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Raising Expectations

BY MICHAEL ROACH, P.E.

New design freedom for architects and engineers, and a growth opportunity for steel joist manufacturers.

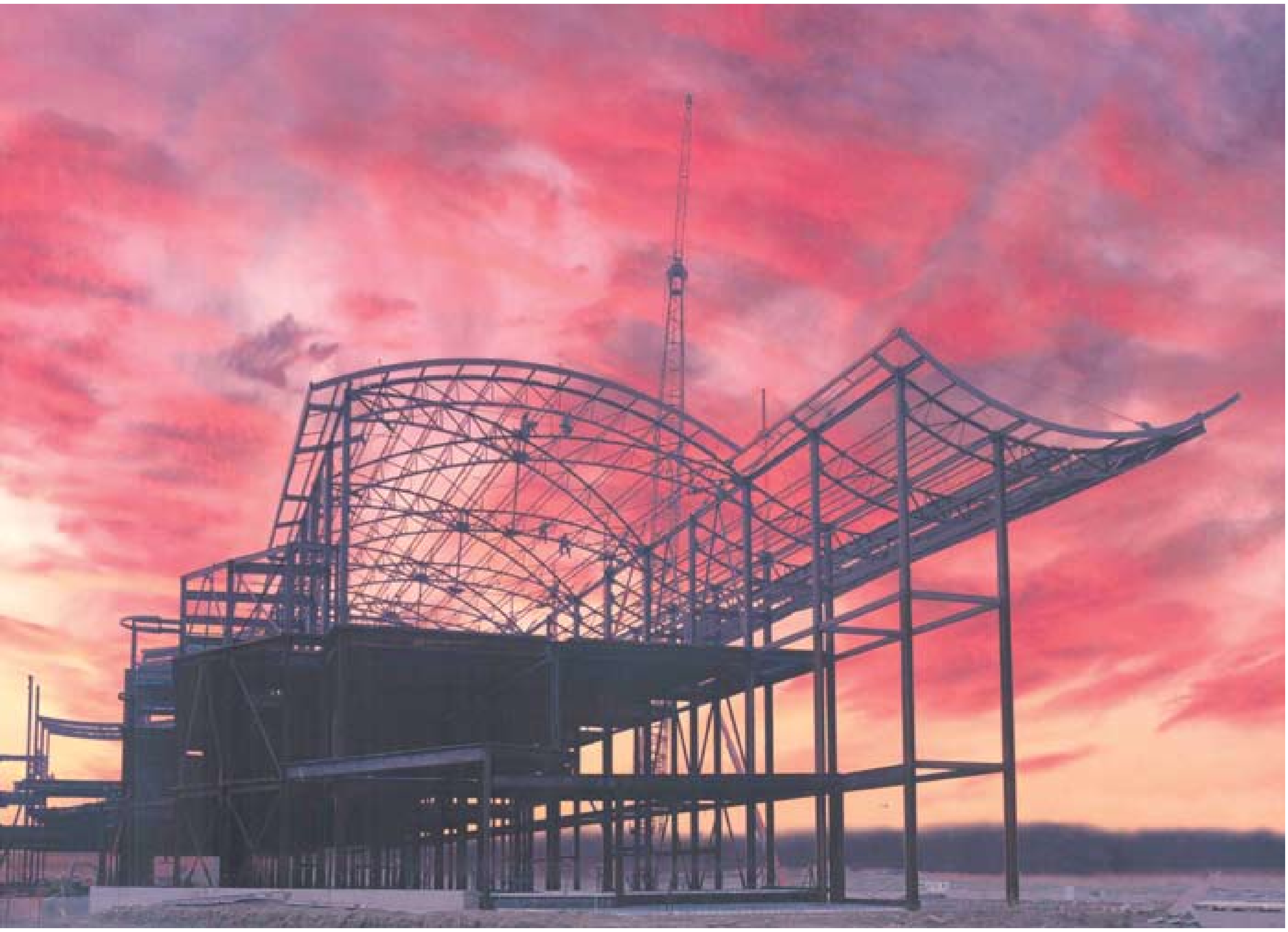
TWO YEARS AGO, when engineers at New Millennium began developing a new architecturally oriented steel joist catalog, we thought it would be straightforward enough. By expanding the engineering specifications for gable, bowstring, scissor, and arch type steel joists, we believed architects could more readily achieve their most creative roofline designs using steel joists rather than alternative structural materials.

Thousands of engineering hours later, and after seemingly countless rounds of calculations and validations, the catalog became a reality. It wasn't so straightforward a task after all, but the purpose of the project has stayed the same. Using this specialty catalog, professionals have the creative freedom to specify special profile steel joists with the confidence of a design specification written with this purpose in mind. Hundreds of architects, engineers and fabricators have asked for the new catalog, and while we hope the catalog will benefit our business, the fact is that no joist company can own an engineering specification.

In the long run, and looking at the big picture, what's good for the steel industry is good for all of us. The opportunity fabricators have, once they recognize a simple truth regarding architectural roofline designs, is this: Specifying professionals need to be shown what is possible with steel joists, and how to open up and explore the possibilities.

Architectural schools for years have been teaching cost-accountable design. As a result, early conceptual sketches of novel roofline designs are soon tempered by engineering and fiscal realities.

