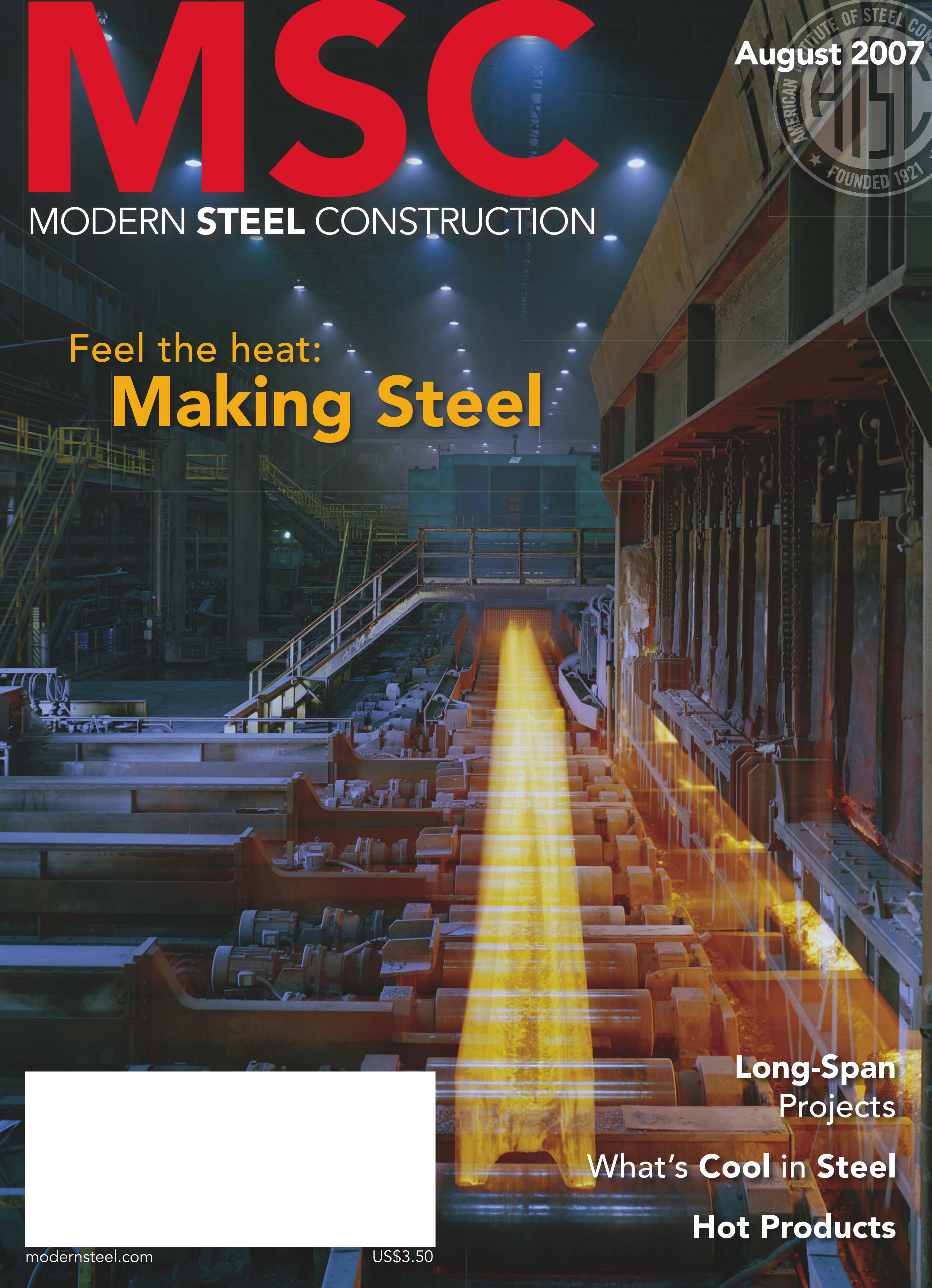
MSC

MODERN **STEEL** CONSTRUCTION

August 2007



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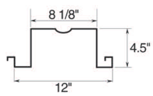
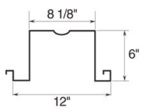
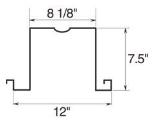
LS4.5



LS6



LS7.5



DEPTH TYPE	GAGE	Wt. psf	I_p in.^{4}	S_p in.^{3}	S_n in.^{3}	ASD V lbs.	ASD R_1 lbs.	ASD R_2 lbs.	ASD R_3 lbs.	LRFD ϕV lbs.	LRFD ϕR_1 lbs.	LRFD ϕR_2 lbs.	LRFD ϕR_3 lbs.
LS4.5	16	5.2	4.82	1.96	1.99	6250	1140	1305	1495	9390	1585	1810	2075
	14	6.5	6.01	2.47	2.47	7990	1950	2135	2380	11980	2705	2960	3305
	12	9.0	8.39	3.42	3.42	11100	4125	4430	4740	16655	5725	6150	6575
	10	11.6	10.82	4.26	4.26	14170	7040	7470	7900	21255	9770	10365	10960
LS6	16	5.8	9.44	2.94	2.98	6250	1080	1235	1415	9390	1500	1715	1965
	14	7.2	11.77	3.71	3.71	9750	1870	2045	2285	14655	2590	2840	3170
	12	10.1	16.44	5.14	5.14	15245	4010	4305	4605	22865	5560	5975	6385
	10	13.0	21.09	6.54	6.54	19495	6890	7310	7725	29245	9560	10140	10720
LS7.5	16	6.4	15.94	4.02	4.05	5170	1020	1165	1335	7770	1420	1620	1855
	14	8.0	19.87	5.07	5.07	9750	1790	1960	2190	14655	2480	2720	3035
	12	11.2	27.75	7.03	7.03	19120	3890	4180	4470	28740	5400	5800	6200
	10	14.4	35.59	8.96	8.96	24820	6735	7145	7555	37230	9345	9915	10480

SINGLE SPAN CONDITION, Uniform Total Load / Load that Produces l/240 Deflection, psf

TYPE		GAGE	12'	13'	14'	15'	16'	17'	18'	19'	20'	21'	22'	23'	24'	25'	26'
ASD	LS4.5	16	181/183	155/144	133/115	116/94	102/77	90/64	81/54	72/46	65/40	59/34	54/30	49/26	45/23	42/20	39/18
		14	229/228	195/180	168/144	146/117	129/96	114/80	102/68	91/58	82/49	75/43	68/37	62/32	57/29	53/25	49/22
		12	317/319	270/251	233/201	203/163	178/134	158/112	141/94	126/80	114/69	103/59	94/52	86/45	79/40	73/35	67/31
		10	394/411	336/323	290/259	252/211	222/173	197/145	175/122	157/104	142/89	129/77	117/67	107/58	99/51	91/45	84/40
LRFD	LS4.5	16	264/183	242/144	209/115	182/94	160/77	142/64	126/54	113/46	102/40	93/34	85/30	77/26	71/23	66/20	61/18
		14	358/228	305/180	263/144	229/117	202/96	179/80	159/68	143/58	129/49	117/43	107/37	98/32	90/29	83/25	76/22
		12	496/319	423/251	365/201	318/163	279/134	247/112	221/94	198/80	179/69	162/59	148/52	135/45	124/40	114/35	106/31
		10	618/411	527/323	454/259	396/211	348/173	308/145	275/122	247/104	223/89	202/77	184/67	168/58	155/51	142/45	132/40

SINGLE SPAN CONDITION, Uniform Total Load / Load that Produces l/240 Deflection, psf

TYPE		GAGE	20'	21'	22'	23'	24'	25'	26'	27'	28'	29'	30'	31'	32'	33'	34'
ASD	LS6	16	98/77	89/67	81/58	74/51	68/45	63/40	58/35	54/31	50/28	47/25	44/23	41/21	38/19	36/17	34/16
		14	124/97	112/83	102/73	94/64	86/56	79/49	73/44	68/39	63/35	59/32	55/29	51/26	48/24	45/22	43/20
		12	171/135	155/117	142/101	130/89	119/78	110/69	101/61	94/55	87/49	81/44	76/40	71/36	67/33	63/30	59/27
		10	218/173	198/150	180/130	165/114	151/100	140/89	129/79	120/70	111/63	104/57	97/51	91/46	85/42	80/39	75/35
LRFD	LS6	16	150/77	139/67	127/58	116/51	107/45	98/40	91/35	84/31	78/28	73/25	68/23	64/21	60/19	56/17	53/16
		14	194/97	176/83	160/73	147/64	135/56	124/49	115/44	106/39	99/35	92/32	86/29	81/26	76/24	71/22	67/20
		12	269/135	244/117	222/101	203/89	187/78	172/69	159/61	147/55	137/49	128/44	119/40	112/36	105/33	99/30	93/27
		10	342/173	310/150	282/130	258/114	237/100	219/89	202/79	187/70	174/63	163/57	152/51	142/46	133/42	126/39	118/35
ASD	LS7.5	16	102/131	97/113	93/98	89/86	85/76	82/67	78/60	74/53	68/48	64/43	60/39	56/35	52/32	49/29	46/27
		14	169/163	153/141	140/123	128/107	117/94	108/83	100/74	93/66	86/59	80/53	75/48	70/44	66/40	62/36	58/33
		12	234/228	213/197	194/171	177/150	163/132	150/117	139/104	129/93	120/83	111/75	104/67	98/61	92/56	86/51	81/46
		10	299/292	271/252	247/219	226/192	207/169	191/150	177/133	164/119	152/106	142/96	133/87	124/78	117/71	110/65	103/59
LRFD	LS7.5	16	142/131	135/113	129/98	123/86	118/76	114/67	109/60	105/53	101/48	98/43	93/39	87/35	82/32	77/29	73/27
		14	248/163	236/141	219/123	200/107	184/94	170/83	157/74	145/66	135/59	126/53	118/48	110/44	103/40	97/36	92/33
		12	367/228	333/197	304/171	278/150	255/132	235/117	217/104	202/93	187/83	175/75	163/67	153/61	143/56	135/51	127/46
		10	468/292	425/252	387/219	354/192	325/169	300/150	277/133	257/119	239/106	223/96	208/87	195/78	183/71	172/65	162/59

1. Tables show stress load/deflection load. Deflection is limited to L/240. Loads controlled by bending are shown in ***bold italics.*** The bearing width, R_1 = 3" controls all others. R_2 = 4" bearing; R_3 = 5" bearing. R_1 through R_3 are exterior one flange loading web crippling capacities in PLF.
2. Section properties and load values are based on a yield stress of 33 ksi. Properties are per ft. width.

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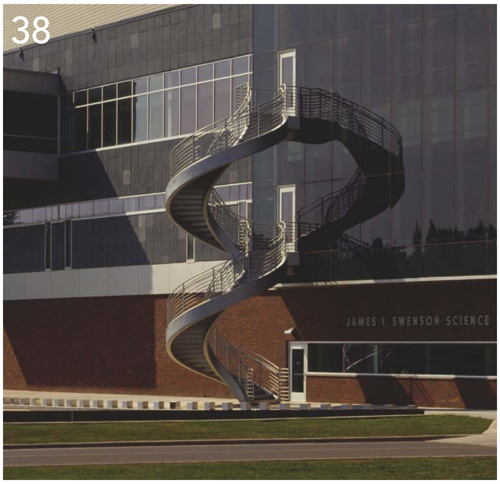

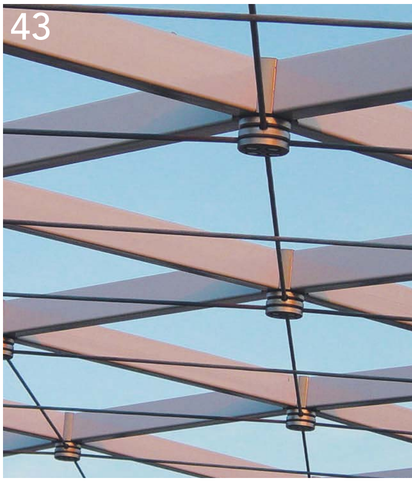

ON THE COVER: Inside the Nucor-Yamato Steel Co. plant outside Blytheville, Ark. Photo by Tim Hursley.

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editor's note

ONE OF MY MOST VIVID MEMORIES FROM CHILDHOOD IS PLAYING HIDE-AND-SEEK AT MY FATHER'S SHOP. He was a subcontractor (doors, frames, and hardware) and his storage building included rows and rows of hollow metal frames—perfect tunnels for kids to run through and hide in.

My dad's company, Sanflo (named for my mom and my dad's original partner's wife), was a successful, vibrant, and growing company for more than two decades. But none of my siblings were interested in going into the business, and when my father's health slipped, the business went under. As with too many family businesses, there was no management succession plan in place. A recent survey by FMI Corporation (if you're not familiar with them, FMI is one of the leading contractor and construction industry consulting firms) reports that 24% of all contractors expect to no longer be active in their business in less than five years—yet 30% are not ready to transfer ownership and another 20% are unsure or unaware of techniques for transferring ownership. According to Hugh Rice, chairman of FMI, "Many owners simply do not understand how difficult it can be to manage a successful internal transfer. Transferring internally can take eight to 10 years and is not an easy proposition."

Rice offers five key components to ownership transfer and succession management:

1. Defining objectives and parameters of the plan
2. Valuing the business
3. Exploring and selecting appropriate ownership transfer techniques
4. Understanding and addressing management succession issues
5. Implementation and follow-through

Of course, management transfer isn't the only key workplace issue facing the fabrication community today. In response, this year's AISC Annual Meeting is focusing on this area. The Annual Meeting is a networking and educational opportunity open to all AISC members, but is primarily targeted to fabricators, service centers, mills, detailers, and suppliers.

The meeting is at the Red Rock Resort Casino and Spa in Las Vegas (visit **www.aisc.org/annualmeeting** for more information) and will focus on a wide range of critical issues, including:

- Andrew Patron from FMI discussing "Attracting and Retaining a Quality Workforce"
- Patrick L. Cont from Sturm & Cont on "Immigration Reform and the Fabrication Industry"
- Author and Consultant Cam Marston on "Realities of the New Age Workforce"
- Wayne Rivers from the Family Business Institute on "Ownership Transition".

These issues affect all of us and are critical for the future success of the steel construction industry. In addition to these presentations, there are several formal and informal networking opportunities. The meeting is being held October 4-6 and provides an intriguing counterpoint to AISC's annual Steel Conference. While the latter is the industry's premier event and includes an enticing smorgasbord of technical sessions plus an ever-growing exhibit hall, the fall meeting is much smaller, focused on specific topics, and offers great opportunity for relationship building.

If you're intrigued, visit **www.aisc.org/annualmeeting** to register. Hope to see you in Las Vegas!

SCOTT MELNICK
EDITOR

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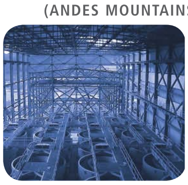
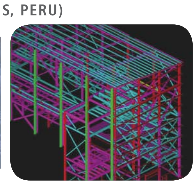
SDS/2 DESIGN DATA

CONNECTING STEEL ACROSS THE GLOBE.

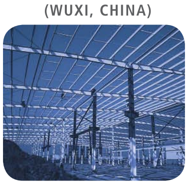
>>> SPLASH DOWN DUNES WATER PARK (NASHVILLE, TENNESSEE)

>>> ANTAMINA COPPER MINE (ANDES MOUNTAINS, PERU)





>>> DONALDSON PLANT (WUXI, CHINA)



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IF YOU'VE EVER ASKED YOURSELF "WHY?" about something related to structural steel design or construction, *Modern Steel Construction*'s monthly Steel Interchange column is for you! Send your questions or comments to solutions@aisc.org.

Elevated Slab Tolerances

For a steel-framed project with concrete slabs on metal deck, I know that the AISC *Code of Standard Practice* sets the tolerances for the steel, but what typically defines the tolerances for the top of concrete slab on metal deck? Normally, the concrete subcontractor uses the ACI "F" number criteria from the cast-in-place section of the project specifications, but is this correct if one just references the basic ACI and AISC standards without additional project specifications?

Remember that top-of-concrete elevations for a framed slab are as much a function of the design process as they are of the construction process. The "F" numbering system is really a measurement of the contractor's performance of the slab finishing process, rather than of the actual elevation of a framed slab. Therefore, to answer your question, the engineer really needs to be involved in the process of determining what is required to achieve acceptable slab elevation results.

I wrote a SteelWise article for *MSC* (June 2005) titled "Tolerating Tolerances" that discussed the subject in some detail. Back issues of *MSC* can be accessed at **www.modernsteel.com/backissues**.

Kurt Gustafson, S.E., P.E.

OCBF and Tension-Only Bracing

Section 14.2c of the 1997 version of *Seismic Provisions for Structural Steel Buildings* does not allow tension-only bracing. The 2005 version states that tension-only bracing can be used, but not in K, V, or inverted V configurations.

Am I reading this correctly? When did it change that tension-only could be used? I do see that there are many restrictions to this.

There have been substantial changes made to the 2005 *Seismic Provisions* (AISC 341-05) with respect to earlier editions of the document. You are correct that AISC 341-05 permits the use of tension-only braces in OCBF. This is found in the user note under Section 13.1. As per the user note in Section 14.2 the tension-only members in OCBF need not satisfy the slenderness requirement of Section 14.2, but cannot be used in K, V, and inverted V configurations. This change was made possible by the changes in the system design requirements in the referenced ASCE 7-05 standard.

Amanuel Gebremeskel, P.E.

Pretensioned Bearing-Type Joints

Please let me know whether a bearing-type connection can be pretensioned.

If yes, should the pretension (70% of the proof load of the bolt) be taken into account and checked for combined shear and tension when using N- or X-type bolts?

What is the purpose behind pretensioning bearing type joints? Is the pretension to be in accordance with RCSC 2004? Will prying occur in a pretensioned joint?

A bearing-type connection may be snug-tightened or pretensioned. Hence, a bearing connection can be pretensioned.

The pretension force should not be considered part of the tensile load on the fastener. These are not additive. The tension load in a pretensioned bolt does not change when an external tension force is applied until the parts separate, which would require a tension force in excess of the pretension. Additionally, shear deformations occur prior to bolt failure. These deformations also relieve the pretension prior to bolt failure.

The purpose behind pretensioning is generally to minimize the variation of force in the bolt. This should not be confused with slip-critical connections, which are designed to prevent slip. Refer to Section J1.10 of the 2005 AISC specification (**www.aisc.org/2005spec**) and Section 4.2 of the 2004 RCSC specification (**www.boltcouncil.org**) for cases when pretensioned joints are mandated.

Sergio Zoruba, Ph.D., P.E.

Historic Shape Data

I am interested in purchasing a copy of the book *Dimensions and Properties, Rolled Shapes—Steel Wrought Iron Beams and Columns, as rolled in the USA, Period 1873 to 1952.* It was compiled and edited by Herbert W. Ferris, and it looks like the 9th printing was in 1983.

The "Ferris Book" has been out-of-print for some time and is no longer available from AISC. *Design Guide 15, Rehabilitation and Retrofit Guide* has superseded the Ferris Book, including shape information up until the year 2000. AISC also has a shapes database CD available that includes historic shapes. Both the design guide and the shapes database are available for AISC members at **www.aisc.org/epubs** or can be purchased from the AISC bookstore at **www.aisc.org/bookstore** by others.

If you still want to find a copy of the Ferris book, check with a used bookstore. Also, copies sometimes pop up for sale on eBay.

Kurt Gustafson, S.E., P.E.

Stiffeners and Concentrated Forces

We need more information on Section J10.8 in the 2005 AISC specification. The basic question is: Where do the $25t_w$ and $12t_w$ parameters come from? What about when you have two stiffeners within $25t_w/2$ of each other? Are the strengths additive? Is there any provision by which the $25t_w$ limit can be increased?

These are based upon stiffener research and testing that goes back many years. The stiffener is assumed to have an effective area of web of $12t_w$ on each side. For an interior location, a total length of $25t_w$ is assumed. ($12t_w$ is approximately half of $25t_w$.) If the stiffener spacing is less than or equal to $25t_w$, the area between the stiffeners is fully effective. On both sides of this area, an additional $12t_w$ is effective. Thus for spacing that is less than $25t_w$ the effective width is $12t_w$ + spacing + $12t_w$ for an interior location. Essentially, this means the effective width for multiple stiffeners can't overlap. Similarly, it can't extend beyond an edge at an exterior location.

Amanuel Gebremeskel, P.E.

Girt Bracing

I am designing a building with vertical siding, channel girts, and sag rods. I was told that the industry standard is to consider the channel braced at the sag rods. How is this possible, since the sag rods are neither at the compression flange nor able to act in compression? Is this the appropriate way to look at bracing the channel, or is there a more appropriate method?

The siding attached to the tension flange of the girt acts like a torsional brace. Unfortunately, it may be an ineffective brace in terms of restraining the compression flange of the girt, since it is attached to the tension flange. One needs to calculate the adequacy of such a brace using Appendix 6 (torsional bracing) in the 2005 AISC specification (a free download from **www.aisc.org/2005spec**).

Procedures in AISC *Design Guide 7, Industrial Buildings—Roofs to Anchor Rods*, 2nd edition, for the design of girts are outlined on pages 17 and 18 of the document (**www.aisc.org/epubs**). Note that item 6 mentions that the sag rod acting in conjunction with the siding should be designed to prevent the twist of the girt under suction loads in accordance with Chapter F of the AISC specification. As such, double nutting would be required to provide resistance to twisting.

