MODERN STEEL CONSTRUCTION

December 1994

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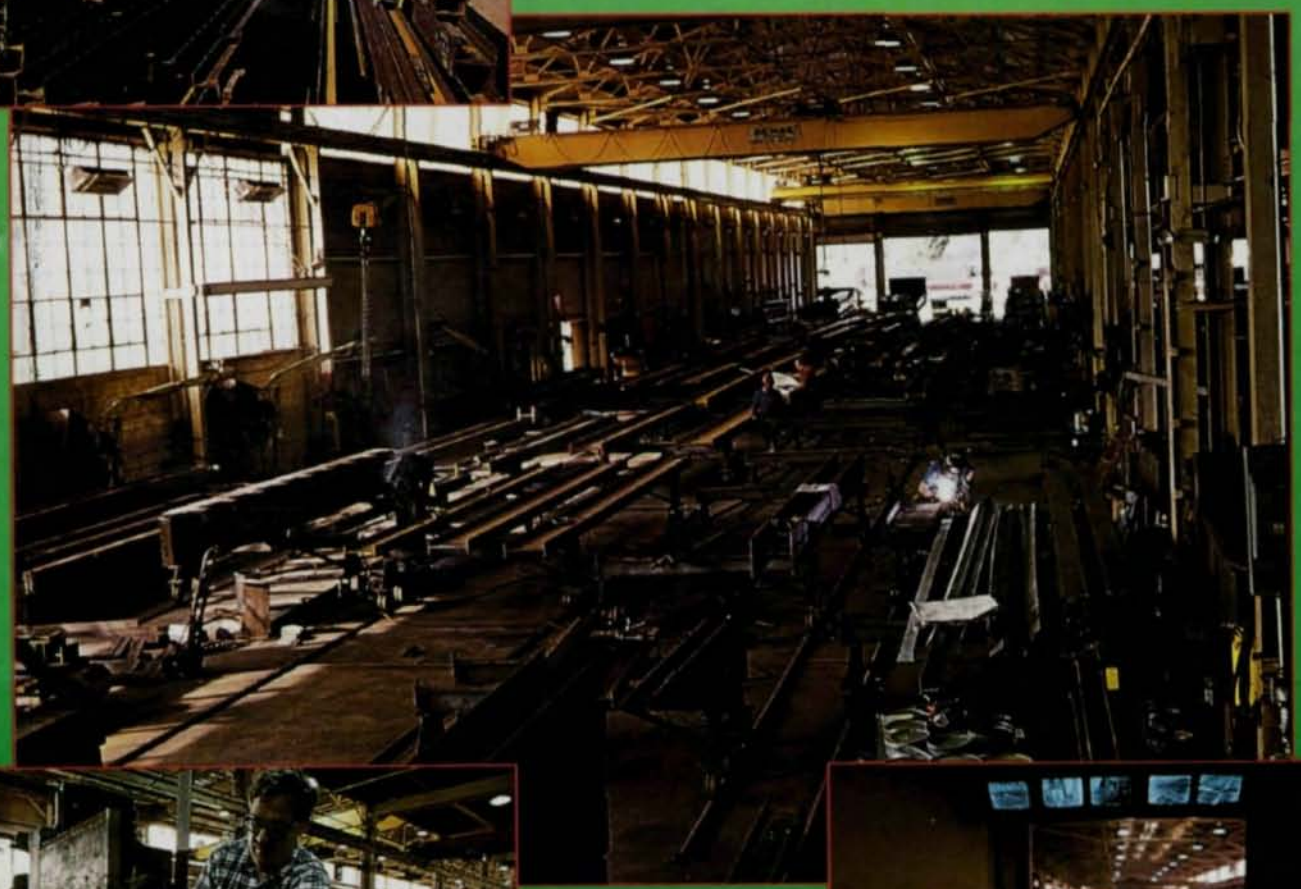
AISC Quality Certified Fabricators



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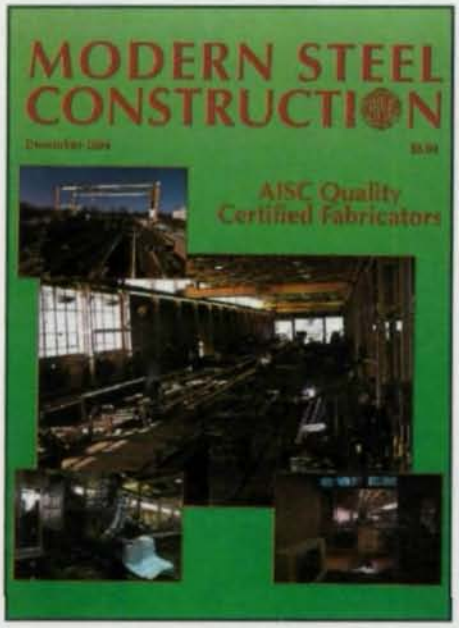
Volume 34, Number 12 December 1994



A listing of AISC Quality Certified Structural Steel Fabricators begins on page 32. Shown on the cover are four views of Interstate Iron Works, a New Jersey fabricator with a Type II certification.

FEATURES

DEPARTMENTS

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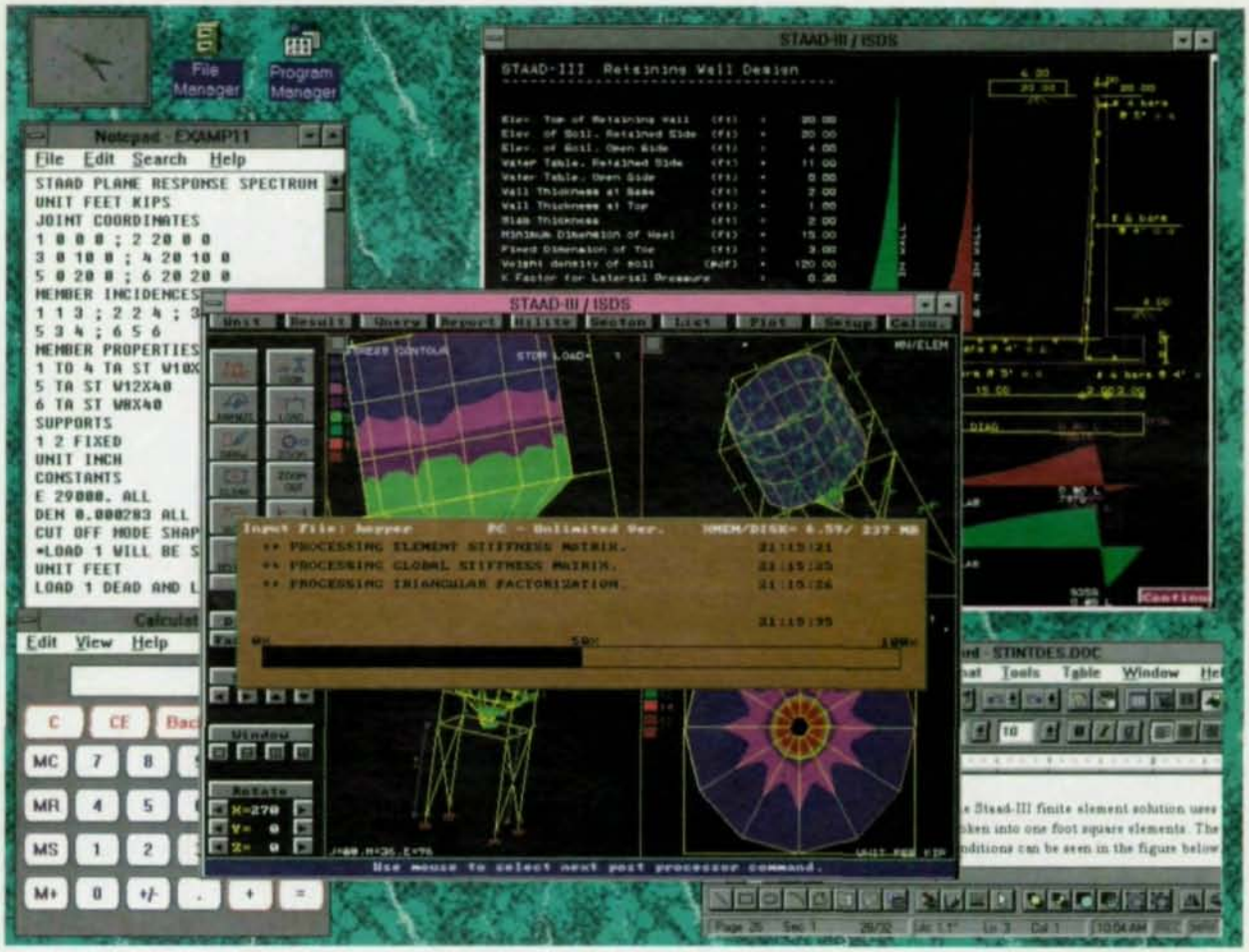

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PREQUALIFICATION

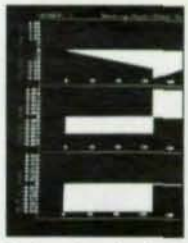
WHILE MY VOCATION IS EDITING THIS MAGAZINE, MY AVOCATION IS COLLECTING KALEIDOSCOPES. Whenever I contemplate purchasing a new edition to my collection, I carefully examine the scope, considering such factors as the way the mirrors are joined, the quality of the exterior, the beauty of the objects in the interior viewing chamber.

One advantage I have in purchasing a scope is that I can examine and evaluate the finished product. And, I'm never under a time constraint to choose a scope. If I don't find one that I love one day, I simply won't buy one. Unfortunately, when choosing a structural steel fabricator, owners, contractors and engineers don't have the luxury of purchasing a finished product; nor can they simply decide to put off hiring a subcontractor. If time and money are available, it's possible to interview several previous clients, to examine work in progress and even to inspect numerous fabricators' shops. Practically speaking, however, few professionals have the resources to undertake this daunting assignment.

Fortunately, there is an alternative. While no one can guarantee the quality of work on a future project, AISC does administer a Quality Certification Program that inspects fabrication shops to ensure they are capable of performing a specified level of work. This month, for the first time, MSC is publishing the entire listing of Quality Certified structural steel fabricators. The listing includes type of certification, plant location, a marketing contact and a phone number. In addition, the listing is followed by a breakdown of certified fabricators by state. The discussion of the Certification program on page xx goes into detail about what is involved in certification and what the different levels of certification mean. It also includes information on changes being made in the program in 1995 to further enhance the reliability of the program.

While it is undoubtedly true that you can find a good fabricator who is not certified, requiring AISC Quality Certification certainly simplifies the process. **SM**

How to get from here



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STEEL INTERCHANGE

Steel Interchange is an open forum for *Modern Steel Construction* readers 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 to solve, please forward it to *Modern Steel Construction*. At the same time, feel free to respond to any of the questions that you have read here. Please send them to:

Steel Interchange
Modern Steel Construction
One East Wacker Dr., Suite 3100
Chicago, IL 60601-2001

Answers and/or questions should be typewritten and double-spaced. Submittals that have been prepared by word-processing are appreciated on computer diskette (either as a Wordperfect file or in ASCII format).

The opinions expressed in *Steel Interchange* do not necessarily represent an official position of the American Institute of Steel Construction, Inc. and have not been reviewed. It is recognized that the design of structures is within the scope and expertise of a competent licensed structural engineer, architect or other licensed professional for the application of principals to a particular structure.

Information on ordering AISC publications mentioned in this article can be obtained by calling AISC at 312/670-2400 ext. 433.

The following responses from previous Steel Interchange columns have been received:

What type of framing is considered bracing the compression flange?

The answer depends on how the member is loaded. If the member receives lateral load directly into its compression flange, such as a crane beam, it could be capped with a channel or other suitable means. Other examples, in building construction, of directly attached lateral support include formed metal deck, grating (welded in place) and shear connections in composite construction.

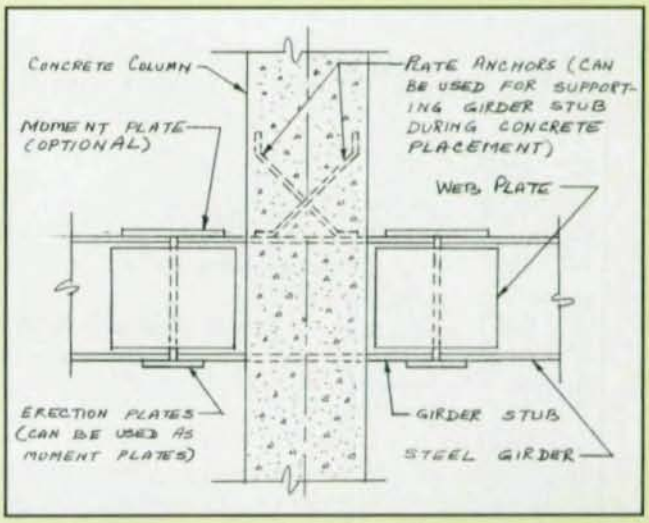
If the member receives no significant lateral load, and support is required primarily to keep the member in its intended plane, sub-framing can supply the needed support. The sub-framing need not attach directly to the compression flange. There are many examples of this in reliable service today. However, engineering judgement must be exercised. In the questioners example, the intended support was at mid-depth of a 10-in. deep beam, i.e. 5-in. from the compression flange and may not have provided the necessary lateral support to the flange because the resisting forces needed to travel through a relatively thin beam web. But a 40-in. beam, braced 5-in. from its compression flange might be okay. Everything is relative and must be judged accordingly. I am unaware of any literature that would assist in the judgement.

David T. Ricker
Payson, AZ

What is the most efficient and cost-effective way to connect a steel wide flange girder to a concrete column?

A conceptual scheme to connect a wide flange steel girder to a concrete column is presented in the Figure.

The proposed method of embedding a girder stub in the concrete column will require careful attention during the concrete placement, but it will offer a convenient way of making the desired connection. The length of the girder stub will depend on the type of the connection required.



Vijay P. Khasat, P.E.
Clinton, OH

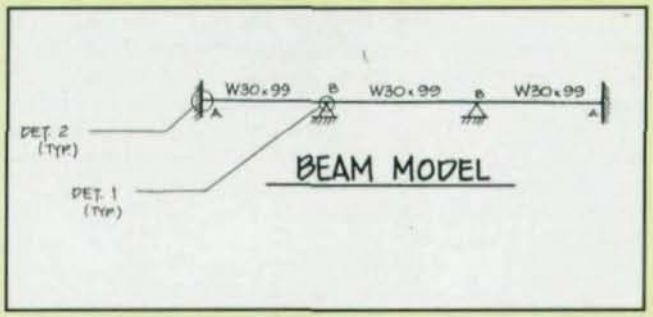
Can an existing steel beam and concrete slab be made to work together in composite action by adding studs to the steel through cored holes?

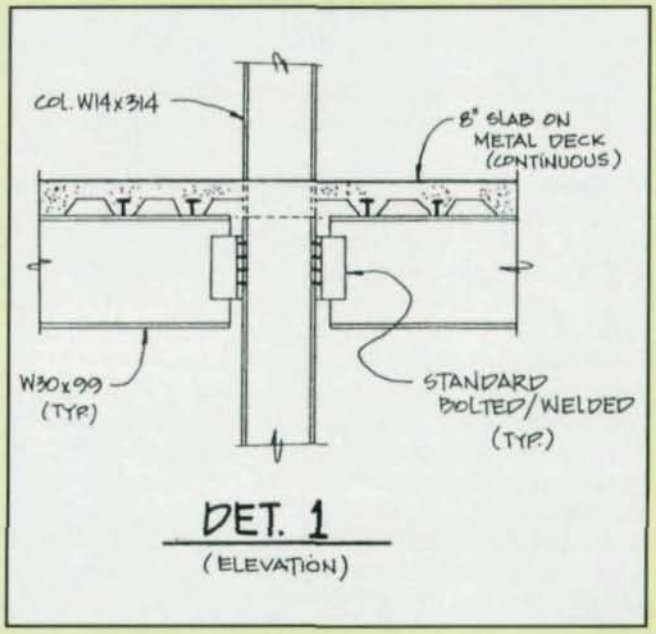
The answer given in the October 1994 Steel Interchange presents an alternative solution to composite action; many existing situations will not allow an increase the depth of the member because of interferences with existing ductwork or telephone and electrical conduits. Cutting off HVAC and communications for tenants below can be extremely expensive, if not unacceptable. The idea of making an existing slab and steel beam composite makes a lot of sense. The work would be done from above the beam, in the space being retrofit. Disruption to tenants below would be minimized.

