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MODERN STEEL CONSTRUCTION

May-June 1990

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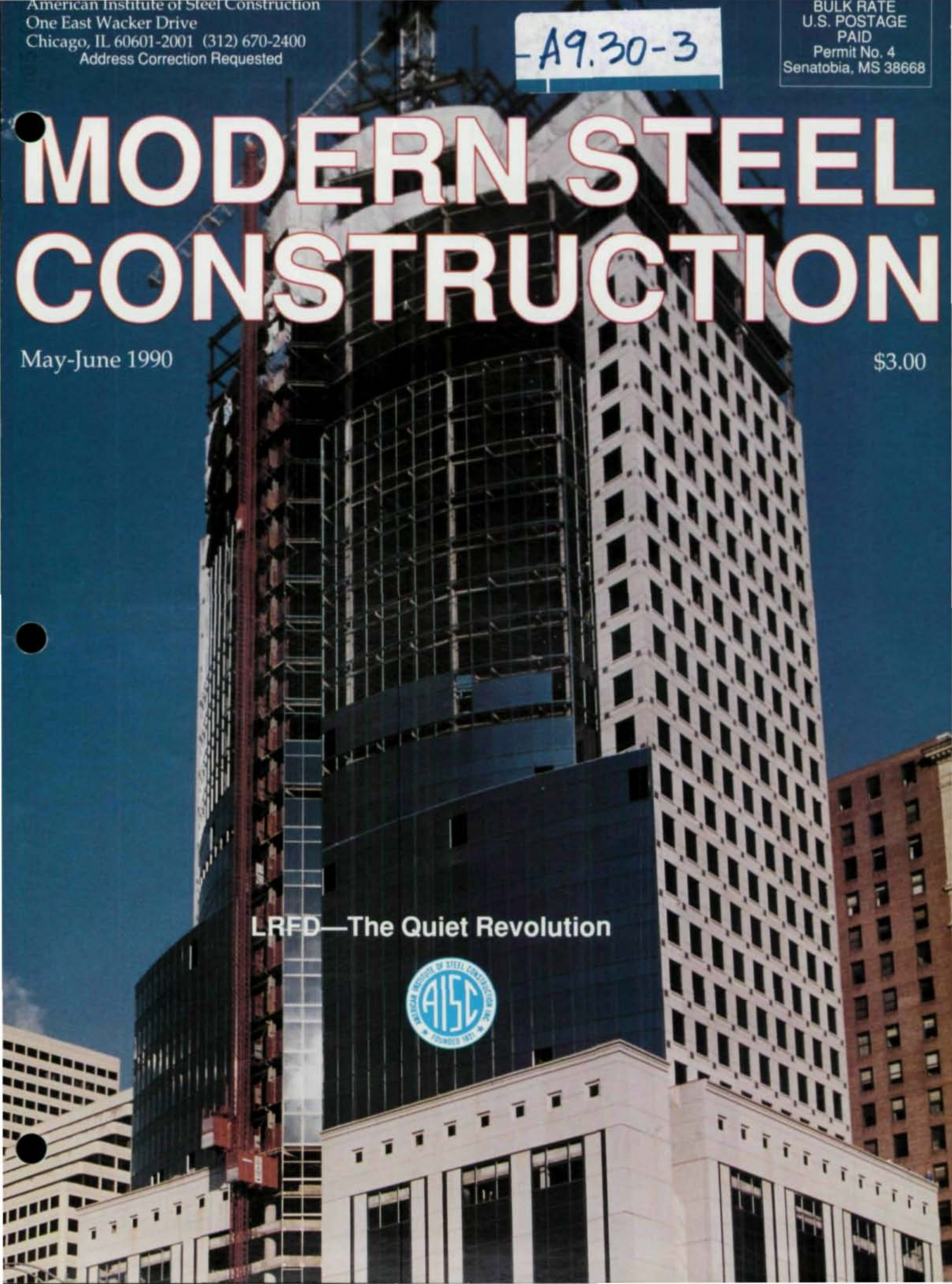

LRFD—The Quiet Revolution

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DECK DESIGN DATA SHEET
No. 14

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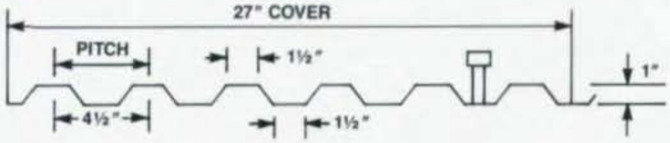

SECTION PROPERTIES (PER FT. OF WIDTH)					
GAGE	INCHES	I	Sp	Sn	WT. PSF
26	0.0179	0.040	0.066	0.072	1.0
24	0.0239	0.057	0.097	0.104	1.3
22	0.0295	0.074	0.128	0.136	1.6
20	0.0358	0.091	0.165	0.170	1.9

NOTES

1. Bottom flange of deck has room for ¾" diameter studs; w/h=2.25 Composite beam and girder tables are available on request.
2. Available with 1.5% venting for use with insulating fills.
3. Other gages and steel grades are available on special order.
4. Steel grade used as a basis for the table is grade E; Fy=80 ksi (ASTM A611 or ASTM A446).
5. Standard finishes are galvanized (G60 or G90) or bare (uncoated) steel. Painted finishes are available on special order.
6. Loads shown that are limited by 'STRESS' are the loads that will produce a stress of 36 ksi.
7. Loads shown that are limited by '1/240' or '1/180' are the loads that will produce a deflection of 1/240 or 1/180 of the span.
8. *The load that produces 1/240 or 1/180 deflection exceeds the limiting stress load.
9. The shaded area in the table indicates that a 200 lb. midspan concentrated load would cause a 1/120 deflection. Do not use the Gage/Span combination in the shaded area for lightweight fill roofs or for concrete forms.

SECTION	SPANS	LIMITING CONDITION	UNIFORM LOAD, PSF — SPAN, FEET 3'-0"	3'-6"	4'-0"	4'-6"	5'-0"	5'-6"	6'-0"	6'-6"	7'-0"
26 GA.	SINGLE	STRESS	176	129	99	78	63	52	44	37	32
		1/240	97	61	41	29	21	16	12	10	8
		1/180	130	82	55	38	28	21	16	13	10
	DOUBLE	STRESS	192	141	108	85	69	57	48	41	35
		1/240	*	*	99	69	51	38	29	23	18
		1/180	*	*	*	*	67	51	39	31	25
	TRIPLE	STRESS	240	176	135	107	86	71	60	51	44
		1/240	183	115	77	54	40	30	23	18	14
		1/180	*	154	103	72	53	40	31	24	19
24 GA.	SINGLE	STRESS	259	190	146	115	93	77	65	55	48
		1/240	139	87	58	41	30	22	17	14	11
		1/180	185	116	78	55	40	30	23	18	15
	DOUBLE	STRESS	277	204	156	123	100	83	69	59	51
		1/240	*	*	141	99	72	54	42	33	26
		1/180	*	*	*	*	96	72	56	44	35
	TRIPLE	STRESS	347	255	195	154	125	103	87	74	64
		1/240	261	164	110	77	56	42	33	26	21
		1/180	*	219	147	103	75	57	44	34	27
22 GA.	SINGLE	STRESS	341	251	192	152	123	102	85	73	63
		1/240	180	113	76	53	39	29	22	18	14
		1/180	240	151	101	71	52	39	30	24	19
	DOUBLE	STRESS	363	266	204	161	131	108	91	77	67
		1/240	*	*	183	128	94	70	54	43	34
		1/180	*	*	*	*	125	94	72	57	45
	TRIPLE	STRESS	453	333	255	201	163	135	113	97	83
		1/240	339	214	143	100	73	55	42	33	27
		1/180	452	285	191	134	98	73	57	44	36
20 GA.	SINGLE	STRESS	440	323	248	196	158	131	110	94	81
		1/240	221	139	93	66	48	36	28	22	17
		1/180	295	186	124	87	64	48	37	29	23
	DOUBLE	STRESS	453	333	255	201	163	135	113	97	83
		1/240	*	*	225	158	115	86	67	52	42
		1/180	*	*	*	*	153	115	89	70	56
	TRIPLE	STRESS	567	416	319	252	204	169	142	121	104
		1/240	417	263	176	124	90	68	52	41	33
		1/180	556	350	235	165	120	90	69	55	44

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MODERN STEEL CONSTRUCTION

Volume 30, Number 3 May-June 1990

The $40 million, 860,000-sq.-ft. 312 Walnut Building in Cincinnati is the largest building built to date using the new LRFD Specification. A special report on LRFD begins on page 23.
Cover photo courtesy of Robin Bruelheide Photography

FEATURES

NEWS AND DEPARTMENTS

Yes, we know it's a big claim. And, yes, we understand that steel detailing is a complex and demanding process. After all, Steelcad was designed by steel detailers.

As detailers, we felt that computers could offer a solution to the traditional problems facing our business. Our goal was to increase drawing productivity through computers, at a level of operator expertise that did not require a degree in rocket science, engineering or a huge level of experience in steel detailing.

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State-Of-The-Art Technology

When I was in journalism school, we wrote our copy on typewriters—usually electric, but sometimes manual. And in the magazine program, we did all of our layouts by hand—cutting out little pieces of paper and gluing them to art boards. Recently, however, I toured my alma mater and was happy to see students busily writing on computers. And the magazine program has switched to state-of-the-art electronic publishing technology.

Had you visited the offices of *Modern Steel Construction* a year ago, you would have seen an editor working much the way I did back in college. But beginning with the first edition of this year, we moved into the modern age. We produce our copy on word processors, and we do our layouts on a computer screen.

We switched for two reasons. First, it is a more economical way to produce a magazine. Second, and perhaps most important, we are able to produce a higher quality magazine.

The structural engineering profession is going through a comparable change. In 1986, AISC published the Load and Resistance Factor Design (LRFD) Specification. And until last year, you would have been hard pressed to find an engineering school that included LRFD in its curriculum. But by the start of the 1990-91 school year, 41% of the engineering schools will be emphasizing LRFD, and another 42% will teach both LRFD and Allowable Stress Design (ASD).

So far, the revolution has barely penetrated into professional offices. Very few professional engineers have spent the time to learn the new design system. But those who have expended the effort have made two important discoveries: LRFD reduces the cost of structural framing on many projects and LRFD produces a more rationally designed structure.

Believe me, I can sympathize with the difficulties of learning and putting into practice a new system. But with all the benefits that come with LRFD, can any engineer ignore the competitive edge that switching to the new system will provide? **SM**

Special Provisions For Earthquake Design

Steel-framed buildings came through the Loma Prieta earthquake with flying colors, while many masonry buildings suffered substantial damage. Pictured at right is a modern steel-framed office building with no apparent damage, while shown above is a nearby 11-story concrete office building that has been damaged to such an extent that it could not be reoccupied until repairs were made. The damage included having large portions of the brick facade dislodged, broken windows, and a failure of the concrete moment connection. Photos courtesy of AISI

AISC will publish a Special Provisions For Seismic Design supplement to the Load and Resistance Factor Design (LRFD) Specification this fall. The timely supplement will help to meet the need for additional seismic design data.

LRFD's seismic provisions are superior to any other design methodology, and this new supplement will help clarify the special requirements for earthquake design, according to Geerhard Haaijer, vice president of technology and research for AISC.

The supplement will include requirements for: columns, including nominal column strength and column splices; ordinary and special moment frames, including beam and column joints; concentrically braced frames; special bracing configurations; and eccentrically braced frames.

"Steel has proven to be the best material for design in seismic areas," Haaijer stated. In a continuing series of lectures on seismic design, he has focused on steel's advantages over concrete, including steel's lower weight, higher ductility, and greater strength.

When designing for seismic forces, it is crucial to increase the lateral load resistance, he pointed out. As the potential severity of an earthquake increases, it is important to strengthen the structural frame.

"Picture a building on rollers," explained Robert Lorenz, AISC director of education and training. "Vertical strength won't stop it from moving if it is pushed sideways. Only lateral strength will help." Steel buildings are

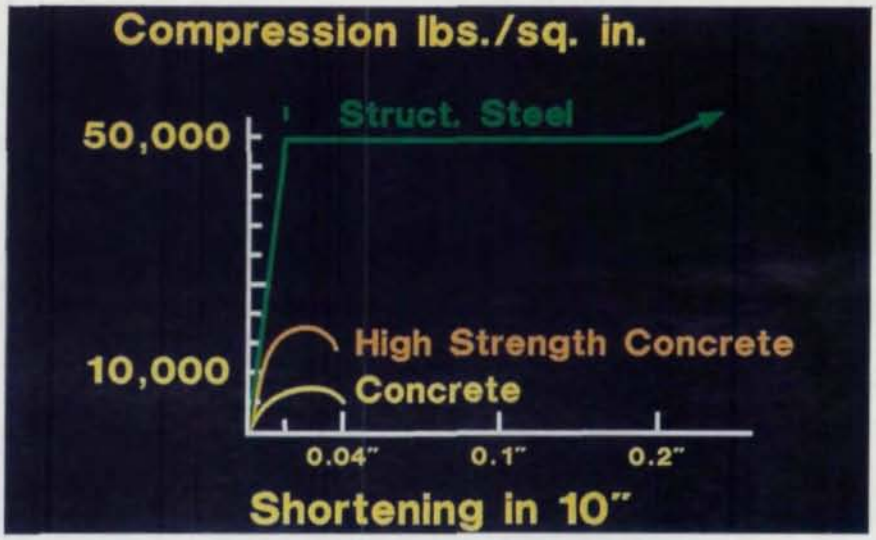
Continued on page 10

Quake, Cont.

readily designed to resist horizontal loads because of the quality of connections and the inherent strength of steel.

"Steel is the ideal material for an earthquake resistant structure," Haaijer said. Tension tests of typical structural steel reveal that 50,000 lbs. of tension applied to a 1" x 1" x 10" piece of steel will result in an elastic elongation of about 0.02". The steel will then start yielding until it stretches about 0.2". At this point, the steel becomes stronger, before finally failing at 70,000 lbs. of tension and an elongation of 1.8" in the 10" piece. Compression tests yield equally favorable results.

Concrete, however, will fail somewhere between 4,000 and 5,000 lbs. of compression. And even high strength concrete fails between 15,000 and 20,000 lbs.



"Concrete tries to get around this by making ever larger, and ever heavier members," Haaijer says. But concrete doesn't yield, and it can only compress about 0.04" in a 10" length. "The only way you can use concrete is to put in a lot of reinforcing steel to achieve ductility. When you don't have enough reinforcement, the structure fails."

Some engineers refer to a "canary test" to check for adequate amounts of reinforcing: If a canary could pass through the openings between the reinforcing rods, then there's not enough reinforcement.

In the recent Loma Prieta earthquake, the California Department of Transportation (CalTrans) reported major damage to 25 bridges and tunnels, and minor damage to 64 more. While there was some damage to steel bridges, the majority of this damage was actually due to inadequate concrete column detailing. And while

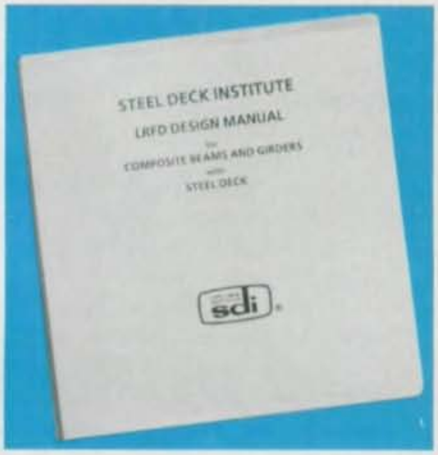
Surprisingly, a relatively new five-story concrete office building came through the earthquake unscathed. Upon closer inspection, it becomes apparent that damage was most likely prevented by reinforcing the soft first story with steel-braced frames.

all of the steel bridges were back in service within one month, the same cannot, unfortunately, be said of the damaged concrete structures.

For buildings, much of the damage was limited to unreinforced masonry structures. While this type of construction is now mostly prohibited by building codes in California, it is still used in many eastern areas where earthquakes are a distinct possibility.

Additional information on seismic conditions and construction is available from the Building Seismic Safety Council, 1201 L St., N.W., Suite 400, Washington, DC 20005 (202) 289-7800. Some of the available free publications include: *The (NEHRP) National Earthquake Hazards Reduction Program Recommended Provisions for the Development of Seismic Regulations for New Buildings* (two volumes plus maps); *Guide to Application of NEHRP Recommended Provisions in Earthquake Building Design; Seismic Considerations* (office buildings, hotels and motels, elementary and secondary schools, health care facilities, and apartment buildings); and *An Action Plan for Reducing Earthquake Hazards of Existing Buildings.* Also available are a variety of workshop proceedings.

For more information on designing with steel, contact: AISC Marketing, 650 Smithfield St., Suite 750, Pittsburgh, PA 15222-3907 (412) 394-3700. For information on Specifications, contact: AISC, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.



Mixed Reactions To Welder Certification

A standing-room only crowd at this year's American Welding Society show in Anaheim expressed mixed reactions to a presentation on the new Certified Welder program.

"The program is designed so that welders can transfer their certification from employer to employer, location to location," explained Richard Blaisdell, quality control manager with Black & Veatch Engineers, Kansas City, and a member of the AWS committee that established the certification program. "The program is most useful for places with a high turnover, such as the construction industry."

