Exposed structural steel features prominently in the employee-friendly headquarters of ADC Telecommunications in Eden Prairie, MN.

HIGH-TECH HOME BASE

Daniel Grant, P.E., and Mark Hoel, P.E.

The world headquarters building for ADC Telecommunications was bound to be a little different. These are, after all, the folks that call themselves "The Broadband Company," a high tech manufacturer with a giant claim in both the past and future of electronic communications. Their new world headquarters in Eden Prairie, MN, would have to somehow reflect the mind and mission of this global supplier of equipment and software, whose annual sales exceeded $3.3 billion in year 2000.

The architects at HGA sought a structural program that would synthesize a number of potentially disparate design concepts. They wanted a humanized work environment with a scale that would be immediately familiar and comfortable to the occupants. Further, they wanted to identify with the technical, systems-oriented nature of the client's work by exposing the systems within the building to view. Structural, HVAC, plumbing and electrical components would be left exposed as often as possible in order to illustrate the interrelationships between them, as well as develop a sense of hierarchy and completion. Clarity and definition were also highly valued and informed many architectural and engineering design decisions.

ARCHITECTURAL CONSIDERATIONS

The exposed structure became an essential element of the architectural program. The structural engineers worked closely with the architects and model builders as various concepts were explored. In order to clearly define the workspaces as separate zones within the building, the team chose to pull the columns out of the exterior wall and move them 6′ to the interior. This exposed line of columns set off the work areas and created a corridor between the work area and the exterior wall. The 44′ wide work bay is also enclosed on the interior side by an identical line of columns, separating it from a central atrium area that runs the length of the office space. This organization can be seen most clearly in the building section. The architects also sought to create a particular structural form that would clearly identify the work areas within the building.

There were several framing issues that needed to be solved in the process of creating this unique form. The separation of the exterior wall from the exterior column line created the need for some type of cantilevered element to support both the exterior wall and the floor framing for the corridor space. The architects wanted to mirror this cantilevered walkway condition on the interior side of the office bay as well, projecting into the central atrium. Another notable complication was the requirement of recessed access flooring. This recessed area was to be strictly limited to the work bay between the columns. The framing for the corridor outboard of the column lines would have to be raised back up to the finish floor elevation.

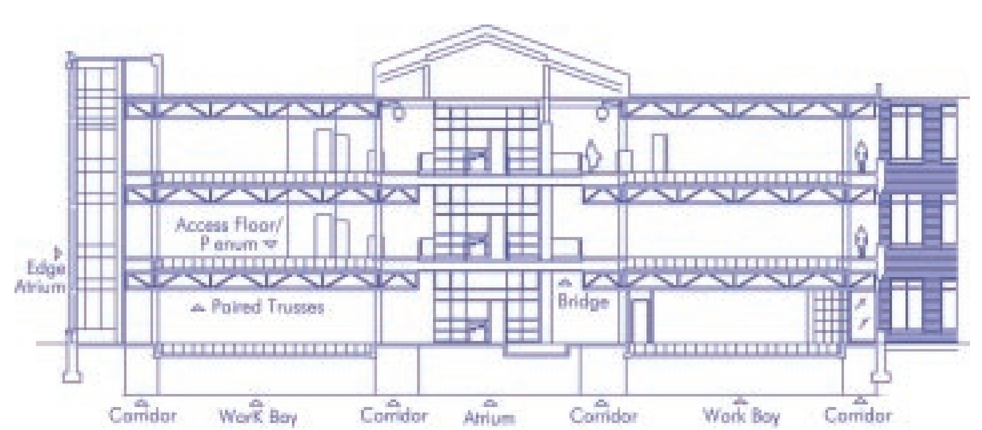
The team's solution was to create pairs of custom-fabricated truss girders at each column line. The trusses are offset to either side of the column, such that the girders cantilever cleanly past to pick up corridors, exterior walls and framing from the atriums. The typical purlins between the trusses are W14×22 beams, crossing the 25′ bay, with W24×55 beams employed to frame the drop for the access floor areas. In this manner, a regular and disciplined hierarchy of members was created. Each particular size and shape is used for only one particular purpose, and the flow of forces is readily apparent even to the non-engineer.

