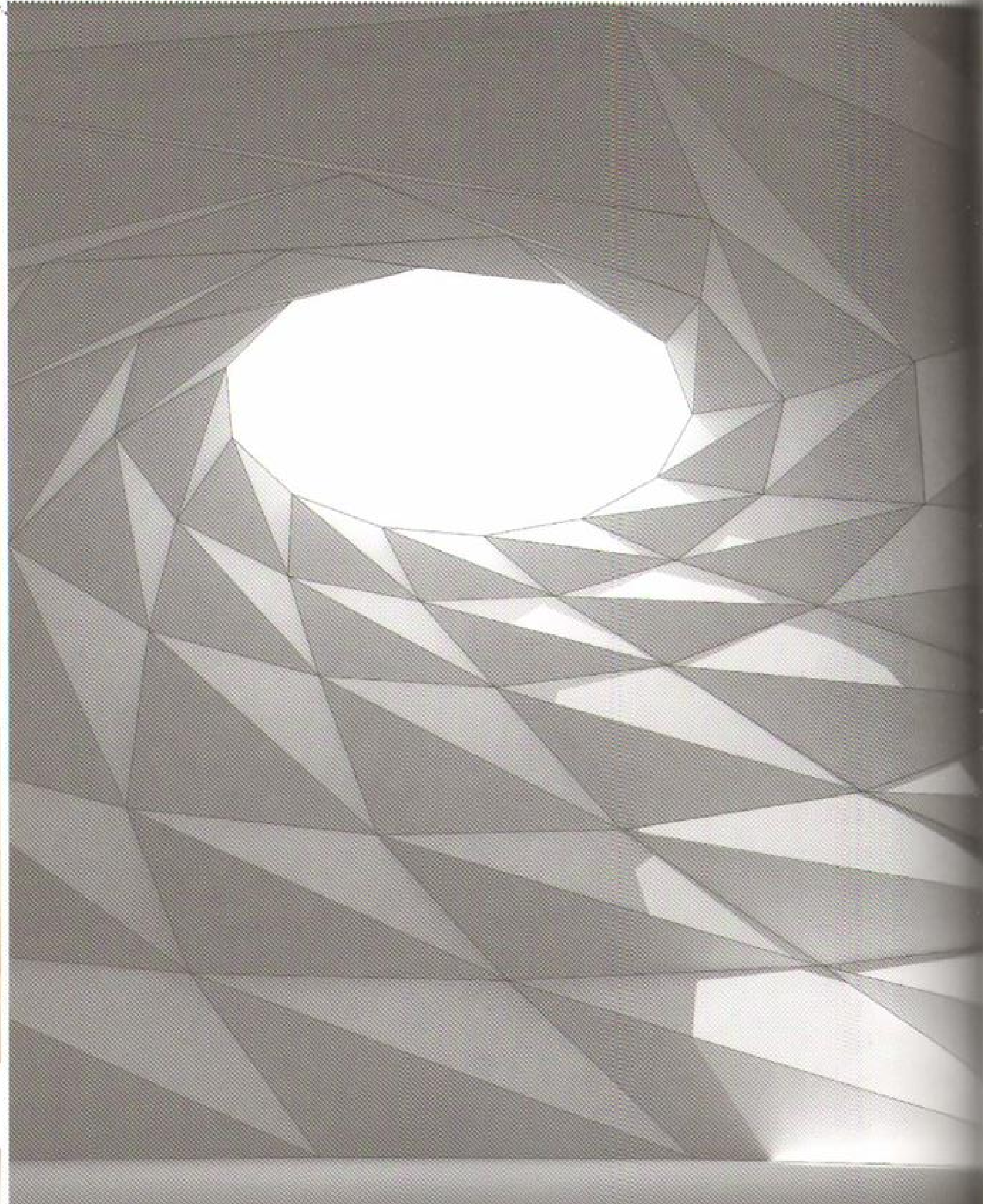
The steel surface folded around a circle creates a ring-shaped base unit that tessellates vertically while varying in scale and folding profile to transmit an affect of conicality and pleating.



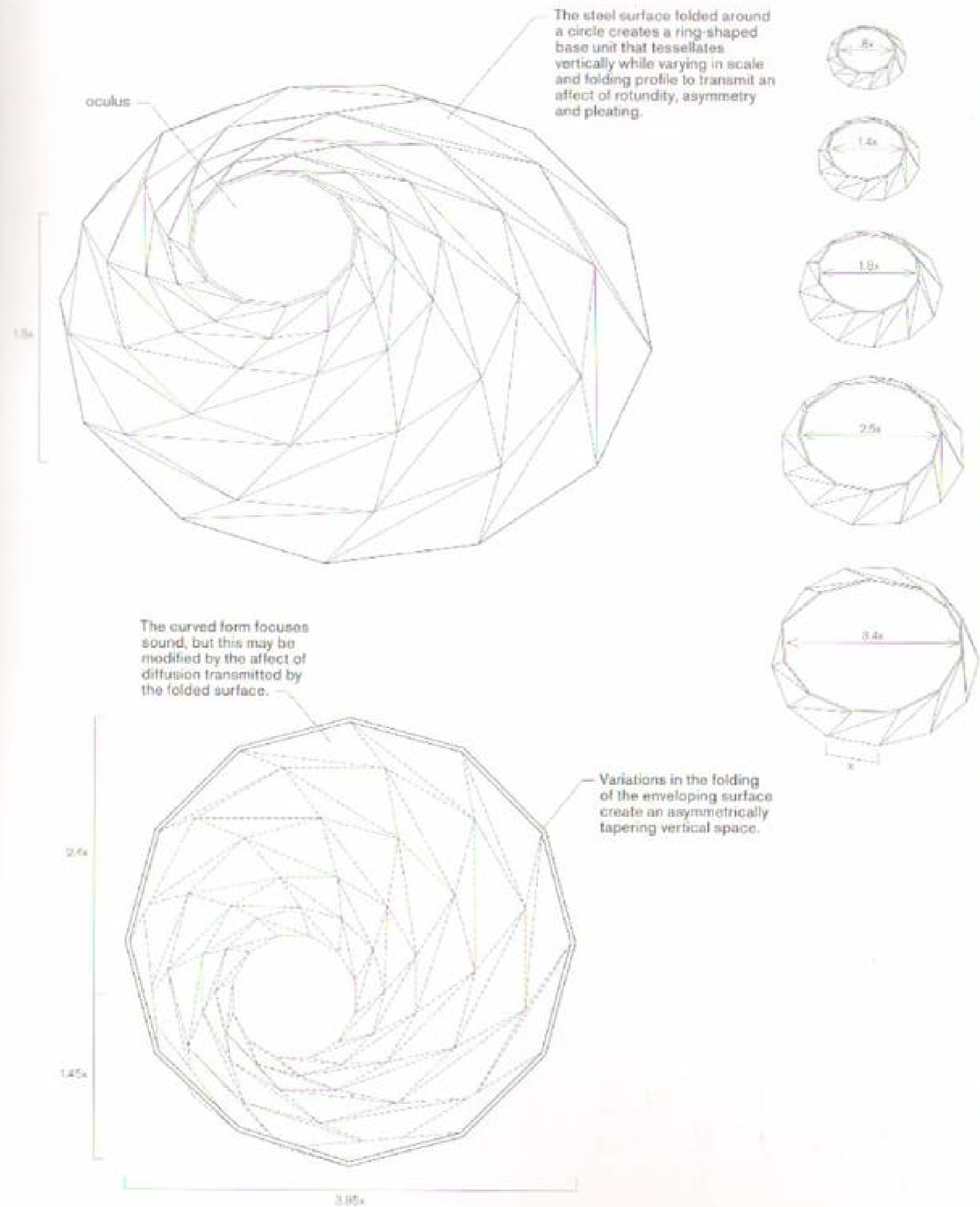
The curved form focuses sound, but this may be modified by the affect of diffusion transmitted by the folded surface.

This form is produced by the vertical tessellation of a folded plate base unit, a surface which is folded to create a twelve-sided polygonal ring. The scale of the rings increases in the center to create fourteen differently sized rings and a tapered profile. This assemblage transmits an optical affect of pleating and conicality, and an acoustical affect of diffusion and focusing.

Pleating, Rotundity, Asymmetry, Diffusion, Focusing

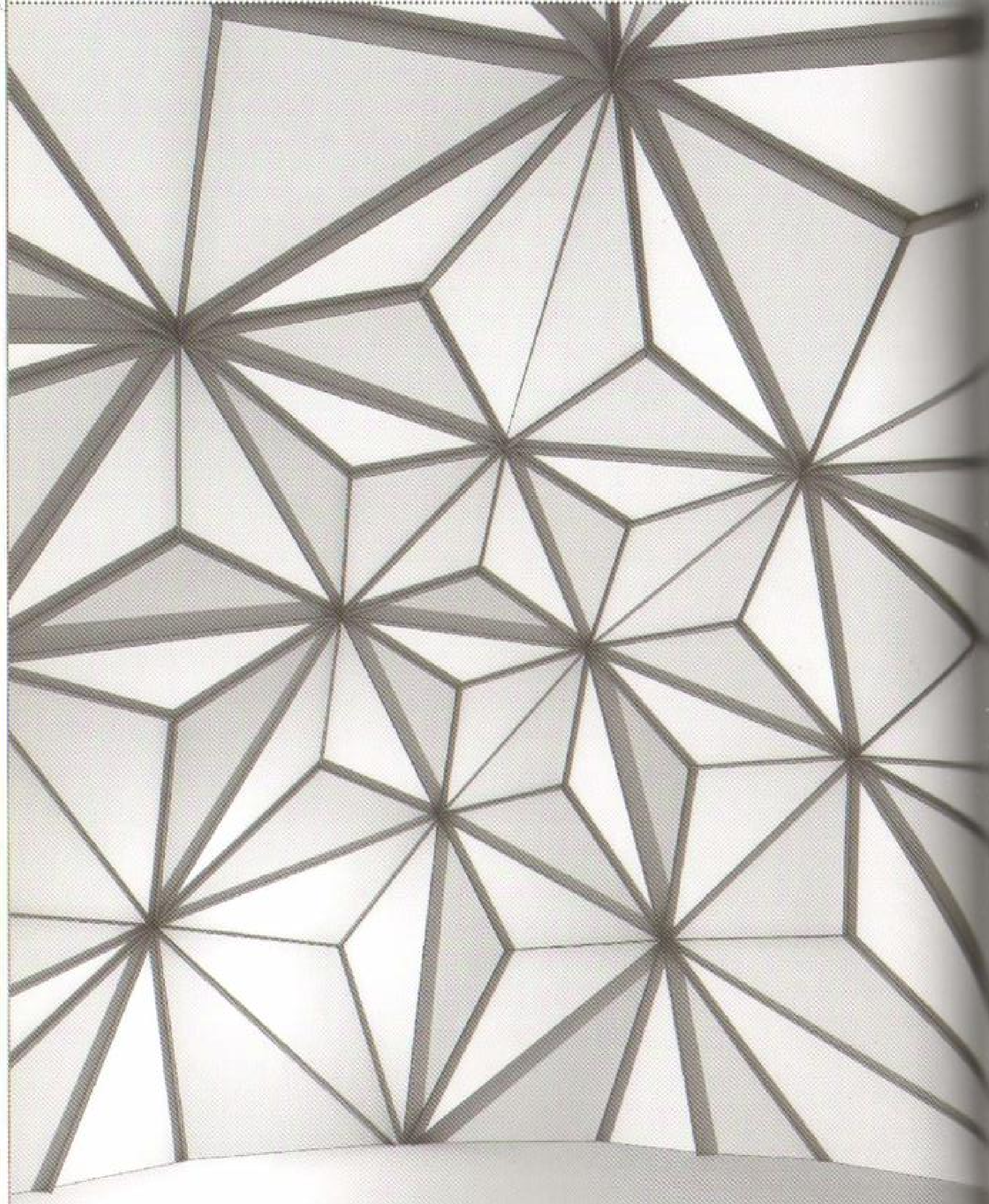


Vertical / Folded Plate



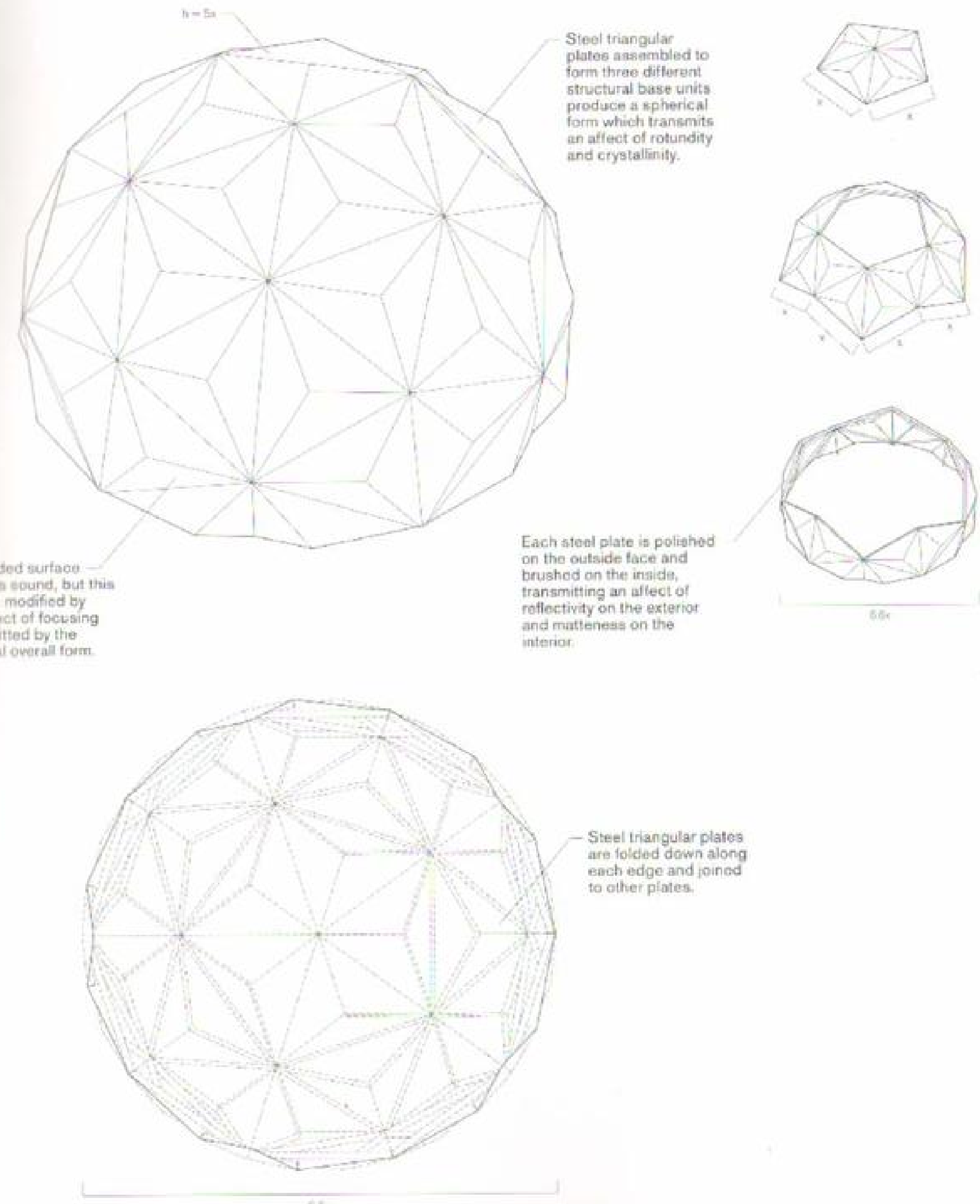
This form is produced by the vertical tessellation of a folded plate base unit, a surface which is folded to create a twelve-sided polygonal ring. The scale of the rings decreases to form five differently sized rings, stacked to form a domed structure. The height of the rings and their radii in plan gradually decrease to form a domed structure. This assemblage transmits an optical affect of pleating, rotundity and asymmetry, and an acoustical affect of diffusion and focusing.

Crystallinity, Rotundity, Reflectivity, Matteness, Diffusion, Focusing



Vertical / Folded Plate

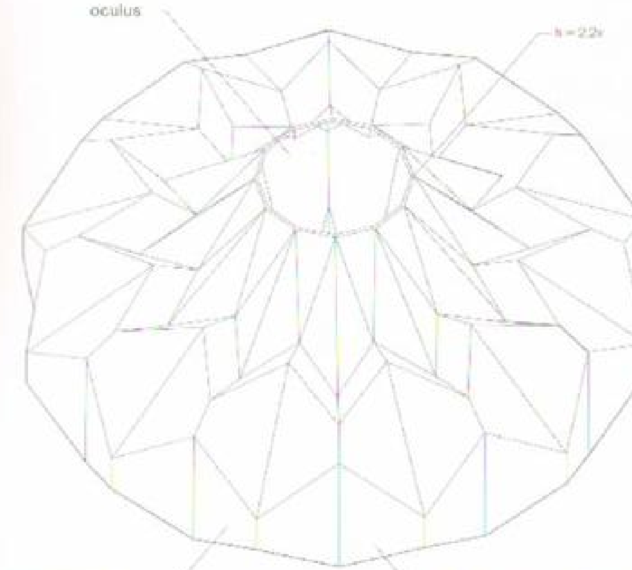
PLAN-TYPE GEODESIC STRUCTURE | R. BUCKMINSTER FULLER | 1949



The Plan Type Geodesic Structure is produced by the vertical tessellation of a folded plate base unit, a surface which is folded to create a ring. The scale and the degree of surface corrugation of the base unit are determined by the scale of the facets that subdivide the surface in a star-shaped pattern and approximate to the curvature of a dome, here tessellated as triangulated, planar, folded-plate surfaces. The curvature is generated by the scale of the facets. This assemblage transmits an optical affect of crystallinity, rotundity and symmetry, and an acoustical affect of diffusion and focusing.

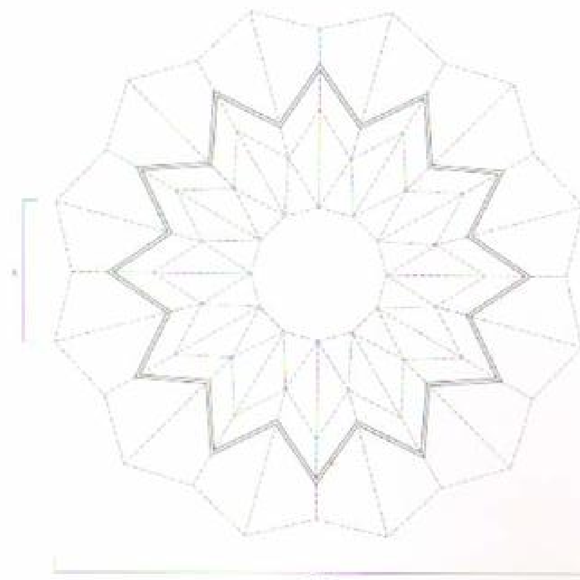
Pleating, Rotundity, Fanning, Diffusion, Focusing

Vertical / Folded Plate



The folded surface diffuses sound, but this may be modified by the affect of focusing transmitted by the domical overall form.

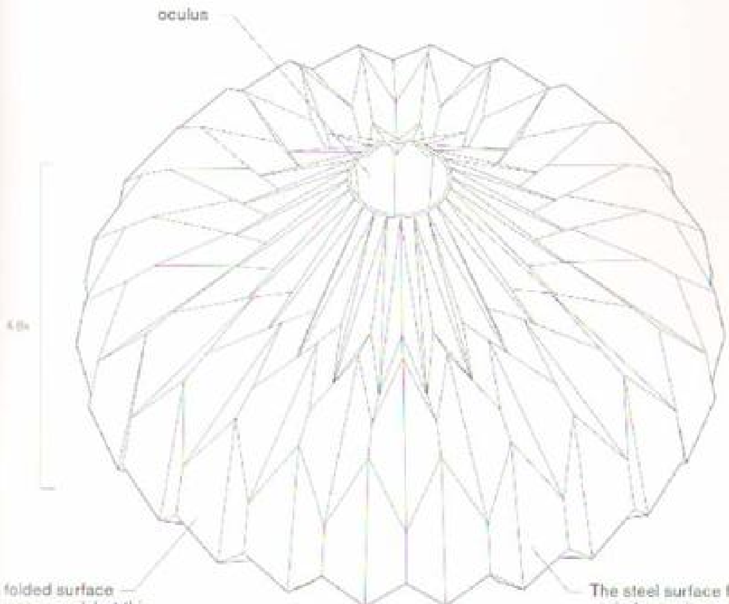
The steel surface folded around a circle creates a ring-shaped base unit that tessellates vertically into four different structural rings which together create a domed form transmitting an affect of pleating, rotundity and fanning.



This form is produced by the vertical tessellation of a folded plate base unit, a surface which is folded to create a ring. The scale and degree of surface corrugation are determined by the number of folds introduced into the plan, which in this case is twelve. As the envelope rises, the depth of the folds decreases in plan to create the domed form. This assemblage transmits an optical affect of pleating, rotundity and fanning, and an acoustical affect of diffusion and focusing.

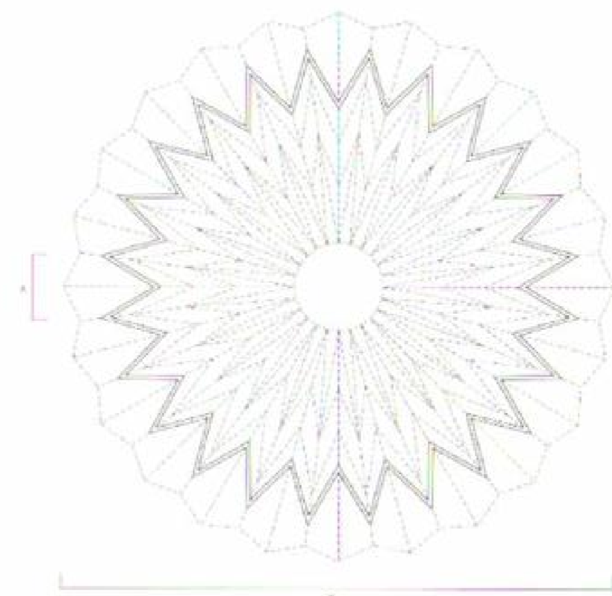
Pleating, Rotundity, Fanning, Diffusion, Focusing

Vertical / Folded Plate



The folded surface diffuses sound, but this may be modified by the affect of focusing transmitted by the domical overall form.

The steel surface folded around a circle creates a ring-shaped base unit that tessellates vertically into four different structural rings which together create a domed form transmitting an affect of pleating, rotundity and fanning.



This form is produced by the vertical tessellation of a folded plate base unit, a surface which is folded to create a ring. The scale and degree of surface corrugation are determined by the number of folds introduced into the plan, which in this case is twenty-four. As the envelope rises, the depth of the folds decreases in plan to create the domed form. This assemblage transmits an optical affect of pleating, rotundity and fanning, and an acoustical affect of diffusion and focusing.

Folded Plate and Truss

The base unit of a steel truss folded plate is composed of steel truss members triangulated to form a stiff, stable lattice. Steel truss folded plates direct the bending through the top and bottom chords of the truss while shear stresses are directed through the diagonal elements. The combination of the individual elements, even if they are individually under-dimensioned, provides structural strength. The distribution of loads through steel plate produces a portal form with the truss in the upper part of the section and the folded plate in the lower. This distribution of loads along the surface and lines of the folded plate and steel truss embeds the plate and truss folded plate with an optical affective property of pleating and diamonding that remains consistent within any space it defines. A plate and truss folded plate adds diffusion to modify or dominate the acoustical affect of its macro-geometry, which can be focusing (curved) or specular (flat).

Plates and truss folded plates are flexible in several ways:

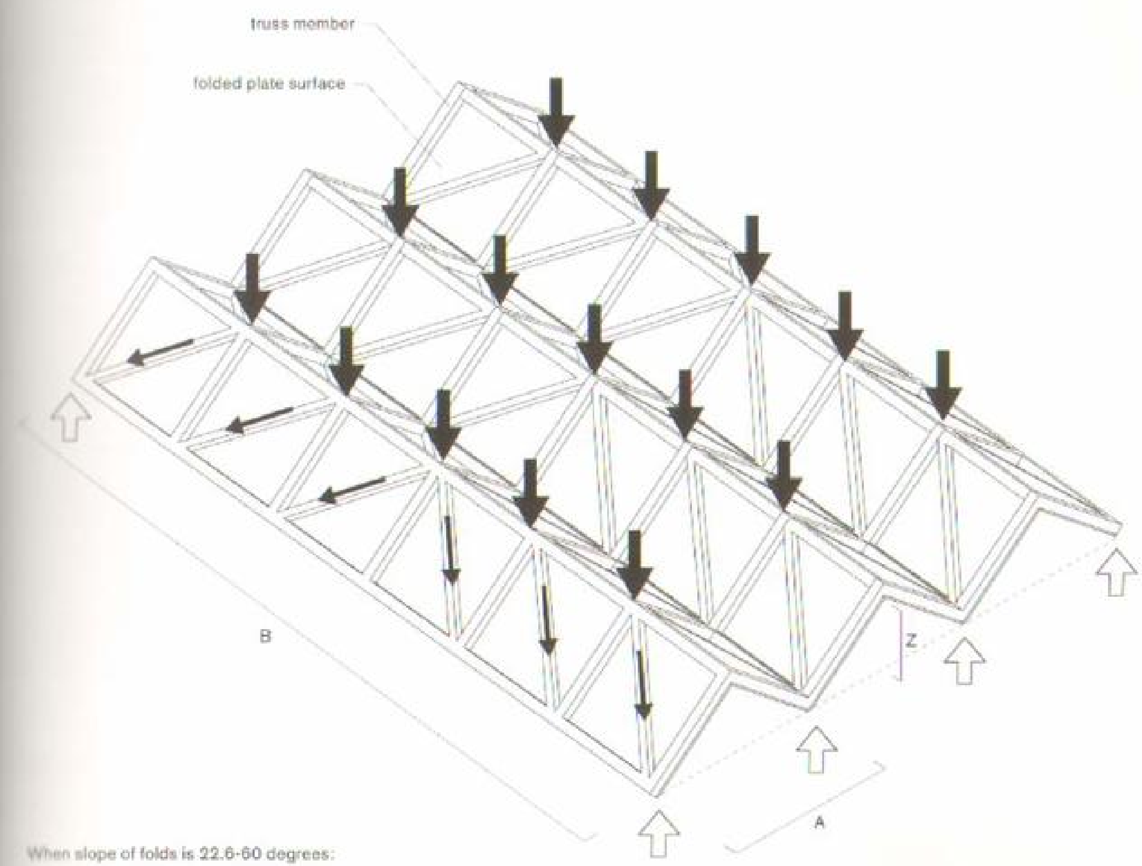
Profile: The protogeometry of steel plates with truss folded plates allows them to be flexible, in similar fashion to the concrete folded plate, by varying the location of the apexes of the folds, ranging from spanning two supporting walls, to a basic three-sided "portal" section, to a highly folded nave section.

Steel plates with truss folded plates can tessellate horizontally and concentrically along horizontal or vertical axis of growth to produce structures which are horizontal (sheds) or vertical towers and domes.

Scale: The rate and scale of the folds can vary, changing the overall subdivision of the section.

Depth: The depth of the folds can also vary according to the scale and rate of subdivision of the overall plate. The deeper the folds, the more structural depth they gain, thus the more structural depth is available for the truss.

Affect: The affective property of steel plates with truss folded plates can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to pleating and diamonding, a structure built of steel plates with truss folded plates can transmit other optical affects, including arching, differentiation, cantilevering, asymmetry, flatness, branching, fluidity, vaulting, twisting, non-directionality, horizontality, folding, fanning, symmetry, slanting, tubularity. The acoustical affect is diffusion.



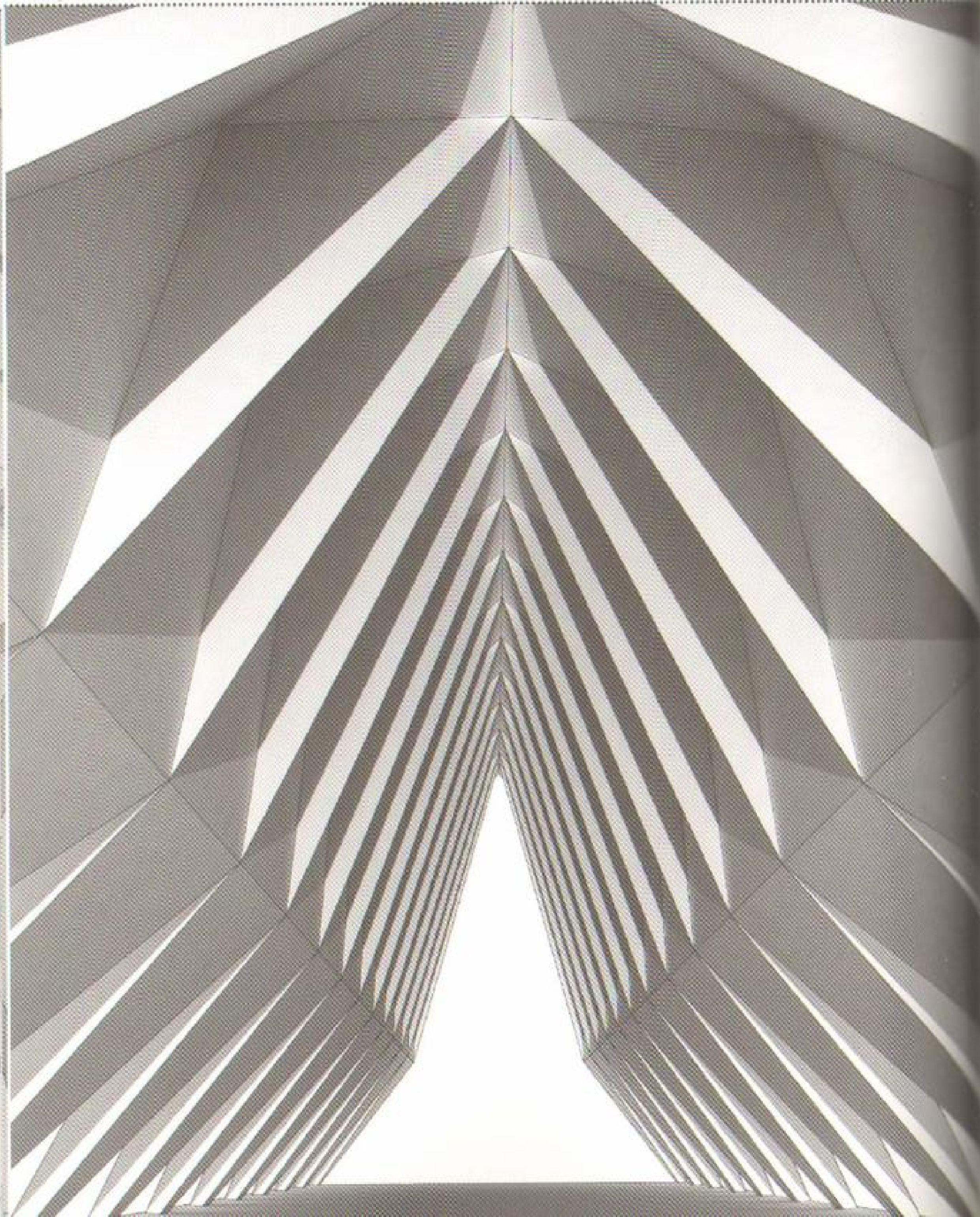
When slope of folds is 22.6-60 degrees:

Z/A = 0.2–0.8

As B increases, Z/A must also increase.

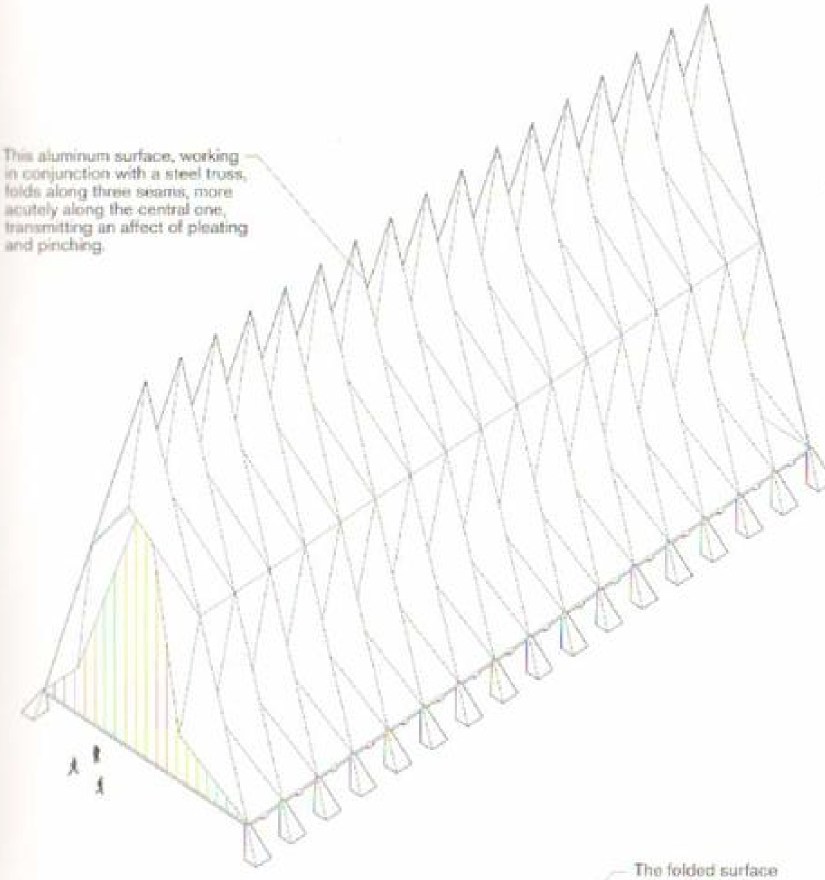
If Z/A is 2 or less the internal bending and shear forces will result in tension in the top of the folds and tension in the bottom at mid span. Similarly, shear stresses will be greatest close to the supports in the plane of the folds. The fold acts like the section of a beam when resisting bending and shear forces.

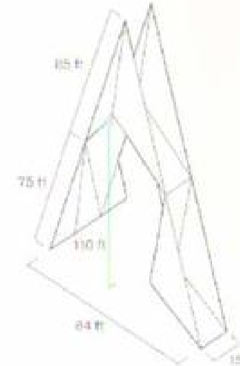
Pleating, Axiality, Pinching, Diffusion

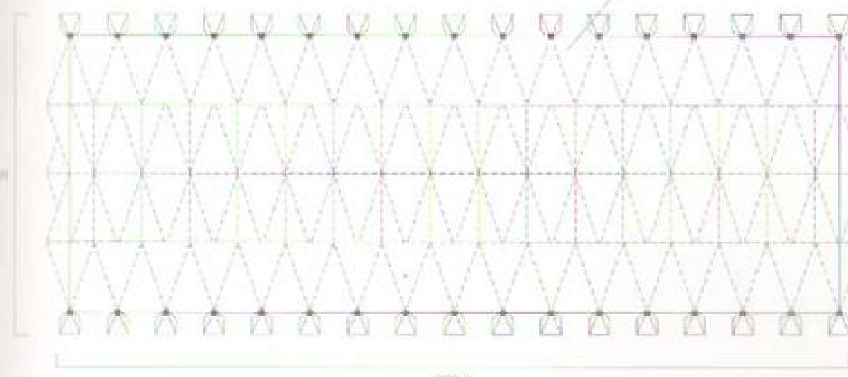


Horizontal / Folded Plate and Truss

AIR FORCE ACADEMY CHAPEL | SKIDMORE, OWINGS & MERRILL (W.A. NETSCH, G. BUNSHAFT) | COLORADO SPRINGS, USA | 1962



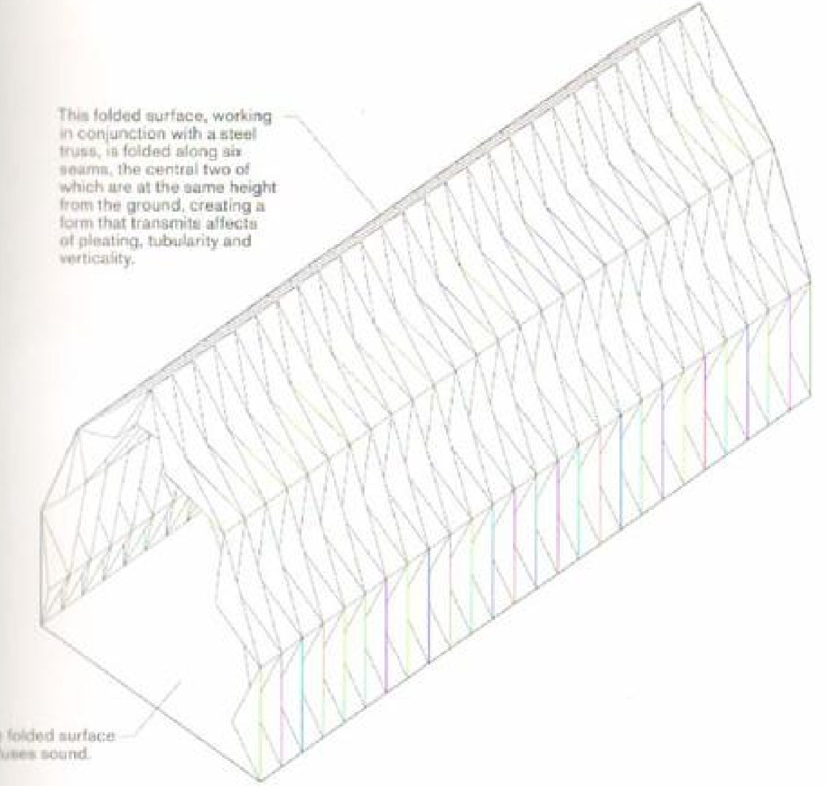


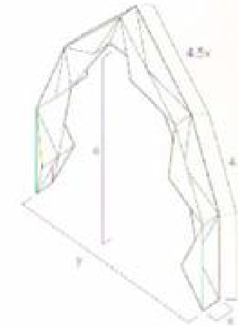


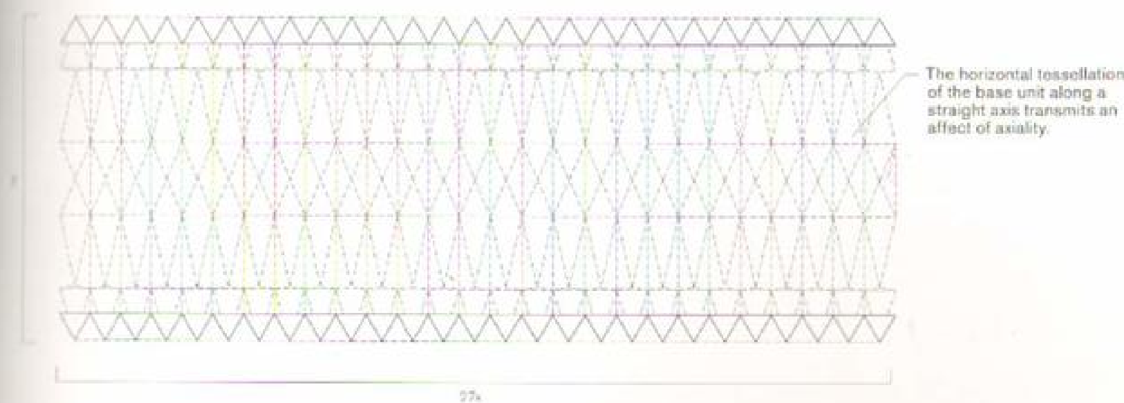
The Air Force Academy chapel is formed by the horizontal tessellation of a plate and truss folded plate base unit, a series of repeating folded surfaces, complemented by a truss, to create a portal section with a pointed apex at its center. The surfaces bend to produce surface continuity and rigidity along the section. The corrugation of the overall surface is determined by the density and depth of the folds, complemented in section by the truss. The folds and truss give structural strength to the section, allowing it to span like an arch. The Air Force Academy chapel transmits an optical affect of pleating, axiality and pinching, and an acoustical affect of diffusion.

Pleating, Tubularity, Verticality, Diffusion

Horizontal / Folded Plate and Truss



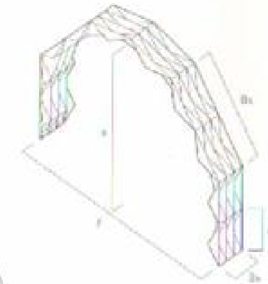


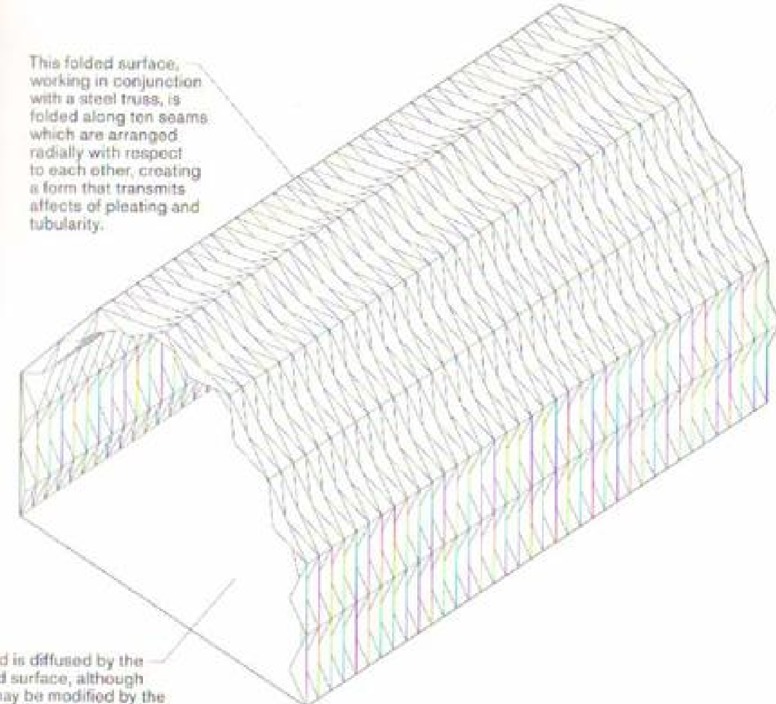


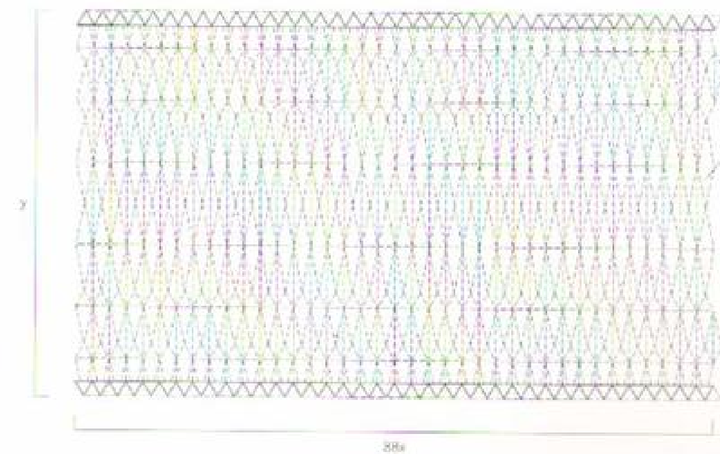
This form is produced by the horizontal tessellation of a plate and truss folded plate base unit, shaped into a portal section with a faceted apex at its center. The surfaces bend to produce surface continuity and rigidity along the section. The corrugation of the overall surface is determined by the density and depth of the folds, complemented in section by the truss. The folds and truss give structural strength to the section, allowing it to span like an arch. This assemblage transmits an optical affect of pleating, tubularity and verticality, and an acoustical affect of diffusion.

Pleating, Tubularity, Axiality, Diffusion, Focusing

Horizontal / Folded Plate and Truss

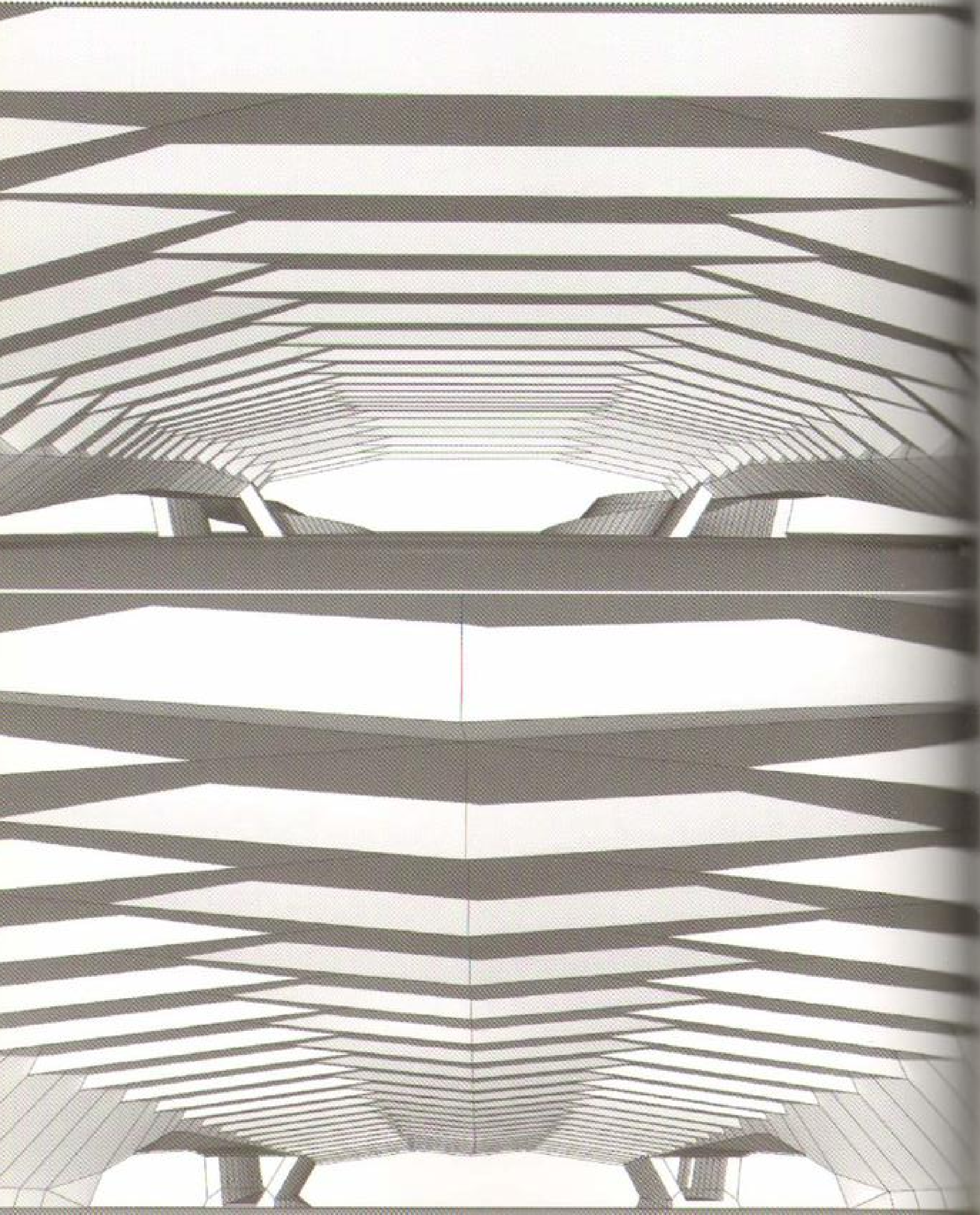






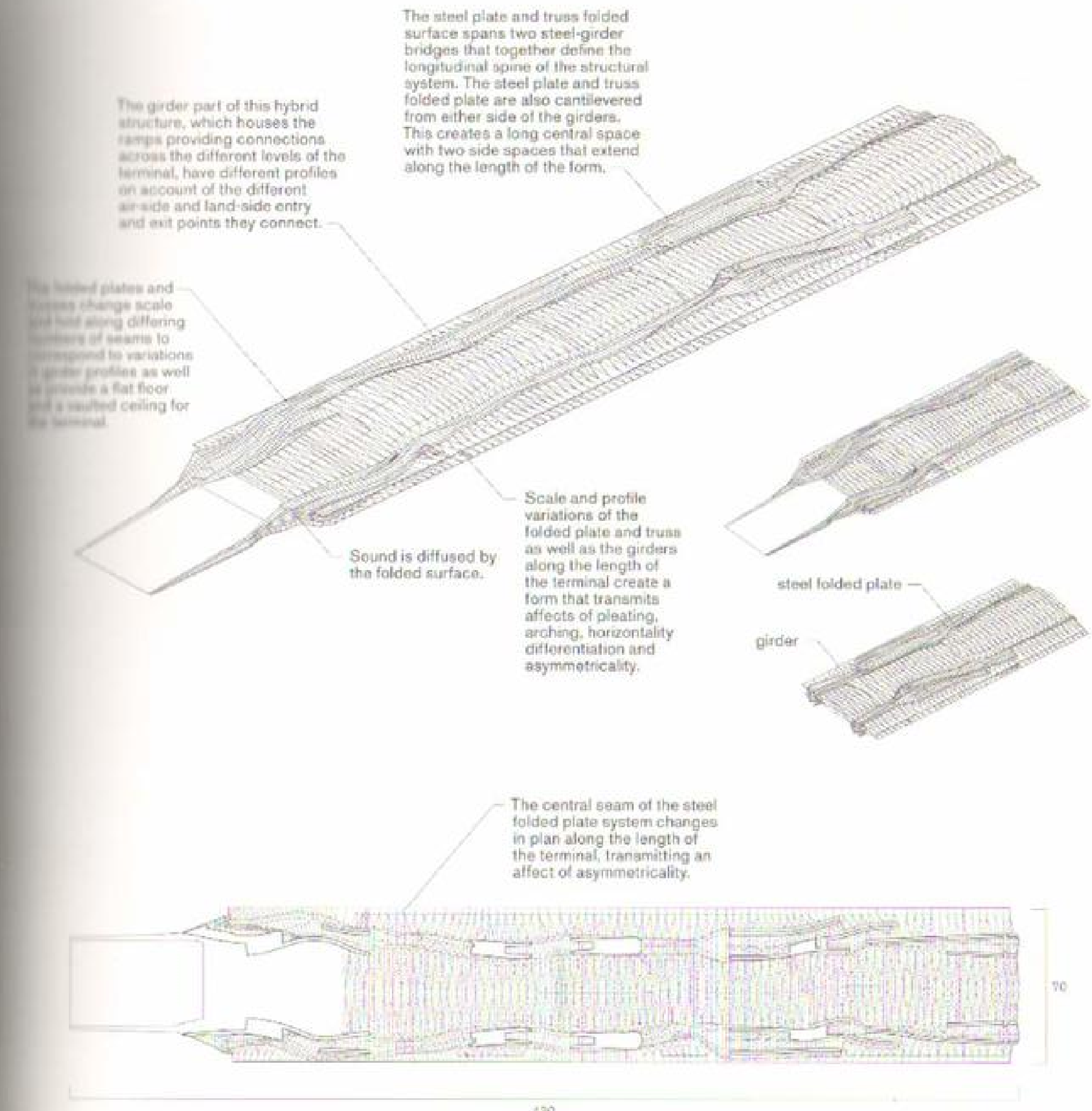
This form is produced by the horizontal tessellation of a plate and truss folded plate base unit, shaped into an arched section that approximates to a barrel vault. The surfaces bend to produce surface continuity and rigidity along the section. The corrugation of the overall surface is determined by the density and depth of the folds, complemented in section by the truss. The folds and truss give structural strength to the section, allowing it to span like an arch. This assemblage transmits an optical affect of pleating, tubularity and axiality, and an acoustical affect of diffusion and focusing.