Early in the design process, an architect will look to a structural engineer for a reality check. In turn, the engineer



Both pages: Steel joist design possibilities are endless when you consider various joist profiles, loadings and applications. These possibilities rise from four distinct joist profiles: gable, bowstring, scissor, and arch. An architect's vision often can be cost-effectively met during the early design stage of a project, based on one of these four types, a variation of one type, or a combination of types.

will look to the specification tables of various suppliers (perhaps not just steel, but other materials as well) to assess the concept's feasibility and cost. These specification tables are very likely the same tables used in the past, mostly because the engineer is familiar with them.

Moreover, there are bigger reasons an engineer will look to the tables. Straying from well-worn specification tables may seem risky. And given the fact that so many incomplete structural drawings are being handed down to fabricators, it is clear that fewer structural engineers are in a position to push the design envelope.

Whether for reasons of reduced engineering fees and fewer funded design-engineering hours, the tendency is to be creative only so long as creativity stays within the boundaries of a familiar, tried-and-true set of structural specification tables.

Enter into the design process an opportunity for fabricators to show architects and engineers greater design possibilities using steel joists. The new catalog includes more than 40,000 special profile steel joist designs—more than 10,000 designs for each profile. The tables include a wide variety of possible geometries for spans from 10 ft to 150 ft and include guidance on design considerations such as load, span, seat depth, bridging, and horizontal deflection. Whether for aesthetic architectural reasons or to help owners and developers reduce project cost, the specialty catalog offers a breadth of tools upon which fabricators may capitalize.

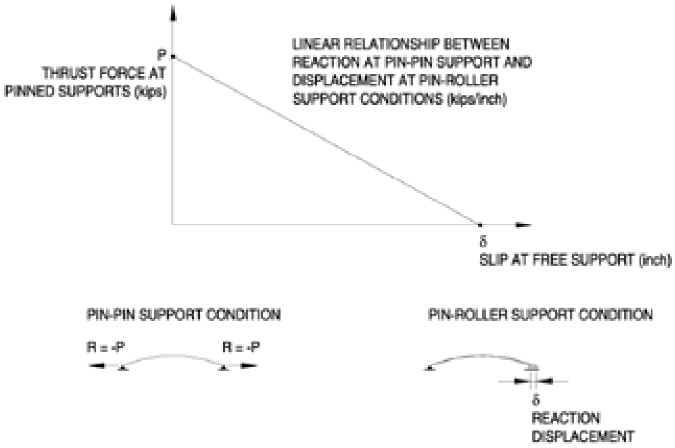
Accounting for Additional Stress

In the process of writing an expanded specification for special profile joist designs, we addressed several engineering problems that have long been neglected in the realm of published technical documents pertaining to steel joist design.

One of these issues is in regard to rolled chords. At the core of any structural analysis package is a stiffness matrix created in the modeling of the structure (e.g. truss, joist, girder, etc.) The matrix mathematically represents the stiffness properties of the structure being analyzed. All of the node-to-node forces occur along a straight-line, or node-to-node, distance.

Joists with rolled chords are therefore analyzed as joists with multi-pitched chords, where the web-to-chord location is correct but between the chord nodes there is a divergence of the linear element from the actual rolled structural element

Michael Roach, P.E., is an engineering manager with New Millennium Building Systems, Lake City, Fla. Rivers Claytor, Michael Winarta and Carl Pugh assisted in developing the company's new Special Profile Steel Joist Catalog. *You can reach Michael Roach at* ***michael.roach@newmill.com****.*



The new catalog includes text and illustrations providing guidance on design considerations such as load, span, seat depth, bridging, and horizontal deflection (shown here). graphic by: New Millennium Building Systems

(usually a pair of angles). The forces created by this condition may be visualized by imagining the forces that exist in an archer's bow. The compression in the bow is balanced by the tension in the string, but within the bow there is a secondary bending stress that occurs due to the divergence of the member from the line of force in the string. A similar condition exists between every panel point of a truss with rolled chords members. In the New Millennium Standard Specification, SP-Series, this stress condition was given the term "divergence stress" and added as a component to be included in the design of rolled chord elements.

Another structural condition that we frequently design for is that of a pitched or rolled bottom chord and a pin-roller truss anchorage condition. Such conditions require close coordination between the engineer of record and the joist engineer. Our special profile joist catalog specification provides a more thorough discussion of this topic than previously available.

The key concept that both the specifying engineer and the joist engineer should remember is that if the joist anchorage at each end is fixed by means of welding or slip-critical bolting, the horizontal displacement present in the structure is a function of the combined stiffness of the joists and the supporting structure along the direction of horizontal thrust or slip.

If the engineer of record requests that there be very little slip, there must be a mechanism in place to resist the thrust forces. The most common means of achieving this is by means of a tension tie. This mechanism effectively turns the entire joist (as fabricated) into a built-up top chord element, and the tie provides the tension. In this manner, the effective depth of the section becomes very large, and the resulting bending forces required to generate the bending moment are greatly reduced. Subsequently, the design may be more efficient and more economical.

Innovation Before Standardization

In the history of our industry, non-standard design has always been at the discretion of the manufacturer, well before such innovations have been refined and accepted as common practice. So it has been with the adoption of higher strength steels, the use of expanded standard joist load tables into longer and deeper products, the creation of custom designs using computer technology, the use of joist girder products as economical replacements for rolled beams, along with joist substitutes and composite joists.

Industry leaders establish standards by way of innovation, so that the innovations of today become standards for tomorrow. With the *Special Profile Steel Joist Catalog*, architects, engineers, and fabricators have an opportunity to prove this yet again. MSC