Cable Net Glass Walls

J.H. Conrad

Advanced Structures, Inc.

INTRODUCTION

Advanced Structures, Inc. is the leading design/build contracting company in the United States for lightweight long span curtainwalls and skylights. Our focus has been to develop an array of framing concepts that explore the possibilities for minimal structure and maximum transparency.

In this pursuit we have progressed from tensile strengthened carbon steel truss systems to combination carbon steel vertical trusses and horizontal rod or cable trusses, to full rod or cable trusses with solid member compression struts, to finally all cable net structures.

The final cable net structures have the form of single or double cable supported structures that are straight in both plan and elevation, planar but sloping vertically, and finally curved in two directions.

In practice these cable net structures are the most resilient and forgiving structures to withstand wind or blast loadings. This is due to the fact that they can deform to many times the deflection criteria that normal steel or aluminum structures without permanent deformation or failure occurring.

GLASS SUPPORT OPTIONS

There are a few options available for the connection of the glass system to the cable net structure. These are drilled glass held by spider castings that bolt to the cable clamp assemblies (see figure 1), pinch plate clamps that support the dead load of the glass on ledges within the cable clamp and restrain the glass for lateral loads by the exterior clamp and bolt assembly (see figure 2 and 3), and a unitized framing system that can be bolted to a modified cable clamp assembly (see figure 4).

The considerations for the alternatives above are price and installation tolerance. The drilled glass alternative is the highest cost and least adjustable in the field. The pinch plate is less costly, and more adjustable during installation. The final alternative is the least costly, and most adjustable. However, the unitized system has more visible framing than the other two alternatives.

CRITICAL DESIGN REQUIREMENTS

Stiffness

Cable net structures work due to the fact that they are prestressed to levels that maintain the deflection requirements for the project. This prestress loading and the ultimate design loadings must be resisted at the boundary of the cable net by building structural members that can both sustain the loads and maintain the required stiffness of the system.

In many instances we are placing this type of structure within a small portion of a new significant building structure. In that case the building framing can be used and usually only slightly strengthened to accommodate the cable net needs. However, if you have a very lightweight framing in the subject area, or no framing at one edge of the cable net, additional substantial framing will be required to be added. If this additional framing is necessary, the cost for the cable net can be significantly increased. However, in two of our structures they have opted to add a truss at an open end of the cable net, which spans between existing building structures.

Straight Nets

Many conditions can be handled by a single layer of vertical cables, that can carry the vertical and horizontal loads of the glass system. However, if the wall is taller then the cable prestress forces become prohibitive to maintain normal deflection limits. The site location and wind load requirements play a big factor in this determination. In this case we must include a second layer of horizontal cables to resist the lateral loads. The vertical cables then just carry the dead loads. (See figures 5, 6, 7, 8, and 9).

As can be seen in the two examples, different end conditions and framing are accommodated. We can also accommodate a portal framing within the cable net structure (see figure 6). This portal framing can either float with the net at the top (pinned at the base) or can be fixed at the base and designed to resist the cable net lateral forces.

Double Curved Nets

In the case of double curved applications, it is important to stress the need to be flexible in the cable net shape to the Architect (see figures 10, 11, 12, and 13). This is due to the fact that minor adjustments in the shape of the double curved net will significantly decrease the loadings in the cables, as well as enable a more uniform glass size for the project. Each opening geometry will find its own natural shape in the double curved net, allowing for uniform glass panel sizes for a majority of the wall if not for at least each level. Without this adjustment, it can be possible to require a different glass panel size for each panel in the wall. This will also significantly increase the glass costs for the job.

The geometric complexity in the double curved cable net application is significantly higher than the straight cases. This is due to the fact that the tensioning of both direction cables must be done together with the nodes attached on each cable in the correct position before tensioning begins, whereas the straight cables are tensioned at separate times and the nodes attached later. This requirement means much more analysis before the start of tensioning to determine clamp positioning, and possible detensioning and retensioning of the entire net to get correct node locations.

SUMMARY

As can be seen cable net structures enable the least obtrusive curtain wall appearance available, and a wide variety of shapes are available. While the cost is normally higher than other lightweight framing alternatives, in the right application they can provide a dramatic presentation for the building applications that can be worthwhile to the Owners.