Pleating, Arching, Differentiation, Horizontality, Asymmetricality, Diffusion

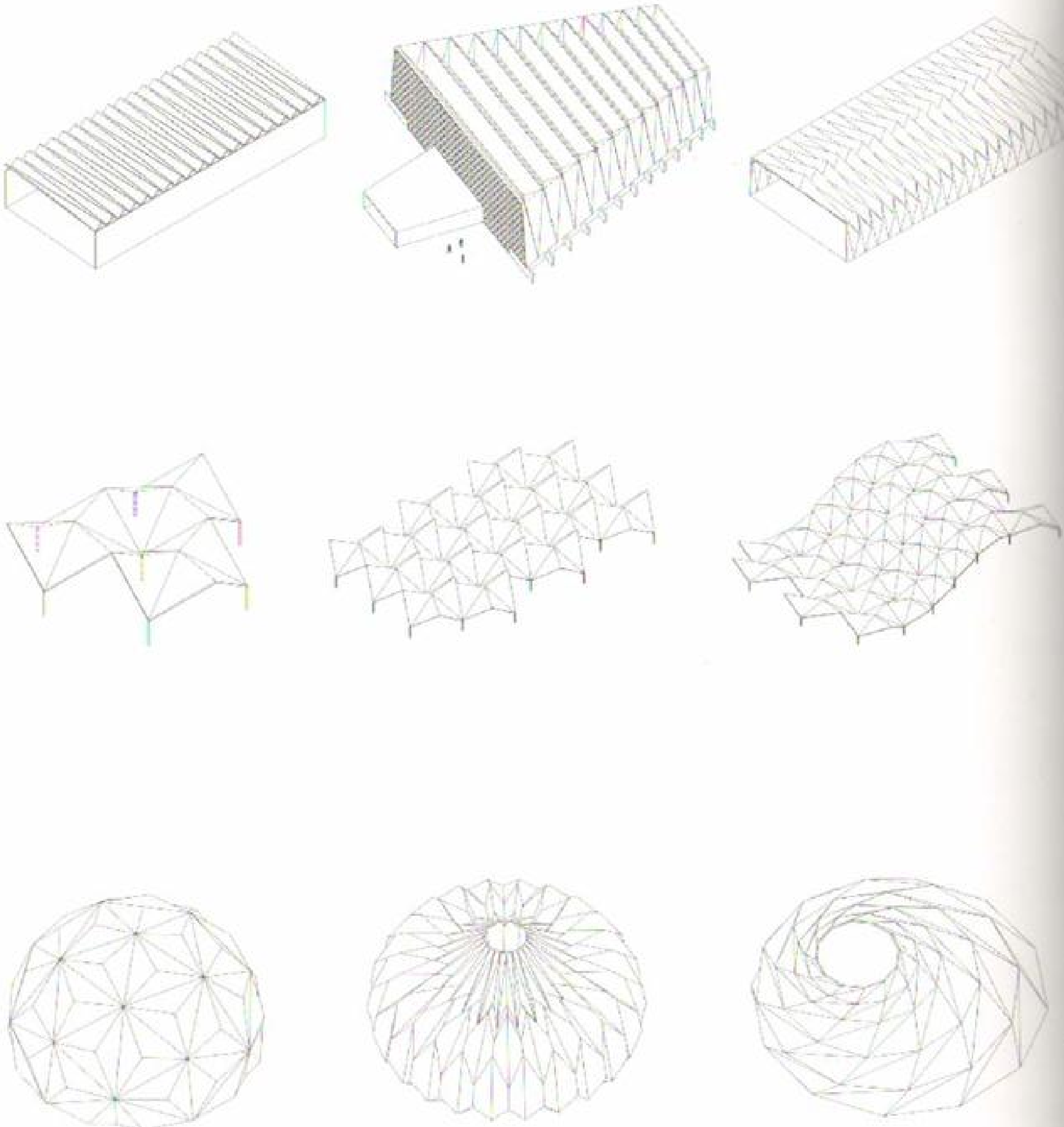


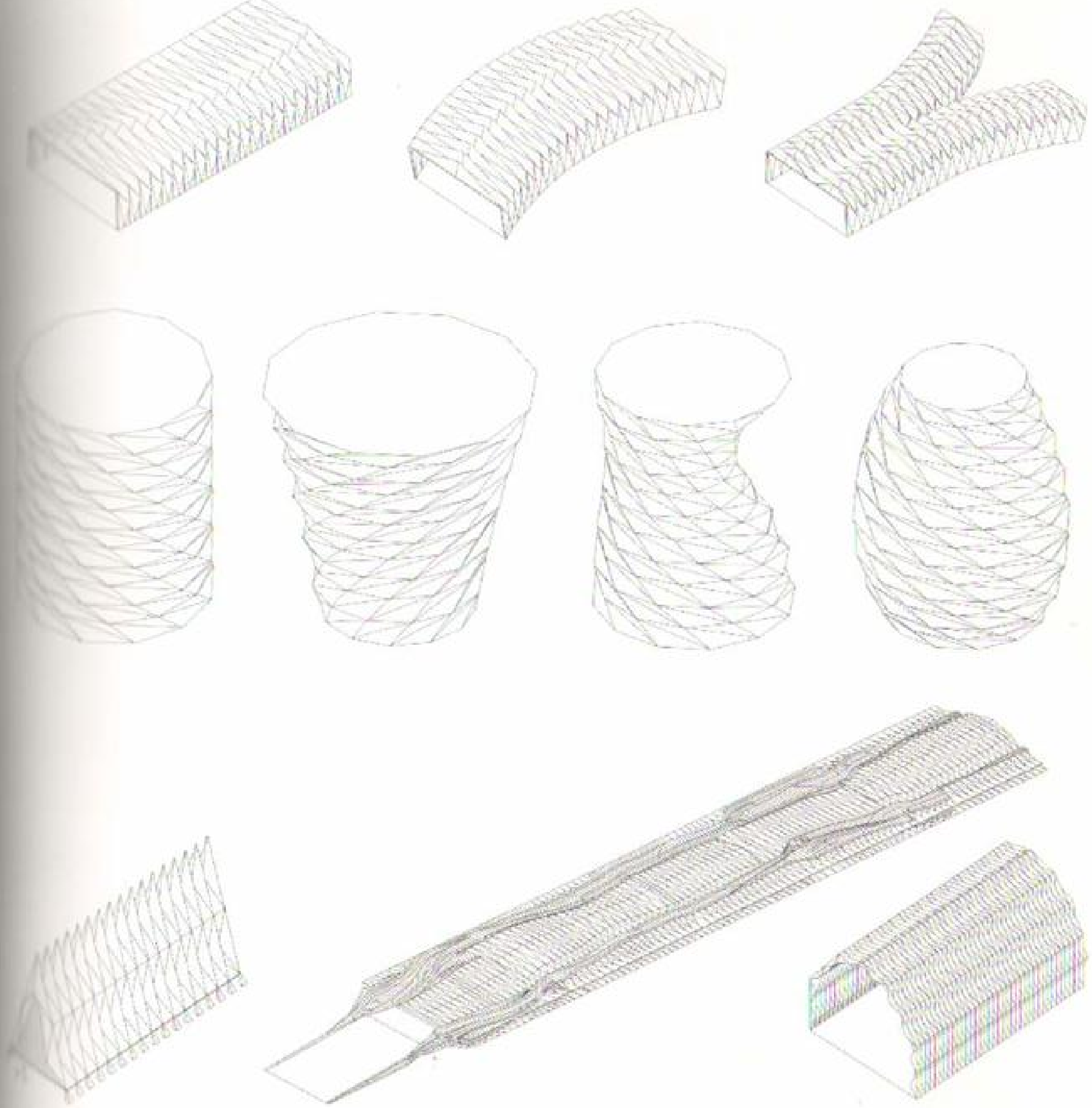
Horizontal / Folded Plate and Truss, and Girder

YOKOHAMA INTERNATIONAL PORT TERMINAL	FOREIGN OFFICE ARCHITECTS; STRUCTURAL DESIGN GROUP, NAGATA ACOUSTICS	YOKOHAMA, JAPAN	2002



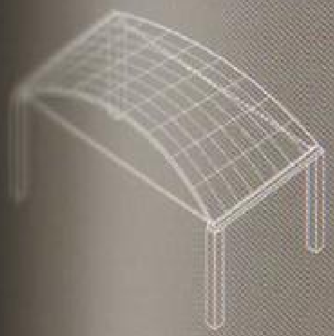
The Yokohama International Port Terminal is formed by the horizontal tessellation of a plate and truss folded plate base unit which spans laterally across two side-girders in the form of shallow arches spanning longitudinally. The plate and truss system together with the longitudinal girders are stacked to produce two concourse and parking levels. The folds of the truss and plate give structural strength and depth to the section as well as hosting environmental systems such as ventilation, fire sprinklers, drainage, etc. The Yokohama International Port Terminal transmits an optical affect of pleating, arching, differentiation, horizontality and asymmetricality, and an acoustical affect of diffusion.



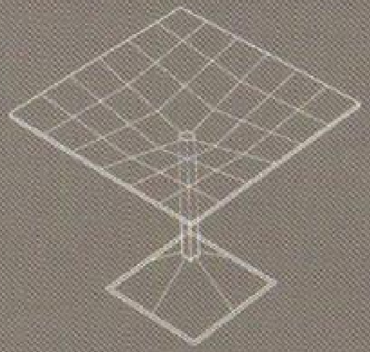


Shells are composed of surfaces that distribute loads in plane and have the greatest efficiency when resisting evenly distributed loads. Shells distribute loads along surfaces that can be made of steel-reinforced concrete in combination with masonry or glass to decrease their weight or increase their porosity with respect to light.
The system of shells is subdivided into three primary subsystems: conical shell, hyper-curved umbrella column shell, and three-pointed hyper-curved shell. This subdivision is based primarily on the curvature of the shell – the bending of the surface in two or three directions.

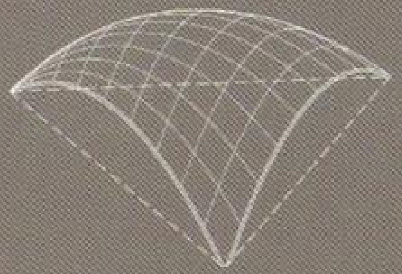
Conical shells are formed as a double-curved surface that passes through a single apex at its centre, subdividing the surface into two congruent halves. In geometrical terms, a conical surface is the infinite surface formed by the union of all the straight lines that pass through a fixed point, or its apex, and any point of a fixed curve that does not include the apex. Characteristically, conical surfaces are ruled and developable, and consist of two congruent halves joined by the apex.
Hyper-curved umbrella column shells are formed by four rectangular hyperbolic paraboloidal surfaces that extend from the four faces of a column, each bending in two different directions.
Three-pointed hyper-curved shells are formed by hyperbolic surfaces that are double-curved and rest on three points.



Conical Shell



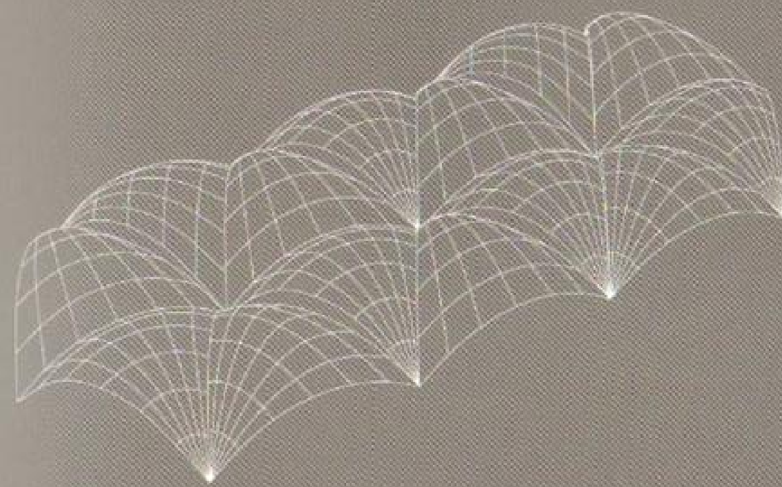
Hyper-Curved Umbrella Column Shells



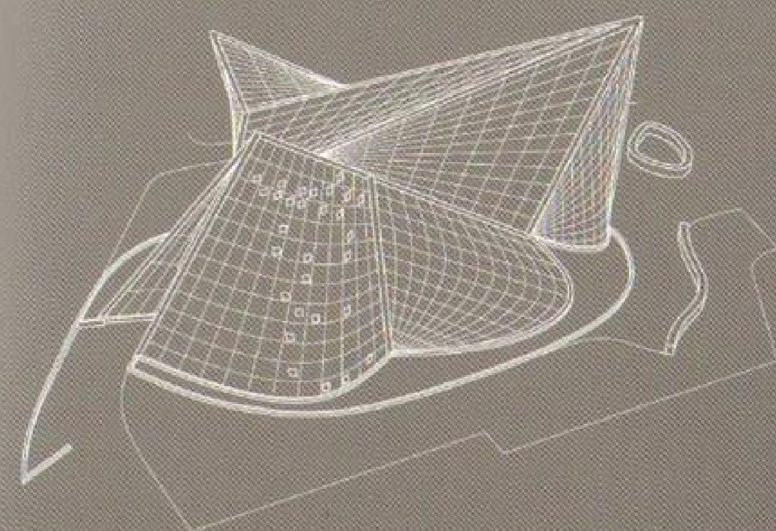
Three-Pointed Hyper-Curved Shells

Shells are able to tessellate along horizontal and curved lines of growth to produce horizontal and curved structural forms. The lines of force are distributed along the surface of the shell, a form which is inherently structural, with the resulting differentiated section offering flexibility, in plan, with respect to the distribution of the load-bearing points.

Horizontal tessellation can occur in conical shells and hyper-curved umbrella column shells because the protogeometry of these systems is capable of distributing loads along the horizontal axis. Horizontal tessellation introduces flexibility at ground level and in the surface of the roof. **Curved tessellation** can occur in hyper-curved shells because their protogeometry allows for a differentiated pattern which is not axial, to produce an eccentric overall form that differs from the inherently curved form of the base unit. Curved tessellation is different from that of horizontal, in that it does not follow a linear or radial pattern of repetition, but one that is based on an irregular and differentiated pattern of repetition that stems from a varying relationship between each of the base units, resulting in an eccentric overall form.



Horizontal Tessellation



Curved Tessellation

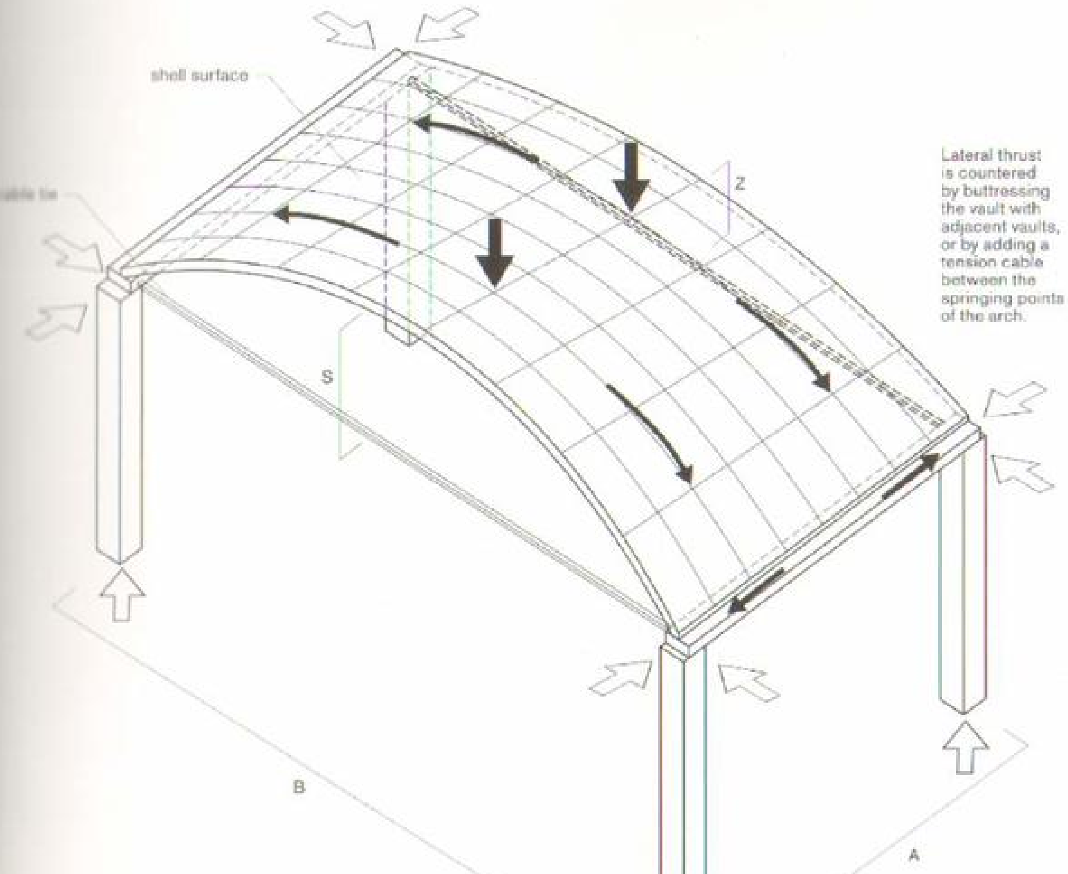
The base unit of a conical shell is composed of a surface that is extruded perpendicularly to join two hyperbolic curves, spanning primarily longitudinally to meet edge beams resting on columns or load-bearing walls, with a cable tie located at the abutment of these edge beams and the columns or load-bearing walls. Conical shells direct the primary loads along the surface of the shell. Conical shells can be made of steel-reinforced concrete, which can also be mixed with lightweight terracotta or glass bricks to reduce the overall weight. Conical shells derive their structural strength when their curvature approximates to that of an arch or catenary. The distribution of loads along the surfaces of a conical shell embeds it with an optical affective property of arching and directionality that remains consistent within any space it defines. The acoustical affect of a shell is determined by the curvature of its surface. Consequently, a concave shell has an affect of focusing near the centre of curvature, and a convex one has an affect of diffusion. At a distance from the center of a concave shell, or in the case of a concave shell with a shallow curvature, the shell has an affect of specularity.

Conical shells are flexible in several ways:

Span: Conical shells can be flexible in the degree of curvature in the shell surface, which allows for a range in the spans that bridge the edges, with the curvature increasing as the span increases. Accordingly, they can tessellate horizontally along straight or curved lines of growth to produce primarily horizontal structures, or sheds.

Profile: The degree of curvature of the shell's surface can vary, resulting in a wide range of profiles. The more the curvature of the shell approximates to that of an arch or a catenary, the more it gains in structural strength as well as the ability to be self-supporting.

Affect: The optical affective properties of a conical shell can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to arching and directionality, a conical shell can transmit other affects, including quilting, piercing, linearity, orientedness, braiding, hyper-curving. The acoustical affect of conical shells can be focusing or specularity.

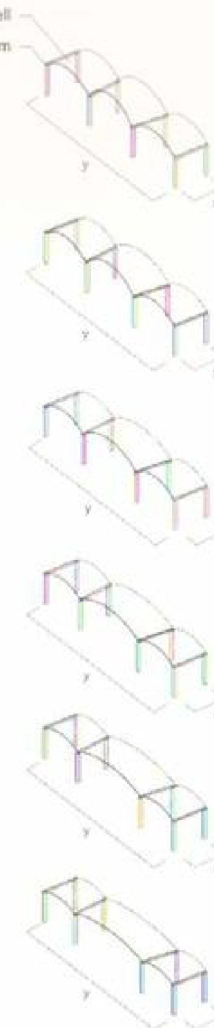


$$Z = \frac{\text{the greater of A or B}}{2\text{–}12}$$

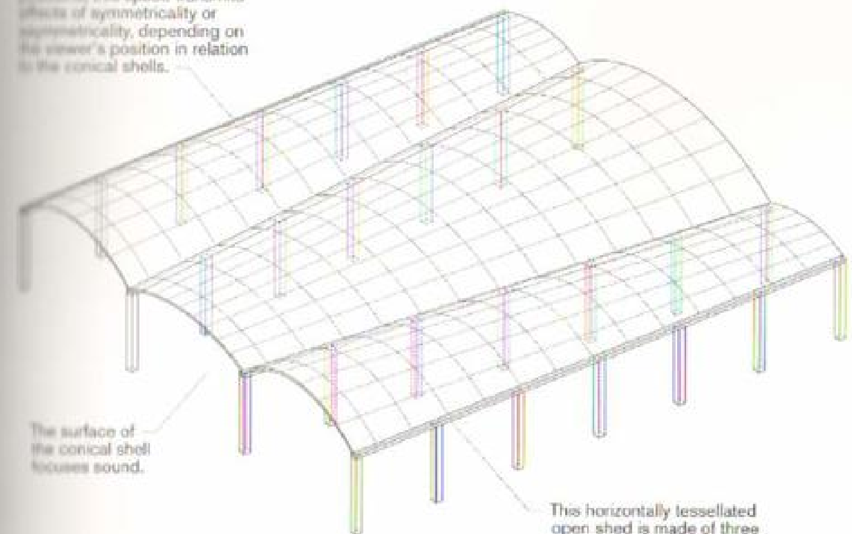
Z and S: heights of the shell at each end.

Vaulting, Symmetricality, Asymmetricality Focusing

Horizontal / Conical Shell

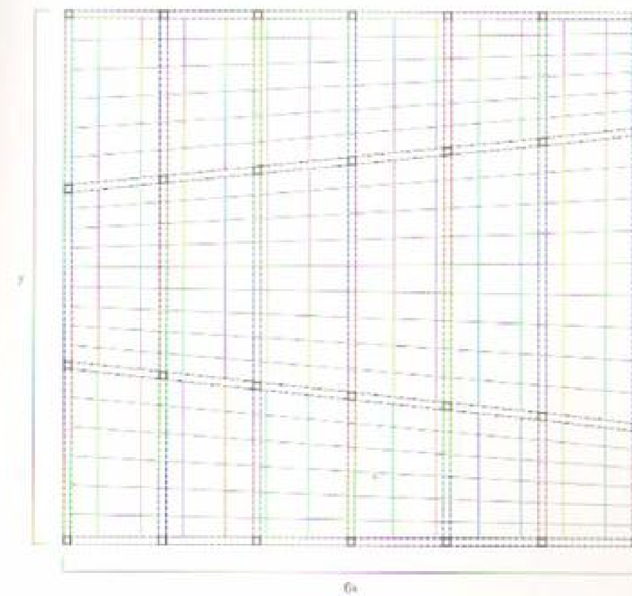


Owing to changes in the ceiling profile and column positions, this space transmits effects of symmetricality or asymmetricality, depending on the viewer's position in relation to the conical shells.



The surface of the conical shell focuses sound.

This horizontally tessellated open shed is made of three variations of a shell base unit.



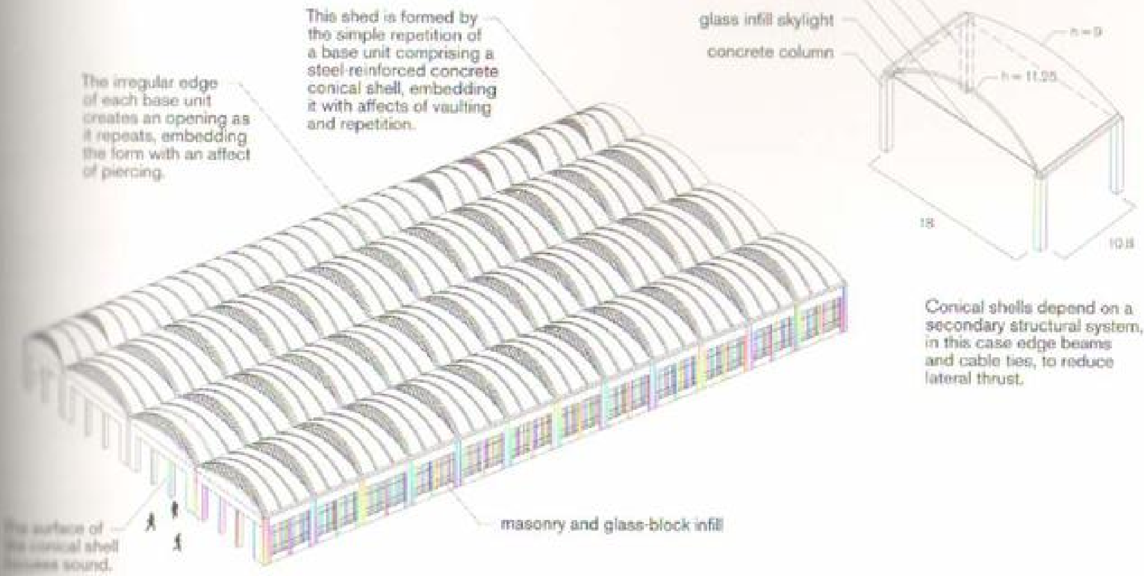
The varying spans and heights of the vaulted bays vary the profile of this form, which transmits an affect of vaulting.

This horizontal form is produced by the tessellation of a conical shell base unit to create three long bays spanning four axes of columns positioned so as to reduce or increase gradually the width of the bays. Gradually increasing or decreasing the space between the columns causes the curvature of the conical shell to change in section, increasing or decreasing its depth correspondingly and enabling the base unit to respond to asymmetrical conditions along the perimeter. This assemblage transmits an optical affect of vaulting, symmetricality and asymmetricality, and an acoustical affect of focusing.

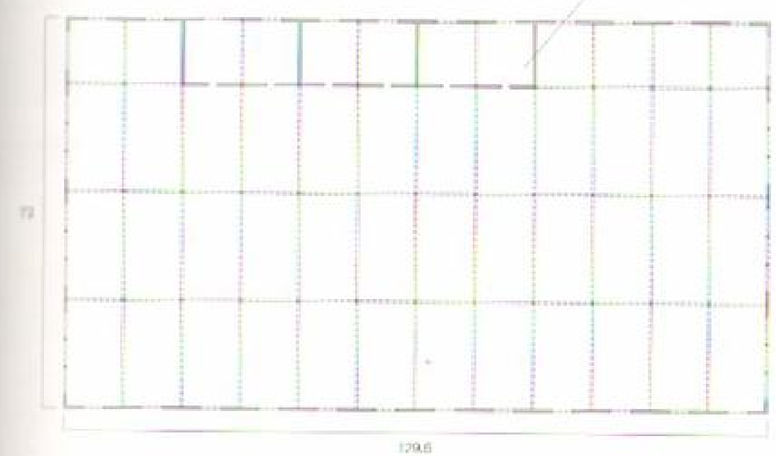
Piercing, Vaulting, Repetition, Focusing

Horizontal / Conical Shell

RAILWAY WORKSHOP | E. FREYSSINET | BAGNEUX, FRANCE | 1928

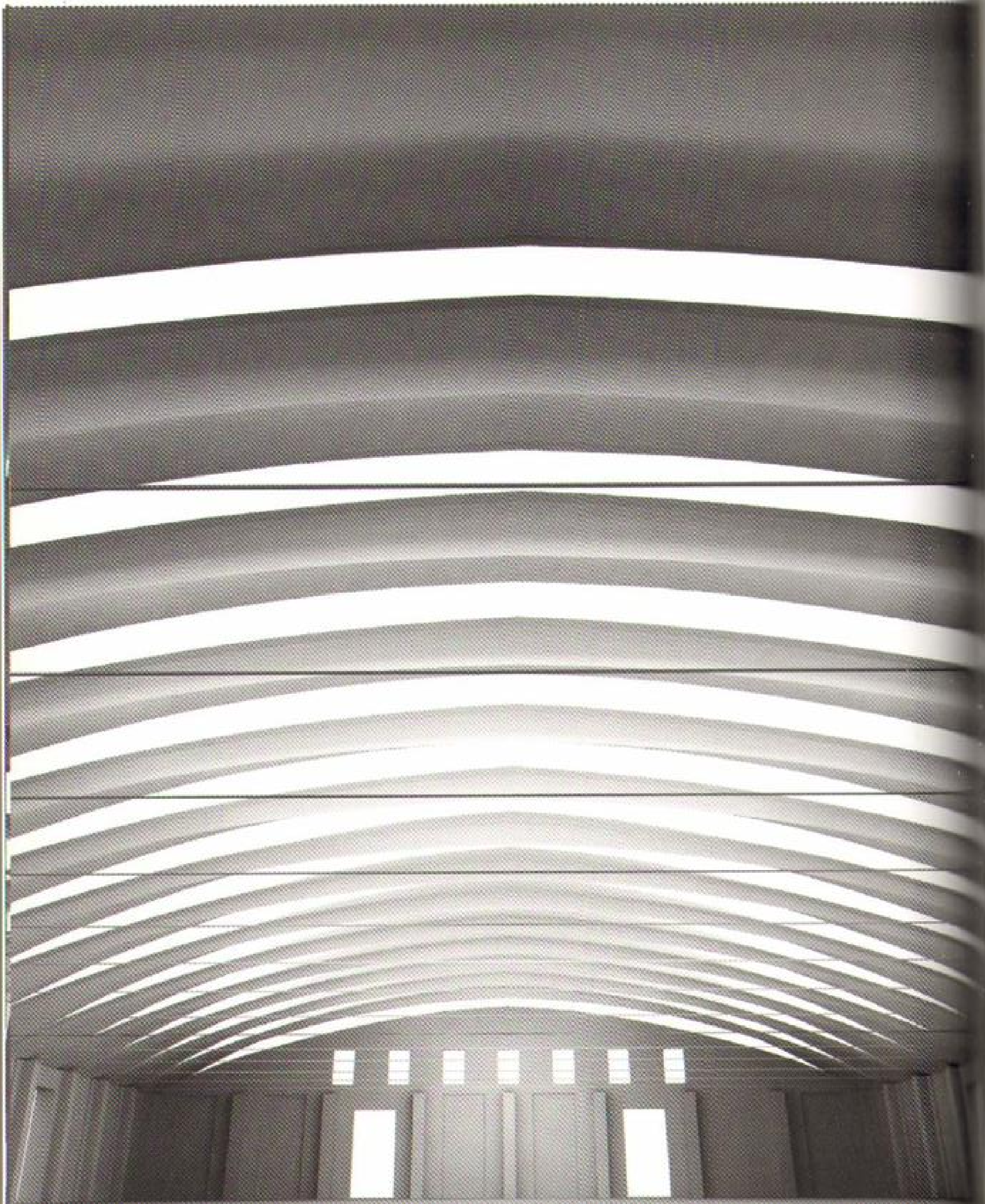


Conical shells depend on a secondary structural system, in this case edge beams and cable ties, to reduce lateral thrust.



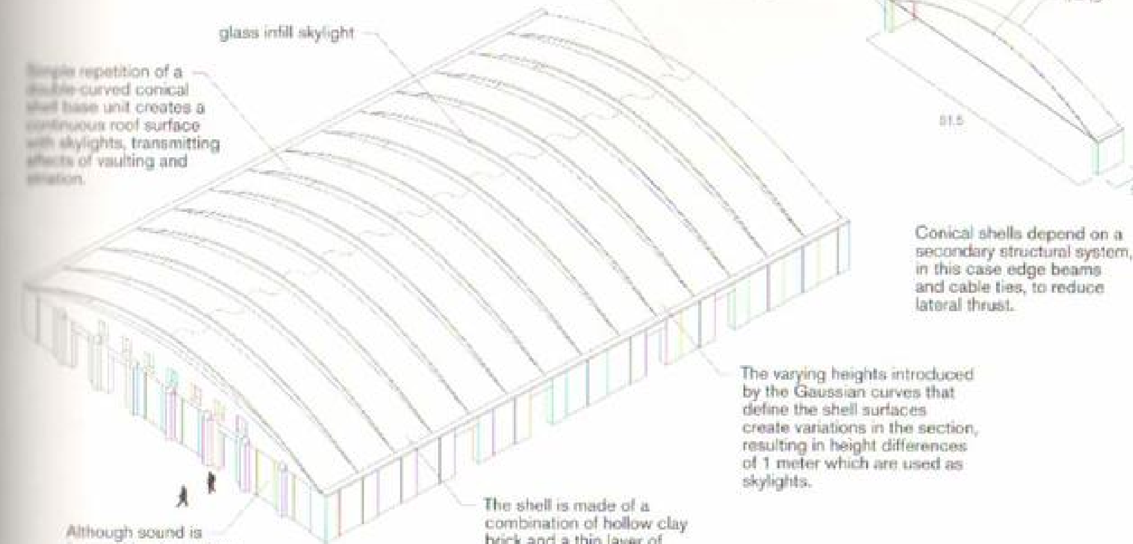
This railway workshop is produced by the tessellation of a curved conoidal shell base unit, to create four barrel-vaulted bays that span four axes of columns and the walls along the perimeter to rest on edge beams. The flexibility offered by this assemblage of base units lies in its section. The apertures in the surface of the roof can be altered by adjusting the double curvature of each of the shells to enable the structure to respond to programmatic or environmental requirements. This railway workshop transmits an optical affect of piercing, vaulting and repetition, and an acoustical affect of focusing.

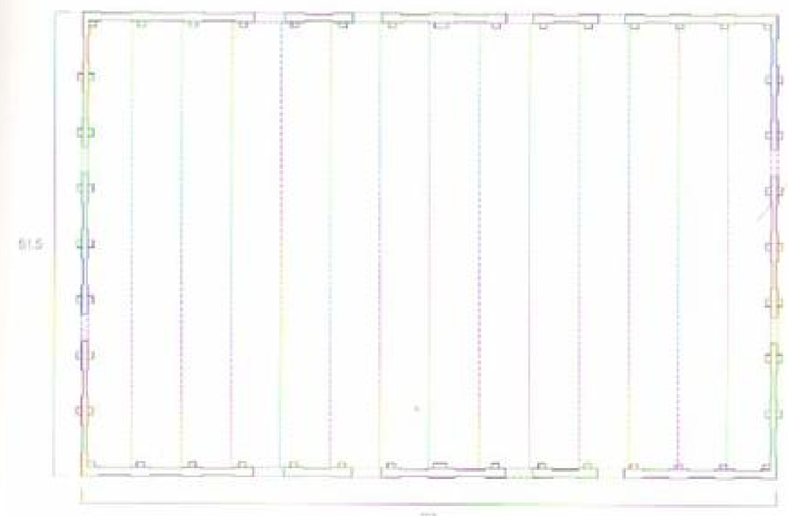
Vaulting, Striation, Repetition, Specularity



Horizontal / Conical Shell

PORT WAREHOUSE | E. DIESTE | MONTEVIDEO, URUGUAY | 1979



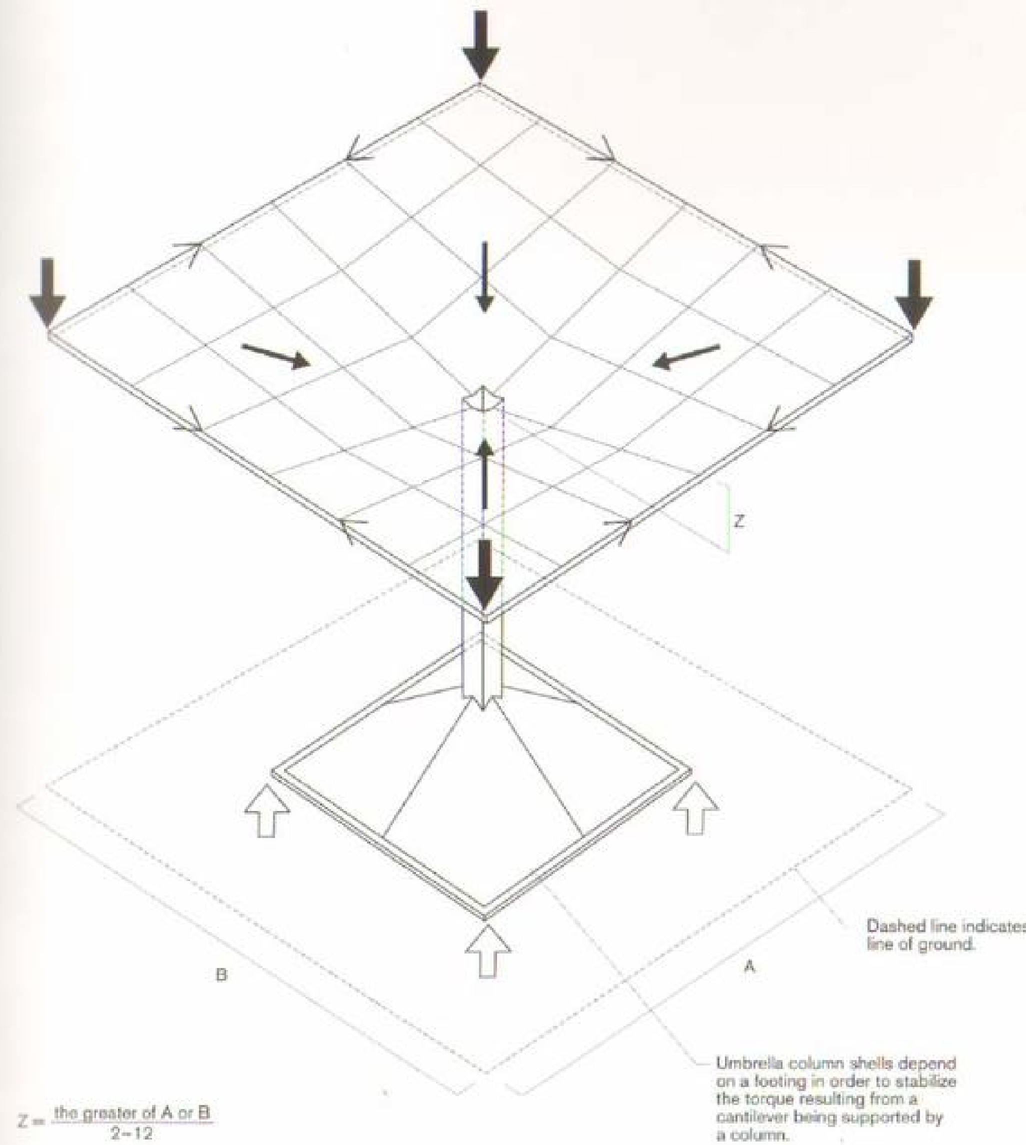


The Port Warehouse is produced by the tessellation of a curved conical shell base unit spanning the full bay to create a series of shells resting on the perimeter walls. The flexibility of this type of assemblage lies in its section. The number and size of the apertures in the roof can be controlled by gradually adjusting the Gaussian curve located at the central apex, which defines the double curvature of each surface, and, similarly, the overall section can be adjusted to increase or decrease the volume to enable the structure to respond to programmatic or environmental requirements. The Port Warehouse transmits an optical affect of vaulting, striation and repetition, and an acoustical affect of specularity.

Umbrella Column Shell

The base unit of a hyper-curved umbrella column shell is composed of surfaces, usually four, which are derived from the extension of the faces of a column that is polygonal in plan. Hyper-curved umbrella column shells direct the primary bending moments through their surfaces, along multiple axes, transferring the forces from the horizontally spanning hyper-surfaces to the vertical faces of the column. Hyper-curved umbrella column shells can be made of reinforced concrete, although in some instances terracotta bricks are incorporated to reduce the overall weight, or glass-block bricks to bring light in. The distribution of loads in a hyper-curved umbrella column shell embeds it with an optical affective property of slanting and linearity that remains consistent within any space it defines. The concave surfaces of the umbrella shell may promote focusing or specularity, depending upon the expanse and radius of curvature of the surfaces.

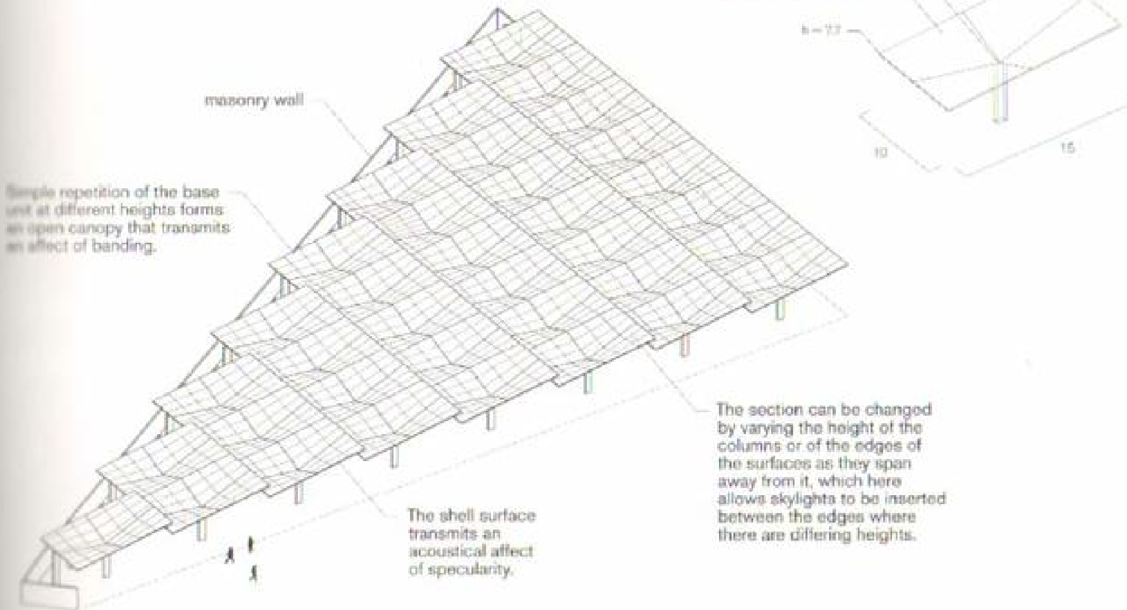
Hyper-curved umbrella column shells are flexible in several ways:
Plan: Hyper-curved columns can tessellate horizontally along straight or curved lines of growth to produce primarily horizontal structures, or sheds.
Profile: The protogeometry of hyper-curved umbrella column shells allows them to be flexible in the section of the surfaces springing from the column, and also in the height of the column itself.
Affect: The optical affect of a hyper-curved umbrella column shell can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to slanting and linearity, a structure made of hyper-curved umbrella column shells can transmit other affects, including folding, tenting, axiality, hyper-curving, focusing, specularity. The acoustical affect of umbrella shells can be diffusion or specularity.

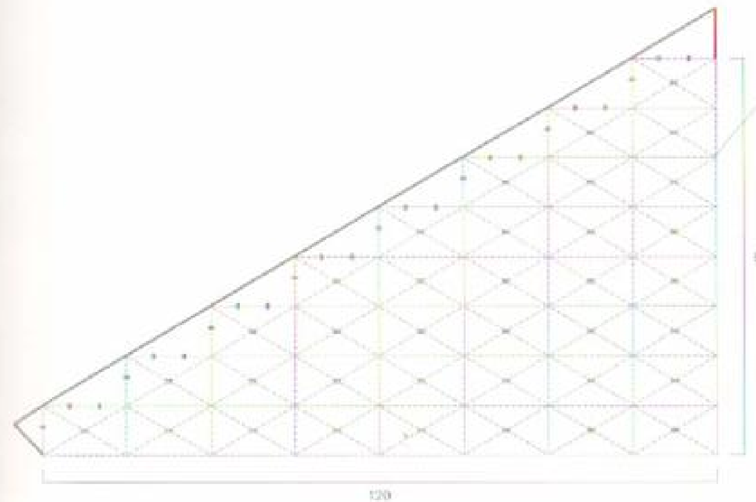


Banding, Specularity

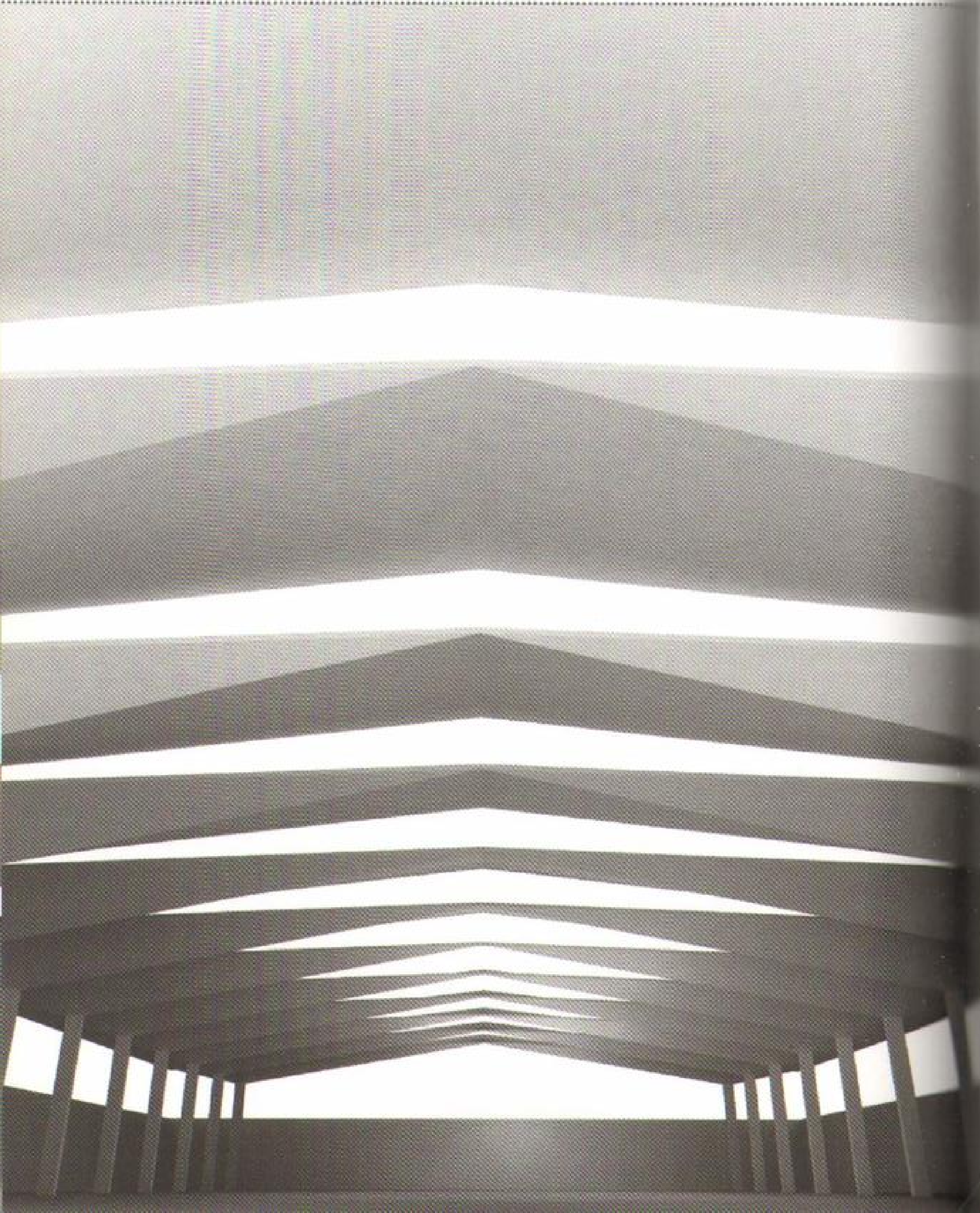
Horizontal / Umbrella Column Shell

RIO WAREHOUSE | F. CANDELA, A. SÁENZ DE LA CALZADA | MEXICO CITY, MEXICO | 1953–54



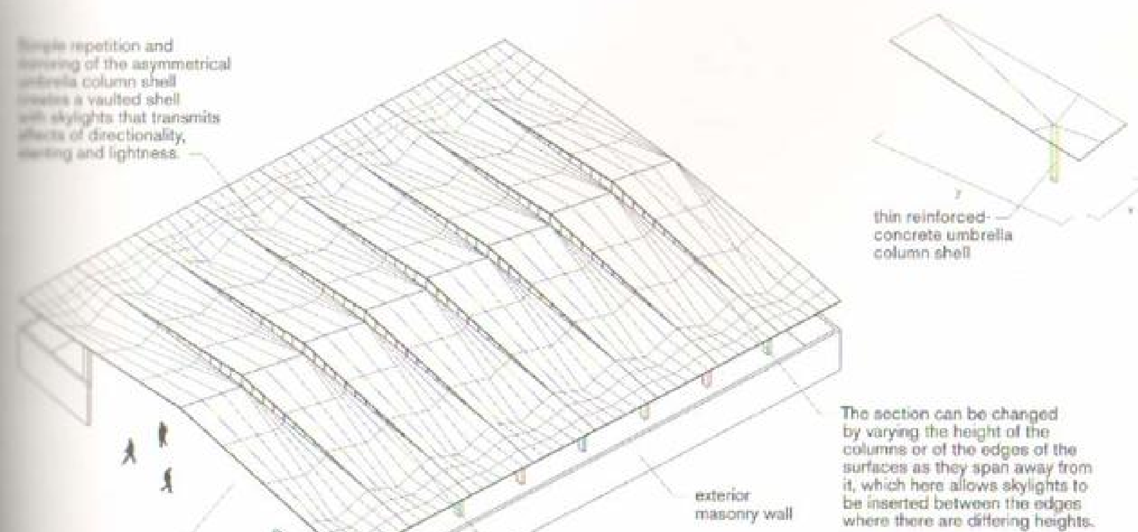


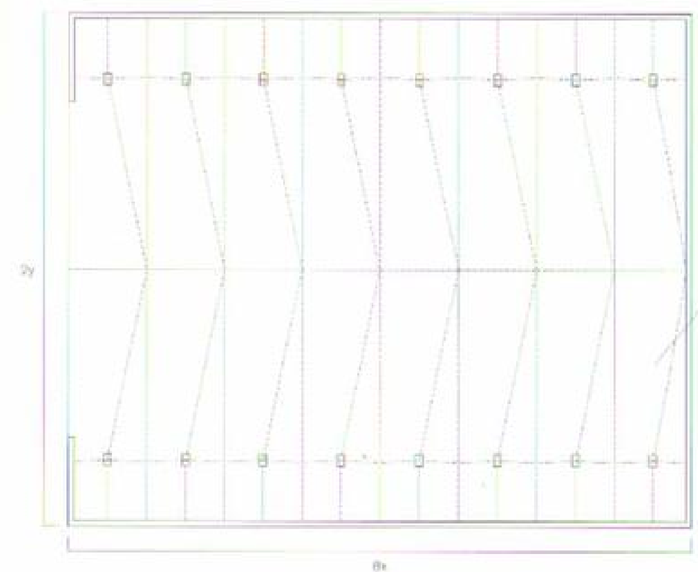
The Rio Warehouse is produced by the tessellation of an umbrella column shell base unit, to create a series of bays in which the shells span outwards from columns symmetrically positioned along the central axis of each bay. The elevations between the surfaces can be changed by gradually changing the height of each of their faces, and the overall height of the column can also vary. Gradual changes to the overall section, in terms of both the shell surfaces and the height of the columns, can change the volume of the space as well as the amount of natural light, allowing it to respond to programmatic needs and environmental conditions. The Rio Warehouse transmits an optical affect of banding, and an acoustical affect of specularity.