Sergio Zoruba, Ph.D., P.E.

Required Edition of a Standard

Do you have a good response to engineers who forbid the use of the AISC 13th edition for connection design on their projects? I am running across a few engineers who take the position that since the IBC predates the 13th edition, the 13th edition cannot be used.

Your use of the term "13th edition" refers to the AISC *Steel Construction Manual*, which is not a referenced standard in the IBC. The IBC instead references standards like the AISC specification (normally, the one that is in effect at the time of the IBC adoption). The 2006 IBC references ANSI/AISC 360-05, which is the current AISC specification and the basis of the 13th edition *Steel Construction Manual*.

The procedures set forth for connection design in the AISC manual are representative of how the AISC manual committee views the current state-of-the-art in terms of connection design. Much of this is based on engineering judgment, not just application of the *Specification* parameters explicitly. There may be changes from the information presented in previous manuals, based on testing and data compiled since the issue of the old manual. This may be especially true if comparing current practices against those found in the 18-year-old 9th edition ASD manual.

Ultimately, each new manual reflects the state-of-the-art in knowledge, research, and experience. For that reason, it is preferable to use the latest information available if permitted by the applicable building code and/or the authority having jurisdiction. To us, this means the 2005 AISC specification and 13th edition AISC manual. Our experience is that rejection of this approach is the exception rather than the rule.

Kurt Gustafson, S.E., P.E.

Certification Exemption

How does AISC Certification for fabrication of steel building structures relate to the IBC 2003 Paragraph 1704.2.2, Fabricator approval? If a fabricator is AISC Certified, can I assume they qualify for the special inspections exemption under IBC?

The applicable building code for the jurisdiction will often provide an exemption to shop special inspection requirements if a fabricator is approved to perform such work, which can provide a cost savings to the owner. The AISC Certification program essentially satisfies the criteria that are required in the IBC model building code for "approved" status. However, the IBC does not identify any specific certification programs as satisfying fabricator prequalification. Rather, this decision is left to the authority having jurisdiction to determine if the program meets the exemption qualification. Participation in the AISC Quality Certification program is usually accepted, but you may want to check if a particular jurisdiction has made this determination on previous projects and has set a precedent.

Kurt Gustafson, S.E., P.E.

Kurt Gustafson is the director of technical assistance, and Sergio Zoruba and Amanuel Gebremeskel are senior engineers in AISC's Steel Solutions Center. Charlie Carter is AISC's chief structural engineer, and Lou Geschwindner is AISC's vice president of engineering and research.

Steel Interchange is a forum to exchange useful and practical professional ideas and information on all phases of steel building and bridge construction. Opinions and suggestions are welcome on any subject covered in this magazine.

If you have a question or problem that your fellow readers might help you solve, please forward it to us. At the same time, feel free to respond to any of the questions that you have read here. Contact Steel Interchange via AISC's Steel Solutions Center:

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steel quiz

LOOKING FOR A CHALLENGE? *Modern Steel Construction*'s monthly Steel Quiz tests your knowledge of steel design and construction. Most answers can be found in the 2005 *Specification for Structural Steel Buildings*, available as a free download from AISC's web site, **www.aisc.org/2005spec**. Where appropriate, other industry standards are also referenced.

This month's Steel Quiz was developed by AISC's Steel Solutions Center. Sharpen your pencils and go!

1 Is there a difference between the terms *filler metal* and *weld metal*?

2 **True or False:** Block shear rupture should be checked only at bolted connections.

3 What methods are available to pretension high-strength bolts?

4 What is the most common material specification for hollow structural sections?

5 What is the preferred material specification for anchor rods?

6 Which bolts can be galvanized?
- **a.** ASTM A325
- **b.** ASTM A490
- **c.** ASTM F2280
- **d.** All of the above

7 What needs to be done to keep nuts from loosening in a pretensioned joint?
- **a.** Use lock washers.
- **b.** Use a jam nut.
- **c.** Tack-weld the nut to the bolt.
- **d.** Nothing

8 Must one provide transverse stiffeners at the ends of unframed beams and girders?

9 Which are characteristics of special moment frames?
- **a.** The design expectation is to withstand significant inelastic deformations under the design earthquake.
- **b.** The beam-to-column connections must be capable of sustaining an inter-story drift angle of at least 0.04 radians.
- **c.** Qualification testing or prequalification of beam-to-column connections is required.
- **d.** All of the above

10 What minimum connection depth is recommended for shear connections in the AISC manual?

TURN PAGE FOR ANSWERS

steel quiz

ANSWERS

1 Yes, although it is a somewhat esoteric one. Filler metal is the product sold by the manufacturer used to make a weld. Weld metal is what is in place after the filler metal has been melted to form the joint.

2 **False.** It is also required to check block shear rupture around the periphery of welded connections.

3 According to the RCSC specification (www.boltcouncil.org), Section 8.2, one of the pretensioning methods in Sections 8.2.1 through 8.2.4 shall be used (these include turn-of-nut pretensioning, calibrated wrench pretensioning, twist-off-type tension-control pretensioning, and direct-tension indicator pretensioning), except when alternative-design fasteners that meet the requirements of Section 2.8 or alternative washer-type indicating devices that meet the requirements of Section 2.6.2 are used—in which case, installation instructions provided by the manufacturer and approved by the EOR shall be followed.

4 The preferred material specification for round and rectangular (and square) hollow structural sections is ASTM A500 Gr. B, although ASTM A500 Gr. C is becoming increasingly common.

5 The preferred material specification for anchor rods is ASTM F1554 (Gr. 36, 55 and 105), which covers hooked, headed, and threaded and nutted anchor rods. ASTM F1554 Gr. 36 is most commonly specified, although Grades 55 and 105 are normally available when higher strength is required, albeit with potentially longer lead times.

6 **a.** Only A325 bolts may be galvanized. As described in Commentary to Section 2.3.3 of the RCSC specification, "ASTM Specifications permit the galvanizing of ASTM A325 bolts but not ASTM A490 or ASTM F2280 bolts. Similarly, the application of zinc to ASTM A490 or ASTM F2280 bolts by metallizing or mechanical coating is not permitted, because the effect of mechanical galvanizing on embrittlement and delayed cracking of these bolts has not been fully investigated to date."

7 **d.** When properly installed, a nut on a pretensioned bolt will not loosen. No special procedures are required. Refer to AISC FAQ 6.5.1 at www.aisc.org/faq.

8 Yes. According to the 2005 AISC Specification (www.aisc.org/2005spec), Section J10.7, at unframed ends of beams and girders not otherwise restrained against rotation along their longitudinal axes, a pair of transverse stiffeners—extending the full depth of the web—shall be provided. Also see Section J10.8 for additional stiffener requirements for concentrated forces.

9 **d.** All of the above. Refer to Section 9 and Commentary Section 9 of the AISC *Seismic Provisions* (www.aisc.org/2005seismic).

10 Generally, it is recommended that the connection cover one-half the *T* dimension of the supported beam. This is indicated in the AISC manual as a good practice to provide for stability during erection.

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EDUCATION PROGRAM

AISC Launches Service Center Program

Dozens of architects, contractors, engineers, and consultants in the San Antonio area turned out in June for the inaugural presentation of AISC's new Service Center program. The program is designed to explain to fabricators and designers the importance of service centers to the steel supply chain. The program, which included a one-hour presentation and service center tour, was hosted at Triple-S Steel Supply Co.'s new showplace office-showroom-warehouse location on the site of the former Kelly Air Force Base in San Antonio.

Conducted by Chris Moor, AISC's industry mobilization director, the presentation discusses the structural steel market, structural steel manufacturing process, and distribution through steel fabricators and service centers, and the critical role that the steel service center plays in today's structural steel supply chain. The program, which is registered for two continuing education credits with the American Institute of Architects, is important because 70% of the structural steel in U.S. is supplied by steel service centers, and many project team members are unaware that service centers even exist or that they are a vital and available source of structural steel for building projects. This is particularly important today, since too many architects mistakenly believe that steel is difficult to obtain—when in reality service centers around the country have more than 750,000 tons of structural steel currently available for delivery. (For a list of AISC service center members, please vist **www.aisc.org/servicecenter**.)

More service center programs are being planned throughout the country. For more information, please contact Chris Moor at moor@aisc.org.

Following the service center program, AISC presented the facility's design and construction team with awards in recognition of the project's selection as a National winner in AISC's 2007 Innovative Design in Engineering and Architecture with Structural Steel (IDEAS^2) awards program.

The project, whose warehouse features a structural steel exoskeleton and whose office and showroom use architecturally exposed structural steel and a winged roof reflective of its airfield location, was honored in the "less than $15 million" category. The project team included: Triple-S Steel Supply Co., owner; Lake/Flato Architects, San Antonio, architect; Steve G. Persyn, P.E., Consulting Engineers, San Antonio, structural engineer; and Hooker Contracting Co., San Antonio, general contractor. (See the May issue of *MSC* for more on the project, or visit **www.modernsteel.com**.)

At the conclusion of the presentation, AISC and Triple-S Steel President Gary Stein announced the creation of the Johnny Stein Award for architecture, which will be given to an architect in recognition of his or her body of work for the innovative and visual use of exposed structural steel. A $25,000 cash prize will accompany the award.

LEGAL NEWS

Sending Contract Notices by E-mail

Notice is an important concept in construction. Many construction contracts permit or require all notices to be in writing with some specified means of delivery, such as U.S. Mail, fax, or FedEx.

In recent years, more and more project communications are occurring via e-mail, instant message, or some other electronic means. Can such electronic communications serve as "notice" in lieu of a communication in writing? Under the Uniform Electronic Transaction Act, the answer is yes.

The Uniform Electronic Transaction Act (UETA) is a uniform law that is designed to facilitate the conduct of business transactions electronically and to make electronic records and signatures as equally binding as paper and manually signed signatures.

As of 2005, 46 states, along with the District of Columbia and the U.S. Virgin Islands, have enacted the UETA. Only Georgia, Illinois, New York, and the state of Washington have not enacted it.

The UETA provides that where parties have agreed to conduct transactions by electronic means, electronic signatures or electronic notifications are as equally binding as paper. This means that in an UETA-governed transaction, a notice that is emailed and signed electronically is equally as valid and binding as one that is set out on paper and mailed.

The key concept in determining whether the UETA applies is "agreement," since it only applies to those transactions where the parties have "agreed" to conduct transactions by electronic means. While such an agreement may be contained in the contract itself, Section 5 of the UETA also provides that parties may implicitly agree to conduct transactions electronically from their own conduct and course of dealing on a project.

So if it can be shown that parties to a contract have customarily communicated with each other via email or other electronic means, the UETA will likely permit and enforce electronic notices even where the contract contains no specific provisions addressing them.

In light of this, it is best to eliminate uncertainty and include contract provisions either permitting or precluding electronic notice prior to starting a project. This will allow the project participants to know ahead of time whether electronic notice is effective, and not argue about it later in court.

Whether electronic notice is specified or precluded, the UETA will provide the legal framework to assure that each party's choice is enforced.

—By Ronald J. Stay, associate, Stites & Harbison PLLC

Correction

The SteelWise article from January 2007 titled "Prequalified Sesimic Moment Connections" contains a typographical error. In the section titled "Variables and Definitions" under "User Notes," the third bulleted point should read:

➜ The effective beam flange width for compactness can be taken as $b_{bf} - 2[c - R + (R^2 - b^2/9)^{0.5}]$ per 358-5.3.1(6).

news & events

ENGINEERING JOURNAL

Third Quarter 2007 Article Abstracts

The following papers appear in the third quarter 2007 issue of AISC's *Engineering Journal*. *EJ* is also available online to AISC members and ePubs subscribers at **www.aisc.org/epubs**.

Development of a Cast Modular Connector for Seismic-Resistant Steel Moment Frames, Part 1: Prototype Development

ALI SUMER, ROBERT B. FLEISCHMAN, AND BLAKE E. HOSKISSON

A cast modular connector (MC) has been developed for use in seismic-resistant steel moment frames. The MC is a field-bolted beam flange connection intended to serve as the frame's special energy-dissipating detail. The connector is specifically configured for optimal seismic performance through a casting process. The MC possesses inherent ductility through variable-section arms that minimize plastic strain demand and a reliable yet economical fastening method through a base end-region that virtually eliminates prying forces on bolts. This paper focuses on the development of a Beta prototype design for the MC. This development process focused on the isolated connector rather than full-connection behavior. The MC Beta prototype design was developed using a comprehensive analytical investigation of trial configurations and key parameters using nonlinear (material and geometry) finite element analysis. Lessons were learned from an Alpha prototype. Designs were alternately evaluated for structural performance and castability through the electronic exchange of solid model files with steel foundry industry partners. The analytical results indicate the potential for excellent ductility and energy dissipation characteristics in the MC Beta prototype. A subsequent companion paper will describe the creation of a physical prototype and the experimental program that provides verification of the analytical results presented here.

Topics: Seismic design, connections-moment

Development of a Cast Modular Connector for Seismic-Resistant Steel Moment Frames, Part 2: Experimental Verification

ALI SUMER, ROBERT B. FLEISCHMAN, AND NATHAN J. PALMER

A companion paper describes the development of a prototype design for a cast modular connector (MC) for seismic-resistant steel moment frames. The eventual design, termed the MC "Beta" prototype design, was developed through a comprehensive analytical program that focused on the monotonic response of isolated connectors. Analyses of the MC Beta prototype design indicate the potential for excellent ductility and energy dissipation characteristics. This paper focuses on the prototyping and experimental verification of the MC Beta prototype. Steel foundry industry partners cast the MC Beta prototype at approximately half-scale. The scaled MC Beta prototype was tested in isolated fashion under monotonic and cyclic loading. The experimental results confirmed the performance of the analytically-based designs. The MC Beta prototype exhibited exceptional performance in terms of stable energy dissipation, far exceeding qualifying rotational ductility capacities. In direct comparisons to a WT (structural tee) section of similar stiffness and strength, the MC Beta prototype possessed greatly enhanced ductility and energy dissipation characteristics. With the MC Beta prototype developed and experimentally verified under isolated conditions, future work involves comprehensive analytical evaluation and full-scale experimental verification of beam-to-column joints containing the MC using accepted testing protocols and developing a design procedure for moment frames using the MC.

Topics: Seismic design, connections-moment, research

Seismic Design of Steel Joist Girder Structures

UKSUN KIM, ROBERTO T. LEON, AND THEODORE V. GALAMBOS

Current seismic design provisions emphasize detailing that results in large system ductility and energy dissipation. This may not be the best approach for flexible structures that may be able to withstand large earthquakes in the elastic range or with very limited inelasticity. Among these types of structures are tall one-story frames often constructed utilizing joist girder systems. The main objective of this study is to provide a safe and efficient seismic design methodology for steel joist girder structures—typically one-story industrial or commercial structures intended primarily to carry light roof loads. A new design procedure based on the weak column–strong beam concept is developed, and experimental and analytical verification studies are described. A full-scale cyclic test and pushover analyses show that the intended mechanism can be achieved if the required design strength of the joist girder members and connection to column are based on a column flexural strength of $1.2R_yM_{pc}$. This design requirement is needed in order to avoid a buckling failure of the compression angle members of a joist girder and failure of connections at the end of the joist girder.

Topics: Seismic design, connections-moment, structural and building systems

Behavior of Steel Joist Girder Structures with PR Column Bases

UKSUN KIM, ROBERTO T. LEON, AND THEODORE V. GALAMBOS

Little guidance is provided by current building codes for the seismic design of one-story, frame-type industrial buildings. This paper describes tests and companion analytical studies on the behavior of a full-scale, one-bay, two-frame joist girder structure aimed at developing seismic design guidelines for joist girder frames. Two issues are highlighted: the use of a capacity approach for seismic design and the influence of both the girder-to-column and column base-to-foundation connections on the seismic performance of these structures. The cyclic test results indicated that the beam-to-column connections can be considered as rigid when properly detailed and that a simplified model based on the "component method" approach can provide good estimates for both column base stiffness and strength. The companion analytical studies with different column base fixity indicated that the roof drift decreased and base shear increased appreciably when the effect of the column base fixity was accurately modeled. Finally, a practical method that considers the effects of column base fixity and a modified column base design procedure are described.

Topics: Seismic design, structural and buildings systems, base plates

Geometric Formulas for Gusset Plate Design

JANICE J. CHAMBERS AND TONY C. BARTLEY

Common approaches to compute the yield and buckling resistances of gusset plates require knowledge of the lengths y_c, y_{cf}, y_b, y_{bf}, L_1, L_2, and L_3. While numerical values for these resistances have been presented in the literature, formulas for y_c, y_{cf}, y_b, y_{bf}, L_1, L_2, and L_3 have not been published. This paper presents the derivation and validation of equations to compute these lengths. The equations are summarized in flow charts that can be incorporated into software for practical applications. The formulas provided for y_c, y_{cf}, y_b, y_{bf}, L_1, L_2, and L_3 enable optimization of gusset plate design.

Topics: Connection design-simple shear, detailing

Modified Slenderness Ratio for Built-up Members

ATSUSHI SATO AND CHIA-MING UANG

Based on a review of theory, background for the historical development of the AISC specifications, and an updated experimental database, a simple model—which maintains the accuracy for the calculation of the modified slenderness ratio of built-up members with closely spaced individual components (for example, double angles and double channels) that are connected by welded or pretensioned bolted connectors—is proposed.

Topics: Columns and compression members, built-up members

Current Steel Structures Research

REIDAR BJORHOVDE

This regular feature of the *Engineering Journal* provides information on new and ongoing research around the world. In the 11th installment, research projects are summarized on the following topics: analytical studies of the behavior of welded T-stub moment connections, composite construction for buildings, modeling elements for steel frames, seismic response of steel structures, and fire resistance of steel structures and bridge structures, as well as steel towers for wind turbines.

Topics: Research

Structural Steel

We take steel beams for granted as the bones of new buildings, but how are they made?

TEXT BRADFORD MCKEE **PHOTOS** TIMOTHY HURSLEY

At the Nucor-Yamato Steel Co. plant outside Blytheville, Ark., small mountains of rusted scrap metal rise across a stretch of Mississippi River floodplain. Most of the material, sorted by size and type, is completely unrecognizable. Some piles contain thin sheet metal. Some have pieces of buildings or machines, and in spots you see lengths of pipe. The finest scrap, called shredded scrap or "frag," looks like metal garden mulch or tea.

Several heaps hold discarded tails from brand-new wide flange beams—generically called I-beams, though there are several different shapes. This is the basic unit of heavy steel construction for buildings. The 850-acre Nucor-Yamato plant, with its two gargantuan, parallel sheds, makes about 2.2 million tons of structural beams a year. In about four hours' time, 125 tons of the scrap in the yard here will be recycled into steel beams.

Inside the plant's hazy, Piranesian depths, 860 employees work 12-hour shifts—four days on, four days off. They tend exploding furnaces as big as brownstones, monster vats of molten steel, and more than a soccer field's worth of mills and presses that pound metal into shape. Out of the roaring machinery, ranks of near-perfect beams sidle off the line, glowing orange and gradually turning a cool gray.

Steel, the miracle metal of the industrial age, is iron alloyed to any of various elements to suit the desired purpose. That could be pipes, tubes, plates, rebar, bed frames, saucepans, or ship hulls—or, at the Nucor-Yamato plant, structural beams for building frames.

Steelmaking originally depended solely on the mining of iron ore. Yet because steel can be melted and remade almost infinitely, American industry recycles more steel than it does anything else. About 95% of the content in Nucor-Yamato's beams is metal that once existed as something else.

In Nucor-Yamato's scrap yard, piles of ferrous scrap, including discarded ends of beams and finely shredded metal fragments, lie ready for transporting into the plant, where they will be melted into liquid steel. Behind them stands the air-handling equipment that removes and treats hot, dusty exhaust from the melting operations.

The Scrap Yard

Usually, in Blytheville, making steel begins by unloading scrap on the river, though some scrap arrives by truck or train. Barges pull up to the plant's port from up and down the Mississippi and Ohio rivers. Loads vary, but a single barge may hold up to 1,400 tons of shredded scrap. It takes two hours to empty—using a crane-like mechanical claw, known as a grappler, and, sometimes, an enormous magnet—into a fleet of Komatsu hauling trucks with wheels 7 ft high.

In the scrap yard, another grappler is at work. Equipped with a scale, it weighs the scrap—and, sometimes, chunks of processed iron known as pig iron—while loading the piles into an armored vessel called a scrap charging bucket, which stands nearly 20 ft high and looks like a gigantic hand grenade. Nearly everything about the plant is audaciously large.

About 4,000 cu. ft of scrap fit in the bucket. It sits on wheels and, when full, is rolled into the plant and raised on an overhead crane affixed inside the plant's soaring roof structure. Traveling upward, it floats above the factory's maze of moving parts until its hinged clamshell bottom hangs over the lid of the furnace.

On the rails, a vessel known as a charging bucket arrives with a fresh load of scrap inside the plant's melting operation. It will be lifted by an overhead crane and carried to a spot above the electric arc furnace. The bucket's underside opens to drop the metal into the furnace for melting.