Essentially, the program would allow certified testing laboratories to test to D1.1. The cost for the lab to become recognized to offer AWS Certification is $2,500 plus the expenses of the qualifier. The cost for a welder to take a test at the lab would be determined by the individual lab, but AWS expects it to cost between $60 and $250, according to Donald Grubbs, AWS chief instructor. "The program has been established to provide validity, credibility, and reliability."

The certification program was established in January 1990, and by the time of the convention more than 6,000 welders had requested information, though very few had yet to take the certification test. AWS has a total membership of 36,000, and the U.S. Department of Commerce estimates that as of the mid-1980s, there were more than 586,000 welders in the U.S., 60% of whom work in construction.

A potential drawback to the program is the additional paperwork created for a welder's employer. To maintain his certification, the welder must document continuous employment, which means an employer must fill out a form. For companies with few welders, that task might be simple. But for larger firms, it could become onerous.

Another potential problem raised during the presentation is that cities such as Los Angeles and states such as New York and Connecticut have their own certification programs for welders and these are not reciprocal with the AWS program. "And so far," Blaisdell admitted, "no effort has been made in this area."

The program is voluntary, and it is uncertain at this point how many companies will honor the AWS certification. "If the program doesn't work, AWS will pull it off the market," Grubbs said. "But this program is designed to save the industry money."

Five labs are currently certified to offer the AWS test. For more information on the program, either for becoming a certified welder or for offering a welder program, contact: AWS, Q & C Department, 555 N.W. LeJeune Road, Miami, FL 33126.

This year's AWS show attracted nearly 14,000 attendees and 445 exhibitors. Next year's show will be in Detroit April 14-19, 1991.

AISC 1990 ARCHITECTURAL AWARDS OF EXCELLENCE COMPETITION

COMPETITION RULES

Eligibility

All registered architects practicing professionally in the United States are invited to enter steel-framed buildings of their design constructed anywhere in the United States (the 50 states, District of Columbia and all U.S. territories), and completed during calendar years 1987, 1988 and 1989. Each building must have been designed, fabricated and erected in the U.S.

The structural frame of the building must be steel, although it is not a requirement that the steel be exposed or a part of the architectural expression. Buildings of all classifications are eligible, with equal emphasis given to all sizes and types in the judging. Older buildings which have undergone major reconstruction/rehabilitation using steel as the major structural material also are eligible for entry if they meet all other requirements of this competition. There is no limit to the number of entries by any individual or firm. Buildings named as previous AAE winners will not be eligible, except in the rehabilitation category.

Method of Presentation

Each entry should be submitted in an 8 ½ x 11" binder containing transparent window sleeves for displaying inserts back to back. The entry form included in the brochure must be easily removable, so that the identification of the entry can be concealed during judging. All information requested on the entry form must be included.

Awards

Winners will be notified before August 30, 1990. Public announcement of the winners will be made in the November/December issue of Modern Steel Construction magazine. Award presentations will be made to the successful architects' representative on the evening of December 5, 1990, at the AISC Ninth Annual Awards Banquet in Chicago. Local awards not presented at the banquet will be presented later to recognize owner, general contractor, structural steel fabricator, structural engineer and erector as appropriate for each winning structure.

All entries will be retained by AISC for publicity purposes. The use of any entry's submitted data, detail and/or photographs by AISC shall be unrestricted.

Entry Requirements

An entry must consist of an entry form, photographs and descriptive data, all as described below:

Entry Form

Entry Form must include the following:

1. Name, location and completion date of the building.

2. Name, mailing address, telephone number and contact of the following:

Architect	Structural engineer
General contractor	Steel fabricator
Steel erector	Owner

Photographs

1. 8" x 10" color prints should include a minimum of two exterior photographs, showing all principal exposed sides of the building or building group, several interior photographs, any innovative or outstanding applications of steel that might not be evident in exterior photographs. Similar 35 MM color slides are helpful.

2. Photographs (B & W or color) or 35 MM color slides of the building under construction and showing portions of the structural steel framing are encouraged.

3. All photographs should be of professional quality and must be previously cleared for use by AISC in publicity and publications.

Descriptive Data

The following descriptive data is required:

1. An architectural description of the owner's requirements, the design solution, the building's outstanding features and reasons for using a structural steel frame.

2. A site plan, a floor plan and any details that amplify and/or clarify architectural description.

All descriptive data must be on 8½" x 11" sheets.

Deadline for Submission

Entries must be postmarked prior to **August 4, 1990** and addressed to the Awards Committee, American Institute of Steel Construction, Inc., One East Wacker Drive, Suite 3100, Chicago, IL 60601-2001.

AISC 1990 ARCHITECTURAL AWARDS OF EXCELLENCE COMPETITION

ENTRY FORM

Entry date: ____________

Name of building: ____________ Completion date: ____________

Location: ____________ City, state, zip: ____________

Descriptive data: Attach separate sheets (see completion rules)

No. of photographs enclosed: B & W ________ Color prints ________ 35 MM slides ________

Architectural Firm: ____________ Phone

Address: ____________ Street City and State Zip

Person to Contact: ____________ Title

Structural Engineering Firm: ____________ Phone

Address: ____________ Street City and State Zip

Person to Contact: ____________ Title

General Contracting Firm: ____________ Phone

Address: ____________ Street City and State Zip

Person to Contact: ____________ Title

Steel Fabricating Firm: ____________ Phone

Address: ____________ Street City and State Zip

Person to Contact: ____________ Title

Steel Erecting Firm: ____________ Phone

Address: ____________ Street City and State Zip

Person to Contact: ____________ Title

Owner: ____________ Phone

Address: ____________ Street City and State Zip

Person to Contact: ____________ Title

This entry submitted by:

Name: ____________ Title

Firm: ____________ Phone

Address: ____________ Street City and State Zip

(Additional entries may be submitted on copies of this form.)

Beam Replacement In Hazardous Areas

By Chris Colvin, P.E.

While the problem of corrosion in a petro-chemical plant is normally overcome with preventative maintenance, there are times when replacement becomes the only option. Such was the case during the recent upgrading of a production unit in Sarnia, Ontario.

In 1942, the plant was built to produce synthetic rubber. Beginning in 1985, all of the structural steelwork on the then 43-year-old plant was inspected, and where necessary, repaired. However, some of the support beams, including members as large as W36 x 150, needed replacement.

Though it is sometimes possible to restore a beam to its original strength by welding on new flange plates, this involves hot work and the need for a unit shutdown. Instead, the option to use cold work techniques was taken. This resulted in no production disruptions during the four-year project.

Uncovering Corrosion

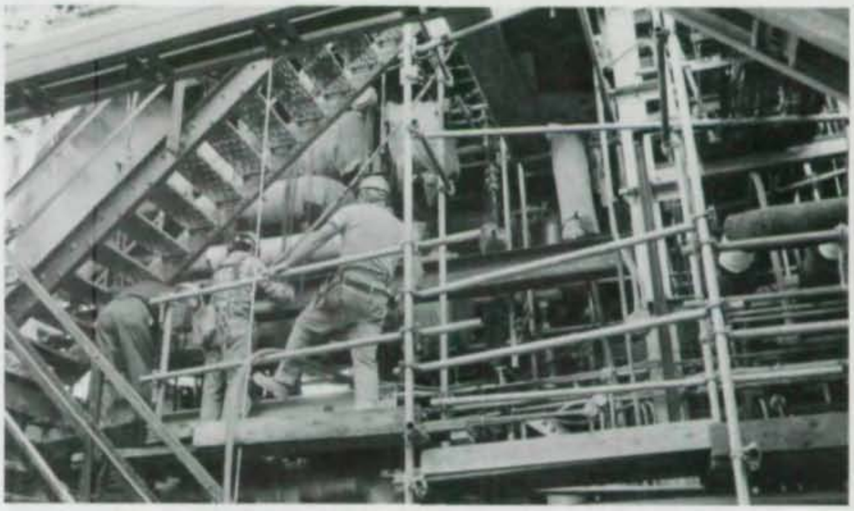
Because the beams were fireproofed with concrete, the degree of deterioration was not at all obvious. It was only when the checkerplate flooring was lifted that the extent of the problem became apparent.

Further worsening the situation, the original concrete had been cast flush with the top surface of the top flange. A shrinkage crack formed in the concrete along the edge of the steel flange, trapping water and thus aggravating the corrosion.

Beam Replacement

When a beam was found to be in need of replacement, the first requirement was to remove all the loads off the beam and to transfer them to the adjacent beams directly above or below. Because this could cause overloading, the spare capacity required was created by

Continued on page 16



Beam replacement in a petrochemical plant in Sarnia, Ontario, was complicated by the tight working conditions, as is evidenced in the photo above. Pictured at left is the replacement of the existing clip angles. Sometimes, this can be avoided by cutting existing beam with 12" of the column, and retaining the stub end. The replacement beam can then be spliced onto this stub end using just a pair of web plates.

Pictured below left is one of the corroded beams. Because the beam was fireproofed with concrete, the degree of the corrosion was not visible under normal working conditions, and only became apparent after removal.

Photos courtesy of NOVA Petrochemicals

Beam, Cont.

strictly limiting the pedestrian and maintenance access in the area.

The easiest method for transferring a load to the beam above was to use steel chokers and a chainfall. The chokers were rigged in either basket hitch or choker hitch, although with a choker hitch a reduced lifting capacity must be used. Where the chokers were wrapped around a beam, softeners made of short lengths of pipe were used to prevent kinking of the steel rope.

When a very critical piece of equipment had to be supported temporarily, both top and bottom supports were used. The top support was as described above, while the bottom supports consisted of temporary structural steel extending down to grade. Both supports were capable of taking the load independently.

Direct Support Of Horizontal Vessels

It was sometimes necessary to directly support a vessel while the beam immediately under it was being replaced. A typical vessel support consisted of: a welded saddle, either with or without a reinforcing pad; a make-up piece made from a short length of structural steel beam; and then the support beam itself.

First, a pair of slings were placed around the vessel as close to the existing support as possible. A series of 2" x 4" timber spacers placed between the slings and the vessel spread out any concentrated loads.

When ready, the structural bolts between the make-up piece and the support beam were removed. The weight of the vessel could then slowly be taken up on the chainfall until a hairline crack appeared between the make-up piece and the support beam. The idea was that while the load needed to be transferred off the support, this had to be done with the absolute minimum change in deflection, otherwise additional loads would be induced in the adjacent pipework, which remained operational during this procedure.

Initially, a feeler gauge was used to check this condition. Later this was found to be unnecessary, though extreme care was still exercised.

Beam Removal And Replacement

With all the loads removed, including any secondary beams spanning on to the beam, the actual beam removal could begin.

While the beam could occasionally be removed in one piece, more typically it had to be cut into two or more pieces. Two constraints (see diagram) on its removal required a single cut. More than two constraints involved two cuts, with the center section of the beam being removed first.

Because this work was being carried out inside a working hydrocarbon unit, all cutting had to be done with an air saw, and a stream of water was poured over the blade to eliminate any sparks.

Replacing the beam was simply the previous stage in the reverse order, except that where the beam was originally cut, now bolted splice plates were installed.

It was found that if a splice could be kept closer than 12" to an end support, then usually only web splice plates were necessary. Beams requiring only a single cut were therefore cut close to one end whenever possible. Splices nearer the center of the beam required both flange and web plates.

This was especially useful where there was restricted access to an existing end connection. If the remaining short length of beam was structurally sound, then by leaving it in place a considerable amount of difficult demolition was avoided.

Because of the restricted access, slotted end holes in the replacement beams were used to ease installation.

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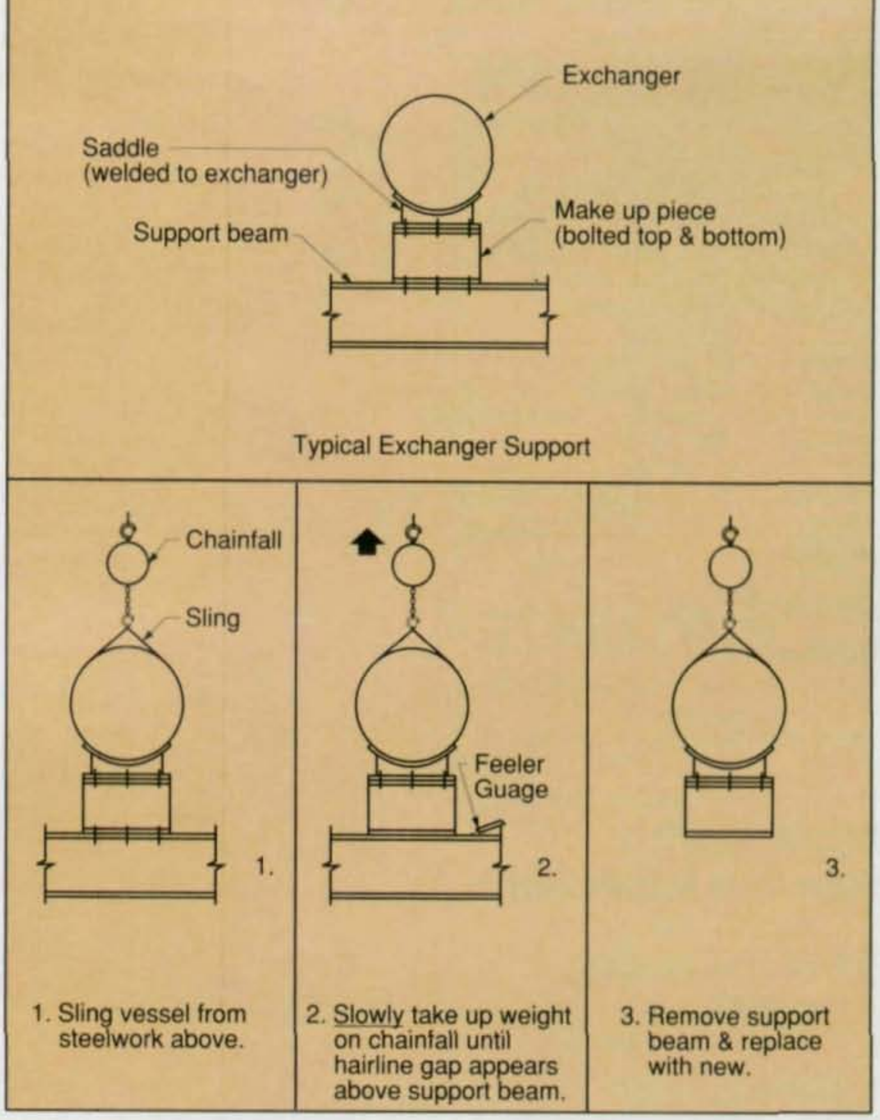
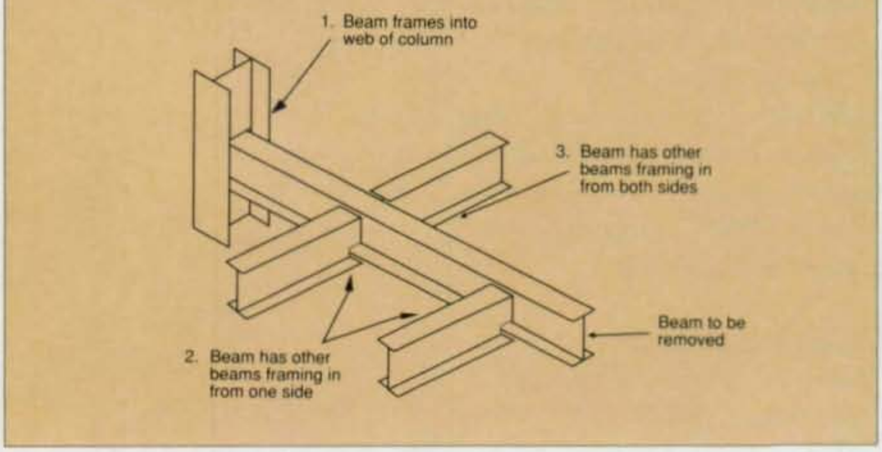
Replacement of Support Beams

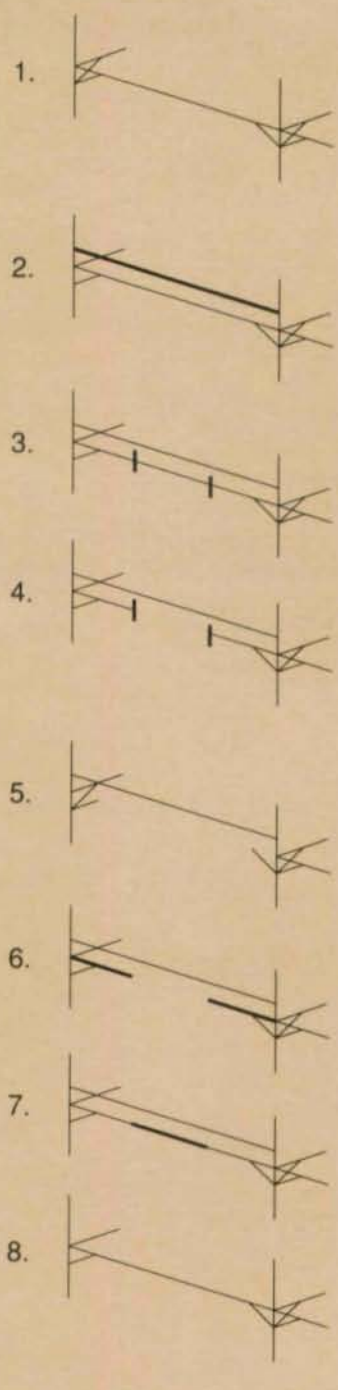


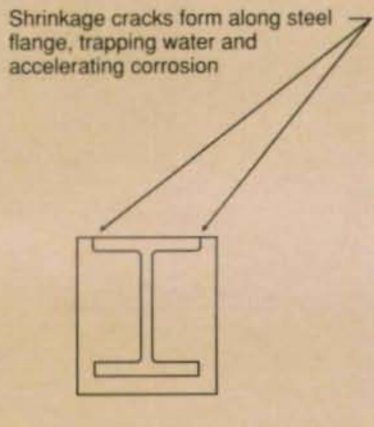
Constraints on the Removal of a Beam



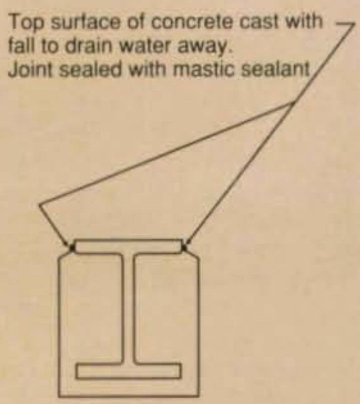
Beam, Cont.

