3600 N/mm2 (theoretical)

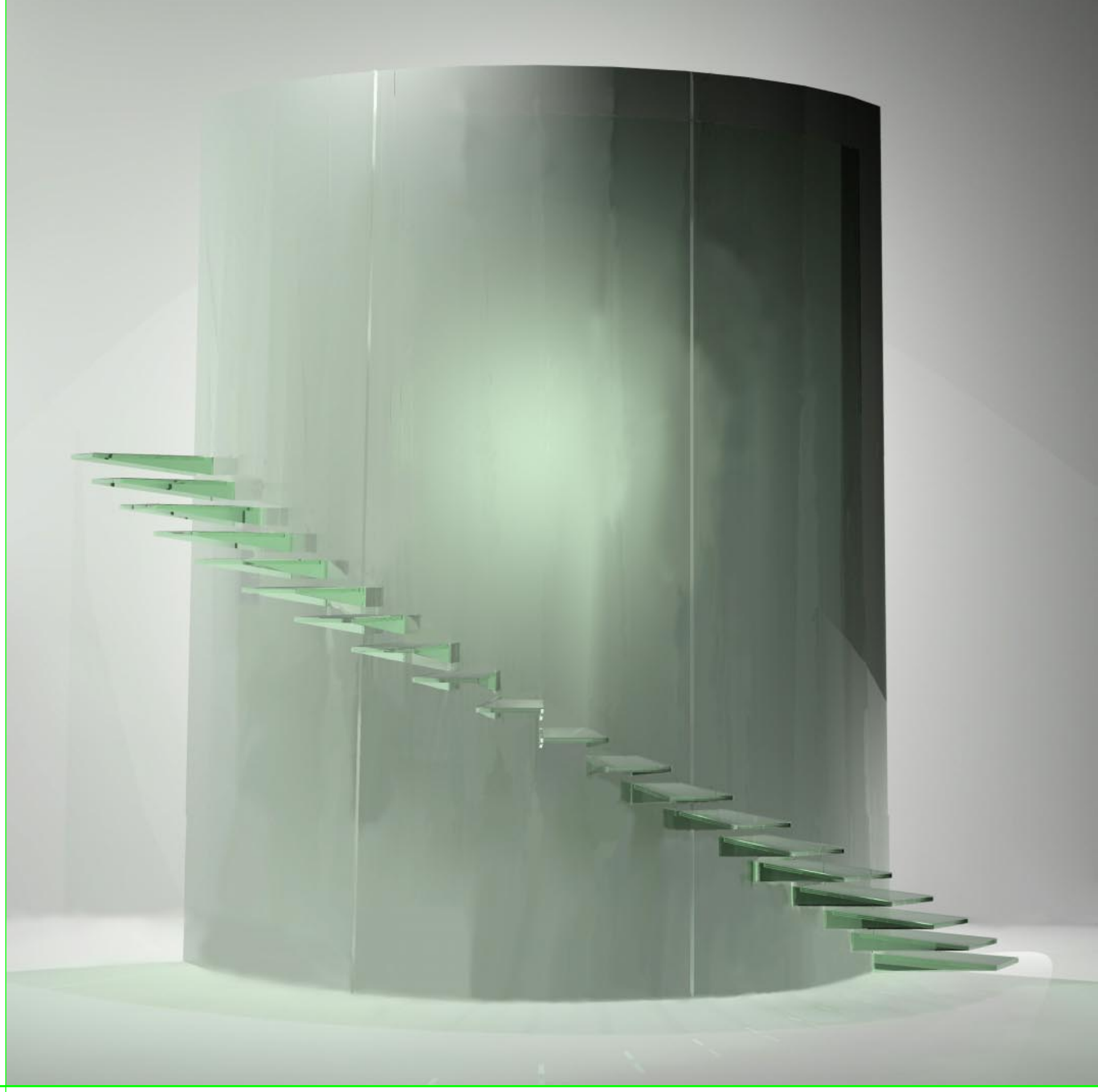
Compressive strength: 21000 N/mm2.
Tensile Strength: 80 N/mm2.
Yield Strength: 3600 N/mm2.

Glass embodies lightness. Yet with the immense strength which is inherent to the physical property of glass, its use as a structural material is inevitable. The challenge is to convey the sense of lightness contained within this heavy, brittle material. This design for a staircase aims to exploit the yield strength of glass and explore both the structural strength of the material and its aesthetic lightness.