I have considered the possibility of creating a

composite section out of a non-composite system, although I have never had an opportunity to put it into practice. I would consider all loads presently on the beam to be acting on the bare steel and the proposed live load to be acting on the composite section. The slab should be cored to a diameter such that the stud welding gun will fit into the core. The studs should be tested with a hammer, then grouted in with an expansive grout with at least the strength of the slab. The in-place slab strength should be determined for use in the design.

Joe DeReuil, P.E.
Baskerville-Donovan, Inc.
Pensacola, FL





NEW QUESTIONS

Listed below are questions that we would like the readers to answer or discuss.

If you have an answer or suggestion please send it to the Steel Interchange Editor, Modern Steel Co nstruction, One East Wacker Dr., Suite 3100, Chic ago, IL 60601-2001.

Questions and responses will be printed in future editions of Steel Interchange. Also, if you have a question or problem that readers might help solve, send these to the Steel Interchange Editor.

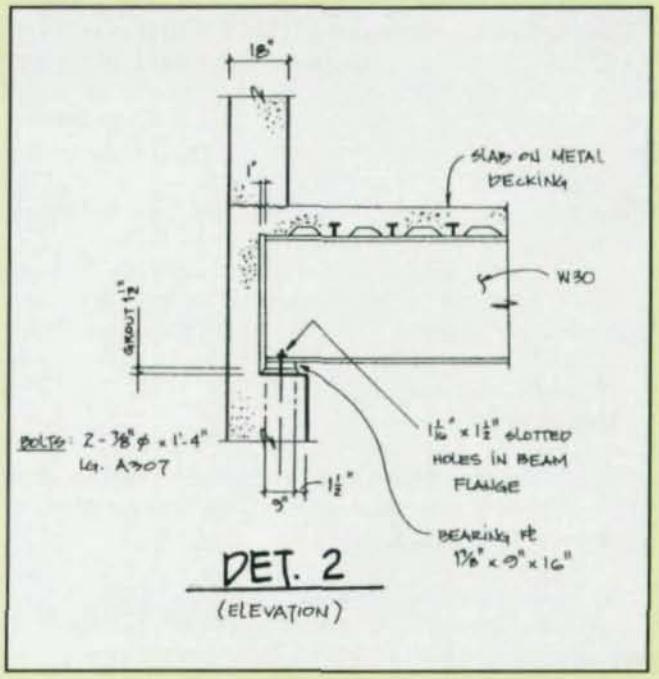
When making a wide flange section out of three plates, can you weld on only one side of the web?

Are there any impact loading requirements for forklifts in industrial applications?

What are the installation requirements for A307 bolts?

In what instances, if any, can the design of the composite beam shown in the figure at right, be treated as a continuous beam at point B and fixed at point A.

Morgan Clack
Scottsdale, AZ



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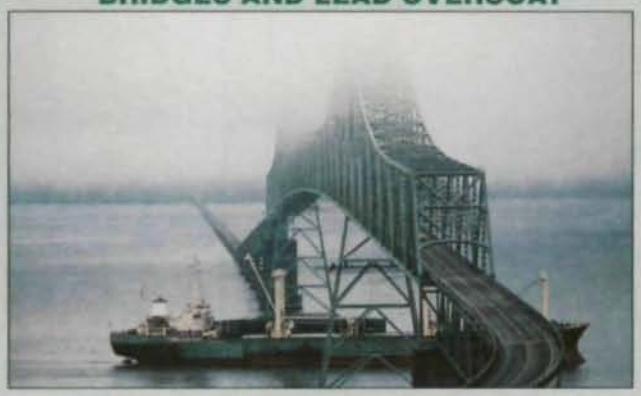

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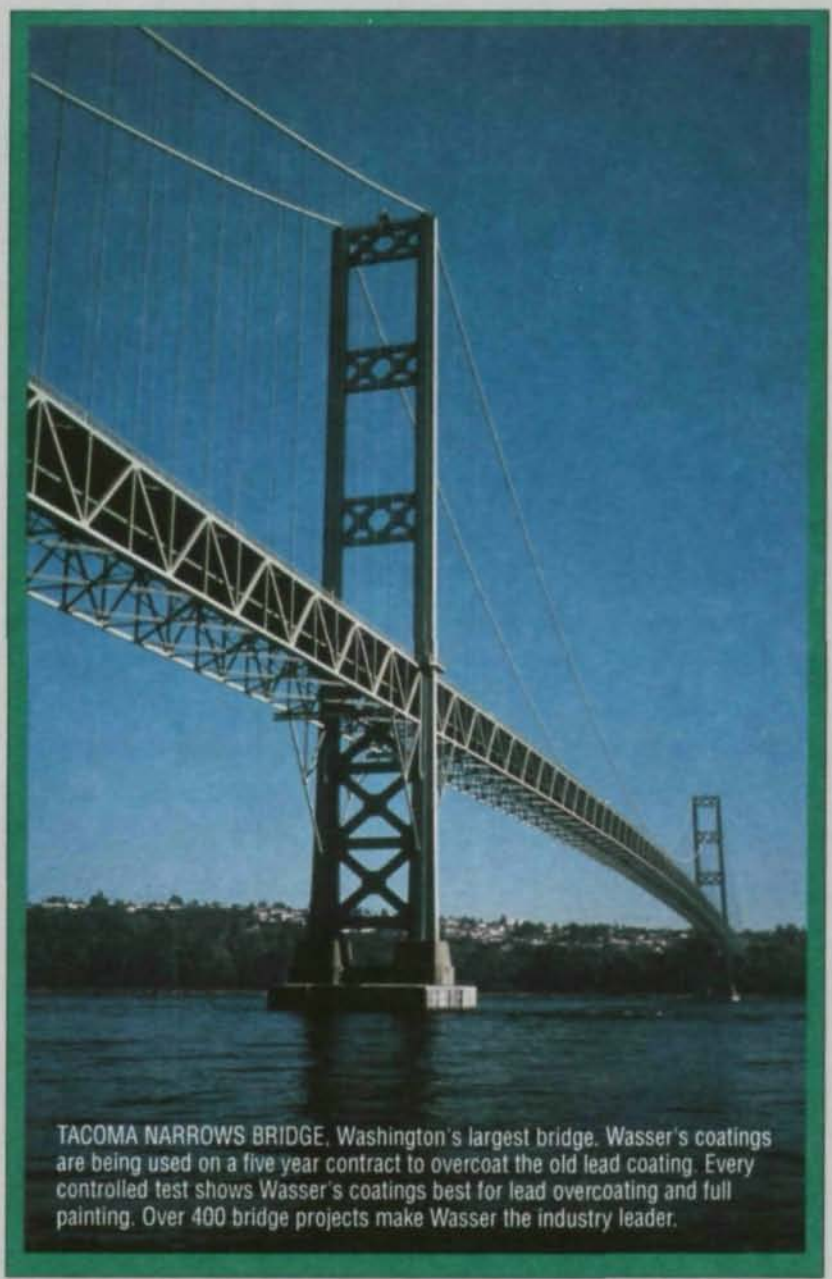

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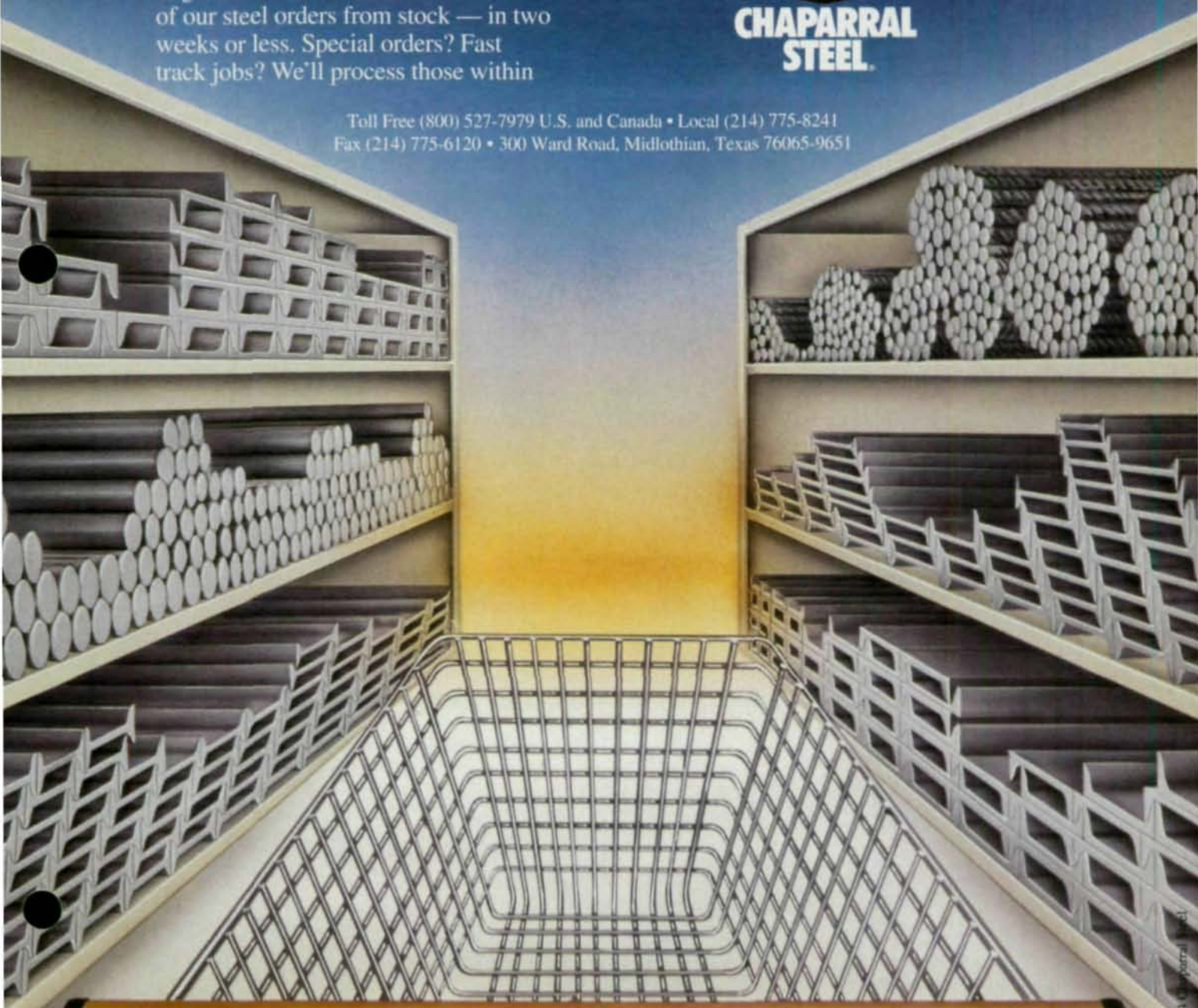

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NSCC To Expand In 1995

In addition to its traditional audience of structural engineers and fabricators, AISC's National Steel Construction Conference is opening its doors to construction managers in 1995. The conference, scheduled for May 17-19 in San Antonio, TX, will feature four professional tracks: Construction Management; Steel Fabrication; Structural Engineering; and Engineering Management. In addition, the conference will include a product exhibition with nearly 100 booths.

"We wanted to expand the conference to involve more of the construction industry," explained Franklin B. Davis, chairman of the AISC NSCC Committee and president of Precise Fabricating. "It's an exciting change that will put more life and spirit into the program."

While seminars are assigned to a specific track, show organizers stressed that there is no additional charge for crossing from one track to another. Registration for the show costs $320 ($270 for AISC members) and includes admission to all seminars and general sessions, as well as the trade show. To receive a registration packet, write AISC, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001 or call 312/670-2400.

A highlight of the construction management track is expected to be a seminar on constructability issues. This seminar is based on research conducted by the Construction Industry Institute and will emphasize the integration of construction knowledge and experience into all phases of a project, including conceptual planning, design and procurement and field operations. Another hot topic is the session on bar coding for material management. In addition, seminars are scheduled on TQM and team building/partnering.

For fabricators, a variety of sessions are scheduled ranging from economical painting methods to the fabrication of hollow structural sessions. In addition, seminars will cover OSHA training, EPA legislation, improving plant performance, new fabrication equipment and methods, and flame straightening technology.

The structural engineering side of the conference also promises to be exciting. New seminars will be offered on two of the most popular subjects from previous years: industrial building design and connections for hollow structural sections. Another topic that should attract a big audience is a session on reducing structural steel costs. This seminar will offer practical "rules-of-thumb" for minimizing fabrication and erection costs, as well as requirements for structural painting. On a more narrow scope, seminars will be presented on steel construction in Mexico and on weldability, fracture mechanics and metallurgy. And finally, a session will be presented on seismic design solutions after the Northridge earthquake.

The new Engineering Management track at the conference will offer seminars on: Protecting your firm from lawsuits; Effective project specifications; Steel erection awareness; and Inspection of welded and bolted joints.

Conference co-sponsors include: American Galvanizers Association; AISI; ASCE; AWI, AWS, Canadian Institute of Steel Construction; Construction Industry Institute; Council of American Structural Engineers; Edison Welding Institute; Mexican Institute of Steel Construction; NEA; NISD; SDI; SJI; Steel Plate Fabricators Association; Steel Service Center Institute; Steel Structures Painting Council; Steel Tube Institute of North America; Structural Engineers Association of Texas; and Texas Structural Steel Institute.

AISC Postpones Steel Bridge Competition & Bridge Symposium

AISC's Prize Bridge Competition, as well as the National Steel Bridge Symposium, have been postponed from 1995 to 1996.

According to Fred Beckmann, AISC's Director of Bridges, the decision was made as a courtesy to the Transportation Research Board and their International Bridge Engineering Conference, which was previously held in 1978, 1984 and 1991. Next year's conference is scheduled for August 28-30 in San Francisco.

The TRB conference, "Extending the Life Span of Structures," provides a forum for the exchange of bridge research results and technical information on planning, design, construction, repair, rehabilitation, replacement, and maintenance of vehicular bridges. The conference will focus on problems and solutions of interest to engineers and administrators of highway, railroad, and transit agencies.

The conference is being sponsored by the Federal Highway Administration and registration costs $300.

For more information, contact: Fourth International Bridge Engineering Conference, Transportation Research Board, National Research Council, 2101 Constitution Ave., N.W., Washington, DC, 20418 or call 202/334-2933.

The National Steel Bridge Symposium, along with the AISC Prize Bridge Awards, will return in the fall of 1996. More information will be available late next year.

LOCK REHABILITATION

Replacing six taintor gates in Upstate New York required careful project coordination

By H. Daniel Rogers, P.E.

AFTER MORE THAN 80 YEARS OF SERVICE, PARTS OF THE NEW YORK STATE CHAMPLAIN CANAL needed renovation. The canal connects the Hudson River with Lake Champlain and is actually channelized within the river for over half its length. Lock C-1 is located just north of Waterford, NY, where the canal begins, and consists of a long concrete dam/spillway and six steel taintor gates with piers in addition to the lock itself.

Taintor gates serve two main purposes. First, in the closed position, they may be used to regulate the upper pool water elevation, allowing commercial and recreational river traffic to navigate the canal during the navigation season (May through December). Second, in the open position, they allow the canal to be drained for the winter and allow high river run-off to pass in the spring, thus reducing flooding of adjacent areas.

A primary emphasis of the recent project to rehabilitate Lock C-1 involved replacement of the six radial arm taintor gates and their concrete piers. Other work included rehabilitation of the spillway and replacement of the upper and lower miter gates in the lock. Since two taintor gates had to be kept operable at all times for potential flood control, the work was staged. Three existing gates were removed, and two new gates were installed during the first stage. During the second stage, the remaining three gates were removed and the other four were installed. All construction on the taintor gates and piers was performed in the "dry" within a cellular cofferdam network.

