VOLUME XXII NUMBER 1/FIRST QUARTER 1982

MODERN STEEL CONSTRUCTION

Special Issue: New York City

MODERN STEEL CONSTRUCTION

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MODERN STEEL CONSTRUCTION HAS A NEW LOOK!

This issue takes on a new look—and the largest size ever—with its new contents. For the first time in its 22-year history, Modern Steel Construction *is accepting advertising, on a limited basis. We want to do some exciting things with the only national magazine devoted exclusively to the subject of steel construction:*

Like increasing its size, and the number of projects we feature . . .
Like expanding its horizons in the types of building and bridge projects . . .
Like increasing its circulation substantially to reach even more of the decision-makers in the steel construction industry.
And we're going to do it by accepting a limited amount of advertising from suppliers of products related to the steel construction industry.

We hope you like our concept—and we think we're off to a running start!

1982 PRIZE BRIDGE COMPETITION JUDGES NAMED

Entries for AISC's 51st Prize Bridge competition—to select the most beautiful bridges opened in 1980 and 1981—are now being accepted. A distinguished panel of professionals has been named as the Jury of Awards:

Stan Gordon*, Chief, Bridge Division, FHWA, Washington, D.C.*
Sherwood Richardson, *Richardson, Gordon and Associates, Consulting Engineers, Pittsburgh, Pennsylvania*
Dr. Frederick M. Law, *F.ASCE, Professor of Civil Engineering, Southeastern Massachusetts University, North Dartmouth, Massachusetts*
Joseph R. Passonneau, *Joseph R. Passonneau & Partners, Washington, D.C.*
Dr. James R. Simms*, President ASCE, Professor of Civil Engineering, Rice University, Houston, Texas*

Judging of entries will take place on June 8, with all contestants advised shortly afterwards of the jury's decision. On October 26, winners will be honored at the Second Annual AISC Awards Banquet in Chicago. Awards are based primarily upon aesthetics, economics, design and engineering solutions. Awards are made in 10 different categories.

Deadline for entries is a postmark of May 15, 1982. Further details and entry forms may be secured from: AISC, Awards Committee, 400 N. Michigan Ave., Chicago, IL 60611.

New Philip Morris Building in busy Manhattan. Far below (bott. photo) two subway systems rush within inches of steel girders erected, creating unique problems in fabrication and erection.

Keep the Trains Running —and the Dollars Turning

by John A. Cavanagh

John A. Cavanagh is senior vice president, Morse/Diesel, Inc., construction managers/consultants, New York, New York

Money, they say, is what New York City is all about. That is why millions of people pour into it every day on the subways and trains.

Now, how do you erect a new 26-story office building with one of the world's busiest subways rushing through the basement area? . . . And how do you reconstruct the main trading floor of the heart of the world's money center, the New York Stock Exchange? . . . *Both without interfering with the* flow of traffic in money and people?

And, at the same time, as construction manager, make certain you don't overrun on the owners' valuable time and money. The above are two good examples of where Morse/Diesel, Inc., New York City, construction managers/consultants, delivered economical, innovative steel-framed projects using structural steel. Let's detail the bigger job first.

Subway Below!

Take a site in the middle of Manhattan at one of the busiest crossroads in America, 42nd Street and Park Avenue. Now, design a building utilizing the maximum allowable area on a plot of 100' x 200', with an operating subway roaring through the basement area. Plus, there has to be a column-free space at the street level housing an art museum. That is the new 26-story, granite-clad *Philip Morris headquarters building.*

This 600,000-plus-sq ft building has several unique features, which helped to complicate the job. One is the public-space area on the ground floor which will house a wing of the Whitney Museum of American Art. Also, there are two- and three-story high loggias on three sides of the building at the 21st floor. And there are double-deck passenger elevators, plus all the necessary facilities to operate a corporate headquarters for one of the country's major corporations.