Horizontal / Umbrella Column Shell

HERNAIZ WAREHOUSE | F. CANDELA | MEXICO CITY, MEXICO | 1956



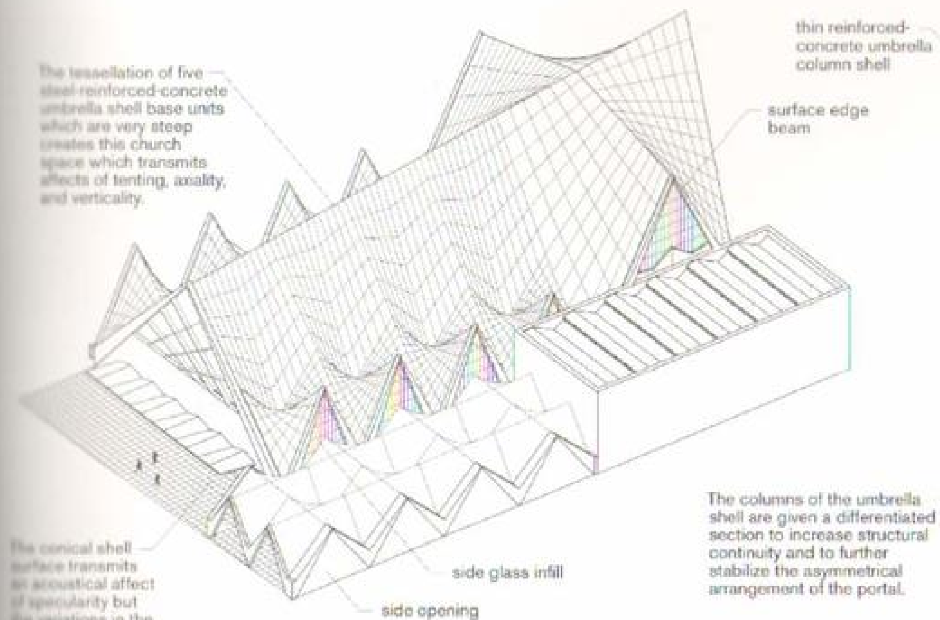


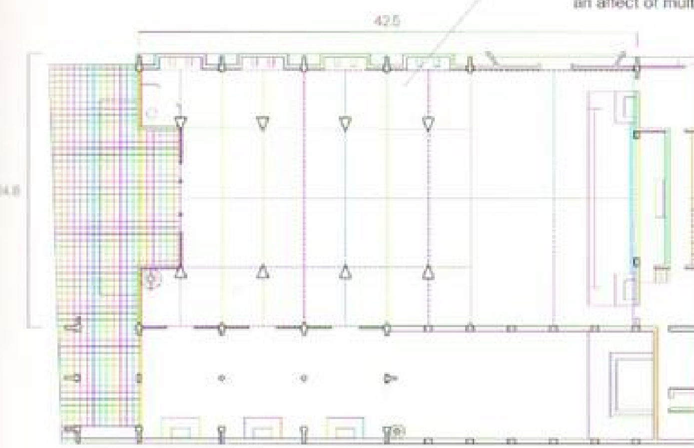
The Hernaiz Warehouse is produced by the tessellation of an umbrella column shell base unit to create a central bay and two smaller side aisles, with the shells spanning outward from a set of columns located asymmetrically along the central axis of each bay. Here the umbrella column shells work in pairs to create a single bay. A gradual increase in height of the apex can vary the section from one bay to the next, increasing or decreasing its height in response to programmatic or environmental needs. The Hernaiz Warehouse transmits an optical affect of directionality, slanting, axiality and lightness, and an acoustical affect of specularity.

Tenting, Axiality, Verticality, Specularity, Diffusion

Horizontal / Umbrella Column Shell

CHURCH OF OUR LADY OF THE MIRACULOUS MEDAL | F. CANDELA | MEXICO CITY, MEXICO | 1953–55





The church of Our Lady of the Miraculous Medal is produced by the tessellation of an umbrella column shell base unit to create a central bay composed of five variations of the base unit and two smaller side aisles, with the shells spanning outward from a set of columns located asymmetrically along the central axis of each bay. The umbrella column shells work in pairs to create a single bay. The height of the section is increased by a gradual increase in the height of the base unit as it repeats. The height of the columns is also reduced gradually, and in the final bay they disappear altogether, leaving the upper surface of the shell free-standing. These adjustments to the section, which alter not only the height of the structure but also the elevations, enable it to respond to both programmatic and environmental needs. The church of Our Lady of the Miraculous Medal transmits an optical affect of tenting, axiality, and verticality, and acoustical affects of specularity and diffusion.

The base unit of a three-pointed hyper-curved shell is composed of a hyper-surface spanning in two directions, which rests on three vertices. Three-pointed hyper-curved shells the primary loads through the section of the shell. The geometry of the shell is determined by the nature and magnitude of the loads it will resist. For predominantly uniformly distributed loads the (ie if the shells self weight governs as is the case in long span roofs) the curvature will be close to spherical. Hyper-curve shells can be made of thin-shell reinforced concrete spanning very great distances. The distribution of loads along the hyper-surfaces of a three-pointed hyper-curved shell embeds it with an optical affective property of lightness and radiating that remains consistent within any space it defines.

The acoustical affect of a shell is determined by the curvature of its surface. Consequently, a concave shell has an affect of focusing near the center of curvature, and a convex one has an affect of diffusion.

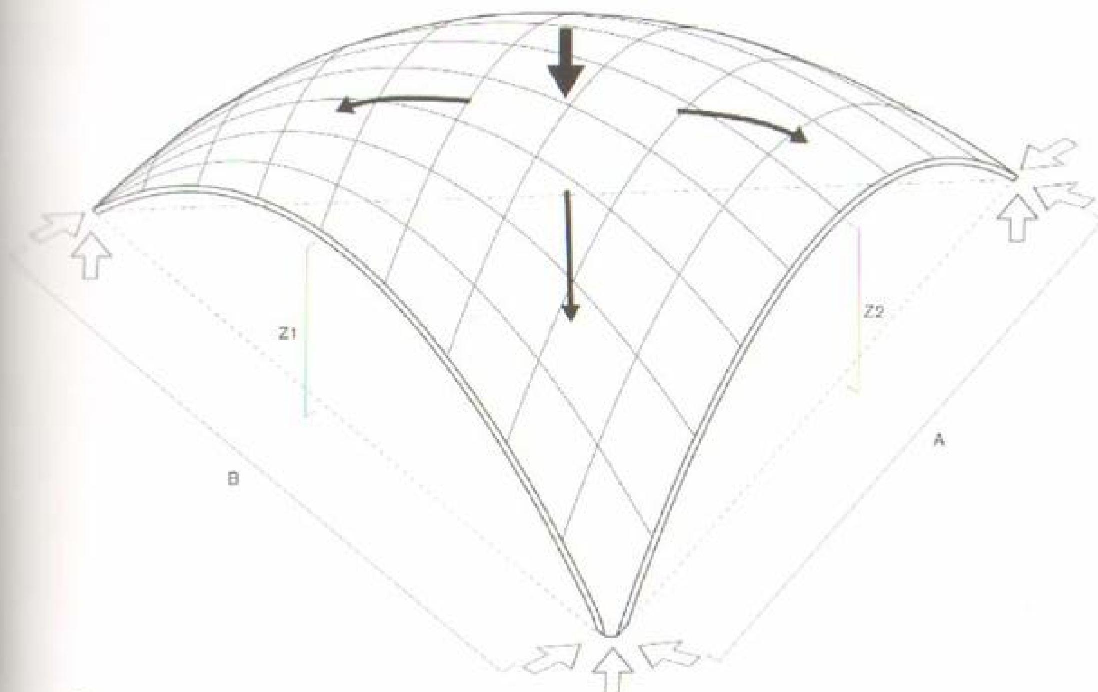
At a distance from the center of a concave shell, or in the case of a concave shell with a shallow curvature, the shell has an affect of specularity.

Three-pointed hyper-curved shells are flexible in several ways:

Plan: Three-pointed hyper-curved shells can tessellate horizontally along straight or curved lines of growth to produce primarily horizontal or curved structures.

Profile: The protogeometry of a three-pointed hyper-curved shell allows it to be flexible in the range of curvature given to the surface and the curvature of the edges, which can form an arched opening in a wide range of widths. The curvature of the shell's surface can also vary, resulting in a wide range of profiles.

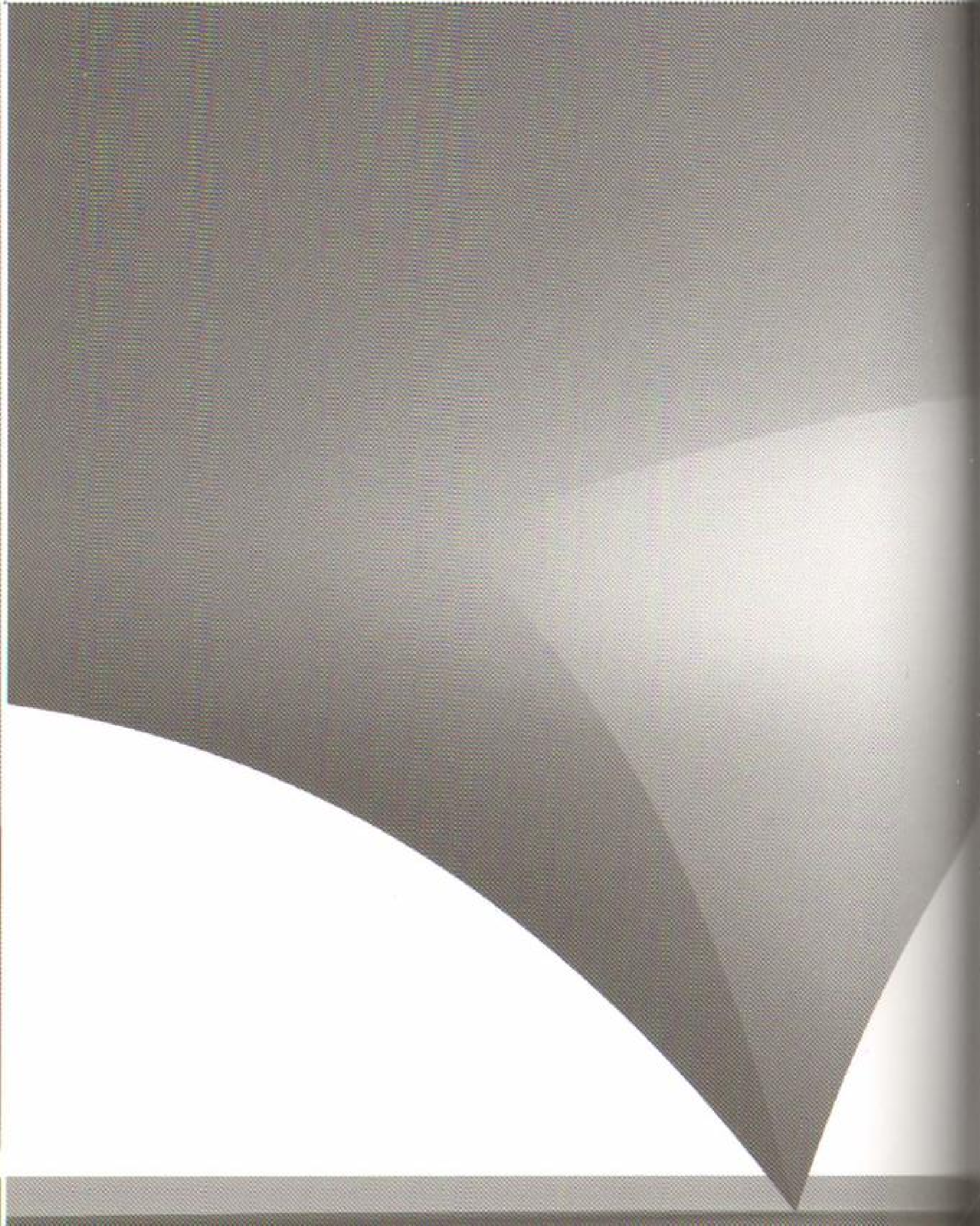
Affect: The optical affective property of a three-pointed hyper-curved shell can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to lightness and radiating, a structure made of a three-pointed hyper-curved shell can transmit other affects, including rotundity, attenuation, thinness, pleating, enclosure, triangularity, slitting, tapering, scalloping, flaring, pleating, torquing. The acoustical affect of a hyper-curved shell can be focusing or specularity.



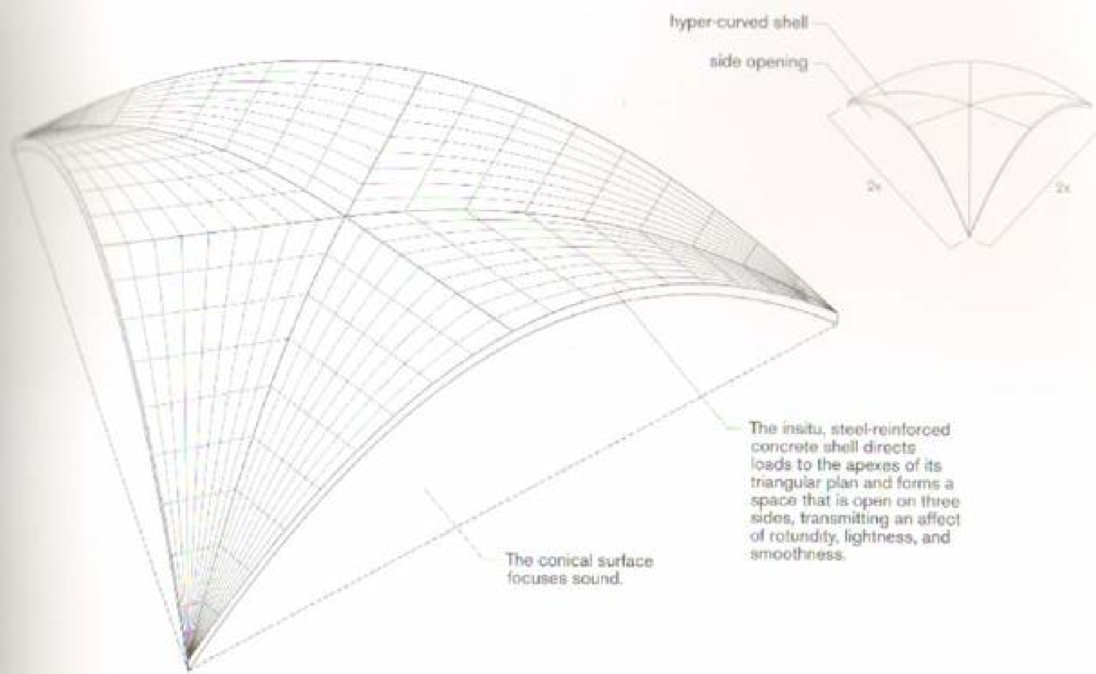
$$Z1 = \frac{B}{2-12}$$

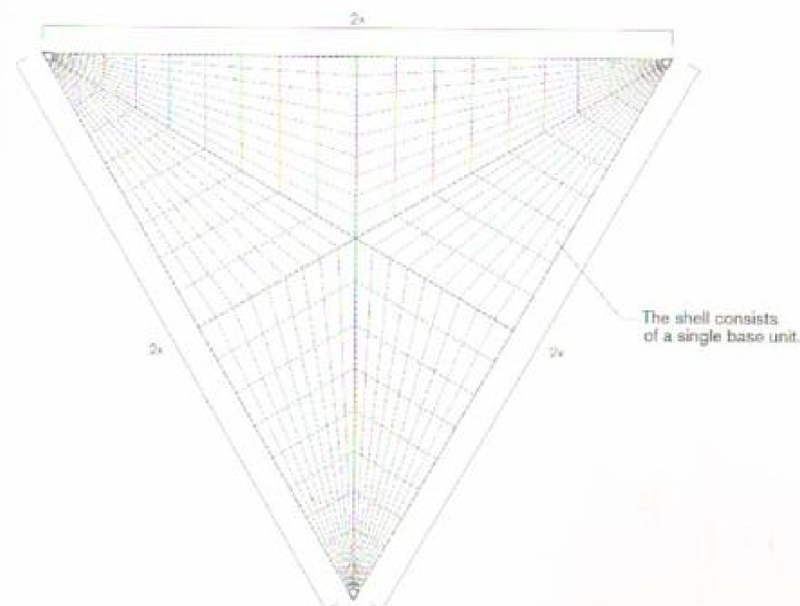
$$Z2 = \frac{A}{2-12}$$

Rotundity, Lightness, Smoothness, Focusing



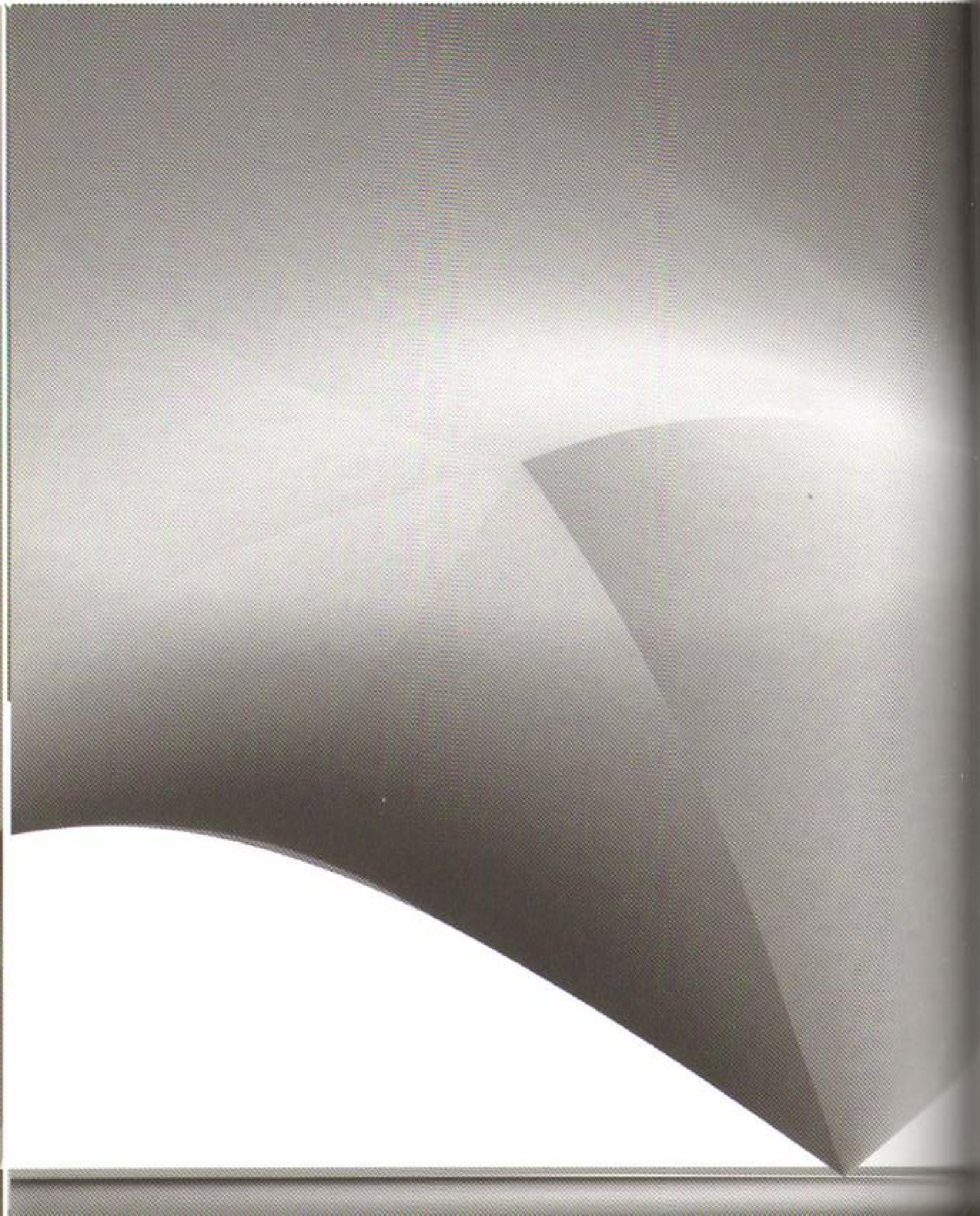
Horizontal / Hyper-Curved Shell





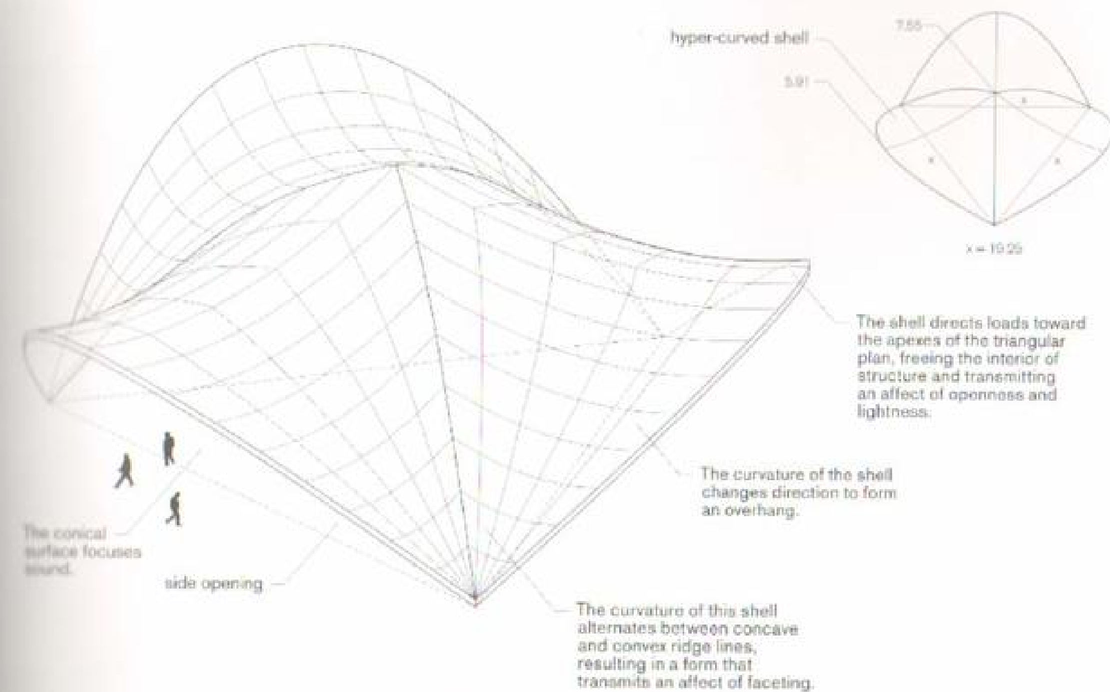
This horizontal form is produced by a hyper-curved shell base unit. This type of assemblage is flexible in the changes that can be made to the curvature of the arch in elevation and to the section as the surface of the shell is developed. Gradual changes in the curvature of the arches that form the three elevations, together with changes in the height of the central apex, enable the form to respond to programmatic and environmental needs. This form transmits an optical affect of rotundity, lightness and smoothness, and an acoustical affect of focusing.

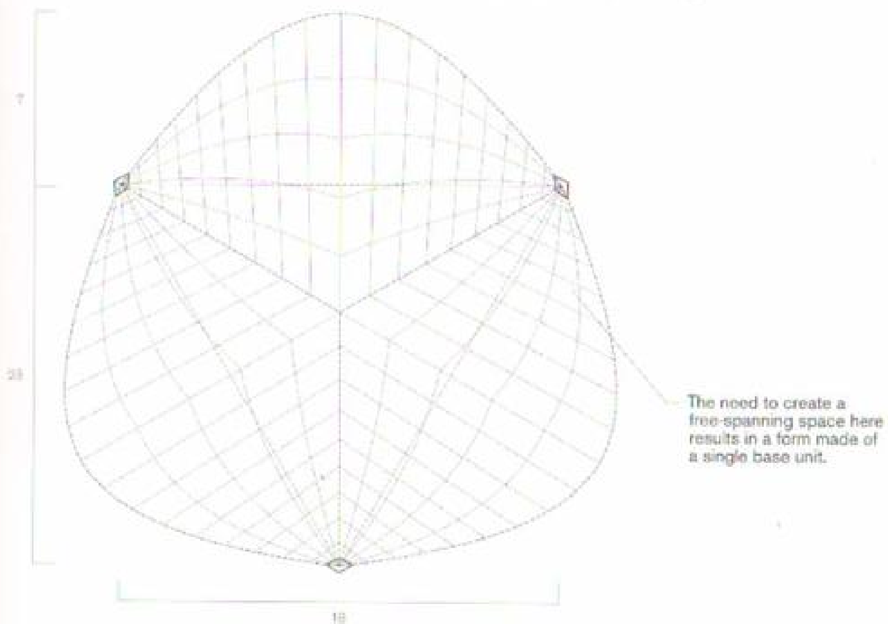
Centeredness, Lightness, Faceting, Focusing



Horizontal / Hyper-Curved Shell

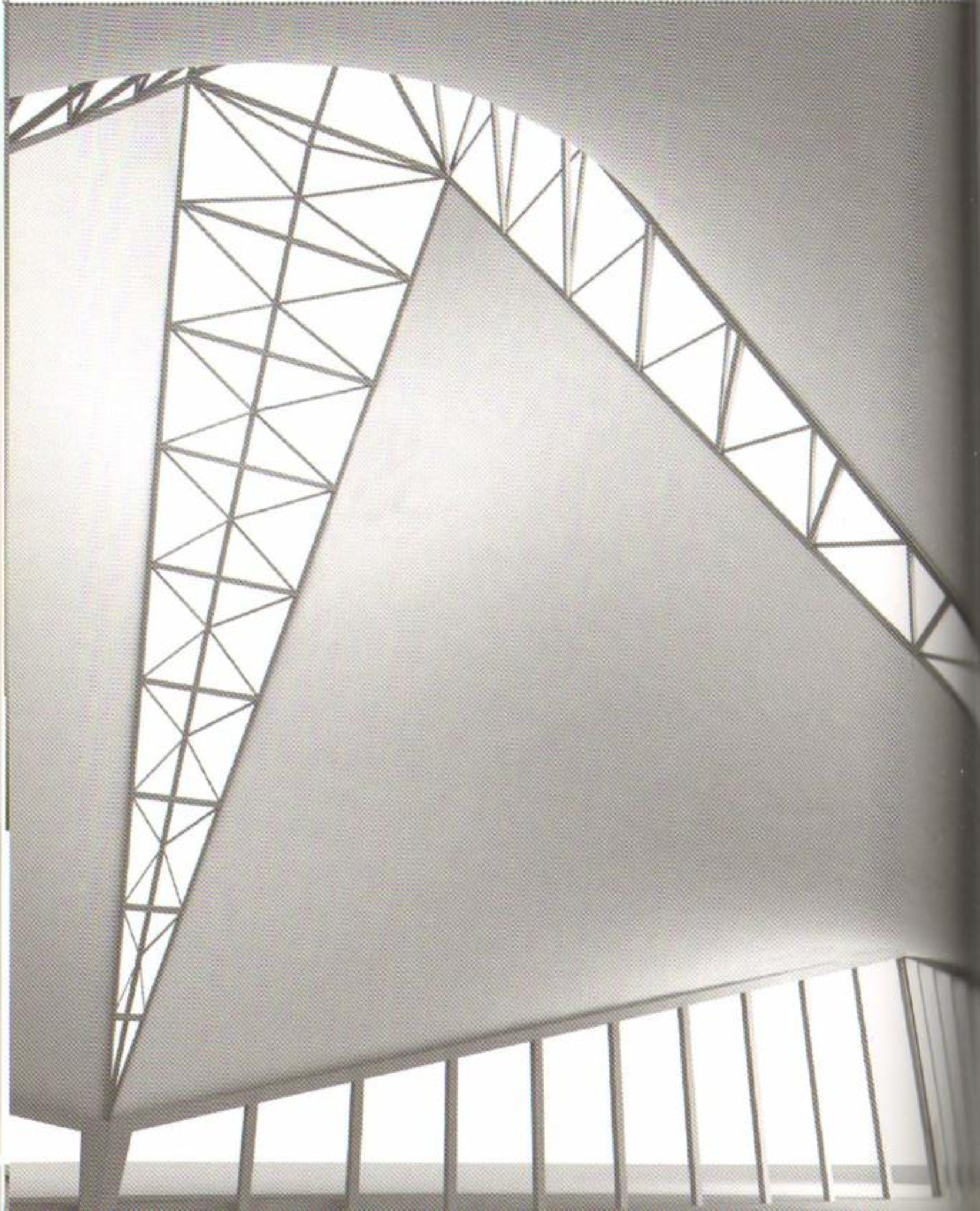
LA JACARANDA NIGHTCLUB | F. CANDELA, J. SORDO | ACAPULCO, MEXICO | 1957





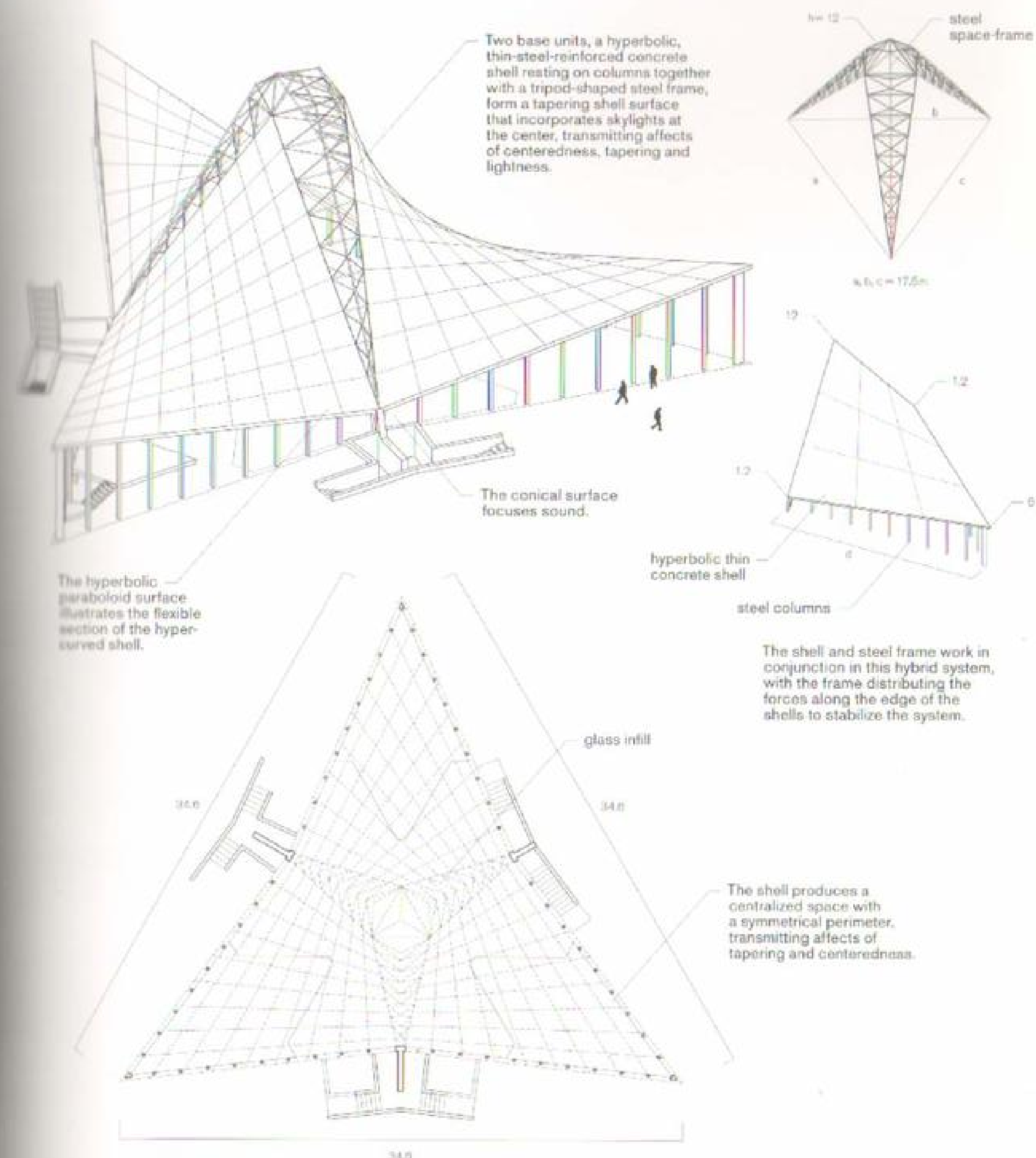
The La Jacaranda Club is produced by a hyper-curved shell base unit. This type of assemblage is flexible in the changes that can be made to the curvature of the arch in elevation and to the section as the surface of the shell is developed. Gradual changes in the curvature of the arches that form the three elevations, together with changes in the height of the central apex, enable the form to respond to programmatic and environmental needs. The La Jacaranda Club transmits an optical affect of centeredness, lightness and smoothness, and an acoustical affect of focusing.

Centeredness, Tapering, Lightness, Specularity



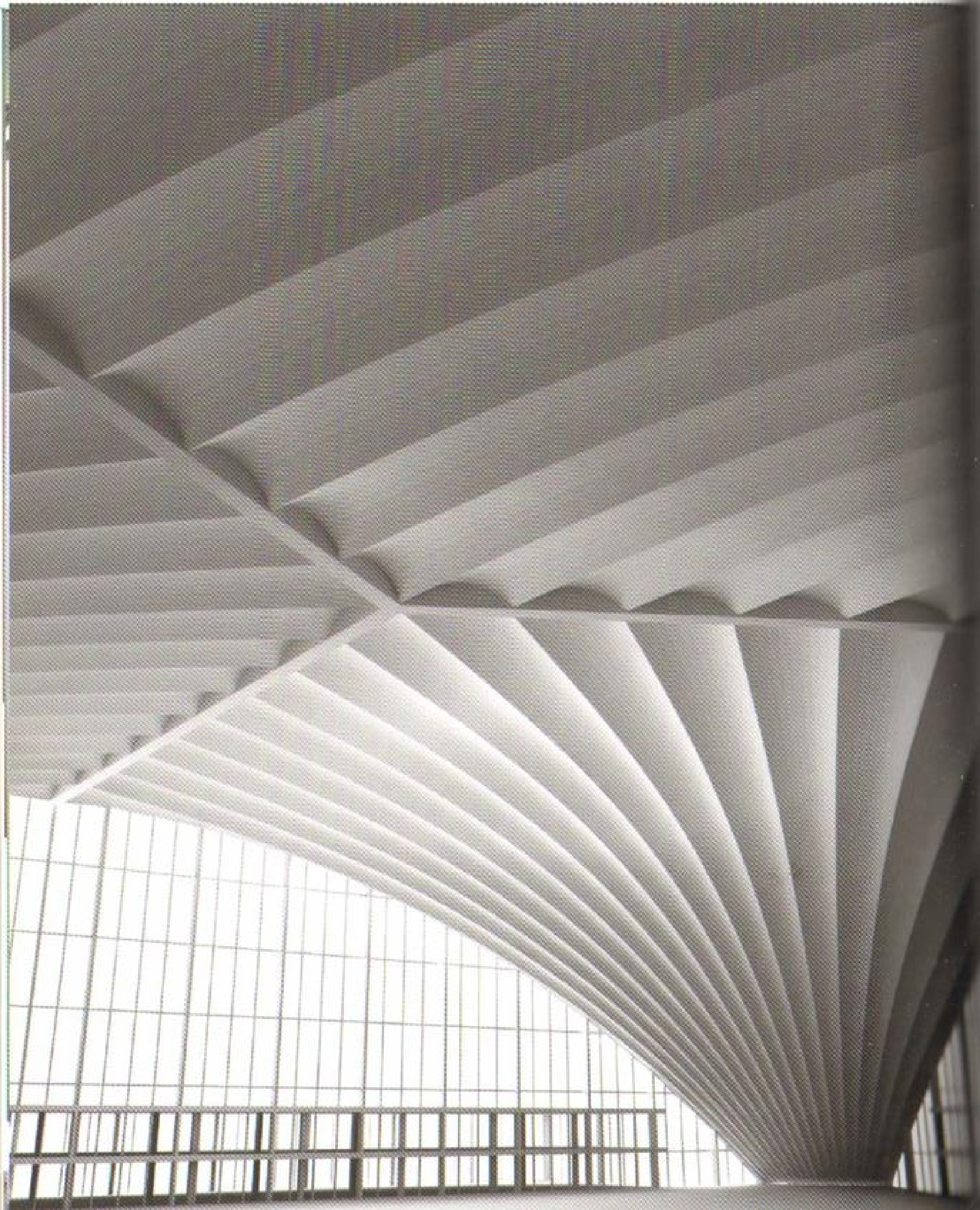
Horizontal / Hyper-Curved Shell, and Frame

ST. VINCENT DE PAUL CHAPEL | F. CANDELA, E. DE LA MORA, A. LÓPEZ CARDONA | MEXICO CITY, MEXICO | 1958–59



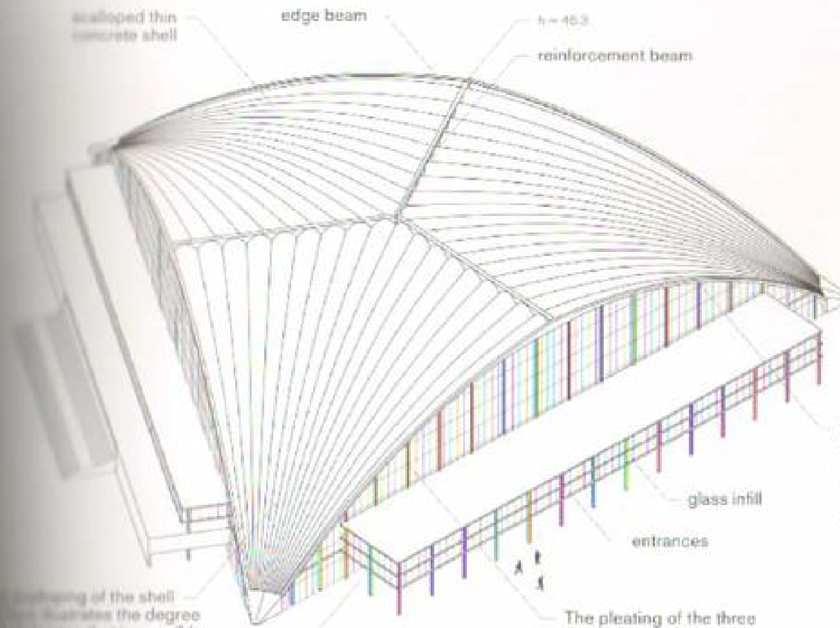
The St. Vincent de Paul Chapel is a hybrid form produced by the tessellation of a hyper-curved shell working in conjunction with a steel space frame. Three shells are supported at their centers by a space frame, a tripod made of open steel trusses. Gradual changes in the height of the apexes of the shells changes their sections and elevations. Higher apexes increase the area of the side elevation. In this type of form more than three surfaces can meet at the central tripod to create enclosed space in a variety of shapes, such as pyramidal or rectangular or linear. The St. Vincent de Paul Chapel transmits an optical affect of centeredness, tapering and lightness, and an acoustical affect of specularity

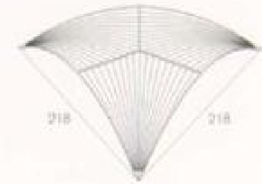
Centeredness, Triangularity, Scalloping, Diffusion

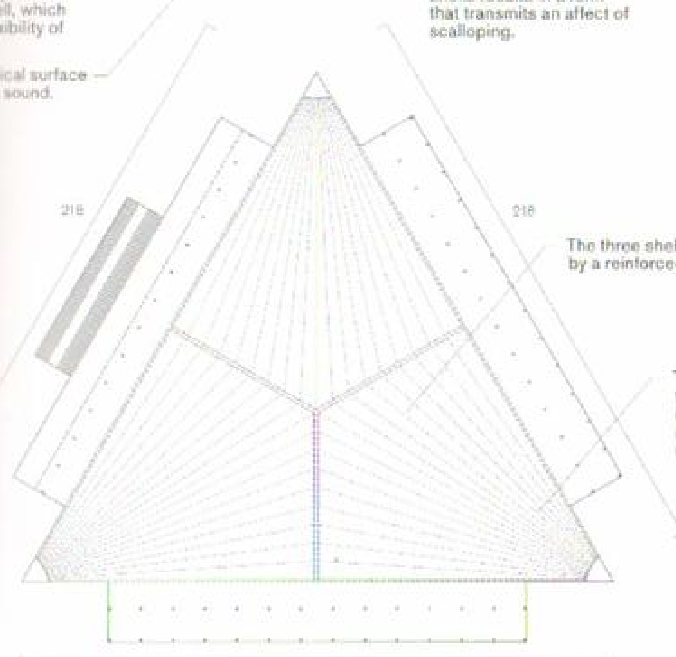


Horizontal / Hyper-Curved Shell

BUILDING | R. CAMELOT, J. DE MAILLY, B. ZEHRFUSS, P.L. NERVI, J. PROUVÉ, N. ESQUILLAN | PARIS, FRANCE | 1958

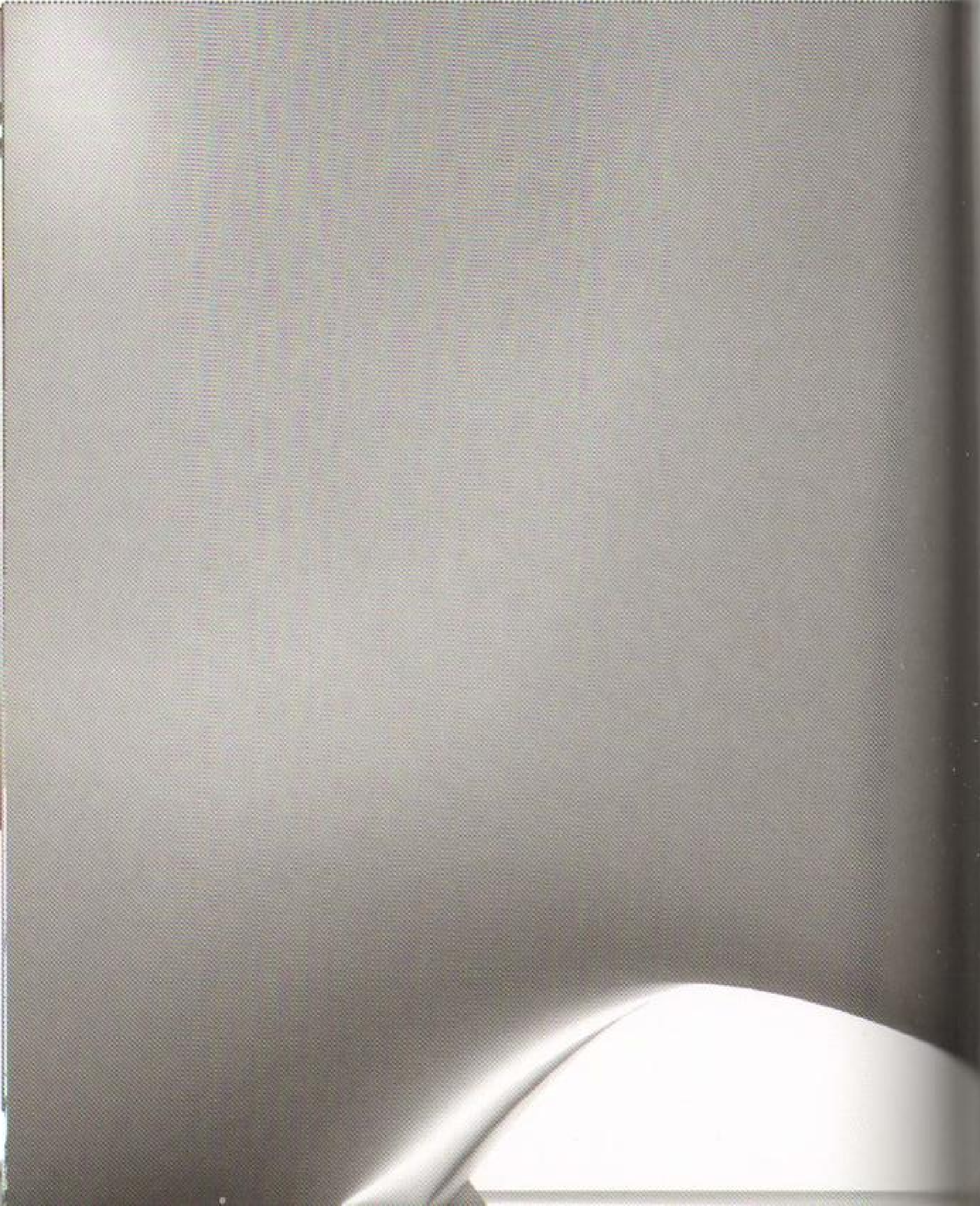






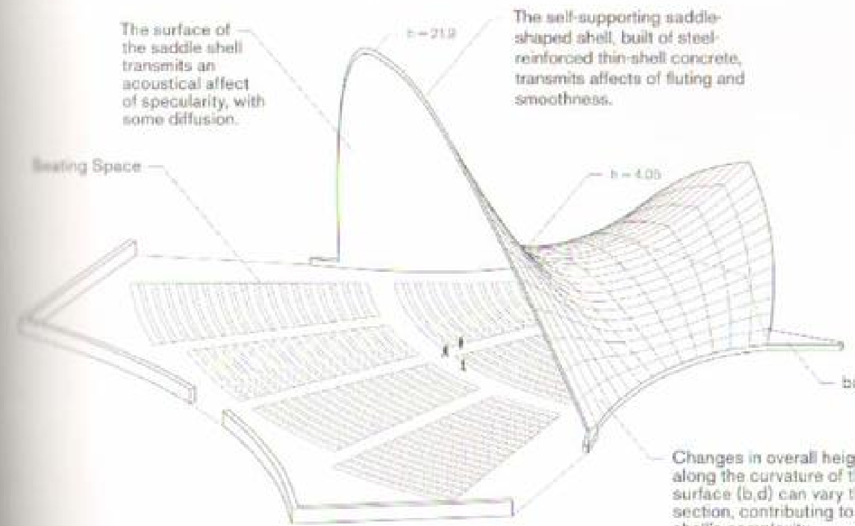
...building is the largest concrete shell in the world in terms of the ratio between the supports and the floor area covered. It is formed by three ...hyper-curved shells that intersect at a central point. The individual shells are not autonomous, but depend on one another to form the ... The flexibility of the design lies in the changes which can be made to the curvature of the arch in elevation, and the changes in section, ...surface of the shell is developed. The CNIT building transmits an optical affect of centeredness, triangularity and scalloping, and an ...affect of diffusion.

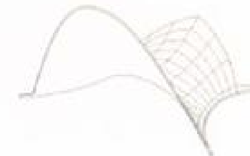
Fluting, Smoothness, Complexity, Eccentricity, Specularity, Diffusion

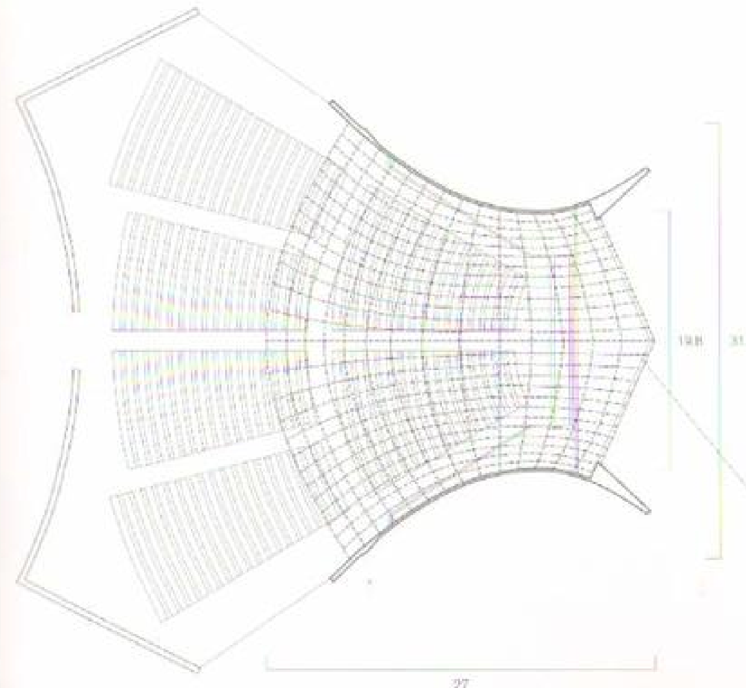


Horizontal / Hyper-Curved Shell

LOMAS DE CUERNAVACA CHAPEL | F. CANDELA, G. ROSELL, M. LARROSSA | CUERNAVACA, MEXICO | 1958

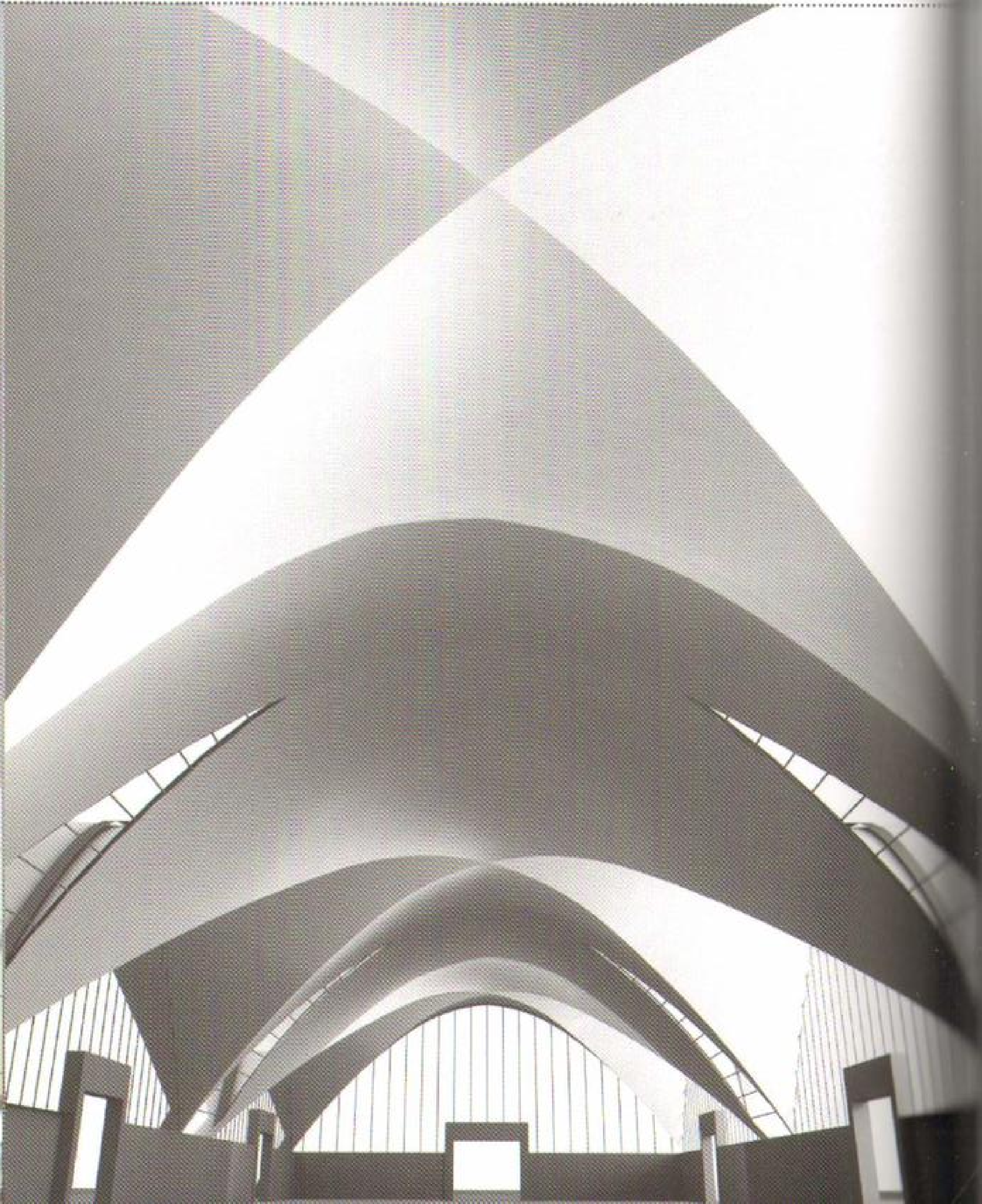






The Lomas de Cuernavaca Chapel is produced by a hyper-curved base unit, which comprises a single paraboloid shell, saddle-shaped and self-supporting. The curvature of the shell can be changed by modifying the radii of the curves that define the plan, while changes in the width or steepness of the shell's curvature can also change its form, to enable this type of shell to adapt to programmatic needs such as acoustical properties, or environmental requirements such as the introduction of natural light to the interior. The Lomas de Cuernavaca Chapel transmits an optical affect of fluting, smoothness, complexity and eccentricity, and an acoustical affect of specularity and diffusion.