The Electric Arc Furnace

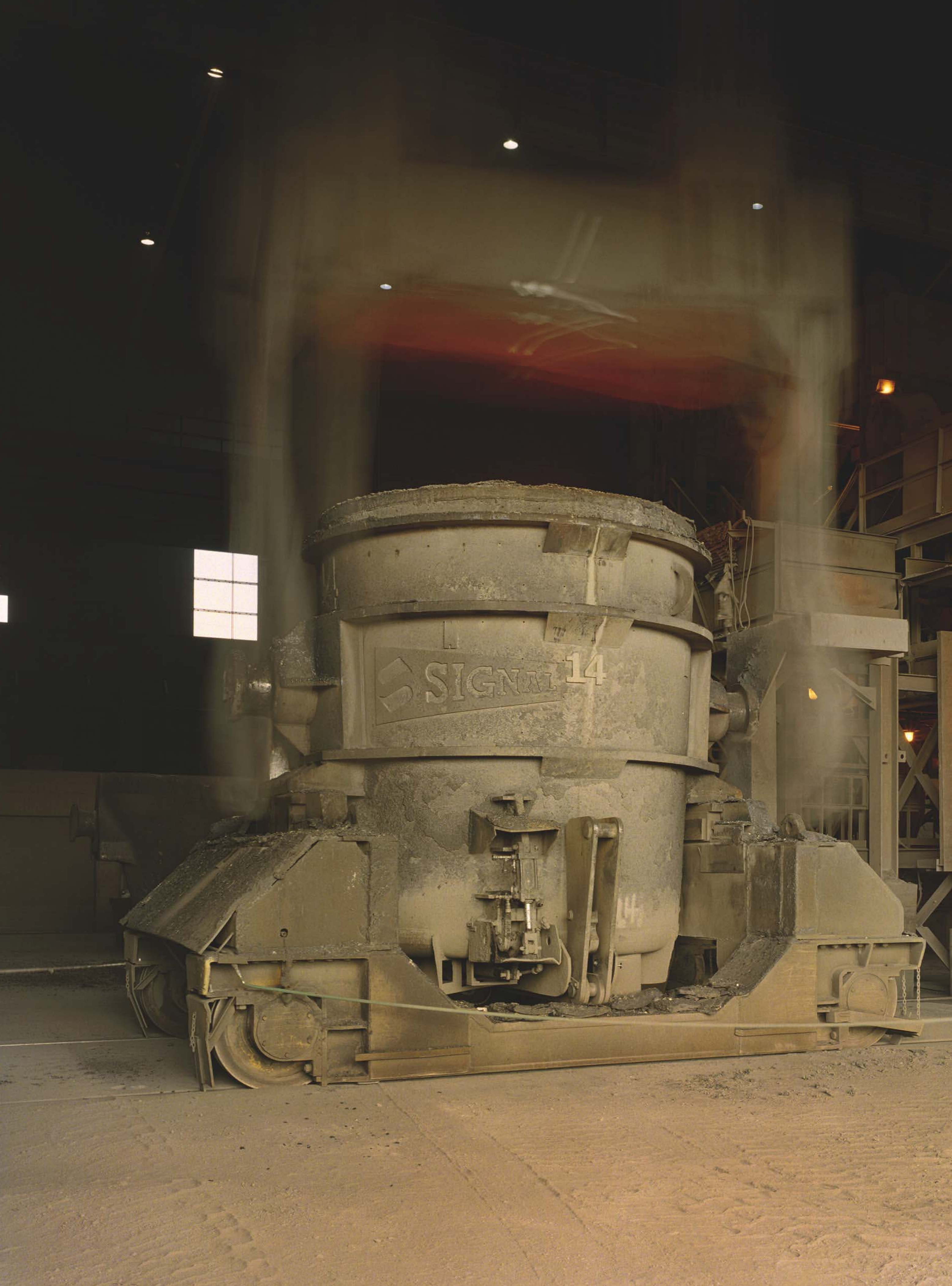
Once the steel is melted to about 3,000 °F and is ready for refining, it is "tapped" from the furnace down to a vessel called a ladle before being taken to the ladle metallurgy furnace. Employees in the control room, or tapping pulpit (at left), monitor the process.

Nucor-Yamato relies on a method of steelmaking called electric arc furnace, or EAF technology. The electric arc furnace proper is a big, dirty cauldron of fire. Its inner lining of refractory brick protects the rest of the furnace from melting in the heat.

When the furnace's roof pivots open, the charging bucket's hinged bottom doors fall open. The scrap crashes into the glowing orange void with a thunderous impact, and flames erupt above the furnace. The roof swings closed.

Three white-hot carbon electrodes, each 2 ft in diameter, descend through openings at the roof's center and strike an arc of electricity into the scrap. A storm begins: Clouds of fire and sparks burst out of gaps in the furnace roof as the electrodes subdue the steel into a blindingly hot porridge. A safe distance away, in a windowed, heat-shielded control room or "pulpit," a worker known as a first helper watches several computer screens that report the status of the melting batch, known as a heat. The first helper tracks the temperature as it rises to about 3,000 °F. He also calculates carbon levels, which fall as oxygen levels rise. Higher carbon content makes steel more brittle. He waits for the carbon to reach a desired low of about 0.1% of the molten steel.

As the steel cooks, its foamy by-product, slag (consisting largely of lime), floats to the top and is skimmed off into a cone-shaped slag pot for processing into an aggregate for roadbeds. When the steel has melted, it is time for the "tap." A slot opens at the furnace's underside to empty the liquid into a wheeled vessel beneath it, known as a ladle.


SIGNAL 14

Perfecting the Mix

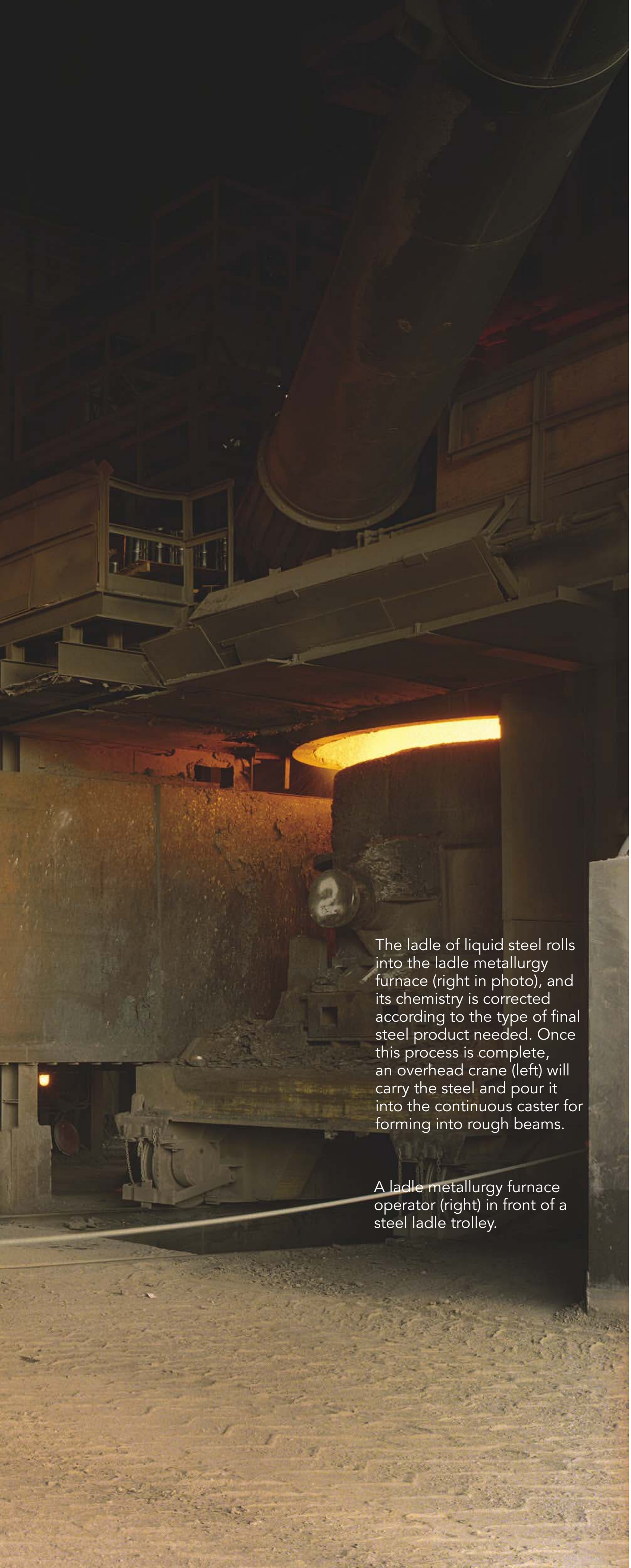
The molten steel filling the ladle is like a blank canvas; other elements, such as silicon, manganese, vanadium, and niobium, are added to create the specific chemistry desired for the final product. For structural beams, Nucor-Yamato makes a grade of steel known as A992, which, since it was first standardized in 1998, has been supplanting other grades (primarily one known as A36) as the standard for building frames because of its high yield strength and tensile strength, especially under seismic stress.

From the electric arc furnace, the ladle of molten steel is moved to the ladle metallurgy furnace for fine chemical tuning. The ladle has a porous plug at its base for pumping argon gas up through the liquid steel, causing it to bubble and stir, much as salad dressing is shaken to mix its ingredients.

When the batch is believed ready (after about 40 minutes), a sample about the size of a silver dollar is taken, cooled, and analyzed in an optical emission spectrometer. The spectrometer provides a kind of fingerprint showing the amounts of various elements. If they seem to fall in the correct range, the batch is ready to cast.

Jim Schoen, a plant metallurgist, has seen the ladle do its work countless times in more than 20 years of making steel. As he stands in the pulpit above the ladle and watches the steel agitate, he marvels at the consistency of the process, which runs 24 hours a day.

The steel mixtures "fall out of spec," as he says, once maybe every two months.



The ladle of liquid steel rolls into the ladle metallurgy furnace (right in photo), and its chemistry is corrected according to the type of final steel product needed. Once this process is complete, an overhead crane (left) will carry the steel and pour it into the continuous caster for forming into rough beams.

A ladle metallurgy furnace operator (right) in front of a steel ladle trolley.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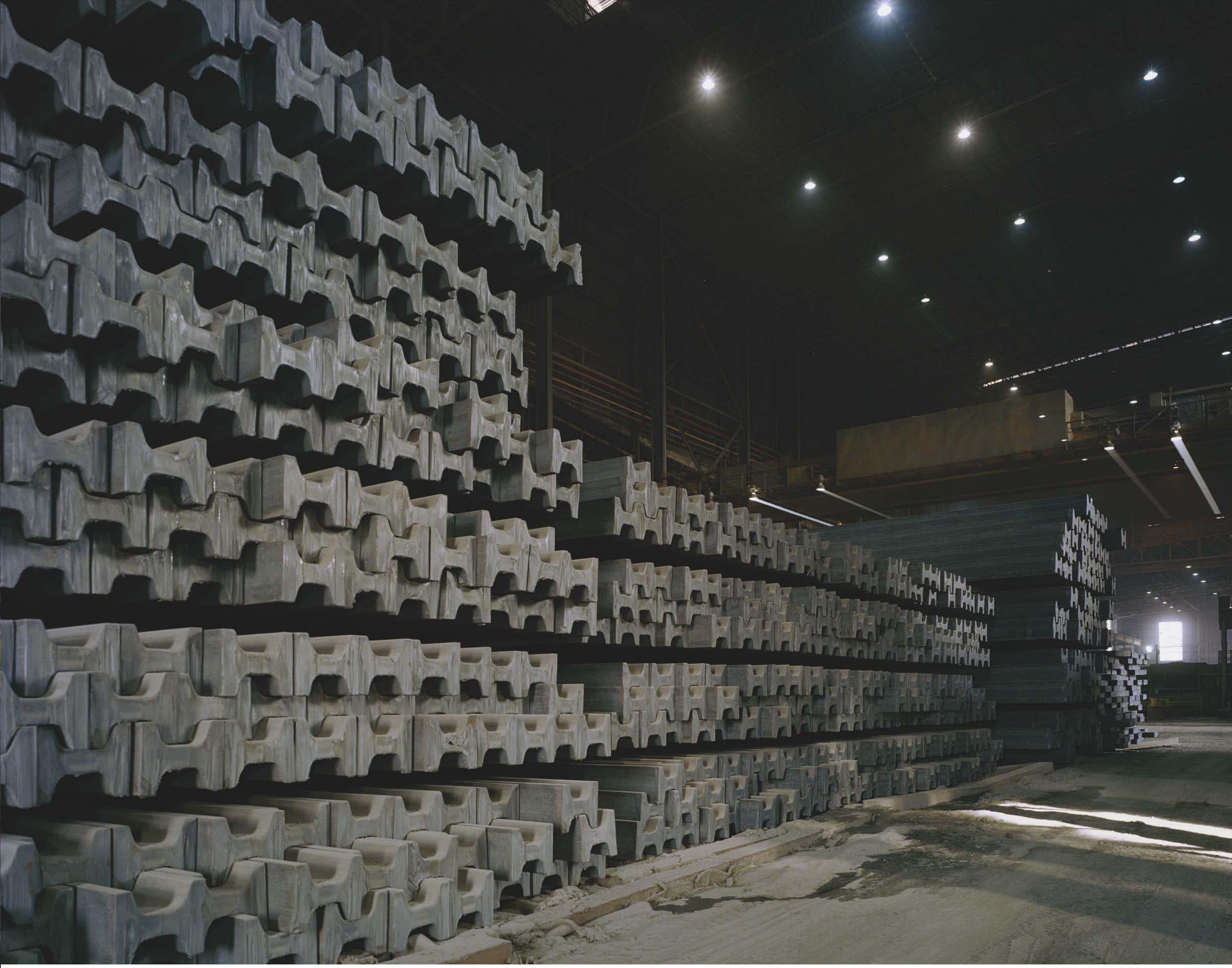


Red-hot wide-flange beams (facing page) roll from the finishing mill, which gives them their final shape, toward large saws (at rear) to be cut into customized lengths for shipping. The saws can cut beams into lengths of up to about 125 ft. Some semifinished "beam blanks" (above) are set aside and stored in a large stockpile within the plant for future reheating and rolling into finished beam sections.

Casting

When the ladle rolls away from the second furnace, a pair of giant hooks lift it—still full of liquid steel—40 ft high, beyond a layer of gray stairs and catwalks, to be poured into its molds for crude shaping. Steel is poured from the ladle into a tub that divides it into two streams (another caster in the plant has four streams), each of which flows down a long mold, forming as a strand, before being cut to length by automatic gas torches at the bottom. The steel is alive, red-hot, and now in the rough form of a beam, called a beam blank or bloom.

Members of the technical staff know the temperature of the steel at all times. Just after casting, the steel registers near 1,800 °F. Sprays of water hit the beam blanks to help cool them to a solid state within minutes.

Some of the cooled ones are stockpiled for finishing later. Some go back in for reheating and final milling.

Finishing Touches

The beam blanks are sent into a 10-ft-deep gas oven and brought to about 2,100 °F. When hot again, they slide into the "breakdown mill," where they are rolled violently back and forth like missiles within flatbed channels, and then through a series of fearsome machines that press them into the correct sizes.

The flanges of the nearly complete beams must be cooled to promote their ductility. A finishing mill evens them out, and a straightener prevents any bow, sweep, or camber along their 27-ft spans. With a terrific grind and a nebula of sparks, the beams are cut to lengths measuring anywhere from 30 ft to 80 ft. Finally, they are taken for shipping to steel fabricators, who ready them for construction.

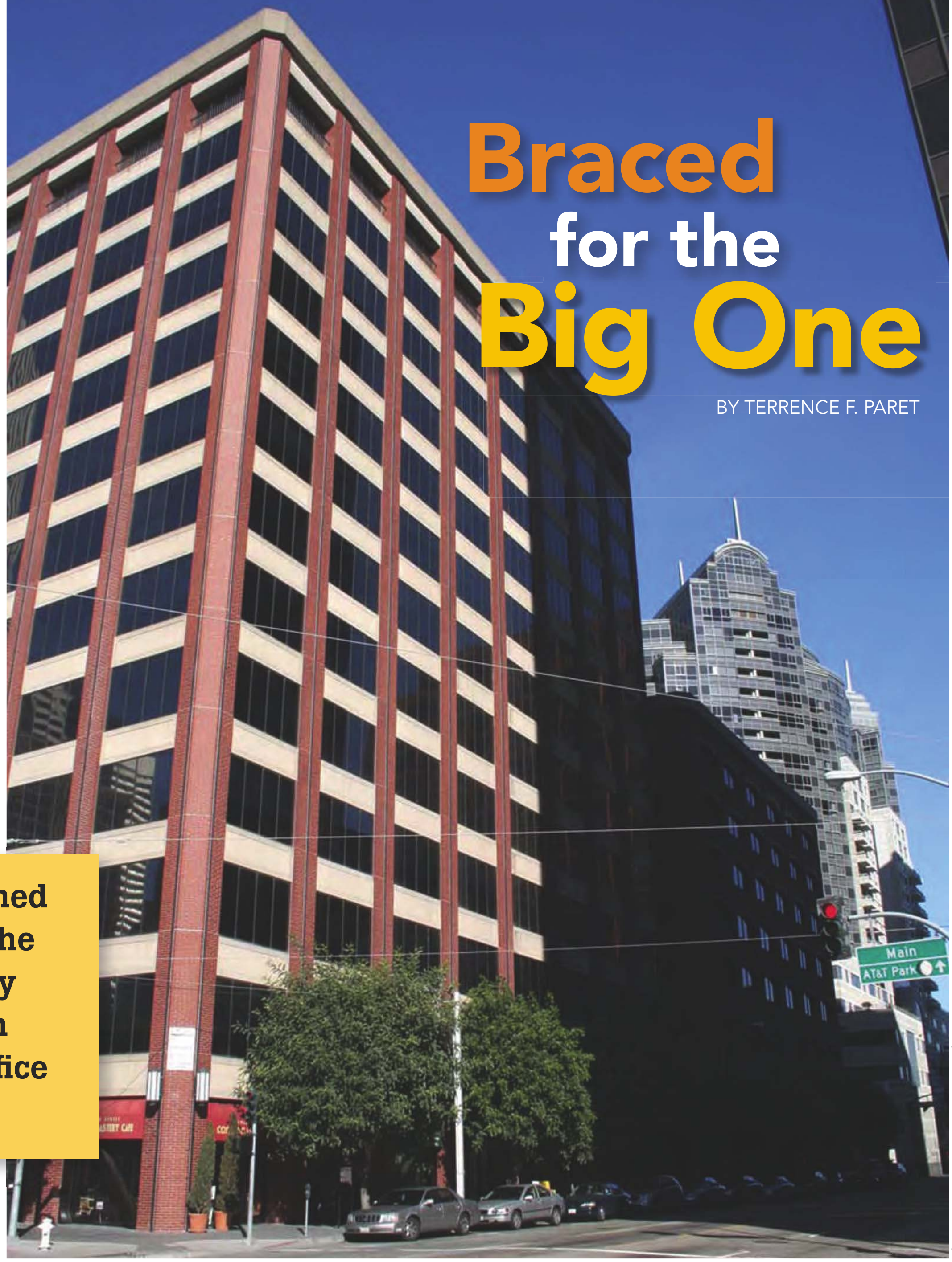
The steel beam, mighty yet plastic, has been melted, muscled, and sculpted into a new life. "Remember," Schoen points out, "this started out as a piece of scrap." MSC

Reprinted with permission from the March 2007 issue of *ARCHITECT* magazine.

Braced for the Big One

BY TERRENCE F. PARET

Buckling-restrained braces improve the seismic reliability of this downtown San Francisco office building.