Further complicating the project was the historical nature of the taintor gates. Links to our engineering forefathers, they were among only a few counterweighted, hand-operated gates left in New York State.

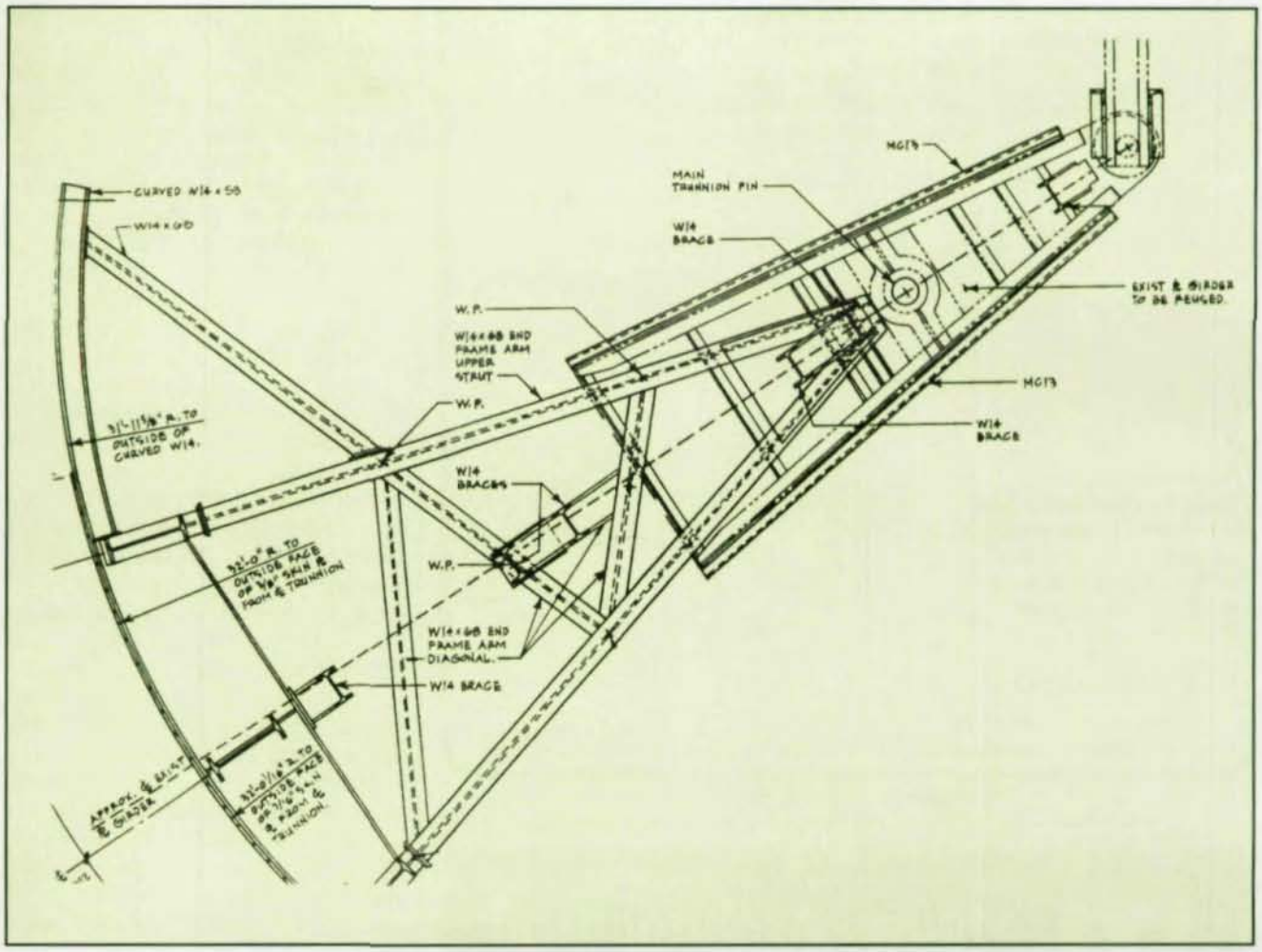
EXISTING CONDITIONS

Each existing gate consisted of a curved steel skin plate assembly with supporting trusses counterbalanced by a concrete counterweight, resembling a giant see-saw. The skin plate was curved to ensure that the hydrostatic pressure was aligned with the gate arms at all times regardless of the gate's position. Anchored on posts, the massive counterweight followed a vertical path as the gate opened and closed. These posts supported the counterweight well above the high-water elevation so as not to restrict water flow at flood levels. A rack and pinion gearing system, driven from both sides of the gate by a pair of "Captain's wheels," allowed the gates to be opened and closed manually.

Due to the historical significance of the gates, the New York State Historic Preservation Office urged that they be rehabilitated rather than replaced. However, after a thorough field inspection and careful consideration, it was deemed impractical to save the skin plate assemblies and their supporting trusses. Many truss members were severely corroded, several were completely severed, and numerous small holes were detected in the skin plates. As a compromise, it was decided to restore and reuse the existing end frame plate girders, the pedestrian walkway and the counterweights, thereby maintaining some usable, as well as visual, elements of the operating equipment.

NEW GATES

Each of the six gates is approximately 50-ft. long by 18-ft. high with skin plates of 22 ft. by 50 ft. Replacement of all six gates required more than 100



tons of steel. Each gate is counterbalanced by a 115-ton concrete counterweight. Horizontal and vertical loads are transferred to the concrete piers through trunnion pins on each side of the gate. A combination of precast and cast-in-place concrete was creatively used to replace the piers.

Each taintor gate is comprised of a skin plate supported by end frame arms on either side, extending to a 32-ft. radius. The $^{3}/_{8}$-in. skin plate is stiffened by 19 curved ST5x12.7 sections framing to three 36-in.-deep horizontal girders. ST5s were chosen to provide a minimum of $^{5}/_{16}$-in. material thickness in all components. The bottom girder was cambered so that, in the closed position, the water pressure "flattens" the girder to create a tighter seal. Contractor on the project was C.D. Perry & Sons, Inc., Troy, NY, and fabricator was AISC-member STS Steel, Inc.

Each arm has a main trunnion pin about which the arm rotates. The existing bearings consisted of a cast steel hub bolted to the arm with babbitt material provided for the running surface of the bearing. As these existing arms were determined to be reusable, they were cleaned and taken to a machine shop

where the babbitt material was bored out.

To allow for the accurate placement of the main and counterweight bearings, the hub inside the diameter was slightly over-bored. New bronze bushings with an interference fit were then pressed into the existing hubs. The inside diameter of the bronze bushings provide for a running fit of 0.002 in. with the trunnion pins.

Special precautions were taken to prevent leakage and to minimize deterioration of the new gates. Each gate was fabricated in pieces for quality control: the skin plate subassembly, weighing in at 30 tons; the end frame arm; and the horizontal bracing, which was required to resist potential seismic forces. The configuration of the horizontal bracing was also designed to look as closely as possible like the original gates in plan.

Each gate also was fitted with rubber side and bottom seals. To allow for movement of the gates while also sealing them, the side seals were laterally adjustable to provide the best fit in any position. A stainless steel side seal rubbing plate assembly filled with anti-freeze was embedded into the piers and fitted with internal electric heating elements to remove ice and facilitate winter operations.

Since all steel joints were seal welded with fillet welds to prevent crevice corrosion, there was some concern that the skin plate would warp due to heat from the welding operations, thereby causing misalignment and rendering the gate useless. However, high quality control in the shop and field resulted in construction with only very minor problems.

Counterweight

The concrete counterweight is, to put it simply, a very large concrete beam (5 ft. by 5 ft. by 58 ft.) supported on two posts. Since the existing counterweights and mechanisms were replaced as recently as the 1950s, these were

determined to be reusable. However, the challenges that remained were how to remove and then replace the taintor gate arms and how to add the required bracing to resist seismic forces. A complicated connection that fitted diagonal struts to the counterweight trunnion pin provided the optimum solution to the latter challenge, thereby bracing the large beam while allowing the trunnion to rotate freely.

In order to remove the existing gates and then install the new gates, the contractor chose to shore the counterweights in place, 50 ft. in the air, rather than set them on the ground, requiring a very complex shoring plan. To further complicate the situation, the new gate geometry was slightly different from the existing gates. Consequently, when a new gate was installed the position of the counterweight trunnion pin was slightly different and thus the counterweights had to be moved slightly laterally.

The existing gates had been designed so that the trunnion pin fell along a line between the center of gravity of the gate and the center of the counterweight trunnion pin. It had been determined that this criterion need not be met when designing the new gates. In fact, it would have been next to impossible to accomplish this while retaining the existing end frame arm plate girders without adding unnecessary weight. This somewhat complicated the erection of the refurbished gate arms, but by carefully jockeying with two cranes, the contractor was able to swing one end of the counterweight into position while placing the gate arms.

Trunnion Pin

Tremendous thrust forces from the water are generated during design floods. These forces, which can approach 250 tons per gate, are transferred to the concrete piers through a 12-in.-diameter trunnion pin at each end. The pin also transfers vertical loads as well as lateral or seismic loads. Approximately 12-in. in diameter and 5-ft.-5-in. long, the forged pin is machined to very tight tolerances. For maintenance purposes, the pin is removable. A 1-in.-diameter rod extends through the pin to a locking plate and holds the pin in place.

The trunnion pin housing, in turn, transfers the pin loads into the supporting piers. Each housing is an 8-ft.-long, 3-ft.-square box beam made of $1^1/_2$-in. steel plate and each weighs six tons empty. The housing is anchored to the supporting piers with eight, $1^3/_4$-in.-diameter anchor bolts embedded 8 ft. into the piers and is then filled with concrete. The pin shaft was machined to tight tolerances, and extreme care was required to fabricate the housing to receive the pins and maintain

the very tight tolerances required.

Pedestrian Walkway

The pedestrian walkway serves three purposes. It provides access to interior gates, piers, etc., for maintenance personnel. It provides support for the gate operating machinery. And it serves as the top support for a temporary upstream needledam that can be installed to de-water the gate for maintenance. As a visible element of the lock, the pedestrian walkway was initially intended to be rehabilitated. However, a careful inspection of the steel components while in the shop revealed extensive deterioration. Most of the bottom flanges of the main girders were badly deteriorated and needed to be replaced.

After careful consideration, it was decided that a walkway would be fabricated to resemble the existing walkway as closely as possible. Spanning 50-ft. with 54-in.-deep steel thru-girders, the new walkway, at midspan, supports a single electric motor used for the operating equipment. Heavy bracing added between the bottom flanges of the two thru-girders creates, in effect, a horizontal truss to support the top of the temporary needledam.

Operating Equipment

The original operating equipment was truly clever in its simplicity. A pair of hand-operated wheels, one at each side of a gate, turned a pinion gear through a gear reducer. The pinion gear meshed with a rack gear attached to skin plate to raise or lower the gate. Most of these mechanisms worked very well. However, because the wheels operating the gate were independent of each other, they had to be turned at exactly the same rate or the gate would be twisted and bind up.

At the start of the project, the operating equipment was in less-than-satisfactory condition. Through the years, the gears had misaligned, and an electric motor now was required to turn the wheels. Only four of the six gates were 100% operational; one was partially operational and one was frozen shut. As before, the New York State Historical Preservation Office wanted to retain as much of the operating system as possible, but the New York State Canals Corp. needed a new, fully functional operating system.

A compromise allowed the new system to be fully automated as long as the original rack-and-pinion design was retained with as many of the existing parts as possible reused.

Automated Operating System

Two synchronized driveshafts transfer power from a small elec-

tric motor mounted at mid-span of the pedestrian walkway through a gear reducer to rack and pinion gears at each end of the gate. The rack gears are thus raised simultaneously, eliminating any binding caused by twisting of the gate. The operating switches for each gate are located on the pedestrian walkway, and the motor control center for the gate motors and side seal heaters are located in the central electrical control building on shore.

A most interesting and complex project, the rehabilitation of historic Lock C-1 was a culmination of a variety of efforts and expertise. Each of the lock components provided a new and separate challenge in itself even before the pieces could be put together. "The outcome of this project is an example of what can be accomplished with coordination of various agencies and concerns working toward the preservation of our valuable infrastructure," said Charles Flewelling, Jr., Albany Division Engineer for the NYS Canals Corp. Jim Stori, president of STS Steel Fabricators, agrees: "The success of the project was directly related to the experience, cooperation and effort put forth by all parties involved."

H. Daniel Rogers, P.E., is a principal with Ryan-Biggs Associates, P.C., in Troy, NY.

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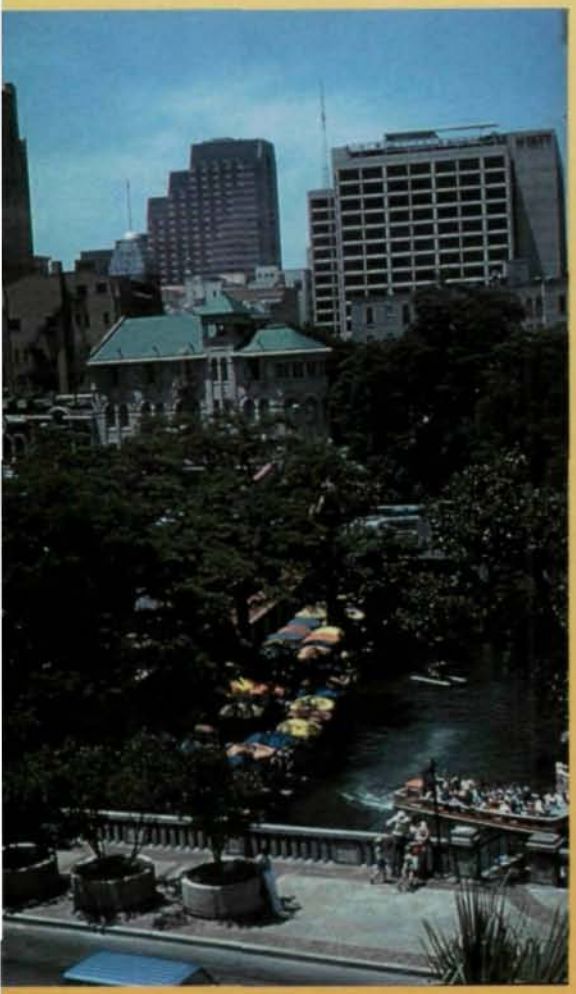

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EARTHQUAKE UPDATE

AISC Technical Bulletin No. 2: Interim Observations & Recommendations On Steel Moment Resisting Frames

AISC, THE CONSTRUCTION INDUSTRY, AND THE ENGINEERING PROFESSION recognize the importance and urgency of addressing the concerns raised by the unexpected structural damage to steel moment resisting frames in the 1994 Northridge Earthquake even though there were no collapses of steel buildings or related casualties. The previously published Proceedings of the AISC Special Task Committee on the Northridge Earthquake Meeting of March 14-15, 1994 contains a description of the nature and extent of the problems, both in general and as documented in several specific buildings, as well as initial observations and recommendations dated April 7, 1994.

Since that time, more similar damage has been uncovered in what is now estimated to be more than 100 buildings in the Los Angeles area. Consequently, a better understanding of the applicable AWS D1.1 weld criteria has emerged together with some associated clarifications and enhancements. In addition, an emergency research project funded by AISC and a private building owner at the University of Texas-Austin during the past summer has been completed; its tangible results not only confirm some of the damage patterns experienced during the Northridge Earthquake but also offer a significant new data base on the performance of reinforced steel moment connections.

The purpose of this AISC Northridge Technical Bulletin No. 2 is to disseminate in concise form this new information applicable to regions of higher seismic ductility demand for use by practitioners and code officials. Its welding and design recommendations, while still considered interim because further research is and will be proceeding, represent the best efforts of the listed AISC Advisory Committee in interpreting the currently available field and experimental evidence within the state-of-the-art. These are intended to supersede the earlier interim guidelines expressed in the March, 1994 AISC Proceedings and its Executive Summary of April 7, 1994. As quickly as ongoing events and research results warrant, additional bulletins, technical advisories or progress reports are expected to be issued in the future.