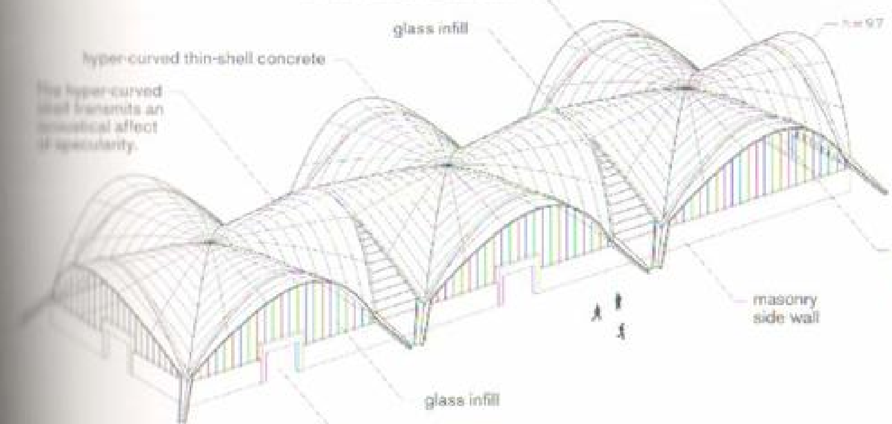
Scalloping, Lightness, Smoothness, Pleating, Specularity

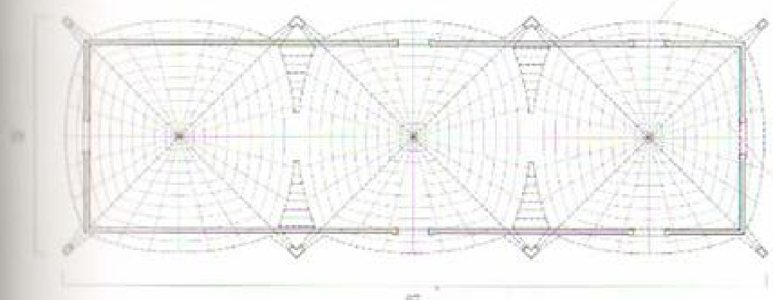


Horizontal / Hyper-Curved Shell

BACARDI BOTTLING PLANT | F. CANDELA, A. SÁENZ DE LA CALZADA, CANCIO-MARTÍN, ÁLVAREZ AND GUTIÉRREZ | CUAUTITLÁN IZCALLI, MEXICO | 1960

Hyper-curved shells can be supported by a secondary structure, as is illustrated here by the arches and piers running along the perimeter.

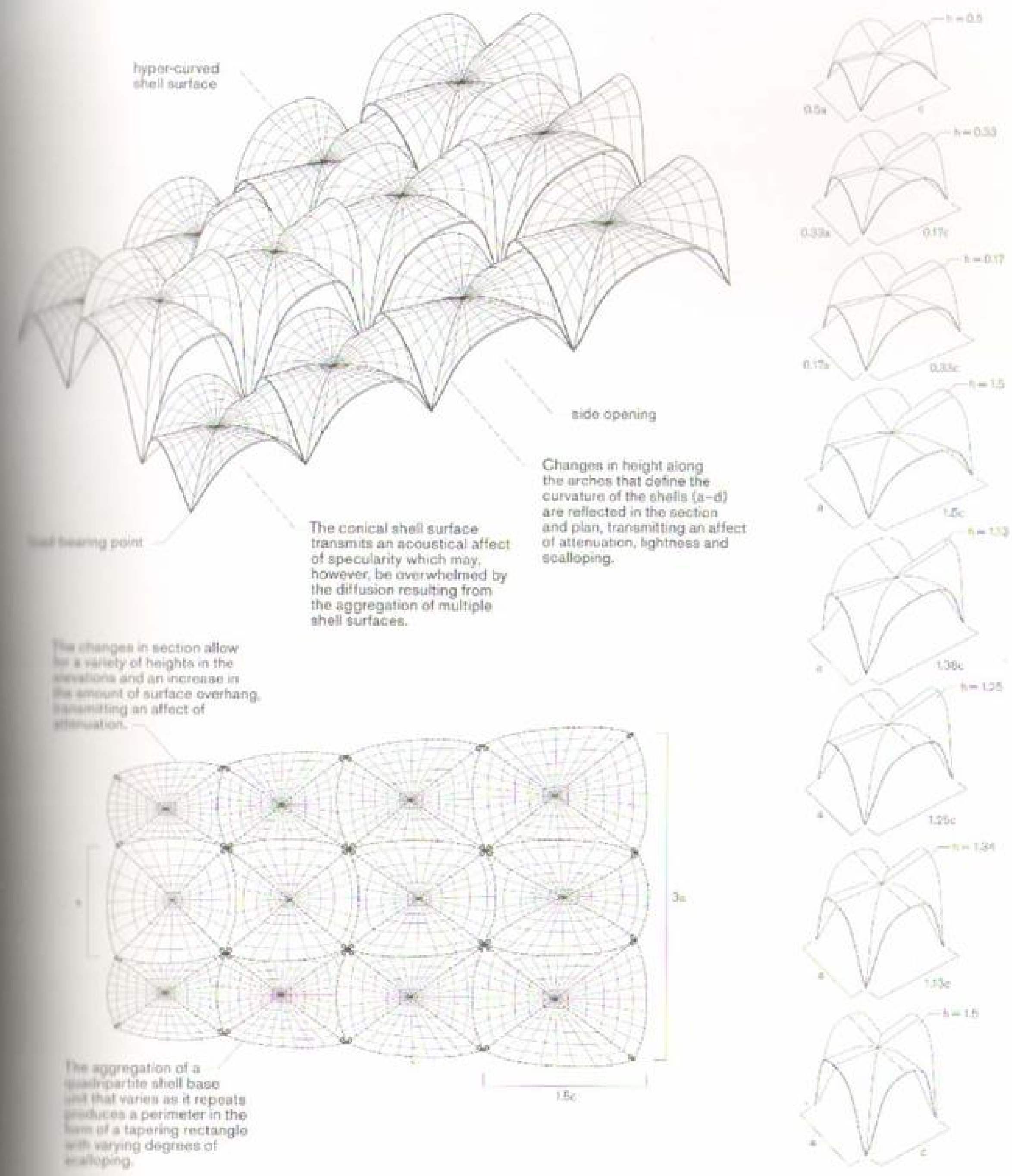




The Bacardi Bottling Plant is produced by a hyper-curved concrete shell base units . Shells intersect to form a cross-vault with glass and masonry infill. The plan and section can be changed by increasing or decreasing the radii of the curves that define the arches in order to change their height, or the area of the glass and masonry infill can be extended, to allow the structure to adapt to programmatic or environmental requirements such as the volume of the space or the amount of natural light. The Bacardi Bottling Plant transmits an optical affect of scalloping, pleating, lightness and smoothness, and an acoustical affect of specularity.

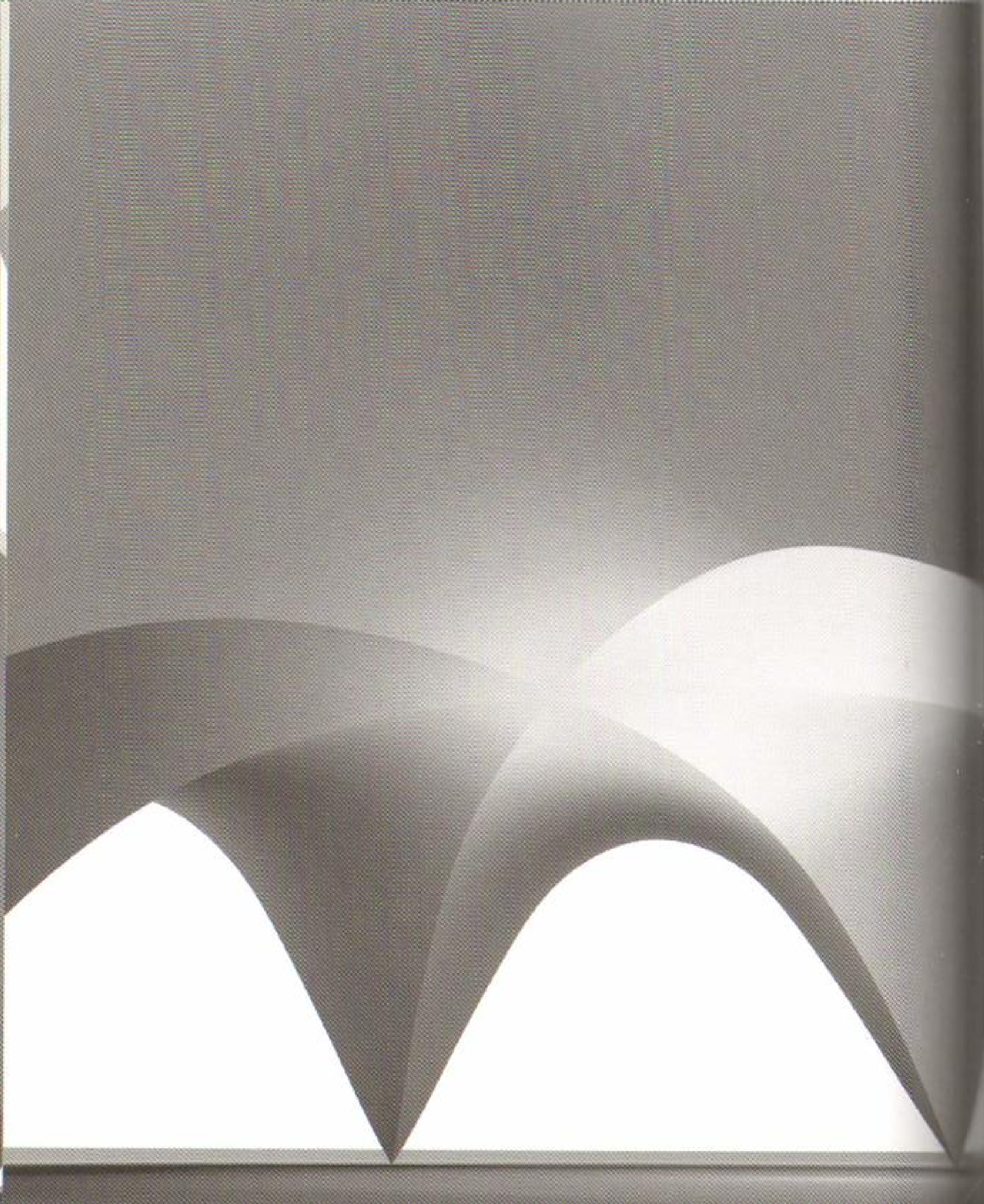
Attenuation, Lightness, Scalloping, Specularity, Diffusion

Horizontal / Hyper-Curved Shell

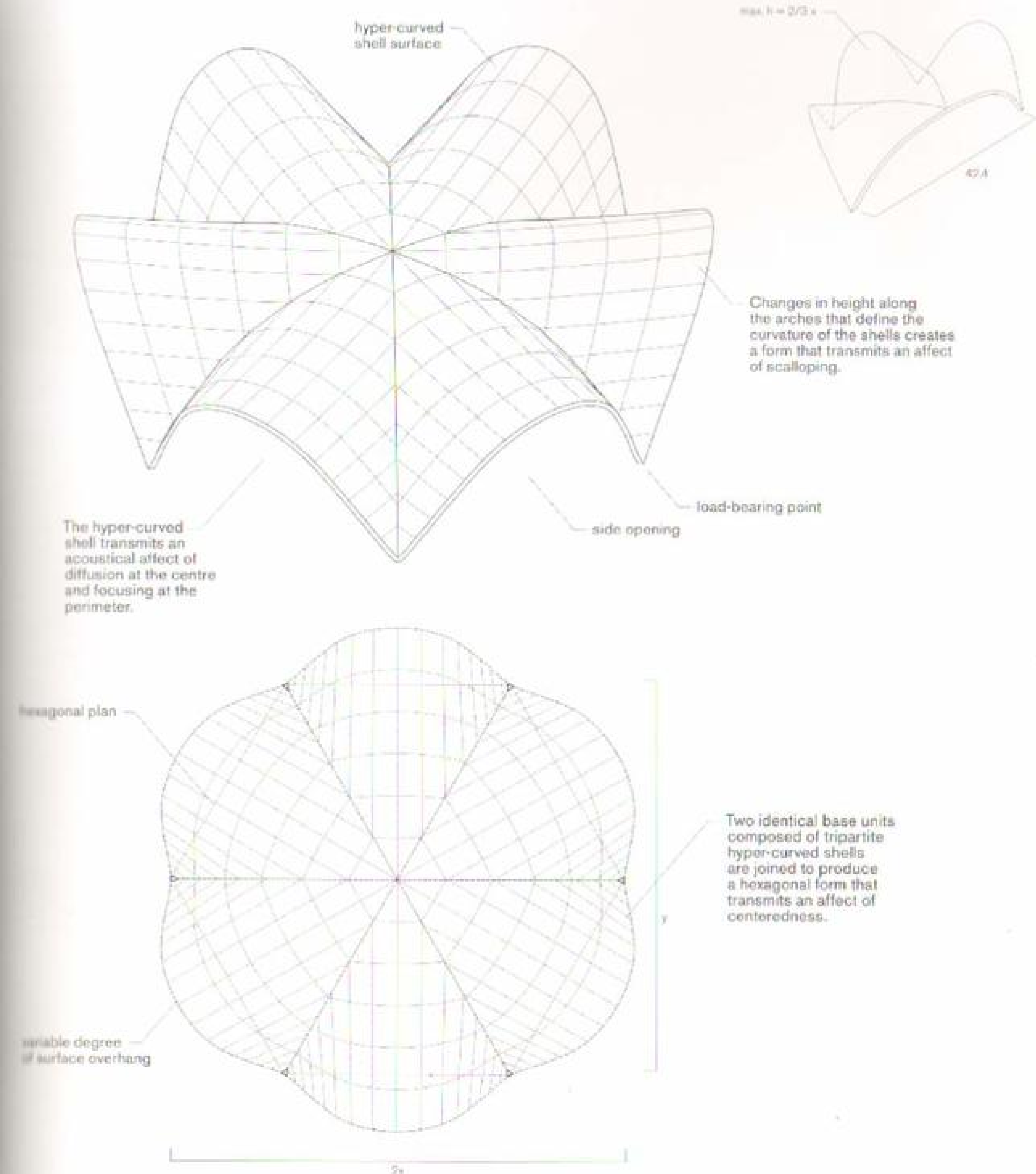


The horizontal form is produced by the tessellation of a hyper-curved concrete shell base unit, forming three irregular bays, with the width of each bay gradually tapering longitudinally. The height of the shells in the central aisle is greater than that of the two side aisles, allowing for changes in the resulting elevations. This assemblage transmits an optical affect of attenuation, lightness and scalloping, and an acoustical affect of specularity and diffusion.

Centeredness, Scalloping, Focusing, Diffusion

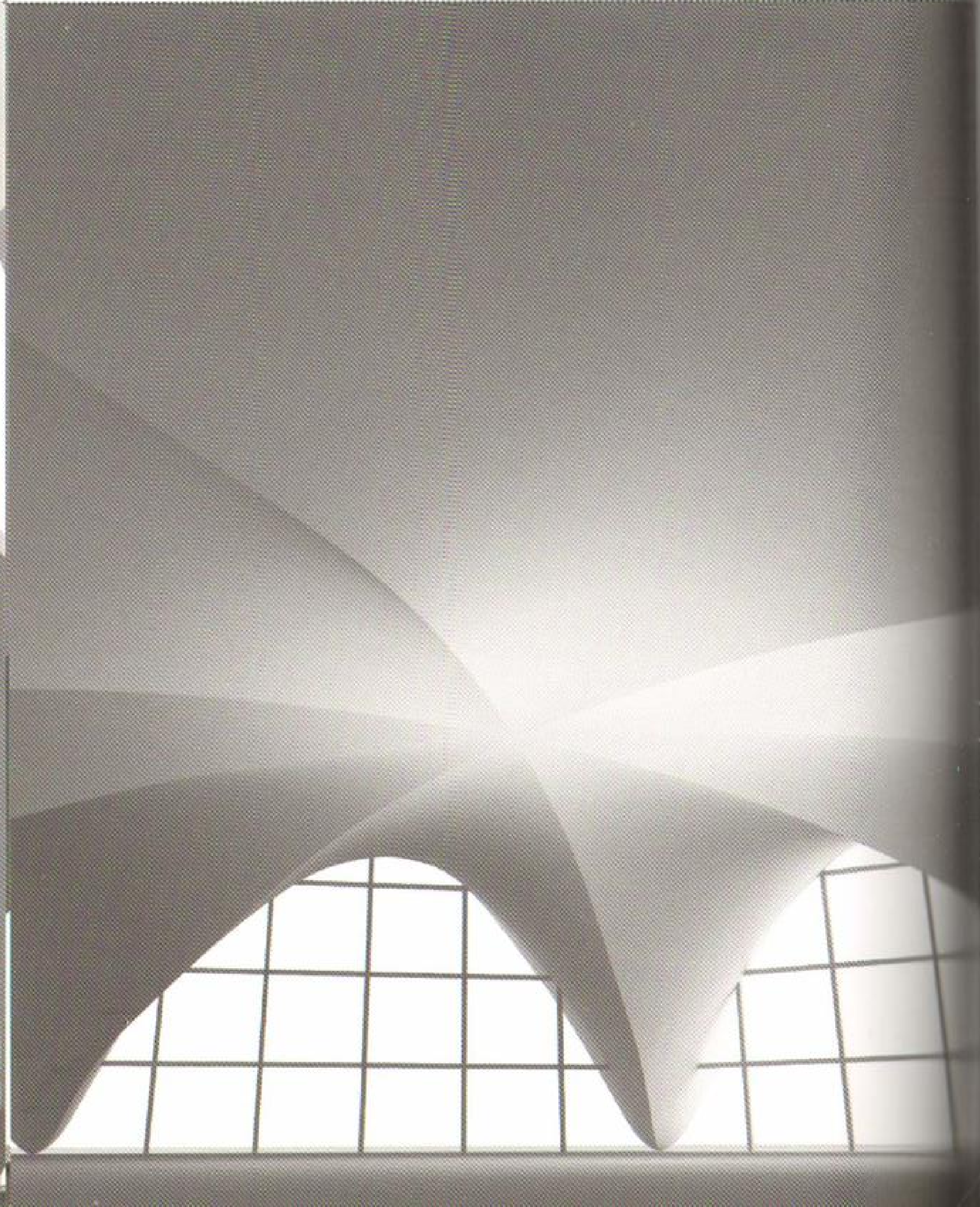


Horizontal / Hyper-Curved Shell



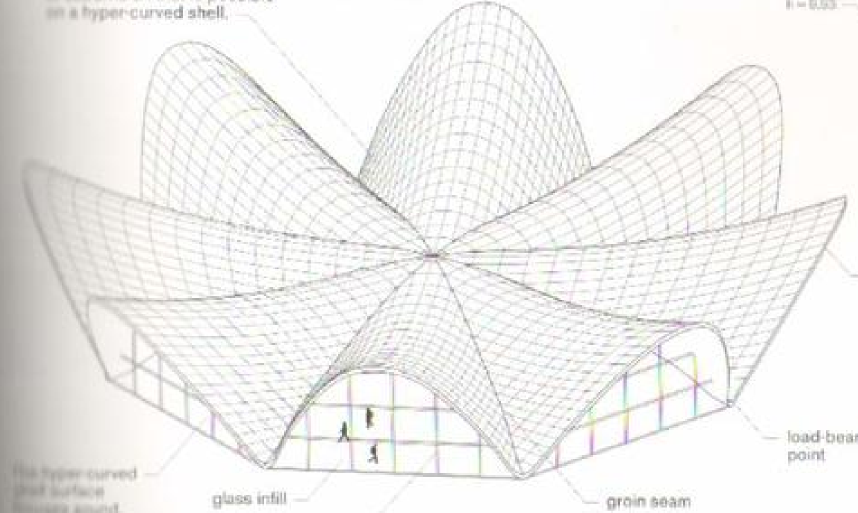
This form is produced by a single base unit comprising three intersecting single-curved shells arranged around a central point repeated once to form a hexagonal plan. The flexibility of the base unit lies in the changes that can be made to the radius of the curvature that defines the surfaces in section, changes to the extent of surface overhang of each shell on the perimeter, and changes to the height of the central point around which the shells are arranged. By changing the height of the arches that define the curvature, the base unit can increase or decrease the interior volume that it defines while simultaneously increasing or decreasing the area of its exterior elevation, enabling it to adapt to programmatic or environmental requirements. This form transmits an optical affect of centeredness, scalloping and faceting, and acoustical affects of focusing and diffusion.

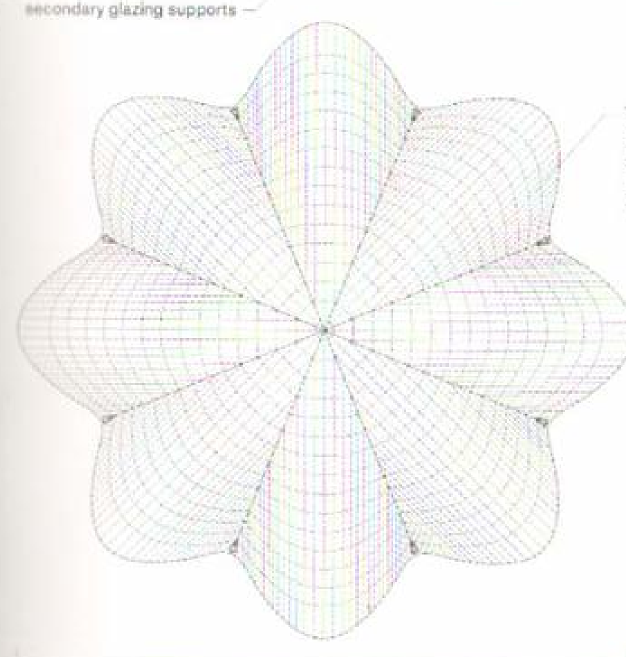
Centeredness, Scalloping, Focusing



Horizontal / Hyper-Curved Shell

LOS MANANTIALES RESTAURANT | F. CANDELA, J. ÁLVAREZ ORDÓÑEZ | MEXICO CITY, MEXICO | 1959



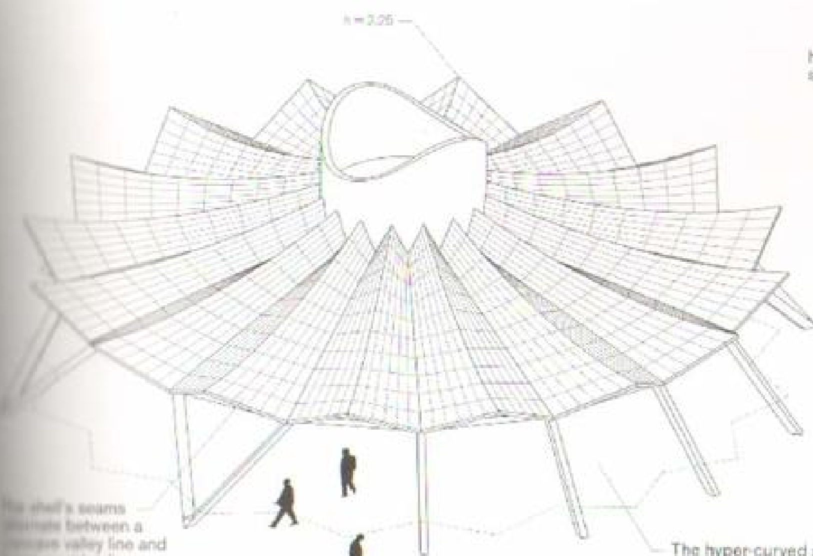


The Los Manantiales restaurant is produced by a base unit comprising four intersecting hyper-curved concrete shells arranged around a central point, repeated once to form an octagonal plan. The flexibility of this base unit lies in the changes that can be made to the radius of the curvature that defines the surfaces in section, changes to the extent of surface overhang of each shell on the perimeter, and changes to the height of the central point around which the shells are arranged. By changing the height of the arches that define the curvature, the base unit can increase or decrease the interior volume while simultaneously increasing or decreasing the area of its exterior elevation, enabling it to adapt to programmatic or environmental requirements. The interior surfaces are outlined by the edges of the eight groins, reinforcing the areas where the stresses converge, while the exterior surface of the shell appears as a continuous surface. The Los Manantiales restaurant transmits an optical affect of centeredness and scalloping, and an acoustical affect of focusing.

Centeredness, Pleating, Specularity, Diffusion

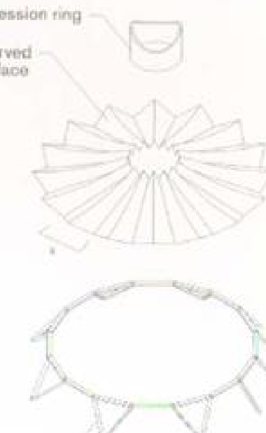
Horizontal / Hyper-Curved Shell

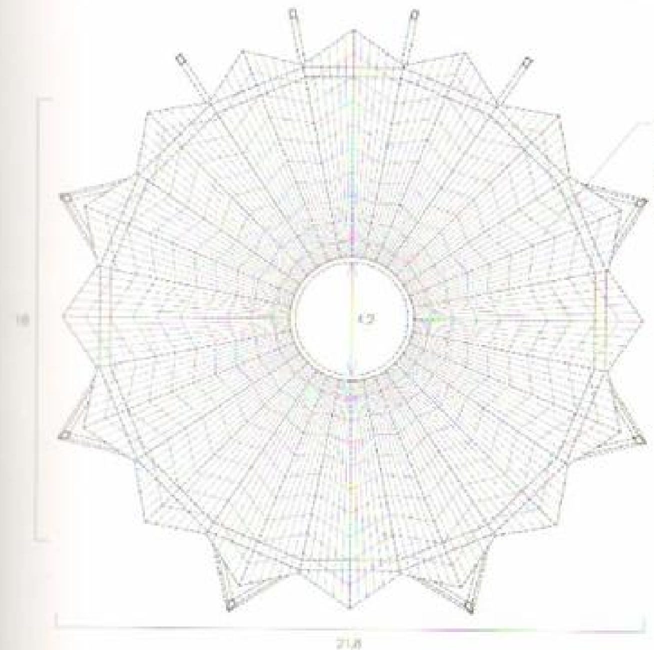
LOMAS DE CUERNAVACA BAZAAR | F. CANDELA, G. ROSELL, M. LARROSSA | CUERNAVACA, MEXICO | 1958



The shell's seams alternate between a concave valley line and a convex ridge line, illustrating the flexibility of the section of a hyper-curved shell.

The hyper-curved shell transmits an acoustical affect of diffusion near the centre and focusing near the perimeter.

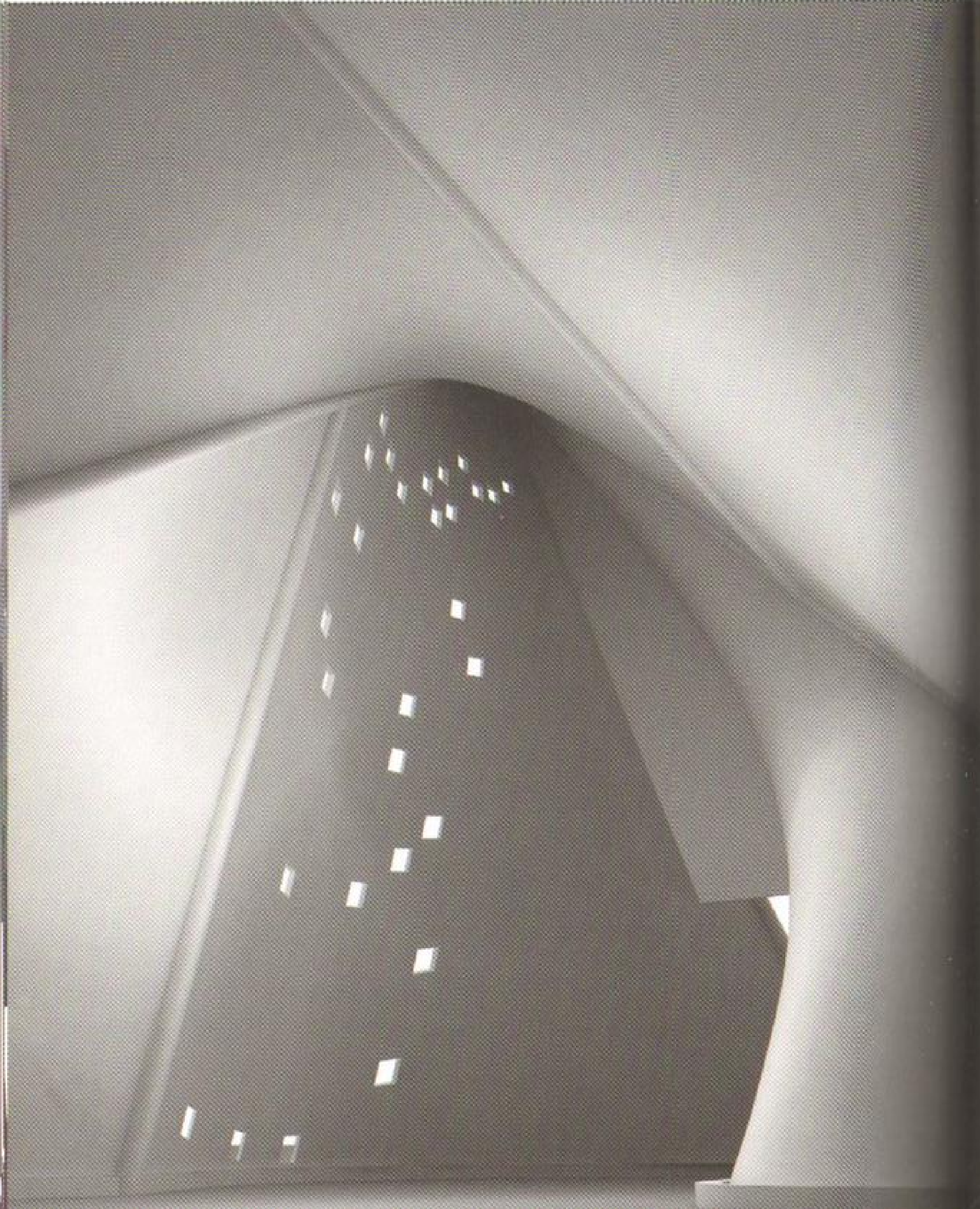




The pleated shell base unit and compression ring are set on top of the support ring and columns, producing a regular hexadecagonal perimeter, transmitting an affect of centeredness.

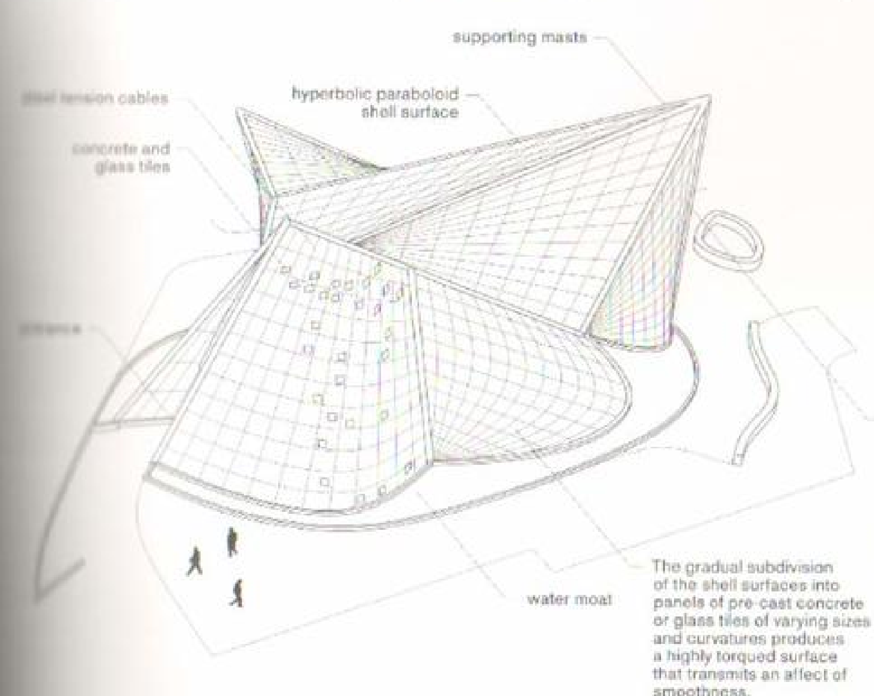
The Lomas de Cuernavaca Bazaar is produced by a single base unit comprising sixteen folded hyper-curved concrete shells arranged around a central compression ring in the form of a tube. The flexibility of this base unit is determined by several characteristics: the height of the apexes of each of the shells as they span outward from the central tube can be changed to increase the structural depth, the depth of the folds that form each of the shells can be changed to increase their strength against bending moments, and the location of the compression ring can be shifted from the center to produce an asymmetrical plan. The Lomas de Cuernavaca Bazaar transmits an optical affect of centeredness and pleating, and an acoustical affect of specularity and diffusion.

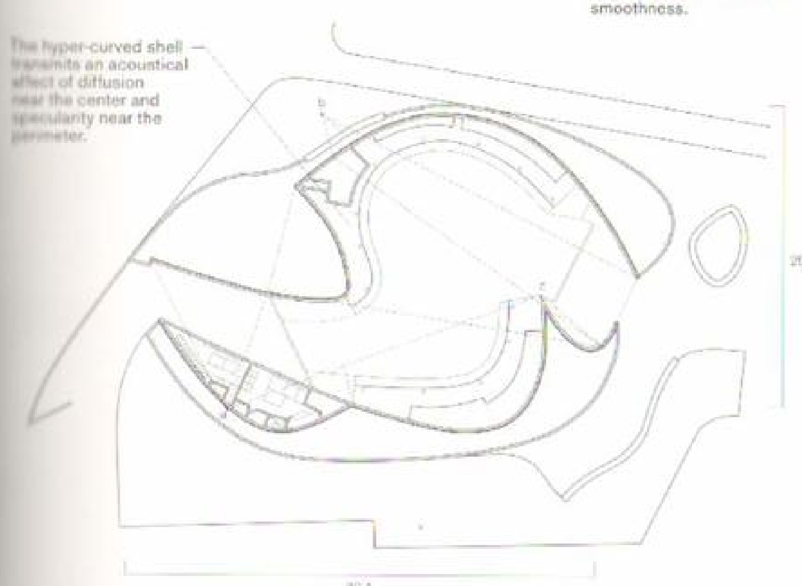
Tenting, Torquing, Smoothness, Lightness, Specularity, Diffusion



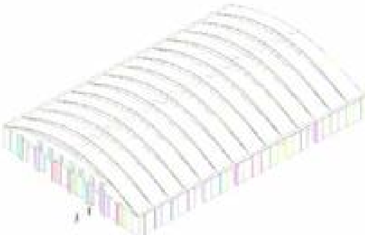
Curved / Hyper-Curved Shell and Tensile Membrane

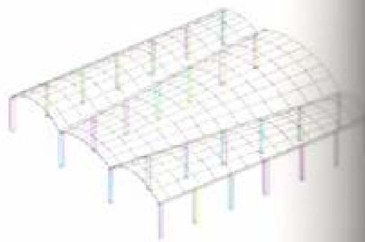
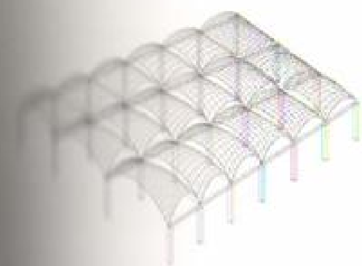
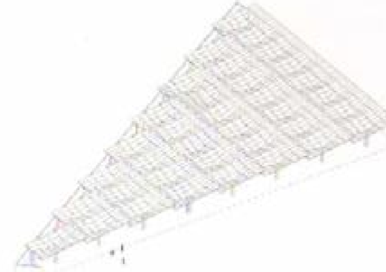
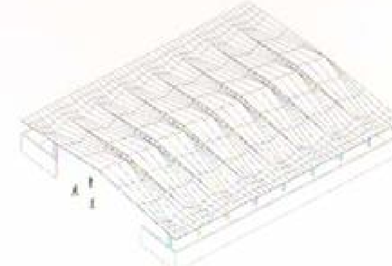
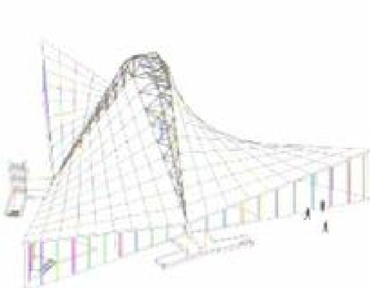
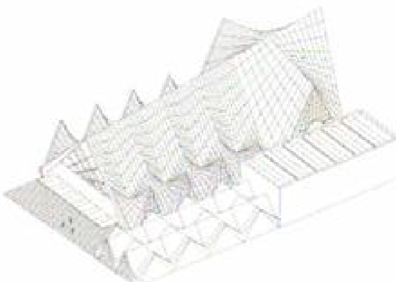
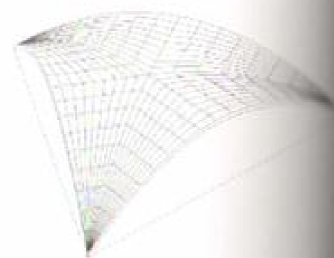
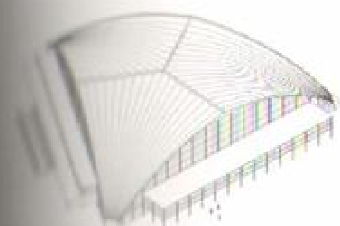
PHILIPS PAVILION | LE CORBUSIER, I. XENAKIS | BRUSSELS, BELGIUM | 1958

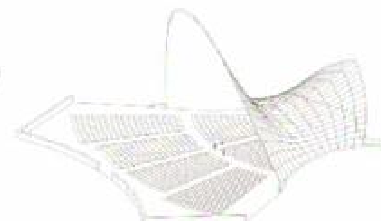
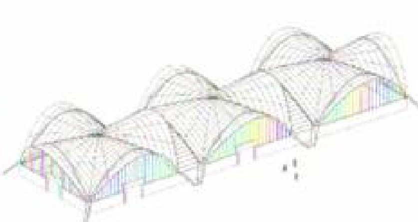
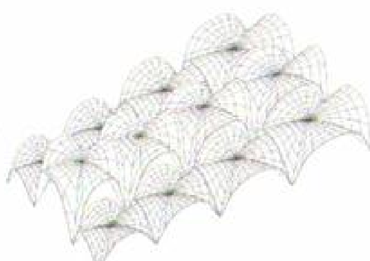
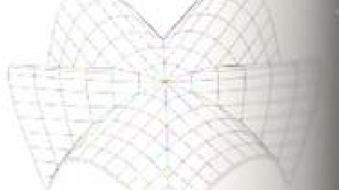
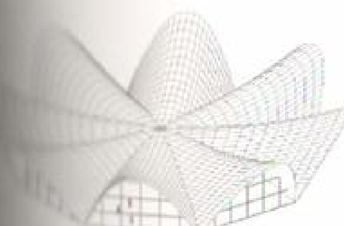
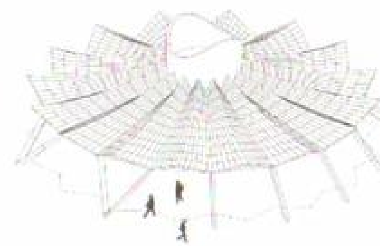
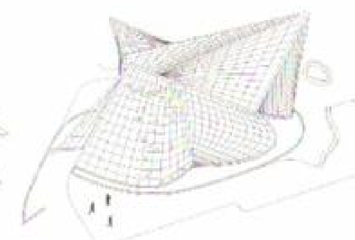




The Philips Pavilion is produced by the tessellation of a hyperbolic paraboloid base unit repeated asymmetrically to create a dynamically angled space that begins as a series of curves in plan and transforms into a number of apex points. The surfaces are made of steel tension cables and precast concrete and glass tiles. A large-scale steel structure controls the regular distribution of cables that give shape to the ruled surfaces of the shells. The flexibility of this base unit is determined by several characteristics that enable it to adapt to changing programmatic requirements: changes can be made in the curvature of the perimeter in plan, in the height of the apex points of the tubular structure, and in the scale of diffusion, which can be generated by the cable grid. The Philips Pavilion transmits an optical affect of tenting, torquing, smoothness and lightness, and an acoustical affect of specularity and diffusion.

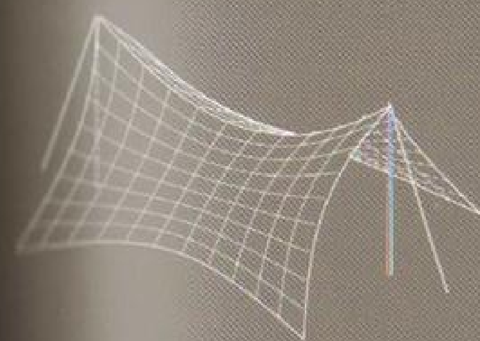


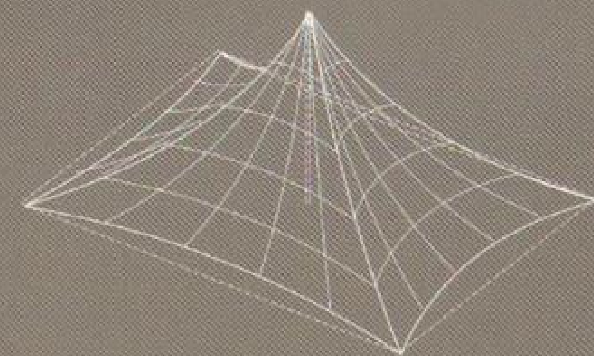








Tensile membranes distribute loads along the surface and the lines of the cables that form the membrane. The membrane and cables act in tension, while the posts act in compression. Tensile membranes vary in kind according to the distribution of loads along an increasing number of the axes that form a post-and-cable and membrane assemblage. Tensile membranes can be built of fabric or polycarbonate or resin-based plastics acting in compression, and steel cables acting in tension. Tensile membrane systems vary according to the different arrangements of posts and cables that subdivide the surface of the membrane and give it form. This analysis has not specifically addressed resistance to lateral loads.

The system of tensile membranes can be divided into two primary subsystems: parallel cable tensile membranes and radial cable tensile membranes.
Parallel cable tensile membranes are built of post-and-cable portals which are distributed in an approximately parallel arrangement along a line, and a membrane with one subdivision on its surface. The subdivision of the membrane's surface occurs at the apex of the catenaries, which is formed by the spanning of the cable from one post to another.
Radial cable tensile membranes are formed by a single post, from the top of which a series of cables are arrayed. The surface of the membrane is subdivided at least four times, but often many more, to respond to loads which are acting in four directions.

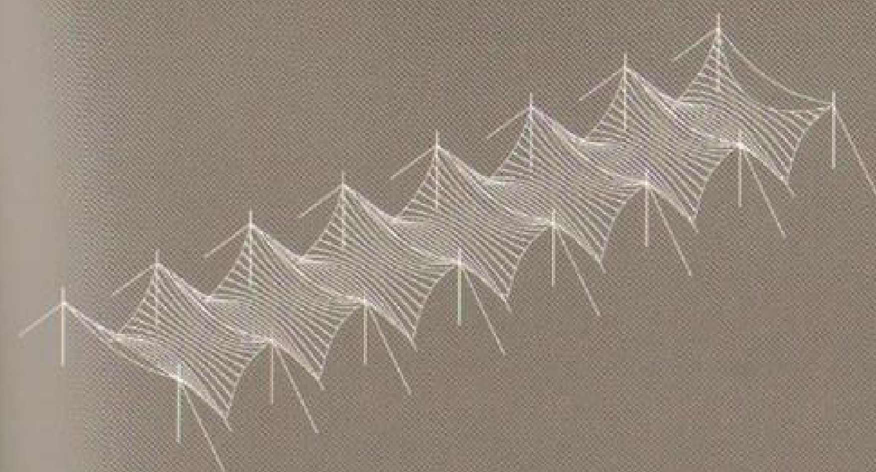


Parallel Cable Tensile Membrane



Radial Cable Tensile Membrane

Horizontal tessellation can occur in the parallel cable tensile membrane subsystem when the masts and cables are arranged in a linear fashion or along a curve in plan. These respond to the forces distributed along surfaces and lines, with the masts acting in compression, and the cables acting in tension, to give form to the surface of the membrane, which further distributes force lines along its surface and is kept in tension. Horizontal tessellation can also occur in the radial cable tensile membrane subsystem, in which individual base units can vary while being placed along the axis of a line or a grid.

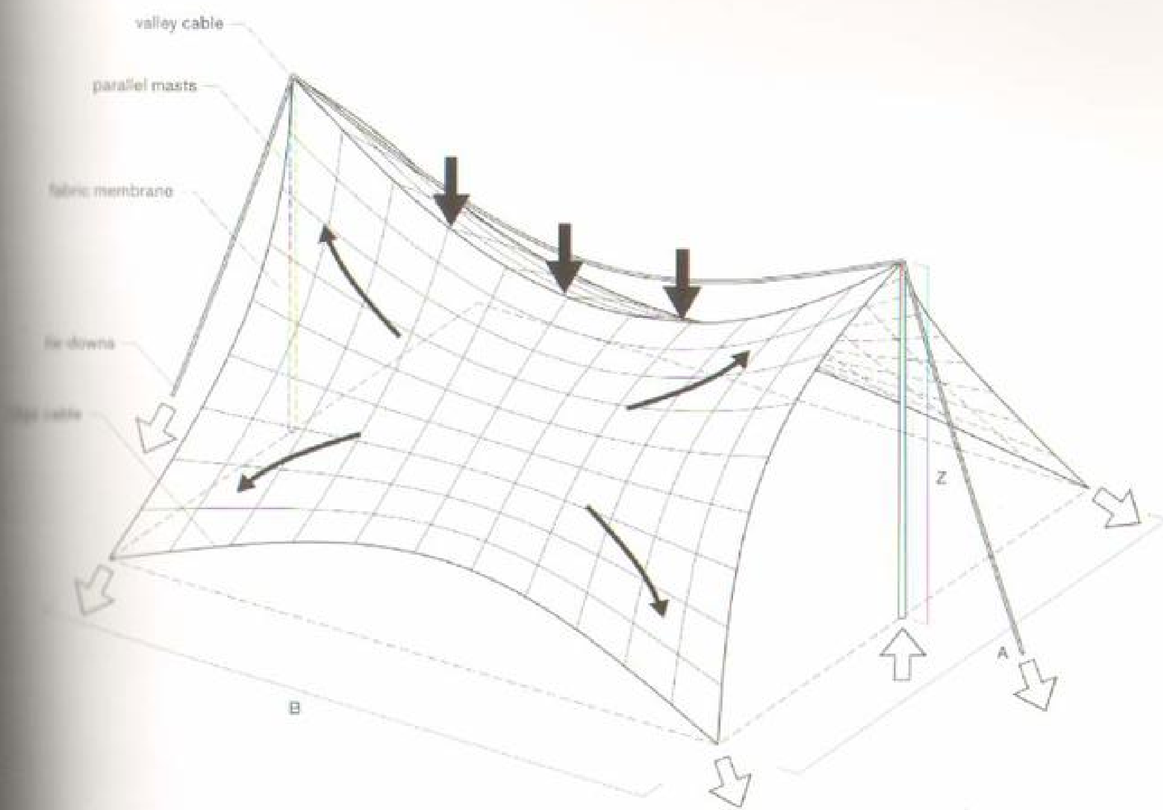


Horizontal Tessellation

Parallel Cable Tensile Membrane

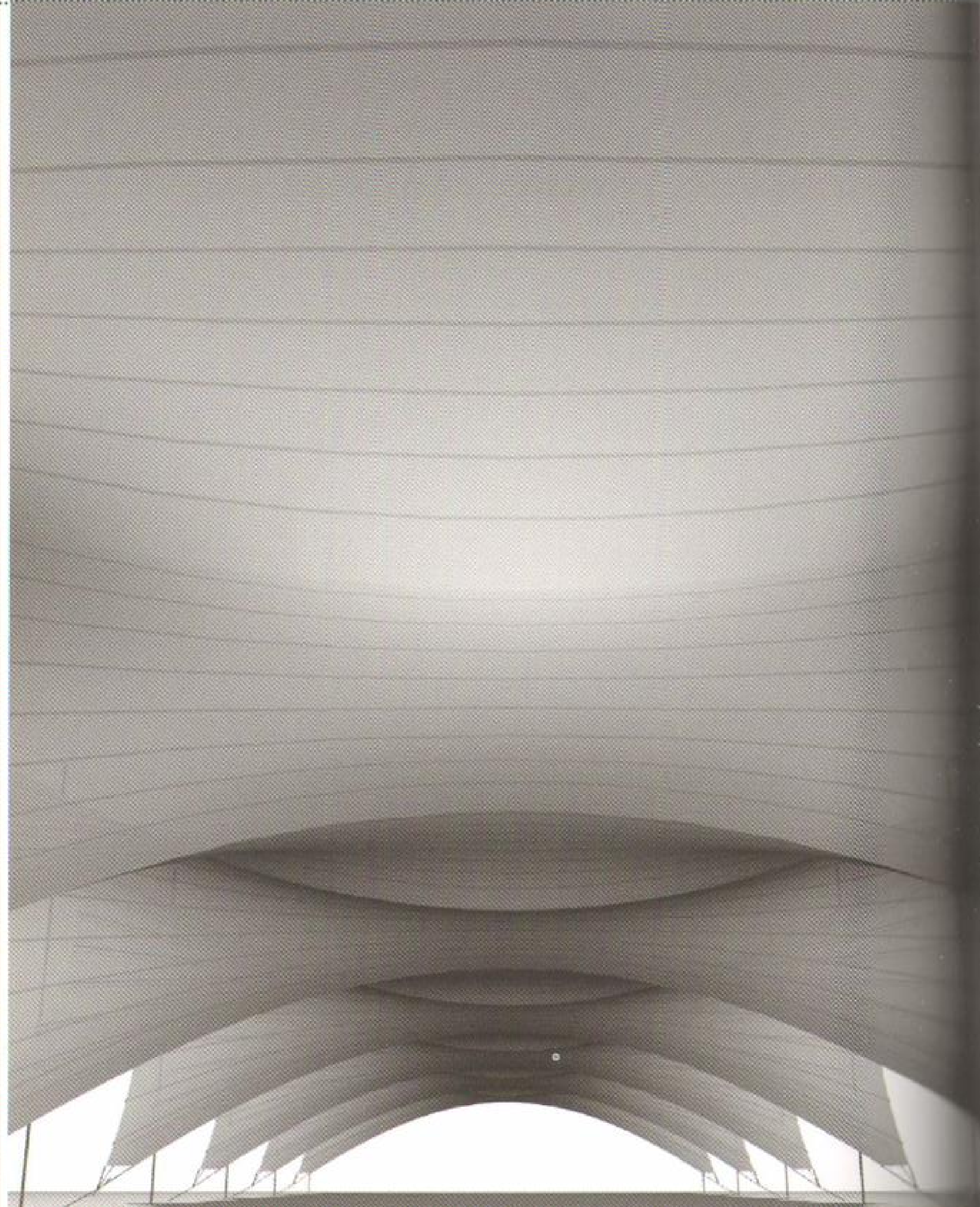
The base unit of a parallel cable tensile membrane is composed of a pair of masts supporting parallel ridge-and-valley cables, a fabric membrane, and the tie-downs that fasten both. The ridge cables span from the top of one mast to the top of the other. As they span, they form a catenary, known as a ridge. The valley cables span from one point on the ground on one side perpendicularly to its counterpoint on the other side, giving form to the lowest profile (valley) of the membrane. These form an arch, known as the valley. The fabric spans between the ridge and the valley cables. All fabric structures are stable because they have a system of internal forces set up within them that are equal and opposing when no external load is applied. These stresses are generated by cables and masts working in an opposite direction and curvature to the fabric itself. When external loading is applied the geometry of the unit changes and the balance of the internal forces also change to find a new equilibrium. Thus fabric structures are long displacement structures by virtue of the manner in which they resist load. The distribution of loads along the lines of the cables and the surface of the fabric embeds the parallel cable tensile membrane with an optical affective property of lightness and stretching that remains consistent within any space it defines. The acoustical affect of tensile membranes is determined by their surface curvature. A convex membrane will have an affect of diffusion. A concave membrane which is shallow will have an affect of specularity but, near its center of curvature, there may be some focusing.