Photos: Courtesy Wiss, Janney, Elstner Associates

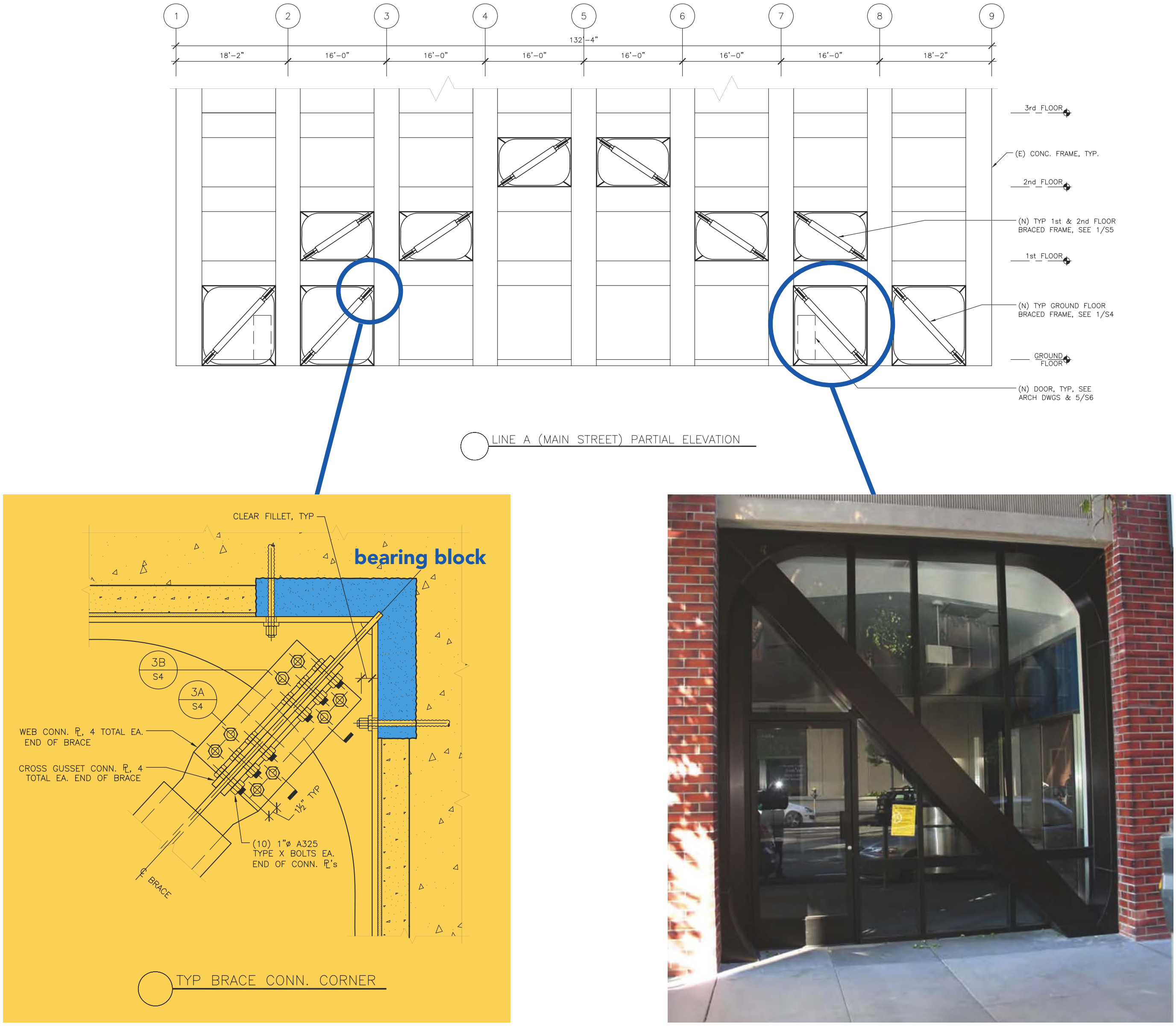
IT'S SAFE TO SAY THAT THE U.S. CITY MOST ASSOCIATED WITH THE WORD "EARTHQUAKE" IS SAN FRANCISCO. So it's a given that seismic considerations are near the top of the priority list when it comes to new high-rise construction in the city.

But when it comes to older high-rises, there's often room for improvement. Such was the case with The State Bar of California Building, a thirteen-story 1970s-era reinforced concrete structure in downtown San Francisco. The building recently underwent a seismic improvement project that employed a state-of-the-practice seismic mitigation technology and a number of other innovations.

The goal was to cost-effectively mitigate a very undesirable primary characteristic in the response of the existing structure to strong earthquake shaking. The deficiency involved the expected performance of the tall ground story, which was predicted by nonlinear response history analyses to experience large inter-story drifts and significant inelastic behavior verging on collapse in the event of a large earthquake. The building owner and occupant, The State Bar of California, desired improved seismic reliability—if it could be achieved without severely disrupting operations—and embarked on a voluntary effort to mitigate the seismic hazard.

A First for San Francisco

The most cost-effective and least disruptive solution that targeted the deficiency and avoided wholesale upgrading consisted of the addition of buckling-restrained bracing—infilled within new structural steel



The lower three floors of the 1970s concrete frame were retrofitted with a series of steel buckling-restrained braces. When the perimeter concrete frame displaces laterally in-plane during an earthquake, the new infilled steel framework is loaded by bearing blocks at the corners of the braced bays.

WT framing—to the lowest three stories of the existing perimeter reinforced concrete moment frame. This was the first application of this technology for seismic retrofit of a concrete building within the jurisdiction of the City of San Francisco.

Buckling-restrained braces consist of a ductile structural steel core located within a grout-filled HSS. The core is isolated from the grout by a bond-breaker, which enables the steel core to deform and yield without engaging the surrounding HSS. As the name implies, buckling-restrained braces exhibit very stable hysteresis relative to other steel bracing systems because they can yield in a ductile manner in both tension and compression. Furthermore, because the material properties of the core steel are tightly controlled, the strength of the braces is very predictable.

The complexity of anchoring an infilled structural steel bracing system to an existing reinforced concrete frame provided the opportunity for significant innovation, particularly with respect to the philosophy employed in designing the load path for the braces and the use of unconventional structural shapes that minimized welding, provided an improved gusset plate design, minimized obstruction of the windows, and promoted an overall sleek appearance.

The design of the infilled diagonal bracing system, including the new steel framework and its attachment to the existing concrete frame, was predicated on a capacity analysis of the braces and iterative performance analyses of the building. Essentially, the maximum force that can be developed by each brace (i.e., the strength of each brace) was identified, and the whole of the supplemental system—including all welds, bolts, plates, and the WTs that created the infilled frames—was designed for those computed forces using LRFD with lower bound yield strengths and associated phi factors. As a result, other than the desired yielding expected to occur in the new buckling-restrained braces, the supplemental system of steel framework is not expected to experience yielding even in the maximum considered earthquake event.

The seismic load path into and out of the new buckling-restrained braces and surrounding steel framework was designed in recognition of the likely behavior of infilled bracing at ultimate. Instead of transferring forces into the braced frames via shear dowels embedded into the concrete frame as might typically be done, loading of the bracing is forced to occur through reinforced epoxy-grout bearing blocks installed at the four corners of each braced-frame assembly. When the perimeter concrete frame displaces laterally in-plane during an earthquake, the new infilled steel framework is loaded by bearing blocks at the corners of the braced bays.

For braces in compression, the bearing blocks at the two corners of the framework—through which the line-of-action of the diagonal braces passes—transfer forces directly from the perimeter concrete frame to the infilled braced frame. For braces in tension, the bearing blocks in the corners—opposite those along the line-of-action of the braces—transfer forces from the perimeter concrete frames to the supplemental steel framework. The steel framework then transmits these forces toward the brace ends via compression of the WTs. Therefore, the WTs are designed as compression members with unbraced lengths equal to the maximum spacing of the epoxy dowels connected to the perimeter concrete frame members through oversized holes. The design spacing of the epoxy dowels enabled the WT webs to be trimmed down to 3 in. in the regions away from the bearing blocks, thus minimizing the visual impairment normally associated with retrofit bracing and allowing for ADA-compliant doors to fit beneath the braces where required.

Using the Web

Another innovation on this project was developed specifically to avoid a failure mode that had been identified during laboratory testing of other buckling-restrained braced frames for other projects. During some of these tests, the braced assembly failed by brittle fracture of welds between the gusset and the steel framing to which it was connected, as the gussets deformed out-of-plane under severe loading. Instead of using traditional gusset plates for the project, the WT webs were employed as the primary gussets; they were spliced together with only longitudinally loaded fillet welds at a cross-gusset used to create the cruciform shape needed to mate with the ends of the braces. The WT webs, which were profiled to minimize obstruction over the majority of the bay openings, were radiused at the frame corners. This radius is reflected in the sheet metal weather-tight covering for the infilled frames and adds to the visual appeal of the frames. Use of the WT webs as gussets minimized total project welding and required only a few fillet welds per bay to be installed outside of shop.

Late Nights

The State Bar of California Building is now better prepared for the next Big One, whenever it may come. And the construction team was able to meet another owner goal as well: Construction was performed in the evening, eliminating loss of occupancy. MSC

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Designing for Long Spans

BY JAY RUBY, P.E.

Long-span designs present structural challenges that go beyond spanning longer distances.

DESIGN OF LONG-SPAN SYSTEMS—STRUCTURAL SYSTEMS THAT CROSS LONG DISTANCES WITH LARGE OPEN SPACES—IS CHARACTERIZED BY UNIQUE CHALLENGES. Typically found in arenas, convention centers, and hangars, these structural systems push the envelope of what buildings can do.

Designing long-span structures requires an obsession with stability. Certainly, the structure has to hold up its own weight; just to span the required distance a structure has to support significant dead load. But the complexity of long-span design increases exponentially when snow load, wind load, seismic load, deflection, serviceability, and the dead weight of the floor or roof system are all factored in. Architectural appeal drives the design of such structures, but many factors working simultaneously and in varying degrees must be analyzed in long-span design. The challenge in developing a long-span design is to integrate the architectural concept and appeal with the most efficient, purest structural system. Relevant questions include:

- What are the site constraints?
- Should the pieces be preassembled, or must the structure be "stick built?"
- What type of temporary support is needed?
- What is the nature of the field connections?
- What is the inherent stability of the elements during assembly?
- How will differential deflection impact the structure?
- How can load be transferred from temporary shores to the permanent structure?

Perhaps the greatest challenge is creating a model of the structure that describes how loads change in an as-constructed sequence. Typically, structural models are developed assuming a zero-gravity system—i.e., they assume a 100% constructed structure prior to any load application. In reality, the structure is built one piece or assembly at a time, and the load path for the dead loads may vary significantly from that assumed in the structural design model. In addition, when and how the structure is temporarily braced creates different gravity and lateral load paths.

By addressing the various load paths as the structure is being constructed, the engineer can adjust the design for erection too—not just the final state. By considering the load paths and how the structure responds as it is being constructed, the engineer is able to develop designs that facilitate sequencing of construction and allow efficient use of temporary shoring. Addressing instability issues that occur during construction impacts member size, temporary shoring requirements, and construction sequencing—all of which have a significant impact on overall project cost and schedule. Modeling structures as-constructed, recognizing the various temporary load paths, and designing connections accordingly—while addressing construction sequencing—allow the structural engineer to develop an enhanced decision matrix and lead to design decisions that reduce costs and improve constructability.

Non-Traditional Approach

Long spans frequently occur adjacent to a more conventional column grid system. Oftentimes, this conventional grid system is merely continued to accommodate the long-span requirements, instead of considering the two areas as individual components. While this approach may simplify the decision matrix, it sacrifices the opportunity to reevaluate the unique structural needs of long-span structures.

Investing in a structural analysis to uncover the unique opportunities inherent to long-span structures can positively impact the materials cost and construction schedule; costs associated with the steel structure are a major component of the total construction cost, and structural engineering considerations drive the critical path for completion of design and construction. Because all other trades follow the structural system, it must be constructed as quickly as possible. Investing in structural analysis, framing system evaluation, site analysis, member and element selection, and construction-friendly connections of the long-span elements will go a long way in controlling the constructability and final cost of the facility.

Inserting Constructability

Long-span design demands attention as an independent system. Following the architectural grid of the building may not deliver the most efficient structure. However, structural analysis and framing system evaluation can provide the optimal spacing for the main structural elements to sustain the unique loading criteria, balance the weight of the structure, and support the additional loads of

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Designing Constructability into an Aircraft Hangar

Aircraft hangars can provide powerful examples of how to effectively integrate constructability into long-span design. Structural design of hangars requires the consideration of multiple elements:

- Bay sizes
- Truss depth, framing direction, and specific truss framing concepts
- Sway frame spacing
- Panel points
- Lateral bracing
- Foundations

Even more important is accurately defining the loads that the long-span structure is required to carry. The impact of design load criteria on long-span design is tremendous. For example, the impact of 5 psf of additional assumed dead load in the design of a typical 30-ft by 30-ft grid building generally does not affect the design of beams, columns, or foundations. But in a long-span structure with a supported area of 100,000 sq. ft, 5 psf translates into 500,000 lb of additional load that must be supported. Defining actual load criteria to reflect realistic conditions can significantly impact design.

Challenging a building's layout parameters can also deliver significant savings. For instance, increasing bay spacing in a structural framing system from a grid of 30 ft to 40 ft can deliver the following results:

Trusses	30% fewer pieces
	26% fewer connections
	27% fewer trusses
Top chord framing	27% fewer joists
Bottom chord bracing	53% fewer pieces
	53% fewer connections
Vertical lateral bracing	28% fewer pieces
	28% fewer connections
Foundations	27% fewer foundations

Figures 1 through 3 illustrate the impact of altering this basic design parameter on the truss system, columns, connections, and bracing. As these figures show, the structural elements are reduced tremendously moving from a grid of 30 ft to a grid of 40 ft—and structural needs are still met.

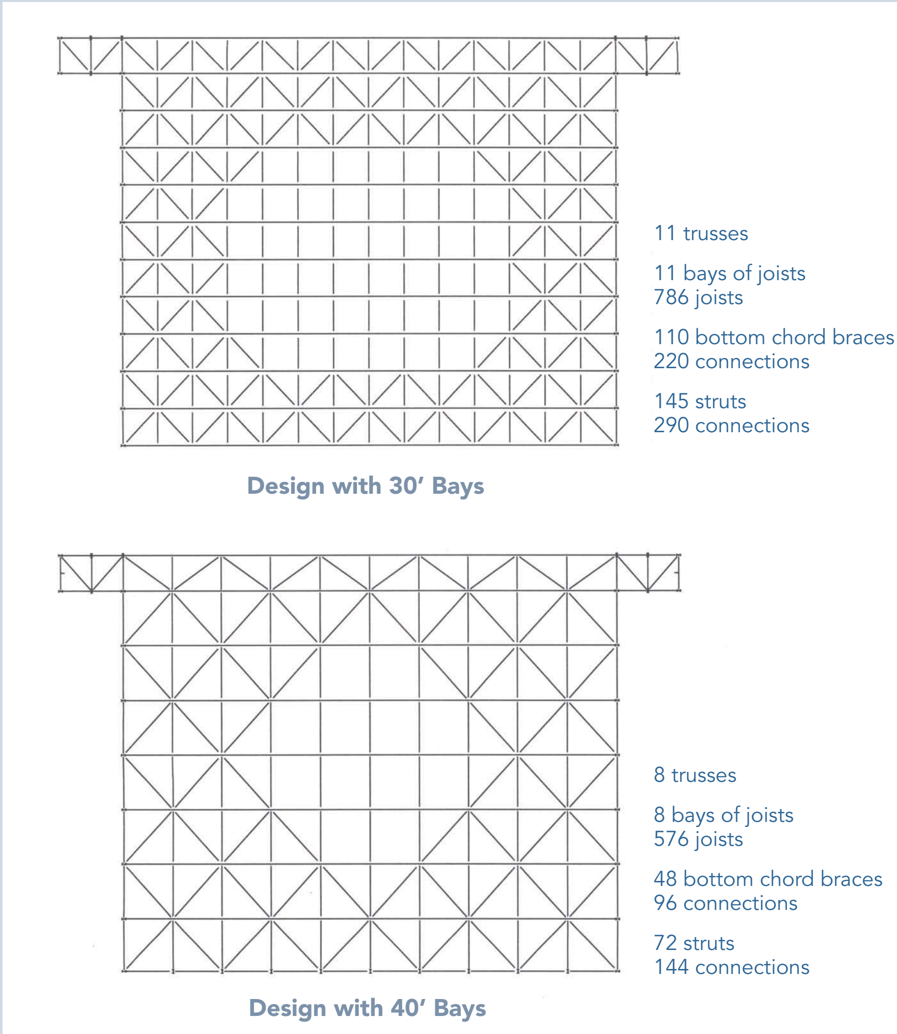


Figure 1.

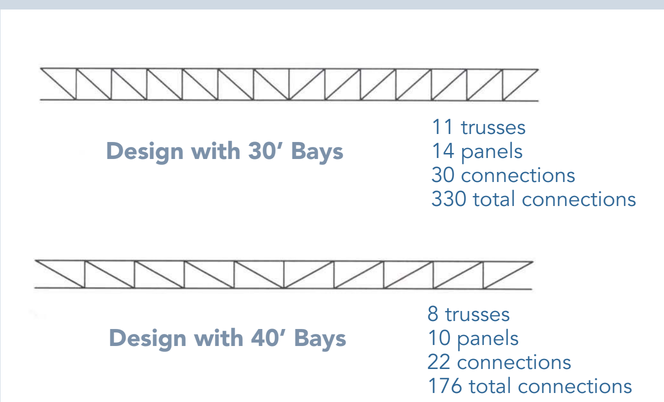


Figure 2.

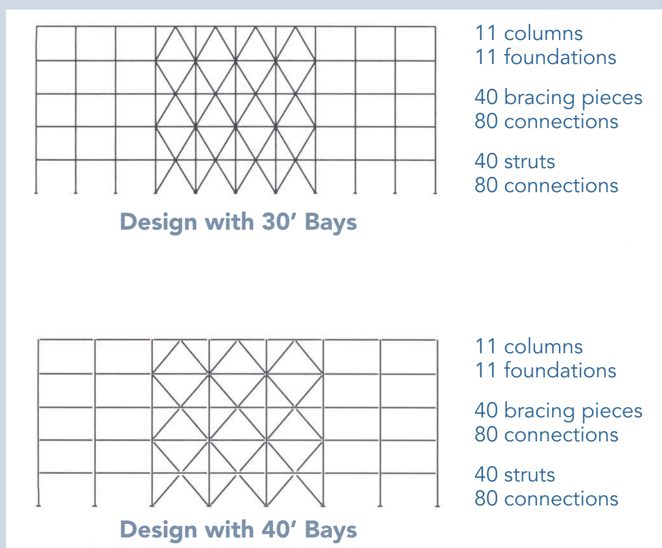


Figure 3.

the roof or floor system. This approach considers:

Structural framing. What is the load path? How can each structural element's efficiency—from the deck/slab to the supporting beams and joists to the trusses—be maximized? Efficiency in size, span, constructability, number of pieces, etc. must all be considered.

Bracing. Bracing established by architectural considerations alone may be insufficient, unbalanced, difficult to install, or very inefficient. First, establish a minimum bracing requirement to accommodate structural demands. Then, determine how this bracing requirement can be made efficient and integrated within the architectural grid.

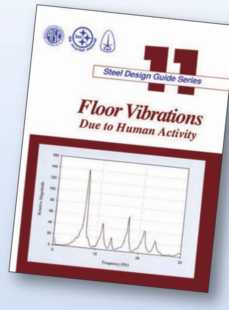
Fabrication. Can shop fabrication be maximized to reduce pieces, improve quality, and minimize field costs? Should the trusses be built to facilitate shipping? If field subassembly is necessary, can connections and member elements be minimized?

Erection. Provide a suggested sequence of construction, not just final building design. How should construction be sequenced to minimize temporary shoring and maximize the efficiency of member sizes? Where should temporary bracing be located? How do load paths change as the structure is being built? Who better to direct how the structure should be built safely than the structural engineer who designed the structure?

Design of the trusses provides an excellent example of balancing material, fabrication, and erection costs. As the depth of the truss increases, material costs decrease. However, fabrication and shipping costs may increase or decrease based on the fabrication shop's capabilities and design requirements. Field time is minimized since deeper trusses carry more load, allowing framing optimization and element reductions. Ultimately, constructability integrates the design decision matrix with construction considerations and drives the lowest total cost alternative.

Optimal Design

Integrating constructability into long-span delivers the optimal structural design. The structural engineer can help the fabricator/erector perform better by guiding construction sequencing based on structural considerations—and without getting into means and methods of construction. With a focus on constructability, the engineer can produce the owner's ultimate goal: an economical, serviceable long-span structure. MSC



Structuring Science

BY CRAIG W. BURSCH, P.E., AND DAN MURPHY, P.E.

A university in northern Minnesota turns to long-span trusses to support its state-of-the-art science building.

IN RECENT YEARS, THE UNIVERSITY OF MINNESOTA DULUTH (UMD) RECOGNIZED A SIGNIFICANT OBSTACLE TO ACHIEVING ITS VISION AS A PREMIER CAMPUS FOR SCIENTIFIC STUDY AND RESEARCH. In particular, the chemistry and life science buildings, 56 and 36 years old, respectively, were rapidly becoming outdated. Ventilation problems, safety issues, and a lack of modern equipment left the facilities inadequate to meet the needs of today's science students.

Along came Jim Swenson, a successful businessman and 1959 graduate of UMD. Swenson's deep gratitude for the education and guidance he received at UMD as a chemistry major prompted him to donate $7.5 million to help finance the construction of a new science classroom building. Named for its benefactor, the 110,000-sq.-ft James I. Swenson Science Building is the new home of the university's chemistry, fresh water research, and biology departments.

The university was presented with several building layout options and eventually selected a T-shaped three-story building. This option was selected as the best fit for the existing campus space constraints as well as plans for a new southern courtyard and wild rice wetland.

The 50-ft by 450-ft east-west wing houses sixteen teaching laboratories, which combines classroom and laboratory functions within the same space. The 60-ft by 150-ft north-south wing houses the research laboratories and is accessible only to designated students and faculty.

Settling on Steel

The structural engineer initially investigated three distinct structural systems for the main building wings: a wide module cast-in-place concrete system with concrete column frame action; a composite structural steel system with braced frames; and a hybrid of the two systems. Preliminary typical bay studies and details were submitted to the project cost estimator early in the process to determine the most cost-effective structural system. The design team eventually selected steel as the project's structural system, as it was deemed to be more economical in the initial estimates due to three driving factors.