RAM Structural System software was used to perform the design of steel members under gravity load. The program sized beams and columns, and the sizes were exported directly to AutoCAD as often as possible. While the trusses were also included in the RAM model in order to produce accurate results, it was necessary to use RISA 3D for the actual design of the trusses, which is discussed below.

With the work areas defined, the central atrium began to take shape. The program called for use of the atrium space for conference rooms, bathrooms and vending areas. These service areas were to be housed in seemingly free-standing elements within the atrium space, accessed by bridges. These bridges also allow traffic across the atrium between work areas. The architects wanted the exposed steel framing in this central core atrium to be of uniform depth, in order to have it appear as a "band" running around the edge of the walkways and enclosed areas. This led to an interesting search for the best trade-off between uniform sizing and overall tonnage for the atrium areas. The ability of the RAM software to do a takeoff on the various schemes was very useful for this study. W14 beams eventually proved to be the best choice for the given geometry and loading. An exception was made for the bridges crossing the 48′ wide atrium, where W24 beams had to be used to satisfy vibration criteria.

The buildings on the headquarters campus were limited to three stories above grade with an occupied basement below most of the footprint. The module described was used as a building block. In plan, the blocks were arranged in a non-orthogonal pattern, creating some diversion and interest to the long sight lines available within the building itself. Because of the many openings, atriums and corners in the building plan, there was not an easy way to link all of the separate areas together as a single diaphragm for lateral load carrying purposes. This difficulty was recognized early in the conceptual stage, and exposed bracing was worked into the plan at the outset. Each work area has its own exposed system of lateral braces. Placed at the ends of the work areas, the braces are

Steel frame for exterior canopy.



Building section showing central atrium flanked by work bays.

Custom-fabricated truss girders are located on each side of the column line.

Edge atrium, located adjacent to a work bay.

"C" shaped in plan. Exposed HSS shapes were chosen for economy and aesthetics and as a clear expression of the lateral system of the building in keeping with the architectural vision. Struts crossing the atrium were employed to connect the work bays together and limit differential movements.

It is also worth noting that a significant portion of the exposed steel structural framing and composite floor assembly and roof deck were protected with an enhanced fire sprinkler system in lieu of more traditional passive fire rated construction. The fire protection and building-code consulting firm, The MountainStar Group, Bloomington, MN, prepared a performance based fire safety design to satisfy the intent of the fire resistive construction provisions of the Uniform Building Code. Fire engineering calculations performed for defined fire scenarios demonstrated structural integrity is maintained using this non-traditional approach. A series of sprinkler systems were provided throughout the building with specific system redundancy and at a hazard design density above normal risk levels. Carefully positioned quick response sprinklers with specific positioning and flow characteristics protected both the floor spaces, floor and roof assemblies and the main structural-framing members, allowing the beams, trusses, columns and composite decks to remain exposed to view.

ENGINEERING ISSUES

The most interesting technical issues on this project related to the design of the custom fabricated HSS trusses. There were over 700 individual trusses on the job, creating the opportunity for economies of scale. The designers consulted the AISC *HSS Connections Manual* and Packer and Henderson's book, *Hollow Structural Section Connections and Trusses*, extensively.

Direct welded connections were employed throughout, which yielded labor savings in the shop and eliminated unattractive gusset plates. A modified Warren truss geometry was selected, minimizing the number of connections and opening the truss up for mechanical systems to pass through. A typical truss consisted of 6×6 chord members and 4×4 web (or branch) members. Vertical members were required at purlin connection locations and at the truss connection to the column. The verticals selected were 5x3 members, with the 5" dimension perpendicular to the truss axis. A 6×3 vertical member, which would have had faces flush with the outside faces of the chord, would have eliminated some fit up work in the tab plates (for the purlin connection) but would also have necessitated more expensive welds and finish grinding. The geometry of the trusses was such that gapped connections were possible everywhere, even with the vertical web member fitted between the sloping web members.