Procedure for Replacing Beam





Original Detail
Concrete cast to top of flange



Revised detail
Concrete cast to underside of top flange

To avoid some of the original problems, when the fireproofing was replaced the concrete was cast up to the underside of the top flange with a 1/4" fall on the top surface of the concrete. A bead of butyl sealant was used to seal the joint between the steel and the concrete. The beam also was coated with an epoxy paint to provide both corrosion protection and an effective bond for the concrete.

Chris Colvin, P.E., is a senior structural engineer with NOVA Petrochemicals, Sarnia, Ontario. □

Back To The Future

While I must confess to not feeling especially positive about the *aesthetic* quality of the Home Savings Tower described in your recent article, I was extremely pleased with your expression of the sensibility of "freeing the skin from the structure" as well as the reference to Eiffel's Statue of Liberty. I have been arguing this same concept for some time based on my technical studies of historic structures: in *The Sciences* (October 1982 "The Engineer's Aesthetic"); in a PBS/NOVA program ("The Mystery of the Master Builders", first broadcast in 1988); and in my just-released book (*Light, Wind, and Structure,* MIT/McGraw-Hill, 1990). Bravo for this—and for much else that you publish.

Robert Mark,
Professor of Architecture and Civil Engineering
Princeton University

Unsafe At Any Height

I read with interest your editorial about seismic codes, but I believe that you have been somewhat misinformed.

All cities that have adopted as their building code one of the three major model codes have seismic building code requirements. This would also apply to states like New Jersey that have a statewide code (Basic Building Code in N.J.) Those model codes have seismic design provisions, but the most detailed is the Uniform Building Code. All three of the model codes provide maps showing the five seismic zones defining the degree of seismic activity to be expected. The two most active zones are generally along the west coast and Alaska. The Zone 2 areas you have pointed out are areas where little thought is given to the possibilities of earthquakes because of complacency.

The real problem is in the engineering profession and with building officials where there is little interest in learning about seismic problems and design. Last October the International Conference of Building Officials conducted a seminar in Arlington, Texas, covering the background changes to seismic provisions of the 1988 Uniform Building Code. Only about 12 engineers and no building officials attended.

When an engineer designs and seals structural drawings for a building in Chattanooga, Tenn., or Dalonega, Ga., (Zone 2) he is also accepting responsibility for the seismic design. Many do not even know that the codes have seismic requirements, but some consider probabilities as a reason not to calculate the seismic forces. Building officials generally do not enforce the seismic provisions of their codes. Just because a building in in Zone Zero does not mean there are no provisions. The "Big One" may cause damages in Houston (Zone Zero).

Just having codes is not enough, they must be enforced

The answer is in education of engineers, architects, and building officials, but they must be interested in learning. Even public interest will probably not come until there is a measurable activity in one of the non-Rockies Zone 2 areas.

Just having the codes is not enough, they must be enforced.

R.V. McGaughy
Consulting Engineer
Sugar Land, Texas

Operative Opposites

I have just finished reading your article in the March-April 1990 issue of *Modern Steel Construction* on the Cooper Chapel in Bella Vista, Ark. As a registered civil engineer I am appalled to the articles inference that because Mr. Jones "studied civil engineering for three years" he was competent to act as the structural engineer for the project.

As AISC should be a strong advocate for properly designed buildings, I find the wording of the article very disturbing.

Stephen T. McNeice, P.E.
Manager, Structural Engineering
Carlson Associates, Inc.
Cochituate, Mass.

Steel Trusses

I read, with interest, your article "Steel Trusses Create Expansion Opportunity" in the March-April edition of *Modern Steel Construction* because our office designed a similar project practically 30 years ago in the historic Palace Hotel in San Francisco in order to create one very large ballroom from two adjoining smaller rooms. Four columns were removed using two plate girders of 4'6" depth spanning 101'. Because of erection constraints, the girders were erected in segments to a cambered position reflecting the calculated dead load deflection.

Similar to Kansas City, prior to connecting to and removing the columns, the plate girders on each side of the columns were prestressed by jacking against the load above at each column, equal to the calculated dead load. When the column segments were removed, no further vertical movement of the girders occurred.

The two girders were spaced 7'5" apart in order to accommodate the suspension of a folding partition that would permit subdividing the space again into two rooms as occasions required.

Stanley E. Teixeira
Vice President
H.J. Brunnier Associates
San Francisco

Letters to the editor are welcomed. Please send your comments to: Scott Melnick, *Modern Steel Construction,* Suite 3100, Chicago, IL 60601-2001.

The increasing availability of software and textbooks, and the growing emphasis in civil engineering curricula, is combining to bring LRFD to the forefront of steel design

LRFD
The Quiet Revolution

Steel's reluctant revolution is beginning to pick up steam. While less than a year ago *ENR* was bemoaning the industry's lack of progress on adopting Load and Resistance Factor Design (LRFD), today there are indications that widespread acceptance will occur within the decade.

"The revolution has started and it's irreversible," according to Lawrence G. Griffis, Walter P. Moore and Associates, Inc., Houston. Griffis' firm has used LRFD on several projects, most notably the 312 Walnut office building in Cincinnati (see accompanying article). LRFD provides more uniform reliability, is more rational (strength and serviceability limits), saves steel, saves money, is flexible to change, and is in line with the world-wide trend toward ultimate strength materials, Griffis said.

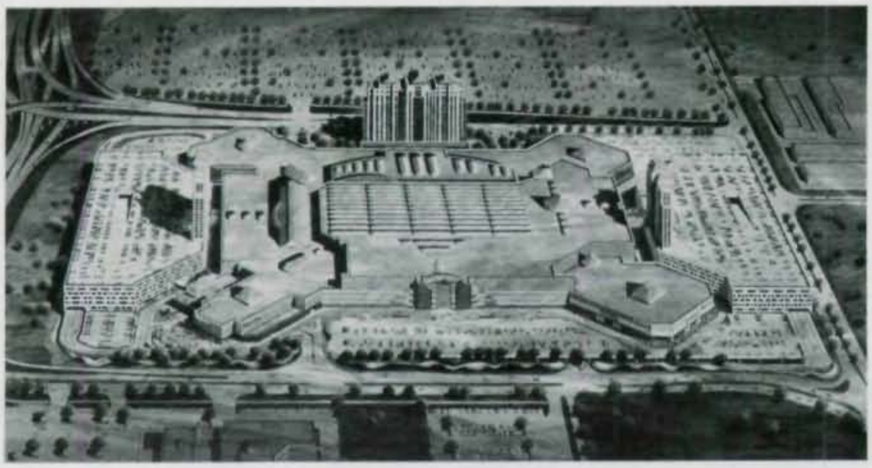
Another firm that has begun using LRFD is Shenberger and Associates, Inc., Brechsville, Ohio. Shenberger is the structural engineer on the recently begun Mall of America project in Bloomington, Minn., which at 2.6 million sq. ft. will be the nation's largest retail center. In addition, the project will include several hotels and a 300,000-sq.-ft. indoor theme park named Knott's Camp Snoopy.

"We began looking at LRFD a year ago and this is the first project we used it on," according to Tom Shenberger, the company's president. The firm sent several engineers to an AISC LRFD seminar, and they returned and began teaching the method to the firm's younger engineers. "The advantage to our client is that it is more cost effective," he explained. And contrary to some earlier reported opintions, "the advantage for us is that it saves time. It's easier and less time consuming for the engineer."

The entire project utilizes composite design. "We'll use LRFD on all our composite structures in the future," Shenberger said.

A More Rational Approach

"LRFD is an improved approach to the design of structural steel for buildings," explained Geerhard Haaijer, vice president of technology and research for AISC. "It involves explicit consideration of limit states, mul-



The Mall of America in Bloomington, Minn., is being designed using the LRFD Specification. The Mall, which will be the biggest in the U.S., will include 2.6 million sq. ft. of retail space, several hotels, and a theme park.

tiple load factors and resistance factors, and implicit probabilistic determination of reliability. The designation LRFD reflects the concept of factoring both loads and resistances. This type of factoring differs from the Allowable Stress Design (ASD) specification, where only the resistance is divided by a factor of safety to obtain allowable stresses, which are compared with calculated stresses corresponding to service loads," Haaijer stated.

"The fundamental difference between LRFD and the Allowable Stress Design method is that the latter employs one factor (i.e., the factor of safety), while the former uses one [reduction] factor with the resistance and one [increase] factor each for the different load types," wrote Theodore V. Galambos, professor of civil engineering at the University of Minnesota (Minneapolis) and one of the people instrumental in developing LRFD theory for buildings. "LRFD, by employing more factors, recognizes the fact that, for example, beam theory is more accurate than column theory, or that the uncertainties of the dead load are smaller than those of the live load. LRFD thus has the potential of providing more consistency, simply because it uses more than one factor," he explained in an *Engineering Journal* article.

"The LRFD method was devised to offer the designer greater flexibility, more rationality and possible overall economy," Haaijer said. And while the academics have stressed the rationality of the LRFD approach, the key to its practical acceptance may be in its potential for reducing costs.

ASD Vs. LRFD

Last year, AISC presented a series of lectures comparing the material costs of designing in ASD and LRFD. The study presented a wide variety of buildings, and in most cases there was a substantial material cost savings with LRFD. For example, on a proposed 16-story office building in Denver there was a 9% material savings with LRFD—mostly in the gravity beams—and a 17% shear stud savings. A 32-story office building study in Minneapolis presented almost identical results, while a six-story office building in Fairfax, Va., produced about a 6% material savings and a 10% shear stud savings with LRFD. The eight office buildings studied showed an average weight reduction of 6.6% for beams, 3.6% for columns, and a combined weight reduction of 5.5%, on average.

The savings were even more dramatic for parking structures. For example, a two-level parking structure in Cleveland, Ohio, produced an 8% material savings—primarily due to decreased beam weight—and a 41% shear stud savings with LRFD. A four-story parking structure in New York City showed about a 12.5% material savings and a 46% shear stud savings with LRFD.

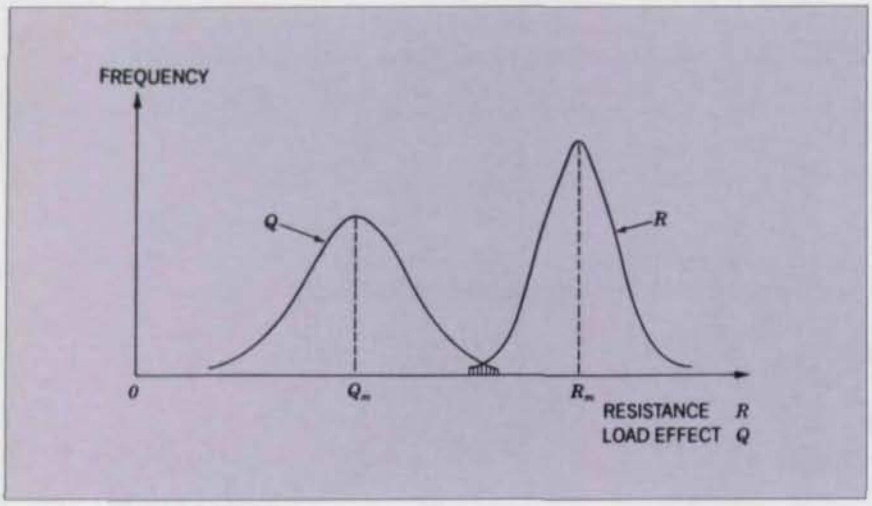
LRFD's most obvious advantage is in floor systems. According to the AISC study, there were sub-

Which Design Method Will Be Taught In Your Undergraduate Civil Engineering Program During The 1990-91 School Year?

LRFD Only	LRFD w/some ASD	ASD w/some LRFD	ASD Only
41%	13%	29%	15%

Which Design Method Will Be Taught In Your Graduate Civil Engineering Program During The 1990-91 School Year?

LRFD Only	LRFD w/some ASD	ASD w/some LRFD	ASD Only
41%	28%	21%	10%



The probabilistic basis for LRFD is illustrated by the diagram above. The load effects Q and the resistance factor R are assumed to be statistically independent random variables. Frequency distributions for Q and R are portrayed as separate curves on a common plot for a hypothetical case. As long as the resistance R is greater than (to the right of) the effects of the loads Q, a margin of safety for the particular limit state exits. However, because Q and R are random variables, there is some small probability that R may be less than Q, (R<Q). This is portrayed by the small shaded area where the distribution curves cross. (Source: LRFD Manual of Steel Construction, 6-144.)

stantial cost savings, including:

- For bare beams an approximate savings of 4%;
- For composite floors, the savings averages 8-12%, or \$0.15-\$0.22/sq. ft., with a lower percentage of high-strength steel, fewer shear connectors, more deflection/camber, and unchanged vibration.

For industrial buildings, LRFD offers substantial benefits in heavy roof systems. Also, benefits may be found in the interaction design of beam columns in LRFD.

AISC is currently preparing another LRFD lecture series for 1990-91. For more information, write: LRFD Lecture Series, AISC, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

Shayne Manning, P.E., S.E., an engineer with THP Limited in Cincinnati, compared LRFD with ASD on three buildings back in 1986-87, and since then has switched entirely to LRFD. On the three buildings—a 20-story office building, a four-story office building, and a 14,000 seat arena with a 235-ft. roof span—Manning found a substantial weight savings with LRFD.

"For members controlled by gravity, there was a 10 to 15% weight savings with LRFD," he said. "However, the members controlled by wind required larger members. But because the wind-control members are such a small percent of a building, LRFD was much more economical." Calculations show there can be a slight weight savings using ASD when there is a minimal live load as a percent of the total load, and a high wind load.

Manning is the only engineer in his 35-person firm using LRFD, primarily because of the time it takes to learn the system, he said. "Consulting engineers are very concerned about billings, and if you factor the learning time into a project it would not be cost effective [on that project, though on subsequent projects LRFD won't take any longer to use than would ASD]. Also, there's a lot of concern with making mistakes and the potential liability issue [with any new system]."

LRFD Lecture Series

A new series of lectures on Load and Resistance Factor Design will be held throughout the country by AISC during 1990-91. To receive more information on these lectures, return this form to: AISC-LRFD Lecture Series, One East Wacker Dr., Suite 3100, Chicago, IL 60601-2001.

Name: ____________________

Company Name: ____________________

Street Address: ____________________

City/State/Zip: ____________________

Phone Number: ____________________

Growing Emphasis In Schools

Perhaps the biggest sign of the widening acceptance of LRFD comes from the national model building codes and from the engineering schools.

All three U.S. model building codes—BOCA, SBCCI and ICBO—have approved LRFD as an alternate design method to ASD. "However, local building codes will take time," cautioned Griffis. "But if you take a trip and explain the system to a local official, approval is usually forthcoming. I've yet to find a building code official who wouldn't approve LRFD."

During the 1988-89 school year, only 10% of the civil engineering schools surveyed in an ASCE Composite Study emphasized LRFD, while 72% emphasized ASD and 18% included both. A recent AISC study shows that in 1989-90, the number of schools emphasizing LRFD had increased to 37%, with only 31% emphasizing ASD and 32% including both. And the trend is expected to swing even further towards LRFD in 1990-91, when 41% of the surveyed schools responded that they will be emphasizing LRFD, only 15% say they will emphasize ASD, and 42% will include both. In addition, 69% of graduate level courses currently emphasize LRFD.

During the educator meetings at the National Steel Construction Conference in March, only one person objected to teaching LRFD, according to Bob Shaw, associate director of education for AISC. "His objection was that schools shouldn't teach it since engineers weren't using it," Shaw said. "But other educators responded that schools should be the leaders, not the followers. Also, some educators said that some engineering firms are waiting to use LRFD until their new hirees can teach it to the other engineers in the firm."

While the LRFD Specification was first issued in 1986, textbooks were not generally available until recently. "The big growth in LRFD will be the availability of the Jack C. McCormac textbook and the Charles G. Salmon/John E. Johnson book will help even more (see reviews in this issue)," Shaw said.