In addition to this report, several members of the AISC Advisory Committee have submitted papers providing discussion, interpretation, or additional data related to design and construction of steel moment connections. This additional information is available from AISC in a booklet "Northridge Steel Update I (October 1994)" for a nominal $10 shipping and handling fee. It contains the research report, discussion of updated welding guidelines, specimen cost ratios and a design approach paper. These supplementary documents have not been completely reviewed nor endorsed by the AISC Advisory Committee, and, therefore, should be considered to only represent the views of their respective authors. To receive a copy, send $10 to Northridge Steel Update I, AISC, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

AISC appreciates the dedicated work during the past 6 months of all the individuals and organizations who have contributed to a better understanding of the Northridge steel problems, their mitigation, and the development of improved ductile moment connections. We look forward to continued cooperation with the public agencies, code bodies, professional interests, research investigators and the construction industry in resolving the remaining issues in a timely manner.

The reader is cautioned that professional judgment must be exercised when technical data or design recommendations are applied. The publication of the material contained herein is not intended as a representation or warranty on the part of the American Institute of Steel Construction, Inc.—or any other person named herein—that this information is suitable for general or particular use, or freedom from infringement of any patent or patents. Anyone making use of this information assumes all liability arising from such use. The design and detailing of steel structures is within the expertise of professional individuals who are competent by virtue of education, training, and experience for the application of engineering principles and the provisions of this specification to the design and/or detailing of a particular structure.

OBJECTIVES

THE EXTENT OF THE DAMAGE EXPERIENCED BY SPECIAL STEEL MOMENT FRAMES during the 1994 Northridge Earthquake demanded an expeditious response, a response that would address both the immediate as well as the long term needs of the construction indus-

try. The long term objective will not soon be attained, for it will require careful planning and significant analytical and experimental research efforts. Such a program is now underway under the direction of S.A.C. (SEAOC, ATC, and CUREE). Several research efforts have also recently been funded by the NSF. AISC, AISI, the existing Advisory Group on SMRF Research. The entire steel industry is committed to remaining active participants in the process.

However, this document was intended to fulfill a more immediate need. A design procedure needed to be developed quickly which would allow for the effective modification of beam-to-column connections in buildings damaged during the earthquake, for those currently in some state of design or construction, and, where considered appropriate, in undamaged existing buildings. The material included herein is a response to the immediate need and, accordingly, is intended to communicate the lessons learned during the last six months, in particular from the large-scale testing at the University of Texas-Austin. It is hoped that current and future researchers will be able to present conclusions in a manner that will allow for a facile assimilation of new data by the users. Accordingly, it is incumbent on the user to continually update the suggestions contained herein to reflect the latest information.

Initially the AISC Advisory Committee intended to develop an alternative welding procedure that would allow for the continued use of the previously accepted welded beam-to-column connection in the higher seismic risk regions. When it became obvious, in spite of the weld enhancements currently available, that this requalification of the "standard" unreinforced detail would not be accomplished within the objective time frame, alternative means of reinforcing the beam-to-column connection were devised and tested. Given the range of needs and possible connection reinforcement alternatives, the need to describe an analytical procedure which would allow for the engineering justification of designs became apparent. The material assembled herein reports on the following three distinct committee-directed efforts:

- The extensive experimental test program;
- Welding enhancements that should improve and control the quality of welds;
- Design suggestions developed from the experimental effort.

Table 1: Test Results
University of Texas-Austin (1994)

Specimen # & Type	failure type & location	max. energy dissipated (in.-kips)	max. plastic rotation (radians)	overall assessment
1A (standard detail)	Brittle fracture near top CJP weld	680	0.005	Very Poor
1B (standard detail)	Brittle fracture near bottom CJP weld	1,600	0.005	Poor
2A (all-welded)	Brittle fracture near top CJP weld	300	0.0025	Very Poor
2B (all-welded)	Brittle fracture near bottom CJP weld	2,600	0.009	Poor
3A (cover-plated)	Brittle fracture near top CJP weld	3,750	0.015	Poor
3B (cover-plated)	Ductile tearing of bottom flange	16,800	0.025	Very Good
5A (cover-plated)	Ductile tearing of bottom flange	19,700	0.025	Very Good
5B (cover-plated)	Brittle failure at bottom flange (divot removed from column)	1,600	0.005	Poor
6A (vertical ribs)	Ductile tearing of bottom flange	19,250	0.025	Very Good
6B (vertical ribs)	Ductile tearing of top flange	22,250	0.030	Very Good
7A (cover-plated)	Test terminated to protect loading frame	25,500	0.035	Excellent
7B (cover-plated)	Test terminated to protect loading frame	25,500	0.050	Excellent
8A (cover-plated)	Test terminated to protect loading frame	26,300	0.035	Excellent
8B (cover-plated)	Ductile tearing of bottom flange	25,800	0.035	Excellent

Recent Test Results

A limited post-Northridge Earthquake testing program has been sponsored by AISC and a private sector building owner to provide initial guidance regarding detailing and fabrication methods for beam-column frame joints. The full University of Texas-Austin research report is contained in the Northridge Steel Update I. These tests conducted during the summer of 1994 used larger beam and column sizes and geometries specific to a particular project which are not representative of the entire range of

member sizes within the damaged building inventory. Nevertheless, the failure of the test specimens appear to replicate at least some of the failure characteristics observed in damaged structures.

On the whole, the tests were intended to be representative of field conditions. In order to focus on the region where failures were noted, design of the specimens limited the participation of the column, thereby concentrating inelastic deformation in the beam. A series of slowly applied cyclic loads to a cantilevered beam-column assembly was used to simulate the dynamic effects of an earthquake. Most loading steps were repeated three times. The use of this loading protocol and the very stiff column, which concentrates the plastic deformation in the beam, may place greater demands on the beam-column joint than would occur in most earthquakes or in other beam-to-column configurations. In addition, the effects of the floor slab, applied axial column loading, fast strain rate, and additional building restraint were not considered in the test setup.

For a test specimen to be judged successful, a minimum plastic rotation of at least 0.02 radians, and preferably, 0.03 radians, was desired. In addition, a specimen was not judged acceptable if the failure initiated in a brittle manner, such as weld or rapid flange fracture. Table 1 summarizes the results of the tests. Two replicates provided by different fabricators "A" & "B" were used for each specimen. According to the testing protocol, three complete cycles of loading were performed at most displacement levels. There is a significant difference in the amount of energy dissipated as additional loading steps (rotation) are achieved.

A review of these new test results suggests that the standard unreinforced and the fully welded joints, similar to Specimens 1 and 2, are not capable of achieving the targeted high levels of plastic rotation without brittle fracture. Their performance was judged to be very poor to poor. Previous research had produced more successful data, but also some indications of poor to marginal results. This recent poor performance suggests that the prescriptive provisions in Section 8.2c of AISC Seismic Provisions for Structural Steel Buildings, and similar recommendations in other codes and guidelines, do not produce a joint capable of achieving acceptable performance for regions of high seismic ductility demand, at least for beam-column combinations similar to those in the test program. Conversely, the remainder of the tests demonstrated that reinforced moment connections can be capable of achieving the desired ductility in most cases.

Preliminary Guidelines for Moment Frame Connections and Joints

COMPREHENSIVE TESTING OF ALL RELEVANT JOINT PARAMETERS AND GEOMETRIES has not been completed, and conclusive findings will not be available for many months. Observations from the Northridge Earthquake and the limited AISC testing program to date provide some general guidance regarding the performance of beam to column joints in steel moment resisting frames. The following interim guidelines are presented for use in developing reliable ductile frame joint designs for regions with higher demands for seismic ductility in compliance with the applicable building codes.

1. Use of Welded Flange/ Bolted Web Connections in New Construction: Based on reported tests (Specimens 1 & 2) and post-earthquake observations, beam-to-column connections with configurations corresponding to the basic requirements of Section 8.2c of AISC Seismic Provisions for Structural Steel Buildings, as well as the all-welded unreinforced detail, have not performed well. They have been unable to reliably develop adequate magnitudes of plastic rotation necessary for acceptable performance in a large earthquake or to avoid brittle modes of failure. This unreliable behavior occurred in spite of efforts to insure a high level of workmanship. Improved welding techniques included removal of back-up bars, additional reinforcing by fillet welds and fully welded web connections. Acceptable performance may be possible in joints whose design is based on the prescriptive provisions with smaller beams and lighter columns; however, this has not been investigated in the AISC test program and should not be presumed pending further research.

Recommendation: Suspend the use of details similar to those prescribed in Section 8.2c of AISC Seismic Provisions for Structural Steel Buildings consistent with the recent actions taken by the ICBO in the deletion of this prescriptive detail from the 1994 UBC.

2. Reinforced Joint Detail Geometry for Improved Performance: Tests (Specimens 3, 5-8) of reinforced connections that shifted the plastic hinge away from the face of the column and reduced the demand on the complete joint penetration (CJP) weld demonstrated significantly better and more consistent performance than those that were not reinforced. The specimen reinforcing was accomplished by supplementing the beam with cover-plates and vertical "ribs". Other modified detail geometries (such as haunches, intentional reduction of the beam flange areas (dog-bone or flange holes), bolted and semi-rigid concepts) are possible but were not tested.

Recommendation: In the absence of additional test results, it is recommended that beam to column joints be designed to meet the performance criteria subsequently outlined in the Design Approaches section of this Bulletin. Accepted engineering principles should be used to justify the demand on the components in the joint. If concluded that a reinforced joint is needed, the reinforced beam cross-section should be designed to remain essentially elastic at the face of the column under the maximum moment generated by a fully yielded and strain hardened beam. This reinforcement is intended to shift the plastic hinge approximately d/2 away from the face of the column, where d is the depth of the beam. Sufficient data is not yet available to provide definitive design criteria for accomplishing this design goal. A suggested interim approach is to size the connection reinforcement so that the elastic section modulus of the total reinforced cross-section is approximately 1.5 to 2.0 times the elastic section modulus of the unreinforced beam. The reinforced connections in the test program satisfied these criteria.

3. Evaluation of Existing Joints and Repairs of Damaged Joints: Even though there were no collapses, many joints have been damaged by the Northridge Earthquake, while others sustained no apparent damage. It has not been demonstrated that there are sufficient benefits in strengthening all joints in a structure. However, the unacceptable performance of the damaged joints and the improved performance of reinforced joints suggests that repair procedures that consist only of replacing damaged welds and/or material without other connection or structural enhancements may not provide a reasonable assurance of acceptable future performance.

Recommendation: The structural engineer should undertake a program to establish the expected demand on the joints in a damaged frame to identify critical joints in the seismic force resisting system. Based on the results of this analysis and the engineer's professional judgement, a repair program should be developed that provides for reliable performance of the entire system and the critical joints. The repair program may consist of a combination of repair of damaged joints and reinforcement, or other enhancement, of some or all damaged and undamaged joints to provide a reliable lateral load resisting system.

4. Expected Steel Yield Strength: The expected (mean)

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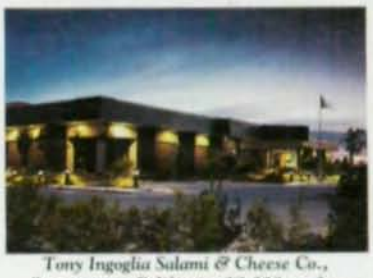

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strength of A36 steel has always been higher than the minimum requirement of 36 ksi. While in the past, the average A36 yield was approximately 42 ksi, a recent mill survey indicates that the mean yield strength of A36 steel has increased to approximately 48 ksi. This higher strength places additional demand on the beam-to-column joint and the CJP weld as the beam reaches its plastic moment and later undergoes strain hardening.

Recommendation: Designers should consider the effect of actual average material strength in the design of beam to column joints in steel moment resisting frames.

5. Welding Procedures Specification: The AWS D1.1 Structural Welding Code mandates that all welding be performed in adherence with written Welding Procedure Specifications (WPS). Strict adherence to such an approved WPS appears to offer an opportunity for improved weld integrity. The testing program suggests that it is difficult for even experienced welders to produce reliable welds when they deviate from an approved WPS. Ultrasonic inspection (UT) is unable to detect with certainty all discontinuities that may be present in welds, particularly in the vicinity of the beam web.

Recommendation: Projects using welded beam-column joints in steel moment resisting frames should develop and strictly enforce welding procedures specifications (WPS) for the project welding. The WPS should follow the requirements of AWS D1.1 and specify, at a minimum, the following:

a. Procedure Identification
b. Base Metal Identification
c. Welding Process
d. Type of Weld
e. Position of Welding
f. Filler Metal Specification
g. Filler Metal Classific.
h. Number of passes (single or multiple)
i. Welding Current
j. Welding Polarity
k. Pre-heat and Interpass Temperatures
l. Welding Parameters (electrode diameter, amperage range, voltage range, travel speed range, wire feed speed range, and electrode stickout)

The welding parameters are a function of each electrode. The written WPS should be developed by a competent welding engineer, and the individual welding parameters should be within the electrode manufacturer's range of operation. It is recommended that the fabricator submit to the engineer with the WPS a copy of the electrode manufacturer's technical information to confirm the parameters listed in the WPS.

6. Welding Inspection: It is difficult to detect defects in beam bottom flange welds that are ultrasonically examined from the top side of the bottom flange because of the interference of the beam web. Discontinuities caused by coverplates also make complete inspection of the CJP welds difficult.

Recommendations: Ultrasonic inspections of the CJP welds should be conducted from both the top and bottom sides of the beam flange, and from the back side of the column flange, as necessary, to obtain as complete an understanding as possible of potential rejectable welding defects.

7. Other Observations: The testing program did not fully resolve a number of outstanding issues, although actual observations provide some insight into their relative impact. The following items have elicited comments from different parties since the earthquake. The observations stated are based on the available test data, and the recommendations reflect the professional judgment of the AISC Advisory Committee.

a. Welding Electrode Diameter: The tests did not demonstrate that the electrode diameter itself was a critical variable that affected joint performance. Welds using electrodes up to 0.120 inches in diameter performed well, and performance of the connection was more dependent on the overall design and weld procedure than on the electrode diameter employed.

Recommendation: AWS D1.1 requirements regarding the electrode diameter and the position in which the electrode is used should be strictly enforced.

b. Column Stiffeners: The tests were unable to clearly distinguish the effect of column stiffeners (continuity plates) on joint performance. The columns tested had very thick flanges and are not representative of all column shapes. Of the reinforced connection specimens, nine of ten performed well when continuity plates were employed, and one of two performed well when the continuity plates were not employed. The four "standard" details (unreinforced) did not contain continuity plates, and all performed poorly. However, this is probably more a result of the unreinforced connection detail rather than the lack of a column stiffener.

Recommendations: Until further research is completed, use full width column stiffeners with a thickness of at least tf/2, wherein tf is the beam flange thickness, when stiffeners are not required by current criteria. Otherwise, comply with the existing code required stiffener thickness.

c. Electrode Notch Toughness Requirements: The tests did not show any trend regarding the use of electrodes with vs. without specified notch toughness properties. Of the reinforced designs, three of four specimens with notch tough weld metal performed well, while seven of eight specimens that used weld metal without mini-

mum specified notch toughness properties performed well. All four unreinforced specimens that performed poorly used only weld metal without toughness properties. The effect of weld quality, presence of notches, and stress level appear to be more important than merely notch toughness on the performance of these connections. However, faster loading rates have not yet been evaluated, nor the effect of structural steel impact toughness (all specimens used main member material of regular structural steel grades (ASTM A36 and A572, Gr. 50) without any toughness rating).