Parallel cable tensile membranes are flexible in several ways:
Section: The protogeometry of a parallel cable tensile membrane allows it to be flexible in the range of curvature of the perpendicular section. The curvature of the ridge and valley cables that shape the fabric can be made shallower or deeper, resulting in a corresponding change in the overall perpendicular section.
Plan: Parallel cable tensile membranes can tessellate horizontally along straight or curved lines of growth to produce primarily horizontal structures, or sheds.
Affect: The affective property of a parallel cable tensile membrane can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to lightness and stretching, a parallel cable tensile membrane can transmit other optical affects, including smoothness, vaulting, asymmetry, orientedness. The acoustical affect can be diffusion or specularity.



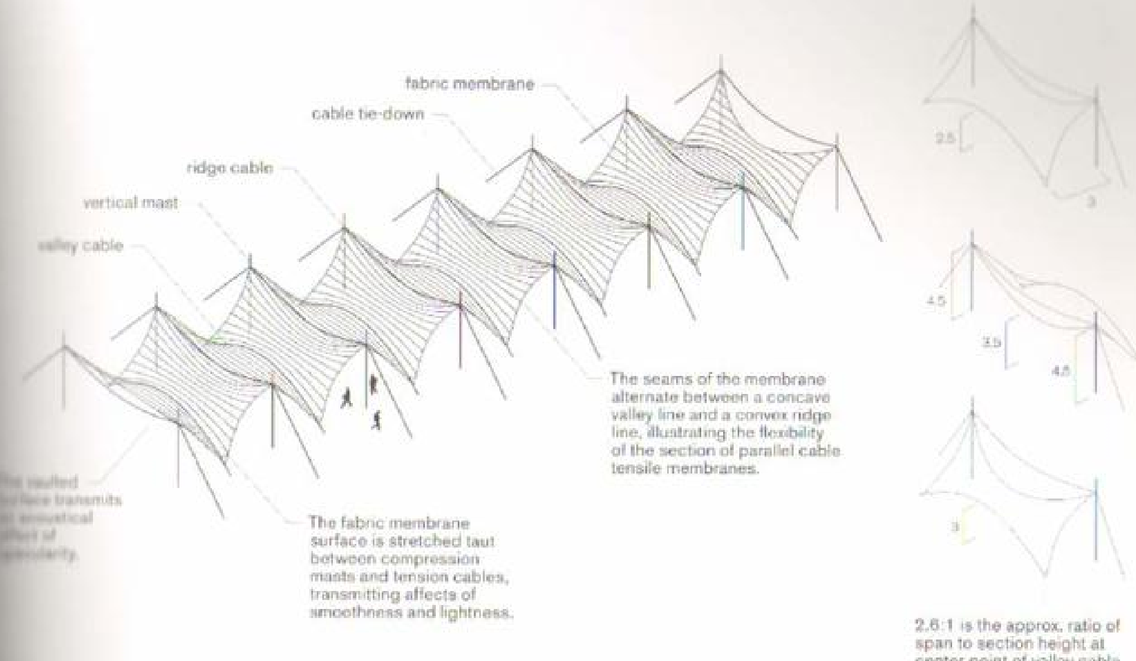
... by aesthetic and functional requirements but internal forces and reactions increase as Z/A reduces and B increases.

Smoothness, Lightness, Vaulting, Variegation, Specularity



Horizontal / Parallel Cable Tensile Membrane

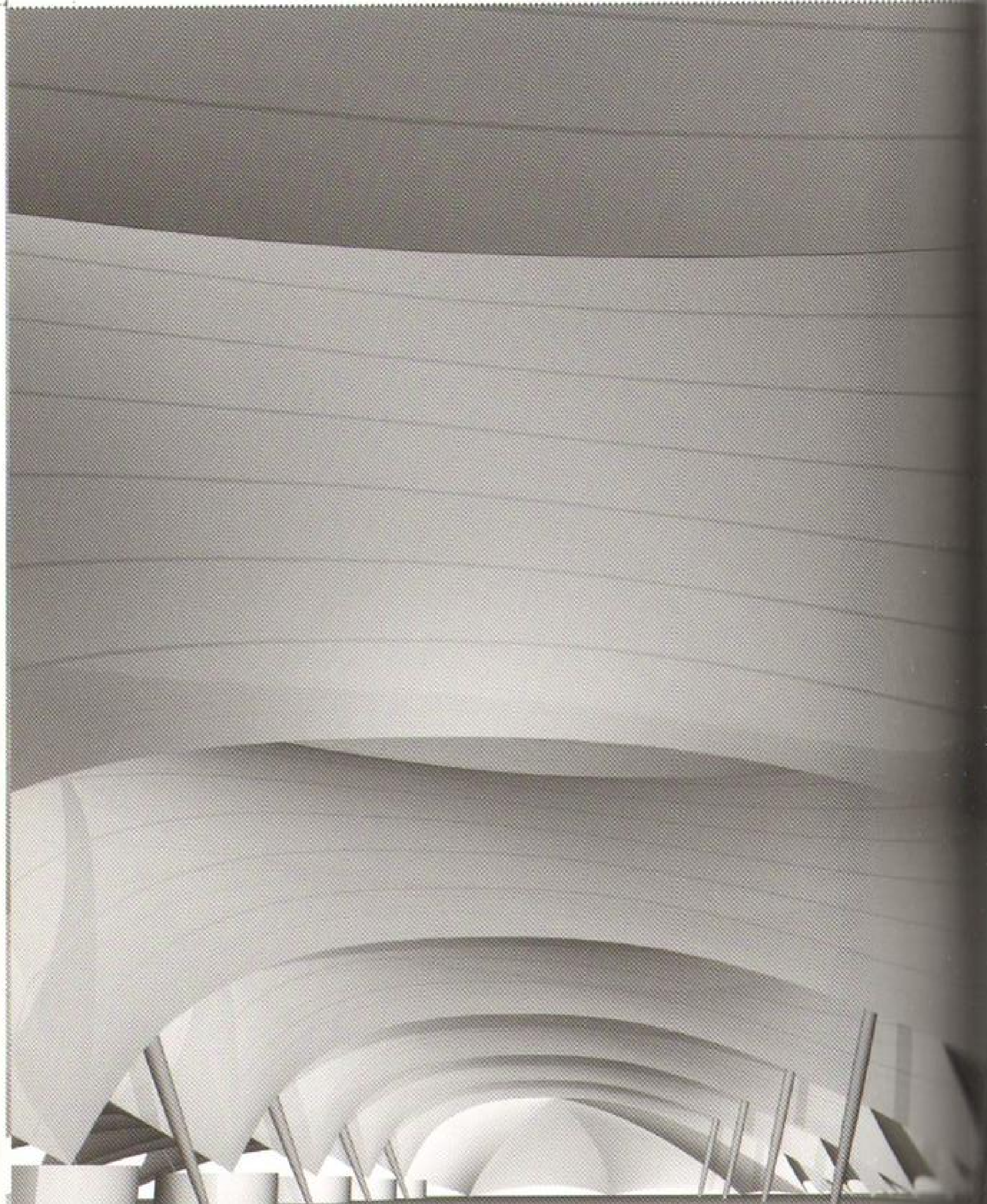
FOLKLORE PAVILION | H2L2 ; GREIGER BERGER | PHILADELPHIA, USA | 1976



2.6:1 is the approx. ratio of span to section height at center point of valley cable

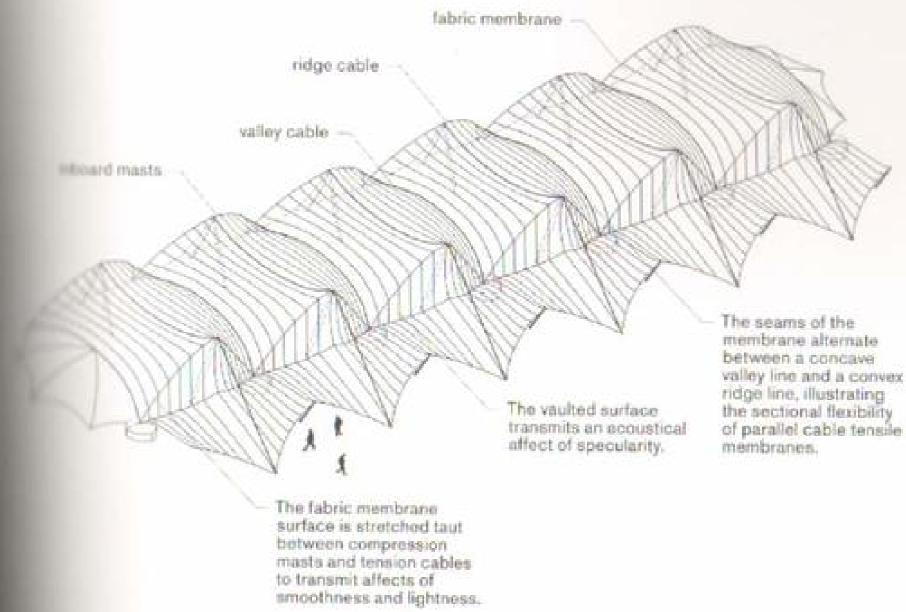
The Folklore Pavilion is produced by the tessellation of a parallel cable tensile membrane base unit which varies three times to create five full bays and two side bays, spanning between the primary portals composed of two inboard posts, and two cables that form the upper ridge and the lower valley profile of the membrane. The flexibility offered by this assemblage lies in the section, where a wide range of catenary curves can be inscribed by the cables that give form to the membrane. It can also extend to the plan with respect to the perimeter masts, which are able to follow a wide range of lines or curves, or even form an asymmetrical perimeter. The Folklore Pavilion transmits an optical affect of smoothness, lightness and vaulting, and an acoustical affect of specularity.

Smoothness, Lightness, Stretching, Vaulting, Asymmetry, Specularity

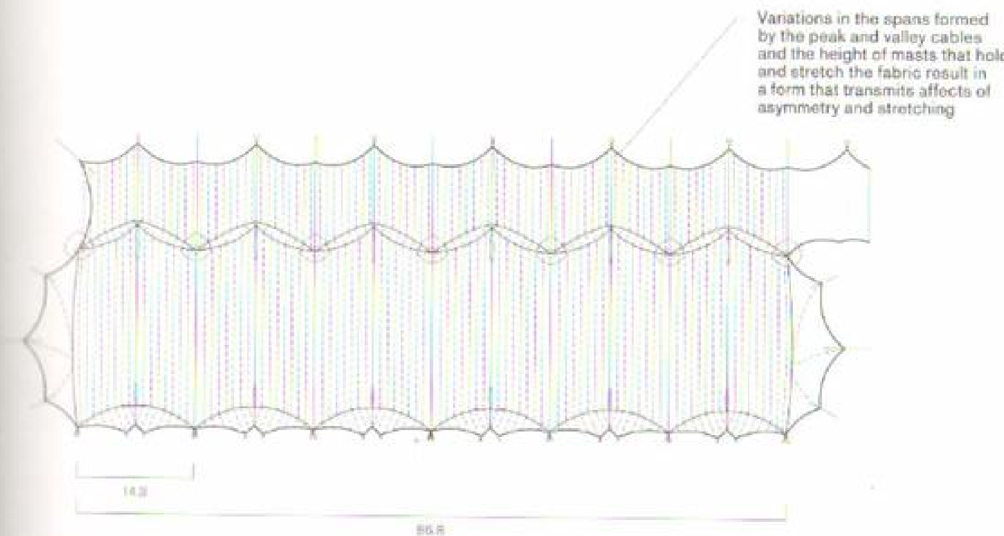


Horizontal / Parallel Cable Tensile Membrane

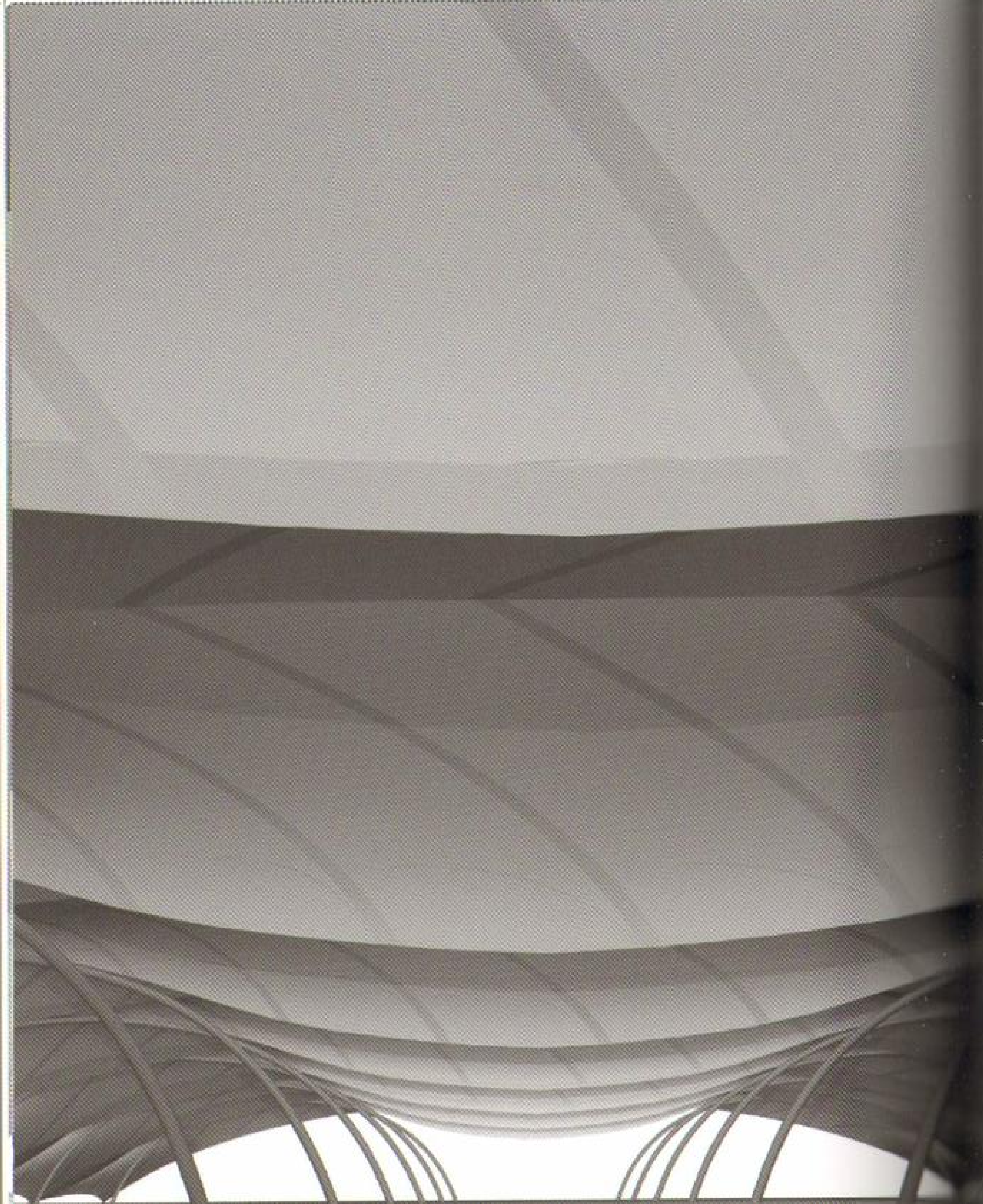
HORTICULTURE EXHIBITION TENT | F. OTTO; L. STROMEYER & CO. | HAMBURG, GERMANY | 1963



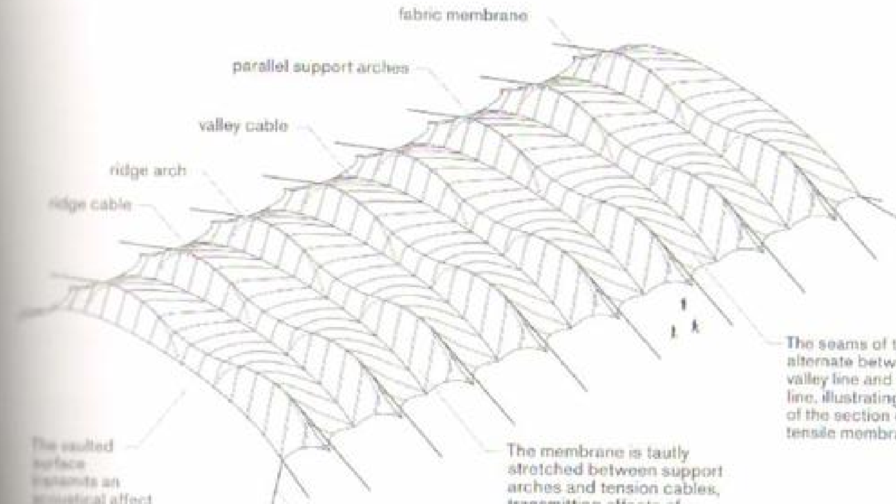
3:1 > approx. ratio of span to section height

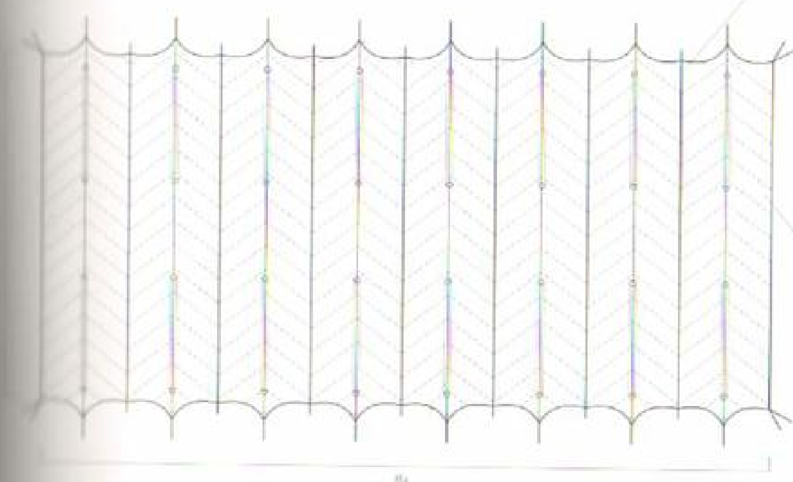


The Horticulture Exhibition Tent is produced by the tessellation of a parallel cable tensile membrane base unit to create six full bays and two side bays, spanning between the primary portals composed of two inboard posts, and two cables which form the upper ridge and the lower valley profile that gives form to the membrane. The flexibility offered by this assemblage lies in the section, where a wide range of catenary curves can be inscribed by the cables. It can also extend to the plan with respect to the perimeter masts, which are able to follow a wide range of lines or curves, or even form an asymmetrical perimeter. The Horticulture Exhibition Tent transmits an optical affect of smoothness, lightness, stretching, vaulting, and asymmetry, and an acoustical affect of specularity.



Horizontal / Parallel Cable Tensile Membrane



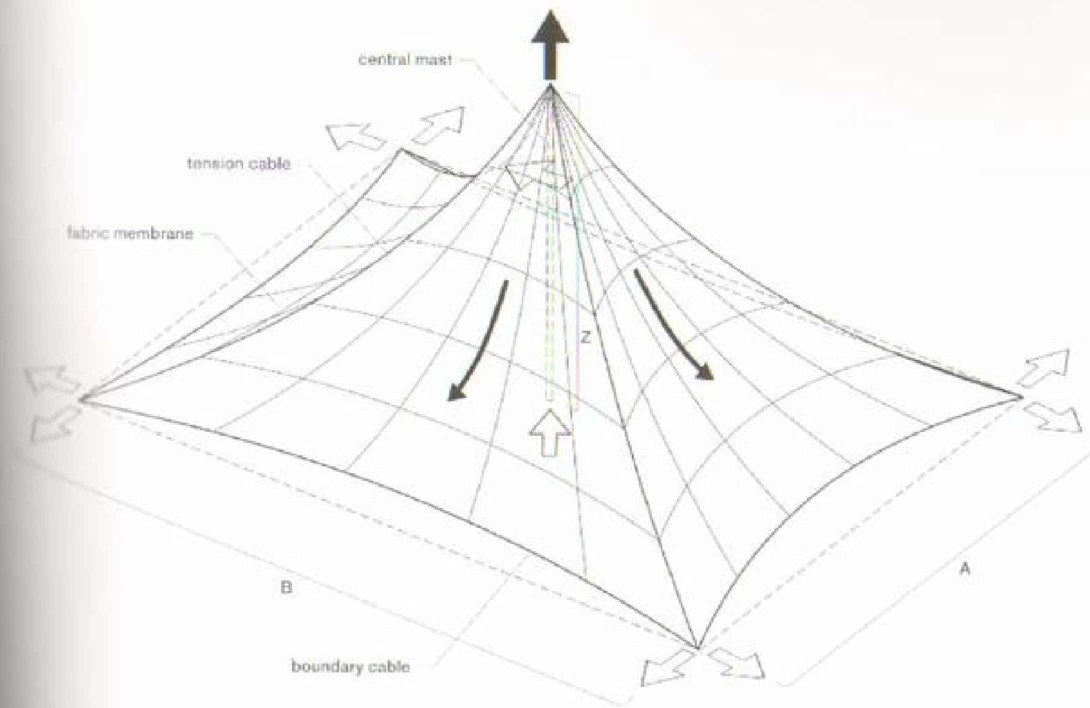


[illegible] form is produced by the tessellation of a parallel cable tensile membrane base unit to create eight full bays and two half-bays, [illegible] between primary portals composed of two inboard arches that form the upper ridge, and cables that form the lower valley profile, [illegible] to the membrane. The flexibility offered by this assemblage lies in its section, where a wide range of heights can be assigned to the [illegible]. These can be evenly distributed, or slightly staggered to follow a diagonal line, enhancing the flexibility of the plan. The arches that form [illegible] can also be arranged along a curve, or can increase in radius to create an asymmetrical perimeter. This form transmits an optical affect [illegible] lightness, stretching, vaulting and repetition, and an acoustical affect of specularity.

Radial Cable Tensile Membrane

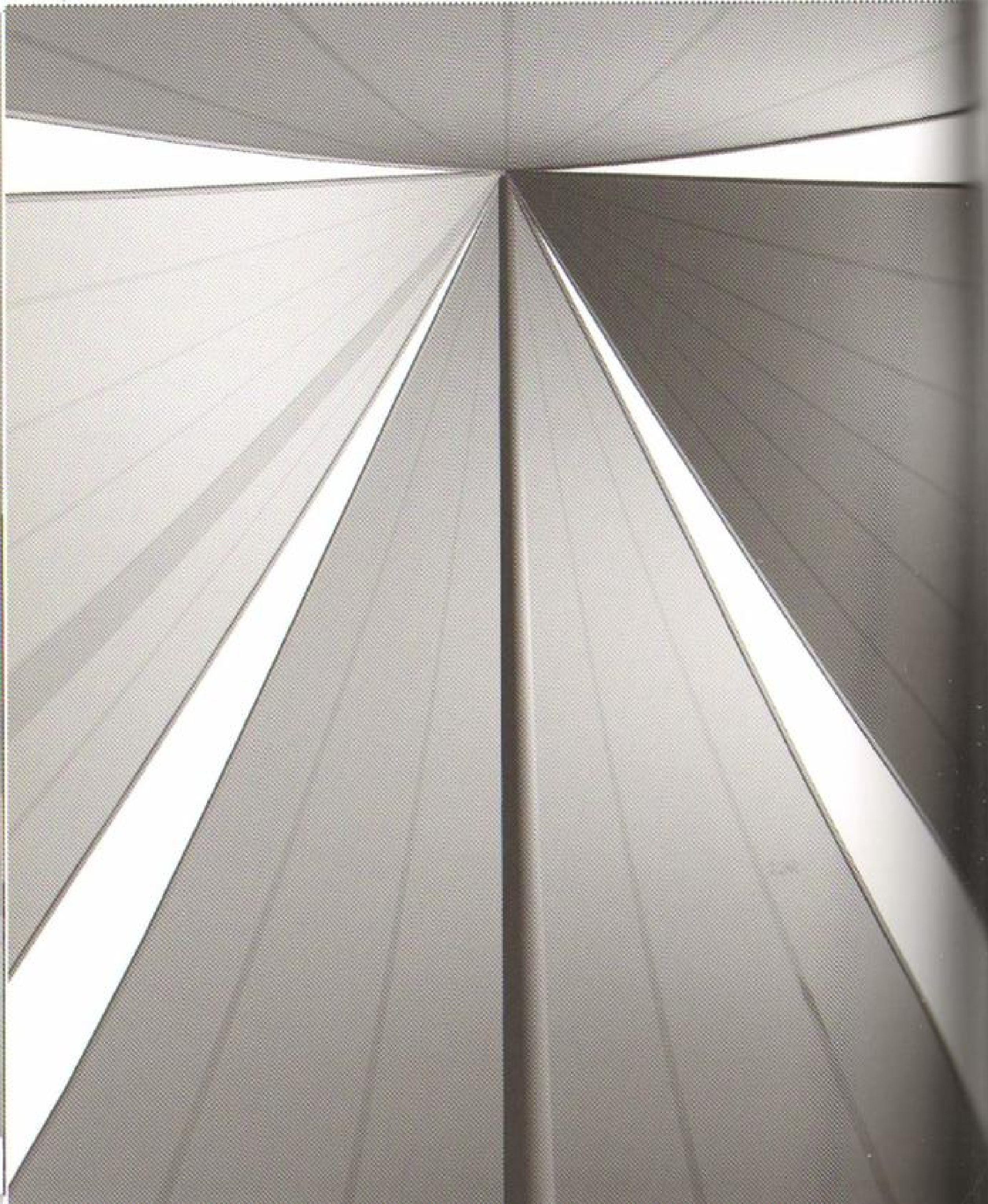
The base unit of a radial cable tensile membrane is composed of a central mast supported by a variable number of cables arranged in a radial pattern. In cases where the masts follow a linear axis, the areas they cover are similar; where they are set out along a curved line, they become differentiated. All fabric structures are stable because they have a system of internal forces set up within them that are equal and opposing when no external load is applied. These stresses are generated by cables and masts working in an opposite direction and curvature to the fabric itself. When external loading is applied the geometry of the unit changes and the balance of the internal forces also change to find a new equilibrium. Thus fabric structures are long displacement structures by virtue of the manner in which they resist load. Radial cable tensile membranes are made primarily of steel mast, cable and fabric, or sometimes of timber or trussed steel columns. The distribution of loads along the lines of the cables and the surface of the fabric embeds the radial cable tensile membrane with an optical affective property of flying and tapering that remains consistent within any space it defines. The convex surfaces of a radial cable tensile membrane transmit an acoustical affect of diffusion or specularity, depending upon the radius of the curvature. However, the membrane material may possess sound-absorbing properties which can reduce or even eliminate the usual affects.

Radial cable tensile membranes are flexible in several ways:
Profile: The protogeometry of a radial cable tensile membrane allows flexibility in the range of curvature that can be given to the tension cables which give shape to the fabric.
Plan: A radial cable tensile membrane system can tessellate horizontally along straight or curved lines of growth to produce primarily horizontal structures, or sheds.
Affect: The affective property of a radial cable tensile membrane can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to tenting and tapering, a radial cable tensile membrane can transmit other optical affects, including orientedness, arching, vaulting, floating, lightness, verticality, cellularity, non-orientedness, enclosure, rotundity. The acoustical affect can be diffusion or specularity.

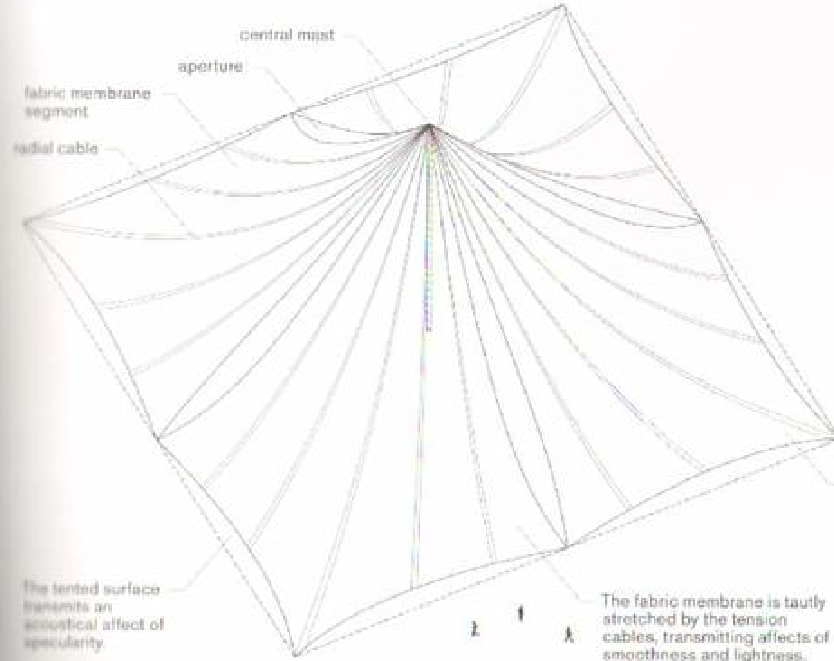


[illegible] by aesthetic and functional requirements but internal forces and reactions increase as Z/A reduces and B increases.

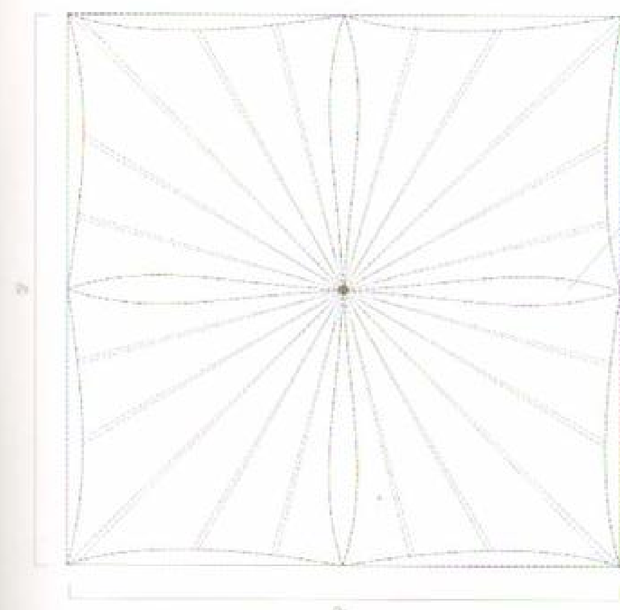
Tenting, Lightness, Verticality, Specularity



Horizontal / Radial Cable Tensile Membrane



1:0.75 is the approx. ratio of span to section height at outer edge

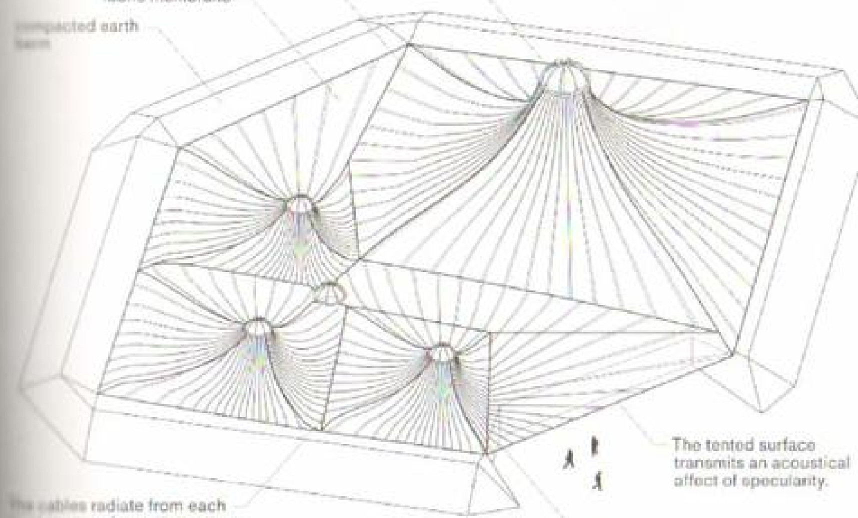


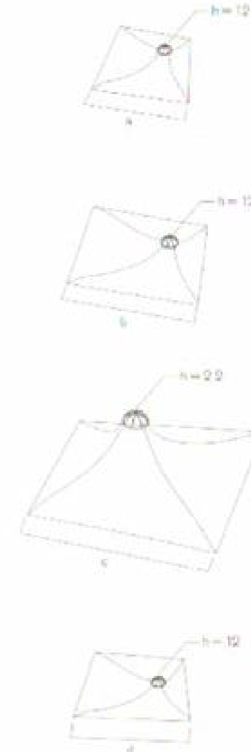
This horizontal form is produced by a radial cable tensile membrane base unit composed of a central mast to which are attached in a radial system a series of cables that give form to a segmented membrane. The flexibility of this assemblage varies in both plan and section: the cables can be attached to the ground in a wide range of plan configurations, either rectangular or circular as well as asymmetrical, and each of these types would produce a different section and a different degree of segmentation in the membrane. This form transmits an optical affect of tenting, lightness and verticality, and an acoustical affect of specularity.

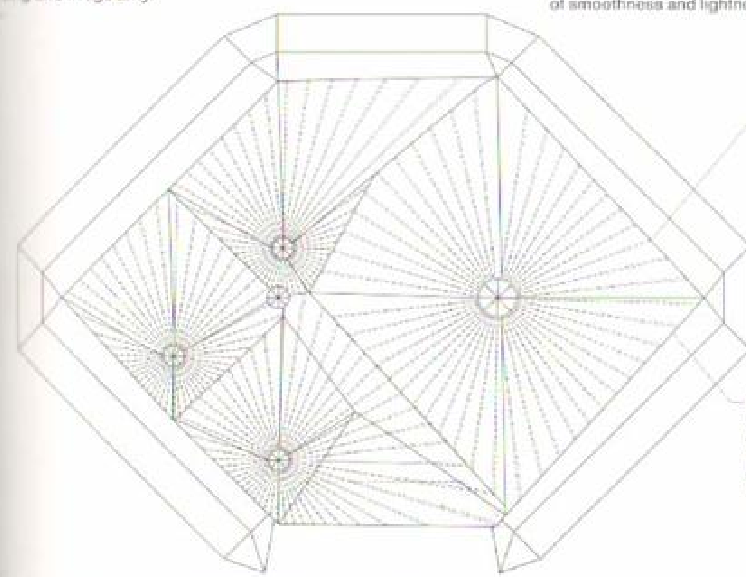
Tenting, Irregularity, Lightness, Smoothness, Specularity

Horizontal / Radial Cable Tensile Membrane

FESTIVAL PAVILION | R. LAMB HART; GEIGER BERGER | ORLANDO, USA | 1980





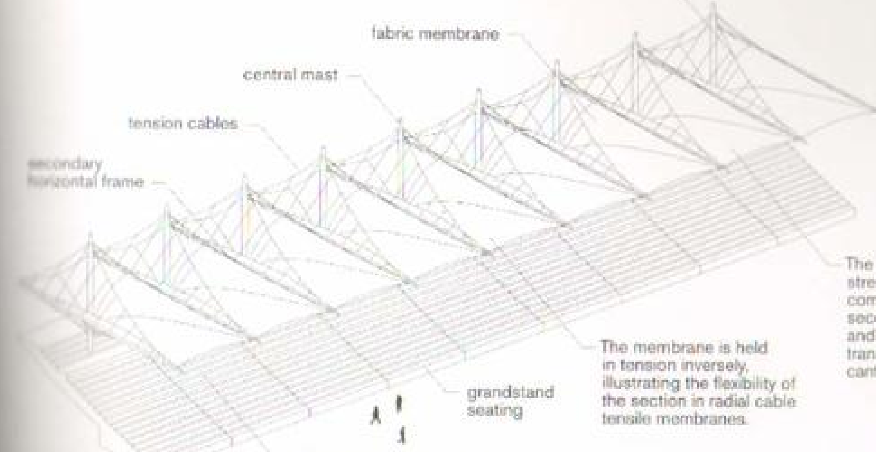


Festival Pavilion is produced by the tessellation of a radial cable tensile membrane base unit to create five central masts of differing heights, each of which is attached a set of radial cables. The radial cables land, above grade, on a second network of cross cables, and on the overall perimeter wall made up of a compacted-earth berm. This allows for an open plan that is differentiated by a range of section heights which are determined by the heights of the masts. Each of the areas defined by a mast and its cables corresponds to a different condition in plan, enabling the structure to adapt to the varying volumetric requirements of the program, and also to different perimeter conditions. The Festival Pavilion transmits an optical affect of tenting, lightness and smoothness, and an acoustical affect of specularity.

Cantilevering, Lightness, Specularity

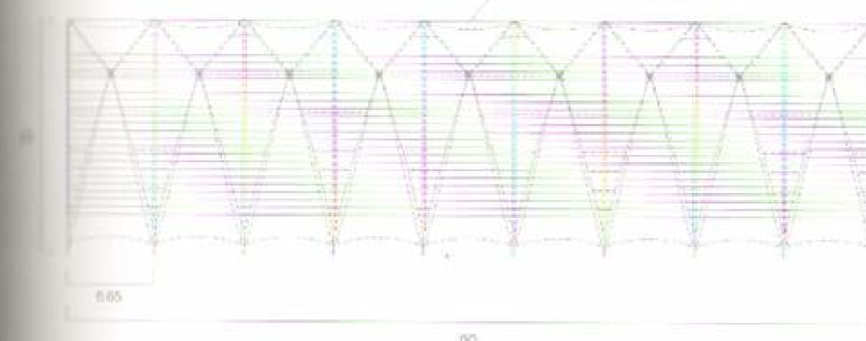
Horizontal / Radial Cable Tensile Membrane

OLDENBURG GRANDSTAND | SCHLAICH BERGERMANN | OLDENBURG, GERMANY | 1995



1.9:1 is the approx. ratio of span to section height

Cables of unequal length that radiate from the masts define the perimeter of each bay to produce a cantilevering and inversely tented form.

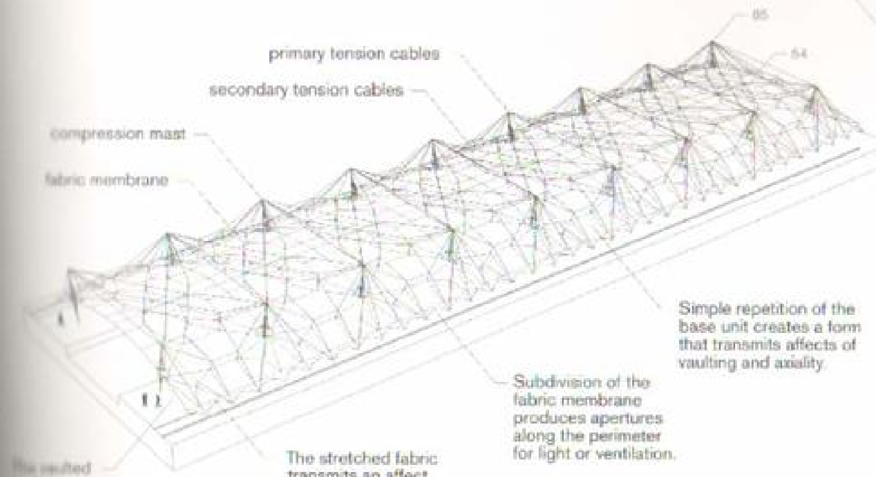


The Oldenburg Grandstand is formed by the tessellation of the base unit to create a series of central masts identical in height and aligned along a linear axis, with each mast holding a set of eight radial cables. The base units follow the perimeter of a stadium with a linear axis, and each of the areas covered by the central mast and its cables is therefore identical, but the base units can be aligned to a wide range of perimeters, allowing flexibility with respect to the plan. The Oldenburg Grandstand transmits an optical affect of cantilevering and lightness, and an acoustical affect of specularity.

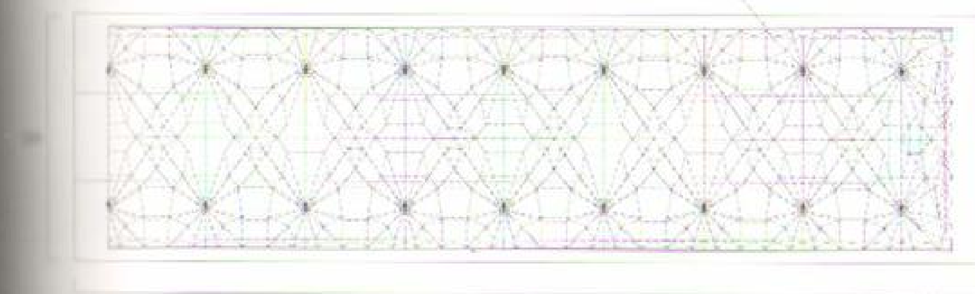
Vaulting, Axiality, Lightness, Specularity

Horizontal / Radial Cable Tensile Membrane

BREMEN DOCK ROOF | F. OTTO, H. BUDDE, D. HEINRICHS, C. SCHROCK | BREMEN, GERMANY | 1960



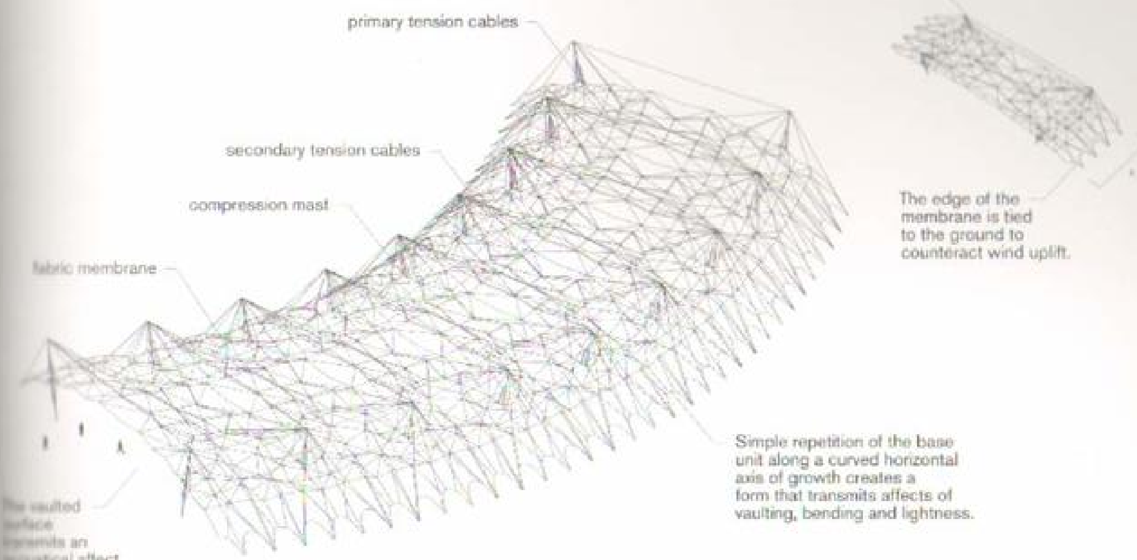
The Bremen Dock roof was designed to cover a new dock basin under construction on the left bank of the Weser River. To ensure unrestricted unloading and easy access to storage, it was necessary for the roof structure to have a free span of at least 200m. The tensile solution was devised in response to the dimensional requirements as well as the desire for a lightweight structure, economic concerns, ease of construction, and minimal use of materials.

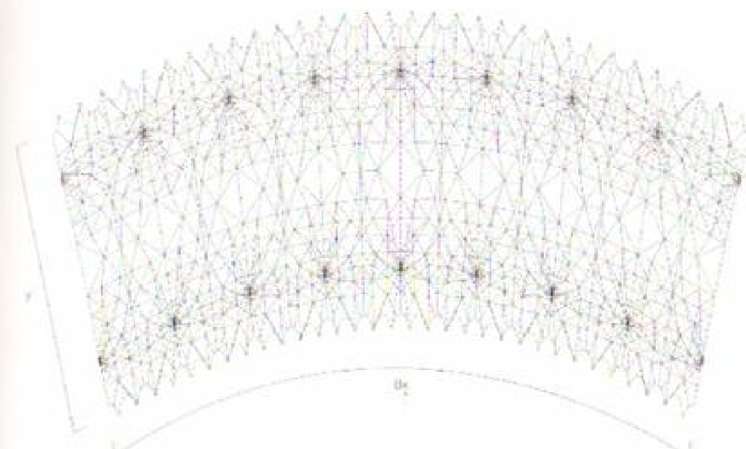


The Bremen Dock is produced by the tessellation of a radial cable tensile membrane of the base unit to create an assemblage of bays, each composed of four inboard masts from which span a set of primary and secondary cables. The primary cables form the barrel-vault section while the secondary cables are interlaced and connected to the membrane by a series of points at which the surface can be adjusted. The Bremen Dock transmits an optical affect of vaulting, axiality and lightness, and an acoustical affect of specularity.

Pleating, Vaulting, Bending, Lightness, Specularity

Horizontal / Radial Cable Tensile Membrane



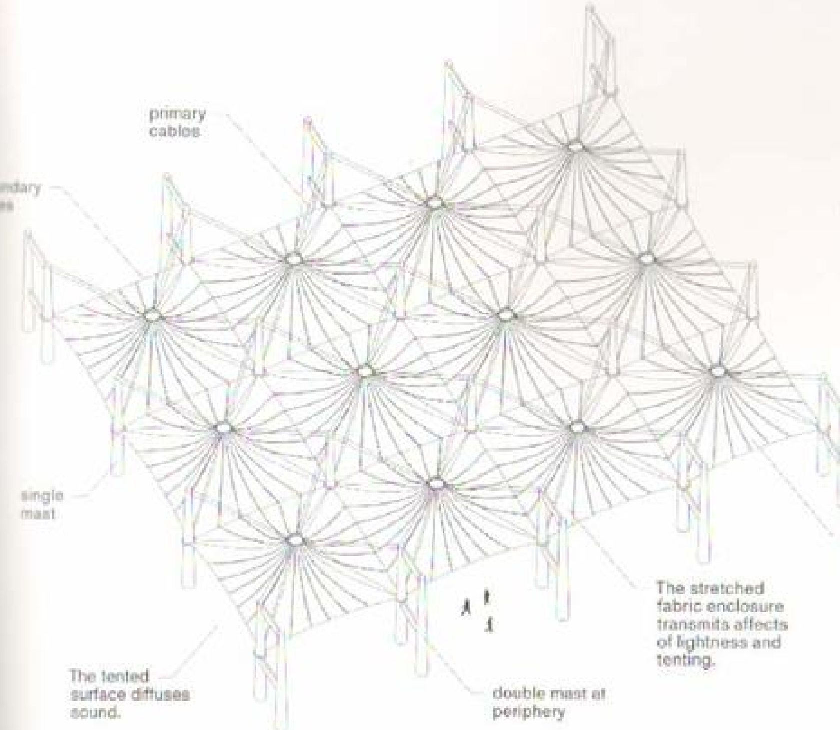


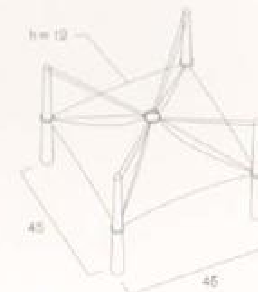
This horizontal form is produced by the tessellation of a radial cable tensile membrane base unit curved in plan and composed of four inboard masts from which span a set of primary and secondary cables. The primary cables form the barrel vault section while the secondary cables are interlaced and connected to the membrane at a series of points where the membrane surface can be adjusted. This combination of cables and membrane forms a light surface that transmits an optical affect of pleating, vaulting, bending and lightness, and an acoustical affect of specularity.