Another roadblock has been the lack of software for LRFD, but that is now starting to be remedied. Some available programs include:

- American Computer & Engineer's SCADA, 11726 San Vicente Blvd., Suite 212, Los Angeles, CA 90049 (213) 820-8998;
- ECOM Associates' SD4C (steel beam/column design), 8634 W. Brown Deer Road, Milwaukee, WI 53224 (414) 354-0234;
- HESCO's composite steel beam design and column design programs, 13839 SW Freeway #128, Sugar Land, TX 77478 (713) 545-9820;
- LRFDCOMP from Precision Programming (composite beam design), P.O. Box 3731, Minneapolis, MN 55403 (612) 936-4031.

There also has been some grumbling among engineers that they're comfortable with ASD and shouldn't have to take the time or expense to learn a new system. But as Griffis put it: "If you're going to be a professional, you have to take the responsibility to keep up with the latest developments. And LRFD isn't that difficult to learn." □

Two New LRFD Textbooks

By Robert Lorenz

Complaints about the lack of Load and Resistance Factor Design (LRFD) textbooks should be stilled by the publication of two new works by established authors.

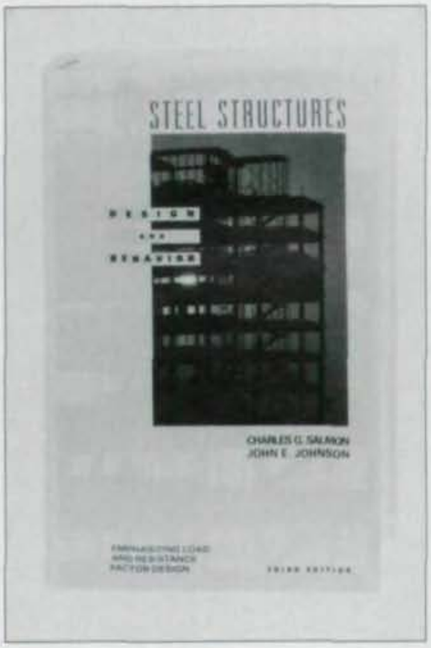
Both books are published by Harper and Row and they share the advantage that they are actually complete updates of already popular and respected textbooks on the Allowable Stress Design (ASD) method.

The first book is *Structural Steel Design LRFD Method*, by Jack C. McCormac, and it should please the fans of his earlier ASD book. It is similar in style, with a simple, almost colloquial, text that most readers will find "user-friendly". It should be popular with those who want to avoid a critical dissection of the new design philosophy and are more interested in getting to the bottom line of design procedures.

Professor McCormac's text—all 514 pages and 20 chapters—is relatively unburdened, and should be a quick "read" for the experienced designer.

On the downside, the textbook suffers from a lack of reference material that may be demanded by experienced professionals interested in deeper learning. Also, a minor irritant is provided by the at-times almost whimsical text. This, however, is no doubt a positive attribute for the neophyte student, who, after all, is undoubtedly the author's primary audience. For the new student, the book contains 107 design examples and 326 problems.

McCormac's book is an excellent way to get into the process of LRFD design very quickly. The simple explanation of reliability theories in just over two pages is no doubt enough for most people. However, this is not the book for those who want references and sources.



A more comparative approach between ASD and LRFD is taken by Charles G. Salmon and John E. Johnson in *Steel Structures—Design and Behavior Emphasizing Load and Resistance Factor Design*. Despite its "Third Edition" label, this is a completely revised textbook. And while it completely shifts its emphasis to LRFD, it still maintains a comparative ASD section in its design-oriented chapters. This comparative approach provides the strong benefit of allowing readers to compare both methodologies.

Given this dual function, the book is very well organized. It remains a comprehensive, if not exhaustive, reference of just about every niche-and-cranny of both traditional and state-of-the-art structural steel technology. The authors take great pains to give a clear understanding of basic principles, which is clearly the objective of their text. This is exemplified by clear diagrams and sketches, thorough design examples, and consistency in layout. They succeed amazingly well in blending the LRFD into existing knowledge, and it is done in such a way as to be totally unobtrusive. Credit must be given both to the authors' skill, and to the more logical presentation of the material inherent in LRFD.

For structural steel junkies, the Salmon-Johnson text boast 670 selected references spread among its 16 chapters and 1086 pages. These citations alone guarantee the value of the book as a focus of structural steel technology. In addition, steel educators are provided with 172 design examples and 257 problems.

Depending on the specific needs of the reader or student, both books can be recommended. Each is very clear in its presentation, and both have a very readable style. Both books are recommended additions to the libraries of any design firm contemplating adopting LRFD.

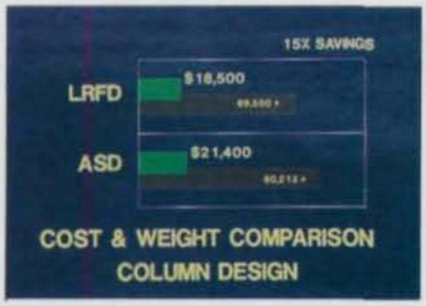
The McCormac text sells for \$44.25, while the Salmon/Johnson book lists for \$45.00. Both can be ordered from: Harper & Row, Publishers, Inc., 10 East 53rd St., New York, NY 10022 (212) 207-7000.

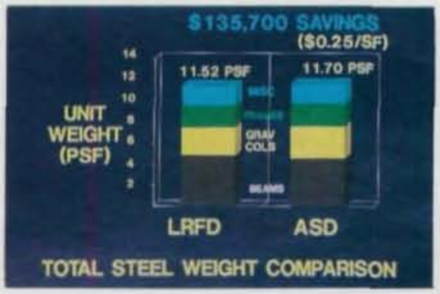
Robert Lorenz is director of education and training at AISC. □

The Quiet Revolution LRFD

Value Engineering Points To LRFD

Using composite shear walls and the new LRFD specification combined to cut costs on a 34-story building in Cincinnati by $335,700





By Lawrence G. Griffis, P.E., and Ali A. K. Haris, P.E.

As competition in the construction industry continues to grow, value engineering becomes more and more important. In the case of the 312 Walnut Building in Cincinnati, a comparison of structural systems and design methods resulted in substantial savings.

The $40 million, 860,000-sq.-ft. building consists of 525,000 leasable sq. ft. on the upper floors, and a nine level parking garage below. The project's architects, 3D International, Houston, and Glaser Associates, Cincinnati, designed a glass, granite, and precast clad tower, with the curved glass facade affording spectacular unobstructed views of the Ohio River. Developed in a joint venture of Duke Associates and the Mayerson Company, both of Cincinnati, the building was recently topped out and occupancy in expected during the summer of 1990.

Value Engineering Studies

As is common in many major projects, intense value engineering studies were undertaken to determine the most cost effective structural system.

The lower garage levels were specified by the developer to be reinforced concrete, and lower forming costs and a relatively short span parking bay (typically 30′ x 30′) dictated the selection of a mild reinforced flat slab system.

A composite steel and metal deck floor system or a concrete flat slab system similar to the lower parking levels were each considered for the upper office floor framing. The composite floor system, which consisted of an 18 gage composite metal deck on a 10′ typical purlin spacing with 2½" of normal weight concrete over the deck (total slab thickness was 4½"), was chosen as the most economical. The entire floor system was spray fireproofed to achieve a three hour fire rating. The longer rating was required by the local building code for the entire building floor system because space was allocated to a day care center on one of the lower floors. Typical purlins are A36 steel and girders are A572 Grade 50 steel.

A study also was conducted of the lateral load resisting system. Three systems were evaluated in detail, including a jump-formed concrete core wall system, an all-steel braced core system, and a steel braced core system utilizing composite shear walls. A cost comparison of the three lateral load resisting systems showed an approximate savings of $200,000 with the composite system. The advantages of the system included the speed and ease of construction that allowed simultaneous construction by many construction trades.

In the composite shear wall system, steel erection columns (light W14 A572—Grade 50 sections) were utilized and erected ahead with the steel frame that consisted of the floor beams and girders, exterior columns, and those interior columns not part of the core brace system. The composite walls utilized high strength normal weight concrete. Judging by the speed and relative ease of the construction of the composite shear wall system, it is probable that the actual savings exceeded the anticipated $200,000 figure.

General contractor on the project was Duke Construction Co., Cincinnati. Steel fabricator was Ferguson Steel Co., Inc., Indianapolis, and erector was Ben Hur Erectors, St. Louis.

Composite Beam Design Criteria

A typical floor of the office tower was designed using both the ASD ninth edition (1989) and the LRFD Specification first edition (1986). Computer programs designed by Haris (HCOMPL and HCOMPA) were used for the comparison. Design criteria included: partial composite action; deflection limitation of L/360 under live load plus long term sustained dead load with a maximum allowable value of 1"; and spandrel beam deflection of ⅜" under superimposed floor load.

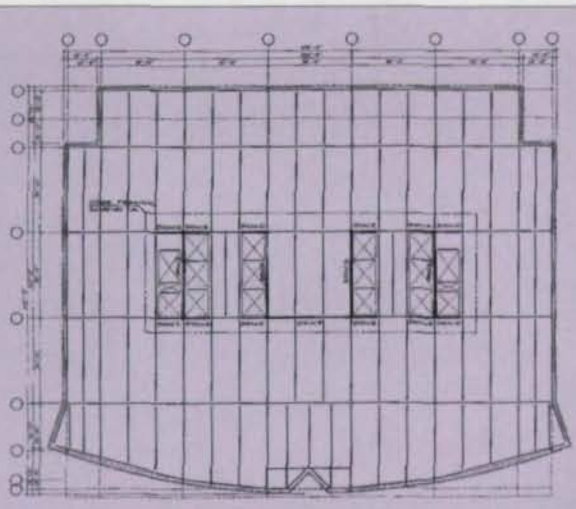
Floor vibration was evaluated and compared for each scheme following guidelines reported by Thomas M. Murray in the AISC *Engineering Journal* (3rd quarter 1975 and 2nd quarter 1981).

Because least weight does not always translate into the least cost design, the following unit prices were assumed by Moore & Assoc.:

- A36 Steel Material Cost = $0.238/lb.;
- A572-50 Steel Material Cost = $0.266/lb.;
- Camber Cost = $0.03/lb.;
- ¾" diameter x 3½" studs = $1.40/each (in place).

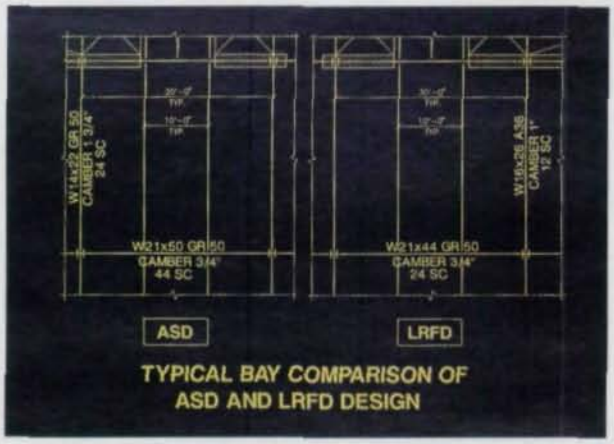
It was reasoned that beam

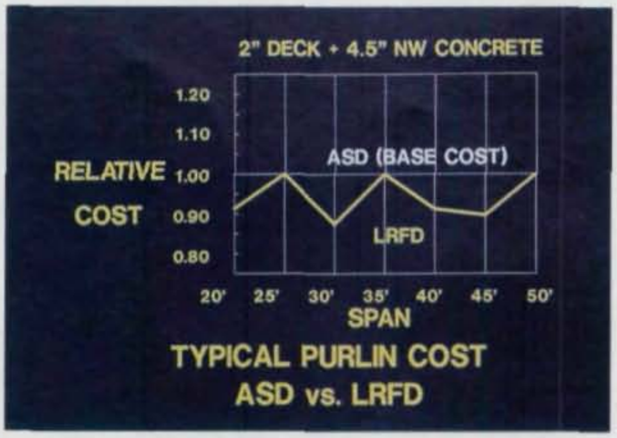
At 860,000 sq. ft., the 312 Walnut building (right) in Cincinnati is one of the largest structures designed to date using the LRFD Specification. Photograph courtesy of Robin Bruelheide Photography



Scheme 1:
Composite Steel System

Value engineering revealed that a composite floor system utilizing LRFD design would be the most economical alternative. Compared to two ASD alternatvies, the LRFD design reduced the cost by 9% and 22%, respectively. Likewise, designing a typical 30′ purlin and girder using LRFD reduced the project's cost by $0.12/sq. ft., or $67,000.





fabrication and erection costs were substantially the same for each scheme on a per member basis and therefore did not enter into the comparison.

Composite Floor Designs

The composite floor system utilized for the building and in each redesign contained 2½"-deep 18 gage composite metal deck with a total slab thickness of 4½" normal weight concrete. The floor system was spray fireproofed to achieve the required three-hour fire rating. Three designs were considered:

- Scheme 1. LRFD design using A36 purlins and spandrel beams and A572-50 girders;
- Scheme 2. ASD design using A36 purlins and spandrel beams and A572-50 girders (same mix as design 1.);
- Scheme 3. ASD design using all A572-50 steel.

Typical purlins span 30′ and vary from 20′ to 32′. Typical girder spans are 30′ and vary from 30′ to 40′.

A study of the results shows that the LRFD design was the most economical, and it was chosen for the project. The LRFD design (Scheme 1) reduced the cost by 9% compared to Scheme 3 and 22% compared with Scheme 2. Note however, that least weight does not translate into least cost because of camber and stud costs.

Lighter-Weight Purlins

A typical 30′ purlin and girder were also designed by LRFD using all A572-50 steel. That design saved approximately 5% in steel weight but cost the same as the LRFD design using A36. The all A572-50 design was not chosen since it produced a less-stiff floor at no cost savings. The savings using the LRFD design instead of the most economical ASD design (Scheme 3) on the floor saved approximately $0.12/sq. ft., or $67,000.

It appears that in many cases the new LRFD design procedure will require significantly less shear connectors compared with the ASD design procedure. In this study, the as-built LRFD design reduced the number of shear connectors by 50% compared with the most economical ASD design. Therefore, in any meaningful comparison of the two design procedures, the stud cost must be considered. This element of the composite beam cost often means that least beam weight does not necessarily mean least overall cost.

Steel Column Design

Structural steel gravity columns in the building as-built were A572-50 steel and were designed by LRFD. In comparing the columns designed under the LRFD procedure with columns designed under the ASD procedure, the LRFD gravity columns resulted in savings of $0.11/sq. ft., or $59,000. In addition, the LRFD core-braced frames reduced the costs by $0.02/sq. ft., or $9,050. A weight comparison reveals that the LRFD design saves about 15% in the gravity columns.

LRFD design is a more rational design procedure in terms of overall safety factors and reliability. It is as easy or easier to use than the ASD procedure, and it is consistent with the world-wide trend toward the use of ultimate strength design methods.

The detailed model of 312 Walnut reveals its beautiful curved glass facade. The project is expected to be completed in mid-year 1990. Photograph courtesy of Walter P. Moore and Associates.

This article is adapted from a paper delivered at the 1990 National Steel Construction Conference in Kansas City. Lawrence Griffis is senior vice president of Walter P. Moore and Associates, Inc., Structural Division, Houston. He is a registered structural engineer in 19 states and a member of the AISC, American Society of Civil Engineers, Consulting Engineers Council of Texas, and the Houston Engineering Council. Ali Haris is vice president and group director at Walter P. Moore, Structural Division. He is a registered professional engineer in Texas and Washington, and a member of the American Society of Civil Engineers. □

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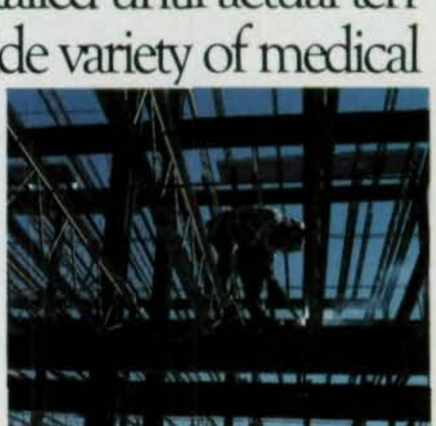

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Rising Above Adversity

The 31-story Walnut Building in Kansas City, which is still under construction, was built on top of an existing six-story parking garage.

The designers of a 31-story office building in Kansas City weren't deterred by an existing parking garage on the site

When you build a 31-story office building on top of an existing six-story parking structure, the design of the office building will be a reflection of that difficult circumstance. Fortunately for the designers of the Walnut Building in Kansas City, the parking structure only extended beneath half the building.

"Steel was crucial for this job because of the parking structure below," stated Charles R. Page, P.E., president, Seiden & Page Consulting Engineers, Shawnee Mission, Kan., "Concrete would have just been too heavy."

"The building is a modified braced frame with five bays of bracing extending to grade at the north 40% of the building and columns supported by six transfer girders at the sixth level for the south 60%," said William G. Richey, vice president of engineering with Havens Steel Co. in Kansas City, the project's steel fabricator. The transfer girders frame over new concrete columns that extend through the garage and about 60′ below to bed rock.

Because of the parking structure's layout, the sixth floor has transfer girders to move the load, Page explained. "The columns needed to be shifted because otherwise they would have been in the middle of aisles. We needed to minimize the loss of parking spaces which are worth $5,000 to $6,000 each."