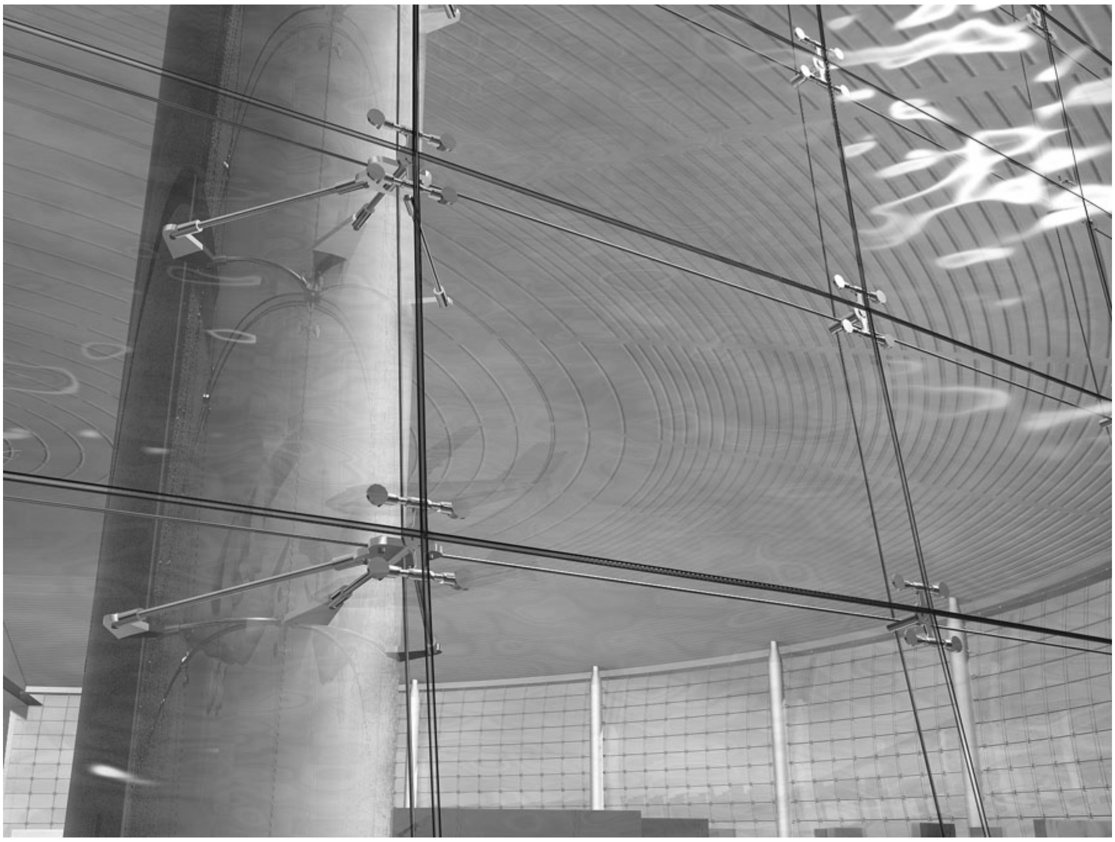

Figure 1. Cable Net – Spider Connection

Figure 2. One North Wacker Drive Node Detail

Figure 3. One North Wacker Drive Exterior View

Figure 4. Cable Net – Unitized Frame Connection

Figure 5. One North Wacker Drive Interior View

Figure 6. One North Wacker Drive End Bay with Portal