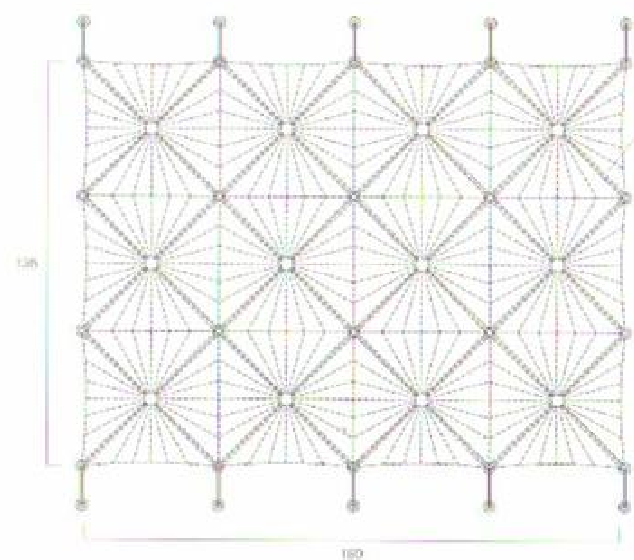
Cellularity, Tenting, Lightness, Diffusion

Horizontal / Radial Cable Tensile Membrane

HAJ TERMINAL | SKIDMORE, OWINGS AND MERRILL; GREIGER BERGER | JEDDAH, SAUDI ARABIA | 1981

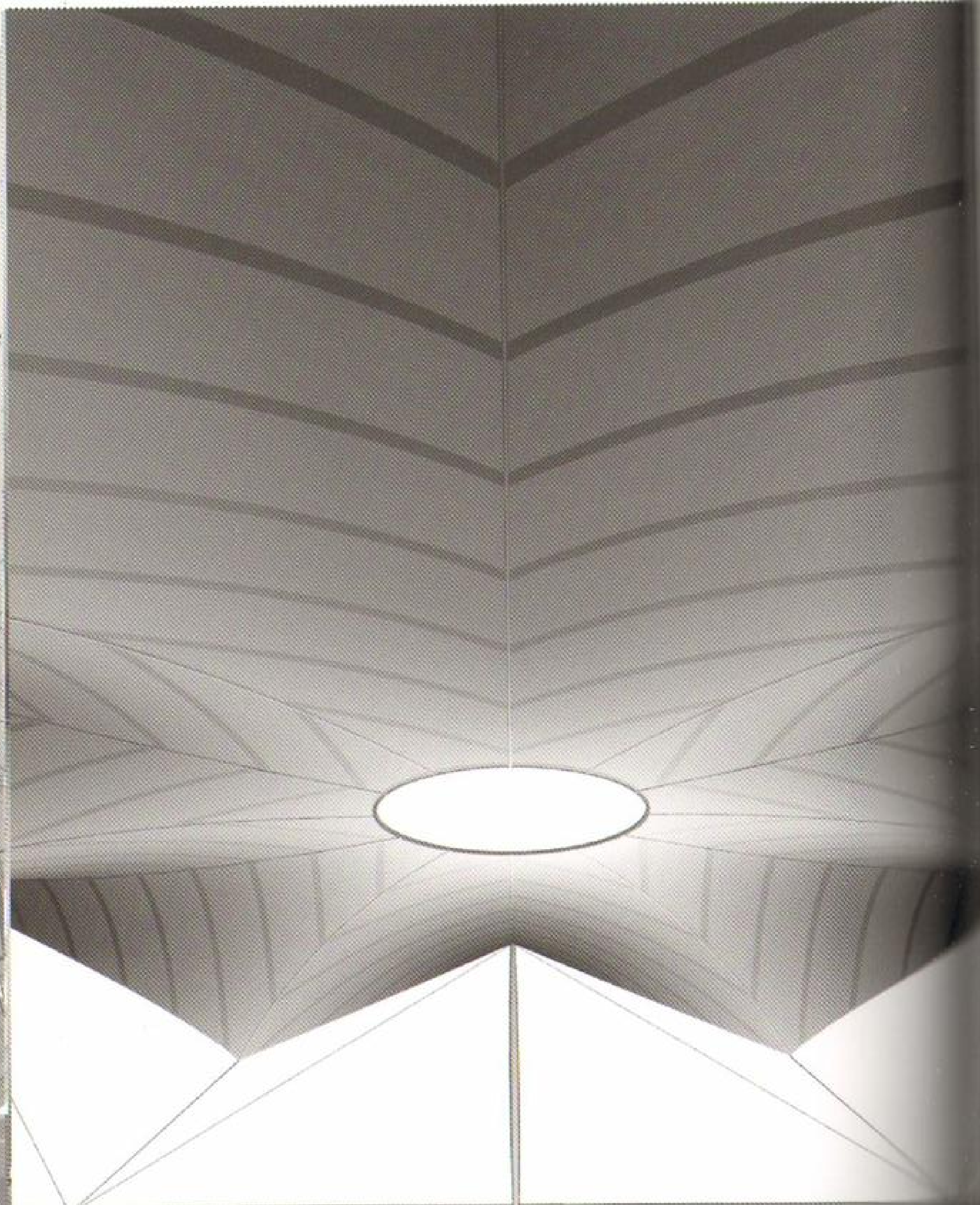






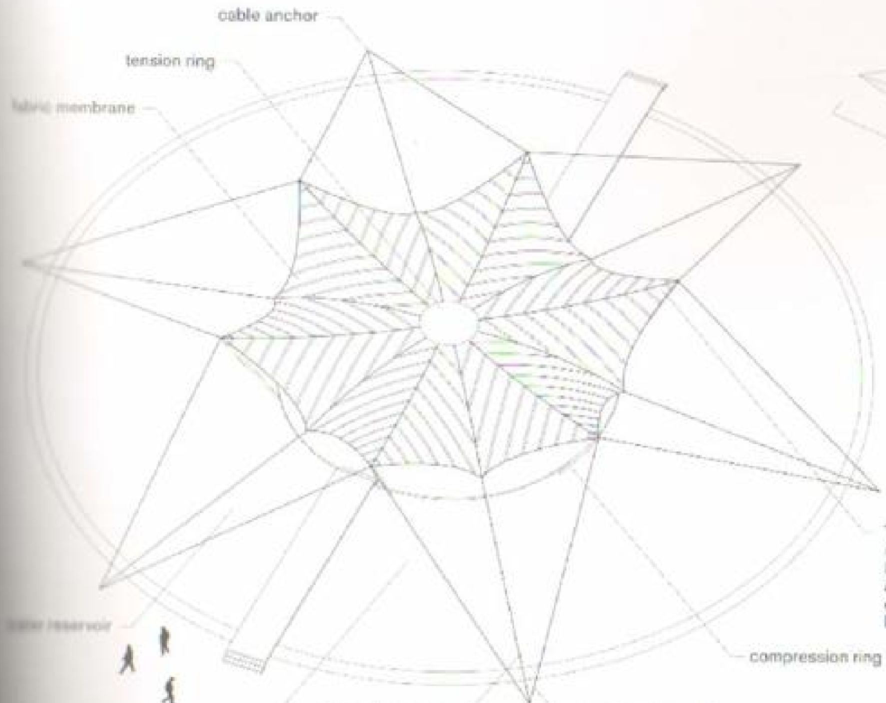
The Haj Terminal is formed by the tessellation of a radial cable tensile membrane base unit to create an assemblage of square bays, each composed by four outboard masts from which a double layer of primary cables extend to support a double connector ring. The height of this ring can be varied to create different sectional profiles, and the arrangement of the outboard columns can be varied to create different shapes and perimeter outlines. The Haj Terminal transmits an optical affect of cellularity, tenting and lightness, and an acoustical affect of diffusion.

Stellatedness, Rotundity, Tenting, Specularity



Horizontal / Radial Cable Tensile Membrane

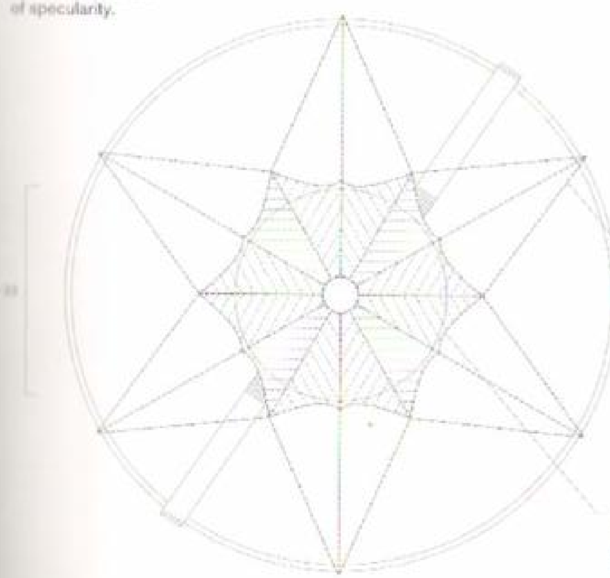
DANCE PAVILION (TANZBRUNNEN) | F. OTTO; H. SPANDOW | COLOGNE, GERMANY | 1957



4.7:1 is the approx. ratio of span to section height

The surface of the fabric membrane is tautly stretched between the compression masts along the perimeter and a central compression ring that introduces light to the space below.

The tented surface transmits an affect of specularity.

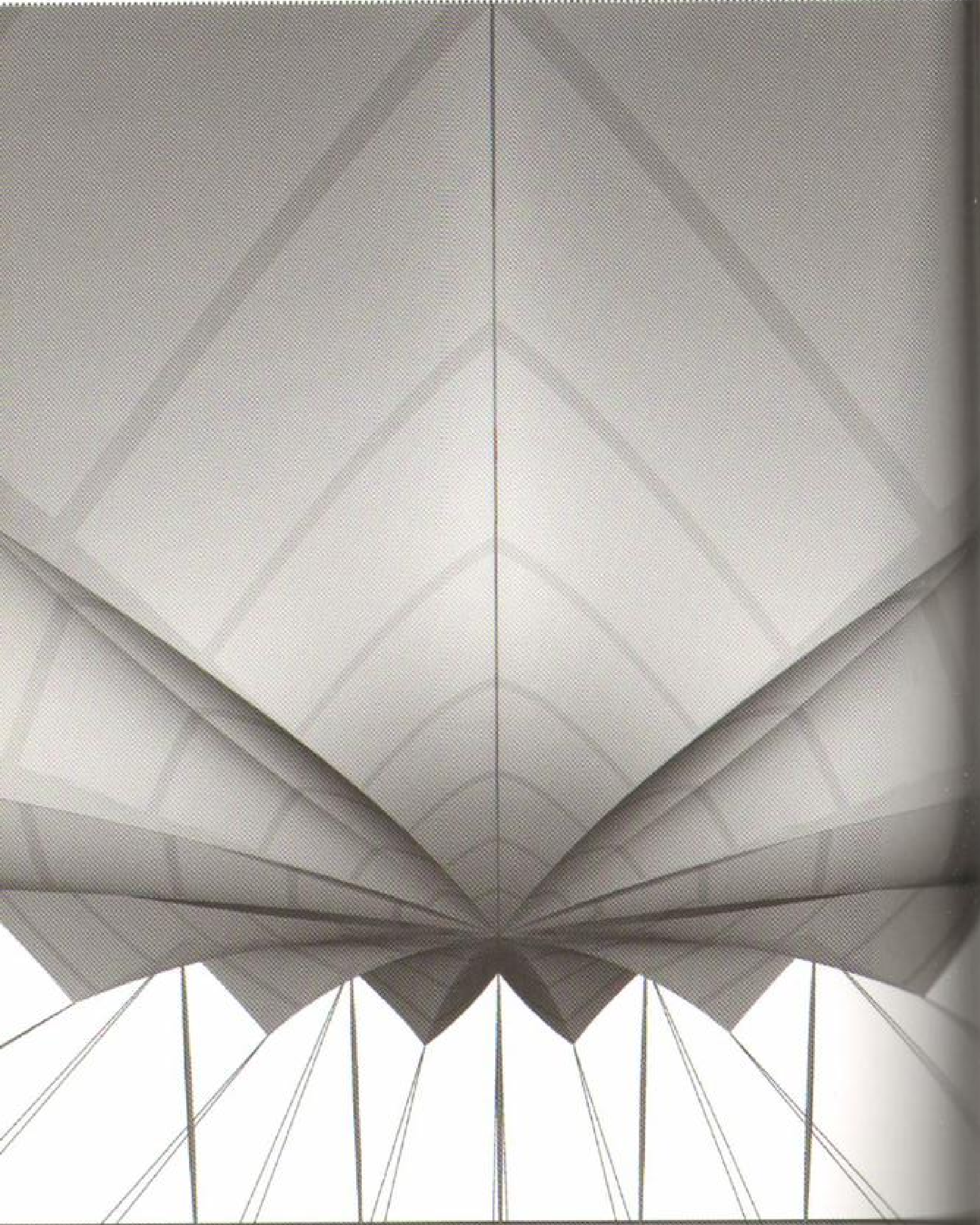


The cables radiating from the tension ring subdivide the fabric surface into twelve equal segments, creating a form that transmits affects of stellatedness and tenting.

Equal spacing of the cables radiating from the tension ring creates a form that transmits an affect of rotundity.

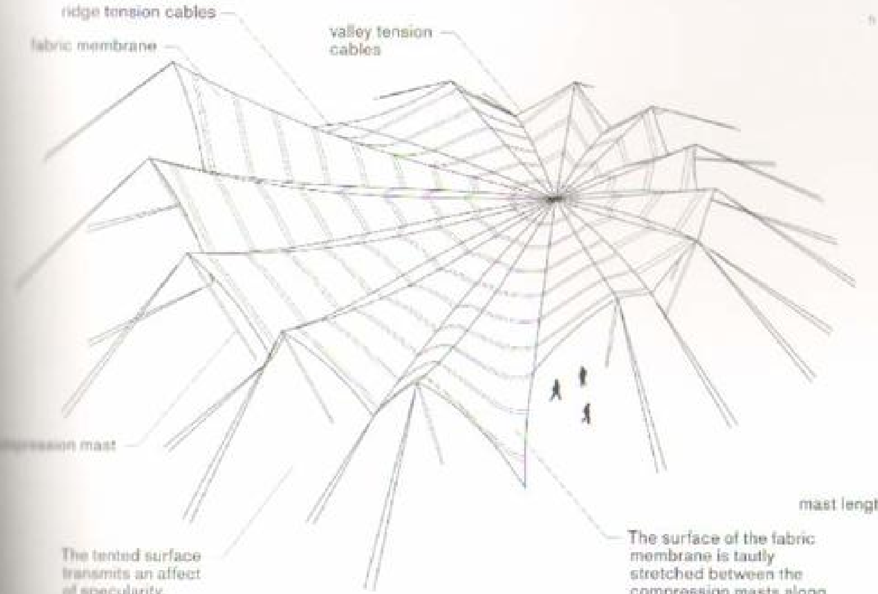
The Dance Pavilion is produced by the tessellation of a radial cable tensile membrane base unit to create an assemblage of triangular bays, each composed of two compression masts from which cables extend outwards, one through the top of the column and a second directly from the tension ring towards the ground. The Dance Pavilion transmits an optical affect of stellatedness, rotundity and tenting, and an acoustical affect of specularity.

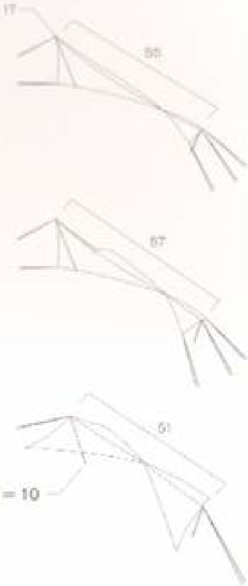
Tenting, Pleating, Orientedness, Specularity

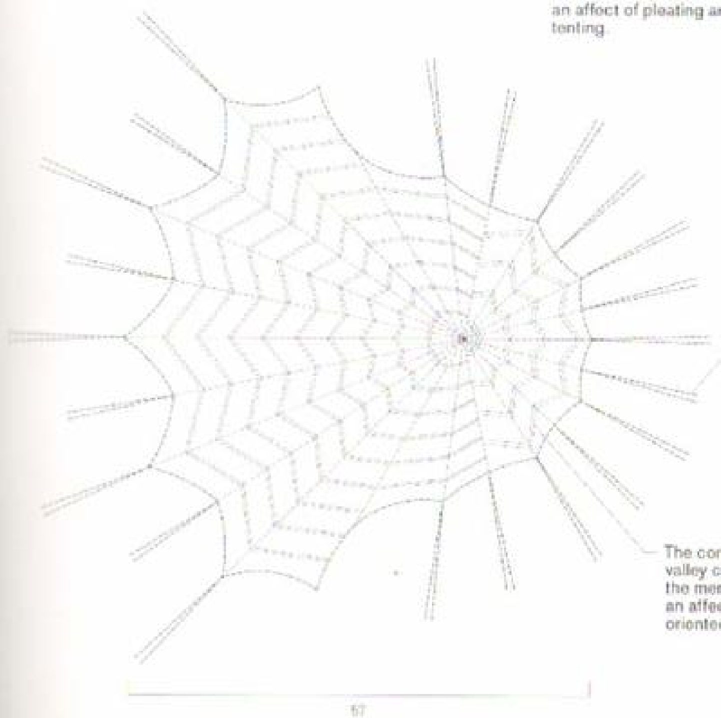


Horizontal / Radial Cable Tensile Membrane

MOBILE THEATER | F. OTTO | BRUSSELS, BELGIUM | 1968

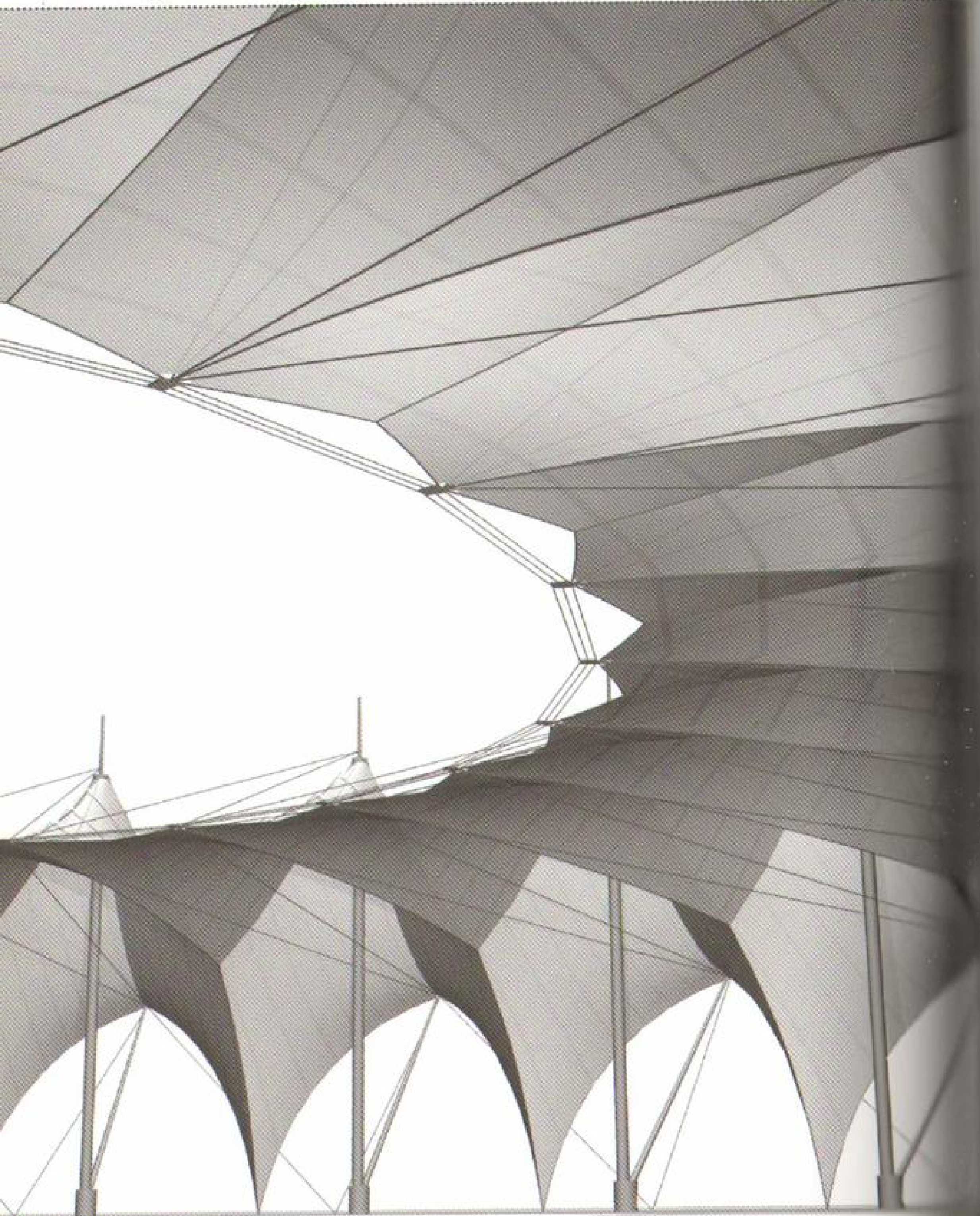






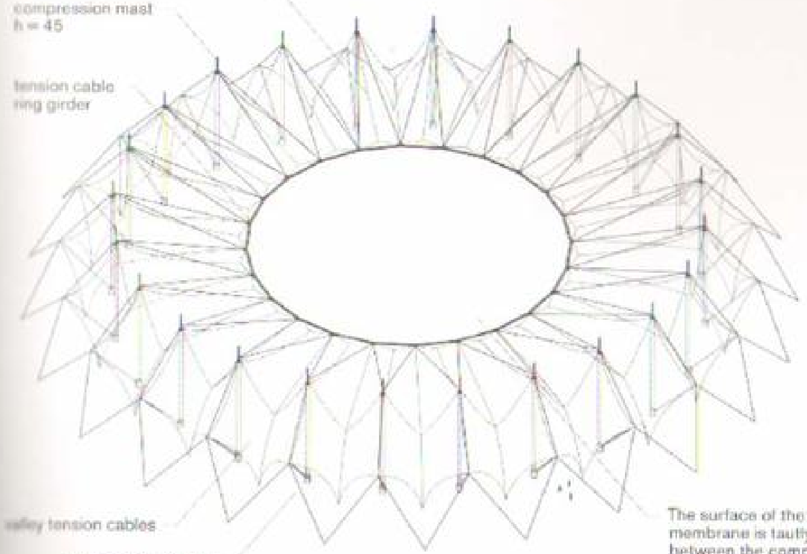
The Mobile Theater is produced by the tessellation of a radial cable tensile membrane base unit to create a radial assemblage composed of a network of cables of irregular lengths that is supported by twelve masts. The membrane is attached to this network of cables, which consists of a series of radial cables, ridge-hanger tension cables connected to the masts, and valley cables spanning directly from the central point to the ground. The Mobile Theater transmits an optical affect of tenting, pleating and orientedness, and an acoustical affect of specularity.

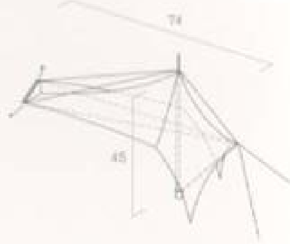
Pleating, Hollowness, Tenting, Specularity



Horizontal / Radial Cable Tensile Membrane

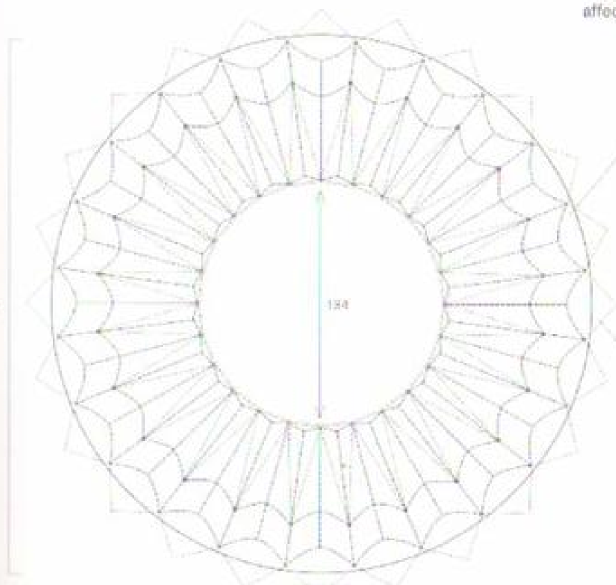
KING FAHD STADIUM | I. FRASER, J. ROBERTS; GEIGER BERGER | RIYADH, SAUDI ARABIA | 1985





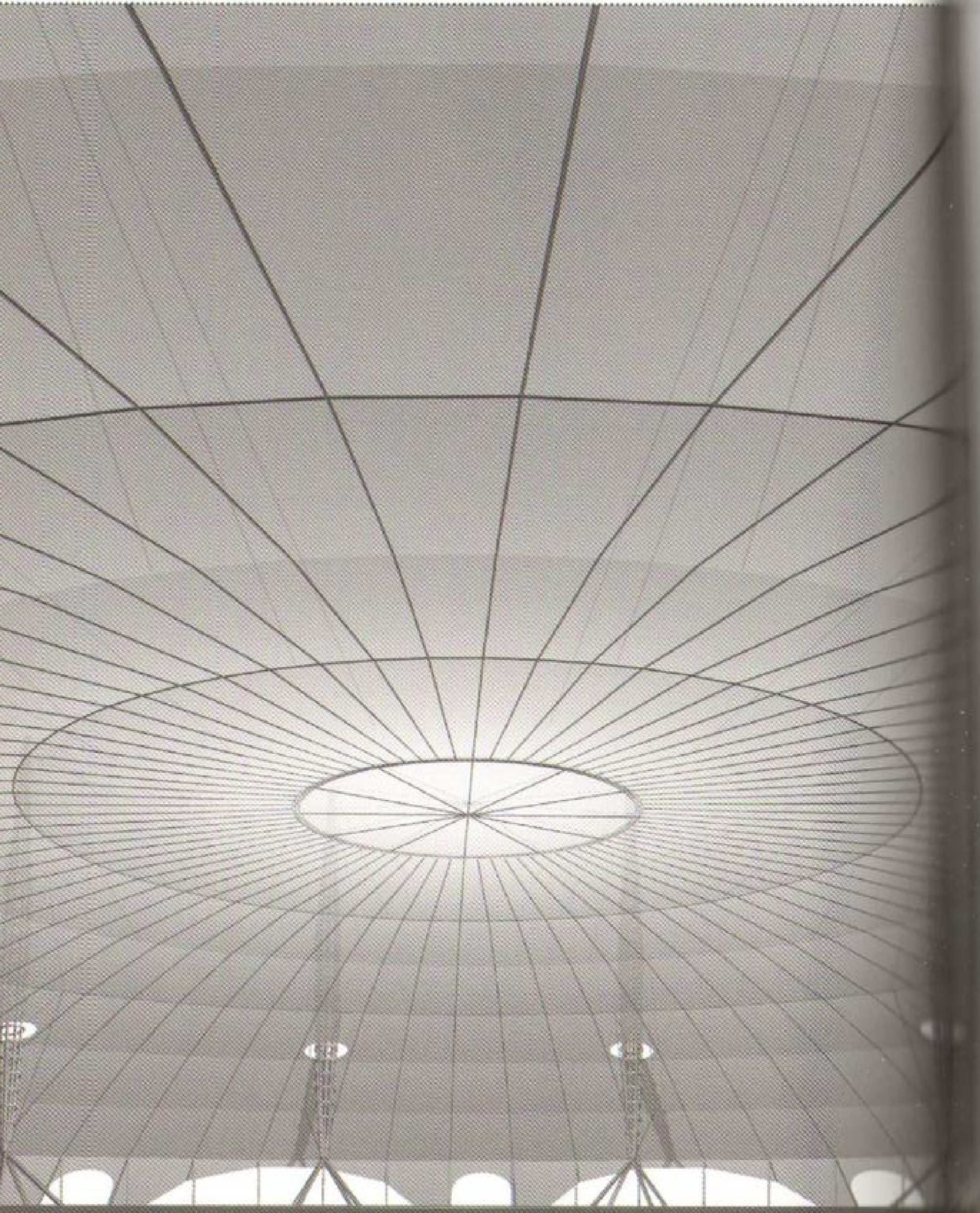
1.6:1 is the approx. ratio of span to section height

total surface area = 57,220m²
total covered area = 43,220 m²



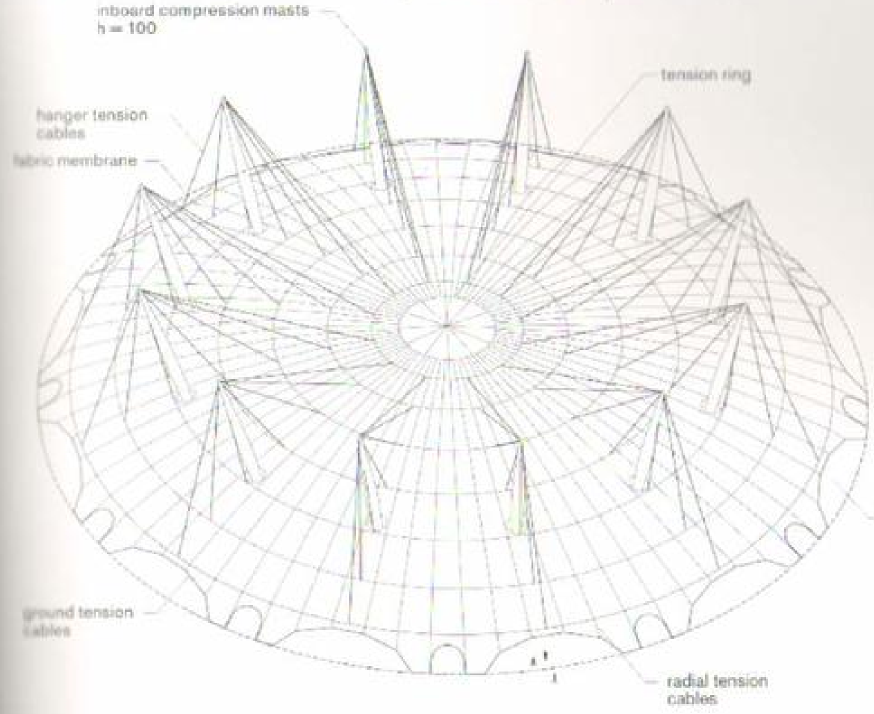
The King Fahd Stadium is produced by the tessellation of a radial cable tensile membrane base unit to create a cable network suspended from twenty-four masts, which supports the membrane. The cable network is composed of a series of radial cables, ridge-hanger tension cables connected to the masts, and valley cables spanning directly from the tension cable ring girder to the ground. The King Fahd Stadium transmits an optical affect of pleating, hollowness and tenting, and an acoustical affect of specularity.

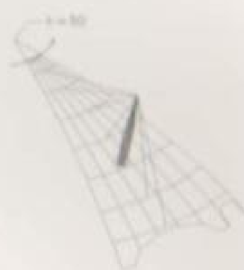
Enclosure, Rotundity, Tenting, Deadness



Horizontal / Radial Cable, Tensile Membrane

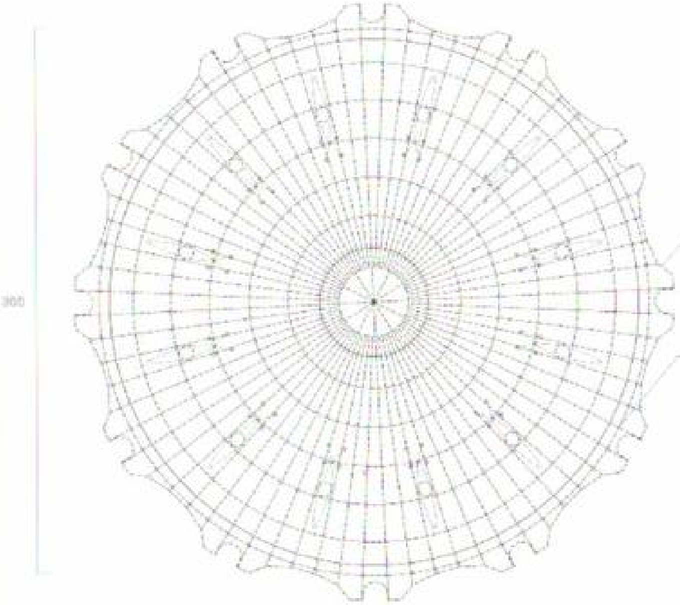
MILLENNIUM DOME | R. ROGERS; BURO HAPPOLD | LONDON, UK | 2000





7.3:1 is the approx. ratio of span to section height at center of dome

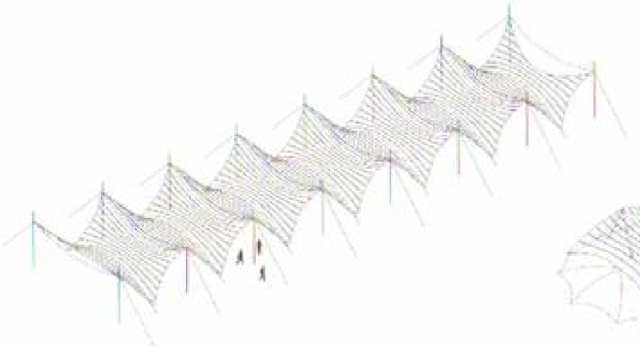
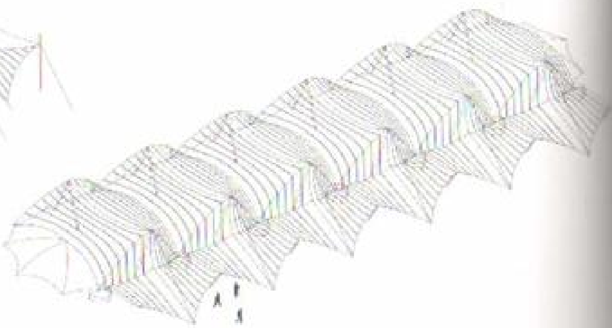
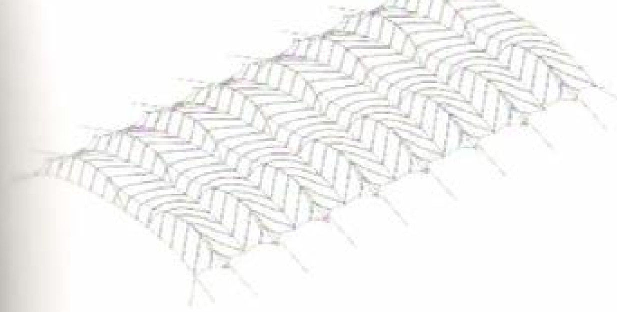
The inner lining of the membrane absorbs sound to such an extent that there is no noticeable specularity, and the acoustical affect is one of deadness.

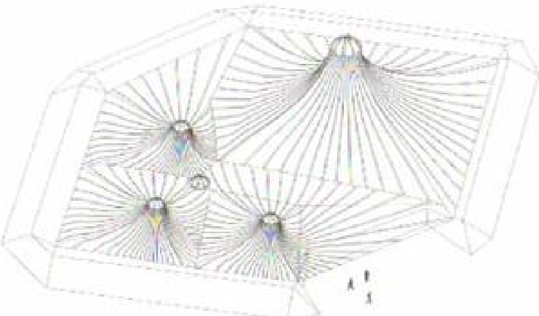
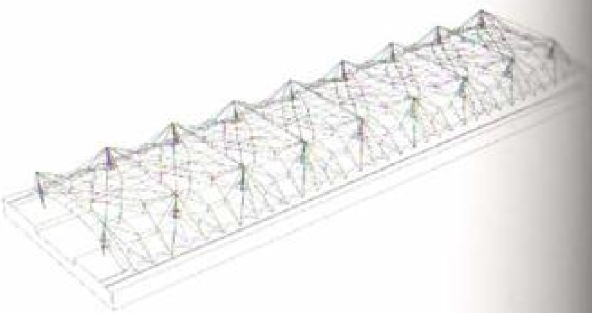
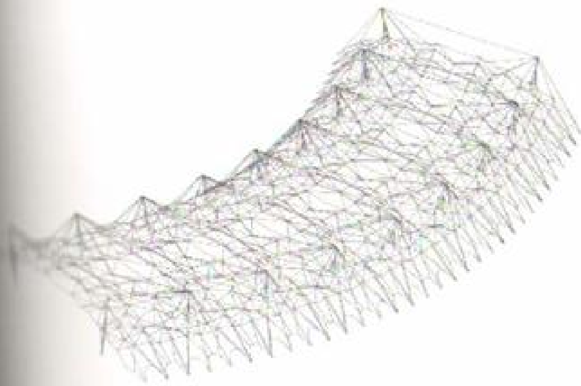
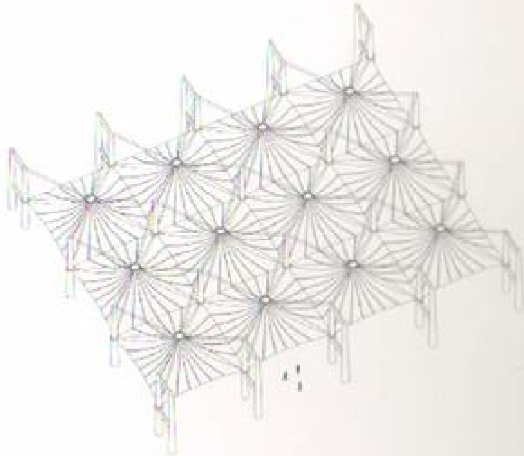
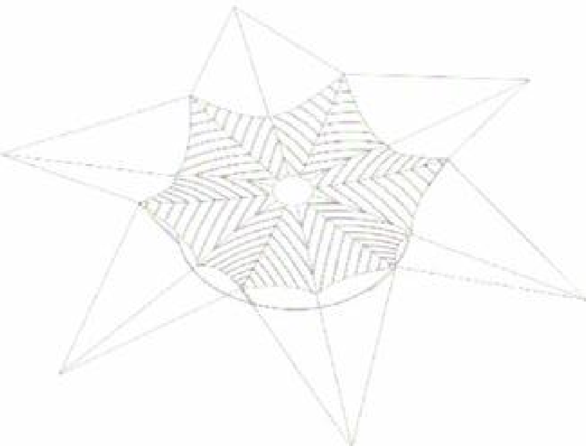
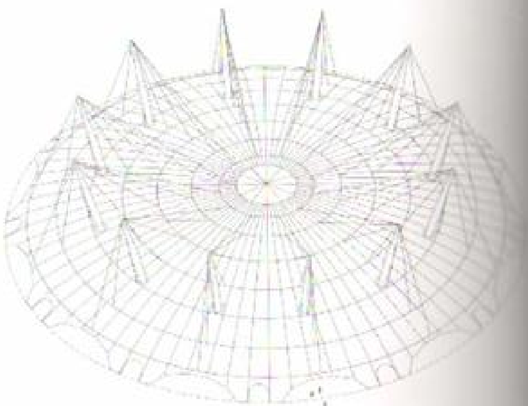


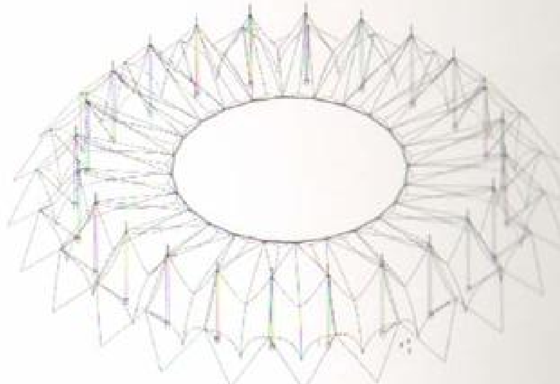
The regular arrangement of the membrane bays radiating from the central ring results in a regular subdivision of the surface and a uniform perimeter, transmitting affects of enclosure, rotundity and tenting.

The nodes are connected by circumferential cables which provide stability.

The Millennium Dome is produced by the tessellation of a radial cable tensile membrane base unit along a curved axis of growth to create a dome-shaped assemblage composed of a cable network supported on a ring of twelve masts. The cable network to which the membrane is attached consists of a series of radial cables, in pairs, which span 25 meters between nodes supported by hanger cables which connect them to the tops of the masts. The Millennium Dome transmits an optical affect of enclosure, rotundity and tenting, and an acoustical affect of deadness.

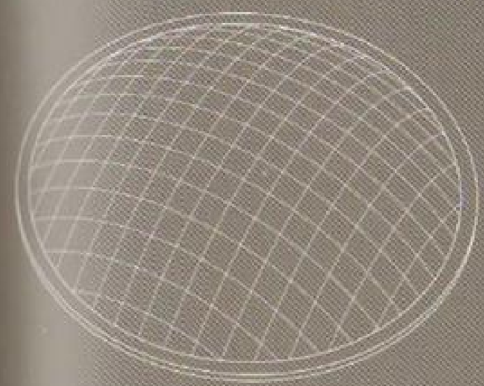




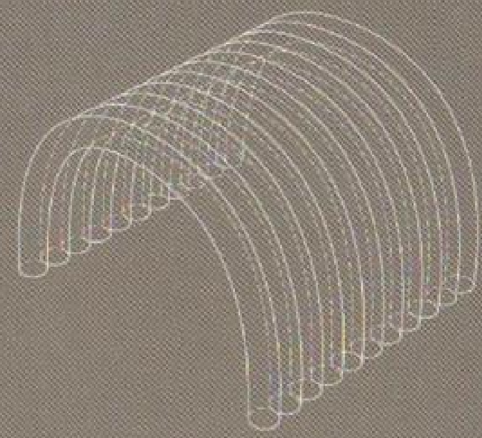









Pneumatic membranes distribute loads along the surfaces of membranes supported by cables, complemented by air pressure either in the interior volume or within air tubes, giving form to the membrane and subdividing its surface in varying degrees. Pneumatic membranes vary in kind based on the distribution of loads along an increasing number of the axes that give them form. Pneumatic membranes can be made of a combination of a membrane and a network of steel cables for reinforcement. System considerations have not specifically addressed resistance to lateral loads. The system of pneumatic membranes is subdivided into two primary subsystems: air supported pneumatic membranes, and inflated beam pneumatic membranes, according to the arrangement of the cables and the nature of the membranes they support.

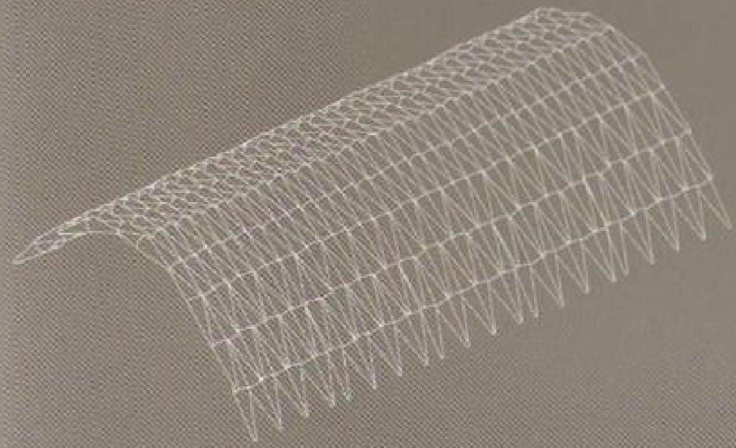
Air supported pneumatic membranes are formed by introducing air pressure to the interior of a structure – increased slightly above normal atmospheric pressure and maintained by compressors or fans – which pushes upwards from the lower surface of the membrane, while the upper surface is reinforced by a grid of cables acting in tension. The subdivision of the membrane's surface can be increased by increasing the density of the grid of cables.
Inflated beam pneumatic membranes are formed by inflated tubes, also by introducing air pressure to the interior of a structure – increased slightly above normal atmospheric pressure and maintained by compressors or fans – which form arches that define the section of the structure. The structure is formed by tying the tubes together to increase their structural strength.


Air Supported Pneumatic Membrane

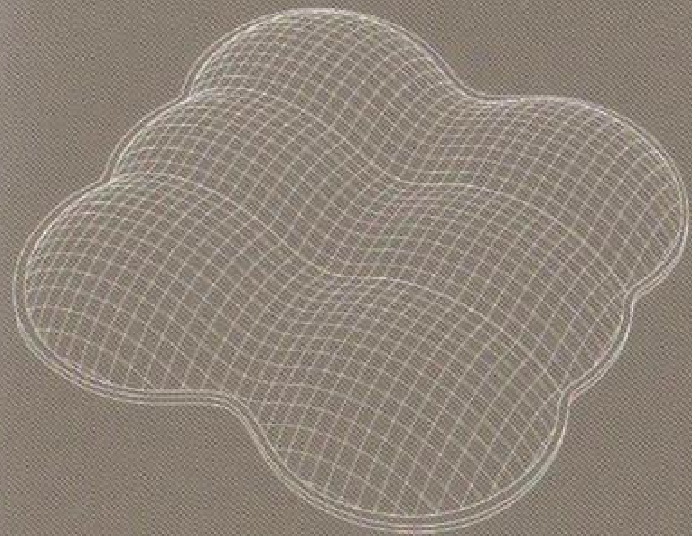

Inflated Beam Pneumatic Membrane

Pneumatic membranes tessellate along horizontal or curved lines of growth.

Horizontal tessellation can occur in both air supported and inflated beam pneumatic membranes, with the supporting cables or inflated tubes distributed in plan along a line or curve to extend the structure horizontally while also allowing a wide range of flexibility along the section and perimeter. **Curved tessellation** can occur in air supported pneumatic membranes. Curved growth is different from that of horizontal, in that it would not be derived from a regular pattern following a series of linear or radial axes, but one that is based on an irregular and differentiated pattern of repetition that arises from a differentiated relationship between each of the base units and results in an eccentric overall form.



Horizontal Tessellation

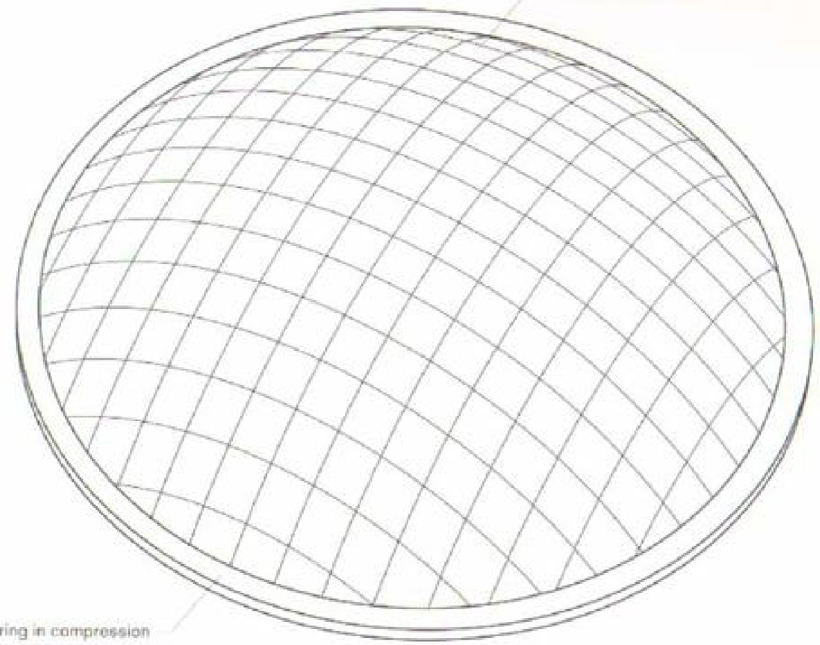


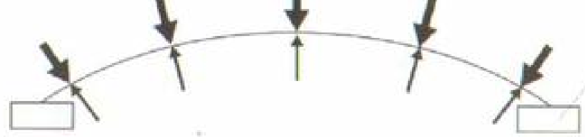
Curved Tessellation

Air Supported Pneumatic Membrane

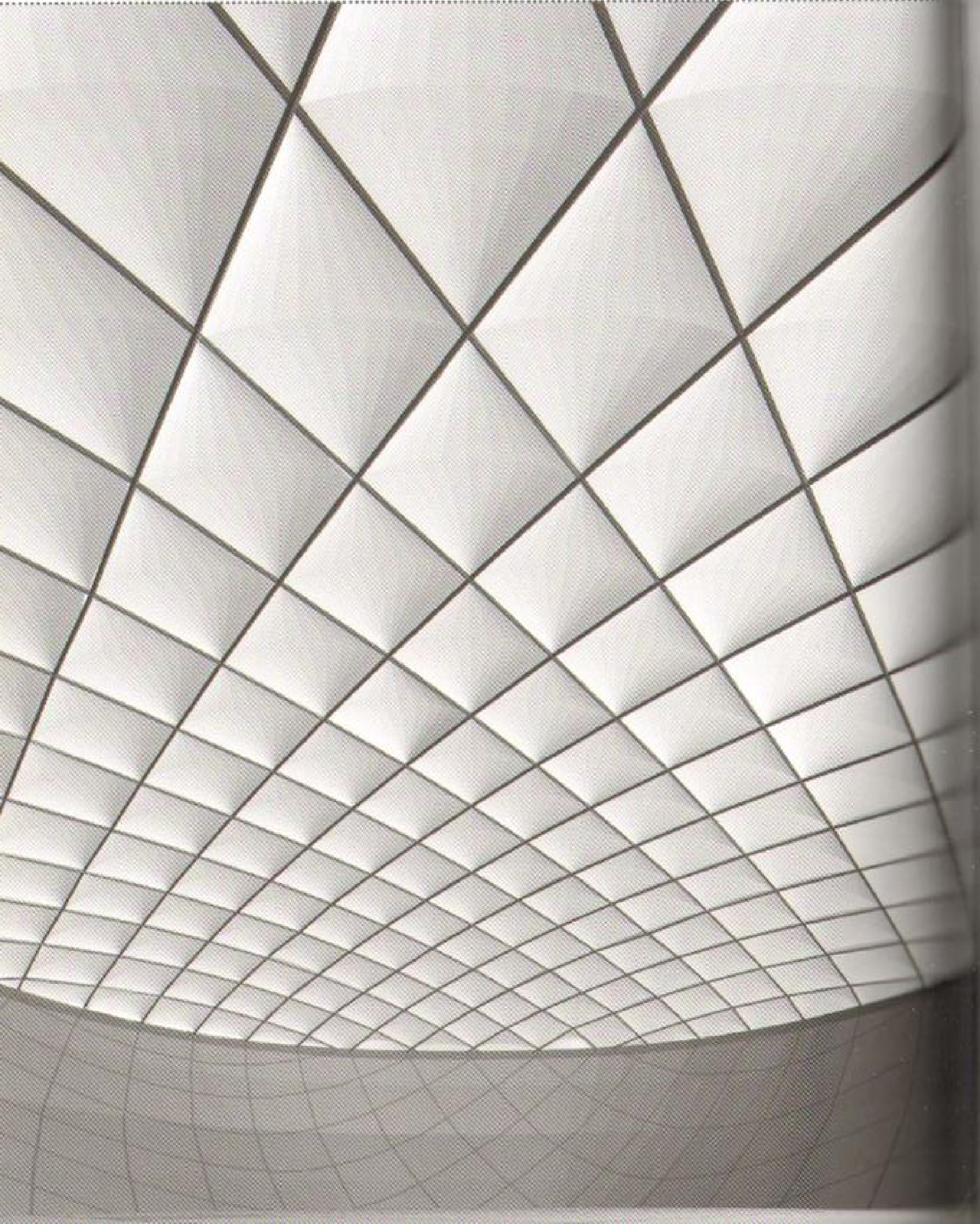
The base unit of an air supported pneumatic membrane is composed of a pressurized envelope enclosed by a membrane which is shaped and reinforced by a network of cables.
Air supported pneumatic membranes are the result of the difference between the internal pressure creating the structure's shape and the external forces and self-weight acting upon it. Air supported pneumatic membranes are made primarily of steel cable and fabric. The distribution of loads along the lines and surfaces of steel cable and fabric embeds the air supported pneumatic membrane with an optical affective property of quilting and undulation that remains consistent within any space it defines. The acoustical affect of an air supported pneumatic membrane is determined by its surface curvature. This is usually concave, in which case there is an affect of focus near the centre of curvature, although a shallow concave surface will have an affect of specularity. However, surface undulations in the form of air-pockets or other elements can result in an affect of diffusion.

Air supported and cable reinforced membranes are flexible in several ways:
Depth: The flexibility of this subsystem lies in variations in the pattern of the cables that subdivide the surface of the membrane. This surface variation can range in depth in accordance with the depth in section of the inflated profiles.
Plan: Air supported pneumatic membranes can tessellate horizontally along straight or curved lines of growth to produce primarily horizontal structures, or sheds.
Affect: The affective property of an air supported pneumatic membrane can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to quilting and undulation, an air supported pneumatic membrane can transmit other optical affects, including rotundity, lightness, amorphousness, centeredness, stacking, bubbling, inflatedness, vaulting. The acoustical affect of an air supported pneumatic membrane is determined by the macro-geometry, which is usually focusing (curved).