The design of direct welded HSS trusses follows a somewhat different sequence of steps than trusses constructed out of wide flanges or using gusset plates at the connections. Because the capacity of the connections is dependent upon the wall thickness of the members being joined, the design of the connections becomes an integral part of member sizing. Also, in order to achieve the desired gap between the branches, the work point must often be shifted away from the central axis of the chord. There is a permissible range of these connection eccentricities for which the design criteria in the manuals are applicable, but the truss model must in the end be modified to include them. In our designs, the secondary moments from these eccentricities seldom, if ever, effected member sizes. Wall thicknesses of the chords were increased during the connection design step such that the secondary moments generated in the revised truss models did not require any further increase in member size. RISA 3D was used for the truss designs as well as design of the lateral braces on the project.

The fabricator, LeJeune Steel Company, performed design of the weldments for the HSS to HSS truss connections. Procedures are given for the weld design in the *HSS Connections Manual*, as well as AWS D1.1. It was necessary for the design engineers to provide the fabricator with detailed geometry at the nodes, as well as the member forces. While the goal of gapped, direct welded HSS truss connections is to use fillet welds all around the branches, the steep angle between branch and chord in our trusses did not permit fillets at the toe and heel of the branch. Instead, these welds are prequalified and were detailed as partial penetration welds. The fabricator sectioned mock-ups of critical joints in order to demonstrate that the required weld throat was being provided.

The truss to column connection was perhaps the most unusual condition on the project. The columns were designed for moments due to unbalanced eccentric loads from the trusses. The connection would need to cantilever out to pick up the truss as near to the truss centerline as possible, provide for installation tolerances, and also permit in-plane rotation of the truss at the support. Rotational fixity at the support was ruled unacceptable, because it would have placed either high torsional moment or high rotational ductility demands on the connection, neither of which could be solved satisfactorily. It was also essential that the connection be field bolted, both for the erection schedule and the project budget. The fabricator and engineer worked together closely on the problem and eventually arrived at a wide flange bracket with an end plate. The truss would receive a "side plate," which was then bolted to the end plate on the bracket in the field. This minimized the out of plane demands on the truss while permitting some in-plane rotation at the connection. In order to promote slip between the faces of the plates, they were specified to be painted, and the bolts were installed to the snug tight condition.

The cantilevers on either end of the trusses put the bottom chord of the truss in compression over a portion of its length. Because of this, the bottom chords required some sort of bracing to limit the unbraced length of the chord. In addition, the trusses are essentially loaded on one face only by the purlins and supported on the opposite face by the columns, placing additional lateral loads on the chords through torsion. Cross braces between the trusses at the quarter points were sufficient to alleviate these two issues.

The ADC World Headquarters project presented an exciting opportunity to the structural engineers to see their work integrated as a vital part of the architecture and experience of the building. It was necessary for the team to work together in order to solve design issues and achieve what was conceived by the architects. Both architect and engineer had to be flexible and willing to explore unusual ideas. The collaborative, multi-disciplinary environment at HGA was the perfect catalyst for this innovative project. In addition, the contractor, fabricator and erector made invaluable and essential contributions through their participation on the team at every phase of the project. Perhaps most gratifying of all has been the response of the client, ADC, now enjoying its new home.

Daniel Grant, P.E., is Project Structural Engineer, and Mark Hoel, P.E., is Associate Vice President with Hammel Green and Abrahamson, Inc., in Minneapolis, MN.

OWNER
ADC Telecommunications,
Eden Prairie, MN

STRUCTURAL ENGINEER
Hammel Green and Abrahamson, Inc.,
Minneapolis, MN

ARCHITECT
Hammel Green and Abrahamson, Inc.,
Minneapolis, MN

STEEL FABRICATOR/DETAILER
LeJeune Steel Company,
Minneapolis, MN (AISC member)

GENERAL CONTRACTOR
Kraus-Anderson Construction
Company, Minneapolis, MN

SOFTWARE
RAM Structural System, RISA 3D

Photography by George Heinrich
Photography, Minneapolis, MN