Image courtesy of Perkins&Will

ENSURING COMPLEX STEEL CONNECTIONS SATISFY STRUCTURAL CHALLENGES

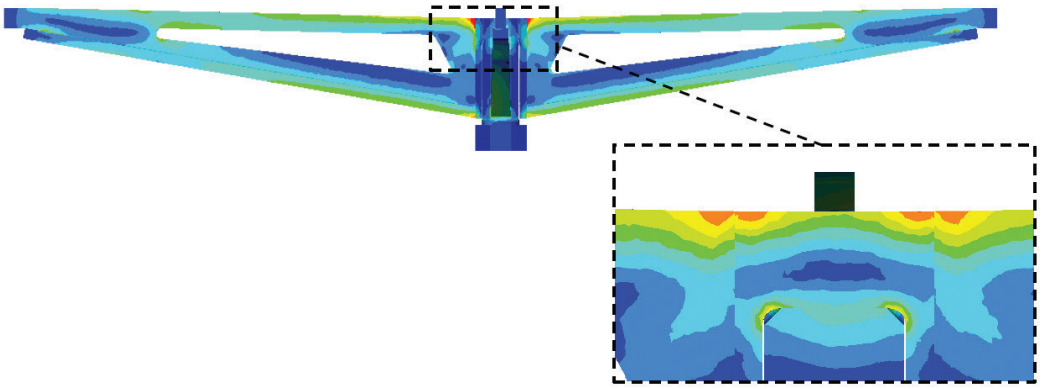
CAST CONNEX'S INNOVATIVE CONNECTION DESIGN MEETS AESTHETICS, FUNCTIONALITY, AND ASSEMBLY NEEDS

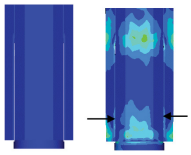
> "Advanced modeling and analysis tools that integrate preprocessing and postprocessing workflows helps Cast Connex develop and verify innovative connections.
>
> Jennifer Pazdon, VP, Cast Connex

About the Customer

Cast Connex is an industry leader in the architectural and structural design and manufacturing of cast steel connection components for buildings and bridges. Their standardized and custom-designed steel connectors are used in a diverse portfolio of architecturally challenging projects; arenas, universities, and transportation, where their innovative and often exposed steel connections both enhance building aesthetics and improve upon structural performance as compared to traditionally fabricated alternatives.

Upper Casting and Adjoining Cantilevers





LEFT: Lower assembly compression and tension, and Von Mises Stresses.
TOP: Simulating the 1.5 mm assembly gap that closes once loading is applied.
BOTTOM: Sliding assembly without need for welds or bolts.

Their Challenge

Cast Connex needed to develop a custom steel connection to transfer roof loads to supporting columns in a mass timber structure for a University of Victoria student hall* constructed from Glulam beams and columns. The innovative solution involved a central connection from which four steel arms cantilever to support the roof and transfer the loads to the mass timber columns, thus creating an exposed tree-like connection that facilitated an open-space aesthetic design. One challenge faced was designing the two steel connection parts at extremely tight tolerances enabling them to slide together for assembly at the construction site without the need for welds or fasteners. This assembly required a small gap (~1.5 mm) between the vertical faces of the two connecting castings to enable assembly, which would close once the roof loads were applied. The resulting deflections and stresses induced at the cantilevered arm tips could not exceed allowable limits.

Our Solution

To ensure the cast components could be smoothly assembled on-site, and the roof loads effectively close the gap between the sliding connection, Cast Connex simulated the cast elements and the assembled cantilevered sections to confirm the deflections of the central connection assembly, the maximum deflections experienced by the cantilevered arm tips, and the overall strength and stability of assembled steel connector. FEA (Finite Element Analysis) models were developed for the upper and lower castings and assembly using Altair® HyperWorks® to predict the resultant stresses and displacements. All components were meshed with first-order tetrahedral elements in Altair® HyperMesh®; fixed contacts were used to model welds, and compression-only contacts (which allow separation) were needed between the two connecting arms. Altair® OptiStruct® was used to perform second-order geometry, non-linear material, quasi-static analyses.

Due to the small gap (~1.5 mm) between the vertical faces of the two castings, there is a change in stiffness in the upper casting cantilever that occurs when that gap is closed. Analysis results showed a 7 mm additional displacement for the upper casting assembly, compared to the lower arm tip's displacement. Once the gap is closed (which occurs at around half of the service load), the stiffness of the two cantilevers is shown to be virtually identical.

Results

The results for the ULS (Ultimate Limit State) generated from OptiStruct showed that all components in the analyses remained elastic, and the principal tension was well below the ultimate stress of the materials, indicating that the castings possessed sufficient strength under ULS loads. Cast Connex conceived of the idea of the top and bottom assemblies sliding together such that each unit could be shipped to site flat packed to allow for ease of transport. Simulation of relative movement of the assembly utilizing the cast steel components confirmed this creative approach would be successful when implemented in the field.

To learn more, please visit altair.com/structural-engineering

* In addition to the Altair solutions mentioned, Cast Connex would like to acknowledge their partners in this project: Architects: Perkins&Will, Structural Engineer: Fast + Epp, General Contractor: EllisDon-Kinetica, and Steel Fabricator: George Third and Son.