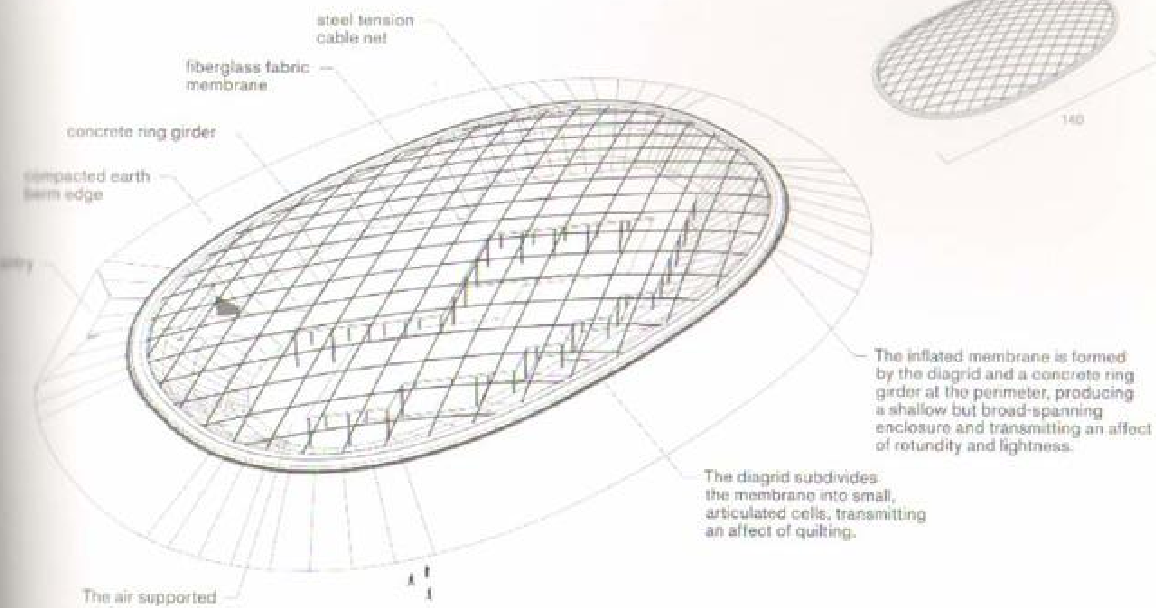


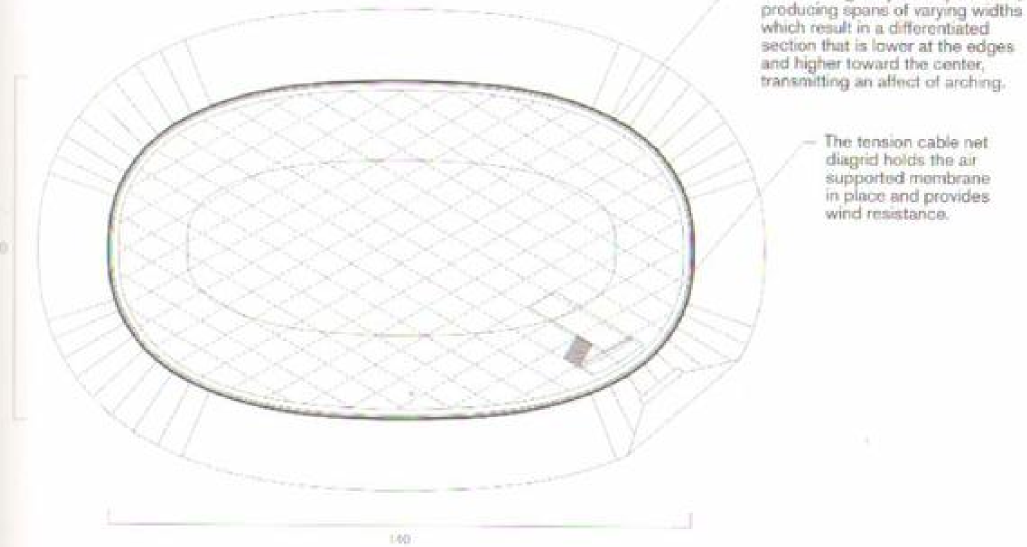
Quilting, Rotundity, Arching, Lightness, Specularity



Curved / Air Supported Pneumatic Membrane

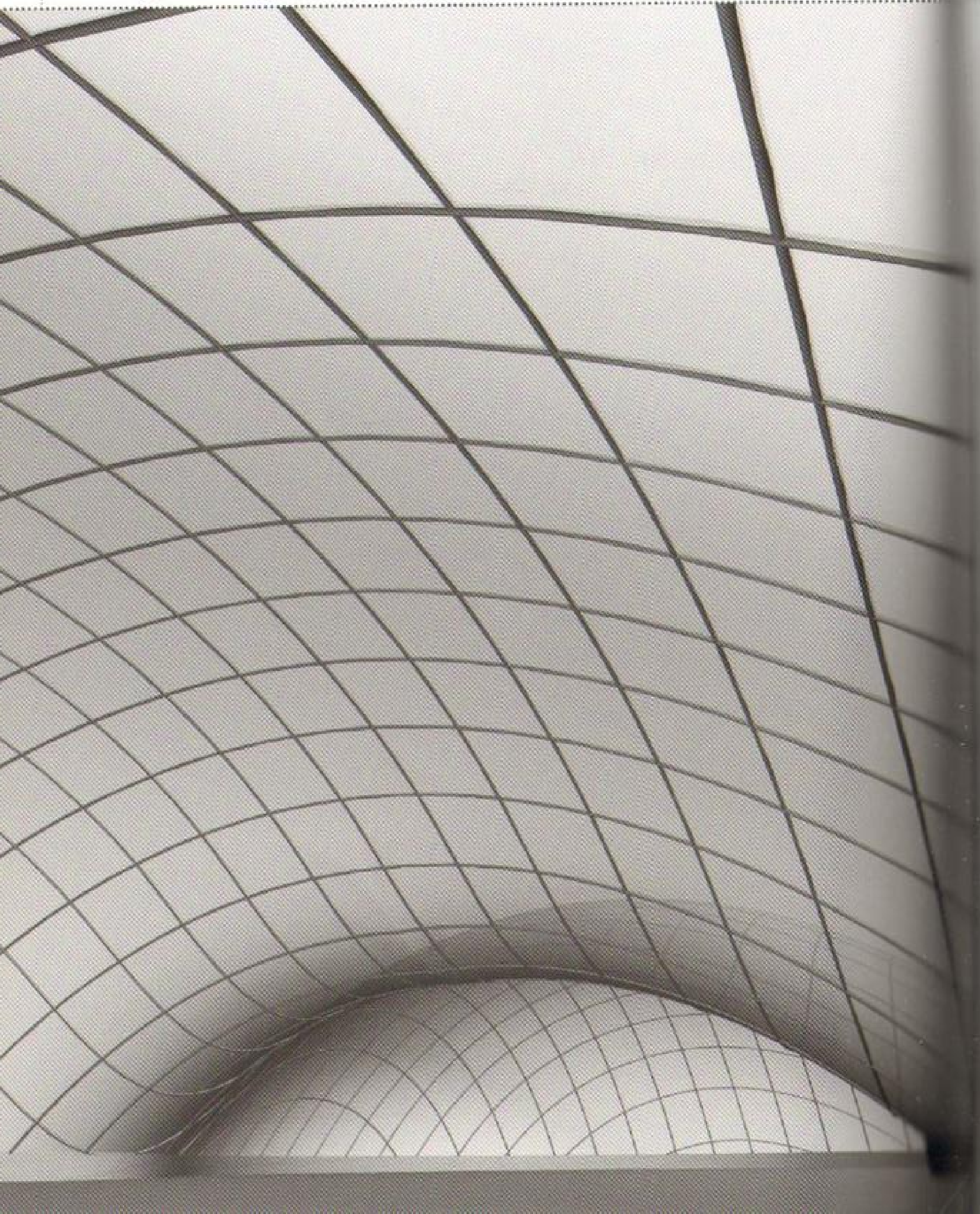
US PAVILION | DAVIS, BRODY, CHERMAYEFF; GEIGER BERGER | OSAKA, JAPAN | 1970



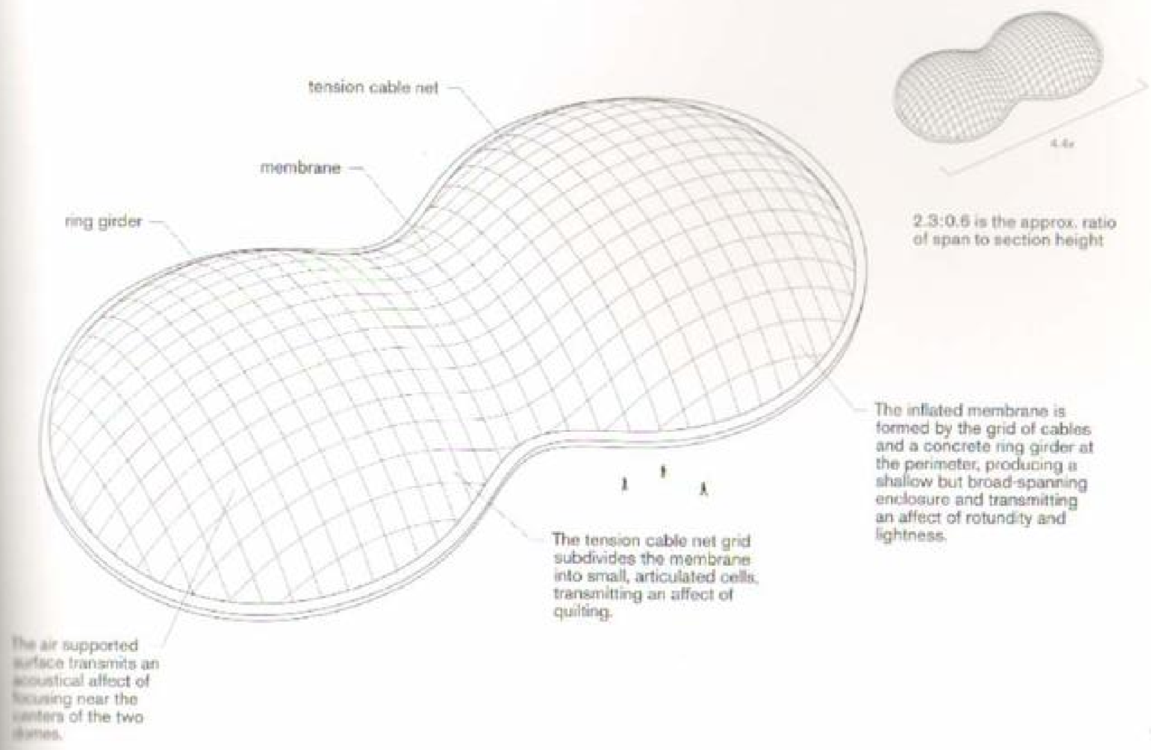


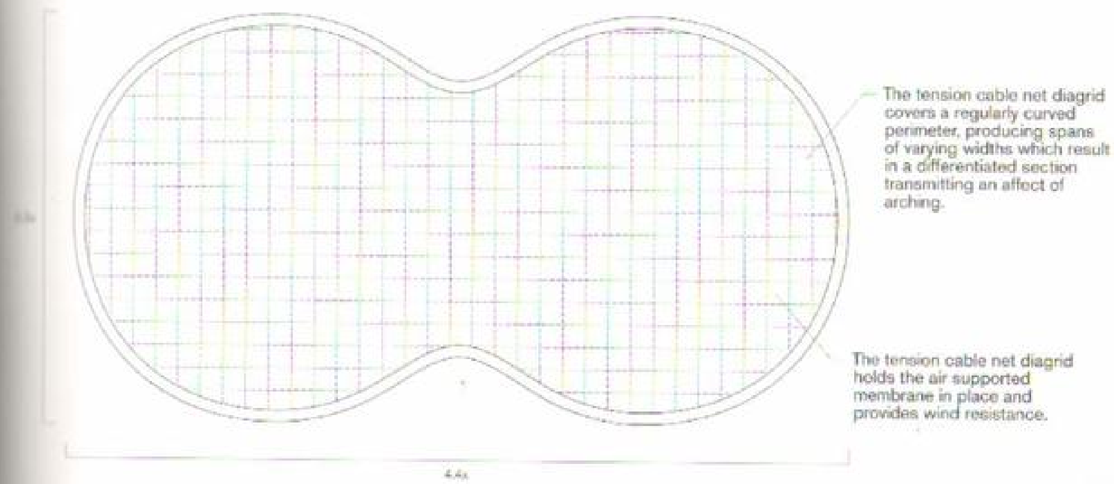
The US Pavilion is produced by an air supported pneumatic membrane formed by a regular network of cables which consists of a diagrid spanning the perimeter and determining the curvature of the structure. The US Pavilion transmits an optical affect of quilting, rotundity and lightness, and an acoustical affect of specularity.

Arching, Quilting, Amorphousness, Rotundity, Lightness, Focusing



Curved / Air Supported Pneumatic Membrane

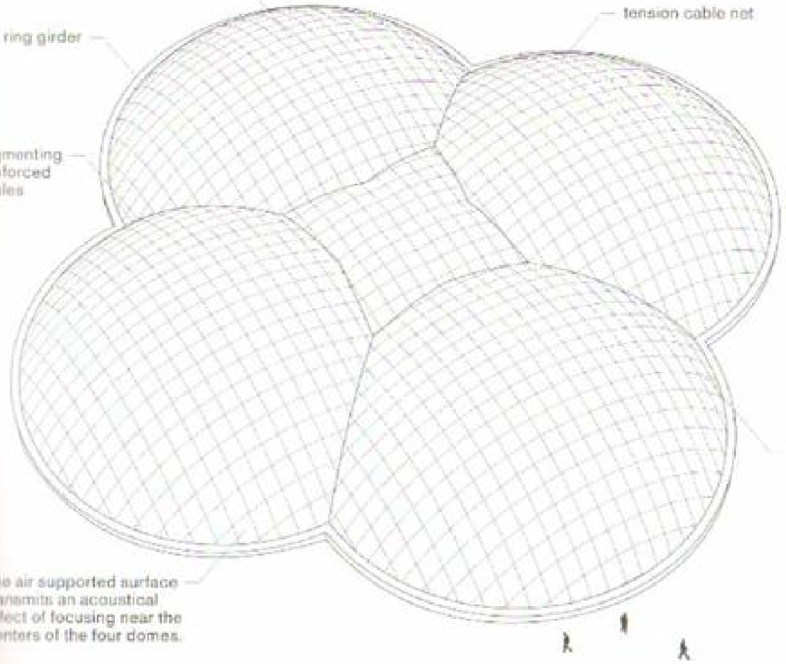




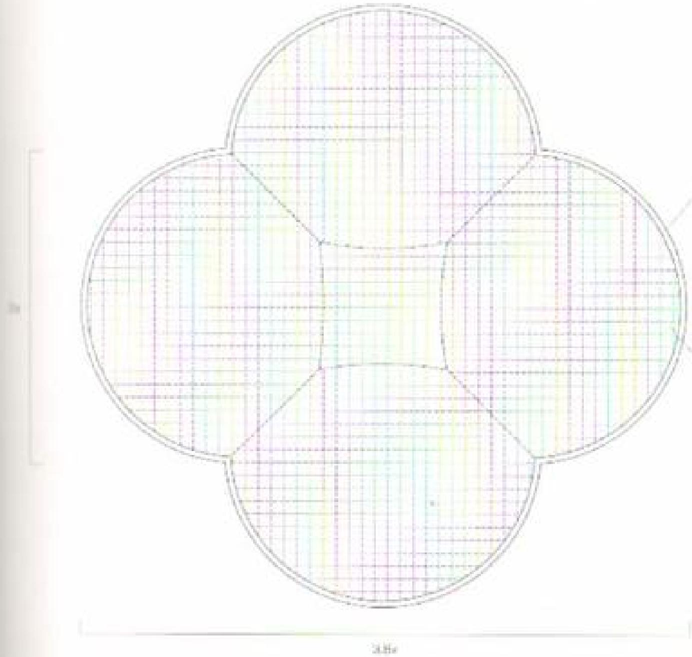
The curved form is produced by an air supported pneumatic membrane and a regular network of cables that consists of a regular grid spanning the perimeter and determining the scale of subdivision of the membrane as well as the curvature of the structure. This form transmits an optical affect of arching, quilting, amorphousness, rotundity and lightness, and an acoustical affect of focusing.

Quilting, Amorphousness, Lightness, Focusing

Curved / Air Supported Pneumatic Membrane



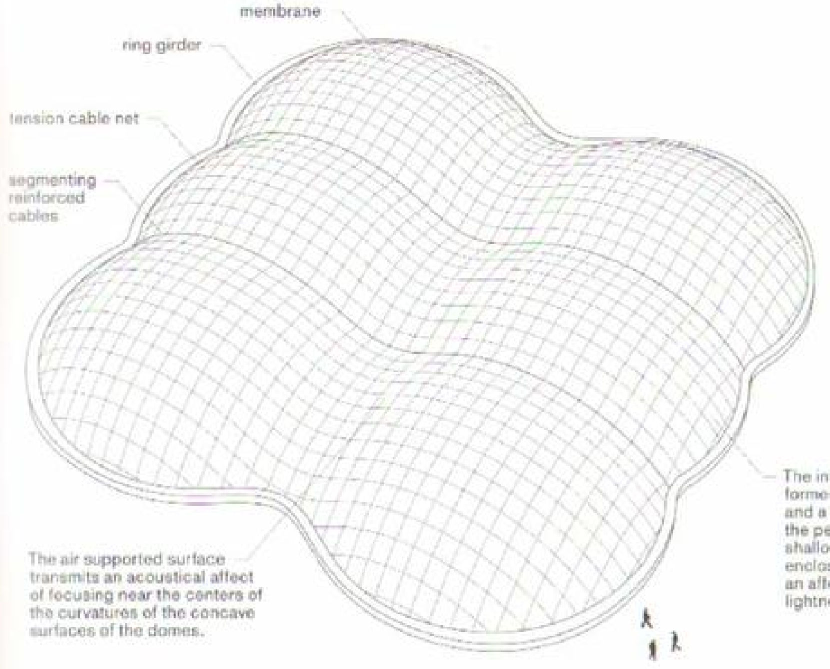
4.3:0.3 is the approx. ratio of span to section height along the longest span

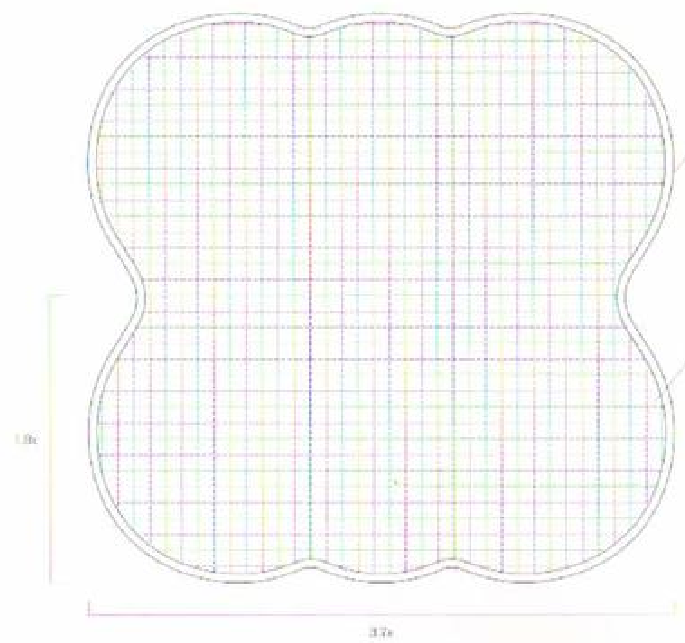


[...] curved form is produced by an air supported pneumatic membrane and a regular network of cables spanning the perimeter and [...]ning the scale of subdivision of the membrane as well as the curvature of the structure. This form transmits an optical affect of [...]ing, amorphousness and lightness, and an acoustical affect of focusing.

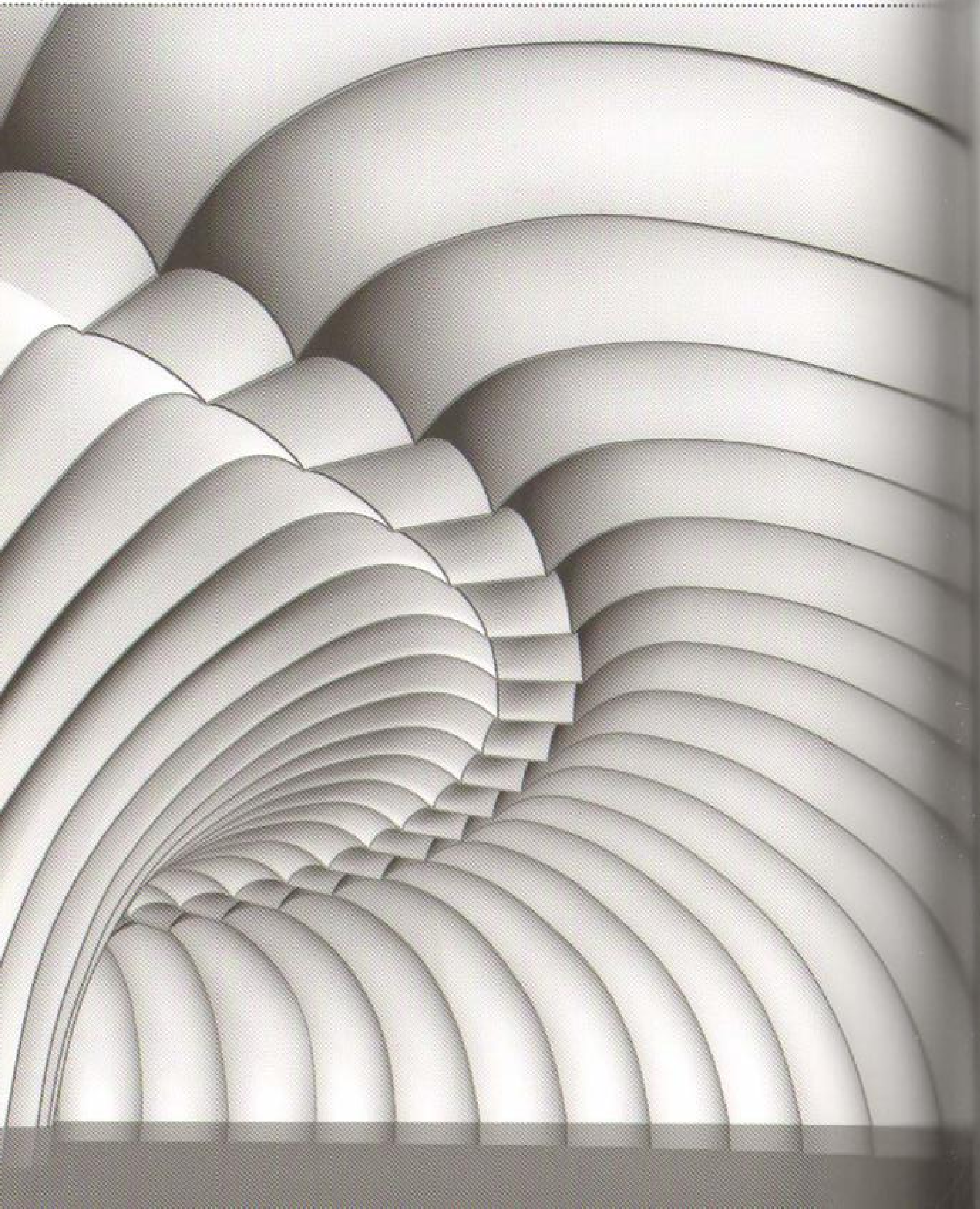
Quilting, Undulation, Rotundity, Lightness, Focusing

Curved / Air Supported Pneumatic Membrane



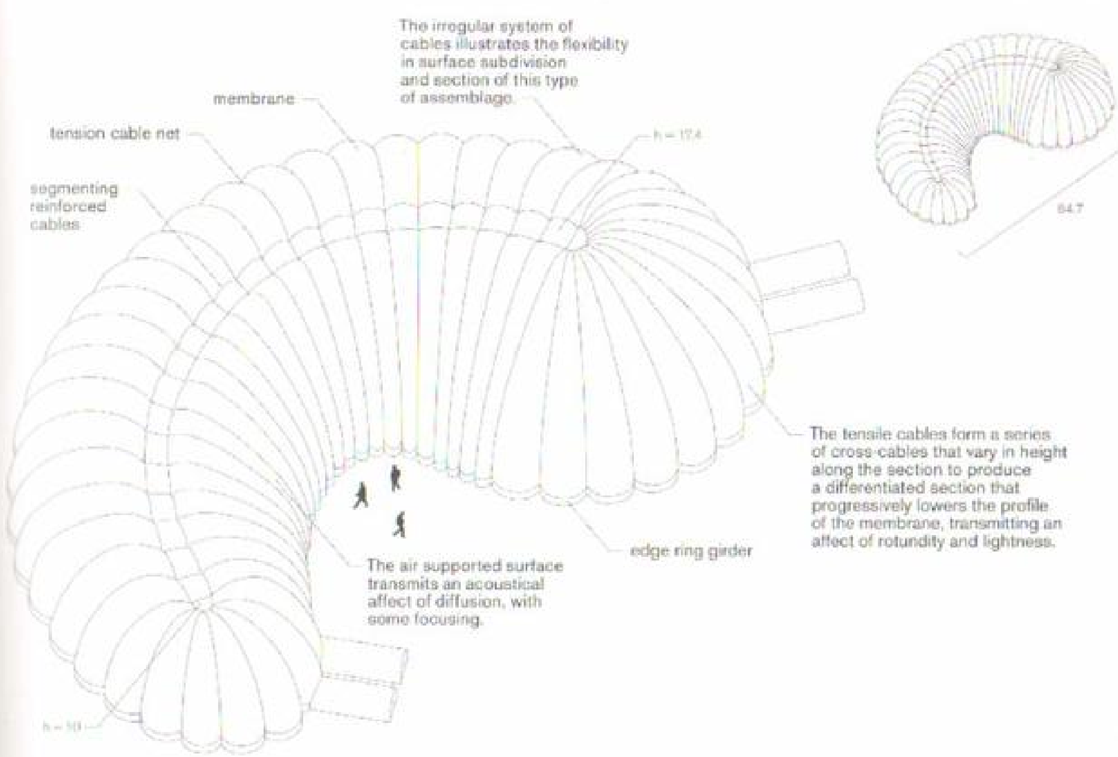


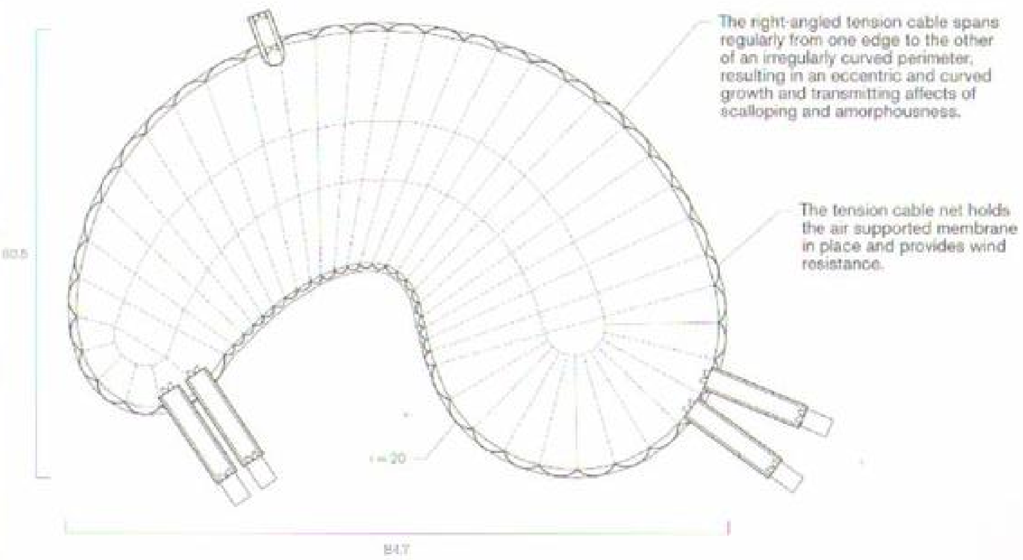
This curved form is produced by an air supported pneumatic membrane and a regular network of cables spanning the perimeter and determining the scale of subdivision of the membrane as well as the curvature of the structure. This form transmits an optical affect of quilting, undulation, rotundity and lightness, and an acoustical affect of focusing.



Curved / Air Supported Pneumatic Membrane

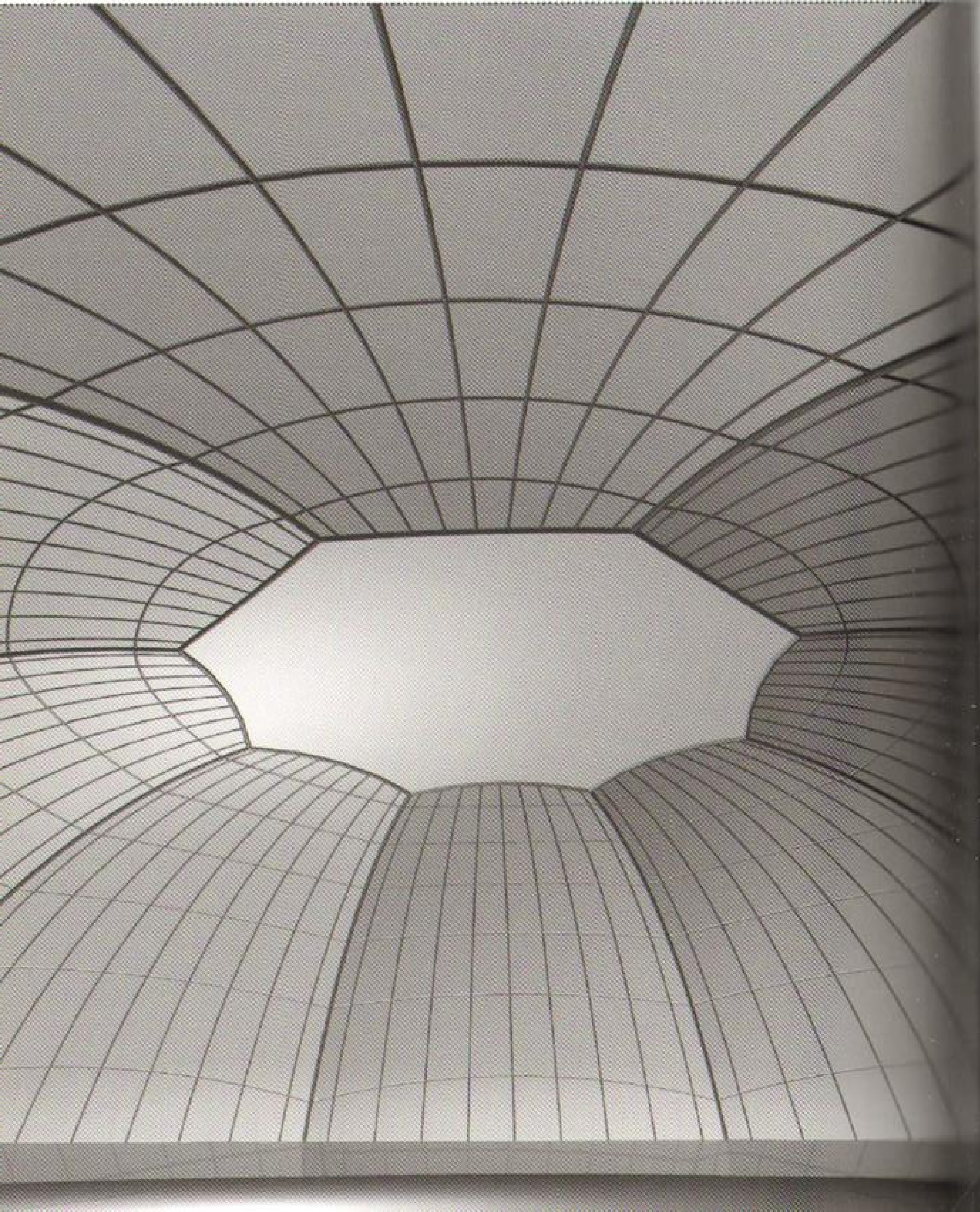
ORCHID PAVILION | Y. MURATA; M. KAWAGUCHI | TOKYO, JAPAN | 1987



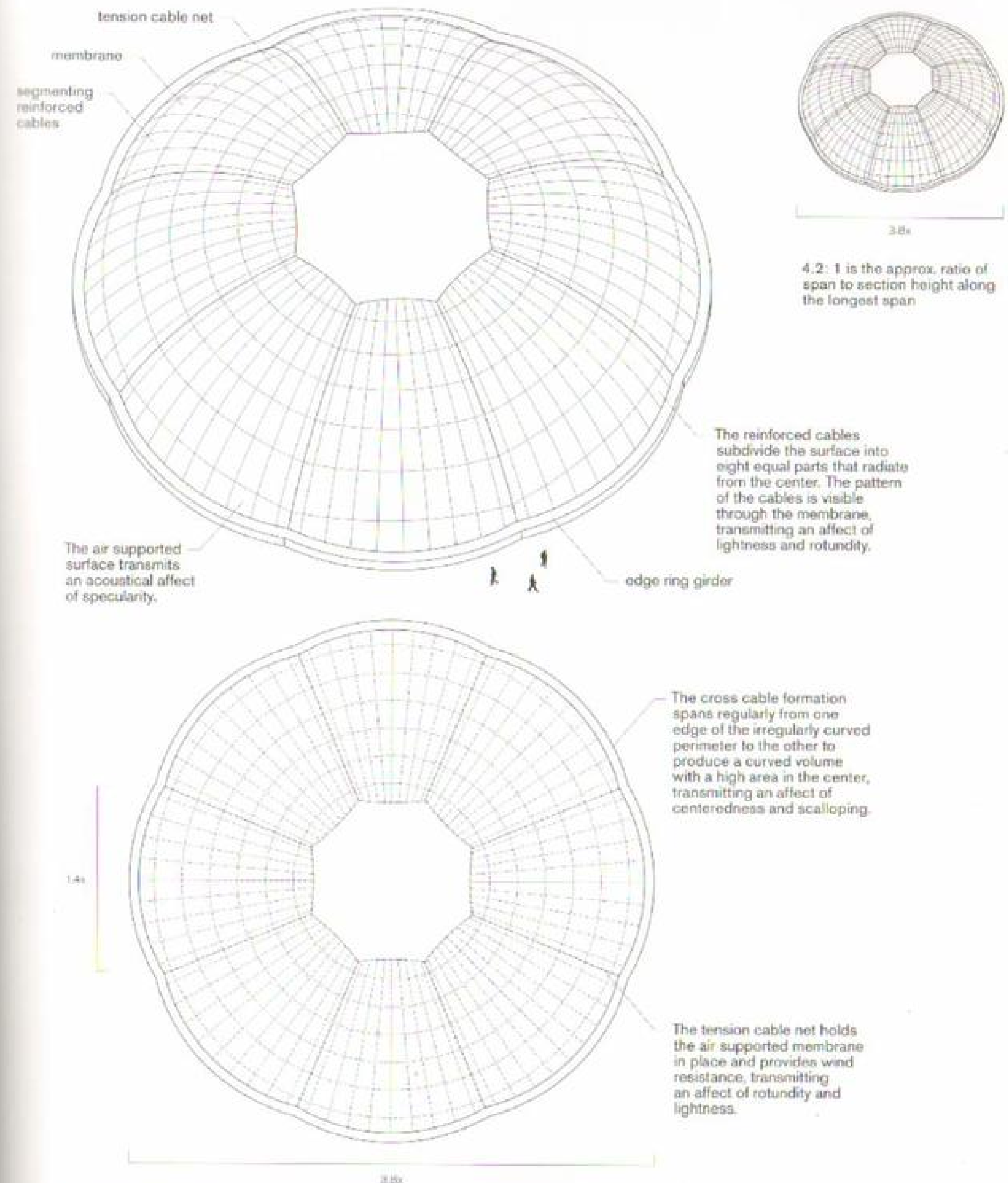


The Orchid Pavilion is produced by an air supported pneumatic membrane and a network of cables spanning an irregularly curved perimeter and determining the scale of subdivision of the membrane as well as the curvature of the structure. The cable ribs form arches that vary in height to create an irregular overall profile. The Orchid Pavilion transmits an optical affect of scalloping, amorphousness, rotundity and lightness, and an acoustical affect of diffusion and focusing.

Scalloping, Centeredness, Rotundity, Lightness, Specularity

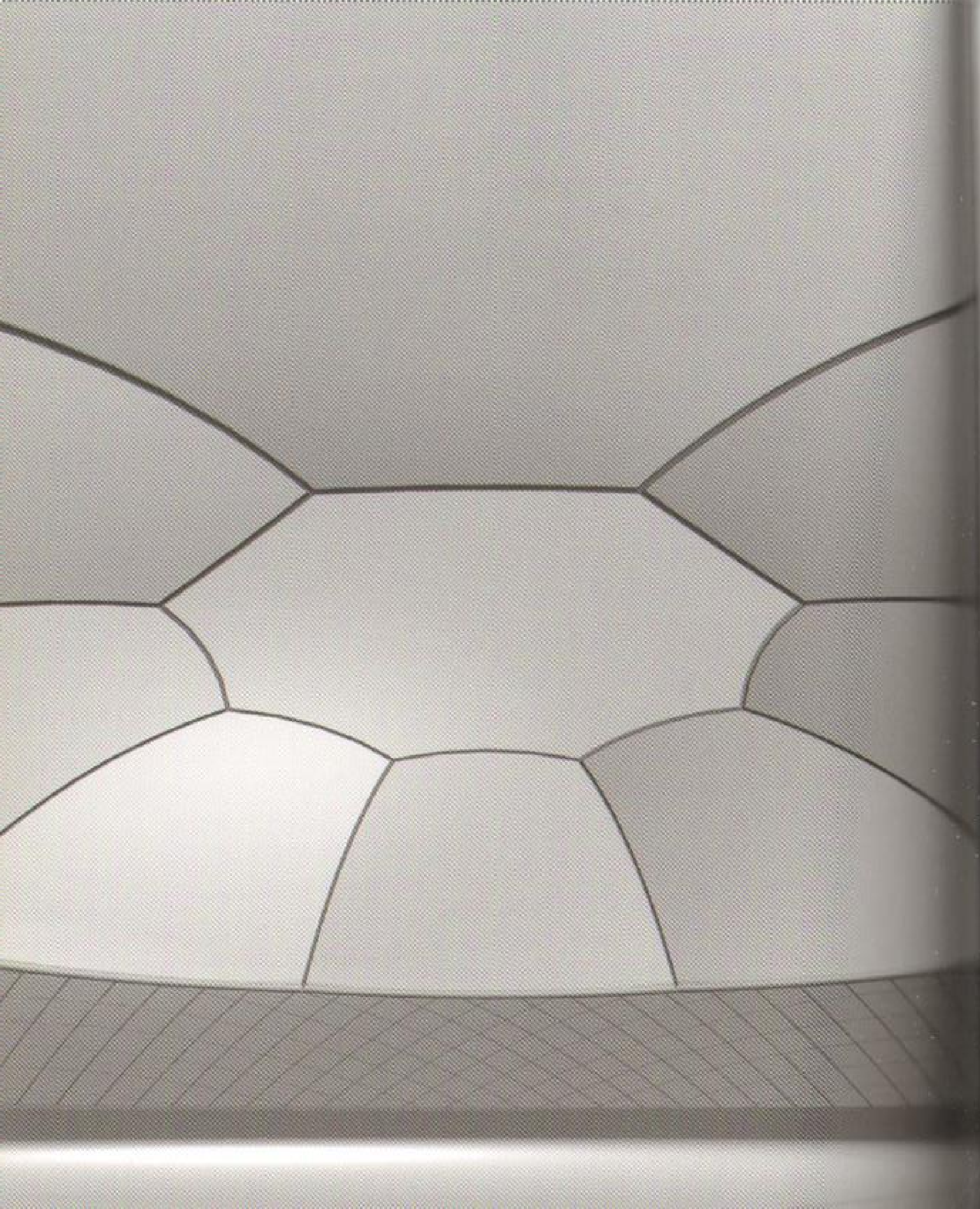


Curved / Air Supported Pneumatic Membrane

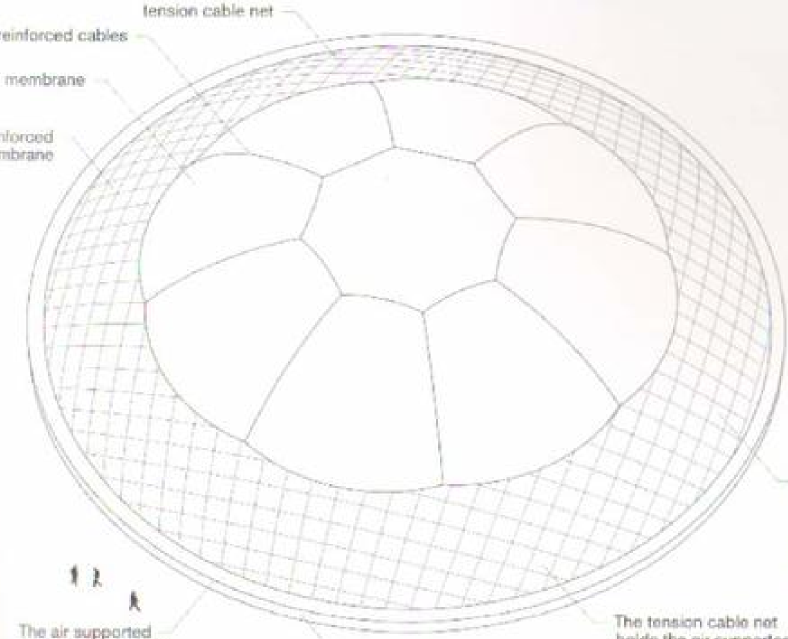


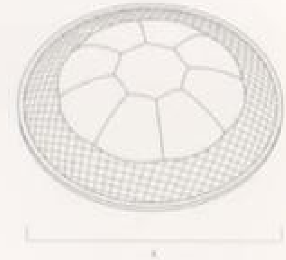
This curved form is produced by an air supported pneumatic membrane and a network of vertical and horizontal tension cables as well as a series of tension ribs that determine the scale of subdivision of the membrane as well as the curvature of the structure. This form transmits an optical affect of scalloping, centeredness, rotundity and lightness, and an acoustical affect of specularity.

Bubbling, Rotundity, Lightness, Specularity

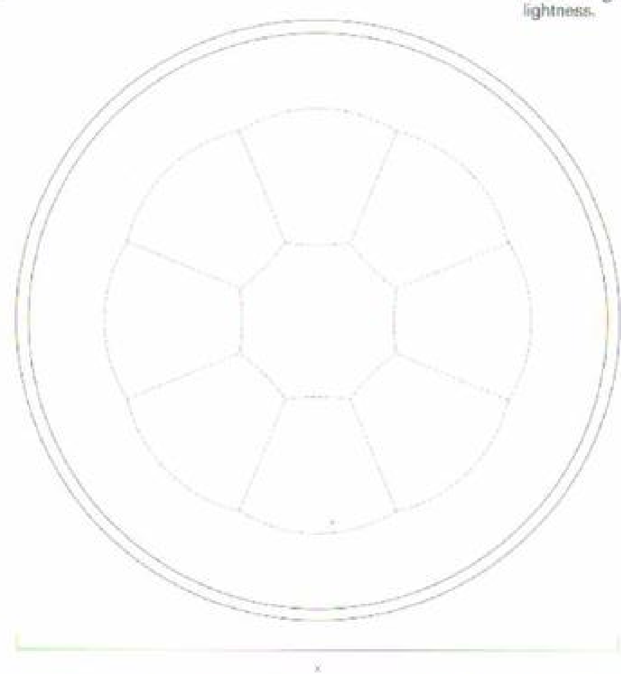


Curved / Air Supported Pneumatic Membrane





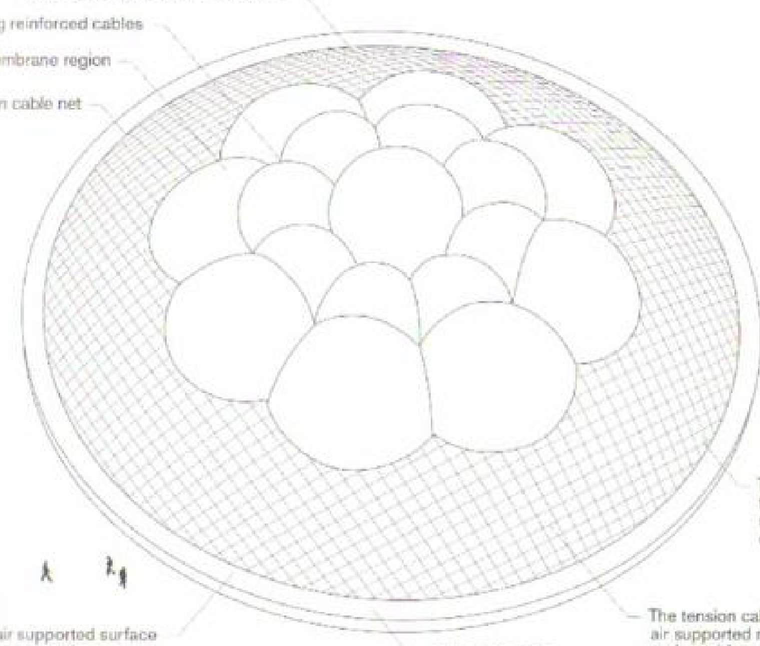
4.2:1 is the approx. ratio of span to section height along the longest span

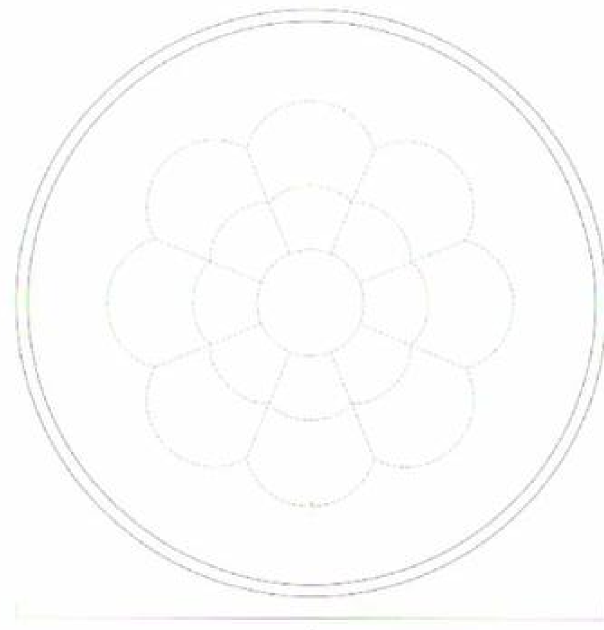


This curved form is produced by an air supported pneumatic membrane divided into a lower and a network of cables. The surface of the lower region is reinforced by a high density of cables, distributed in a regular pattern, while the surface of the upper region has a much lower density of cables which are larger in section and form the overall divisions of the membrane. This form transmits an optical affect of bubbling, rotundity and lightness, and an acoustical affect of specularity.

Bubbling, Rotundity, Lightness, Diffusion

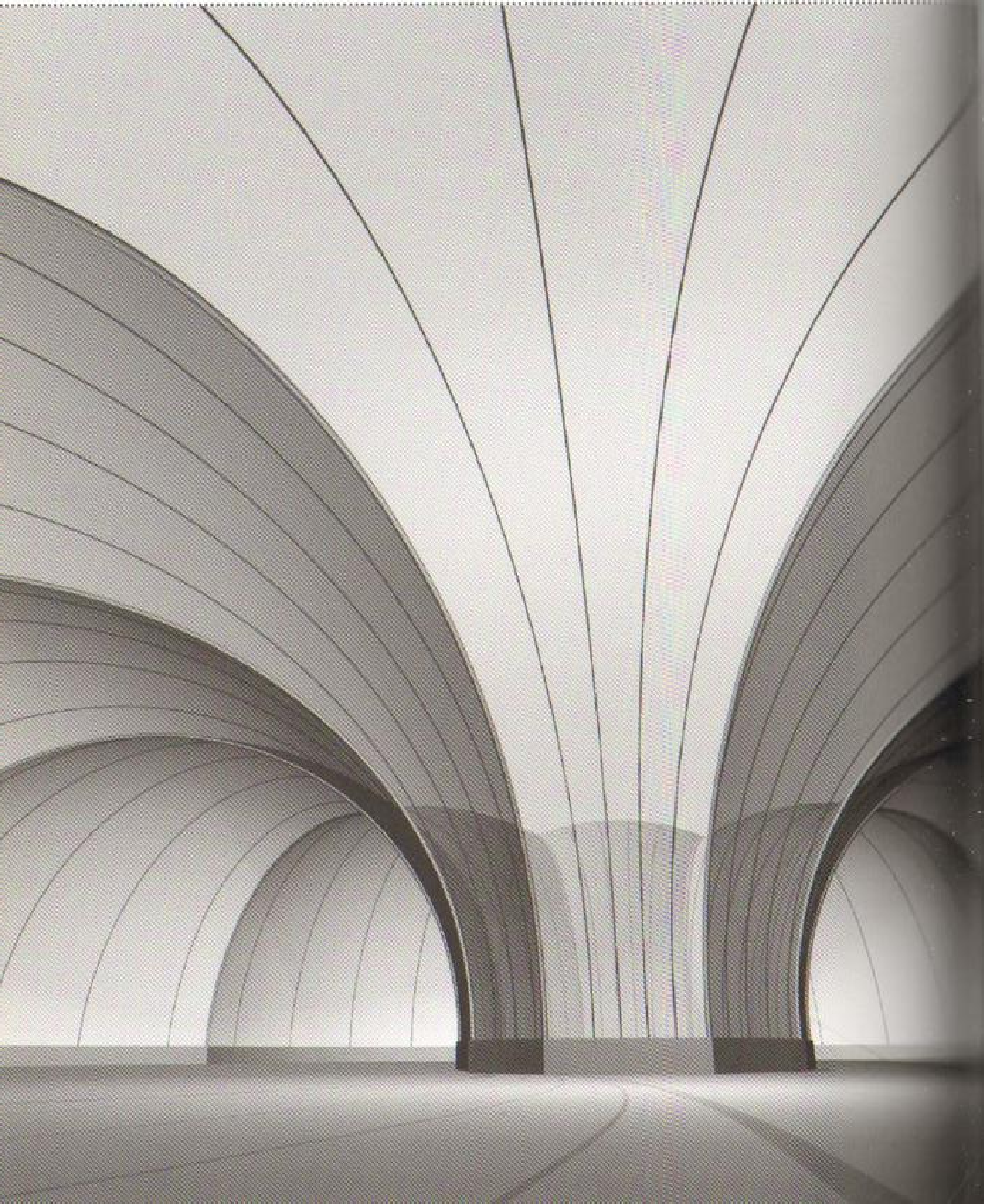
Curved / Air Supported Pneumatic Membrane



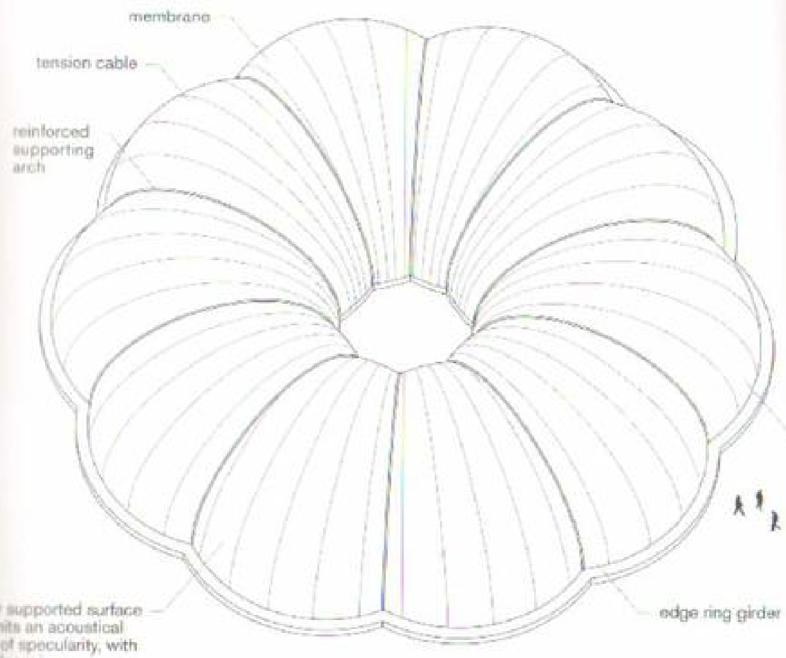


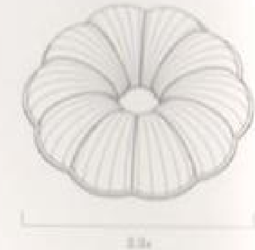
This curved form is produced by an air supported pneumatic membrane divided into a lower and a network of cables. The surface of the lower region is reinforced by a high density of cables, distributed in a regular pattern, while the surface of the upper region has a much lower density of cables, larger in section, which subdivide it into scalloped sub-regions that can be shaped individually by increasing their internal air pressure. This form transmits an optical affect of bubbling, rotundity and lightness, and an acoustical affect of diffusion.