To meet all requirements, the architectural firm and its structural engineer decided upon a structural steel building with the following features:

The below-grade levels, four in all, have minimal floor-to-floor height, requiring a combination of structural steel columns and flat-plate concrete slabs. The unsupported building box columns in this area were 59-ft long with built-up shearheads for the flat slab concrete construction on four levels. This, combined with the subway, created unique problems in both fabrication and erection for all concerned—construction manager, fabricator and erector.

To erect the structure through the fifth floor, a 200-ton Manitowoc 4100W crawler crane with a 160-ft boom was used. The crane operated on wooden mats about 55 ft below grade. It was used to erect the steel, including the transfer trusses below the fifth floor, to a height of 80 ft above grade. Temporary bracing and shoring were required for support against the lateral pressures created by the surrounding streets and the subway.

The crawler crane had to be lowered through this temporary bracing and shoring over a single weekend—since this was the only kind of permit available for this operation. The crane was broken down into components of less than 50 tons each. The crawlers, car body, upper works, counter weights and boom sections were dropped separately and reassembled within the foundation.

The new steel was erected through the bracing and shoring which could not be removed until the slabs were poured through to grade for the necessary diaphragm action against the foundation walls. New columns also had to be threaded through the existing subway construction between the curved tracks and the existing subway walls and

Way down in basement, crawler crane performs ticklish erection feats. Tight area (top, r.) is adjacent to Grand Central and Pan Am buildings to right.

set on the narrow grillages built in-place.

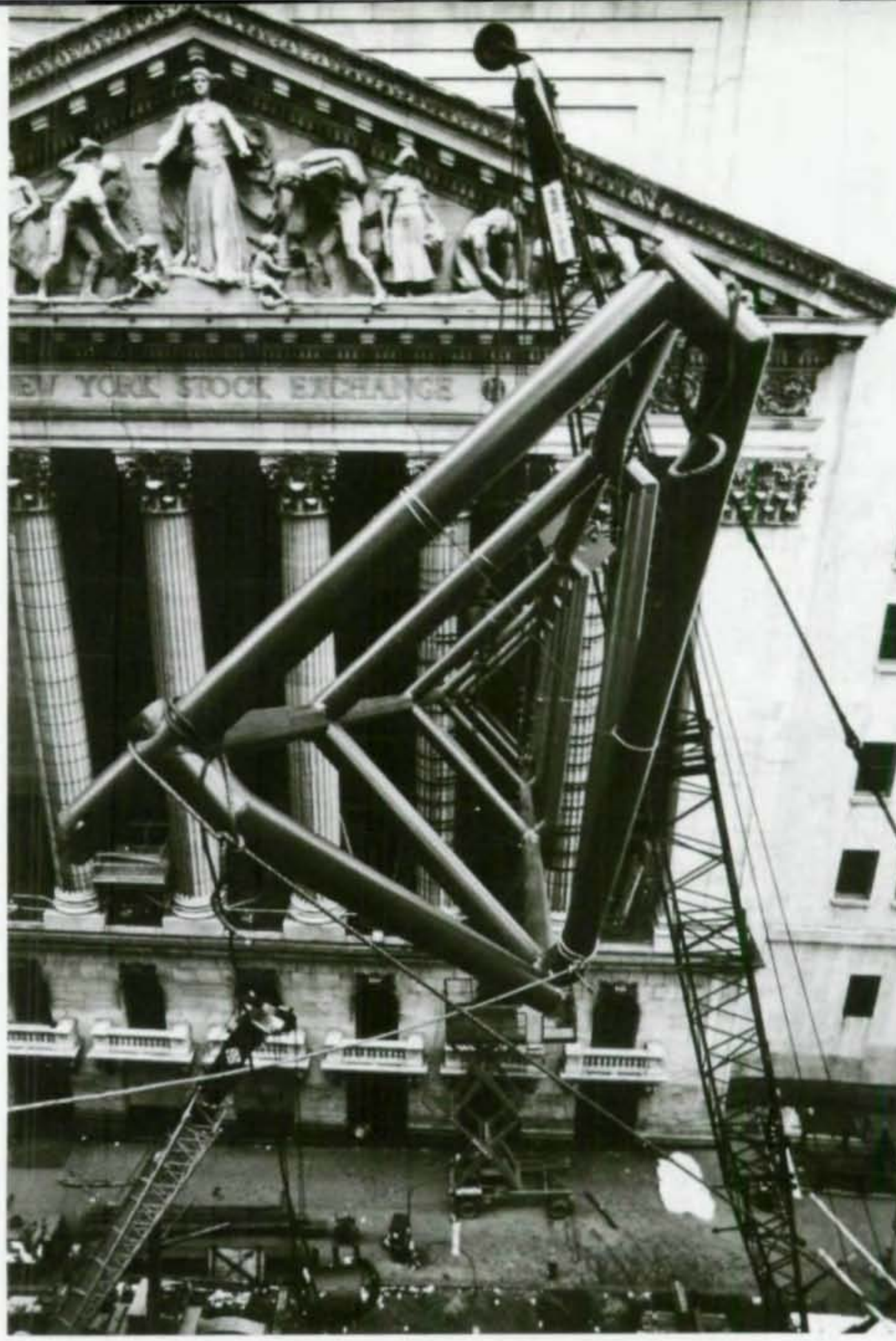
Unfortunately, two different subway systems were involved under 42nd Street—the 42nd Street shuttle and the Flushing line. So, footings and piers supporting the steel grillages had to be cut through bedrock below one subway tunnel and down to the spring line of the other subway tunnel. Because of the requirements of the New York City Metropolitan Transit Authority, blasting was not feasible, and rock had to be cut out by hand to a depth of up to 42 ft. Also, new transfer girders were built over the shuttle subway tunnel to support the columns above.