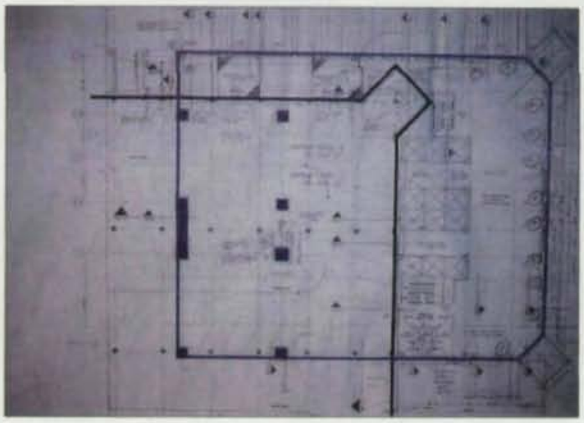
Construction Sequence

Because the existing garage was post-tensioned concrete, the contractor couldn't simply cut through the concrete slab. Instead, first the tensioning rods needed to be located; then the cables were heated so they would relax; a post tension jacking device was used to reset the cable at each end of the hole cut for the new concrete piers; and finally the contractor burned off the cable that extended through the hole. General contractor on the project was Tom Martin Construction, Shawnee Mission, Kan. "We needed about a 6'-square concrete pilaster to support the building," Page said.

The steel columns support and are connected to spandrel beams with semi-rigid connections. The transfer girders vary in size, weight, and capacity, from a minimum of 8' high and 24' long with a weight of 10 tons, to a maximum of 13' high and 40' long with a weight of 54 tons.

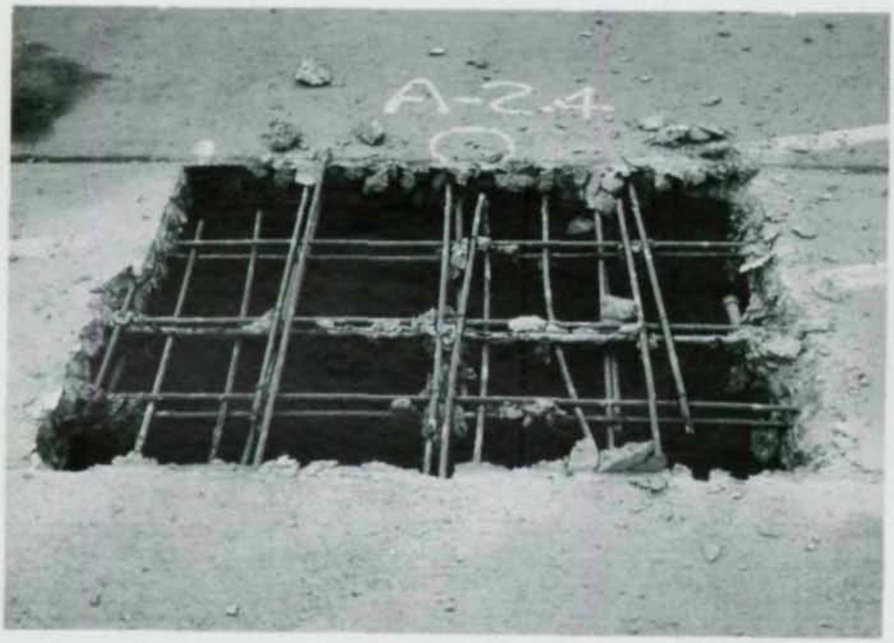
"Each of the beams that needed to be erected is 54 tons," Page said. "They were put into place as two 27-ton girders that were then put together." The girder was split horizontally, and one piece had the stiffening on the left, while the other had the stiffening on the right. "They fit together like a jigsaw puzzle," he explained.

The two-piece installation was needed on three of the girders because of site limitations on crane size and capacity, Richey said. A horizontal field-welded splice was determined to be the best solution because: the girders have relatively short spans for the depth and half the girder depth with one flange would not have any noticeable



The sixth-floor plan shows the location on the columns that extended down through the parking structure and the large transfer girders.

Because of site limitations and the large size of the transfer girders, three of them were installed in two pieces. Even though the horizontal joint has a shear requirement of about 80%, and a complete penetration weld was made, the horizontal joint only required about one-third the weld that a vertical joint would have required.



Supporting the new office building was extremely complex because the parking deck was post-tensioned concrete. The tensioning rods had to be located and a post tension jacking device was used to reset the cable at each end of the hole cut for the new concrete piers.

deflection; shoring would not be required with a horizontal field splice; and even though the horizontal joint has a shear requirement of about 80%, and a complete penetration weld was made, this horizontal joint only requires about one-third the weld that a vertical joint would require.

Complex Bracing

The structure is partially stabilized with braced frames around the elevator core. These frames resist lateral forces in the north/south direction in three bays, and in eight bays in the east/west direction.

"We started out thinking about K-bracing in the north/south direction, but switched to X-bracing to gain efficiency," Page said. "The two-story X-bracing uses less material with shorter runs, there's about a 15% improvement in the way the building uses materials in the lateral system."

The X-braces are 28' wide and 26' high. The bracing consists of double channel members back-to-back, connected through their webs to gusset plates shop welded to columns and struts. These double channel struts also act as floor supports and are located at the top, bottom, and mid-height of the X-braces.

Because the east/west direction is interrupted by the elevator doors, it was decided to use single-story K-bracing in that direction. These braces are 8' wide and 13' high. The bracing consists of wide flange members with gusset plates shop welded to brace ends and framed to connection clips welded to wide flange columns and struts.

Page designed the building using a combination of Load and Resistance Factor Design (LRFD) and Allowable Stress Design (ASD). "We used LRFD on the main load-carrying beams—primarily the frame because it substantially reduced costs," he explained.

For example, a 50'-long interior beam designed using ASD weighed 182 lbs. per running ft. With LRFD, the beam weighed only 150 lbs. per running ft. Since the typical floor member is repeated 62 times, the change in the interior beam resulted in a total savings of 99,200 lbs. Likewise, a 50'-long exterior beam designed using ASD weighed 130 lbs. per running ft., while with LRFD the beam weighed only 116 lbs. per running ft. Again, that member is repeated 62 times, which meant a savings of 42,400 lbs.

"The typical floor member is used 62 times on this project," Page stated. "A savings of 20 or 30 lbs. per running ft. can amount to thousands of lbs. on the total job."

According to Page, it takes longer to design with LRFD because it involves keeping track of the factored loads versus the unfactored loads. For members that are repeated, the savings can be substantial. But for individual members, the added design time is not recouped by material weight savings. However, as designers become more familiar with LRFD, the time differential should be minimized. "We used ASD for the small and secondary members and the columns," he said. "The columns are stiffness controlled, so LRFD wouldn't have provided savings."

The columns are designed in the 14"-wide flange family, Richey said. "In order to increase capacity some of the lower sections are reinforced with shop welded cover plates." Three splices were used, including: a gravity splice that required milled column ends and a connection equal to 10% of the upper column area; a gravity and partial moment splice that required milled column ends and a connection capable of transferring 50% of the upper column section modulus; and a gravity and moment splice that required a connection capable of transferring 100% of the upper column section modulus.

Tower floors are generally supported with long-span bar joists, except around floor openings were wide flange shapes are used to frame the short spans.

The project will require Havens to fabricate and erect 5,600 tons of structural steel. Miscellaneous steel, including the stairs, was fabricated by the Bratton Corp. of Kansas City and totals 150 tons. The average weight of the structural frame is 21 lbs./sq. ft. Project developer is Copaken, White, Blitt, Leawood, Kan.

The structure is partially stabilized with braced frames around the elevator core. In the north/south direction, X-bracing was used to take advantage of the economies inherent in a two-story high frame. The bracing consists of double channel members back-to-back, connected through their webs to gusset plates shop welded to columns and struts.

K-braces were used in the east/west direction to accomodate the elevator doors.

Architectural Considerations

The placement of the building over the existing parking structure dictated many of the architectural considerations, according to James Galle, AIA, project manager with Howard, Needles, Tammen & Bergendoff, Kansas City, the project's architect. "The building is built over the northwest corner of a garage that wasn't meant to have a building built over it," Galle explained. "This located the core for us, and that dictated the floor and plate sizes."

The building is aimed at professionals—lawyers and accountants. "The original concept was that it should be clad all in granite, but that was too expensive," he said. "Instead, we used punched granite and areas of curtainwall glazing."

To minimize the cost, the granite on the floors above the sixth level is glazed into the window system, instead of installed on individual backup. "The color of the granite was chosen to work into the beige/limestone coloration of downtown Kansas City. But we also wanted a more lively appearance, so we chose Sunset Beige, which has pink and gray striations. We used black aluminum mullions and gray glass."

The design is intended to project a professional appearance, rather than a corporate image. "If it was a corporate building, it would have been more flamboyant. This is more restrained and elegant." □

A Cost Advantage

A small speculative office building realized weight savings of 9% by using the LRFD specification

When structural engineers Lanna Dunlap & Spriggs, P.C., Richmond, Va., designed a new three-story, 49,388-sq.-ft. office building for Pruitt Associates in an established office park in Henrico County, Va., they naturally used Allowable Stress Design (ASD).

Around the same time, however, Dave Spriggs, P.E., a principal at the engineering firm, attended an AISC lecture on the new Load and Resistance Factor Design (LRFD) specification. "We were at a point in our office where another project was put on hold, so we had a window of opportunity," Spriggs explained. He used that opening to redesign the building using LRFD. "The advantage was that we had an entire building designed using ASD to compare it against. And the initial calculations suggested we could save the owner some money."

Because the project wasn't priced as an ASD job, exact cost savings were not computed. "The effect on the Highland I office building was to knock the beam sizes down," Spriggs said. "For example, a 24 X 68 beam became a 24 X 62," which translates into a weight savings on the horizontal members of approximately 9%. The column sizes weren't effected by the switch to LRFD. The 185 tons of structural steel on the project was fabricated by Liphart Steel Co., Inc., Richmond, Va.

Code approval was not a problem on the three-story project because the BOCA code was adopted locally with only minor amend-

Because the Highland I office building in Richmond, Va., was designed as speculative office space, the developer wanted a design that would help market the space. In response, the architect designed a mixture of masonry and glass facade, and two three-story curved bay windows.

Because the owner had a preference for avoiding a structural steel stud system to support the masonry cladding, the engineers designed a block and brick veneer system. The projected curtainwall, which did not effect the project cost, is supported by lintel spandrels. Photographs courtesy of Bass Construction

ments, and BOCA has accepted the LRFD specification.

"Learning LRFD was more time consuming than intellectually difficult," Spriggs asserted. "It takes some time to get up to speed on the new spec, but once you're familiar with it, there's no more actual time needed to design a building." Part of the learning process for Spriggs included developing spreadsheets for LRFD design. "I'd feel uncomfortable using something off-the-shelf for something that is this new. Also, in the process of developing the spread sheets, you become more familiar with the design process," he said.

"The biggest thing is cost savings. ASD has worked well and people are happy with it. If you've been in practice for a while, you stay with something that works, unless someone comes along with something that is better, and by better that means a cost savings. In 10 years, we're all going to be using LRFD, it will be the standard," Spriggs stated.

The interior structure of the Highland I office building is fairly straightforward, with steel wide flange columns set 30 ft. on center. The floor is bar joist with a 3"-thick concrete top. Where the project becomes complicated is on the perimeter, where there is a setback store-front at the first floor, curved bay windows, and a projected curtainwall.

Supported Curtainwall

"We designed tubes at the top of the bay window—a short span—to act as torsion beams," Spriggs said. The two windows stretch the full three-story height of the building.

A more complicated situation arose over the masonry curtainwall. "The owner had some concern with using standard stainless steel ties so we did a cost analysis of using a heavier steel structure with a block and brick veneer versus a structural steel stud system welded back to the building," explained Gerry Canavan, project manager with Bass Construction, Richmond, the project's general contractor. Because the costs were similar, the supported curtainwall was specified.

The projected curtainwall is supported by lintel spandrels—one at each story—over the window openings. The spandrels carry the load of the exterior cavity wall, and kickers were installed with a 6′ spacing to take the torsion out of the spandrel.

"This project is planned as the first in a series of buildings," said Eugene Sikes, project architect with Freeman & Morgan, Richmond. "It's a speculative office building, but we wanted it to be one step above the other spec buildings in the office park. The column details and bay windows really set the building off."

Project completion is expected by July 30, almost one month ahead of the scheduled contract completion. "The main steel structure went up in four weeks," Canavan said. □

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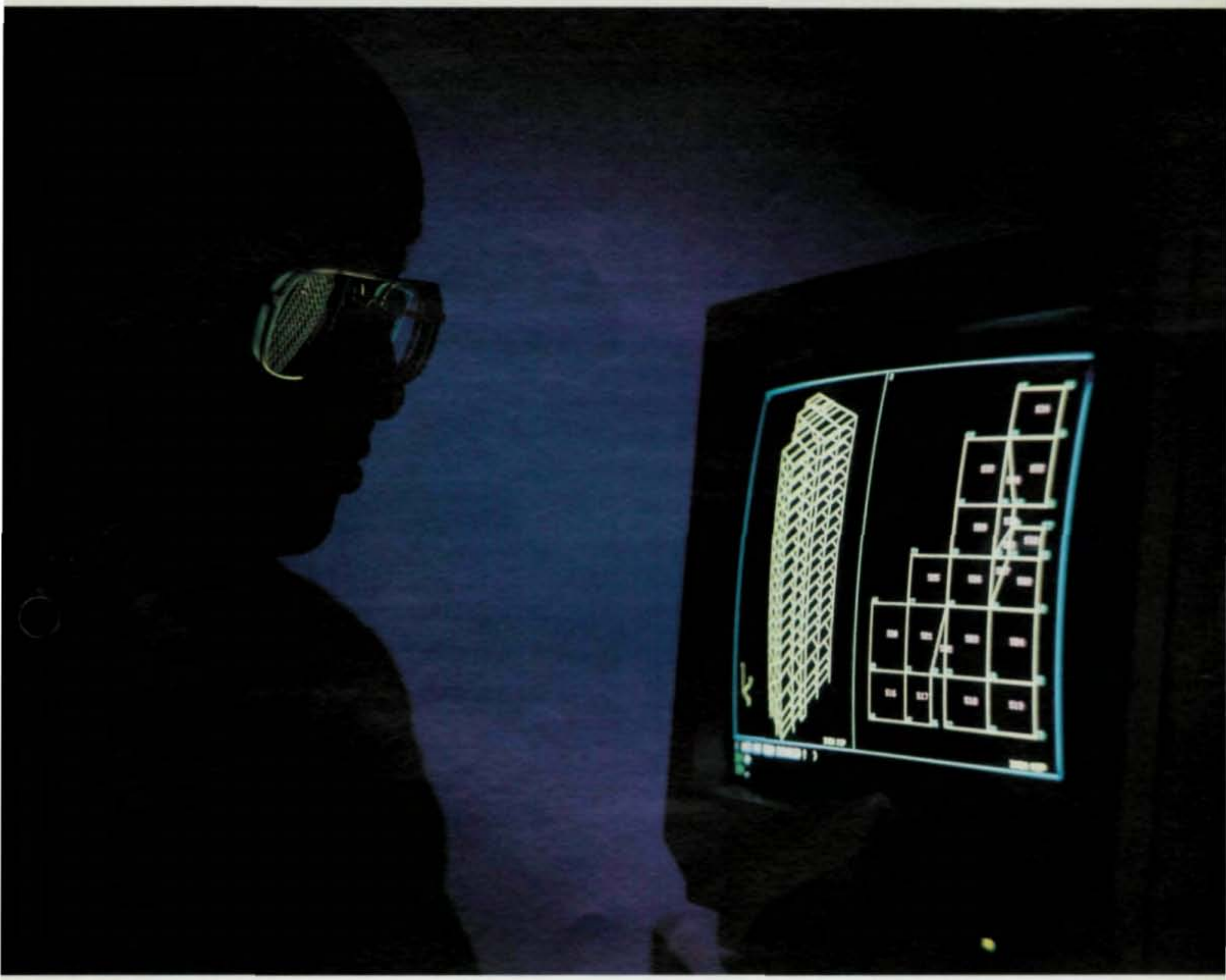

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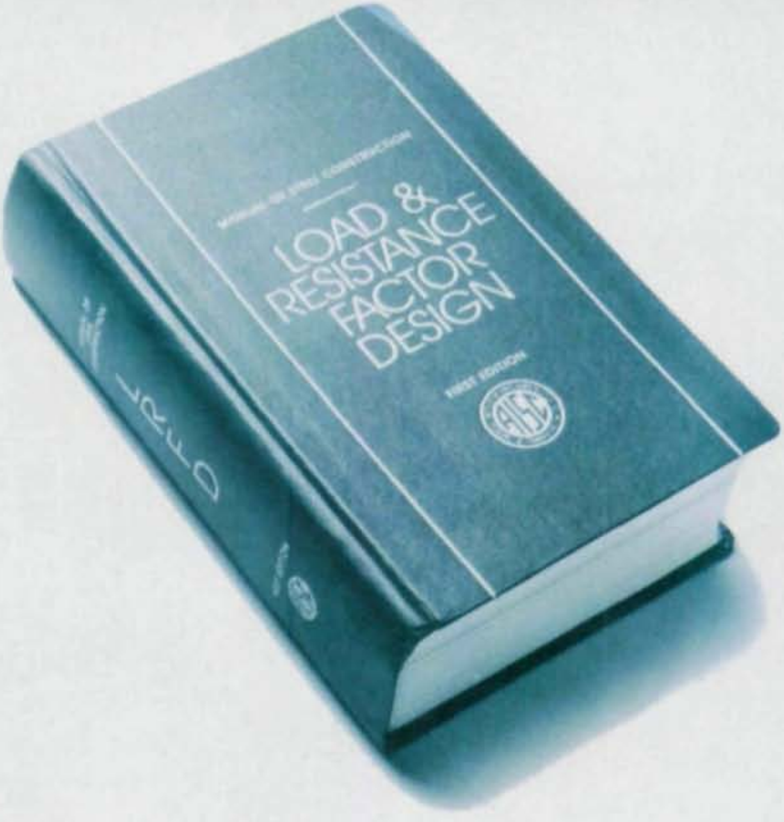