The staircase consists of three elements: a curved wall, risers and treads. All are made of glass. The handrail, a fourth element, is stainless steel. The structure of the glass stair is derived from the strength of its form. A curved wall is inherently stable, utilizing the compressive strength, which allows the wall to be freestanding. The wall, a laminated glass cavity wall, is constructed using pre-fabricated components. Glass sheets are adhered to a series of vertical glass fins. Horizontal stair risers are cantilevered out from the wall. To join glass with metal connections not only decreases its strength and its transparency but also ultimately jeopardizes this lightness. Consequently, these risers are joined through an adhesive moment connection rather than the typical metal connection. The joints are cured with the application of ultra-violet light and as a result, become transparent, and create a distinct sense of lightness.

Research in the United States and at the Centre for Window and Cladding Technology in England has demonstrated the potential that exists for the use of adhesives in structural glass. The glass stair utilizes a structural adhesive manufactured by the Dymax Corporation. The adhesive has a strength capacity of 6100 psi. The designed fin-riser connection has been calculated to carry about 220 lbs, the equivalent of a very heavy person. During design development, large safety factors have been applied, and as a result of a properly engineered load testing procedure, the strength capacity has exceeded the calculated loads. Combining the immense strength of glass with this adhesive demonstrates the inherent structural potential for glass.

Beyond the immense strength, the optical qualities of glass are encompassed within the design. The apparent lightness achieved through the laminated glass and epoxied connections is amplified with the manipulation of light. Through the use of translucent and transparent glass the wall utilizes the unique qualities of light to create an ethereal experience.



The Material:

Annealed ¼" plate glass
Strength capacity of glass:
load capacity: 5000 psi
calculated for a factor of safety: 10
compressive strength: 21000 N/mm²
tensile strength: 30-80 N/mm²
yield strength: 3600 N/mm²
Multiple laminations: redundancy for safety

A Curved Wall:

Interior surface: 2 ply laminated clear plate glass
Fins: 2 ply laminated clear plate glass
Exterior surface: 2 ply laminated translucent plate glass
Neoprene cushion at riser-wall connection
Metal floor connection: redundancy for safety

A Glass Stair:

Annealed ¼" plate glass
Annealed ½" plate glass
1 ply sand-blasted plate glass
2 ply laminated clear plate glass

Riser:

Annealed ¼" plate glass
3 ply laminated clear plate glass

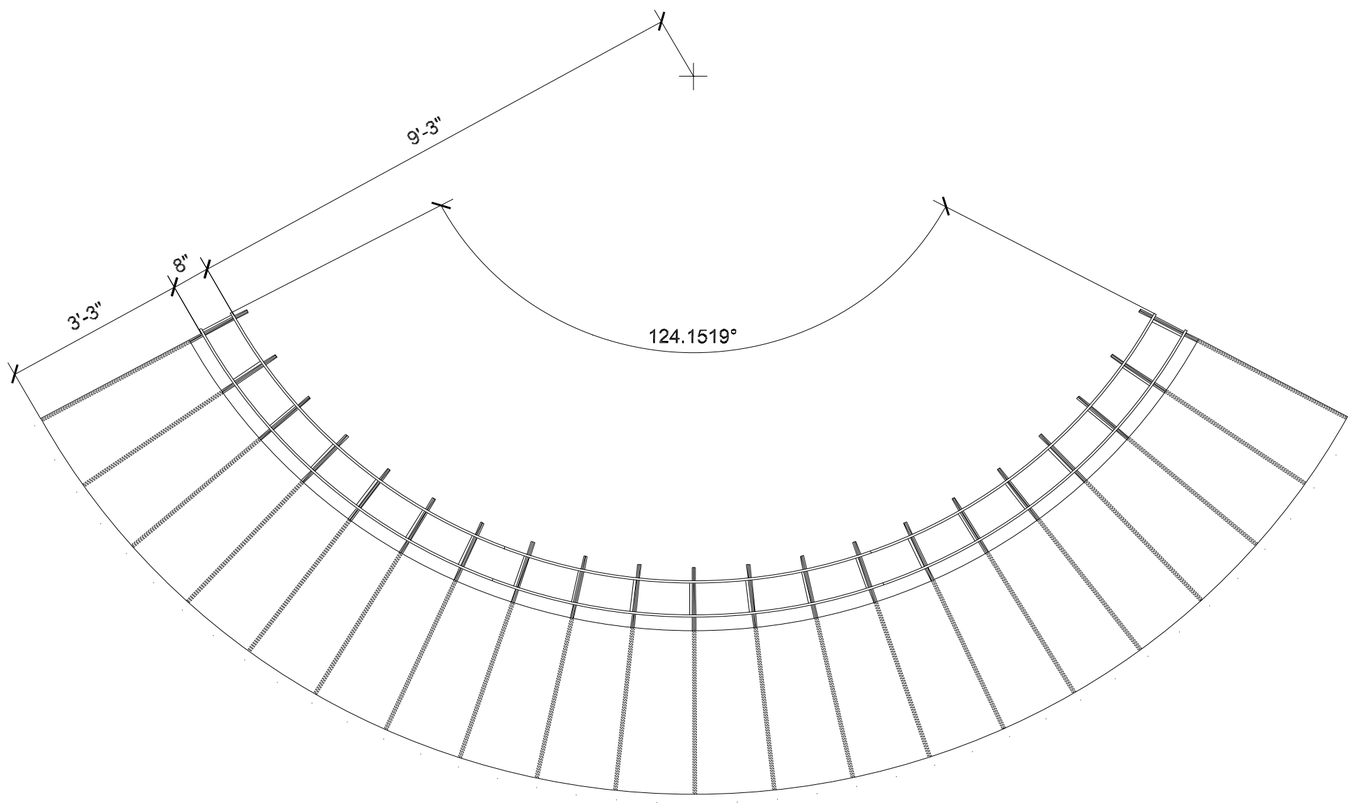
Adhesive:

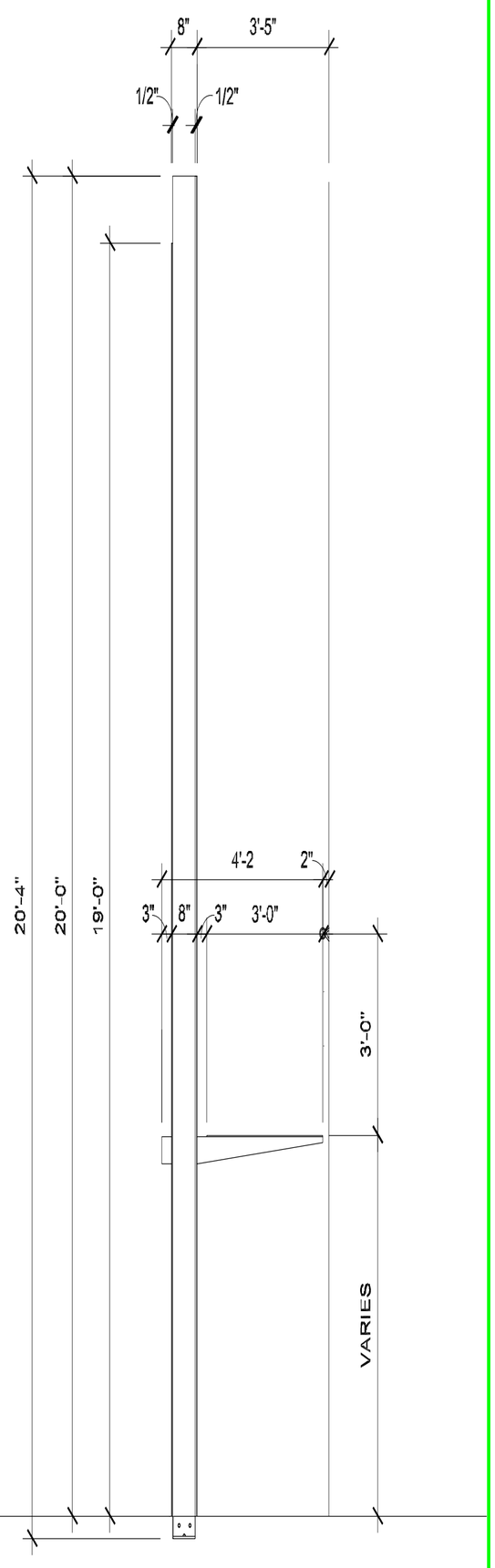
Ultra Light-Weld[R] 4-20260 High Performance Glass Adhesive
Dymax Corporation
used in all connections
UV activated
Appearance: clear
Tensile yield: 6100 psi
Elongation at yield: 9%
Thermal limit (brittle/degrades): -51° to 149°C
Viscosity: 4,000 cP
Linear shrinkage: 1.9%