First, the selected layout included an 80-ft span over Kirby Drive, a significant campus circulation corridor. This element was no trivial design exercise, as the entire span would be occupied by two stories of classroom and laboratory space with a

The skywalk structure (far left, above) consisted of trusses spanning approximately 76 ft with an 8-ft cantilever near the existing building.

design live load of 100 psf, plus an enclosed mechanical penthouse space at the roof. Due to excessive estimated formwork costs, a story-deep steel truss system provided greater project economy than post-tensioned concrete beams, along with a more attractive exposed structure.

Second, a ribbon window extends along 90% of the building's perimeter, requiring thousands of connections to support the building façade and window head and sill conditions. While connection to embedded plates in a concrete frame system would have been possible, the structural steel framing option provided a greater degree of flexibility during design and, during construction, required less coordination in the field.

Third, the architectural layout did not permit vertical alignment of the lateral force resisting system of the building. The offset orientation of bracing elements quickly eliminated masonry or concrete shear walls as practical solutions. The design team selected a combination of chevron and K-shaped braced frames over a concrete column frame option.

Final Framing Selections

One of the more significant framing challenges of the project was the design of trusses to carry the three-story, 80-ft span. The lower trusses are 16 ft deep, with bottom chords supporting the first structured level and top chords supporting the second structured level. Typical chord sizes are W24s and W21s with HSS8×8 and HSS6×6 web members.

The uppermost story consists of a mechanical penthouse. Due to the unusual curved geometry of the space, a central truss was designed to carry the penthouse floor and roof, similar to the two classroom levels below. At the spandrel (edge) condition of the low roof, 6-ft-deep trusses with W10 and W8 chord members and 3-in. and 4-in. double-angle web members were used.

The structural engineer designed all connections on the project, including the truss web and chord connections, and during the submittal phase of the project worked closely with the fabricator to work out final geometry of the truss and connecting elements. This effort was critical to the overall aesthetic success of the project, as the project architect did not conceal the full-story truss elements. Rather, the symmetrical beauty of the Pratt truss design was incorporated as a visual architectural element of the building.

The final gravity system in the majority of the classroom spaces consisted of a 4½-in. concrete slab over 2-in. composite deck (a total thickness of 6½ in.) spanning approximately 8 ft between W14 purlins. The purlins frame to W18 girders, supported by W12 columns. The building is supported on conventional spread footings. The final lateral force resisting system consists of HSS tubes arranged in staggered chevron and K-shaped layouts.

The Atrium

Other unique structural challenges on the project were associated with the feature bridge and wall in the student commons and atrium space located at the intersection of the two building wings. The layout included a 50-ft by 50-ft opening in the third floor with a special pedestrian bridge extending through the space. The architectural vision for the 5-ft-wide feature bridge was a single centered tube element beneath the bridge with outriggers supporting the full walking surface.

Due to deflection and vibration concerns, the engineer selected a built-up 26-in. by 20-in. tube section as the primary structural element of the bridge. The tube walls consisted of 2-in.-thick top and bottom plates and 1-in.-thick side plates.

The feature bridge spans from the north laboratory wing to the "double helix" exterior stairway that leads to the south courtyard. The stairway symbolizes DNA and the "science on display" theme permeating the building.

The 40-ft-high interior feature wall serves to attract people to the commons area. It also serves to collect natural light from the roof skylights and reflect it into the commons area. Sloping steel members support the architectural finishes in this unusual assembly space.

A further structural consequence of the atrium floor opening was to separate the building into distinct lateral load resisting systems. Each distinct area is designed to resist wind loads without significant contribution from the others. Strut elements surrounding the commons area provide redundancy in transmitting the load to adjacent frame elements.

Constructability Concerns

Because site constraints and the sprawling nature of the building prevented efficient use of a tower crane, the larger lifts were made with two "crawler" cranes. According to the general contractor, there were two lifts that were deemed "critical" on this project. (A lift is defined as critical if it exceeds 80% of the crane's tabulated capacity or is extremely complex.) The first such lift was

On the north and west sides of the building, one level is approximately 15 ft below grade. Cantilever retaining walls allowed for early backfilling, providing additional area for staging construction activities.

a skywalk linking the new Swenson building to the existing Life Science Building. The second was the "pick" of the feature bridge.

The skywalk structure consisted of two trusses spanning approximately 76 ft with an 8-ft cantilever near the existing building. The long span was required due to a network of underground utility tunnels present between the Swenson Building and the Life Science Building, which made placement of additional footings uneconomical. The lift had a difficult geometry due to the relative skew and elevation difference between the two buildings. The engineer detailed a 2-in. expansion joint that also provided erection tolerance between the end of the trusses and the existing brick face.

The feature bridge came to the site shop fabricated, with only the grating and handrail yet to be installed. With much of the building already erected, this was a tight lift: Only 1 in. of tolerance was allowed at the north end of the bridge. At the request of the contractor, the engineer designed a bottom flange extension on the adjacent wide flange beam to allow for a wider bearing surface for the bridge.

Construction Schedule

The north and west sides of the building perimeter are one story (approximately 15 ft) below grade, while the south and east sides are located at grade. Accordingly, the "walk-out" nature of the building creates large unbalanced earth pressures. Two options were considered for supporting these loads. The first was using the first-floor diaphragm to transfer this lateral force to the vertical braced bays. The second option, which was eventually selected, evaluated the basement walls as cantilevered retaining walls. This approach permitted the contractor to backfill large areas of the site early in the construction phase. Additionally, when backfilling was complete, the contractor had valuable additional space for staging of structural steel and other building activities. By anticipating construction issues, MBJ was able to facilitate the contractor's schedule and help bring the project to a timely conclusion in 21 months

Achieving the Vision

The structural steel framing system was fabricated and erected with few problems or unusual challenges. In fact, despite vandalism of the project site that caused more than $8.2 million in damages during construction, the James I. Swenson Science Classroom Building opened on time and under budget.

Structural steel provided a flexible and dependable building system for the project. The long-span trusses in particular were the perfect solution to a challenging and unique space, meeting owner expectations and the architectural vision. MSC

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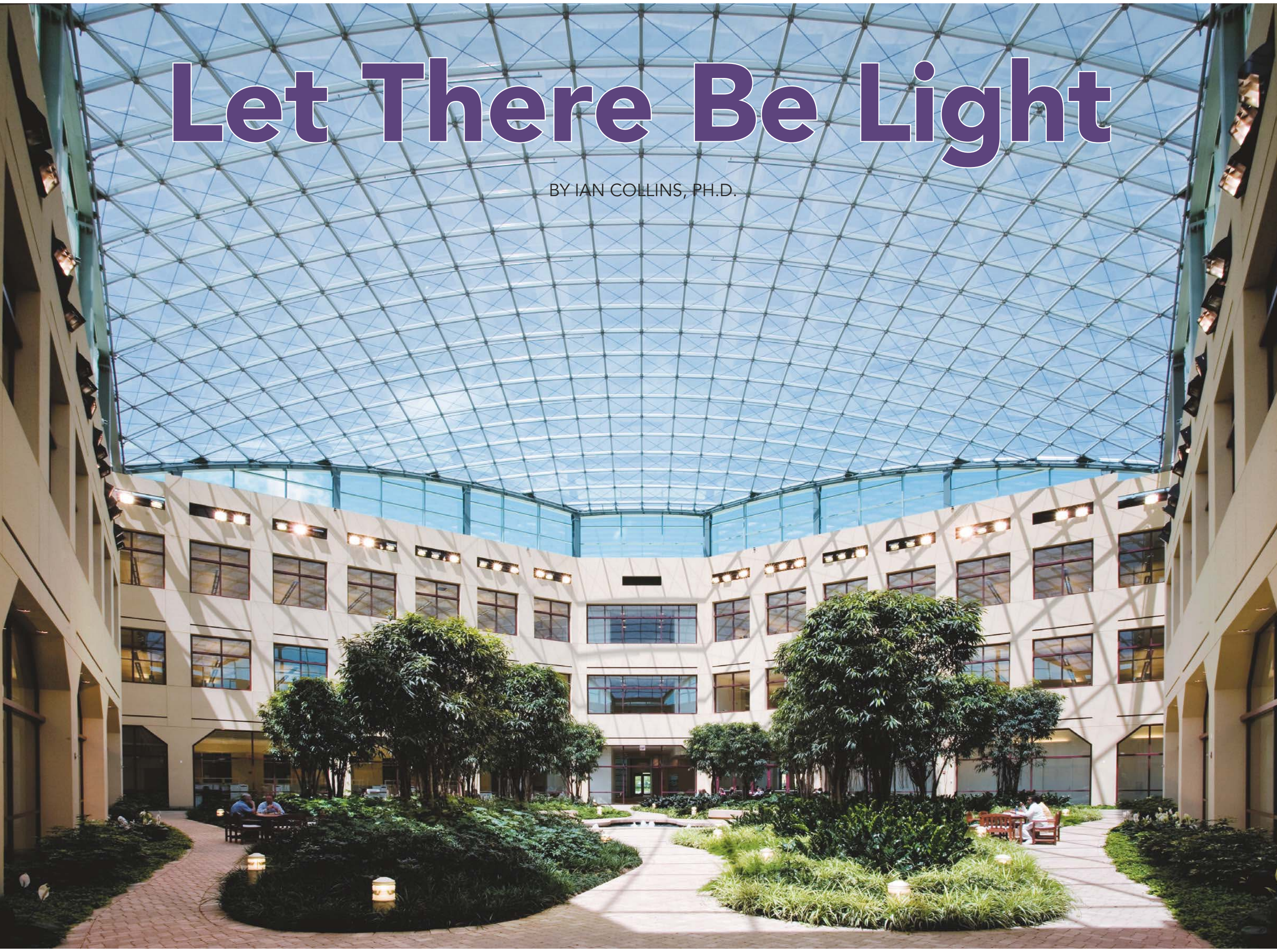
Ted Mannstedt and Son, Inc., La Crosse, Wis. (AISC Member)

Erector
Northern Industrial Erectors, Grand Rapids, Minn. (AISC Member)

Engineering Software
RAM Structural System

Let There Be Light

BY IAN COLLINS, PH.D.



Novum Structures

An expansive, innovative skylight in Chicago sets a U.S. structural and architectural precedent.

IT WOULD SPAN 148 FT BY 137 FT, 80 FT ABOVE GROUND LEVEL. It would be a precise, carefully engineered union of steel and glass—and the first of its kind in the United States.

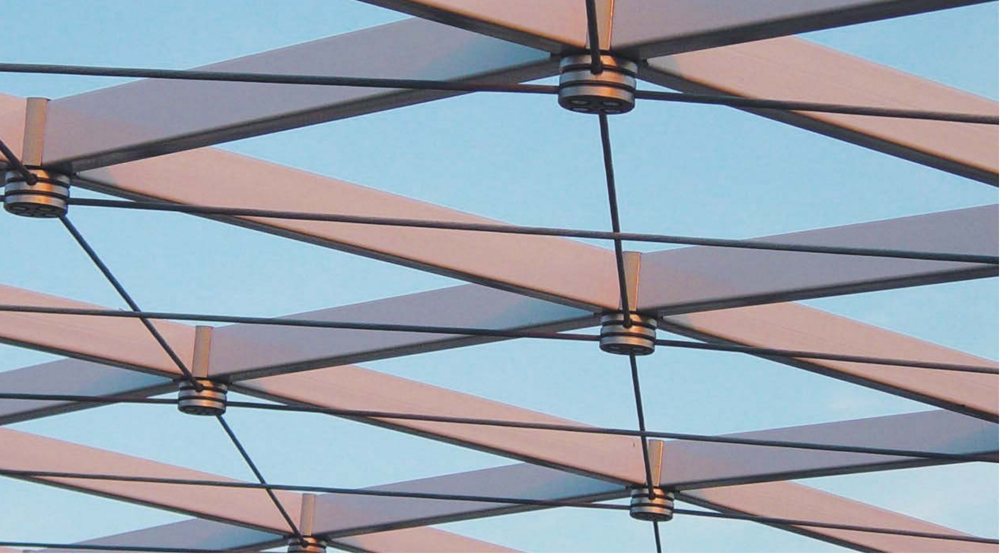
This glazed skylight, through which natural light floods, now tops the atrium of the 153,000-sq.-ft William Wrigley Jr. Global Innovation Center on Chicago's Goose Island. An enormous, highly irregular, "diamond" shaped structure, it was envisioned with incredible transparency to seamlessly allow natural light to pass through to support abundant plant life along the atrium's floor.

A Ground-breaking Challenge

To bring the challenging design to life, Chicago-based architectural firm Hellmuth Obata + Kassabaum (HOK) contacted Novum Structures, a specialty contractor for high-technology spatial architectural structures and enclosures. HOK's initial design objective called for a single-layer skylight spanning more than 130 ft. To further complicate the endeavor, the budget was tight and site logistics difficult, as the atrium was located a significant distance from the building's outside perimeter. Because of this, larger, more expensive crane equipment would be necessary to handle the huge reach, putting greater strain on the project's budget.

"One of the challenges was just getting the whole 12,000-sq.-ft skylight in the center of the building to coordinate and interface with the rest of the building, because the rest of the building was built first and then the skylight system followed," says Jeff Geier, project executive at Power Construction, the project's general contractor. "All the tolerances had to be worked out."

The challenge was to economically resolve the nearly mutually exclusive objectives of large span and transparency. For the limited budget of approximately $150 per sq. ft, including all



Novum Structures

Concealed mechanical connections allowed for very high-quality factory finishing.

glass and supporting members installed, the architect essentially wanted the look of a 5-in.-deep conventional skylight frame that would span more than 130 ft. In Chicago, where heavy snow loads must be considered, conventional skylights typically span only 40 ft.

In an effort to adhere to this norm, Novum's initial concept used intersecting three-dimensional trussing supports to break up the span into 40-ft by 40-ft skylight modules. However, HOK rejected this initial design. It became clear early on that the firm was resolute on the single-layer concept, and Power Construction strongly reinforced the need for a guaranteed budget.

Innovative Systems Create a Solution

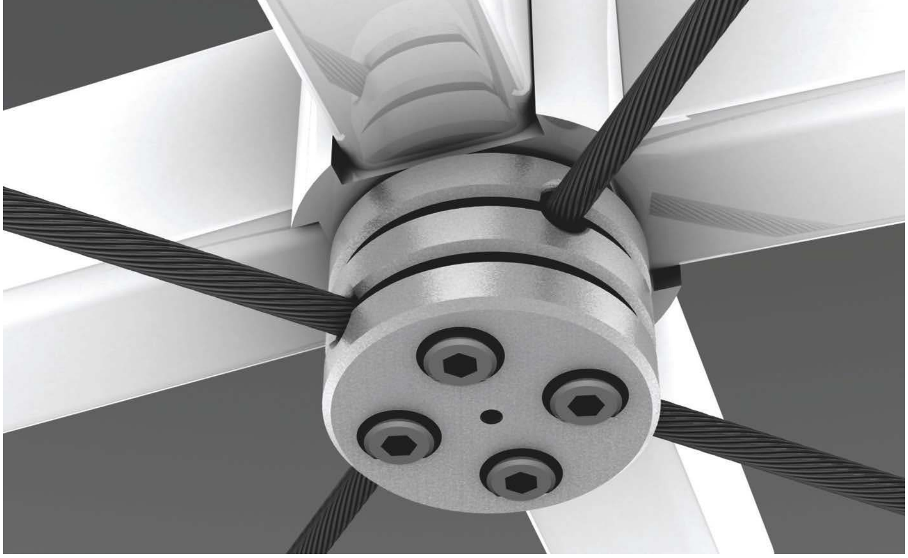
Resolving the span with such a thin shell was difficult and put Novum to the test. The team found the answer in using steel "mullions" to form a structural grid while introducing triangulation of some kind. Possibilities included:

- a full triangulated grid with bolted connections;
- a stiffened orthogonal shell using some double layer construction; or
- a post-tensioned system using a cable triangulation method. To maximize the transparency objective, it became clear that the third option was the best choice.

Triangular glass panels are extremely expensive, so Novum immediately sought to maximize the number of rectangular panels by tweaking the architectural form of the double-curved atrium into a sphere. This allowed for the use of square glass lites of uniform sizes while maintaining non-warping, flat glass panels. Custom panels were required at the perimeter as panels were fit in to the diamond shape borders. The flush-glazed, fully caulked glass panels were attached directly to the steel support structure using a very thin aluminum rafter and an easy-to-install toggle bolt attachment.

While the square grid geometry is ideal for glass economy, it is not stiff structurally and thus cannot be relied on to span large distances. The fully triangulated structural grid would resolve the problem structurally but not aesthetically or within budget. Hence, Novum proposed

Structural component system: an accessory system for the very elegant and lightweight tension stiffening of grids comprised of other Novum structural systems.



Novum Structures

a post-tensioned two-way diagonal system of very thin (14 mm) stainless steel cables using attractive disc-like clamps at each node to secure the tensioning elements to the structural grid. The clamping device allows cable to intersect with some space between, and the effect is to provide a very transparent triangulation of the grid so it acts like a shell and can then thrust to the perimeter. In dealing with this thrust, lateral deflections of the interface of shell to edge condition have to be controlled in order to avoid potential geometric instabilities in the roof. Therefore, most of the perimeter is comprised of vertically cantilevered wide-flange steel beams oriented for stiffness.

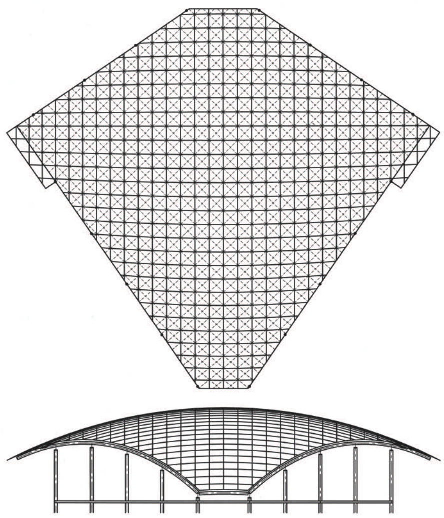
The structural grid spanning the field of the skylight allowed for four-sided support of the glass panels. Thin, rectangular members (3 in. by 5 in.) are attached to block-shaped, forged nodes via a moment-resisting double-bolt connection concealed within the steel tube. This technology takes advantage of very tight tolerance production and the ability of the structural grid to be stiff enough to install without triangulation. Triangulation is later provided via post-tensioning before the glazing is placed. An additional advantage of the mechanically attached grid from an economic and quality standpoint is that it can be prefinished in the factory, eliminating field paint that is less reliable and more costly.

A Milestone is Met

The structure was erected from outside the building in multiple preassembled sections set onto beams and shoring towers established to support the shell at the correct temporary heights. Each new section is tied in the air to the previously installed portions. The extremely tight tolerance production available with the system allowed for the necessary, excellent fit. Then, tension cables were run below the structure and attached via the clamping devices and post-tensioned prior to glazing activities.

"[The skylight] is strong in both load of snow and weather on the top side, as well as uplift and suction from wind," says Todd Halamka, design principal/director of design with HOK. "It creates a very thin, very transparent, visually quiet structure to meet the goal we wanted to achieve for Wrigley: this simple, thin transparent membrane creating a year-round garden that feels like you're outside."

In guaranteeing a budget for the complete glazed structure, Novum took a single-source approach in engineering, sourcing, manufacturing, and installing the complete enclosure, including horizontal and vertical glazing, edge beams, the structural grid system, and all required post-tensioning materials.



Novum Structures

A tilted spherical form and superimposed square grid helped to economize the use of glass panels for the atrium.

The resulting glass and steel structure is an architectural beauty to behold. Its presence is tremendous, yet represents even more than meets the eye. As the enormous skylight in the William Wrigley Jr. building is the first such post-tensioned steel shell ever built in the U.S., it's an appropriate accomplishment when considering the building's use as a Global Innovation Center.

Ian Collins is President of Novum Structures LLC.

Architect
Hellmuth Obata + Kassabaum, Chicago

Atrium System Engineering, Steel Fabrication, and Detailing
Novum Structures LLC, Menomonee Falls, Wis. (AISC Member)

Getting to the Root of the Matter

BY PAT THOMASHEFSKY

Using a more in-depth problem-solving method can be effective in unearthing the true cause of a quality-related issue.

HOW MANY TIMES HAVE WE HEARD OR SAID THE TITLE OF THIS ARTICLE? I WAS THINKING ABOUT THIS WHILE GARDENING THE OTHER DAY. I had a pesky plant; I'm trying to be nice by not calling it a weed. I thought I had gotten it out the week before, but there it was, growing in the same place as tough as ever! If I don't figure out how to rid my garden of these invaders, they are going to pop up all over the place. By just addressing that one plant I will not have looked at the bigger picture. Are they coming up other places? Is there a common cause? In applying some deeper analysis, I may be able to do a better job of fixing the problem than by focusing on just that one weed—er, pesky plant.

So what does this have to do with your business as an AISC Certified Fabricator or Erector? Well, root cause analysis (RCA) is a methodology for finding and correcting the most important reasons for performance problems. It differs from troubleshooting and general problem solving in that those two methods typically seek solutions to specific difficulties, whereas RCA is directed at the underlying issues.