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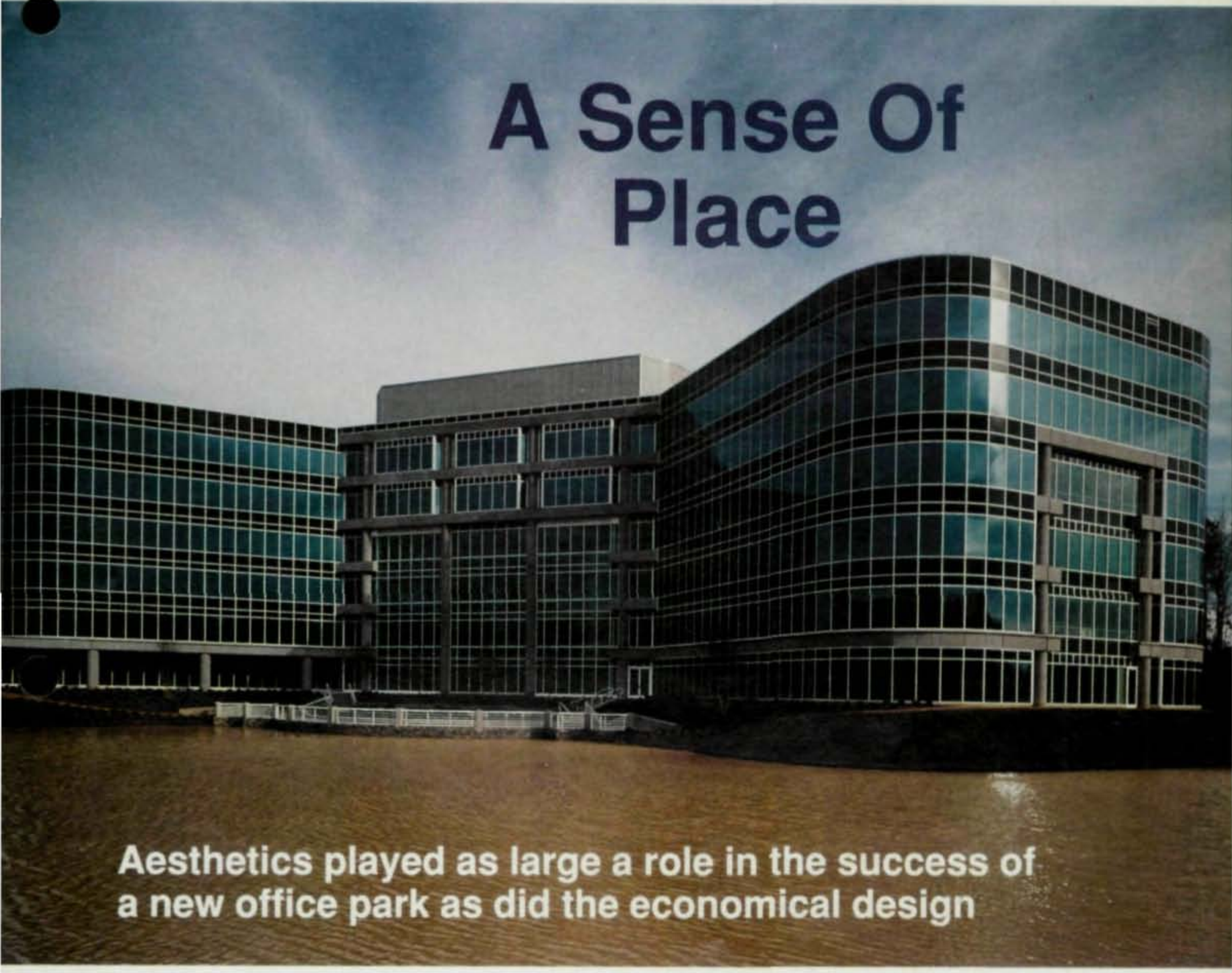


A Sense Of Place

Aesthetics played as large a role in the success of a new office park as did the economical design

Cost consciousness is almost always a prime consideration with speculative developments, and a recent project in Richmond, Va., was no exception.

For Arboretum III, one in a series of buildings in the office park, the developer, Childress Klein Properties of Richmond, hired a construction consultant to analyze a variety of structural systems. Because the building was preleased to Travelers Insurance Co., in addition to cost, one of the major considerations was the need for flexibility for power distribution and telephone and computer lines, according to Philip I. Levine, P.E., president of Levine Engineers, Inc., Atlanta.

"One of the requirements from the tenant was an underfloor power supply system," explained Levine.

The cost consultants considered five designs: conventional concrete double skip joist/post-tensioned girder; one-way post-tensioned concrete slab and post-tensioned girder; two-way post-tensioned concrete flat slab; composite structural steel framing with 2" composite floor decking; and composite structural steel framing with 3" composite floor decking.

Two factors pointed to steel as the obvious choice for the project. First, a steel frame supporting composite electrified cellular steel deck and floor slab best satisfied the tenants requirement for an underfloor power supply. And second, it was determined that the foundation loads for a concrete structure would be approximately 40% greater than those for steel.

When all the factors were considered, the composite structural framing with 3" composite floor decking was chosen. Additional economy was gained through ex-

tensive use of ASTM A572 Grade 50 high-strength steel. Virtually all of the columns through the fourth level and most of the principal floor beams are Grade 50 steel, while the rest of the building is A36. A beam that would have been W21 x 44 with A36 was instead a W18 x 35 with A572 Grade 50, which translates into a 15% material cost savings for that member. About 74%, or 479 tons, of the total steel fabricated and erected for the project was A572 Grade 50. Steel fabricator on the project was SteelFab, Inc., Charlotte, and steel supplier was Bethlehem Steel Corporation. General contractor was McDevitt & Street Co., Benteen Division, Richmond.

LRFD Produces Added Savings

As an added bonus, even more savings were realized through the use of Load and Resistance Factor Design (LRFD).

"When I first started looking at the new LRFD specification, it looked like every member on this project would come down a size, both for the beams and columns—every member governed by stress," said Levine. For example, what would have been a W18 x 40 beam using Allowable Stress Design was reduced to a W18 x 35 using LRFD.

Shortly before beginning work on the six-story, 224,000-sq. ft. project, a member of Levine's firm had attended an AISC seminar on LRFD design. Levine was impressed by his staff member's report and he ordered several

copies of the LRFD manual for his firm. "There were substantial savings staring us in the face," he stated.

"I called AISC Marketing and had them check our calculations, and we sent pricing drawings to Bethlehem [Steel Corp.] to look at the numbers and they concurred. According to the calculations, we saw a 12% material savings."

"Using LRFD is really just a matter of reading the specification," Levine claims. "It's actually similar [in concept] to the concrete [ultimate strength] specification."

Due to the high office vacancy rates nationally, the developer of the Arboretum office park knew that his structures couldn't look like every other speculative office building. "One of the things we tried to establish with the whole Arboretum project was a sense of place," explained Gil Garrison, AIA, project designer with Smallwood, Reynolds, Stewart, Stewart & Associates, Inc., Atlanta, the project's architect.

Arboretum III is across a pond from Arboretum II, and both buildings took their shapes to enhance their relationships to the water. Arboretum III has a V-shape with the sharp point of the V flattened and pushed up. The building is further distinguished with rounded corners.

"The tenant required large floors, and to minimize the impact of that large floor area, it was appropriate to bend the straight line," Garrison said. A deeper floor plan was not possible due to site limitations.

The original plan for the office park included 10 buildings, of which five have been built to date. "All of the buildings have a unique design, but they are all visually linked with a similar palette of colors and materials," Garrison said. The cladding materials include architectural finish precast concrete, glass curtainwall, and window wall. □

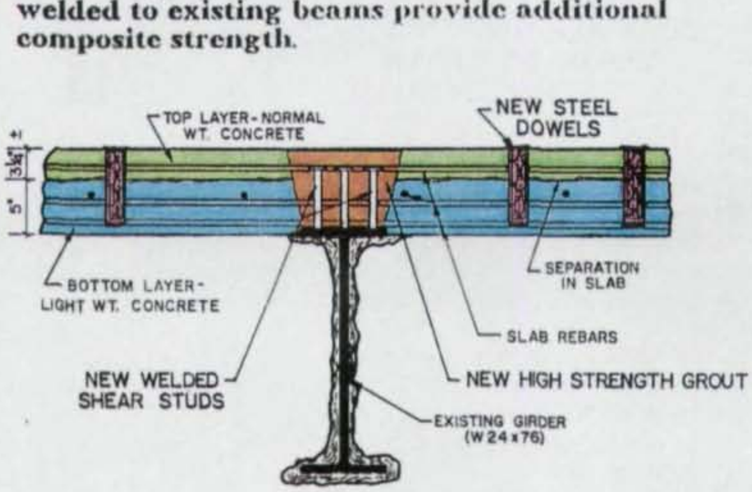
The steel framing and some of the connections used in Arboretum III, Richmond, Va., are illustrated in the three construction photographs shown above left. Also pictured is the completed main entrance to the building (above). All of the photography accompanying this article is courtesy of Bethlehem Steel Corporation.

The Quiet Revolution LRFD

Composite Action Crucial For Renovation

More than 4,000 sq. ft. of floor area was brought up to required strength with the addition of 550 slab ties and 55 shear studs

No major reconstruction required. New steel dowels, set into slab, mend separation and restore integrity to concrete. New shear studs welded to existing beams provide additional composite strength.



In order to support the weight of new diagnostic equipment (above) at the Hospital of St. Raphael in New Haven, Conn., the floors needed to be strengthened. New steel dowels were set into the slab to mend the separation and restore integrity to the concrete. And new shear studs were welded to existing beams to provide additional composite strength.

By George Torello, Jr. and Howard I. Epstein

The efficiency of Load and Resistance Factor Design (LRFD) in analyzing composite construction proved crucial during the renovation of the radiology department of a hospital in New Haven, Connecticut.

The Hospital of St. Raphael was planning to install a new diagnostic laboratory equipped with the latest angiographic and electronic devices. As part of the hospital's agreement the state Commission on Hospitals and Health Care, the equipment, which would allow the hospital to eliminate coronary bypass surgery on some patients, needed to be operational within a few months.

The existing structural system consisted of a concrete slab supported by steel girders and columns. Unfortunately, a structural investigation revealed that the existing structure did not even meet code requirements for live loads for the existing usage, let alone for the higher loads desired.

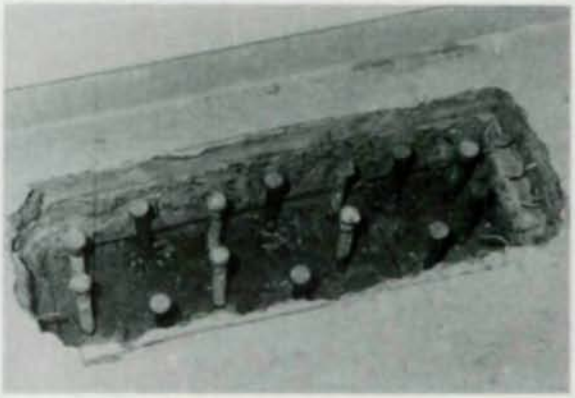
In addition, core samples taken at the site revealed two separate pours of concrete not bonded at the interface.

It was confirmed by the hospital that during the original construction of the building there was a scheduling problem. As a result, a 5" lightweight slab was poured first; piping and conduits were then laid out and a top 3" layer of what turned out to be normal weight concrete was then poured. Borescope investigation of the slab verified the two separate pours in more than 4,000 sq. ft. of the floor, with insufficient bond to transfer the shear needed for composite design.

Even after it was decided to hang the new equipment from the roof framing, the full live load capacity of the floor could not be realized by the existing structure. A conventional approach to solving the problem would have been to add cover plates or increase the section of the primary steel members. However, those solutions would have severely disrupted hospital services. Also, the immediate area under the floor was very congested with utility pipes, hangers, and ductwork, rendering it almost inaccessible.

Instead, LRFD's more sophisticated approach to dealing with composite construction was utilized, and a simple—though innovative—solution was devised. Howard Epstein, professor of civil engineering at the University of Connecticut, was retained as a consultant due to his expertise in interpreting the new codes and applying the new engineering analysis methods.

With Epstein's aid, it was determined that the full composite strength of the flooring system, which is available in the LRFD code, could only be obtained by adding shear studs to the existing girders. In all, 55 new shear studs were added as determined by LRFD composite design criteria.



New steel studs were welded to the steel girders to provide composite strength (left), while high strength non-shrink grout was used to insure adaquate bonding (above left). The contractor installed new steel dowels to tie the two layers of concrete together without interrupting any hospital functions (above).

In addition, the two slabs needed to be tied together with shear pins to take advantage of the full composite strength of the floor. Number 8, Grade 60 rebar was selected to be imbedded in polyester resin to dowel the two slabs together. Prior to the insertion of the pins, holes were checked to insure no hangers below the slab were encountered. The 550 slab ties were inserted into the floor with a HILTI HIT C10 dowelling system. In some instances, shear studs had to be welded to beams and girders to achieve full composite action.

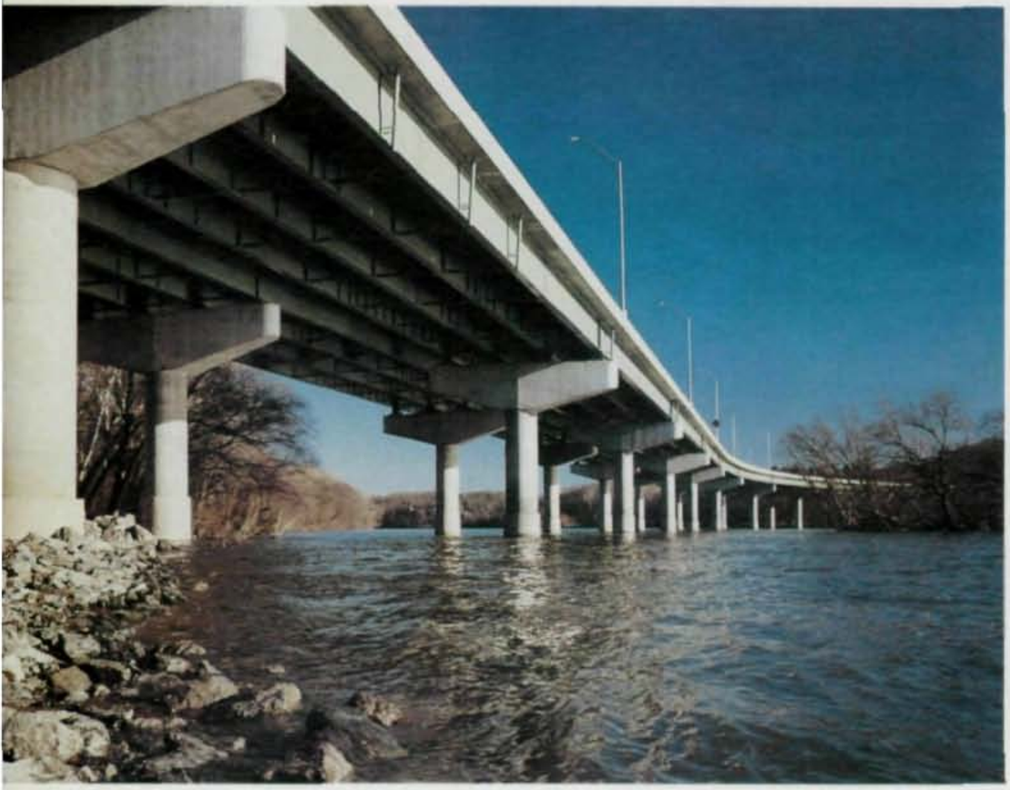
Another unique problem arose when hospital officials advised us that the slab density was critical for resisting x-rays emitted by the diagnostic equipment. Charles Hellier, P.E., of Hellier Associates, Essex, Conn., was retained as a consultant to analyze the situation. Hellier's solution was for lead shot to be spread at the bottom of the holes to preserve the radiation shielding characteristics of the slab.

The contractor for the project, Petra Construction Co., Inc., New Haven, Conn., arranged his schedule to minimize interruptions to the hospital staff. The installation was simple, quick, clean, and quiet; and for the most part, the project went unnoticed by both patients and staff.