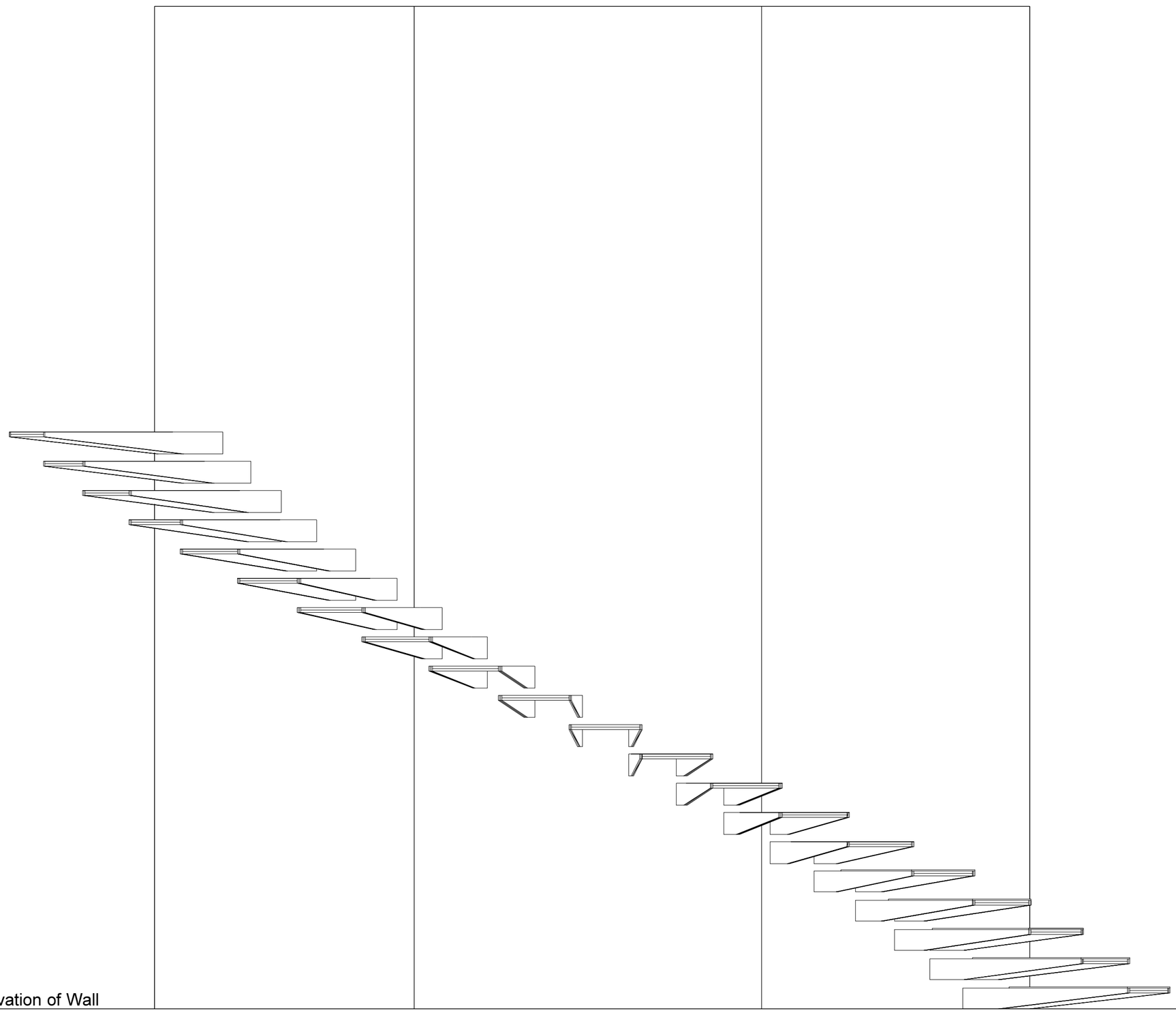
Handrail:

Tensioned piano wires
from floor to ceiling
Stainless steel handrail

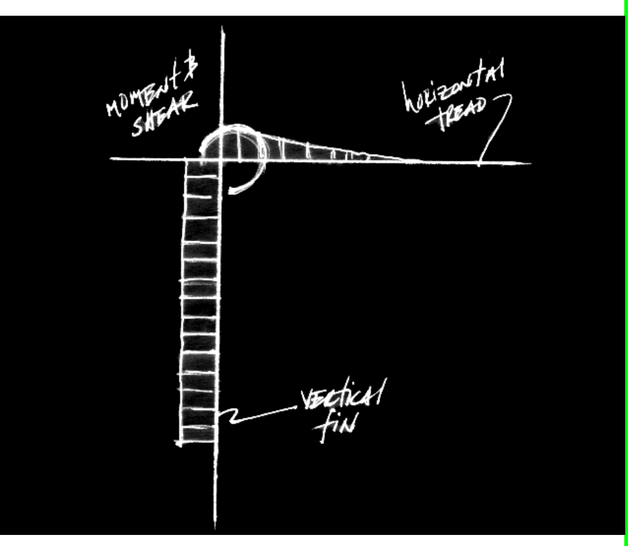
Plan of Stair

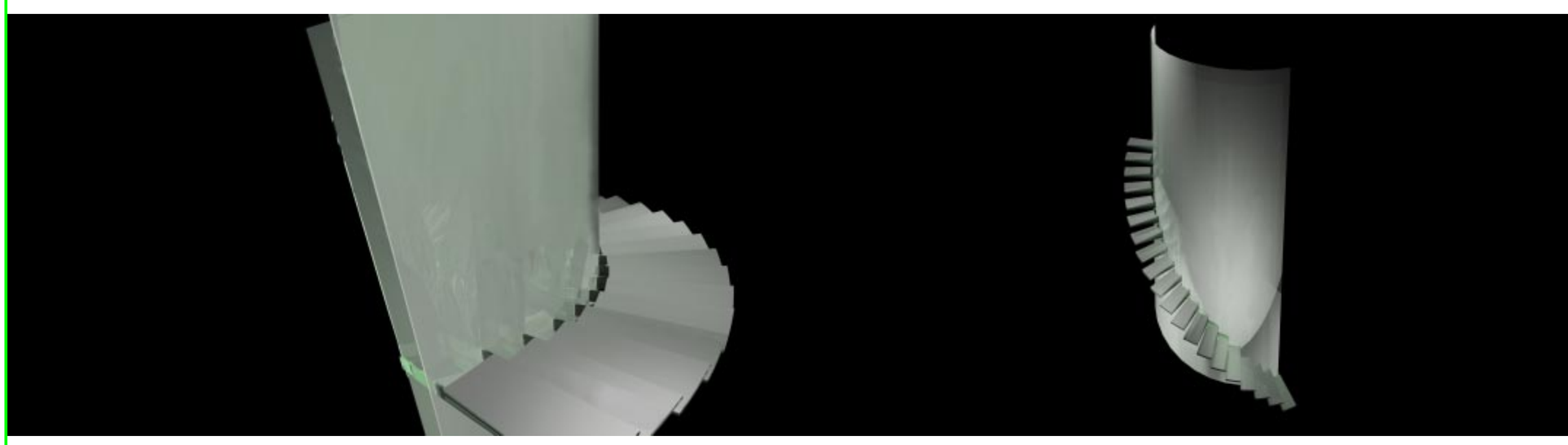






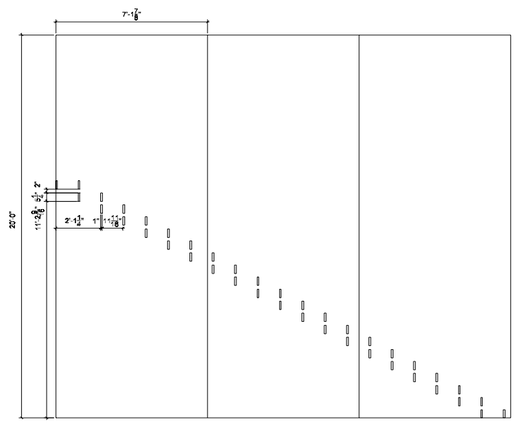
Elevation of Wall



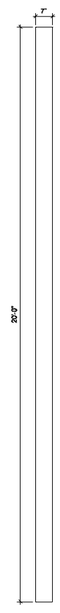


Cutting Patterns

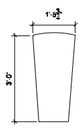
Elevation Of Translucent Wall Plys



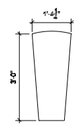
Side Elevation Of Clear Vertical Wall Fins