Recommendations: Until further research is conducted, it is recommended that the filler metal be capable of delivering notch toughness that is equivalent to what may be required of the steel base metal for a specific project. When necessary, the filler metal should be capable of delivering a minimum of 20 ft-lbs absorbed energy at 70 degree F as measured by a standard Charpy V-notch test in accordance with the applicable AWS filler metal specification. Structural steel material toughness is not generally required for interior building applications, except as covered by 1993 AISC-LRFD Sect. A3.1c or 1989 AISC-ASD Sect. A3.1c.

d.Weld Backing and Weld Tab Removal: The tests did not evaluate the configuration where the backing bar would be present on the exterior surfaces of the floor beam, as would be the case with the beam bottom flange-to-column connection. Backing bars were left in place on some of the specimens when located on the interior surface of the beam flange. The tests did not include a floor slab, so it was impossible to distinguish between the performance of "top" vs. "bottom" flange connections. All four of the non-reinforced details performed poorly, in spite of the removal of weld backing and weld tabs. The strengthened joints were tested with the interior backup bar in place and with all weld tabs removed, and produced generally good performance.

Recommendations: As an interim recommendation, the exterior (bottom flange) weld backing should be removed and a reinforcing fillet applied. Weld tabs should be removed from both the top and bottom flange connection and the weld ends be ground smooth. It is not recommended to remove weld backing from the interior (top flange) connection, nor from joints where the backing is located on the interior side of the flange. "End dams" do not constitute weld tabs and shall not be used.

8. Remaining Research

Needs: A number of related research issues still need to be addressed before a more comprehensive and definitive design solution can be offered. Some of these relative to alternative connections, effects of specific filler metal and structural steel properties, weld and column stiffener details, main member sizes, floor slab, axial column loads, and faster strain rates have already been alluded to previously. A more complete discussion of these, and other current and future research topics, is contained in the SAC Proceedings of the "Invitational Workshop on Steel Seismic Issues", Sept. 8-9, 1994. Inquiries about the availability of this document should be made directly to SAC, via Fax, (916) 965-6234.

Design Approaches

THE DESIGN APPROACH ADOPTED FOR STEEL MOMENT RESISTING FRAMES IN SEISMIC AREAS assumes that a significant level of system ductility can be developed. This ductility is potentially available in steel ductile frames if premature brittle failures are prevented. The unequivocal exclusion of brittle failure modes in a welded beam-to-column connection may not be easily attained given the current state of the knowledge and the number and diverse types of ductile steel frames which exist in seismically active areas. Testing to date suggests that the behavior of beam-to-column joints will depend on the strain states imposed on the more brittle elements along the load path. Post-yield strain states are difficult to quantify and, at least for now, do not have well defined limit states. Some suggested items to be considered in the design of seismic resistant moment frames are:

1. Yielding in steel moment resisting frames (SMRF) should be discouraged in columns and those connection regions which require the post-yield straining of welds or structural shapes in a through-thickness direction (normal to the grain or at 90 degrees to the longitudinal direction of weld.) Post-yield behavior should be promoted in those portions of a steel moment resisting frame (SMRF) which have been shown by both test and analysis to possess sufficient ductility to accomplish seismic design objectives.

2. Where post-yield straining is expected in the weld region or thru-thickness direction of a structural steel shape it should be demonstrated by analysis that induced

strains at a post-yield drift angle of 2% are within achievable limits.

3. The stiffness and factored strength of the lateral load resisting system should comply with that required by the prevailing building code. Member and connector strength limit states should be developed in accordance with provisions contained in the LRFD.

4. Where the behavior of a member or connector is presumed in the design to be elastic, the seismic forces used in determining the appropriate element size should be based upon those forces generated from a mechanism, e.g. "push-over" analysis.

5. The flexural strength of a beam should be based on the expected, or certified, yield strength of the specified material. It should be assumed for analysis purposes, in the absence of specific supporting test data, that the effective centroid of plastic behavior will occur at a distance of d/2 from the face of rigid restraining element and d/4 from the end of a flexible restraining element, where d is the beam depth.

6. Strain states should be developed from accepted material behavior models or those confirmed by test. Post-yield strain levels should be shown to be below attainable limit states given post-yield story drift angles of at least 2%. Members and their constitutive plates should be compact.

IT IS RECOGNIZED THAT THE DESCRIBED DESIGN PROCEDURES vary significantly from those which currently constitute the state of practice. Until such time as prescriptively describable and reliable load paths are substantiated by a significant experimental data base, it is the opinion of the Committee that the described procedure represents a rational application and interpretation of the available research information.

By the AISC Advisory Subcommittee on SMRF Research: *N. Iwankiw, AISC (Act. Chm.); H. Martin, AISI; A. Collin, Consultant; D. Miller, Lincoln Electric Co.; M. Engelhardt, Univ. of Texas-Austin; L. Napper, Steel Committee of California; M. Engestrom, Nucor-Yamato Steel Corp.; C.W. Pinkham, S.B. Barnes Assoc.; R. Englekirk, Englekirk & Sabol; E.P. Popov, Univ. of CA-Berkeley; R. Ferch, Herrick Corp.; T. Sabol, Englekirk & Sabol; F. Long, PDM/Strocal; M. Saunders, Rutherford & Chekene; J. Malley, Degenkolb Assoc.; R. Lorenz, AISC (Secretary)*

AISC Quality Certification Program

THERE ARE TWO WAYS TO CERTIFY AN INDUSTRY, according to Thomas Schlafly, AISC's director of fabricating operations and standards. "You can certify the product, the way Underwriters Laboratory does, or you can certify a system, the way ISO 9000 does." Since 1976, the AISC Quality Certification Program has been examining fabricators and certifying the way they do business.

Rather than inspecting individually fabricated pieces, "we try to see that the people are qualified, management understands and wants to provide a compliant product, and the way the people do business is one that will produce adequate work and deal with problems," Schlafly explained. "The program is intended to help the construction community distinguish fabricators that have quality programs from those that do not."

The Quality Certification Program concentrates on personnel, organization, experience, equipment, procedures and commitment required to provide material complying with common project specifications at a level of quality commensurate with the sophistication of the job.

Short of an engineer or contractor individually inspecting each shop personally, the Quality Certification Program provides the finest method of evaluating whether a shop is capable of performing the required work. Many states, as well as the Army Corps of Engineers, use the program to pre-qualify fabricators.

Categories

The program has provisions for three categories (certification in Category II includes Category I and certification in Category III includes Categories I & II):

- **Category I** — Conventional Steel Structures (including small public service and institutional buildings; shopping centers; light manufacturing plants; miscellaneous and ornamental iron work; warehouses; sign structures; low-rise truss/beam/column structures; and simple rolled beam bridges)

- **Category II** — Complex Steel Building Structures (including large public service and institutional buildings; heavy manufacturing; powerhouses; metal producing/rolling; crane bridge girders; bunkers and bins; stadia; auditoriums; high-rise buildings; chemical processing and petroleum processing)

- **Category III** — Major Steel Bridges (all bridge structures except for simple rolled beam bridges); in addition, some bridge fabricators can ask for a review and endorsement of their Fracture Critical experience. These fabricators are designated in the listing as IIIF.

In addition, AISC administers a certification program for the Metal Building Manufacturers Association (Category MB, which is listed separately).

Eligibility

All structural steel fabricators are eligible for certification in Categories I, II & III, whether they're members of AISC or not. Typically, nearly a third of all fabricators must adjust their procedures prior to receiving certification.

"The differences between categories include differing requirements for equipment, experience of personnel, procedures appropriate for the various types of work anticipated within each category and a separation between Quality and Production in the organization," Schlafly said.

"We're in the process of reworking the program to make it more product quality oriented and less paper quality oriented (see sidebar on opposite page)," explained Robert G. Abramson, chairman of the AISC Committee on Fabricating Operations & Standards. "Our model is the ISO 9000 program. We're also bringing the program more in line with critiques from DOTs and building authorities. The better we can make the program, the more confidence engineers will have in it, and the more likely it will be written into specifications."

Certification Requirements

The requirements for certification consist of the documentation of organization and procedures used to implement quality assurance and the successful completion of an annual review conducted by an independent auditing firm. Schlafly said the questions forming the auditors checklist were developed by the AISC Committee on Fabricating Operations and Standards in conjunction with a review committee of approximately 35 practicing engineers and is updated regularly.

Administratively, the program runs in three-year cycles. The initial review and those conducted every three years thereafter are considered "full" reviews and consist of a check of all items on the checklists. The reviews in the intermediate years are con-

ducted with a minimum of forewarning. The essential items on the checklist, marginal items from the previous review, and a random selection of non-essential items from the checklist are included in the intermediate reviews. The minor abbreviation permits a cost reduction and helps keep the program within the financial capabilities of smaller shops. The minimum acceptable quality standards are defined by the checklists and "objective criteria" that are developed and maintained by the governing committee. The size of the plant and its niche in the structural market are not factors in judging shops, except as they relate to the certification categories.

Inspection Procedures

Five departments are inspected at each facility: General Management; Drafting; Purchasing; Operations; and Quality Control. Each department must have an organization and job functions that promote communication of quality requirements to the forces performing the work and experienced key personnel to oversee the workings of each department. There also must be procedures to review projects to make sure the particular facility is capable of performing the work, controlling design and specification documents, shop fabrication documents, and marking of material.

Welding must be done by AWS qualified personnel to qualified procedures. Material and equipment has to be adequate and maintained in a manner that will produce good work.

Bolting procedures and equipment must be in place. Weld procedures must be used and the appropriate provisions of AWS must be followed. Painting equipment and gages must be available and working. The quality department is to have a Certified Weld Inspector available (though not necessarily on staff) and is checked to see if there are NDT technicians on staff. Quality Control must have the authority to stop work if there is a problem.

The following pages list Quality Certified Fabricators, as of October 15, 1994, two ways: alphabetically and by region.

If you have any questions about AISC Quality Certification, please fax them to AISC Quality Certification at 312/670-5403.

New Direction For 1995

Several major changes are expected to take place in mid-1995 for the AISC Quality Certification Program.

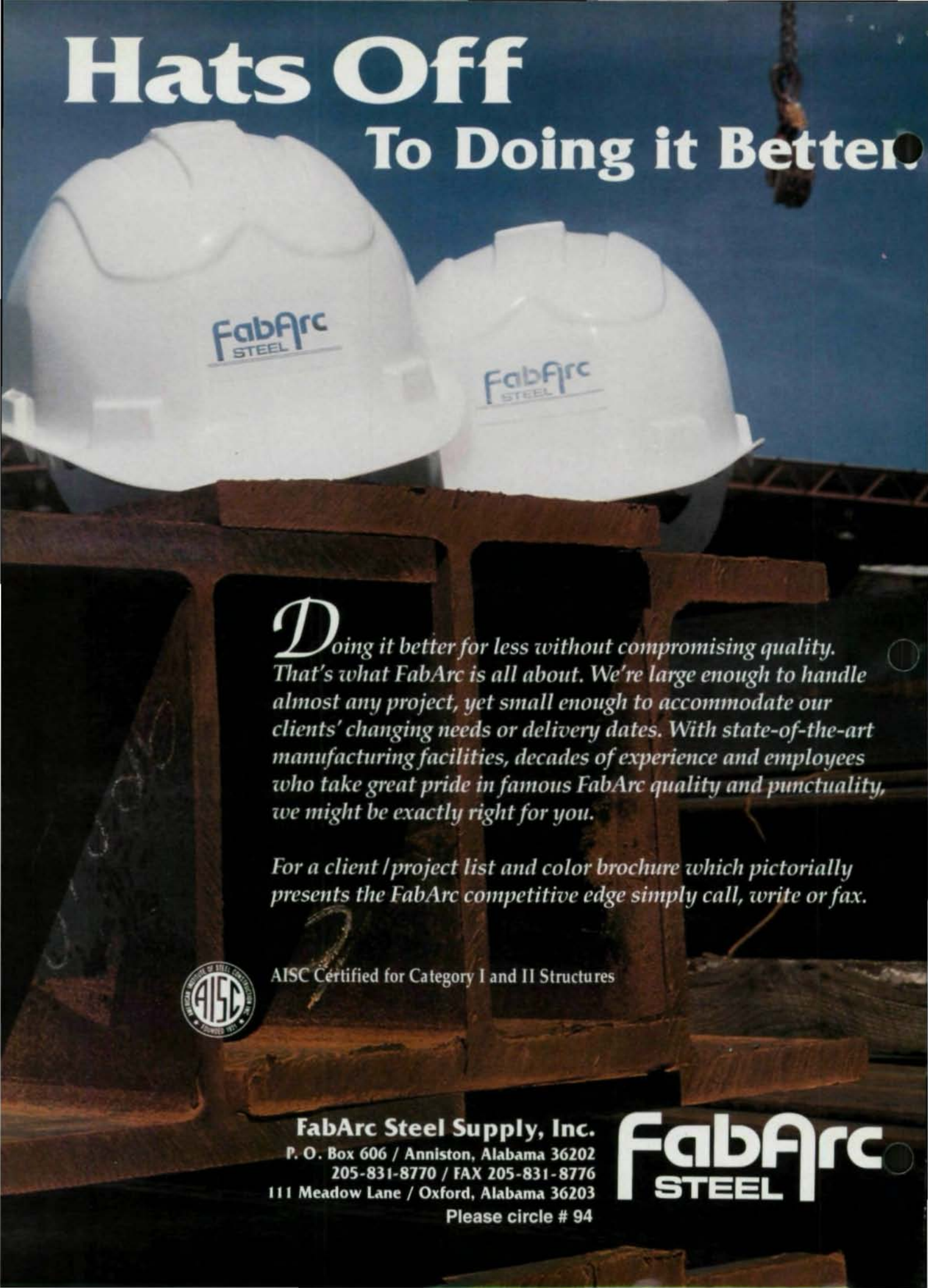
- *The biggest change scheduled is in the category designations.* Currently, simple bridges and conventional structures are combined into one category. The proposed change would split these two categories apart, creating two bridge categories (for simple and major steel bridges) and two building categories (for conventional and complex steel buildings). Fabricators certified for major steel bridges would no longer be automatically certified in any building category but would be eligible to receive both certifications.

- In a related change, the program will add an endorsement for a fabricators ability to apply sophisticated coating systems. This would be in addition to the existing Fracture Critical endorsement. And in the future, a bridge component category will be created so that bearing manufacturers will no longer require certification that they can build a bridge.

- Another important modification of the certification program will change the audit method. Fabricators will be required to submit certain procedures—such as welding, bolt installation, inspection and non-performance procedures—for review prior to the audit. Also, the checklist will be condensed and revised to better reflect current organizational structure. Initial and full inspections will continue to review the fabricator's systems, but will concentrate more on what is being made in the shop and drafting rooms. Intermediate reviews will more fully concentrate on daily operations and there is the possibility that unannounced audits will be conducted.

- Some requirements will be changed. For example, fabricators will be permitted to contract NDE personnel from outside sources. Also, for complex bridge shops, a CWI will be required on staff. The program will require extensive experience in key managers and in the shop. And finally, project management criteria will be added and the drafting room review will be more extensive than in the past.

- The scoring system will be changed to pass/fail to reduce arbitrary judgements.