The Right Response

Bad things happen, mistakes are made; these are facts of life. The extent of the damage now, or whether bad things happen again, is a product of how you respond. RCA is by no means a requirement of the AISC Certification program. Within your corrective action program it is generally required that once you realize the non-conformance, you find out the root cause, then determine the remedial action or corrective measure and figure out how you may prevent it from happening again.

However, RCA goes further. It can be used in almost any situation where a gap exists between actual and desired performance. Furthermore, RCA provides critical information about what to change and how to change it within systems or business processes.

Often, without RCA, you may charge ahead with quick-fix solutions that merely sweep the errors under the rug for the time being, only to have them inadvertently revealed at some later date—potentially in some much worse incarnation. What you need is a method that identifies the core issues affecting the performance.

As a business process improvement tool, RCA seeks out unnecessary constraints as well as inadequate controls. In safety and risk management, it can reveal both unrecognized hazards and broken or missing barriers. It also helps target corrective action efforts at the points of most leverage. RCA is an essential ingredient in pointing organizational change efforts in the right direction. If you want your problems to go away, your best option is to kill them at the root.

Five Simple Questions

OK, by now you may be thinking, "I understand what you are saying, but isn't RCA time consuming?" Fortunately, there's a simple tool to help you implement RCA, and once you master this tool you will realize that the benefits far outweigh the costs.

The tool is known as the "Five-by-Five Whys." Asking "Why?" repeatedly is a favorite technique of most three-year-olds in an effort to drive parents crazy, but it can also teach you and your team a valuable lesson in quality. By repeatedly asking "Why?"(five is just a good rule of thumb), you can peel away the layers of symptoms, which can lead to the root cause of a problem. Very often, the reason that appears to be the "true" cause of a problem will lead you to ask another question. You may find that you will need to ask the question fewer or more times than five before you find the answer.

The following is an example of how to use this tool:

- Write down the specific problem. Writing out the issue helps you formalize the problem and describe it completely. It also helps your whole team focus on the same problem.

Pat Thomashefsky is Lead Auditor with AISC Certification. Contact Pat via e-mail at patt@qmconline.org.

Quality Corner is a monthly feature that covers topics ranging from how to specify a certified company to how long it takes to become a certified company. If you are interested in browsing our electronic archive, please visit **www.aisc.org/QualityCorner**.

The Five Whys in Action

Let's say a customer calls a fabricator and complains that the sophisticated painting the fabricator performed in its shop has failed: the paint is peeling from the steel.

Taking this problem through the root cause analysis (RCA) process will show that due diligence was taken on the fabricator's part to prepare the material and apply the coatings according to the manufacturer's and customer's specifications.

Using the Management, Man, Method, Measurement, Machine, Material and Environment (MMM-MMME) model, the **Management** ensured that they understood the customer requirements with a thorough contract and specification review. The **Methods** were in place and followed with documented procedure. The process was performed according to the documented procedures by the **Man** (or woman), and inspection of the process and final product took place and were recorded. The required **Measurements** were recorded and reviewed for correctness. The **Environmental** elements were adhered to, and records kept and reviewed. The **Machine** (equipment) was maintained and in confident working order; preventive maintenance and calibration records indicate this.

At this point, five M's and the E are accounted for, leaving only one M: **Material**. Reviewing the data sheets may show that the material was within specification, but in this case the fabricator did not have the means to test it in-house. With all of the due diligence taken in the other MMMMMME areas the fabricator now has the confidence to consider that the material may be the problem. If this proves true and the fabricator can show due diligence, the problem now is external and the cost of repair shifts.

This is just one example of using a fishbone diagram for RCA. The diagram on QMC's web site is set up as a simple version of this exercise. You can imagine how much more information could be derived if this diagram were expanded upon. Why not apply it to a problem you might have within your business and see how it goes? We'd love to hear whether it was useful.

- ➜ Ask why you think the problem happens and write the answer below the problem.
- ➜ Ask why again and write that answer down.
- ➜ Loop back and ask why until the team is in agreement that the problem's root cause is identified. This may take fewer or more times than five.
- ➜ Using a Management, Man, Method, Measurement, Machine, Material, and Environment (MMMMMME) "fishbone" diagram to list the causes while you are asking the questions will help focus the on where the true cause may exist. (You can find a fishbone diagram on our web site at **www.qmconline.com** under "Resources.")

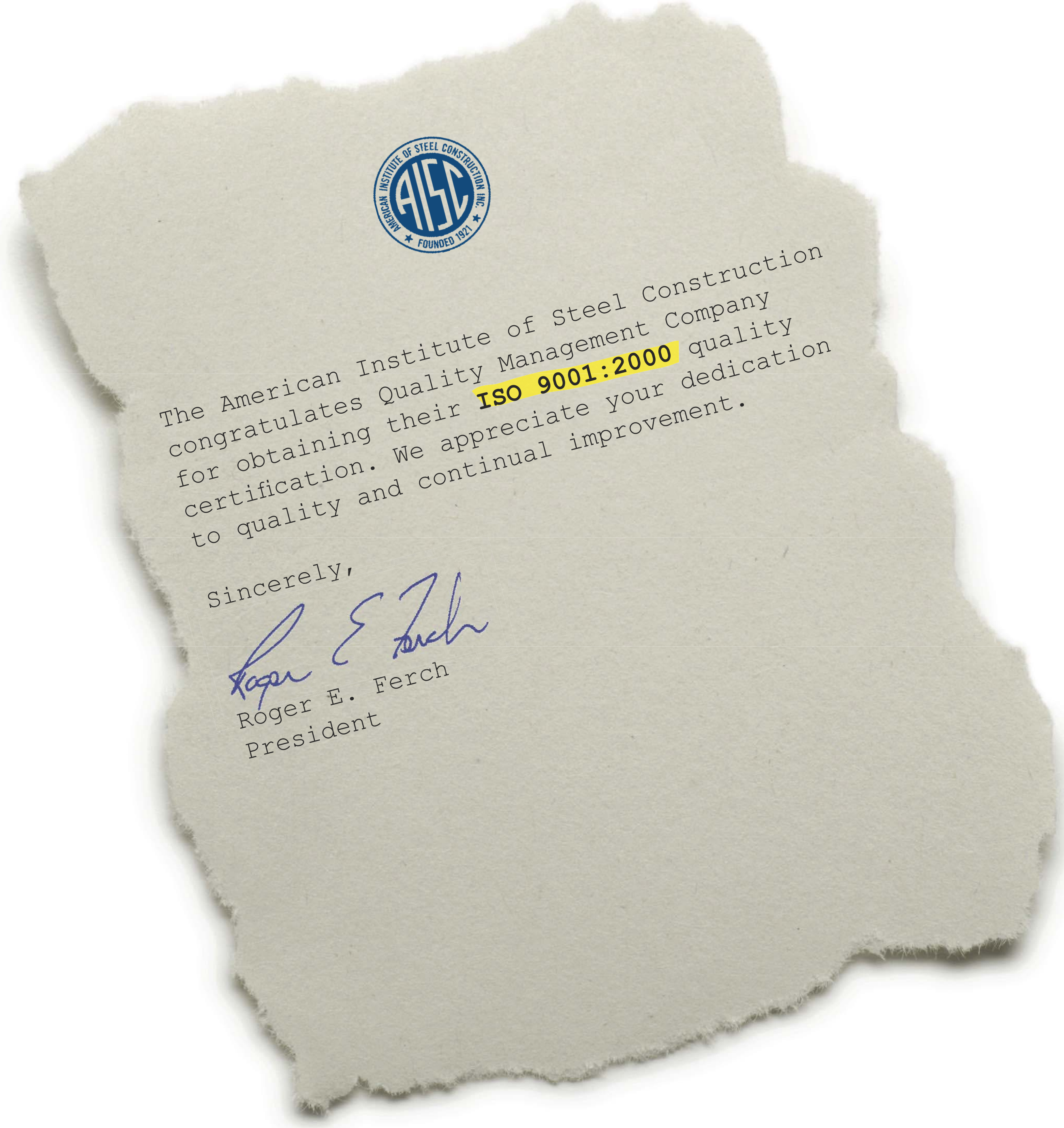
Once you've finished your initial line of questioning and feel you have the cause of the problem, go back to your answer for the first "why" and ask these questions:

1. What proof do I have that this cause exists? Is it solid? Is it measurable?
2. What proof do I have that this cause could lead to the stated effect?
3. What proof do I have that this cause actually contributed to the problem I'm looking at? Even given that it exists and could lead back to this problem, how do I know it wasn't actually something else?
4. Is anything else needed, along with this cause, for the stated effect to occur? Is it self-sufficient? Is something needed to help it along?
5. Can anything else, besides this cause, lead to the stated effect? Are there alternative explanations that fit better? What other risks are there?

The point of these questions is to establish existence, necessity, and sufficiency. Keep asking these five questions for each cause, at every level of questioning. If you diagram all of this, you will end up with a tree of causes leading up to the original problem. Some may be less important than others, but you will have a much more complete picture of the causes leading up to your problem. Even better, you may find a more important cause than previously considered. At the very least, you will have avoided the "straight-line causation" trap.

Visit **www.bill-wilson.net** for more information on the Five-by-Five Whys and root cause analysis. MSC

QMC: Committed to Quality



The American Institute of Steel Construction congratulates Quality Management Company for obtaining their ISO 9001:2000 quality certification. We appreciate your dedication to quality and continual improvement.

Sincerely,

Roger E. Ferch
President

There's always a solution in steel.

American Institute of Steel Construction, Inc.
One East Wacker Drive, Suite 700
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312.670.2400 www.aisc.og

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Solid Answers

COMPILED BY JASON ERICKSEN, S.E.

The Engineering FAQs section of AISC's web site may just have the answers you've been looking for.

SINCE ITS INCEPTION IN 2001, THE AISC STEEL SOLUTIONS CENTER HAS ANSWERED MORE THAN 53,000 TECHNICAL INQUIRIES. As these questions are by no means all unique, we've organized the most-asked ones into 12 categories in the "Engineering FAQs" section of our web site, **www.aisc.org/faq**.

Originally based on the contents of AISC's out-of-print handbook *Engineering Quality Criteria*, the "Engineering FAQs" online have been expanded and updated based on the 2005 AISC specification (**www.aisc.org/2005spec**) as well as common industry practice.

To illustrate the depth and breadth of information that can be found in this section of our web site, we have provided a sampling of our FAQs and their answers:

2.2.4. Is it commonly necessary to mill bearing surfaces after sawing?

No. As stated in the 2005 AISC Specification, Section M2.6, "compression joints that depend on contact bearing ... shall have the bearing surfaces of individually fabricated pieces prepared by milling, sawing, or other suitable means." The 2005 AISC *Code of Standard Practice* Section 6.2.2 Commentary states that "Most cutting processes, including friction sawing and cold sawing, and milling processes meet a surface roughness limitation of 500 per AISI/ASME B46.1." Cold-sawing equipment produces cuts that are more than satisfactory.

2.2.8 To what profile must re-entrant corners, such as corners of beam copes, be shaped?

Re-entrant corners should provide a smooth transition between adjacent surfaces, but generally need not be cut exactly to a circular profile. The recommendation in the the 13th Edition AISC *Manual*, Part 9, is that an approximate minimum radius of ½ in. is acceptable. However, the primary emphasis should be that square-cut corners and corners with significantly smaller radii do not provide the smooth transition that is required. From the 2005 AISC Specification Section J1.6, it is acceptable to provide radius transitions by drilling (or hole sawing) with common-diameter drill sizes (not less than ¾ in.) as suggested in the 2005 Specification Commentary Figure C-J1.2.

When the corner of a cope has been square-cut, a common solution is to flame-cut additional material at the corner to provide a smooth transition as illustrated in Figure 2.2.8-1. Note that the sides of the cope need not meet the radius transition tangentially. Any notches that occur at re-entrant corners should be repaired as indicated in 2.2.7.

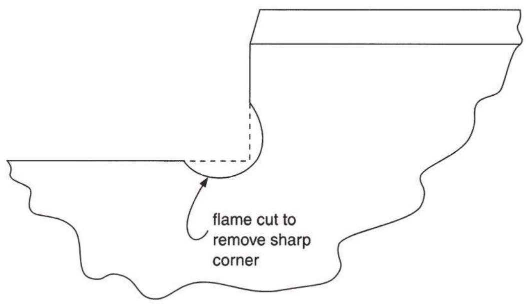


Figure 2.2.8-1

Editor's Note: *FAQ 2.2.7 (not reproduced here) is titled, "When surface roughness for thermally cut edges/surfaces does not meet the limitations in 2.2.6, how is the surface repaired?" FAQ 2.2.7 is available at* ***www.aisc.org/faq****.*

4.6.1. In a built-up I-shaped cross-section, how are welds connecting the plates designed?

Assuming that continuous fillet welds are used, the welds may be minimum size per the 2005 AISC Specification Table J2.4 (fillet welds) if the member is subjected only to axial compression or tension. If the member is subjected to flexure, the shear flow (kips/in.) can be calculated from the beam shear V_u as V_uQ/I and the weld sized to provide for this required strength; Q is the first moment about the neutral axis of the flange area and I is the moment of inertia of the entire cross-section.

4.6.3. What is tension-field action?

Tension-field action is the post-buckling development of diagonal tensile stresses in slender plate-girder web panels and compressive forces in the transverse stiffeners that border those panels. When tension-field action is considered in design, the 2005 AISC Specification G3 provisions apply; otherwise the AISC Specification Section G2 applies.

Editor's Note: Tension field action is most commonly utilized in plate girder design and for special plate shear walls. See AISC's Design Guide 20, Steel Plate Shear Walls *(**www.aisc.org/epubs**) for detailed information on the design and construction of steel plate shear walls.*

5.3.7. In many design examples in the 13th Edition *Steel Construction Manual*, yielding and buckling in a gusset plate or similar fitting are checked on a Whitmore section. What is a Whitmore section?

A Whitmore section identifies a theoretically effective cross-sectional area at the end of a connection resisting tension or compression, such as that from a brace-to-gusset-plate connection or similar fitting. As illustrated in Figure 5.3.7-1 for a WT hanger connection, the effective length for the Whitmore section L_w is determined using a spread-out angle of 30° along both sides of the connection, beginning at the start of the connection. It is applicable to both welded and bolted connections.

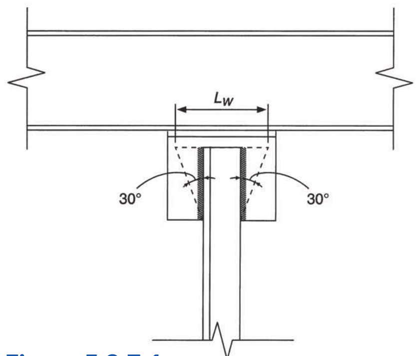


Figure 5.3.7-1

6.5.2. What is the definition of snug-tight bolt installation and when is it allowed?

The 2004 RCSC Specification defines a snug-tightened joint as a joint in which the bolts have been installed in accordance with Section 8.1. Note that no specific level of installed tension is required to achieve this condition, which is commonly attained after a few impacts of an impact wrench or the full effort of an ironworker with an ordinary spud wrench. The plies should be in firm contact, a condition that means the plies are solidly seated against each other, but not necessarily in continuous contact.

It is a simple analogy to say that a snug-tight bolt is installed in much the same manner as the lug nut on the wheel of a car; each nut is turned to refusal and the pattern is cycled and repeated so that all fasteners are snug. Essentially, snug-tight bolts utilize the higher shear/bearing strength of high-strength bolts with installation procedures similar to those used for ASTM A307 common bolts, which are never fully tensioned (see 6.6.2).

*Editor's Note: FAQ 6.6.2, "Can an A307 Bolt be fully tensioned?", is not reproduced here. View it at **www.aisc.org/faq**.*

6.5.4. When should bolted connections be specified as slip-critical?

Slip in bolted connections is not a structural concern for the majority of connections in steel building structures. The 2004 RCSC Specification Commentary Section 4.1 states that: "The maximum amount of slip that can occur in a joint is, theoretically, equal to twice the hole clearance. In practical terms, it is observed in laboratory and field experience to be much less—usually about one-half the hole clearance. Acceptable inaccuracies in the location of holes within a pattern of bolts usually cause one or more bolts to be in bearing in the initial, unloaded condition. Furthermore, even with perfectly positioned holes, the usual method of erection causes the weight of the connected elements to put some of the bolts into direct bearing at the time the member is supported on loose bolts and the lifting crane is unhooked. Additional loading in the same direction would not cause additional joint slip of any significance."

In some cases, slip resistance is required. The AISC and RCSC specifications list cases where connections must be designated by the Structural Engineer of Record as slip-critical:

- Connections with oversized holes
- Connections with slotted holes when the direction of the slot is not perpendicular to the direction of the load, unless slip is the intended function of the joint.
- Connections subject to fatigue or significant load reversal.
- Connections in which welds and bolts share in transmitting shear loads at a common faying surface.

Other connections stipulated as such on the design plans (e.g., from RCSC Specification Commentary Section 4, "(1) Those cases where slip movement could theoretically exceed an amount deemed by the Engineer of Record to affect the serviceability of the structure or through excessive distortion to cause a reduction in strength or stability, even though the resistance to fracture of the connection and yielding of the member may be adequate; and, (2) Those cases where slip of any magnitude must be prevented, such as in joints subject to significant load reversal and joints between elements of built-up compression members in which any slip could cause a reduction of the flexural stiffness required for the stability of the built-up member").

One special case also exists. A nominal amount of slip resistance is required at the end connections of bolted built-up compression members so that the individual component will act as a unit in column buckling. As specified in the 2005 AISC Specification Section E6.2, "The end connection shall be welded or pretensioned bolted with Class A or B faying surface."

6.6.1. What torque is required to fully tension a high-strength bolt?

Torque is an invalid measure for fully tensioned installation, unless it is calibrated. In1951, the first RCSC Specification incorporated a table of standard torque values for the installation of fully tensioned high-strength bolts. However, depending upon the condition of the threads, it was demonstrated that the resulting installed tension varied by as much as plus or minus 40%. It is now known that clean, well-lubricated threads result in tensions that are higher than required (and probably a few broken bolts), whereas rusted, dirty, or poorly lubricated threads result in tensions that are below the minimum required. Therefore, recognition of these standard torque values has long been withdrawn. Accepted procedures for fully tensioning high-strength bolts can be found in the 2004 RCSC Specification Section 8.2 (see also 6.6.3.). If torque is to be used as in the calibrated wrench method as described in the 2004 RCSC Specification Section 8.2.2, it must be calibrated on a daily basis for the lot, diameter, and condition of bolts being installed.

6.6.3. What are the accepted procedures for fully tensioning high-strength bolts?

Provisions in the 2004 RCSC Specification Section 8.2 include four methods for the installation of high-strength bolts in fully tensioned bearing and slip-critical connections: turn-of-nut method, calibrated wrench method, alternative design bolt method, and direct tension indicator method. When used properly, each method can produce properly tensioned high-strength bolts. The use of these methods is described in 6.6.4 (turn-of-nut), 6.6.5 (calibrated wrench), 6.6.6 (alternative design bolt), and 6.6.7 (direct tension indicator).

Editor's Note: *Visit www.aisc.org/faq for FAQs 6.6.4, 6.6.5, 6.6.6, and 6.6.7*

6.9.1. The RCSC Specification discusses a "calibration device capable of indicating bolt tension." What is an example of such a bolt tension calibration device?

One such device is the Skidmore-Wilhelm Bolt Tension Calibrator, manufactured by the Skidmore-Wilhelm Manufacturing Company, Cleveland, OH, 216.481.4774, www.skidmore-wilhelm.com. When a sample bolt is installed in the "Skidmore," the tension is measured on a dial gauge. Thus, the appropriate torque for use in the calibrated wrench installation method may be determined, or the proper tension resulting from the turn-of-nut, alternative design bolt, or direct tension indicator methods may be verified. It is not intended that the use of other similar devices be excluded by this discussion. MSC

Jason Ericksen is the director of AISC's Steel Solutions Center.


MAX
WEISS

What's COOL in STEEL

Every year, *MSC*'s editorial staff puts together a list of interesting and fun people, buildings, structural elements, and other odds and ends associated (sometimes, very loosely) with steel. The items on this year's Cool List range from a skylight based on a famous moment in American history to a wrench with super powers to a massive, intricate gingerbread village. They're all cool and they're all somehow related to steel. Enjoy!

COOL FURNITURE

A Chair With Flair

Imagine watching television in a 180-lb stainless steel chair. Then again, such a chair would probably be more appropriate in a museum than a TV room—if it even existed.

It does. Daniel Libeskind and Toronto furniture designer Klaus Nienkämper have created the new limited edition custom-built Spirit House Chair, constructed entirely of 14 gauge stainless steel with a brushed finish, for the opening of Michael Lee-Chin Crystal, a new addition to the Royal Ontario Museum in Toronto. It can be oriented in five different positions—and can even be used as a side table. Each chair takes 40 hours of labor to complete and has Libeskind's signature etched onto it.