Figure 7. One North Wacker Drive Mock-Up Test

Figure 8. AOL Exterior View

Figure 9. AOL Interior View

Figure 10. Seattle Tacoma Airport Interior Elevation

Figure 11. Seattle Tacoma Airport Exterior Elevation

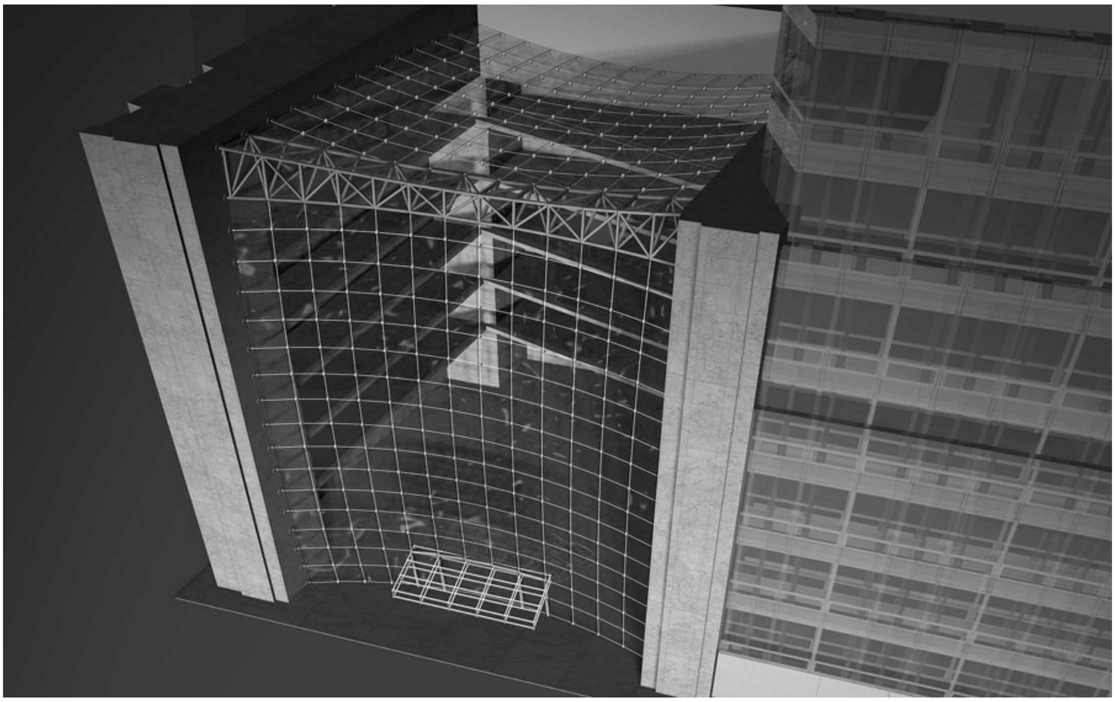

Figure 12. SEC Building Exterior View

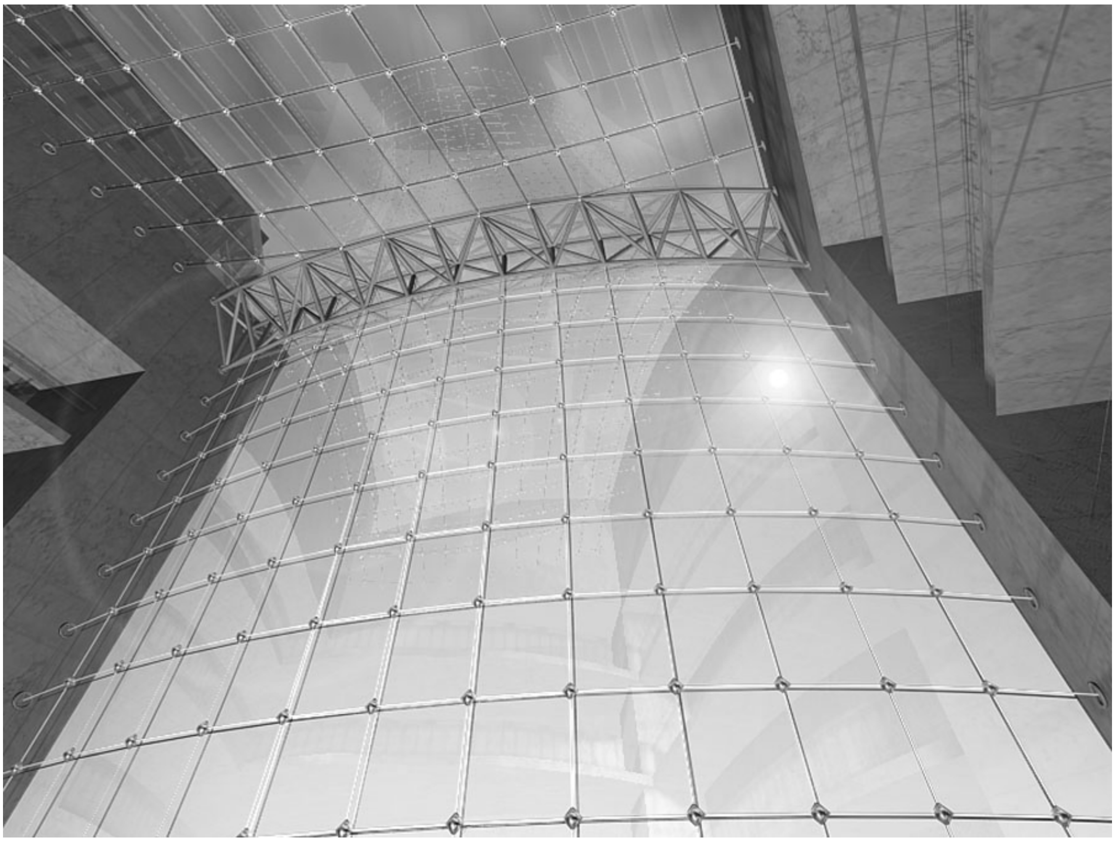

Figure 13. SEC Building Interior View