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AISC Certified for Category I and II Structures

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Please circle # 94

FabArc STEEL

AISC Quality Certified Fabricators (Categories I, II & III)

Type	Company Name	Location	Contact	Phone #
II	A. Spadafora Iron Works, Inc.	Everett, MA	Frank Spadafora	(617) 387-4020
II	Able Iron Works, Inc.	Charleston, SC	George Bigbee	(803) 571-2253
II	Acme Structural, Inc.	Springfield, MO	Hugh Wiley	(417) 865-6691
II	Addison Steel, Inc.	Albany, GA	Gene Blohm	(407) 295-6434
II	ADF International Inc.	Quebec, Canada	Pierre Paschini	(514) 625-1911
I	Advanced Resources & Constr. Ent., Inc.	Kingfield, ME	Walter Kilbreth	(207) 265-2646
IIIF	AFCO Steel	Little Rock, AR	Grady Harvell	(501) 340-6285
II	Alamo Steel Co.	Waco, TX	Ronald Merrit	(817) 799-2471
II	Alert Steel Fabricators, Inc.	Chicago, IL	Russell Pavlock	(312) 375-9600
II	Alfab, Inc.	Enterprise, AL	M. Brown	(205) 347-9516
II	Allstate Steel Company, Inc.	Jacksonville, FL	Yancey Montgomery	(904) 781-6040
II	Almet Inc.	New Haven, IN	Thom Bada	(219) 493-1556
II	American Steel & Aluminum Co., Inc.	Grand Prairie, TX	Ken Teel	(214) 264-1533
I	American Steel Fabricators, Inc.	Milford, NH	Mark Carter	(603) 547-6311
IIIF	American Welding Company, Inc.	West Greenwich, RI	Richard Silva	(401) 821-7186
II	Amfels, Inc.	Brownsville, TX	Eric Phua	(210) 831-8220
III	Amthor Steel Co.	Erie, PA	Richard Carrara	(814) 452-4700
I	Antenna Products Corp.	Mineral Wells, TX	Sam Risner	(817) 325-3301
II	Arlington Structural Steel Co., Inc.	Arlington Heights, IL	Ralph Clarbour	(708) 577-2200
IIIF	Atlas Machine & Iron Works, Inc.	Gainsville, VA	Werner Quasebarth	(703) 754-4171
IIIF	Augusta Iron & Steel Works, Inc.	Augusta, GA	G. Bovard	(706) 722-0721
III	Avondale Industries, Inc.	Avondale, LA	John Simpson	(504) 436-5192
I	BAAB Steel, Inc.	Colorado Springs, CO	Arnold Simon	(719) 634-5511
II	Beck Steel, Inc.	Lubbock, TX	John Beck	(806) 762-3255
II	Bell Steel Company	Pensacola, FL	Daniel Davis	(904) 432-1545
III	Berlin Steel Construction Co., The	Berlin, CT	John Holcomb	(203) 828-3531
III	Bethlehem Contracting Co.	Bath, PA	John Cancelliere	(610) 837-9444
IIIF	Beverly Steel, Inc.	Knoxville, TN	Clarence Nelson	(615) 687-7921
II	Bratton Corporation, The	Kansas City, MO	Paul Arnsmeyer	(816) 363-1014
II	Brenner Companies	Winston-Salem, NC	Thomas Underhill	(910) 725-8333
I	Brookfield Fabricating Corporation	Brookfield, MO	Charles Woods	(816) 258-2214
II	Burcamp Steel Company	Wichita Falls, TX	Gary Anthony	(817) 322-1135
II	Burger Stuctural Steel Company	Akron, OH	George Hascher	(216) 253-5121
I	Burtman Iron Works, Inc.	Readville, MA	Charles Burtman	(617) 364-1200
I	C & C Iron, Inc.	Merrillville, IN	Gerry Chandler	(219) 769-2511
II	Canam Steel Corporation	Washington, MO	Gregg Baldwin	(314) 239-6716
IIIF	Canron Construction Corp. (Eastern Div.)	Conklin, NY	Jeff Gannett	(607) 723-4862
IIIF	Canron Construction Corp. (Western Div.)	Portland, OR	Michael Eckstein	(503) 255-8634
IIIF	Capital Steel Co.	Lincoln, NE	Curtis Smith	(402) 476-1021
IIIF	Capitol Steel & Iron Company	Oklahoma City, OK	John Nesom	(405) 632-7710
IIIF	Carolina Steel Corp.	Nash County, NC; Colfax, NC	Bob Rice	(910) 275-9711
III	Carrara Steel	Erie, PA	Richard Carrara	(814) 452-4700
III	Carter Steel and Fabricating Co.	Bellefontaine, OH	Marvin Silverstein	(513) 593-3010
II	Cen-Tex Marine Fabricators Inc.	Smithville, TX	Gene Hinnant	(512) 237-2496
II	Central Steel, Inc.	Wichita, KS	Les Aaby	(316) 265-8639
II	Central Texas Iron Works	Waco, TX	David Hartwell	(817) 776-8000
II	Chillicothe Iron & Steel, Inc.	Chillicothe, MO	Kent Peterson	(816) 646-2250
IIIF	Cianbro Corporation	Pittsfield, ME	Leroy Vanadestine	(207) 487-3311
I	City Welding & Fabricating Inc.	Jackson, MS	Danny Lee	(601) 922-2909
IIIF	Cives Steel Co. (Mid-South Div.)	Rosedale, MS	Edwin Montgomery	(601) 759-6265
IIIF	Cives Steel Company (Mid-Atlantic Div.)	Winchester, VA	Duncan McGilvray	(703) 667-3480
IIIF	Cives Steel Company (New England Div.)	Augusta, ME	Barry Brackett	(207) 622-6141
IIIF	Cives Steel Company (Northern Div.)	Gouverneur, NY	Dominic Centofanti	(315) 287-2200
IIIF	Cives Steel Company (Southern Div.)	Thomasville, GA	James Jackson	(912) 228-9780
IIIF	Colonial Iron Works, Inc.	Canonsburg, PA	Joseph Barravecchio	(412) 745-1423
IIIF	Conn Fabrication & Engineering Co.	New Castle, PA	William Branscome	(412) 654-6672
II	Construction Supply & Erection Inc.	Germantown, WI	Bruno Henke	(414) 255-3003
III	Craft Machine Works Inc.	Hampton, VA	Richard Rea	(804) 380-8615
II	Crown Steel, Inc.	San Antonio, TX	Adrian Augustin	(210) 674-5931
III	D. S. Brown Co., The	N. Baltimore, OH	David Arps	(419) 257-3561
III	Daewoo Heavy Industries Ltd.	Kungynam, Korea		
II	Dave Steel Company, Inc.	Ashville, NC	Tim Heffner	(704) 252-2771

Type	Company Name	Location	Contact	Phone #
IIIF	DeLong's Inc.	Jefferson City, MO	Jim DeLong	(314) 635-6121
II	Delta Steel Company Inc.	Jackson, MS	Sydney Geiger	(601) 956-4141
II	DEXCO (Ross Technology Corp.)	Leola, PA	Dan Speicher	(800) 345-8170
II	Dialco Steel Fabricators Co.	Birmingham, AL	Daniel Shields	(205) 856-0117
II	Dollinger Steel Company	Gonzales, TX; Beaumont, TX	Karon McCullough	(409) 892-4311
IIIF	Drake-Williams Steel Inc.	Omaha, NE	John Williams	(402) 342-1043
IIIF	E & H Steel Corporation	Midland City, AL	Shawn Evans	(205) 983-5636
III	East Coast Steel	Greenfield, NH	Walter Ohlson	(603) 547-3316
IIIF	East Coast Steel	South Portland, ME	Maurice Luckern	(207) 773-1862
II	East Hartford Welding, Inc.	South Windsor, CT	Kenneth Corneau	(203) 289-2323
IIIF	Egger Steel Company	Sioux Falls, SD	Doug Johnson	(605) 336-2490
II	Ellis Steel Co.	West Point, MS	Frank Hopper	(601) 494-5955
II	FabArc Steel Supply Inc.	Oxford, AL	Steve Vinyard	(205) 831-8770
II	Fairfield Engineering Company, The	Marion, OH	Marvin McFann	(614) 387-3327
II	Falcon Steel Company	Fort Worth, TX	Herold Harveson	(817) 581-9500
II	Fischer Steel Corp.	Memphis, TN	C. Caldwell	(901) 363-4986
III	Flohr Metal Fabricators, Inc.	Seattle, WA	William Taylor	(206) 633-2222
II	Florida Structural Steel	Tampa, FL	Jim Stephens	(813) 623-2675
IIIF	Fought & Company	Tigard, OR	Rex Smith	(503) 639-3141
III	Geiger & Peters Inc.	Indianapolis, IN	Don Peterson	(317) 359-9525
II	General Steel Fabricators Inc.	Latham, NY	Terry Vallely	(518) 785-3221
II	Gipson Steel, Inc.	Meridian, MS	E. Gipson	(601) 482-5131
II	GLENCO, Inc.	Clovis, NM	Randy Kelley	(505) 763-4414
IIIF	Globe Iron Construction Co.	Norfolk, VA	Morgan Steele	(804) 628-0124
II	Grace and Wylie Fabricators, Inc.	Springfield, TN	Kenneth Petty	(615) 373-2875
I	Graco Inc.	Chattanooga, TN	J. Hilbert	(615) 892-4484
II	Graham Steel Corporation	Kirkland, WA	Kevin Larson	(206) 823-5656
IIIF	Grand Junction Steel Co.	Grand Junction, CO	Larry Beam	(303) 242-4015
II	H & M Steet, Inc.	Luther, OK	Rick Pauley	(405) 277-3055
I	Hamilton Iron Works, Inc.	Woodbridge, VA	Mike Lucks	(703) 690-2900
III	Hammert's Iron Works Inc.	St. Louis, MO	Robert Smith	(314) 389-0666
IIIF	Harris Structural Steel Company	S. Plainfield, NJ	Richard McCallum	(908) 752-6070
IIIF	Hartwig Manufacturing Corp.	Wausau, WI	Henry Wauserski	(715) 845-3191
IIIF	Havens Steel Company	Kansas City, MO; Ottawa, KS	Tom Collins	(816) 231-5724
IIIF	Helmark Steel Inc.	Wilmington, DE	William O'Brien	(302) 652-3341
II	Hercules Steel Company	Fayetteville, NC	Claude Scott	(910) 488-5110
IIIF	Herrick Corporation, The	Stockton, CA	David Ogilvie	(510) 484-2990
III	Herrick Corporation, The	San Bernardino, CA	David Ogilvie	(510) 484-2990
IIIF	High Steel Structures Inc.	Lancaster, PA	Brad Mills	(717) 293-4068
IIIF	High Steel Structures Inc.	Williamsport, PA	Jay Mellinger	(717) 299-5211
III	Hirschfeld Steel Co. Inc.	Lynchburg, VA; Midland, TX; Abilene, TX;	Sid Dickerson	(214) 541-1166
IIIF	Hirschfeld Steel Co. Inc.	San Angelo, TX	Sid Dickerson	(214) 541-1166
I	Hurtt Fabricating Corp.	Marceline, MO	Robert Walton	(816) 376-3501
III	Hyundai Heavy Industries Co., Ltd.	Ulsan, Korea		
I	IKG Greulich	Cheswick, PA	Darko Jurkovic	(412) 828-2223
II	Impero Construction Co.	Bellingham, WA	John Impero	(206) 733-7052
III	Indiana Steel & Engineering Corporation	Bedford, IN	Troy Moyes	(812) 275-3363
III	Industrial Steel Construction, Inc.	Gary, IN	Karl Iwinski	(708) 482-8549
IIIF	Industrial Steel Construction, Inc.	Hodgkins, IL	Karl Iwinski	(708) 482-7500
IIIF	International Bridge & Iron Co.	Newington, CT	Joseph Bachta	(203) 953-6550
II	Interstate Iron Works Corporation	Whitehouse, NJ	Robert Abramson	(908) 534-6644
I	Interstate Welding & Fabrication Inc.	Terre Haute, IN	Matt Von Dielingen	(812) 232-0474
I	Ironhorse Ironworks, Inc.	Lorena, TX	Bobby Meador	(817) 857-3160
III	Isaacson Structural Steel, Inc.	Berlin, NH	Roger Jones	(603) 752-2044
III	J. S. Alberici Construction Co.	St. Louis, MO	Gene Jenkins	(314) 261-2611
II	Jack K. Elron Company, Inc.	Indianapolis, IN	Timothy Elrod	(317) 632-4391
II	Jackson Steel Company	San Antonio, TX	John Stampley	(210) 633-0100
IIIF	Jesse Engineering Co.	Tacoma, WA	Lanny Lawrence	(206) 922-7433
III	Johnson Machine Works, Inc.	Chariton, IA	M. Garton	(515) 774-2191
I	K & P Machine Company	Cleveland, OH	John Hoffman	(216) 641-2570
III	Kard Welding Inc.	Minster, OH	Kenneth Osterloh	(419) 628-2375
II	KCB Towers, Inc.	Highland, CA	Lynn Bogh	(909) 862-0322
IIIF	Keiser Steel Fabricators	Kent, WA	Bruce Keiser	(206) 852-1910
II	Kilroy Structural Steel Co.	Cleveland, OH	Robert Krejci	(216) 883-3000
II	Kinsley Fabrication	York, PA	Raymond Guzzetti	(717) 741-8326

Type	Company Name	Location	Contact	Phone #
II	Kline Iron & Steel Co., Inc., The	Columbia, SC	David Easterling	(803) 251-8000
I	L. B. Foster Company	Norcross, GA; Pittsburgh, PA	Richard Kelleher	(412) 928-3478
II	Lacy Steel Company	Lawrence, KS	Ed Hoadley	(913) 841-2470
I	LeBlanc Communications, Inc.	Sioux City, IA	Mark Gothier	(712) 252-4101
I	Lehigh Utility Associates	South Plainfield, NJ	William Butrico	(908) 561-5252
IIIF	LeJeune Steel Company	Minneapolis, MN	Larry Kloiber	(612) 861-3321
III	Leonard Kunkin & Associates, Inc.	Line Lexington, PA	Leonard Kunkin	(215) 723-6744
III	Lewis Engineering Company	Chaska, MN	Gordon Lewis	(612) 368-3000
IIIF	Lincoln Steel Co.	Lincoln, NE	William Nessen	(402) 474-3030
IIIF	Littell Steel Company	Fallston, PA	Robert Thaw	(412) 843-5212
II	Lynchburg Steel & Specialty Co.	Monroe, VA	Kenneth Hudnall	(804) 929-0951
I	M & S Fabricators Inc.	Altavista, VA	Siglinde Allbeck	(804) 369-1170
II	Madden Steel Fabrication	Hollidaysburg, PA	F. Madden	(814) 695-4461
IIIF	Maritime Steel & Foundries, Ltd.	New Glasgow, NS	Dale Robertson	(902) 752-1511
IIIF	Mark Steel Corp.	Salt Lake City, UT	L. Van Vleet	(801) 350-2092
II	Martin Iron Works Inc.	Reno, NV	John Pieretti	(702) 329-8631
I	Marysville Steel, Inc.	Marysville, OH	Eugene Clayman	(513) 642-5971
I	Merrimack Sheet Metal, Inc.	Concord, NH	James Dussault	(603) 224-7766
III	Metropolitan Steel Industries, Inc.	Sinking Spring, PA	Anthony Panariello	(610) 678-6411
II	Mid America Steel Inc.	Fargo, ND	Donald Clark	(701) 232-8831
I	Mid-Ohio Products, Inc.	Hilliard, OH	Doug Koch	(614) 777-2795
II	Midland Steel Company	Wathena, KS	Al Simonis	(913) 989-4442
IIIF	Missouri Valley Steel Co.	Sioux City, IA	Robert Jacobsen	(712) 255-1616
III	Moore & Moreford, Inc.	Greenburg, PA	Richard Moreford	(412) 834-1100
II	Mound Steel Corp.	Springboro, OH	Russ Ballard	(800) 488-3957
IIIF	Mountain States Steel, Inc.	Lindon, UT	Bruce Dastrup	(801) 785-5086
IIIF	Munster Steel Company Inc.	Munster, IN	Ronald Robbins	(219) 924-5198
IIIF	National Eastern Corporation	Plainville, CT	Warren Kart	(203) 747-3700
II	Niederhauser Ornamental & Metal Works	Salt Lake City, UT	Butch Niederhauser	(801) 973-8310