George Torello, Jr., P.E., is president and founder of George Torello Consulting Engineers, P.C., Old Lyme, Conn. He has been engaged in civil and structural engineering for more than 30 years.
Howard I. Epstein is a professor in the Department of Civil Engineering of the University of Connecticut in Storrs. ☐

Sweeping Curves Meet Aesthetic Goals

A continuous curved steel girder bridge was chosen for its low cost, quick erection, attractive appearance, and minimal effect it would have on the river below



The sweeping S-shaped curve of the new the Edward E. Willey Memorial Bridge in Richmond, Va., stretches 4,223' as it crosses the James River, Kanawha Canal and CSX railroad tracks. The steel girder design was chosen as the most economical, but in addition, it had the fastest speed of erection and the least effect on the James River. Photography by Don Eiler

By Steven J. Chapin, P.E., James L. Fowler, P.E., and Robert H. White, P.E.

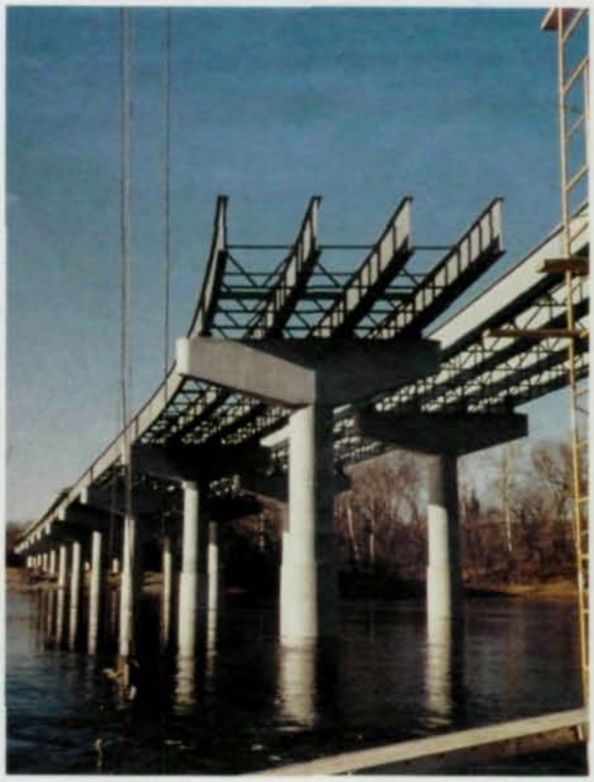
In addition to crossing the James River, the new Edward E. Willey Memorial Bridge in Richmond, Va., had to cross the parallel Kanawha Canal and CSX railroad tracks. After closely examining the site constraints, the designers considered seven alternatives before choosing a continuous curved steel girder structure for the dual 4,223' bridges.

Hayes, Seay, Mattern & Mattern, Inc. (HSMM), Roanoke, Va., was asked by the Virginia Department of Transportation to provide a structure that would adequately support the required traffic loads for an extended period of time, resist the forces exerted by the James River, accommodate the roadway geometry, require minimal maintenance, and be aesthetically pleasing and cost effective.

The seven alternatives considered, and their respective cost indexes, included:

- Scheme 1a. Continuous Curved Steel Girders (150' nominal span length, five lines of girders per bridge, 8.5" concrete deck slab). Cost index = 1.02;
- Scheme 1b. Continuous Curved Steel Girders (150' nominal span length, four lines of girders per

Based on preliminary investigation and a desire to minimize deck expansion joints, the bridge spans selected are nominally 150′ in length and are arranged in five-span continuous units of 750′. A three-span continuous haunched unit (above) with a center span of 215′ is located over the Kanawha Canal.



bridge, 9.5" concrete deck slab). Cost index = 1.00;

- Scheme 2a. Continuous Curved Steel Girders (125′ nominal span length, five lines of girders per bridge, 8.5" concrete deck slab). Cost index = 1.01;
- Scheme 2b. Continuous Curved Steel Girders (125′ nominal span length, four lines of girders per bridge, 9.5" concrete deck slab). Cost index = 1.01;
- Scheme 3. Prestressed Concrete Girders (115′ nominal span length, five lines of AASHTO Type VI girders per bridge, 8.5" concrete deck slab, made continuous for superimposed dead loads and live loads, girders placed on chords in the curved portion of the bridge). Cost index = 1.13;
- Scheme 4. Precast/Post-Tensioned Concrete Box Beams (125′ nominal span length, four lines of specially designed box beams per bridge, 8.5" concrete deck slab, girders precast in segments and transported to site for post-tensioning and erection, girders post-tensioned after erection for continuity, beams curved in curved portion of bridge). Cost index = 1.10;
- Scheme 5. Precast/Post Tensioned Concrete Segmental Box Girder with 150′ nominal span length, 8′-deep single-cell box, girders precast in approximately 8′ segments). Cost index = 1.03.

While the estimated costs for the five least expensive schemes were very close, scheme 1b had two additional advantages. It was estimated that a steel girder structure using conventional construction would be constructed in the least amount of time (construction was completed six months ahead of schedule). Also, the longer span length of 150′ restricted the flow of the James River less than schemes based on shorter span lengths.

AISC Marketing worked with HSMM in developing the low cost design. Interestingly, another nearby bridge over the James River was bid using concrete segmented boxes, and while it ran approximately one year behind schedule, the steel Edward E. Willey Memorial Bridge was completed nearly six months ahead of schedule.

A major concern was the effect the proposed bridge would have on the James River. To determine what the effects might be, a hydraulic analysis was included in the preliminary design. Because of the bridge's skew to the river, piers for the 150′ spans were actually spaced 100′ normal to the flow of the river. With circular shafts of 8′ in diameter, the bridge piers effectively reduced the river flow by 8%.

The superstructure required only 43 lbs. of structural steel/sq. ft. and the entire bridge was built for $60 per sq. ft.

Design Criteria

The design criteria for the bridge, which were developed by VDOT, included a required live-load capacity of HS-25 (and modified military load) and allowance for future wearing surface and construction loads realized by the use of stay-in-place forms. It also was decided ASTM A572, Grade 50 steel would be used for girder web and flanges, and ASTM A36 steel could be used for secondary members, if stresses permitted.

Based on preliminary investigation and a desire to minimize deck expansion joints, the bridge spans are nominally 150′ in length and are arranged in five-span continuous units of 750′. A three-span continuous haunched unit with a center span of 215′ is located over the historic Kanawha Canal. In addition, the span lengths accommodate the required maximum shipping length of 135′ over the highway and the desire to have no more than two girder splices per span.

The SIMON computer program was used to design the girders on the basis of tangent alignment. The results were input into the V-Load computer program, which analyzed the girder with respect to horizontal curvature. Both programs were utilized through a time-sharing arrangement with USX Engineers and Consultants, Inc. (for more information on these programs, contact: Charles R. Bovard, USX Engineers and Consultants, Room 1614, 600 Grant St., Pittsburgh, PA 15230 (412) 433-6548).

All fixed and expansion bearings are rocker-type bearings. In a typical five-span continuous unit, the bearings at the two innermost piers are fixed, with the others in the unit being expansion bearings. In the curved portion of the bridge, the expansion bearings are aligned so that they can accommodate movement along the chord to the nearest fixed bearing, and not along the center line of the girder.

Finger-type expansion joints with elastomeric drainage troughs are used at all deck expansion joint locations. The expansion joints are designed for a total maximum movement of 9". The "fingers" for all the expansion joints are aligned parallel to the center line of the bridge, except for the expansion joint at the north abutment, which is aligned along a chord from the abutment to the first fixed pier to allow for movement of the curved portion of the bridge with respect to the fixed abutment backwall. Rows of bead welds on the top surface of the finger joints improve skid resistance.

R.R. Dawson Bridge Co., Lexington, Ky., was the project contractor. To meet the 30-month construction schedule, two fabricators, including Carolina Steel Corp., Greensboro, N.C., were used to produce the 7,600 tons of structural steel.

The fabrication of the curved girders was accomplished by the heat process. This process allowed the girders to be fabricated initially as straight girders and then curved as a single girder in a laid-down or horizontal position. The girders were then set vertically for any required adjustments and preassembled as a unit to ensure proper fit before shipment to the site. The submerged arc-welding process was used for all girder flange and web welds.

Steven J. Chapin is head of the bridge department at HSMM, and served as project engineer for the Edward F. Willey Memorial Bridge. James L. Fowler, a senior bridge engineer with HSMM, was responsible for the substructure of the bridge. And Robert H. White, a senior associate and senior bridge engineer with HSMM, was responsible for the design of the superstructure. This article is based on a paper delivered at the 1990 National Steel Construction Conference. □

This concrete building went through an earthquake,

Photograph courtesy of Bethlehem Steel

Shouldn't your next design be structural steel?

For a preliminary study, contact:

AISC Marketing, Inc., 650 Smithfield St., Pittsburgh, PA 15222-3907 (412) 394-3700.

Software For Detailers And Fabricators

Vertex Design

The Vertex Detailer was designed by architects for architects to integrate the design, management, and production of detail drawings.

The program features an interface that permits users to assemble details, rather than having to draw them from scratch. Central to the software is a tightly integrated drawing database manager that allows all details and components to be located, stored, and retrieved quickly and easily. The database allows the designer to preview drawings, rather than merely listing file names.

The program runs with AutoCAD on a DOS-based computer.

For more information, contact: James Rowland, Vertex Design Systems, 140 Second St., 5th Floor, San Francisco, CA 94105 (415) 957-2799.

Computers Speed Steel Detailing

According to many pundits, the steel detailing industry is today facing a critical shortage of detailers. But more accurately, the industry is facing a *production* shortage. The answer, according to Larry Shinkaruk of Steelcad International, may lie with computer software that can do the grunt work of detailing—the drawing itself.

Working manually, Shinkaruk reports that he could produce 30 to 40 pieces per day (3-4 drawings), depending on the complexity. "Maintaining this speed tended to tire the hand after two or three weeks, so I would slow and either check [my associate's] work or coordinate the projects," he said.

"Our experience as detailers allowed us to look at an erection plan and know exactly what every piece looked like in detail. The frustrating part was transferring that mental image to paper. The drawing process limited the amount of work our company could do, limited our profits and working to maximum capacity rapidly brought on fatigue."

After developing a steel detailing program—Steelcad II—the firm now produces between 130 to 175 pictures per day, every day. "Hand fatigue is no longer a factor," Shinkaruk explained. "Since we created and installed Steelcad, the office has produced six to eight times the business that it could have handled without Steelcad."

A study was conducted in Orlando to create an accurate picture of the savings produced through automated detailing. It centered on a two-man detailing office, with one person managing the business and doing the detailing, while the second person only checked the drawings and did not have any effect on the amount of work produced.

The study examined three projects—an office building, a shopping center, and a school. All together, the projects totaled 175 sheets of detail drawings.

The results showed that automated detailing increased productivity by more than 300%.

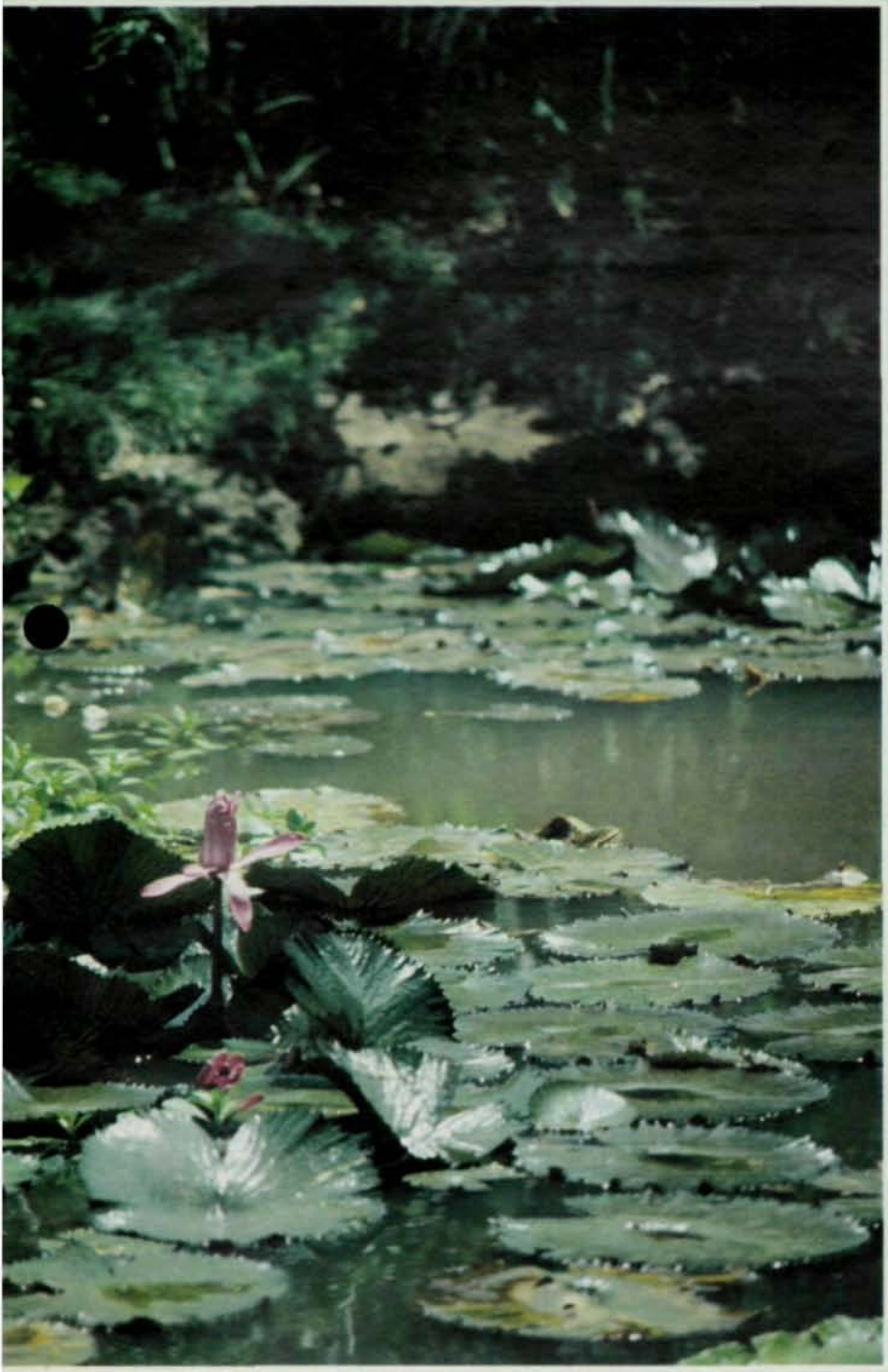
In both manual and automated detailing, job bids and job site meetings consumed 20 hours. Likewise, in both cases project/office management took 70 hours. The difference occurred in the actual detailing work. Producing 175 hand detailed sheets took 875 hours. In contrast, in the automated shop, it took 150 hours to produce 150 computer generated sheets and 160 hours to produce the remaining 25 hand detailed sheets.

Preparing the job with manual detailing would take, based on 10-hour workdays, 96.5 days, or almost five months of work. Using those same 10-hour days, automated detailing completed the project in 40 days, or just two months.

Based on the shop's rate of $30/hour, it saved $16,950 in labor costs. And just as important was the shop's ability to increase its number of jobs.

"Automated detailing will never replace a detailer," Shinkaruk said. "It does enhance his ability by doing the majority of every job, which allows more time to spend on complicated framing (e.g. canopies), increases shop capacity, shortens delivery cycles, and takes away the aggravation of redoing drawings when changes are required."

The Answer Is Water...



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Mountain Enterprises

The ME2 System produces finished details from erection drawings. The drawings can be built with easy on-screen menu choices, by direct entry of individual members, or by a mixture of both. All programs are mouse-based for ease of data entry, which eliminates coded input forms and almost all typing.

The most complex building geometry is fully automated in the erection drawing process, saving days or weeks of number crunching. Final detail sheet composition is completely automatic, eliminating the boring drudgery of placing every piece somewhere on a sheet.

Version 3.0 includes a greater variety of already-computerized connection types, offering immediate productivity from the least experienced detailers on the broadest range of jobs.

For more information on the ME2 System, contact: Gary R. Roderick, Mountain Enterprises Software Systems, 117 E. German St., P.O. Box 190, Shepherdstown, WV 25443 (304) 876-3845.

Silver Collar Systems

The Squad Boss features: automated detailing; industry accepted practices; excellent drawing quality; connection design (field/ shop bolt check, fitting check, fitting weld check, parent material weld check, block shear check, and web bending and buckling check); professional data base management; multi-access; on-screen documentation; and CAD graphics interface.

The program functions for detailing both columns and beams. Column materials include wide flange, pipe and tube, with a wide variety of connections.

Recent enhancements include anchor bolt placement plans and details, erection plans, field bolt list, vertical bracing, channel beams, and moment connections.

For more information, contact: Paul Rutherford, Silver Collar Systems, 902 West I-30, #205, Garland, TX 75043 (800) 962-4100.

Compudron

A series of IBM-PC compatible steel detailing systems use AISC-approved connection design and drafting methods and have many options to provide the detailer with versatility.

For beams, the program produces connection design and details with a selection of shear connections including bolted and welded framing angles, tab plates, angle and built-up seats, end plates, web plates, and knife angles and plates. It includes end connection design and details for beams with end moments using end plates, flange plates, or flange preparations for field welding.

Also included are split and continuous angle connection design and details for beams with axial loads and/or vertical bracing gusset plates including plate design and geometry. In addition, cover plates, curb plates and angles, shelf angles, and extra holes on beams can be added automatically, while standard angles can be created by the detailer.