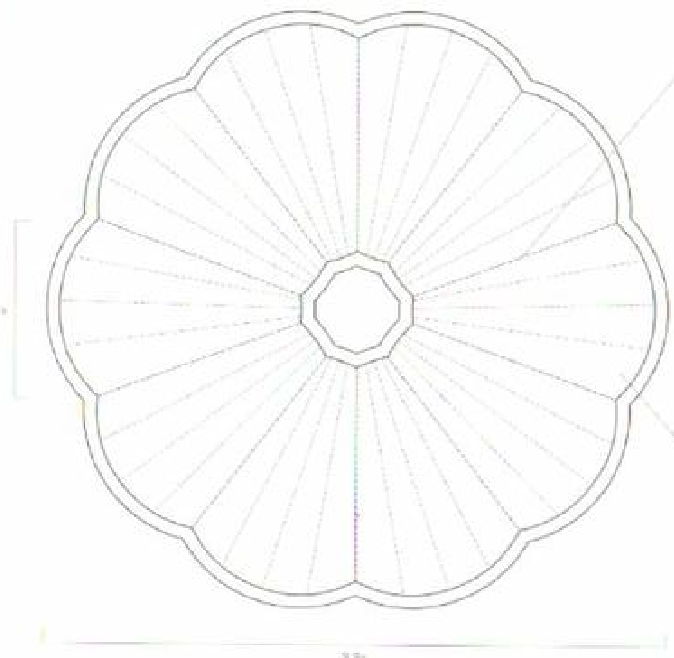
Blastulation, Rotundity, Lightness, Specularity, Focusing



Curved / Air Supported Pneumatic Membrane



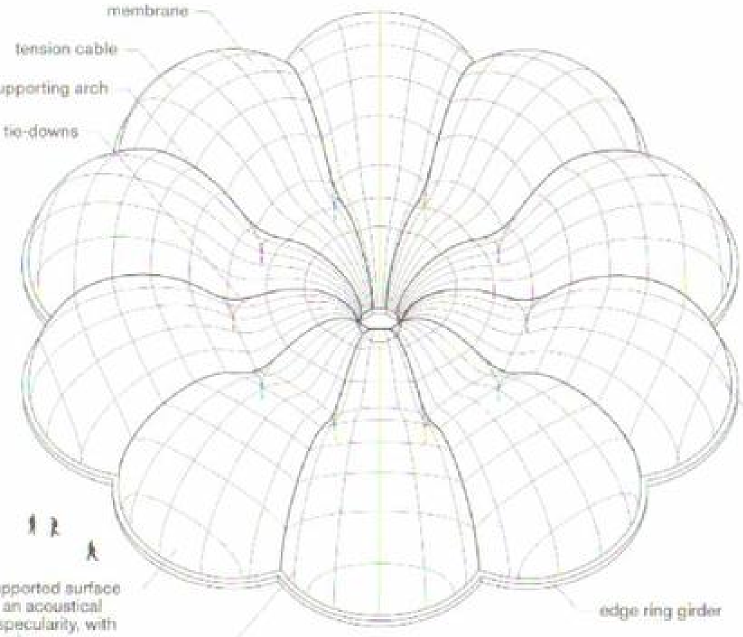


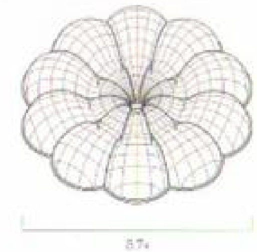


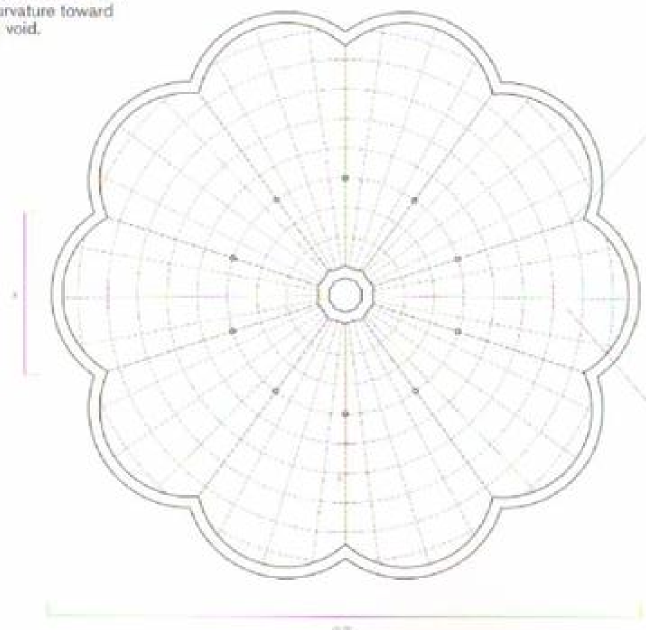
This curved form is produced by an air supported pneumatic membrane, blastular in shape with an exterior void at its center, and a combination of tension cables and reinforced arches spanning from the scalloped perimeter to the central void. This form transmits an optical affect of blastulation, rotundity and lightness, and an acoustical affect of specularity and focusing.

Blastulation, Undulation, Lightness, Specularity, Focusing

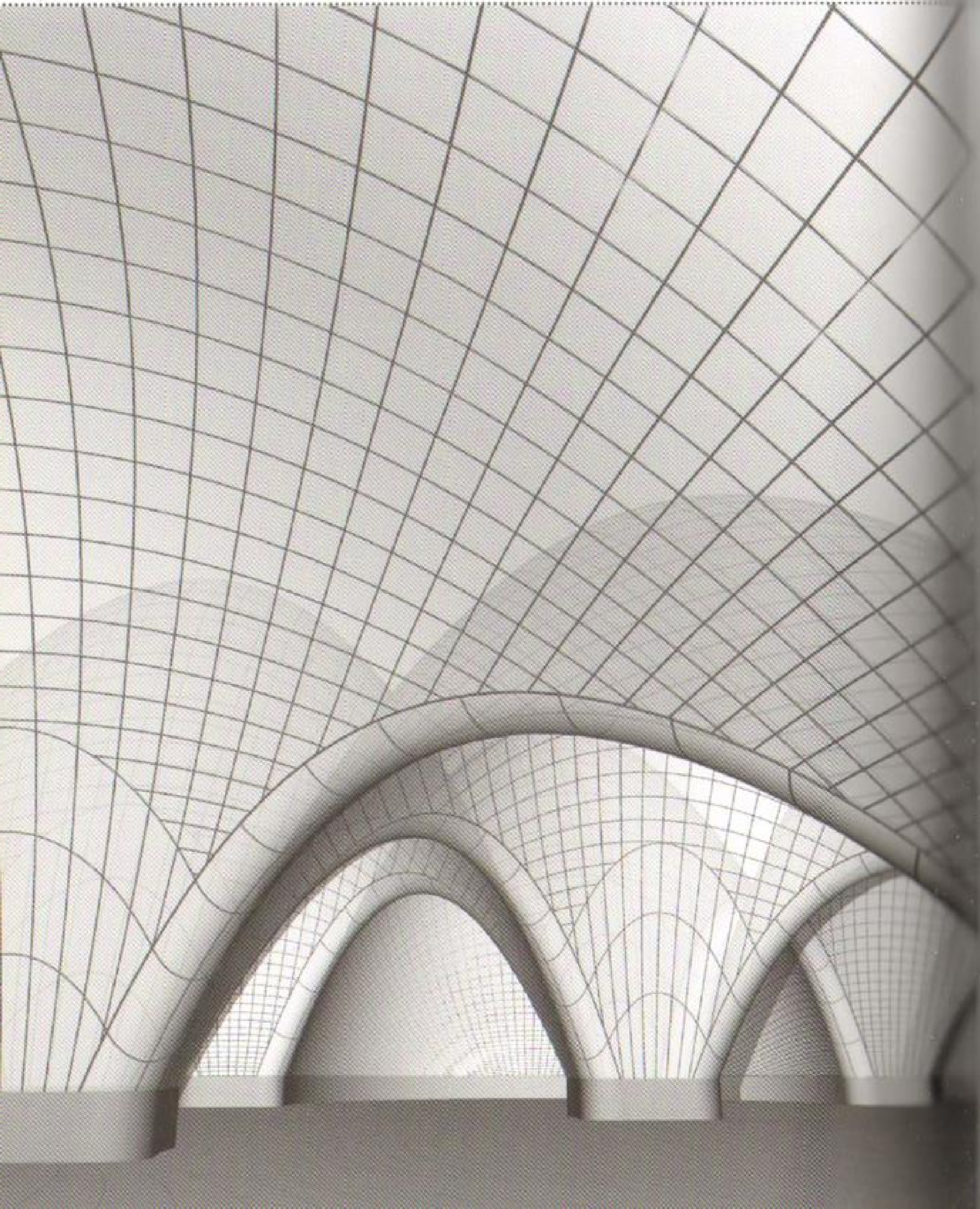
Curved / Air Supported Pneumatic Membrane



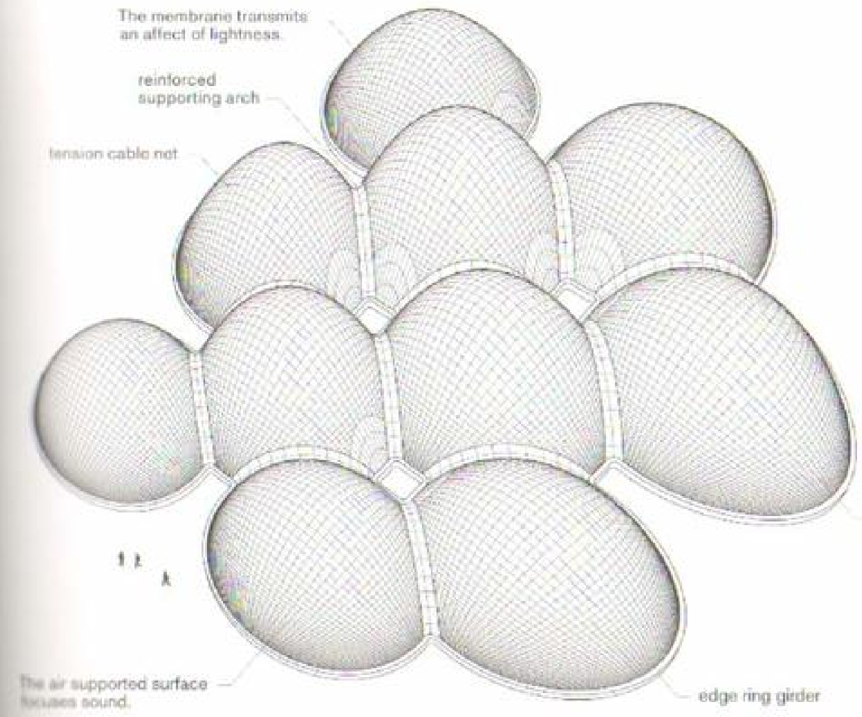


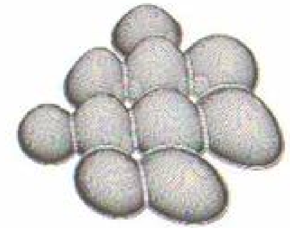


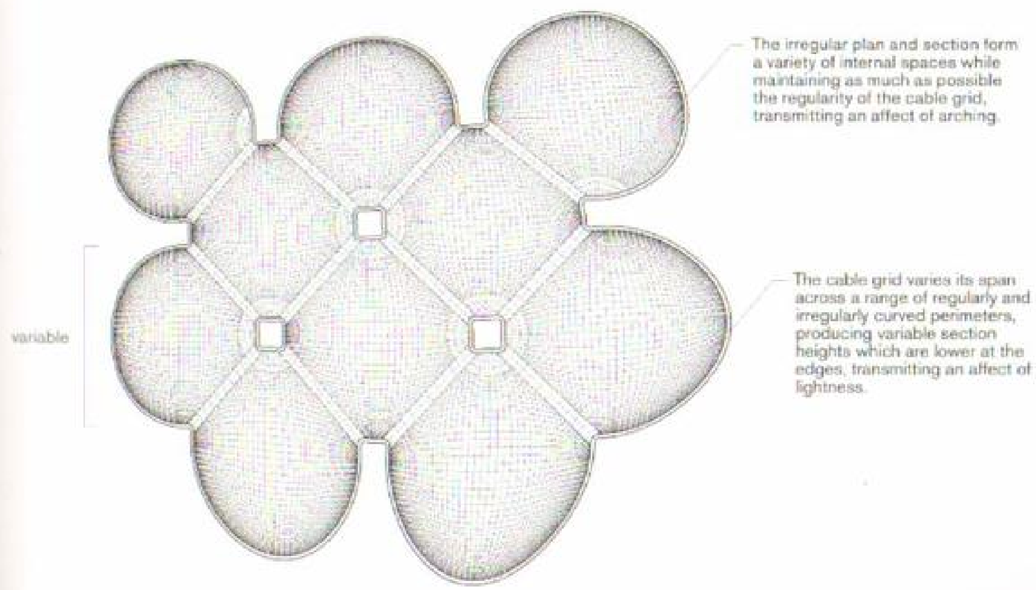
This curved form is produced by an air supported pneumatic membrane, bastular in shape with a void at its center, and a combination of tension cables and reinforced arches spanning from the scalloped perimeter to the central void. This form transmits an optical affect of blastulation, undulation and lightness, and an acoustical affect of specularity and focusing.



Curved / Air Supported Pneumatic Membrane







This curved form is produced by an air supported pneumatic membrane and a system of tension cables as well as reinforcing arches. The system can be expanded to cover large areas, and is capable of incorporating variable spans. This form transmits an optical affect of cellularity, arching, and lightness, and an acoustical affect of focusing.

Inflated Beam Pneumatic Membrane

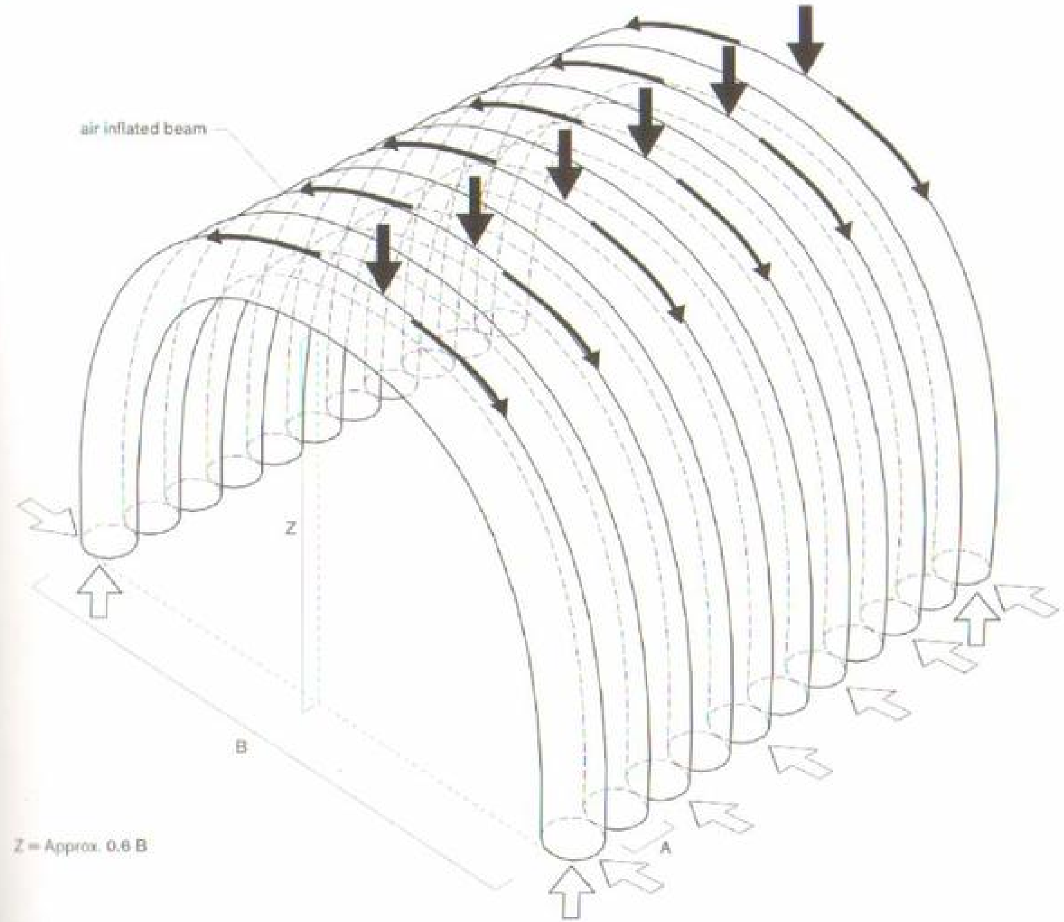
The base unit of an inflated beam pneumatic membrane consists of a series of membranes with a pressurized section which acts like an air inflated beam and shapes the structure. Inflated beam membranes direct the primary bending moments along a number of axes distributing loads along the surface of the beams, or pillows, shaping the overall section. An inflated beam membrane is usually made of steel cables and fabric. This distribution of loads along the surfaces of the membranes and the line of the steel cables embeds the inflated beam membrane with an optical affective property of striatedness and scalloping that remains consistent within any space it defines. The acoustical affect of an inflated beam membrane is determined by its surface curvature. This is usually concave, in which case there is an affect of focus near the centre of curvature. However, the inflated beams may transmit an affect of diffusion which may reduce or dominate the affects of focusing or specularity.

Inflated beam membranes are flexible in several ways:

Section: The flexibility of an inflated beam membrane lies in variations in the air-inflated section and the curvature of the control cables.

Plan: Inflated beam membranes can tessellate horizontally along straight or curved lines of growth to produce primarily horizontal structures, or sheds.

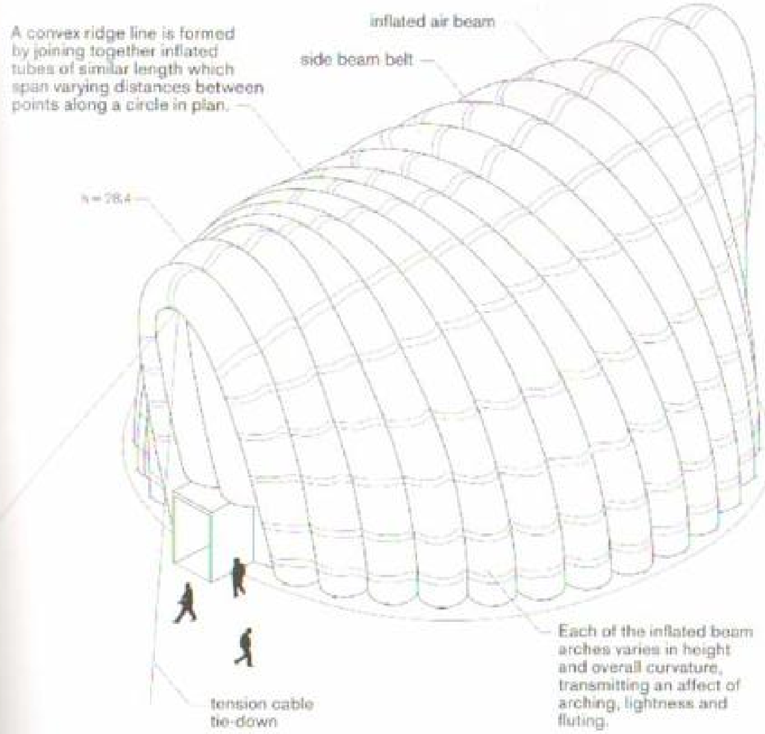
Affect: The affective property of an inflated beam membrane can be multiplied when the base unit imbricates or intertwines with external factors, such as asymmetries that respond to the physical constraints of the site, environmental considerations, programmatic concerns, etc. As a result, in addition to striatedness and scalloping, an inflated beam membrane can transmit other optical affects, including centeredness, rotundity, lightness, bubbling, quilting. The air pockets of pneumatic structures add diffusion to modify or dominate the acoustical affect of their macro-geometry, which is usually focusing (curved).

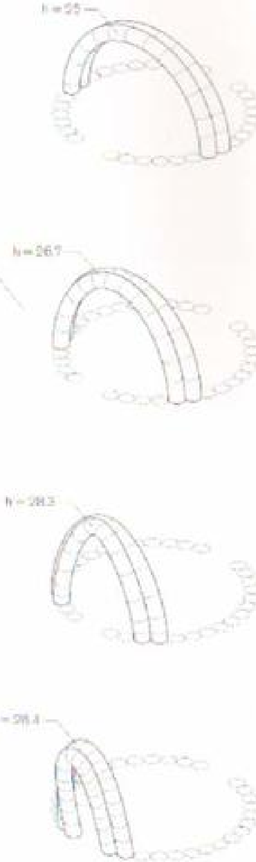


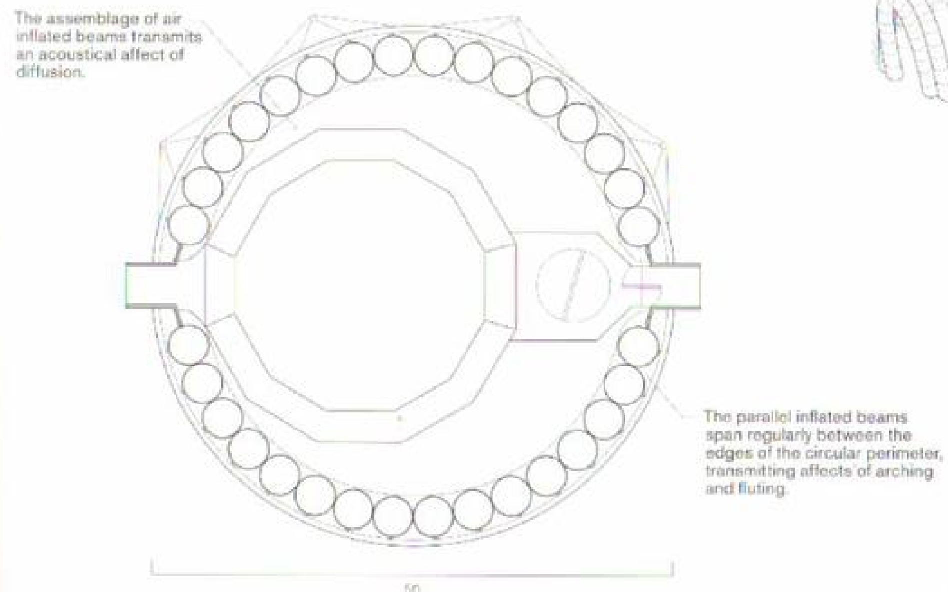
Arching, Lightness, Fluting, Diffusion

Horizontal / Inflated Beam Pneumatic Membrane

FUJI PAVILION | Y. MURATA; M. KAWAGUCHI | OSAKA, JAPAN | 1970

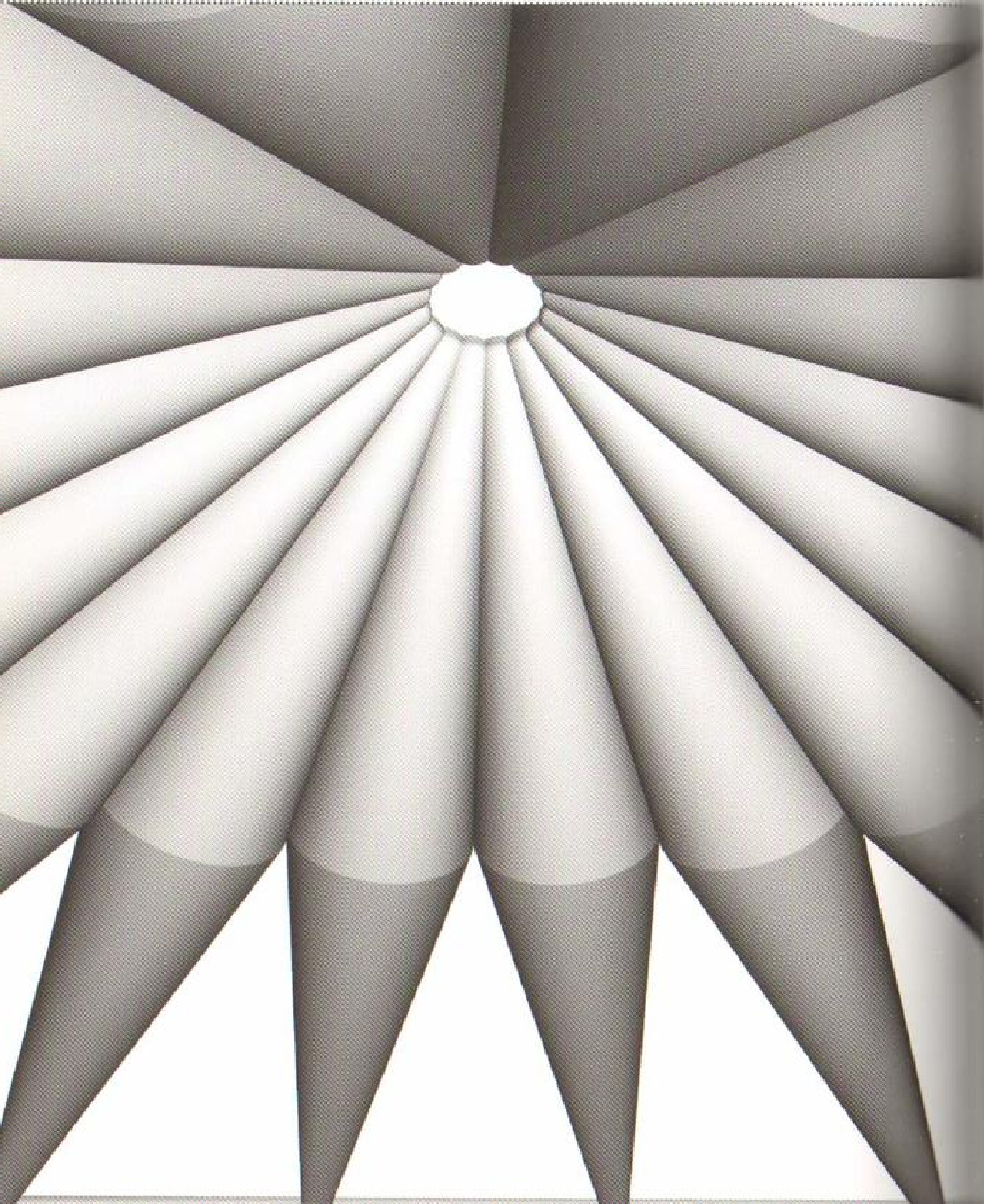




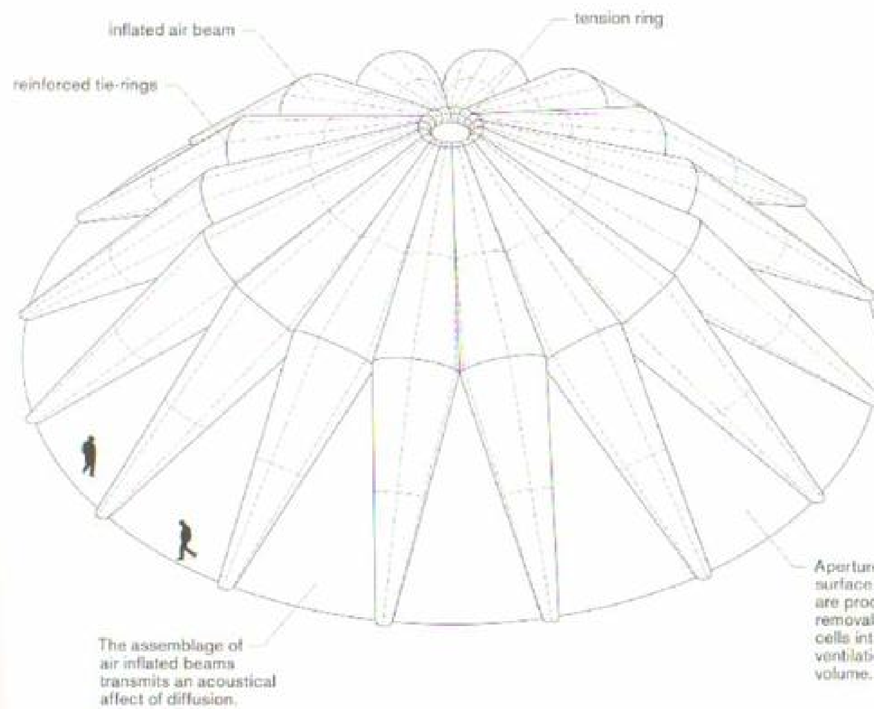


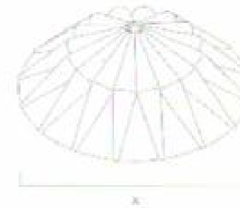
The Fuji Pavillion is formed by the horizontal tessellation of an arch-shaped inflated beam base unit, which is repeated sixteen times. The beams are individually inflated to a range of heights and curvatures, and tied together by reinforcing belts, to form a saddle shape which is circular in plan. The Fuji Pavillion transmits an optical affect of arching, lightness and fluting, and an acoustical affect of diffusion.

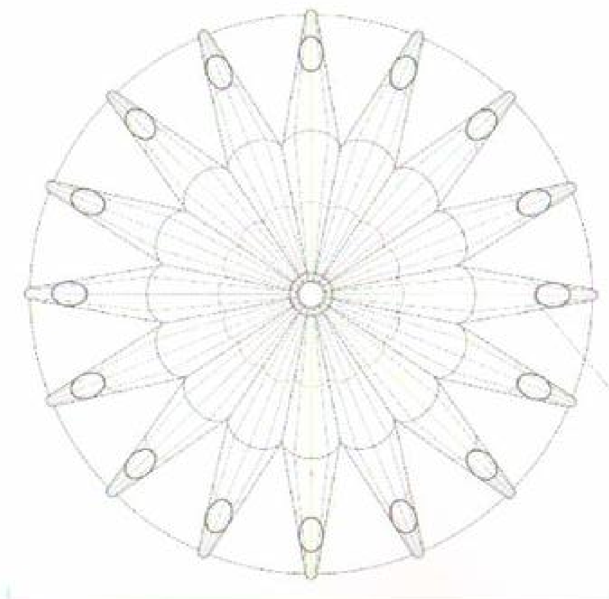
Pleating, Rotundity, Lightness, Diffusion



Horizontal / Inflated Beam Pneumatic Membrane

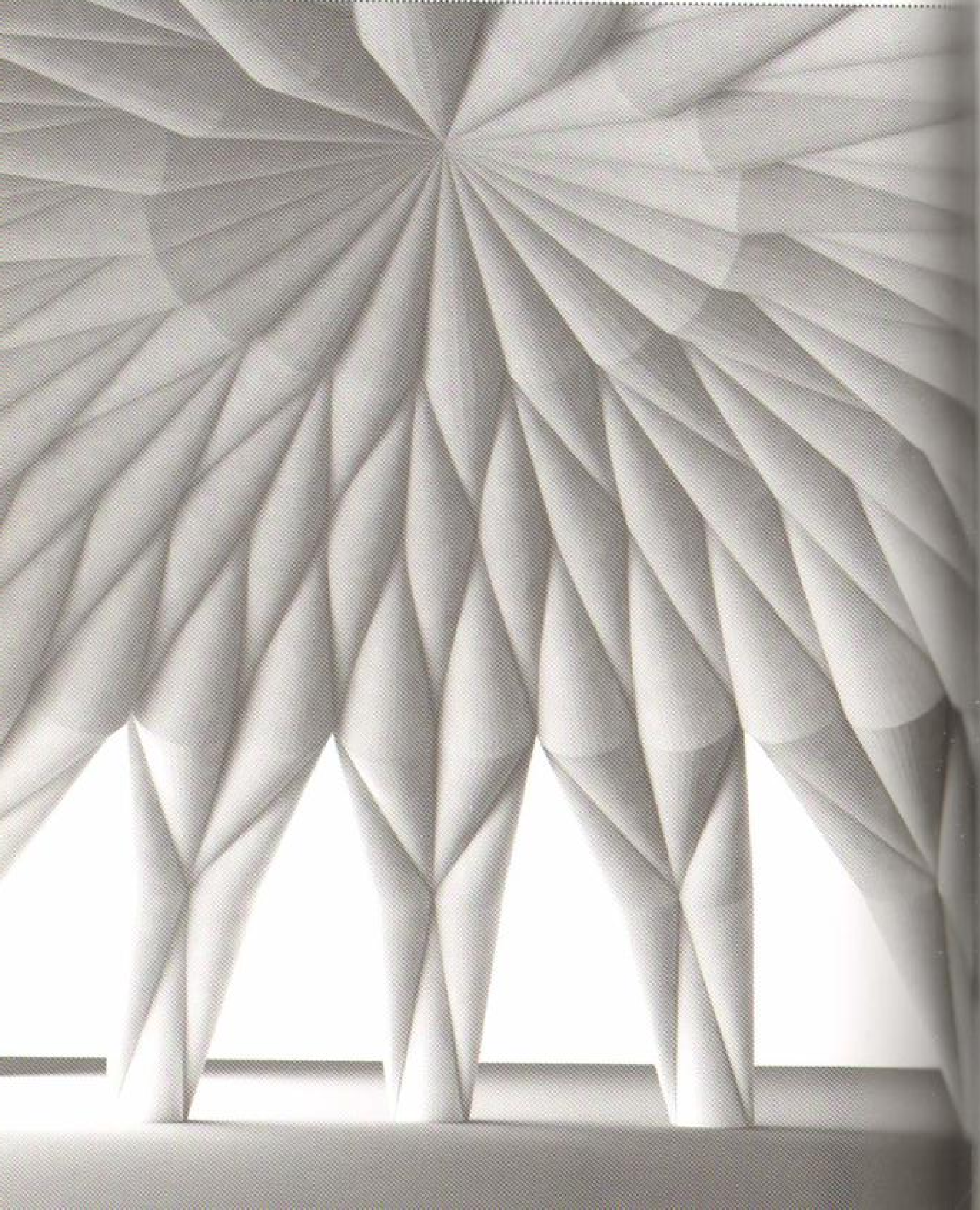




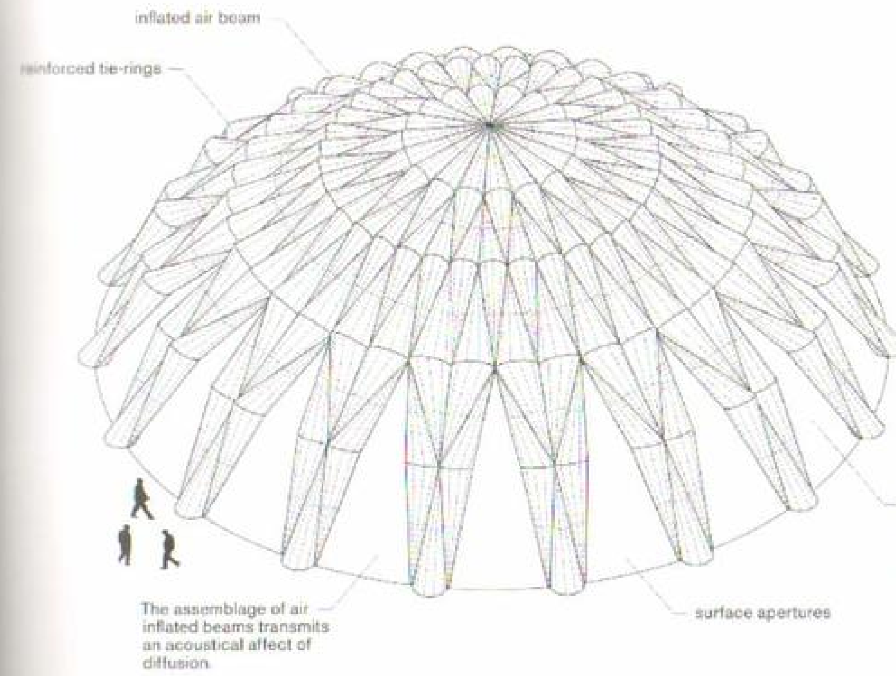


This horizontal form is produced by the tesssellation of an inflated beam pneumatic membrane base unit which is shaped as conical pillows, tied together both for reinforcement and to create an overall curved section. The individual pillows can be aggregated as a continuous surface, or some can be removed or their profiles can be varied to produce openings. This form transmits an optical affect of pleating, rotundity and lightness, and an acoustical affect of diffusion.

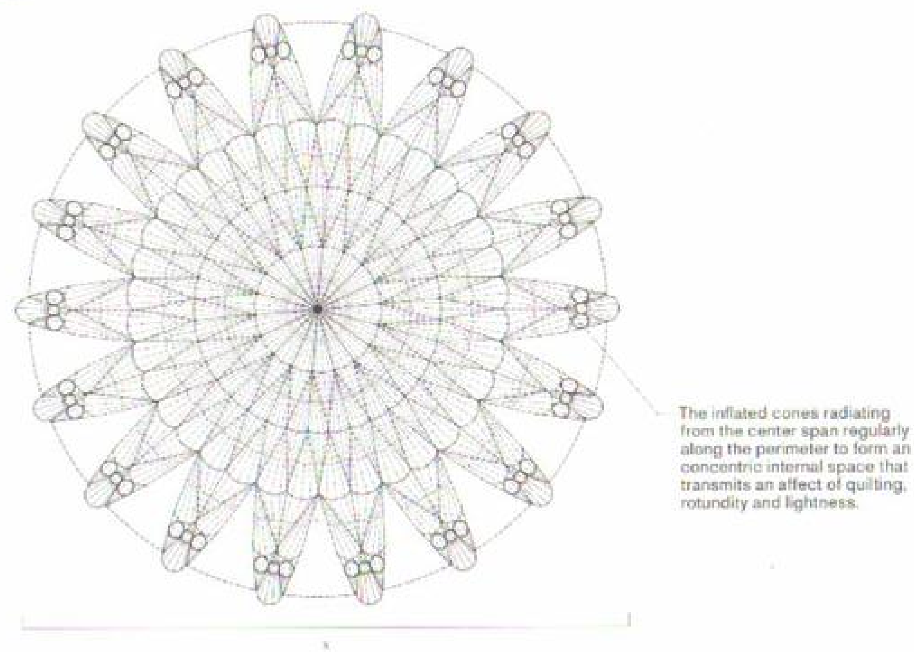
Quilting, Rotundity, Lightness, Diffusion



Horizontal / Inflated Beam Pneumatic Membrane



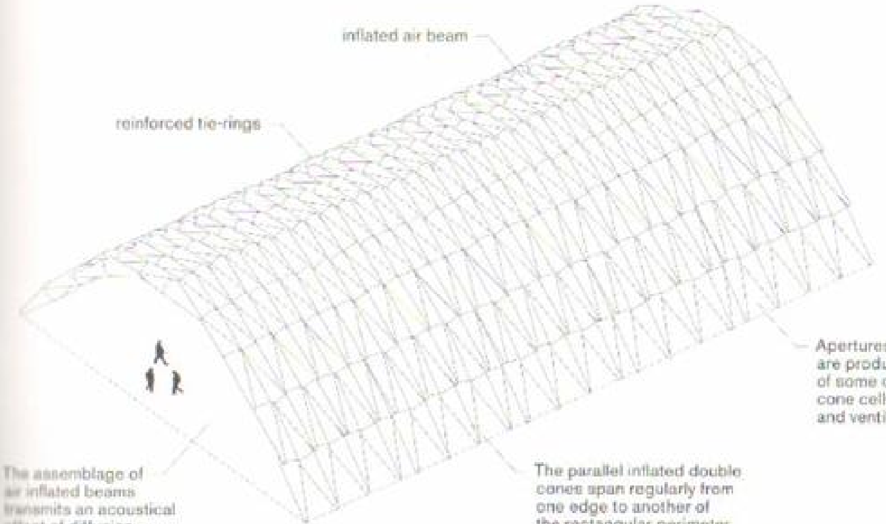
3.25: 1 is the ratio of span to section height along the longest span

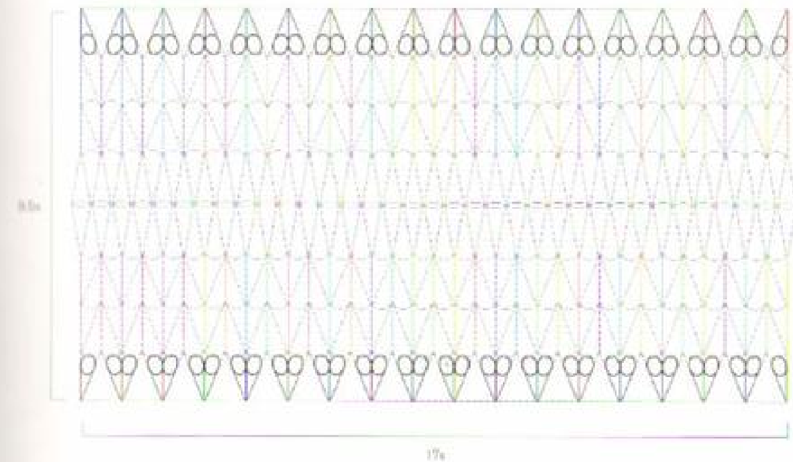


This horizontal form is produced by the tessellation of an inflated beam pneumatic membrane base unit which is shaped as asymmetrical conical pillows, tied together both for reinforcement and to create a curved section. The individual pillows can be aggregated as a continuous surface, or some can be removed or their profiles can be varied to produce openings. This form transmits an optical affect of quilting, rotundity, and lightness, and an acoustical affect of diffusion.

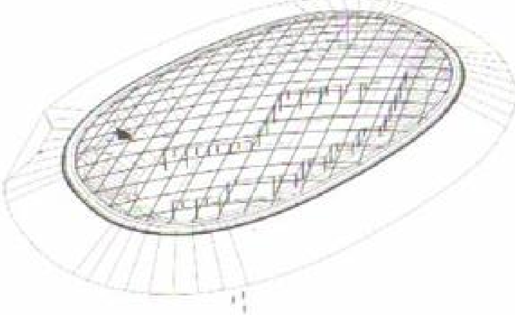
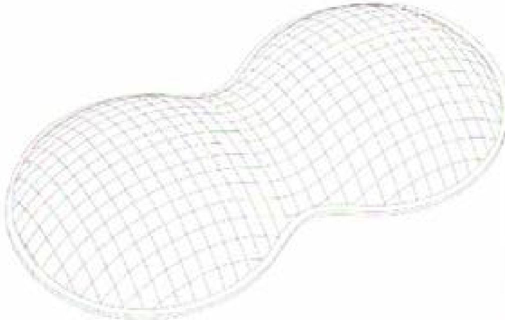
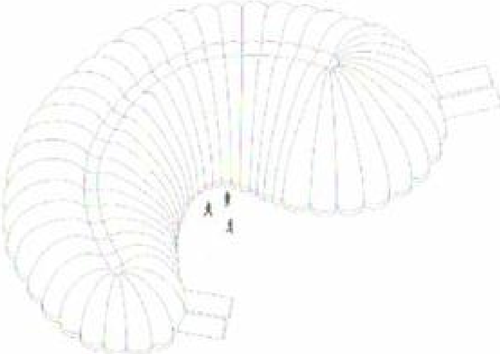
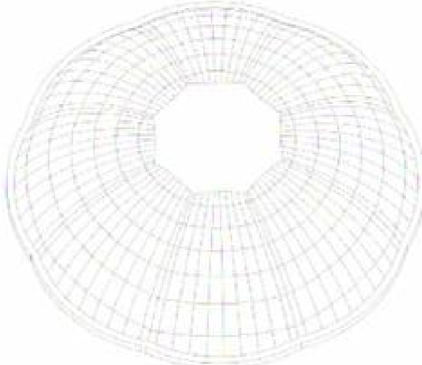
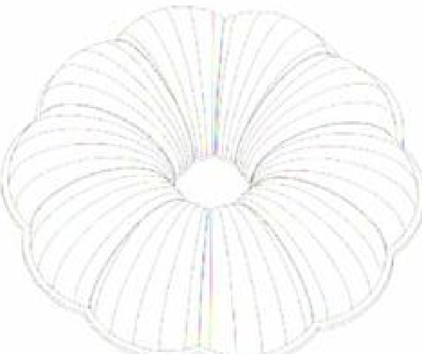
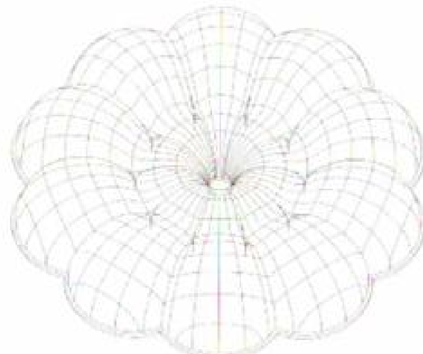
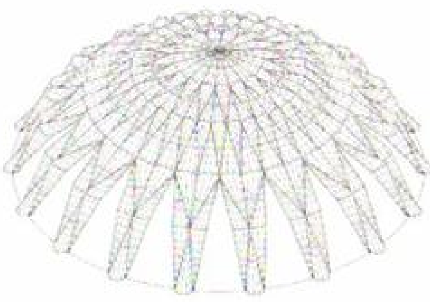
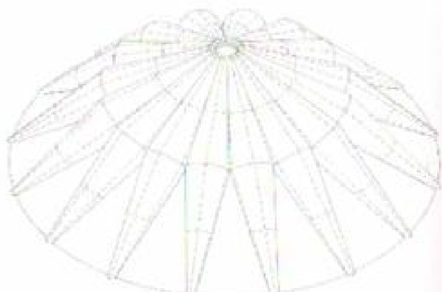
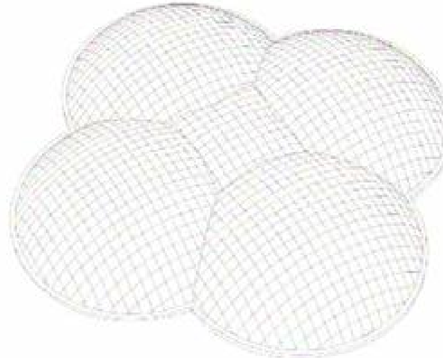
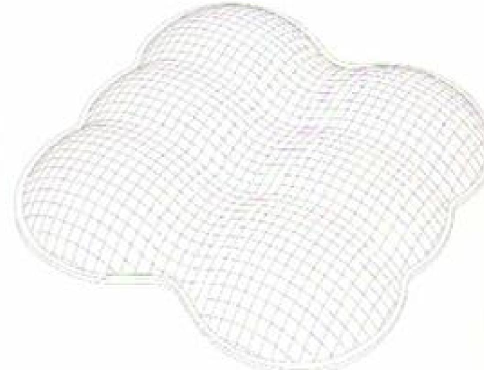
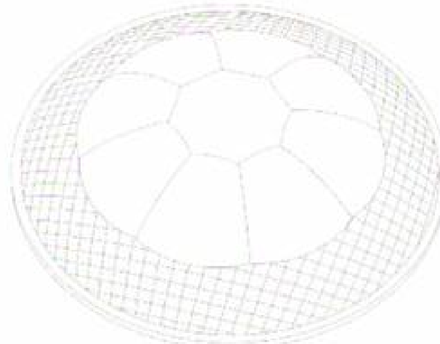
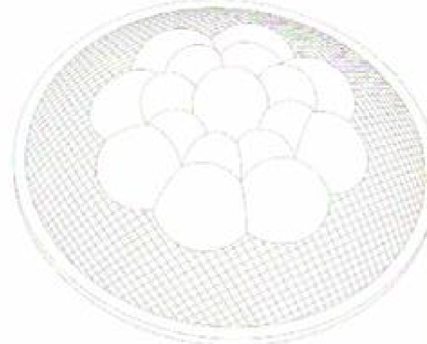
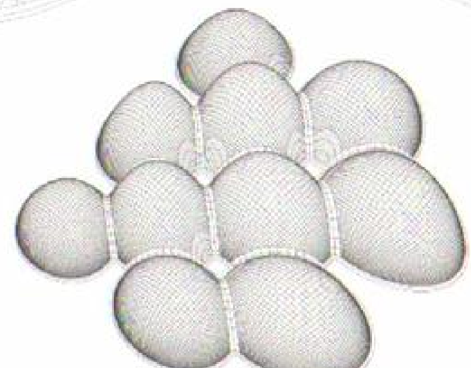
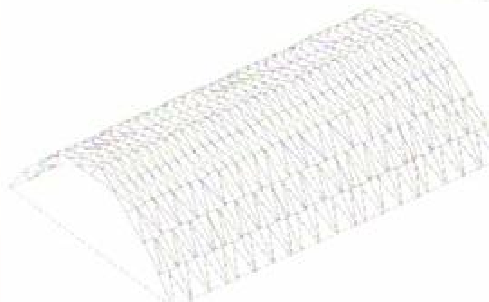
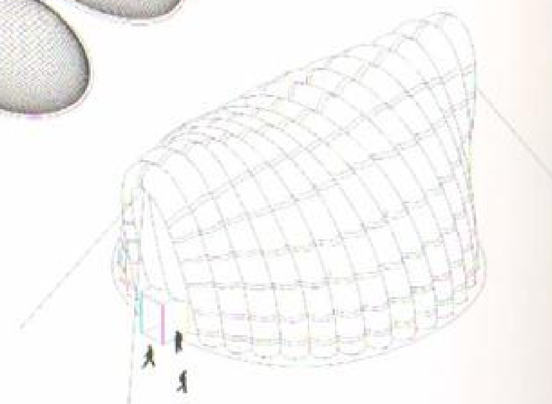
Quilting, Lightness, Arching, Diffusion

Horizontal / Inflated Beam Pneumatic Membrane





This horizontal form is produced by the tessellation of an inflated beam pneumatic membrane base unit, an arched assemblage composed of a series of fourteen pillows in the shape of double cones, individually inflated, shaped, and tied together by reinforcing rings. Asymmetries in profile determine the curvature of each of these units, which are arranged along a linear perimeter to form a barrel vault structure. This form transmits an optical affect of quilting, lightness and arching, and an acoustical affect of diffusion.

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