Type	Company Name	Location	Contact	Phone #
II	North Shore Supply Company	Houston, TX	Lou Rossitto	(713) 450-6232
IIIF	North Texas Steel Co.	Fort Worth, TX	Barry Ennis	(817) 927-5333
III	Novel Iron Works, Inc.	Greenland, NH	Keith Moreau	(603) 436-7950
II	Ogeechee Steel, Inc.	Swainboro, GA	Janet Johnson	(912) 237-2770
III	Ohio Bridge Corporation	Cambridge, OH	Art Rogovin	(614) 432-6334
III	Ohio Steel Industries, Inc.	Summit Station, OH	William McNary	(614) 927-9500
I	Ohio Structures, Inc.	Berlin Center, OH	Sean Giblin	(216) 533-0084
IIIF	Oregon Iron Works, Inc.	Clackamas, OR	Terry Aarnio	(503) 653-6300
IIIF	Orleans Materials & Equipment	New Orleans, LA	John Housey	(504) 288-6361
IIIF	Owen Steel Company Inc.	Columbia, SC	William Saunders	(803) 251-7680
II	Ozark Steel Fabricators, Inc.	Farmington, MO	Gail Brister	(314) 756-5741
II	Pace Iron Works	Albuquerque, NM	Tony Rooyakkers	(505) 823-2611
I	Pacific Rim Consultants, Inc.	Seattle, WA	Roy Deranleau	(206) 282-7232
III	Palmer Industrial Supplies, Inc.	McAllen, TX	Jim Thompson	(210) 686-6575
IIIF	Paxton & Vierling Steel Company	Carter Lake, IA	Roger Goodwin	(712) 347-5500
IIIF	PDM Bridge	Eau Claire, WI	John Grzybowski	(715) 835-2250
IIIF	Pitt-Des Moines, Inc.	Melrose Park, IL	Larry Curtis	(708) 681-5181
II	PKM Steel Service, Inc.	Salina, KS	Steve Hartsuff	(913) 827-3638
III	Platte River Steel, a subsidiary of AFCO	Greeley, CO	Ira Stone	(501) 340-6205
III	Precise Fabricating Corporation	Georgetown, MA	Frank Davis	(508) 352-2591
IIIF	Production Steel Company, Inc.	Gardena, CA	Tom Drum	(213) 321-1061
II	Prospect Steel Inc.	Little Rock, AR	Edward Wright	(501) 945-3625
IIIF	Qualico Steel Co., Inc.	Webb, AL	John Downs	(205) 793-1290
II	Queensboro Steel Corp.	Wilmington, NC	Craig Gilpin	(910) 763-6237
III	R. A. Davis Co., Inc.	Ellwood City, PA	Reno Davis	(412) 752-2600
II	Ramsey Steel Company, Inc.	El Paso, TX	Terry Robinson	(915) 532-2686
II	Red Iron Corp.	Spokane, WA	Ray Johnson	(509) 468-2310
III	Reno Iron Works	Reno, NV	Andrea Pelter	(702) 329-1111

Type	Company Name	Location	Contact	Phone #
IIIF	Reynolds Manufacturing Co.	Avonmore, PA	Michael Perfetti	(412) 697-4522
II	Richmond Steel & Welding, Inc.	Rockingham, NC	Thad Ussery	(919) 582-4026
II	Rome Iron Group Ltd., The	Rome, NY	Bill Oliver	(315) 337-9000
III	*Roscoe Steel & Culvert Co.*	*Billings, MT*	*Dale Butterfield*	*(406) 656-2253*
II	Ross Technology Corp.	Leola, PA	Dan Speicher	(717) 656-5634
II	Roy Case Construction Company	Little Rock, AR	Roy Case	(510) 897-4061
III	RP's Machinery Sales, Inc.	Jersey Shore, PA	Robby Fisher	(717) 398-7456
III	RTW Industries Inc.	Muncie, IN	Terry Warner	(317) 741-4111
II	Ryan Iron Works, Inc.	Raynham, MA	John Cauley	(508) 822-8001
III	S & S Steel Fabrication	Hurricane, UT	E. Staples	(801) 635-9801
I	Safety Guard Steel Fabricating	Millvale, PA	David Campbell	(412) 821-3533
II	Safety Steel Service, Inc.	Victoria, TX	Rod Thompson	(512) 575-4561
III	Samsung Heavy Industries	Changwon Kyungnam, Korea		
IIIF	Schlosser Steel Inc.	Hatfield, PA	James Morehouse	(215) 723-9883
IIIF	Schuff Steel Company	Phoenix, AZ	Randy Eskelson	(602) 252-7787
II	Searcy Steel Co.	Searcy, AR	Gabe Rutherford	(501) 268-2466
IIIF	Shane Felter Industries, Inc.	Uniontown, PA	Ronald Kaczynski	(412) 439-2403
II	Sharon Manufacturing Inc.	Sharon Center, OH	Jerry Kostelny	(216) 239-1561
IIIF	Sheffield Steel Products	Palatka, FL	D. Welsh	(904) 328-4683
II	Shelco Steel Works, Inc.	South Holland, IL	Al Voss	(708) 333-5380
II	Shepard Steel Company, Inc.	Hartford, CT	Rick Beckerman	(203) 525-4446
I	Sigma Industries	Selbyville, DE	David Speier	(302) 436-9610
II	Sioux City Foundry Co.	Sioux City, IA	Michael Potash	(712) 252-4181
II	Skaggs Iron Works	Memphis, TN	Mike Skaggs	(901) 947-3100
III	SME Industries, Inc.	Salt Lake City, UT	Hank Battaglia	(801) 280-0711
II	Southern Iron Works, Inc.	Springfield, VA	Samuel Parker	(703) 354-5500
II	Southern Ohio Fabricators, Inc.	Cincinnati, OH	Stephen Sundin	(513) 771-1600
I	Southington Metal Fabricating Co.	Plantsville, CT	Tom Beland	(203) 621-0149
II	Southwest Steel Fabricators, Inc.	Bonner Springs, KS	Bob Dill	(913) 422-5500
III	Spector Metal Products Co., Inc.	Holbrook, MA	Brian Spector	(617) 767-5600
IIIF	St. George Steel Fabrication	Saint George, UT	Kirk Mitchell	(801) 673-4856
II	St. Louis Fabrication Services, Inc.	St. Louis, MO	Rich Schroeder	(314) 385-4180
II	Stainless, Inc.	North Wales, PA	Peter Starke	(215) 699-4871
I	Steel and Pipe Corp.	Sanford, NC	William Gupton	(800) 776-0752
II	Steel Fabricators, Inc.	Ft. Collins, CO	John Shaw	(303) 484-2752
		Ft. Lauderdale, FL	Brian Kelley	(305) 772-0440
II	Steel Service Corporation	Jackson, MS	John Bear	(601) 939-9222
II	Steel, Inc.	Scottdale, GA	James Burdette	(404) 292-7373
II	SteelFab, Inc.	Charlotte, NC	Don Sherrill	(704) 394-5376
II	Stein Steel & Supply Co.	Atlanta, GA	H. Woodall	(404) 523-2711
II	Stevens Equipment Co.	Salem, OR	Hans Bauer	(503) 581-2511
II	Steward Steel Supply Co.	Sikeston, MO	Larry Steward	(314) 471-2121
II	Stewart-Amos Steel, Inc.	Harrisburg, PA	Russell King	(717) 564-3931
II	Strait Manufacturing & Welding, Inc.	Greencastle, PA	Greg Strait	(717) 597-3125
III	Structural Accessories, Inc.	Terryville, CT	Robert Colpitts	(203) 589-8826
IIIF	Structural Steel Products Corp.	Clayton, NC	Trudy Hales	(919) 553-3034
I	Structures Unlimited Inc.	Ephrata, PA	Brian Richardson	(717) 738-2418
IIIF	Stupp Bros. Bridge & Iron Co.	St. Louis, MO	Robert Stupp	(314) 638-5000
I	Summit Manufacturing Inc.	West Hazelton, PA	Lewis Grant	(717) 454-8730
III	Syro Inc.	Centerville, UT	Dennis Woodard	(801) 292-4461
I	Syro, Inc.	Girard, OH	Ronald Colapietro	(800) 321-2755
IIIF	Tampa Steel Erecting Co.	Tampa, FL	Robert Clark	(813) 677-7184
II	Tech-Steel, Inc.	Clearfield, UT	Scott Rosenlof	(801) 263-0068
II	Thomas Steel Inc.	Bellevue, OH	Daniel Thomas	(419) 483-7540
IIIF	Tidewater Steel Co., Inc.	Chesapeake, VA	William Dunkley	(804) 545-0566
II	Tips Iron & Steel Co.	Austin, TX	Steve Wimberly	(512) 478-8511
II	Topper & Griggs, Inc.	Plainville, CT	Kenneth Eagg	(203) 747-5737
IIIF	Trinity Industries Inc.	Houston, TX	John Gilliam	(713) 861-8181
IIIF	Trinity Industries Inc.	Montgomery, AL	Tom Germanson	(205) 265-6702
		San Antonio, TX	Fred Peters	(210) 333-8222
III	TriState Steel & Fab. Co., Inc.	Tefft, IN	Fred Haas	(219) 828-4011
I	Tuckerman Welding & Fabrication	East Boston, MA	Joseph Burm	(617) 569-8373
I	Union Metal Corporation	Canton, OH	Tom Mueller	(216) 456-0163
IIIF	Universal Structural Inc.	Vancouver, WA	Dave Williams	(206) 695-1261
IIIF	Utah Pacific Bridge & Steel Corp.	Lindon, UT	Clark Olsen	(801) 785-3557

Type	Company Name	Location	Contact	Phone #
II	V & S Schuler Engineering Inc.	Canton, OH	Victor DiMargio	(216) 452-5200
II	V. B. Fabricators, Inc.	Glenshaw, PA	Ray Kuzmovich	(412) 961-0197
I	Valmont Industries, Inc. (Ind. Const. Prod.)	Elkhart, IN	Rick Sampson	(402) 359-2201
		Valley, NE	John Pleiss	(402) 359-2201
IIIF	Van Buren Bridge Co., a subsidiary of AFCO	Van Buren, AR	Grady Harvell	(501) 340-6285
IIIF	Vincennes Steel Corporation	Vincennes, IN	Kevin Day	(812) 882-4550
I	Virginia-Carolina Steel, Inc.	Norfolk, VA	Stephen Nicholas	(804) 853-7403
II	W & W Steel Company	Lubbock, TX;	Robert Meador	(806) 765-5781
		Oklahoma City, OK	Rick Cooper	(405) 235-3621
I	Walpar, Inc.	Birmingham, AL	H. Parker	(205) 925-4990
I	Wascot, Inc.	Wichita, KS	Dwayne Cotton	(316) 942-2238
III	Watson Bowman Acme Corporation	Amherst, NY	Wayne Walter	(716) 691-7566
I	Waukegan Steel Sales	Waukegan, IL	Don Robison	(708) 662-2810
I	Wichita Steel Fabricators	Wichita, KS	Jim Smith	(316) 838-3301
I	Wilborn Steel Corporation	San Antonio, TX	Tom Wilborn	(210) 532-6852
IIIF	Williams Bridge Company	Manassas, VA	Dick Geyee	(703) 361-5885
III	Williams Bridge Company	Richmond, VA	Dick Johnson	(804) 233-7694
II	Williams Steel Company	Jackson, TN	James Campbell	(901) 423-4900
II	Wisconsin Structural Steel Co.	Barronett, WI	John Peterson	(715) 822-2647
I	Woolf Steel Inc.	Middletown, PA	Jerry Woolf	(717) 944-1423
IIIF	Zalk Josephs Fabricators, Inc.	Stoughton, WI	H. Gurthet	(608) 873-6646
IIIF	Zimmerman Metals Inc.	Denver, CO	Dave Denney	(303) 294-0180

AISC Quality Certified Fabricators (Category MB)

Type	Company Name	Location	Contact	Phone #
MB	A & S Building Systems, Inc.	Caryville, TN	B. Ellison	(615) 426-2141
MB	American Buildings Co.	Eufaula, AL; Carson City, NV; El Paso, IL	Joel Voelkert	(205) 687-2000
MB	Behlen Manufacturing Co.	Columbus, NE	John Bowes	(402) 563-7275
MB	Butler Manufacturing Co.	Kansas City, MO	Steve Shearer	(816) 968-4700
		Galesburg, IL	Terry Blank	(309) 345-6800
		Annville, PA	David MacQueen	(717) 867-4606
		Laurinburg, NC	Charlie Brown	(910) 276-7676
		Birmingham, AL	C. Simmons	(205) 798-6300
		San Marcos, TX	Mike Bruns	(512) 396-3636
		Visalia, CA	Alan Goddard	(209) 651-5316
MB	Butler Buildings (Canada)	Burlington, ON	Harry Ragetlie	(416) 332-7786
MB	Ceco Building Systems	Mt. Pleasant, IA	Jeff Saunders	(319) 385-8001
		Lockeford, CA	Faron Moyers	(209) 727-5504
		Rocky Mount, NC	Donald Conley	(919) 977-2131
		Columbus, MS	John Scarbrough	(601) 328-6722
MB	Chief Industries Inc.	Grand Island, NE	Marion Alley	(308) 382-4557
MB	Chief Industries Inc.	Rensselaer, IN	George Groom	
MB	Garco Building Systems	Airway Heights, WA	William Savitz	(509) 244-5611
MB	Gulf States Manufacturers Inc.	Starkville, MS	Thomas Southerland	(601) 323-8026
MB	Kirby Building Systems, Inc.	Portland, TN	Roy Price	(615) 325-4165
MB	NCI Building Systems, Inc.	Houston, TX	Eric Masterson	(713) 466-7788
MB	NCI Building Systems, Inc.	Mattoon, IL	Fred Hensey	(800) 777-9378
MB	Nucor Building Systems	Waterloo, IN	Danny Coggins	(219) 837-7891
MB	Pascoe Building Systems, Inc.	Columbus, GA	Leonard Grabia	(706) 324-3562
MB	Star Building Systems	Oklahoma City, OK; Hamilton, OT; Monticello, IA	Bud Warford	(800) 654-3921
MB	Steelox Systems	Washington Court House, OH; Mason, OH	Ed McQueen	(513) 573-5296
MB	United Structures of America, Inc.	Houston, TX; Portland, TN	Ron Fletcher	(713) 442-8247
MB	Varco-Pruden Buildings	Kernersville, NC	Greg Bava	(910) 996-4801
		Van Wert, OH	Tim Gorske	(410) 757-2016
		Evansville, WI	Mike McLain	(608) 882-5000
		Turlock, CA	Kurt Rorick	(209) 667-4951
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		Rainsville, AL	Bobby Sparks	(205) 638-2264

AISC Quality Certified Fabricators (I, II, III) — By State

ALABAMA
- II Alfab, Inc.AL
- II Dialco Steel Fabricators Co.
- IIIF E & H Steel Corporation
- II FabArc Steel Supply Inc.
- IIIF Qualico Steel Co., Inc.
- IIIF Trinity Industries Inc.
- I Walpar, Inc.

ARKANSAS
- IIIF AFCO Steel
- II Prospect Steel Inc.
- II Roy Case Construction Company
- II Searcy Steel Co.
- IIIF Van Buren Bridge Co.

ARIZONA
- IIIF Schuff Steel Company

CALIFORNIA
- IIIF Herrick Corporation, The
- III Herrick Corporation, The
- II KCB Towers, Inc.
- IIIF Production Steel Company, Inc.

COLORADO
- I BAAB Steel, Inc.
- IIIF Grand Junction Steel Co.
- III Platte River Steel
- II Steel Fabricators, Inc.
- IIIF Zimmerman Metals Inc.

CONNECTICUT
- III Berlin Steel Construction Co., The
- II East Hartford Welding, Inc.
- IIIF International Bridge & Iron Co.
- IIIF National Eastern Corporation
- II Shepard Steel Company, Inc.
- I Southington Metal Fabricating Co.
- III Structural Accessories, Inc.
- II Topper & Griggs, Inc.

DELEWARE
- IIIF Helmark Steel Inc.
- I Sigma Industries

FLORIDA
- II Allstate Steel Company, Inc.
- II Bell Steel Company
- II Florida Structural Steel
- IIIF Sheffield Steel Products
- II Steel Fabricators, Inc.
- IIIF Tampa Steel Erecting Co.

GEORGIA
- II Addison Steel, Inc.
- IIIF Augusta Iron & Steel Works, Inc.
- IIIF Cives Steel Company (Southern Div.)
- I L. B. Foster Company
- II Steel, Inc.
- II Stein Steel & Supply Co.