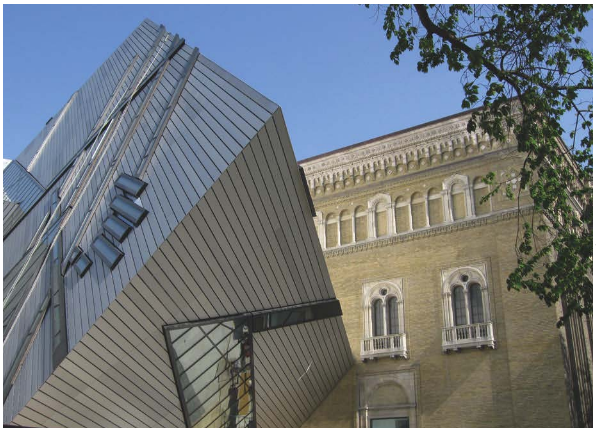
The chair's angular appearance is inspired by the architectural peaks and facades of the Lee-Chin Crystal addition—also designed by Libeskind—a 175,000-sq.-ft aluminium-and-glass-covered steel structure that opened in June and houses seven permanent galleries, a new main entrance and lobby, the ROM Museum Store, Crystal Five (C5) Restaurant Lounge, and special events facilities, as well as Canada's largest space for international exhibitions.

Libeskind's first furniture endeavor, the chair is named after a space within Michael Lee-Chin Crystal (the Spirit House) where the structural support beams unite to form an open space that will be filled with a soundscape reflecting various aspects of the museum. Thirteen Spirit House Chairs reside on Level 1 of the Spirit House, three sit at the front entrance to the Lee-Chin Crystal, and two are on display in the new ROM Museum Store.

And if you decide you need a Spirit House Chair for watching television, they are available for purchase through **www.klausn.com**.

Studio Daniel Libeskind

Above: Daniel Libeskind's Spirit House Chair. Below: The Michael Lee-Chin Crystal addition to the Royal Ontario Museum in Toronto, for which the chair was created.



Royal Ontario Museum 2007

COOL TOOL

Get a Grip

Although we haven't used it to tighten structural bolts, we'd like to have this tool in our garage. Last year LoggerHead Tools LLC introduced the Bionic Grip, an open-ended version of its Bionic Wrench. The tool was the first open-ended wrench to distribute forces 240° over a work surface, automatically fitting multiple sizes of fasteners, pipes, and tubes with the squeeze of a hand.

LoggerHead Tools

Offered in 6- , 8-, and 10-in. versions, the Bionic Wrench features four serrated jaw surfaces and the manufacturer's Interlock mechanism, which stays locked while under torque load and disengages when the force is removed. The tool is well-suited to a wide range of applications that require turning nuts and bolts or pipes and tubes.

The wrench can be gripped in either hand and in almost any orientation. Users can tighten or loosen their work with ratchet-like speed, because there is no need to remove the wrench between turns. When the handles are squeezed, four gripping jaws converge and grab the curved surface of a pipe or the flats of a fastener, distributing force of more than 240°. Combined, all three wrenches cover 35 metric and standard fastener sizes, as well as pipes and tubes from $^5\!/_{16}$ in. to 1¼ in. outer diameter. Learn more about the Bionic Wrench (and see videos of the wrench in action) at **www.loggerheadtools.com**.

COOL SKYLIGHT

Symbol of Freedom

Symbolic buildings are nothing new, but it never gets old seeing well-executed examples—especially when they highlight steel.

The National Museum of the Marine Corps in Quantico, Va. is one such building. The museum opened on November 10, 2006—coinciding with the Marine Corps' 231st anniversary—and contains 120,000-sq. ft of museum gallery space, an orientation theater, office space, a gift shop, and two restaurants.

The heart—and most symbolic portion—of the building is the 150-ft-diameter, conically shaped, steel-framed skylight above the Central Gallery. What makes this skylight so special is that it recreates perhaps the most enduring symbol of the Marines: the 1945 film footage of the raising of the American flag, by a group of four Marines, over Mt. Suribachi on Iwo Jima. The angle of the skylight mimics the "triangular" geometry of the famous moment, when one Marine secured the flag pole into the ground and the other three helped push

Fentress Bradburn Architects

James P. Scholz

it up. A 210-ft stainless steel-clad structural box beam acts as a mast and bisects the skylight at a 60° angle, representing the flag pole. The skylight, along with the aircraft suspended from its structural steel members, weighs 450 tons.

The mast tapers in section from about 15 ft by 7 ft at the base to 4 ft by 3.5 ft at the top, and is framed along its length by a triangular truss and anchored to a 20-ft by 20-ft foundation. It was designed as a hollow spire to lessen its weight and to provide an interior space for HVAC maintenance.

The skylight contains 35,000 sq. ft of glass and is framed by a system of custom-built steel ridge and rib beams, which span from the ring beam and connect to the mast and each other. Lateral bracing between the first and second beams and the fourth and fifth beams consists of stainless steel rod braces that create a triangular truss. Steel stiffeners follow the lines of mullions that hold the glass in place. The still rib and ridge beams are clad in a system of insulated aluminum panels, providing a visual contrast compared to the mast's stainless steel.

While that famous moment in Iwo Jima has been recreated in a more literal sense in the U.S. Marine Corps War Memorial statue, this abstract representation, framed in steel, is equally reverent and stirring.

Erhard Pfeiffer

COOL HOUSE

Home is Where the Steel is

There's always something interesting to look at in Venice, Ca. This vibrant Bohemian area on the Pacific shore just west of L.A. has long been the home of colorful characters, funky businesses, and an artistic vibe.

The 700 Palms Residence fits right in. Designed by Steven Ehrlich Architects, Culver City, Calif., this unique house is framed with structural steel, maximizing not only the openings between the indoor space and outdoor courtyards, but also volume, light, and privacy on a small, urban lot (43 ft by 132 ft). "Raw" materials clad the exterior to help the dwelling fit in with the grittiness of Venice: COR-TEN steel, Trex, copper, masonry, and "flexirock" (stucco). The interior surfaces are left unpainted.

The lot includes a 3,000-sq.-ft. main house with two floors and a mezzanine level, a 1,200-sq.-ft garage/studio/guest house, a lap pool, and three distinct courtyards. The lower level of the main house opens up on three sides via pivoting metal doors mounted on steel slides, transforming the space into an airy pavilion.

The steel (and wood infill) frame structure is outlined by a steel exoskeleton on one side. This structure supports electronically controlled light scrims that roll down horizontally and vertically to shield the front façade of the main house from the sun. Another unique element is a glass bridge—hung on stainless steel cables and supported on a thin steel frame—that connects the mezzanine level to a staircase leading to the upper level and appears to float in midair.

All of these elements add up to an innovative, elegant residence that is supported by and prominently displays steel—and brings an appropriately unusual new icon to the neighborhood.

COOL HOLIDAY PROJECT

It Takes a (Gingerbread) Village

During the winter holidays it seems that every town has one highly decorated house that attracts people in droves. But in Flossmoor, Ill., the house that packs 'em in has its attraction on the inside.

That would be the house of Kurt Gustafson, P.E., S.E., AISC's director of technical assistance, and his wife, Janet. For 33 years now, Janet and Kurt have been constructing an ornate gingerbread village for the holidays.

Photos by Wendy Jimenez

It all started when the Gustafsons moved to Atlanta more than three decades ago. Both being from Chicago, they were used to white Christmases, so Janet decided, "Why not build a gingerbread village?" The first year, it was a much simpler project, with only facades. But, says Kurt, "It just kept growing and growing."

The Gustafsons are once again back in the Chicago area. These days, Kurt estimates, it takes three to four months to assemble the village, which now includes mechanical and moving parts and has each carefully constructed room bursting with Christmas lights, figures, and decorations. All of the snow and icicles on the ground, roofs, and trees are made from real frosting using approximately 50 lb of sugar.

Janet does the majority of the work, Kurt says, and they leave the village up for about two months, meaning that the sun room where they set it up every year is out of commission for about six months. Kurt, who used to run his own engineering company, estimates that about 500 people come through the house every year to marvel at the roughly 4-ft by 12-ft detailed, colorful masterpiece. The theme of the village is different each year, and the last three years there has been a focus on steel (not coincidentally, Kurt has been with AISC for three years). Looking back at all of the villages he and Janet have created over the years, he says his favorite was from a couple of years ago. West Coast structural engineering firm Degenkolb Engineers had sent him a drawing of a seismically engineered gingerbread house, which he and Janet brought to life. They even put it on a shake table and used marshmallows for seismic isolators! (The structure remained intact, even after shaking.)

Last year's village incorporated several Erector Sets and focused on steel fabrication. And the Gustafsons are already at work on this year's village, although it will be a departure from the steel theme. Their house is on the walk for the Cancer Support Society, and Kurt is expecting twice as many visitors as usual this year.

No matter what the theme, every year the village has something for everyone: Kids display the typical child-like wonderment—and are also challenged, as Janet likes to incorporate little things for them to find; last year's project involved tiny alphabet blocks scattered throughout a fabrication shop that spelled out "F-A-B-R-I-C-A-T-O-R," as well as pint-sized versions of AISC publications. Teenagers are inquisitive and ask how certain portions were put together. And adults wax nostalgic. Some have been coming for years and have started bringing their children.

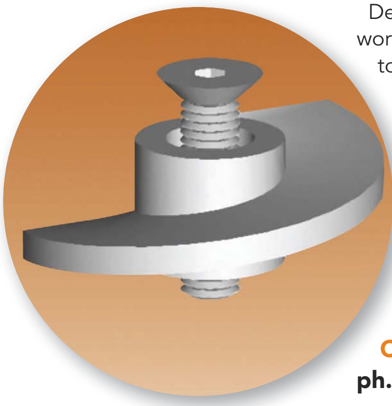
And this is Kurt's favorite part of it all. As an engineer, you might expect that the design and detail are what he enjoys the most. But he says the best part is "seeing the smiles on people's faces."

2007 HOT Products

Machinery, software, tools, and supplies are the steel industry's most important accessories—and innovation among these products can mean faster, more cost-effective steel design and construction. This year's Hot Products are just a sample of some of the creative solutions recently introduced for designers, detailers, fabricators, and erectors. Some offer advanced technology, while others provide simple and practical applications in response to common problems. But all stand out as novel approaches to on-the-job difficulties.

Hot Products were selected by *MSC* staff from products offered by exhibitors at NASCC: The Steel Conference in New Orleans in April. The awards are based on descriptions and claims by the manufacturers; no product testing or evaluation was performed. These awards do not constitute a product endorsement by *Modern Steel Construction* or by AISC.

Floorfix Fastener



Designed to secure steel floor plates from one side, the new Floorfix enables one person, working from above, to position raised pattern floor plates—eliminating the need for access to the underside of the floor plate. The new fastener allows the floor plate to be secured, removed, or repositioned quickly and easily using only simple hand tools. Simple three-step installation includes: 1) assembling the Floorfix clip to the underside of the floor plate and lowering the plate into the desired position; 2) rotating the countersunk screw counter-clockwise with one full turn; and 3) tightening the screw until the plate is securely fixed to the steelwork.

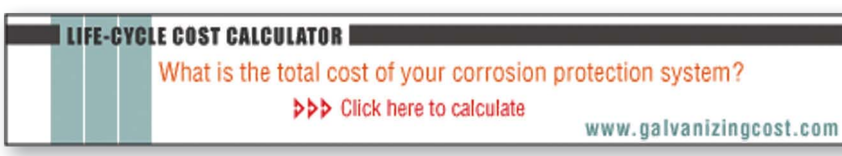
Floorfix is manufactured from ductile iron to standard ASTM A536: Grade 65-45-12 and galvanized for corrosion-resistance to standard ASTM A123/A123M. Three sizes are available—screw diameters of 5/16 in., 3/8 in. and 1/2 in.—to accommodate floor plates ranging from 1/8 in. to 1/2 in. thick and steelwork flanges ranging from 1/8 in. to 5/8 in. thick.

Contact: BeamClamp Division of Kee Industrial Products, Inc., ph. 800.851.5181, www.keeklamp.com

Life-Cycle Cost Calculator

The annual cost of preventable, atmospheric corrosion of steel products is estimated to be 3% to 4% of the gross national product. For the United States, that represents $276 billion. The Life-Cycle Cost Calculator (**www.galvanizingcost.com**) was specifically developed to prevent a specifier from designing projects that contribute to that total cost.

A project's total cost for the duration of the design life is often two to five times greater than the initial cost, and the Calculator is a tool to assist with the decision as to what system is most economical in the long run. Calculating the life-cycle cost for maintenance must consider the impact inflation has on future expenditures and conversely the lost opportunity to invest money used for maintenance at an interest rate over the life of the project. The Life-Cycle Cost Calculator does exactly that, using established financial industry equations and a database of initial cost data for 40 unique corrosion protection systems and specific project input provided by the specifier.



Input required includes the unit of measure, currency designation, coating system being considered, surface preparation method, project size, application method, project design life, and service environment. The result is a direct comparison of the calculated, initial project cost of a chosen corrosion protection system to the initial cost of hot-dip galvanizing as input by the estimator or from the database's national average cost for hot-dip galvanizing.

Contact: American Galvanizers Association, ph. 720.554.0900, www.galvanizeit.org

V630 Structural Drilling System

The Voortman V630 has three high-performance drill spindles with a maximum spindle speed of 2,500 rpm. The spindles are servo driven and have constant torque throughout the full rpm range.

Each spindle is positioned by ball screws that are also servo driven to control exactly the approach, feed per revolution, and retraction of the drill spindles.

Given the speed and feed control via program command, the V630 easily uses carbide indexable drills for superior performance. Feed rates far in excess of 20 in. per minute are easily obtained. Couple this technology with the internal cooling of the drill bit, which is 98% air and 2% lubricant, and the drill can produce holes that look like they have been reamed with no burr in 3 to 4 seconds with no coolant contamination of the material, which can effect welding, painting, blasting, and galvanizing of the beam.

Each spindle has a high-speed tool changer with five tools per axis for a maximum of 15 tools. The tools are measured by laser, so no manual intervention or setting of switches is required by the operator. The lead edge of each piece of material to be run is measured by multiple laser lines to detect miter cuts, straight cuts and pre-coped material. The material is positioned in the "X" axis with a roller-feed measuring system, and the system incorporates two height-adjustable measuring wheels that are positioned at the centerline of the material to be processed, guaranteeing accuracy.

Contact: **Voortman Corporation, ph. 815.935.3010, www.voortmancorp.com**

Ring of Fire

Visitors to this year's NASCC in New Orleans experienced firsthand a new thermal processing technology. The Peddinghaus "Ring of Fire" employs the capacity to effectively process all AISC structural shapes, including beams, columns, angle iron, channel iron, and HSS square and rectangular tubes, as well as plate and flat stock. Thus, all typical functions of today's fabrication shop—sawing, drilling, coping/burning—can now be performed with one machine.

The Ring of Fire employs plasma cutting and precise positioning technologies to obtain precise hole generation; serve as a cut-off device for running multiple sections; provide accurate flange and web surface bevels; achieve all standard AISC

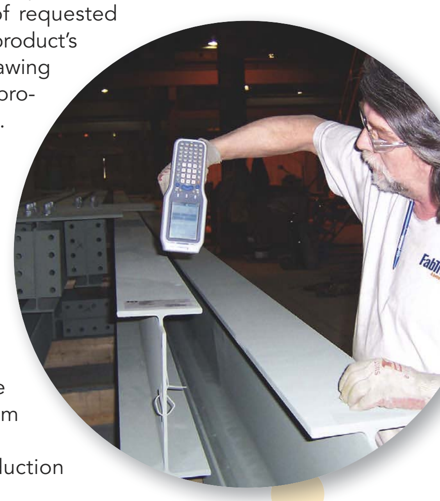
copes and flange thinning; process all interior web/flange cuts for building electrical, heating, ventilation, etc.; and provide part identification to replace laborious shop layout. All of this is available in a compact design that requires a small shop footprint.

NASCC revealed an ongoing trend in the structural industry: a lack of qualified, skilled labor in the fabrication shop. The Ring of Fire effectively combats this problem with the capacity to address many shop functions into one effective, automated system, as well as with its reduction of excessive material handling processes.

Contact: **Peddinghaus Corporation, ph. 815.937.3800, www.peddinghaus.com**

FabTrol MRP Version 2.0

Version 2.0 of this steel fabrication and project management software marks another milestone upgrade. The new release provides a broad collection of requested feature enhancements throughout the product's integrated modules for estimating, drawing management, material management, production control, and shipping functions.



The overriding theme of this release is the new Automated Data Capture (ADC) module. The ADC module is tightly integrated with the production modules and the Shipping Manager module, and provides the ability to both track production progress through the shop and to manage shipping operations, using barcode transactions. The resulting benefits are significant for fabricators as it allows them to:

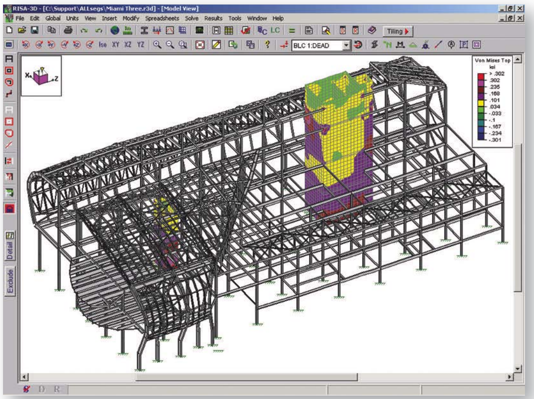
- fully integrate and improve production and shipping operations.
- reduce labor costs and improve accuracy through automated data entry.
- maximize shop throughput and recognize production bottlenecks.
- quickly see the work process in real time and make better decisions.
- increase customer satisfaction by having instant access to project progress.
- improve shipping accuracy and avoid common shipping errors that are often very costly.

In addition, Version 2.0 introduces a powerful new mechanism for tracking assemblies shipped to and from locations other than the job site. It allows fabricators to manage shipments sent to galvanizers and other subcontractors so that everything is delivered accurately and on time to the job site as required.

Contact: **FabTrol Systems, ph. 888.FABTROL, www.fabtrol.com**

RISA-3D Version 7

RISA-3D Version 7 is a significant step forward in the analytical power available to all practicing structural engineers. The proprietary accelerated sparse solver implemented in this latest version has been in development for several years and increases solution speeds by factors of up to 100 or more when compared with current industry standard technology, as well as reduces disk storage requirements by 99% or more. For example, a



model (pictured) that took 11 minutes and required over 600 MB of space to solve using industry standard technology, solves in 6 seconds and requires only 2 MB of space using Version 7. While this new technology is an "under the hood" improvement, it is quite significant in that it makes practical the solution of much larger and more complete models, as well as greatly increases the design engineer's ability to test different scenarios. This usually results in better designs.

Version 7 also adds support for the 2005 AISC specification and 13th edition manual using the Direct Analysis Method, enhanced support for BIM products, and both import and export support of the CIS/2 standard.

Contact: RISA Technologies, ph. 800.332.7472, www.risatech.com

Compact Adjuster

The compact adjuster is a new stainless adjustable fork/clevis end fitting for use with both cable- and rod-tension systems for structural support in architectural and industrial applications. Able to support extremely high yield and break loads for wire sizes from ¼ in. to ⅞ in. in diameter and tie rod diameters from ¼ in. to 1¼ in., it features 316SS strength and corrosion resistance. The telescoping ends provide adjustment in uncompromised proportions while hiding the threads, increasing functional and aesthetic appeal. No midpoint turnbuckles are needed, and with independent adjustment at each end, the compact adjuster reduces installation time by 50%.

Contact: Ronstan International, Inc., ph. 401.293.0539, www.ronstan.com/arch

PythonX Robotic Structural Fabrication System

The PythonX Robotic Structural Fabrication System is designed to help structural steel fabricators automate all their fabrication processes on one machine. Created to replace conventional beam drill lines and band saws for fabrication of structural steel and metal buildings, the machine uses the latest in robotics and plasma technology to fabricate I-beams, channels, HSS, angle, and strip plate. It can produce bolt holes approved for structural joints, cope cuts, slots, cutouts, T-beams, and cut to length, miter cut, and scribe part/layout marks using one robotic plasma torch, eliminating countless hours of material handling. Everything is accomplished on one machine, saving valuable shop space.

Programming the machine consists of taking a DSTV output of a structural member from a standard detailing software package, opening it up in the PythonX, and pressing the Start button. The machine then produces the complete part, with holes, copes, cutouts, and even layout marks for clips and stiffeners, that will be welded to the member. Automating all of the operations that PythonX can accomplish would require several machines, including a drill line, bandsaw, angle line, coping machine, marking machine, and a small burning table, which would cost five times as much and take up five times the shop space.