For columns, the program produces details of wide flange, pipe, tube, and cover plated columns including base plates, cap plates, splices, and girt connections, as well as holes and connections developed by the Beams program.

For vertical bracing, the system produces a wide variety of details and connections.

The system also handles stairs, erection plans, framing plan graphics, interactive graphics, templates, weights, and it produces the data necessary to drive automated fabricating equipment such as drill lines, punch lines, copers, plate fabricators and angle fabricators.

For more information, contact: Compudron, Inc., 411 Rouse Lane, Roswell, GA 30076 (404) 992-0062.

AISC SOFTWARE

LRFD/ASD Computer Data Base For Structural Shapes

The AISC Computer Data Base contains properties and dimensions of structural steel shapes, corresponding to data published in Part I of the *1st Edition, LRFD Manual of Steel Construction* as well as the *9th Edition, ASD Manual of Steel Construction.*

LRFD related properties, such as X1, X2, and torsional properties, are included in addition to ASD related values.

The program includes the Computer Data Base in ASCII format for the properties and dimensions of the following shapes: W Shapes; S Shapes; M Shapes; HP Shapes; American Standard Channels (C); Miscellaneous Channels (MC); Structural Tees cut from W, M and S shapes (WT, MT, ST); Single & Double Angles; Structural Tubing and Pipe.

Steel Connection Design Software (CONXPRT)

CONXPRT is a knowledge-based PC software system for the design of steel building connections. Three basic types of connections are included in Version 1.0: double framing angles, shear end-plates, and single-plate shear connections. More than 80 configurations are possible.

All designs are according to procedures in the AISC *9th Edition (ASD)* or latest available references. CONXPRT includes complete data bases for standard shapes, the structural steel, weld and bolt materials listed in the *9th Edition ASD Manual of Steel Construction.* All strength and serviceablility limit states and dimensional requirements for each design are checked. Help menus are included.

Provisions are available to set default values for particular project or shop needs, for example, detailing dimensions.

Steel Member Fire Protection Computer Program

STEMFIRE determines safe and economic fire protection for steel beams, columns, and trusses. It is intended for use by architects, engineers, building code and fire officials, and others interested in steel building fire protection. The software data base contains all the pertinent steel shape properties and many listed UL *Fire Resistance Directory* construction details and their fire ratings. In this manner, user search time is minimized and the design or checking of steel fire protection is optimized. (5¼" disks only)

WEBOPEN

This state-of-the-art software package is based on and includes the new AISC *Design of Steel and Composite Beams with Web Openings.* The program is designed to enable engineers to quickly and economically design beam web openings. The easy-to-use color coded input windows provide a clear, logical data entry system.

WEBOPEN was written by practicing engineers and incorporates "expert" design checks and warning messages that enhance the application of the AISC Design Guide to your design problems.

The versatile system designs unreinforced or reinforced openings in steel (non-composite) or composite steel beams.

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Dogwood Technologies

Member

The company's unique approach to automation offers an improvement in flexibility and speed while providing features thought only available with framing plan-based systems. The multi-user, multi-tasking environment provides a two- or three-fold increase in productivity to every detailer in the office instead of providing automation to a single detailer. The Procedural Detailing System allows all resources to be applied to a single job or to several different jobs.

Also, where shop control is needed, the program's fabrication management system integrates engineering and detailing automation to make this information available to the shop. The system enables shop managers to control the workload and fabrication sequence at each station.

For more information, contact: Dogwood Tech., P.O. Box 52831, Knoxville, TN 37919 (800) 346-0706.

Structural Software Co.

Member

A new Vertical Bracing module works hand-in-hand with the company's detailing program to help eliminate the guesswork in vertical bracing. The new program automatically details symmetrical and non-symmetrical X-bracing, Knee-bracing, and V- and K-bracing. It can draw braces made of angles, double angles, or wide flange tees.

A special feature is the program's ability to provide an elevation view of any face and of any range of gridlines. Plus, it shows a three-dimensional representation of the building. And, the ease of input allows the user the freedom to locate working points wherever is most convenient.

Another new program from Structural Software is its Estimating Version 5.0. The program is designed for steel fabricators and is pre-loaded with information based on real-world industry averages.

For more information on either of these programs, contact: Structural Software, 5012 Plantation Road, N.E., P.O. Box 19220, Roanoke, VA 24019-1022 (800) 776-9118.

E.J.E. Industries

The Structural Material Sorter is designed to aid steel fabricators and detailers in producing advance material bills, shop cutting lists, inventory lists, weight estimates, and job cost estimates. After material items are entered into the system, it handles all of the tedious calculations normally done by hand. These include weighing the material items, tallying the material prices, totaling the shop and field labor hours, doing a bolt count for each bolt size, doing an item count for each material type, calculating a lineal total for each section size, computing the surface area of the items, finding shipping weights for fabricated members, sorting items into proper order and nesting lineal items.

For more information, or to receive a free demonstration version, contact: E.J.E. Industries, P.O. Box 452, Meadow Lands, PA 15347 (412) 745-2560.

Design Data

Member

The company has introduced new versions of the SDS/2 software products for structural and miscellaneous steel fabrication. Version 4.02 of the Estimating Module offers a more advanced security system that permits only authorized users and system administrators to have access to sensitive data. It also provides materials pricing control for specific projects and more efficient material use through an increased number of passes, user controlled drop percentages, and stock usage. Also new are estimating procedures for DOT bridges.

Version 5.04 Detailing module supports new, lower cost computer technology with larger memory capacity and higher processing speeds. The new version handles more types of vertical bracing (including X-, K-, and Knee-braces), complete with gusset design.

Version 5.04 CNC Interface Module supports new coping and profiling fabrication equipment. And data downloaded to CNC equipment now includes data generated interactively, as well as automatically.

For more information, contact: Edmund F. Bruening, Design Data, 1033 O St., Suite 324, Lincoln, NE 68508 (402) 476-8278.

Data Management

The company has upgraded its Interactive Steel Fabricating System to run on 386 and 486 processors running UNIX V. The program is a series of eight on-line modules, and systems include: estimating; bill of materials; inventory; job cost; general ledger; accounts receivable; accounts payable; and payroll.

For fabricators who do considerable warehouse sales, Data Management also offers an order entry system that allows orders to be input directly into the system while automatically checking material availability.

For more information, contact: Data Management Systems, 12308 Twin Creek Road, Manchaca, TX 78652 (512) 282-5018.

Interactive Design Corp.

Steel-Pac is designed to aid in the production of piece drawings, as well as produce bills of materials and a direct interface to the Peddinghaus series of beam line equipment. The program is designed to run on the UNIX operating system with a wide range of hardware options.

To enhance the program's graphic capabilities, it utilizes the ARRIS system, which allows the user to produce both simple drawings and more complex three-dimensional solid drawings.

An elaborate system of "customer personalization switches" allows the program to be "tuned" to fit individual shop practices and specialized project needs.

For more information, contact: Interactive Designs, Suite 201D, 3970 North Broadway, Boulder, CO 80302 (303) 442-0882.

STEELCAD

STEELCAD III is a powerful program that provides automatic detailing from erection plans. The program allows the user to: input any *framing plan with variable* spacing of bays and floors; input framing at any offset, elevation, or rotation; input any material, including all steel shapes, vertical and horizontal bracing, and angles; input any unique details; input any unique option; create unlimited floor levels with up to nine subframing levels between floors; and *alter bay spacing at any time.*

The program handles beam ends and other beam connections, columns, and produces an advance bill of material as well as production control and length multing.

STEELCAD II is a program for automated detailing piece-by-piece. It handles automatic connection design, friction bolt connections, bearing bolt connections, point loads, reactions, and UDL.

For more information, contact: STEELCAD, 550 Alden Road, Markham, Ontario, L3R 6AB (416) 479-0399.

D.C.A. Engineering

The company's product line includes The Steel Detailer, a program for creating shop fabrication, erection, and bolt setting drawings. Operating interactively within AutoCAD, the detailing system provides the user total control over drawing production. Sophisticated reporting features project material summaries.

For more information, contact: D.C.A. Engineering Software, P.O. Box 955, 7 Liberty Road, Henniker, NH 03242 (603) 428-3199.

Software For Designers

American Computers & Engineers

Truss members and 2D and 3D frames can be designed or checked using the SCADA/H steel design module. The program checks conformance to a variety of codes and specifications, including those in the AISC 8th and 9th Editions ASD manuals, the AISC LRFD manual, and the British, Australian, and Canadian codes.

In the design mode, the program selects the least weight section from the designated section database that conforms to the selected specification. If the user does not like the section selected, the "next best" section can be requested. The members may be checked/designed either one at a time, or the whole structure may be checked/designed. Members can be grouped and a common section chosen for all members in that group. And the user can apply additional restrictions.

An editing function allows user-created sections to be added to the database. Also, the program can be run interactively, or without user input in a batch mode using a previously generated "session file."

For information, contact: American Computers & Engineers, 11726 San Vicente Blvd., Suite 212, Los Angeles, CA 90049 (213) 820-8998.

Member

Fujitsu/ Computers & Structures

During the recent earthquake in San Francisco, many of the skyscrapers that came through unscathed shared a common characteristic: they were "earthquake engineered" using ETABS, a series of computer programs for the static and dynamic analysis and design of multistory buildings.

The program represents a tailored approach to structural analysis and design, isolating and defining special characteristics of buildings to produce algorithms that provide far superior performance, problem capacity and accuracy than general-purpose programs using the same computing resources. Not only does the program identify the special characteristics of buildings, but it also automates many of the numerically intensive and time consuming seismic design tasks. For example, it provides information on the joints and connections of building frames and integrates official industry code requirements.

The program also produces analysis results that directly address the seismic code requirements of multistory buildings. It automatically generates and combines vertical and lateral dynamic loadings to meet various code loading requirements and calculates interstory drifts, overturning moments, and story base shears due to dynamic loads. The program is produced by Computers & Structures and marketed by Fujitsu.

Other programs include: ElmAnalysis, an interactive program for stress analysis of frame structures; ElmCheck, an automated code checking software package; and SAP90, a general purpose 3D analysis program for earthquake engineering.

For more information, contact: Computers & Structures, 1918 University Ave., Berkeley, CA 94704 (415) 845-2177 or contact Fujitsu America, Information Systems Division, 3055 Orchard Dr., San Jose, CA 95134-2017 (408) 432-1300.

HESCO

The firm has introduced two new programs, Steel Column Design Using LRFD and Composite Beam Design LRFD/ASD.

The column program provides: calculations of accumulative factored ultimate loads and load combinations; combinations of forces and moments due to lateral loads with gravity loads; design of combined axial load and biaxial moments; calculation of column maximum tension; and design of a built-up section if the maximum size of a given section's nominal depth is not adequate.

The beam program includes comprehensive loading cases for uniformly distributed loads; up to 50 concentrated loads; up to 20 partial uniform or varying loads; and end moments due to cantilevers or end restraints. Also, it provides comprehensive design for shored and unshored construction; lightest section for both Grades 50 and 36 steel; any number of optional designs with sizes greater than the lightest sections; cost of each design; non-composite steel design; design for end negative moments; bending moment and deflection; camber for shored and unshored construction; and vibration behavior analysis.

Contact: HESCO, 13839 SW Freeway #128, Sugar Land, TX 77478 (713) 545-9820.

J.P. Axe, I.D.

A powerful general purpose finite element program has been updated and is designed for static stress analysis in two and three dimensional structures. New features of Structural Analysis by Finite Element include: simplified data entry; enhanced program control; six new element types; maximum number of nodes increased to 1,250; maximum number of elements increased to 1,500; flexible node and element numbering; improved graphics; output scan for maximum values; and element generation.

For more information, contact: J.P. Axe, I.D., 1429 Crownhill Dr., Arlington, TX 76012 (817) 277-2055.

Buildese

A series of inexpensive programs are designed to work either separately or together.

Bigbeams provides computations for simple and cantilevered spans. Live and/or dead loads can be input and the moment and reactions are shown with the option to choose a regular steel shape or a special steel shape. Other modules calculate members for simple or cantilevered spans, seismic shearing stress, select roof and floor plywood grade, and determine the construction requirements of a retaining wall.

For more information, contact: Buildese Computer Programs, 5236 Overbrook Way, Sacramento, CA 95841 (916) 332-6610.

ASG

ASG Structural is designed to dramatically increase the accuracy and productivity of structural engineers and architects by providing a variety of sophisticated time saving features that automate both the design and drawing process of structural members.

The program includes automatic detailing of welding symbols and notes, and engineering symbols.

The program is part of an integrated CAD product line that includes: ASG Core; ASG Architectural; ASG 2D & 3D; ASG Layer Master; ASG Retriever; and a series of video trainers.

For more information, contact: ASG, 4000 Bridgeway Blvd., Suite 309, Sausalito, CA 94965-1451 (415) 332-2123.

Advanced Structural Concepts

The firm has introduced a new postprocessor called DISPAR for the SAP90 Finite Element Analysis Program. The postprocessor is designed for structural engineers faced with the need to design buildings, towers, or other structures that are stiffness controlled.

The program provides: a breakdown of each member's contribution to global flexibility in terms of member axial, flexural and shear participation; various options for assessing the effects of beam-column joint deformation; information on the efficiency of the structure, including graphs useful for minimum weight optimization; and an approximate but very accurate method of reanalysis.

For more information or to receive a free demonstration disk, contact: Advanced Structural Concepts, 1580 Lincoln, Suite 770, Denver, CO 80203-1509 (800) 462-2456.

Swanson Analysis System

A revision 4.4 of the firm's ANSYS finite element analysis program contains major improvements such as a redesigned user interface, enhanced file handling capabilities, and error approximation.

The program provides a complete engineering environment—preprocessing, solid modeling, analysis, and postprocessing. It performs two- or three-dimensional, static, dynamic, linear or nonlinear structural analysis.

For more information, contact: Swanson Analysis Systems, Johnson Road, P.O. Box 65, Houston, PA 15342-0065 (412) 746-3304.

D.C.A. Engineering Software

The company's product line includes programs for the development of structural engineering design and fabrication drawings.

The DCA Modeler program provides an interactive environment for graphically developing structural analysis models inside AutoCAD. The program creates completely defined models with members, supports, properties and loads.

The Structural Designer provides comprehensive tools for the engineer and draftsperson to create design drawings, including elevations, sections, and details.

For more information, contact: D.C.A. Engineering Software, P.O. Box 955, 7 Liberty Road, Henniker, NH 03242 (603) 428-3199.

Engineering Software Co.

The Integrated Beam Design package completely integrates analysis, graphics, and a materials library for maximum simplicity and speed. Most beam configurations can be analyzed in four to six seconds. Unknown section properties can be calculated on demand and automatically inserted into the analysis.

Other useful features include: distributed or point loads; triangular loads; up to 40 loads; cantilever, simply supported or fixed supports; joint displacements and stresses; full or partial span configurations; varying cross sections; end forces and reactions; and solution graphics of shear moment diagrams.

For more information contact: Nikki Rene, Engineering Software Co., 10670 North Central Expressway, #760, Dallas, TX 75231 (214) 361-2431.

ECOM

A new series of programs conforms to both the AISC 9th Edition (ASD) and 1st Edition (LRFD) manuals.

The programs were written by practicing engineers and have been used in more than 1,700 installations.

SD1C is a steel beam design program capable of analyzing beams with or without cantilevers. The program automatically calculates maximum moments, shears, deflections and inflection points.

SD2C is a steel column design program.

SD3C is a composite steel beam design program capable of analyzing beams with or without cantilevers.

SD4C is a steel beam-column design program that may be run either in a manual input mode or can interface directly with a variety of programs.

For more information or a free demo set, contact: Dave Buettner, ECOM Associates, 8634 West Brown Deer Road, Milwaukee, WI 53224 (414) 354-0243.

Xerox

A high-speed, digital engineering printer/plotter that accepts electronic input from a variety of CAD systems and outputs plain-paper prints up to C size was recently introduced. The 4018 Electronic Graphics Printing System is designed for high-volume demands and prints at a resolution of 400 dpi.

For more information, contact: Xerox, P.O. Box 1600, Stamford, CT 06904 (203) 329-8700.

Prairie Technologies

Igress-2 is a graphical environment for the design and analysis of 2-D steel structures. All functions are member driven with on-screen instructions.

Loadings that can be handled by the program include ANSI wind loads, uniform dead load on all members, and some alternate pattern loadings. More complex member loads can be generated on one member and repeated on others. Member properties can be selected from the AISC tables or calculated properties can be entered.

The program also performs static and/or seismic analyses. Earthquake analysis methods include modal, spectrum, or equivalent static. Results of the static and earthquake analyses can be combined with any number of load combinations for viewing results or checking designs.

A library of well-known earthquake acceleration records and the corresponding response spectra are available.

The program performs a design check and load combination for each member, and reports its status relative to the allowable stress based on the AISC allowable stress specification for flexure and axial load. Member lateral support conditions can be defined. It can be queried for details of the calculations and results and formulas used in the checks.

Three levels of query are available, depending on the level of detail desired.

Igress-2 runs under the DOS operating system on IBM/AT or PS/2 or compatible computers.

For more information, contact: Prairie Technologies, 1776 East Washington St., Urbana, IL 61801 (217) 337-1586. □

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