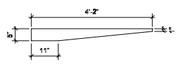
Plan Of Sandblasted Top Tread Ply

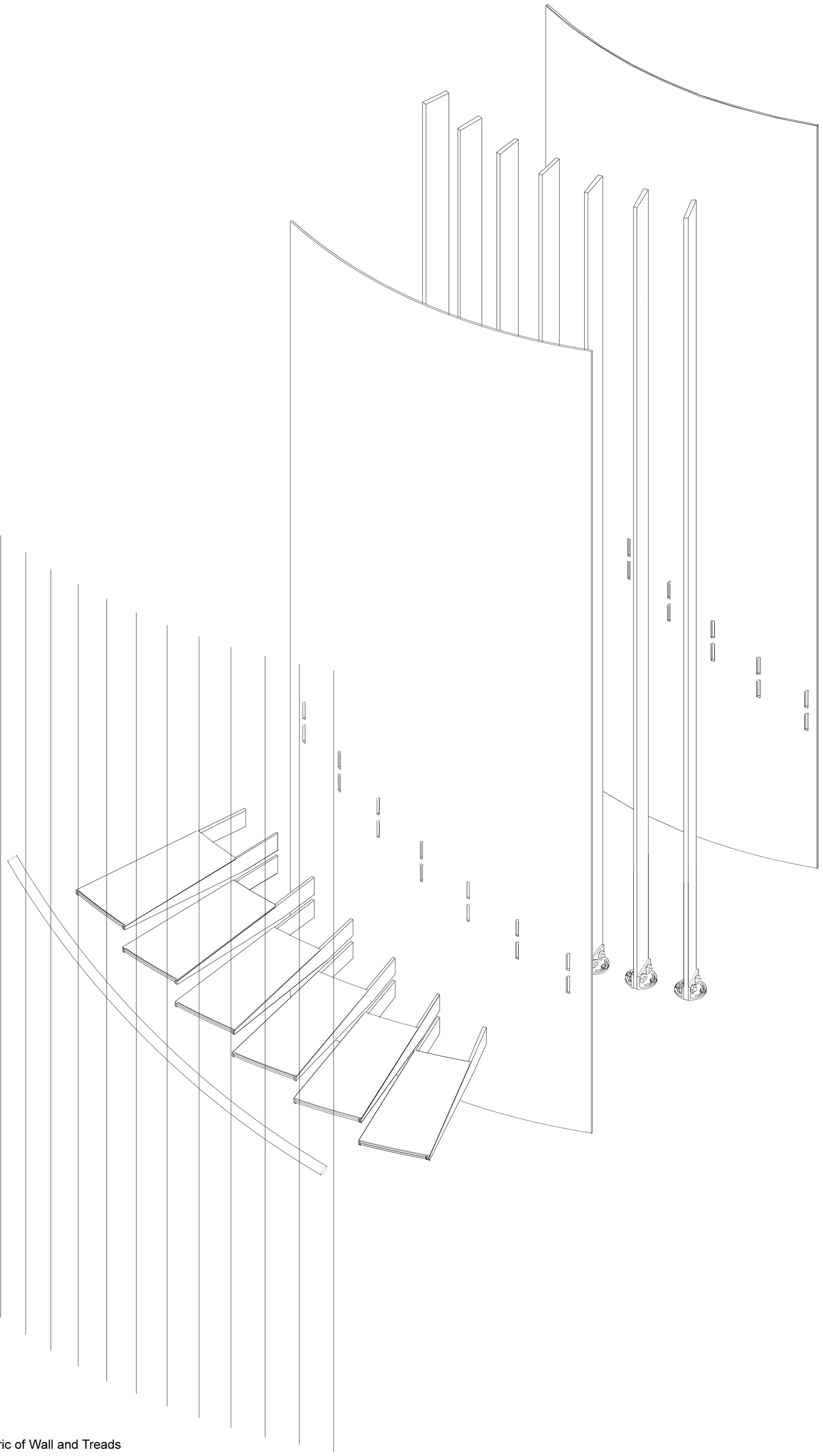


Plan Of Clear Tread Plys

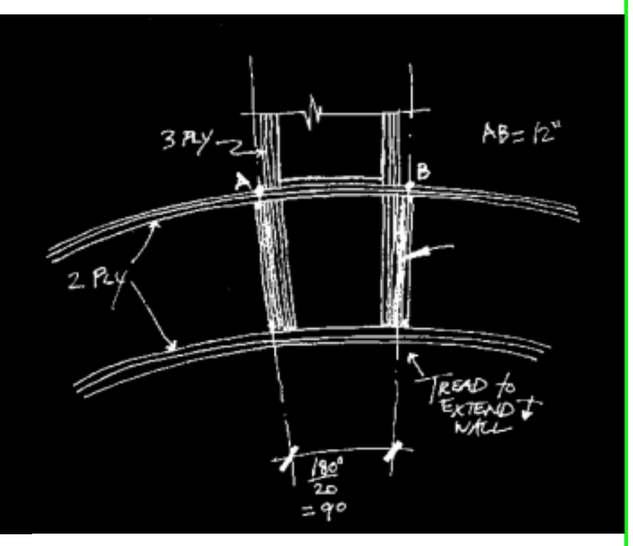


Side Elevation Of Clear Riser Fins



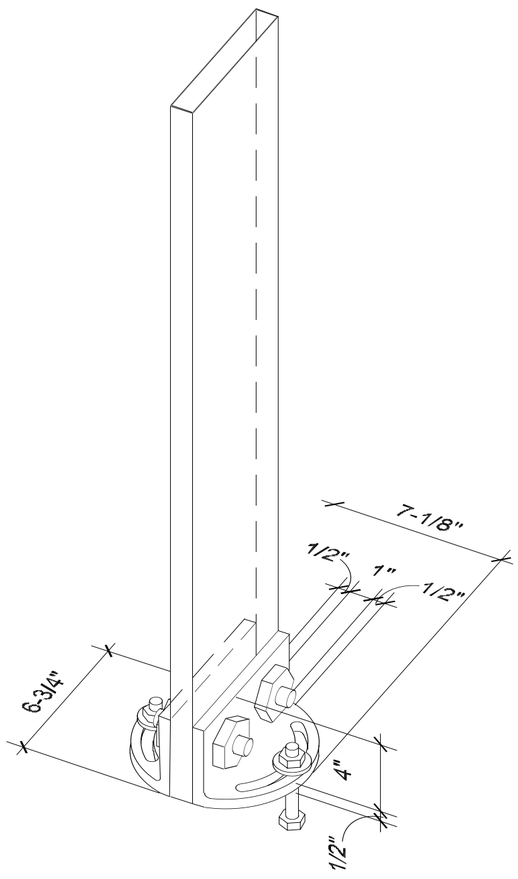


Axonometric of Wall and Treads



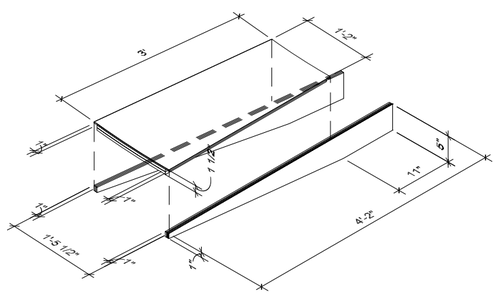
The glass stair has been designed with seven pre-fabricated components. The kit of parts is fabricated using laser cutting technology. This achieves the necessary levels of precision and accuracy which are needed for assembly. Cut with a tolerance of +/- .001 inch, the glass is then laminated to the required thickness and shipped for assembly on site.

The construction of the free-standing stair begins by bonding the horizontal riser fins to the vertical wall fins. They are adhered with Ultra Light-Weld[R] 4-20260. This is a UV activated adhesive produced by the Dymax Corporation. Metal floor connections are added at the bottom of the vertical wall fins for redundancy.



Axonometric of Metal Floor Connection

The front and rear wall panels are then slipped into position and bonded to the vertical glass fins. Finally, the treads are placed into position on top of the vertical riser fins.



Exploded Axonometric of Tread and Riser

With the completion of the assembly, the glass staircase finds its inherent stability and strength. By utilizing these properties in the design, the wall culminates in a freestanding form. Both an aesthetic lightness and immense structural strength have been achieved.

“Lightness for me
goes with precision and determination,
not vagueness and not haphazard
…I look to science to nourish my visions
in which all heaviness disappears.”

Italo Calvino
Six Memos for the Next Millenium