Contact: Burlington Automation, ph. 905.681.9622, www.pythonx.com

products

CONCRETE PLANK PRODUCERS

Company	Product Description
Cement Industries, Inc. **www.cementindustries.com** **239.332.1440**	Manufactures and installs Spancrete hollow-core plank used in the construction of condominiums, schools, hotels, parking garages, stadiums, warehouses, bridge decks, and many other projects.
Coreslab Structures, Inc. (Atlanta) **www.coreslab.com** **770.471.1150**	Coreslab Structures Atlanta is a supplier of hollow-core slabs for floor and roof systems. They serve the southeastern states and specialize in hotels/motels, dormitories, military housing, detention and justice facilities, manufacturing buildings, schools and universities, and water treatment facilities. Coreslab also has an in-house engineering and erection staff.
Coreslab Structures, Inc. (Orlando) **www.coreslab.com** **407.855.3190**	Manufacturers of hollow-core slabs.
Eagle Precast Company **www.eagleprecast.com** **801.966.1060**	Fabricates 8"- and 12"-thick by 8'-wide Spandeck brand hollow-core plank.
Fintech Precast, Inc. **www.fintechprecast.com** **530.241.8397**	Produces precast concrete wall panels and floor planks. Fintech offers both traditional wet cast and prestressed dry cast panels and planks for a large variety of building types including schools, warehouses, supermarkets offices, churches, theaters, and more. Fintech serves southern Oregon, California, and western Nevada and provides in-house engineering and erection construction.
Gate Concrete Products Company (Florida) **www.gateprecast.com** **904.757.0860**	Produces a full line of prestressed and precast concrete products and serves the southeast United States. Included are 4" to 16" hollow-core plank. Gate produces over 2,000,000 sq. ft of plank yearly.
Gate Precast Company (North Carolina) **www.gateconcrete.com** **919.603.1633**	Produces Gate-Core prestressed hollow-core slabs, which come in various depths and are used as floor and roof units for hotels, motels, dormitories, apartments, prisons, jails, and military housing.
Gate Concrete Products Company (Texas) **www.gateprecast.com** **281.485.3273**	Produces Gate-Core prestressed hollow-core slabs in depths of 4", 6", 8", 10", and 12" that are capable of spanning a distance of 40' and supporting 100 lbs per sq. ft. Gate-Core is used as floor and roof units for hotels, motels, dormitories, apartments, prisons, jails, and military housing.
Iowa Prestressed Concrete **www.iowaconcrete.com** **515.243.5118**	Hollow-core plank in 8", 10", and 12" depths, 4'-0" wide.
Kerkstra/Spancrete Great Lakes **www.kerkstra.com** **800.434.5830**	Produces and erects hollow-core plank products in the Great Lakes region. Kerkstra/Spancrete Great Lakes has a design and engineering team available for assistance in building projects.
Mid-States Concrete Products Co. **www.MidStatesConcrete.com** **800.236.1072**	Providing precast building solutions to the Midwest construction market since 1946. Manufactures and installs precast columns, beams, balconies, Flexicore prestressed concrete slabs, and 4'-wide extruded hollow-core elements, as well as structural wall elements.
Molin Concrete Products **www.molin.com** **651.786.7722**	A Precast Concrete Institute (PCI)-certified facility that manufactures and installs 6"to 16" hollow-core. Molin also produces prestressed beams, columns, stadia, and solid precast foundation walls. With a full-service drafting and engineering department, Molin offers value engineering and design-build support.
Nitterhouse Concrete Products, Inc. **www.nitterhouse.com** **717.267.4505**	Offers ConCoreFloor Structural Flooring plank for residential applications, and ECHO precast hollow-core building systems for commercial applications.
Rinker Materials **www.rinkerprestress.com** **800.840.5847**	Rinker Materials produces 8"-thick hollow-core slabs in 4' to 8' sections, depending on the producing plant capabilities. Contact the plant nearest you for product availability.
Schokbéton **www.schokbeton.com** **450.473.6831**	Extra-long S-p-a-n System planks range in widths of 48" and thicknesses from 6" to 12".
The Spancrete Group, Inc. **www.spancrete.com** **414.290.9000**	One of the Midwest's largest suppliers of precast concrete and a manufacturer of precast concrete products and equipment. Offers multi-product capabilities at all of its precast PCI-certified facilities. Manufactures hollow-core wall panels and plank, beams, columns, tees, wall panels, girders, stairs, sound walls, and customized architectural products. Offers full budgeting, engineering, and design/build services.
StresCore, Inc. **www.strescore.com** **574.233.1117**	Strescore provides precast/prestressed hollow-core panels.
Stresscon Corporation **www.stresscon.com** **719.390.5041**	Stresscon Corporation, founded in 1967, fabricates and erects prestressed hollow-core deck members.
Tulsa Dynaspan **www.dynaspan.com** **918.258.1549**	Tulsa Dynaspan, Inc. (TDI) produces precast/prestressed hollow-core plank at its 46-acre manufacturing site.

AISC Engineering & Research Dept.
Senior Engineer

How would you like to help write the next AISC Manual? If you are looking for the next step in your career, have excellent people skills, and like new challenges, AISC is the place for you. AISC is now seeking applicants for a Senior Engineer position in the AISC Engineering & Research Dept. This is a unique opportunity to apply your design experience in developing AISC's Specifications, Manuals, Design Guides, and other technical publications. You will work with the top engineers, educators and leaders in the North American steel design and construction industry, and will be in a position to establish yourself as an expert in steel design. The position will allow you to use your technical expertise and background to develop tools that benefit the entire structural engineering community and structural steel industry.

Applicants should have a BS degree with structural emphasis in architectural or civil engineering, with an MS or M. Eng. preferred, and a minimum of 3 to 5 years of design experience is required. AISC provides a great working environment offering professional development opportunities, flexibility, excellent resources and a competitive salary with an excellent benefit package.

Send resumes to Cynthia Duncan at **duncan@aisc.org**.

PAPP IRON WORKS, INC.
Misc. Metals Estimator

One of New Jersey's leading miscellaneous iron fabricator/erectors with 60-year history of winning performance seeks an experienced estimator with proven ability. Candidate should have minimum 4 years experience with miscellaneous metal take-offs, pricing and sales. Engineering knowledge helpful. Great opportunity. Full benefits including 401(k), company paid medical and life insurance, plus a signing bonus. Send resume along with salary history to:

Papp Iron Works, Inc.
950 S. 2nd St. / P.O. Box 3149
Plainfield, NJ 07063
E-mail: hr@pappironworks.com Fax 908 757 7590.
www.pappironworks.com

Structural & Misc. Steel Fabrication

Our organization has been recruiting for the Structural and Misc. Steel Fabricating industry for over 20 years. Current positions include:

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Please send resume to:
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United Employment Associates, P.O. Box 8, East Texas, PA 18046
phone: (610) 437-5040 fax: (610) 437-9650
e-mail: rstauffer@unitedemployment.com www.unitedemployment.com

PROJECT ENGINEER

Frazier Industrial, one of North America's largest structural steel racking suppliers has an immediate opening for a Project Engineer/P.E. Candidates must have a current P.E. License and have 5-8 years of experience in the structural racking design. Candidates must have strong computer/technical skills, communication and organizational skills, and strong knowledge of the warehousing/material handling industry.

Candidates must have a B.S. Engineering Degree and a current P.E. License.

Frazier Industrial offers competitive salary commensurate with experience, 401 (k) plan, full medical/vacation benefits, and profit sharing.

Qualified candidates to send resume to: **mmiller@frazier.com**, or mail to:

Frazier Industrial
91 Fairview Ave.
Long Valley, NJ 07853
Attn: Marty Miller, HR Manager
908.876.3001 x316

PROJECT MANAGERS & ENGINEERS

$200 million SLC area fabricator/erector is seeking a senior project manager. Must be capable of managing multiple steel fabrication and erection projects. **Excellent salary and benefits.**

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If you would like to invest in a long-term career, please fax resume and references to:
SME Steel Contractors,
attn: Wayne Searle, Chief Operating Officer, Executive V.P.
Fax 801-280-3460
or e-mail resume and references to:
waynes@smesteel.com

ESTIMATOR

Mid-size fabricator (2,200 ton per year) located in Wichita, KS. Looking for Senior Estimator with experience in Commercial Work (office buildings, shopping centers, schools, churches, etc.). 5-10 years experience is required. Will pay for relocation expenses. Fax or email resume, salary requirements and references to:

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or
rayna@centralsteelinc.com

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ProCounsel, a member of AISC, can market your skills and achievements (without identifying you) to any city or state in the United States. We communicate with over 3,000 steel fabricators nationwide. The employer pays the employment fee and the interviewing and relocation expenses. If you've been thinking of making a change, now is the time to do it. Our target, for you, is the right job, in the right location, at the right money.

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mailbox@procounsel.net

STEEL DETAILER

Boulder Steel, Inc., located along the front range of the Colorado Rocky Mountains in the greater Denver area and one of the largest fabrication shops in the Rocky Mountain Region, is seeking experienced, talented and dedicated **Steel Detailers**. We are looking to add to our experienced team of seven detailers. Utilizing SDS/2, our detailers work on projects ranging in size from the most simple rail designs to complicated buildings in excess of 800 tons. BSI offers excellent pay, great benefits, 401(k), profit sharing, overtime and a relocation allowance. If you are a detailer with at least two years of steel detailing experience, have a two year degree and, preferably, have experience with SDS/2, please respond to this ad! EOE M/F/D/V

Resumes to:
Boulder Steel Inc.
11575 Teller St.
Broomfield, CO 80020
or e-mail: **ahill@bouldersteel.com**

Multi-Division Structural Steel Fabricator

Due to company-wide growth, Steel Supply and Engineering, a division of The Armada Group with headquarters in Grand Rapids, Michigan and facilities in Kalamazoo, Michigan and Indianapolis, Indiana has the following openings.

Structural Steel Project Manager: Grand Rapids, Michigan
Structural Steel Project Manager: Indianapolis, Indiana
Miscellaneous Metals Project Manager: Grand Rapids, Michigan
SDS2 Structural Steel Detailers: Kalamazoo, Michigan
SDS2 Structural Steel Detailers: Indianapolis, Indiana
Miscellaneous Metals Detailer: Grand Rapids, Michigan
Detail Manager: Indianapolis, Indiana
Structural Steel Estimator: Grand Rapids, Michigan
Quality Inspector (Structural Steel): Grand Rapids, Michigan
Quality Inspector (Structural Steel): Indianapolis, Indiana
Plant Accountant: Grand Rapids, Michigan

ASSOCIATE MEMBER

Successful candidates will have:
- At least three-five years experience in the Structural Steel industry.
- Experience managing multiple projects.
- The personality and ability to be an analytical self-starter capable of working in a team environment.
- A customer focused and people orientated personality.
- A proven track record of accomplishments.

Steel Supply and Engineering offers competitive pay with an excellent benefit package. We are looking for people with the personality and skills to join a company geared for growth. For more information go to www.the-armada-group.com.

Send resume to: **chris@mfgsearch.com** or mail or fax to:

mfg/Search
431 E. Colfax Avenue, Ste. 120
South Bend, IN 46617
Attn: C. Villaire
Fax: 574.232.0982

Trans-Tex Fabricating Company

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www.trans-tex.com

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Project Managers - San Antonio
Detailing Dept. Checker - San Antonio
Detailers - Structural in Xsteel

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John C. Schuepbach
jobs@trans-tex.com
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San Antonio, TX 78225
Fax: 210-924-0077

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INDIANA STEEL LOCATED IN SOUTHERN INDIANA IS SEEKING A HANDS-ON BRIDGE AND STRUCTURAL STEEL SHOP SUPERINTENDANT. MUST HAVE A MINIMUM OF 3-5 YEARS SUPERVISORY EXPERIENCE IN AN AISC CERTIFIED STRUCTURAL AND BRIDGE SHOP. HOLDING A CURRENT CWI CERTIFICATE WOULD BE A PLUS OR HAVING THE QUALIFICATIONS AND THE ABILITY TO OBTAIN ONE. COMPETITIVE SALARY AND EXCELLENT BENEFITS INCLUDING HEALTH INSURANCE AND A 401K PLAN AVAILABLE.

PLEASE SEND RESUME, REFERENCES AND SALARY HISTORY TO:

INDIANA STEEL & ENGINEERING CORP.
P.O. BOX 668
BEDFORD, IN 47421-0668
OR E-MAIL: **joew.elliott@iseco-bcs.com**

PLANT MANAGER

We have been supplying our quality product from north Texas to top notch General Contractors, Construction Managers and Owners throughout the U.S. since 1958.

Knowledge and hands on capabilities of all fabrication processes a must which minimally includes the operation of computer controlled equipment, scheduling of all production and the staffing and management of all supervisory personnel.

Please do not bother applying unless you have proven experience multitasking in a fast paced constantly changing structural steel fabrication environment.

Position offers a tremendous opportunity for growth and includes a competitive benefits package.

Send resumes to: **plantmgr@staleysteel.com**

AFCO STEEL

A W & W STEEL COMPANY

Steel Detailing Coordinator: Responsible for the coordination of the technical aspects structural steel projects. Applicant must be able to read and understand design drawings, specifications, and shop drawings, and effectively communicate the requirements of these documents to others. Must be familiar with fabrication and erection practices and have a working knowledge of the AISC *Manual of Steel Construction*. Five or more years experience in structural steel detailing is desirable.

AFCO Steel is one of the nation's leading structural steel fabricators with offices and fabricating facilities in Little Rock and Van Buren, AR, as well as Greeley, CO. This position is for our Little Rock location. Complete benefits package includes: health, life and disability insurance, paid vacations and holidays, Sect. 125 plan, and 401k plan.

Please send resume to:
AFCO Steel
Attn: Human Resources
P.O. Box 231
Little Rock, AR 72203
Fax: 501-340-6215
e-mail: bsnyder@afcosteel.com

EEO M/F/H/V

PROJECT MANAGERS, ESTIMATORS, DETAILERS, CNC PROGRAMMERS

STROCAL, INC. is looking for dedicated and experienced candidates for all aspects of its business including management positions, contracts managers, and shop fabrication. STROCAL, INC. is a Large Structural Steel Fabrication and Erection Company headquartered in Stockton, CA with an additional facility in Eloy, AZ. We offer excellent wages and great benefits.

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www.strocal.com

STEEL DETAILER / PROJECT MANAGER

ExpandingDesign-Build firm has an opening for an experienced Miscellaneous and/or Structural Steel Detailer to work on a wide variety of diverse and interesting projects. Candidate must be proficient in AutoCAD. Project Management experience or knowledge of AutoSD would be a plus. Salary is commensurate with experience. Excellent working conditions: Paid Vacation, Personal Time & Group Health Insurance. Fax your updated resume, along with professional references to: 773-275-0900 or E-mail: michael@chicagoarchitecturalmetals.com

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Chicago, IL 60640

For further information on our company visit our website at:
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Detailer Wanted

We are currently seeking a structural steel detailer with a minimum of 5 years experience with computer detailing. We will train you to use our program. The candidate must be able to work with shop personnel and project managers to get the job done in a correct and timely fashion. We are a fast growing company in Augusta , GA and offer a generous salary package with benefits. Please contact Rocky at 706.560.0107 or e-mail him at **rockyr@americanmetalsga.com**.

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Project Manager/Detailers/Checkers

SteelStar Corporation is an aggressively growing detailer/fabricator/erector (16-20 Million/Annually) in the Denver Metro area along the beautiful Front Range of Colorado.

Project Manager ($65-95K Annually)
We are currently seeking an aggressive and skilled project manager with experience in low to mid rise commercial/industrial, miscellaneous and architectural/ornamental metals projects from 500-2000 Tons.

The successful candidate must have a minimum of five years experience in construction project management. Requirements to include, but are not limited to; excellent computer/technical skills, organizational skills, scheduling skills and documentation skills as well as great communication and customer service skills. Most important of all, the successful candidate must have a great attitude! An Associates or Bachelors degree is required; this may be waived in lieu of experience. Relocation to Colorado Required. Must have excellent references and project track record.

Detailers/Checkers ($15-$35 Per/Hour)
We are currently seeking (3) skilled Tekla (Xsteel) and (4) AutoCAD/AutoSD detailers & checkers with experience in low to mid rise commercial/industrial, miscellaneous and architectural/ornamental metals projects up to 2000 Tons.

The successful candidate must have a minimum of (3) year's structural and/or miscellaneous steel detailing experience. Requirements include, but are not limited to; excellent computer/technical skills and Tekla or AutoCAD experience. Most important of all, the successful candidate must have a great attitude! Relocation to Colorado Required. Candidate must be able to provide excellent references and drawing examples. All candidates must be currently eligible to work in the United States.

We offer the security of a financially stable company, profit sharing, competitive wages, relocation reimbursement, medical benefits, 401K, paid holidays and paid leave time, and most of all, a fun place to work with opportunity for advancement. Please send resume to: SteelStar Corporation, P.O. Box 218 - Dacono, CO 80514 Attn: Employment - Fax 303.828.4092 or email employment@steelstar.com. Visit us @ www.steelstar.com.

The Steel Deck Institute – Technical Director

The Steel Deck Institute (SDI), the trade association responsible for setting standards for the steel deck industry, is currently seeking qualified candidates for the position of Technical Director. The Technical Director is responsible for coordinating the Institute's technical committees and research programs, the presentation of technical seminars, representing SDI and participating in activities of other organizations such as AISI, AISC and ICC, providing engineering assistance to design professionals and managing special projects such as updating ANSI/SDI standards.

Qualified candidates should possess a BS in Civil or Structural Engineering. Professional Engineer's License or the ability to be registered is required. Experience in cold-formed steel design or metal building industry is also a plus. Strong communication, organizational, presentation and computer skills a must as well as the ability to work with limited supervision. Relocation to the Chicago, IL suburban area is preferred.

We offer a competitive compensation package including medical insurance and paid vacation.

Applicants should mail, fax or email resumes (in confidence) to:

Steel Deck Institute
Attention: Steven A. Roehrig, Managing Director
P.O. Box 25
Fox River Grove, IL 60021-0025
847-458-4647 (fax) 847-458-4648
email: steve@sdi.org

JOURNEYMAN WORKING FOREMAN

Ready for a change? Seeking more opportunity and responsibility? Small but established Northwest fabricator seeks person to lead a crew producing structural products requiring Cbr certification and FC endorsement.

Minimum requirements:

- 10 years of varied production experience in structural steel.
- Expert in reading blueprints and an English-unit tape measure.
- Ambitious.
- Relevant leadership experience.
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- Legal US resident.

Pay is $1,000 per week. Subsidized health insurance, paid vacation, profit sharing.

ADDISON Corporation
Bend, OR 97708
FAX resume to (541)389-9668

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, INC. AISC FOUNDED 1921
ACTIVE MEMBER

THE FUTURE IS NOW

RISA-3D VERSION 7

The new features in RISA-3D Version 7, from the implementation of the latest design codes to a faster, more robust sparse solver, enable engineers to work more productively and stay ahead of the competition.

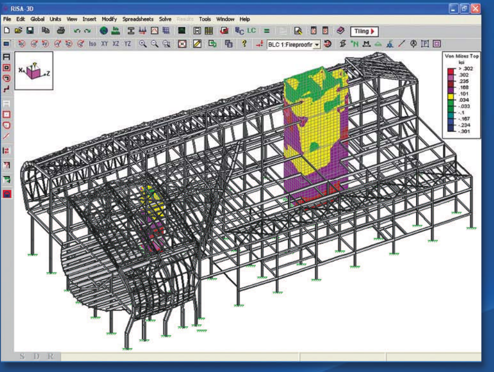
AISC 13TH EDITION STEEL CODE

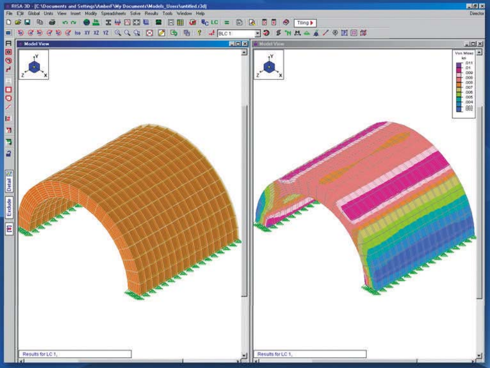
RISA-3D Version 7 incorporates the new Direct Analysis Method of the AISC 13th Edition. This version allows users to design for either the ASD or LRFD requirements of this new steel code.

ACCELERATED SPARSE SOLVER

RISA-3D Version 6 used a Skyline solver, which is the current industry standard. The new accelerated sparse solver offered in RISA-3D Version 7 can solve models up to 100 times faster, making RISA-3D the future of structural analysis.

The Concourse J of the Miami International Airport took nearly 11 minutes to solve and required more than 600 MB of storage space using the current industry standard solver technology. The accelerated sparse solver in RISA-3D Version 7 solved the same model in 6 seconds and required only 2MB of storage space. That's more than 100 times faster!





SOLID ELEMENTS

RISA-3D Version 7 now offers 8-node solid elements which opens a whole new range of modeling and analysis possibilities. This new element combined with RISA-3D's automatic meshing features opens up a whole new world of modeling and analysis possibilities!

Integration with RISAFoundation and Revit Structure 2008 as well as the implementation of the 2005 NDS wood code make RISA-3D Version 7 the right choice for today and for the future.

Try RISA-3D today and see how good structural engineering software can be!

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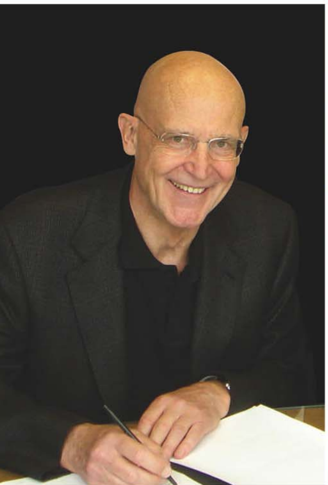

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Using Nonlinear Analysis

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- ***Fiber Cross Sections, Shear Links, Panel Zones and Braces***
- ***Bending and Shear Behavior of Walls, Including Coupled Walls***
- ***ASCE 41 (FEMA 356) Guidelines and Criteria***
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