IOWA
- MB Ceco Building Systems
- III Johnson Machine Works, Inc.
- I LeBlanc Communications, Inc.
- IIIF Missouri Valley Steel Co.
- IIIF Paxton & Vierling Steel Company
- II Sioux City Foundry Co.

ILLINOIS
- II Alert Steel Fabricators, Inc.
- II Arlington Structural Steel Co., Inc.
- IIIF Industrial Steel Construction, Inc.
- IIIF Pitt-Des Moines, Inc.
- II Shelco Steel Works, Inc.
- I Waukegan Steel Sales

INDIANA
- II Almet Inc.
- I C & C Iron, Inc.
- III Geiger & Peters Inc.
- III Indiana Steel & Engineering Corporation
- III Industrial Steel Construction, Inc.
- I Interstate Welding & Fabrication Inc.
- II Jack K. Elron Company, Inc.
- IIIF Munster Steel Company Inc.
- III RTW Industries Inc.
- III TriState Steel & Fab. Co., Inc.
- I Valmont Industries, Inc. (Ind. Const. Prod.)
- IIIF Vincennes Steel Corporation

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II Hercules Steel Company
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I Valmont Industries, Inc. (Ind. Const. Prod.)

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III East Coast Steel
III Isaacson Structural Steel, Inc.
I Merrimack Sheet Metal, Inc.
III Novel Iron Works, Inc.

NEW JERSEY
IIIF Harris Structural Steel Company
II Interstate Iron Works Corporation
I Lehigh Utility Associates

NEW MEXICO
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II Pace Iron Works

NEVADA
II Martin Iron Works Inc.
III Reno Iron Works

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IIIF Cives Steel Company (Northern Div.)
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II Rome Iron Group Ltd., The
III Watson Bowman Acme Corporation

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III Carter Steel and Fabricating Co.
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II Fairfield Engineering Company, The
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II W & W Steel Company

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I Woolf Steel Inc.

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II Jackson Steel Company
II North Shore Supply Company
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II Ramsey Steel Company, Inc.
II Safety Steel Service, Inc.
II Tips Iron & Steel Co.
IIIF Trinity Industries Inc.
IIIF Trinity Industries Inc.
II W & W Steel Company
I Wilborn Steel Corporation

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IIIF Mountain States Steel, Inc.
II Niederhauser Ornamental & Metal Works
III S & S Steel Fabrication
III SME Industries, Inc.
IIIF St. George Steel Fabrication
III Syro Inc.
II Tech-Steel, Inc.
IIIF Utah Pacific Bridge & Steel Corp.

VIRGINIA
IIIF Atlas Machine & Iron Works, Inc.
IIIF Cives Steel Company (Mid-Atlantic Div.)
III Craft Machine Works Inc.
IIIF Globe Iron Construction Co.
J *Hamilton Iron Works, Inc.*
III Hirschfeld Steel Co. Inc.
II Lynchburg Steel & Specialty Co.
I M & S Fabricators Inc.
II Southern Iron Works, Inc.
IIIF Tidewater Steel Co., Inc.
I Virginia-Carolina Steel, Inc.
III Williams Bridge Company
IIIF Williams Bridge Company

WASHINGTON
III Flohr Metal Fabricators, Inc.
II Graham Steel Corporation
II Impero Construction Co.
IIIF Jesse Engineering Co.
IIIF Keiser Steel Fabricators
I Pacific Rim Consultants, Inc.
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New Guide For Painting Steel Bridges

By Rita Robison

While never simple, painting a steel bridge has, in recent years, become even more complicated due to stringent environmental regulations, new methods, new materials and new ideas. Currently recommended specifications often contradict proven methods and materials. They also contradict each other, depending on the specs and standards adopted by various jurisdictions.

Is there a right way to paint or repaint a steel bridge? All 50 states and numerous local governments believe there is—and each can produce specifications to prove it. Collectively they do know the right way to paint a steel bridge, but the vast body of information needed to do it right is fragmented, deposited in scattered files across the country.

Now, for the first time, that information has been collected in one document. To be published by AASHT0, the Guide for Painting Steel Structures 1994, has reached the mail ballot stage. The Guide was developed by a task force convened by the American Iron and Steel Institute (AISI) for the AASHTO T-14 Committee on Steel Structures. If approved by the ballot, AASHTO will be issuing it in 1995.

The Guide was written by task force members representing several disciplines that make up the bridge painting industry: John Peart, research chemist with FHWA; Kirt Clement, sr. chemical research engineer with Louisiana DOT; Bernard Applemann, executive director of SSPC; and Fred Backmann, director of bridges for AISC. Robert Nickerson, P.E., whose consulting office is in Hampstead, MD, spearheaded the effort. The Task Force broke tradition with the Guide's format. Rather than separating the specification and commentary sections, the text places them together. "Separate commentaries tend to get lost," says Nickerson. "But to help readers develop project specifications for bidding documents, we've included model specs for special provisions in the appendix."

The team did, however, stick with Nickerson's term "paint" while many "purists" (his term) insist that the word should be "coatings." His rationale: "You open up a can of paint to put on a coating."

The authors of the Guide did not work in a vacuum. They collected information and comments from various state DOT engineers, including Iowa, Illinois and New York. A New England consortium, which is developing a similar document for that area, also contributed. Source documents from these and other experts are referenced in the Guide and some appear in the appendix.

Scope

The scope of the Guide is such that virtually no steel bridge in the U.S. could be classified as an exception. The Guide covers painting new steel in the fabricating plant and field; existing structures in service; non-hazardous paint systems; multiple-level Volatile Organic Compound (VOC) systems; and how to handle steel coated with hazardous materials in demolition, alteration, repair and renovation. The intent is to provide a guide for paint material selection and application that will provide long-term protection and reduce corrosion control costs. Methods and materials specified meet EPA requirements as of Jan. 1, 1993.

"There's nothing new in the Guide," says Nickerson. "But what's new is having all the information in a single source—it brings together all the information needed for painting new and existing steel bridges. It's especially valuable for officials in local governments or in states that have no full time, fully qualified paint specialists on staff."

Will the Guide bring down the soaring costs of painting and repainting steel bridges? Not necessarily, according to Nickerson. "What it does is bring out all the regulations. Costs vary depending on how people are enforcing those regulations. Because the Guide is based on the latest state-of-the-art information available, there are places where it may conflict with what has been considered standard practice. It may also conflict with the way some owners adhere to the regulations. If they've been ignoring some of them, bridge work is going to cost more than they're used to paying. But if they've been overly meticulous, the Guide may save them some money."

As an example, "There are owners who haven't really thought about topcoating over existing lead-based paint—they may have the idea that it's not good painting practice, or that the coating won't last very long. But the Guide specifically says it is a cost effective solution to the problem of handling the lead-based paint. In fact, Eric Kline of KTA now calls it `beneficial procrastination.' We know that research now being done on removing lead-based paint will improve the procedures, bringing down costs in the future. So it

may be the best idea to recoat now, and if the bridge ever needs to be stripped down to the bare steel for all-new paint, the costs will be under control."

The Guide is intended to reduce the practice of various state and local officials to specify paint systems on the basis of "preference" rather than cost effectiveness. When the bridge engineer in County A specifies System X and the engineer in adjacent County B specifies System Y for virtually identical bridges on similar sites, nothing is enhanced except costs.

Brief Overview

THE GUIDE PROVIDES PROCEDURES FOR EVERY PHASE OF A PROJECT, and its 49 pages—as typed single spaced, plus an equally long appendix—may seem wordy to some readers. For those who like brevity, three tables condense the information—"the guts of the whole thing," in Nickerson's words. From these, he emphasizes, a non-expert can select a paint system for a particular bridge and "be confident that it will be a cost effective one."

The emphasis of the Guide is on coating systems as opposed to a series of coats of paint. Table 1 indicates one of three coating systems available for use in various situations. Table 2 is split between systems for bridges that are to be repainted from bare steel (either new steel or prepared by total removal of existing paint), and those needing only spot painting or overcoating. It shows systems (by the numbers listed in Table 1) suitable for highly corrosive and mildly corrosive environments. It also notes which systems are considered "new technology." New technology is defined as a coating system with less than five years of service on bridges.

The experience of these expert paint specialists shows up in Table 3. It contains a partial list of states that use each type of paint, and notes the possible sources of recommended specifications for the paint. For instance, the Iowa specification is recommended for the EM (epoxy mastic) system, which is also used by Michigan and Ohio.

The Guide's authors prefer that all materials for the coating system be furnished by the same supplier even though different parts of the structure may require different systems. "Provided one follows the manufacturer's directions, the rest of the document is how-to-do-it, plus information on toxicity," concludes Nickerson.

Up-Front Tasks

AN IMPORTANT PART OF THE GUIDE is to delineate Owners' responsibilities. First, they must provide prospective bidders accurate and comprehensive information that includes the regulatory requirements and acceptability of various coatings. Hazardous waste disposal, whether or not handled by the contractor, remains the owner's responsibility.

The Guide recommends that owners conduct a mandatory pre-bid conference so that all bidders are aware of contract requirements and state-of-the-art techniques available to minimize the cost of compliance. Where many contracts are expected to be let over a short time, a "pre-season" meeting of all potential bidders is suggested.

Well before summoning contractors to a pre-bid conference, but within six months, the owner must determine just how to proceed with maintenance painting. An inspection should note areas under expansion joints and other areas prone to corrosion, that may require special treatment such as blast cleaning to bare metal. If the records do not indicate that all existing coats are non-hazardous, tests must be conducted to show their lead content.

The Guide notes that, while 80% of existing bridges are coated with paints containing lead and/or chromium, "Specific guidance on an acceptable level does not exist at this time." The 0.06% lead by weight criterion used by many owners does not automatically mean that the stringent OSHA regulations must be invoked. Instead, levels above the threshold are treated as a "red flag."

The line between spot maintenance painting and complete removal/repainting is generally put at 20% deterioration of surface area, determined by ASTM Standard D610. Surface preparation requirements are noted for both. Another ASTM Standard, D5064, governs compatibility of overcoating paints, and the Guide recommends that paint systems from at least three different manufacturers be evaluated and listed for bidding purposes. Table 4, listing incompatibilities, is compiled from actual experiences of bridge owners.

Surface Preparation

AN EXTENSIVE PART OF THE GUIDE DEALS WITH SURFACE PREPARATION, calling it "the most critical procedure for successful performance...." Preparation establishes an appropriate profile of bare steel and/or previously coated surface. Profile of bare steel is measured as the average depth of the valleys from the peaks created by blasting or other cleaning methods. Also known as "tooth," the depths can range from 1 mil to 3 mils as determined by ASTM D4417.

For new construction or maintenance involving total removal of existing paints, surface defects must be repaired, corners of oxygen-cut or sheared edges rounded, and faying surfaces of slip-critical bolted connections tested and/or certified.

For spot painting, loose paint is removed and the bare steel prepared without damaging the surrounding intact paints. The bare steel may be more rough than 3 mils, so paint must be selected to prevent early rust-through at the peaks. Zone

painting follows the same procedures, and roughening the entire surface may be necessary for proper adhesion when topcoating over existing paints. In any case, the Guide requires painting "before any visible rusting occurs, preferably within 24 hours after preparation," and recleaning if rusting or contamination occurs from any source.

Application

WHETHER WORKERS USE BRUSH, ROLLER, AIR OR AIRLESS SPRAY, applying paint to steel (or to undercoats) must be in accordance with manufacturers' recommendations, SSPC-PA 1, the Guide, and local regulations.

Weather limitations lead this section. Ambient and steel surfaces must be above 40F (4C) but below 100F (37C), and paint must be stored at similar temperatures. No painting should be done during rain, snow, fog or mist, nor to wet, damp, frosted or ice-coated surfaces. Some systems, however, are more tolerant to these conditions than others. Several paints cure by absorbing atmospheric moisture, and these must be applied as per manufacturers' directions.

Specific directions are given for mixing paint and using spray, roller and brush equipment. The Guide provides for either field or shop painting of new steel, or both, but insists that the prime coat be applied to bare steel before any rusting is visible, again preferably within 24 hours of preparation. Dry film thicknesss should be specified, and each coat should hide the color of the previous one. Finally, the contractor is made responsible for protecting the bridge, surrounding property, vehicles and people against marring by spills, spatters and splashes.

Safety & The Environment

SPECIAL REQUIREMENTS FOR PROTECTING WORKERS AND THE ENVIRONMENT makes most maintenance painting very costly when hazardous paint

must be removed. The Guide notes that contract documents shall indicate all applicable requirements for worker safety and environmental compliances. Worker protection requirements are included in Appendix D, but medical surveillance procedures demanded of the contractor are listed in detail, with the caution that some of these may be more stringent than current OSHA regulations.

Requirements also deal with containing debris (hazardous and non-hazardous), collecting and disposing it. While the contract documents should spell out how these tasks are carried out, the Guide notes that "the owner is considered to be the `generator' and is responsible for insuring that all regulations are met." The owner must obtain an EPA identification number.

A section on quality assurance outlines how to set up a quality control plan and an acceptance testing plan. Responsibilities of the owner, paint manufacturer and contractor are set forth, with the owner directed to check procedures at every stage. Finally, as with all good contracts, "Final acceptance will be based on full compliance with the contract documents."

The appendices include a list of Structural Steel Painting Council (SSPC) specifications. There are model specs which require only filling in the blanks for shop coating structural steel, spot painting, zone painting, total paint removal and topcoating. Another model spec deals with handling hazardous substances.

Appendix C is a summary of specific manufacturers' coating slip coefficient test results. OSHA regulations are given in Appendix D, while E is an introduction to worker safety and health provisions.

Rita Robison is a freelance editor/writer based in Albuquerque, NM.

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ZRC Cold Galvanizing Compound stops rust and rust creepage on ferrous and nonferrous metal surfaces. Used to protect bridges, buildings, and other large steel structures, the liquid coating is extremely corrosion resistant. It contains 95% zinc in a dried film and provides true cathodic protection through galvanic action. The compound can be applied by brush, roller or spray and can be used to repair hot-dip galvanizing and to rustproof welds.

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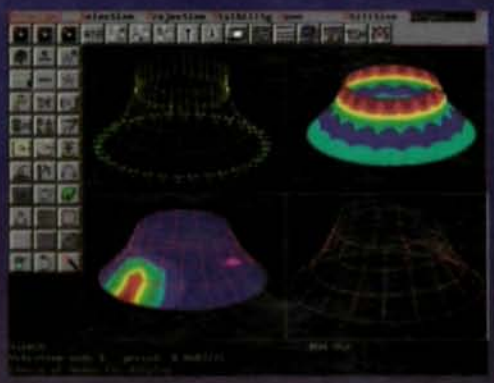

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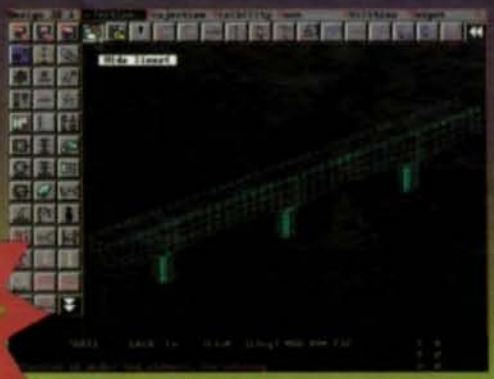

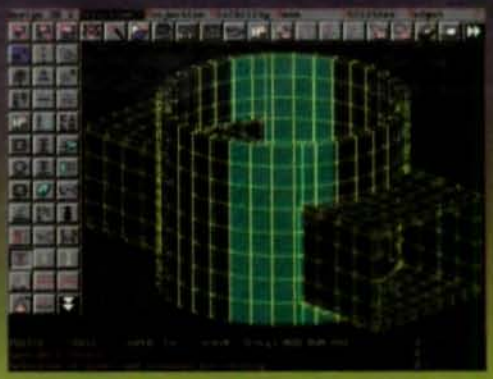

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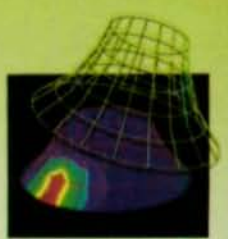

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