The first two pieces of steel to be set after the crane was placed in the foundation were two plate girders, both 33 ft-9½ in. long. One had two web plates, 3 in. x 68 in., and two plates 5 in. x 42 in. for the flanges plus stiffeners. This weighed 57 tons. The other one, with one plate 3 in. x 119 in. for the web with two plates 4½ in. x 24 in. for the flanges plus stiffeners, weighed 42 tons. These were used as tie-downs for the wind system.

To plumb and properly brace the unsupported columns from the billet plates up to the fourth floor during construction, a temporary bracing system was designed, installed and later removed.

Above grade, because of the column-free museum area from grade to the fourth floor, columns were set to support six two-story high transfer trusses—51 ft-5 in. long and two single-story high transfer trusses, about 50-ft long each. This unique concept also used heavy box columns built into the trusses to transfer the perimeter columns for an offset of 1 ft-0½ in. from below the trusses to above the trusses. They were 951 lbs. per foot of fully continuous construction. This was needed to integrate the high open lobby, free of interior columns, and the offset of center lines of the columns with the transfer trusses that supported the upper 21 floors, the roof and the penthouses.

The transfer trusses were made completely from built-up plate sections similar to bridge construction. The six two-story high transfer trusses weighed 105 tons each and were continuous with the rigid built-up columns. These trusses were fabricated and fitted in the fabricator's shop, broken down for shipment and re-erected at the site. The crane was broken down and removed from the foundation before the last transfer trusses were in place. Two guy derricks (25- and 10-ton) were set on the fifth floor to complete the erection.



Tight squeeze. Two 18-ton trusses were prefabricated, shipped to site in sections, then wrestled between historic Corinthian columns through narrow windows (below) of New York Stock Exchange—all without disrupting business.

Construction above the fifth floor was electrified metal deck on structural steel with concrete fill. All columns and wind connections were full-penetration field-welded. Up to 22 welders worked at the site at one time, and some of the full-penetration column connections used over 100 lbs. of weld metal each. Control of the welding was critical at each point. A schedule was set up to partially weld connections on either end of the frame to overcome any internal stresses caused by shrinkage at any given connection. Total steel weight for the structure was 8,434 tons.

The building facade is conventional granite up to the fifth floor and granite-clad precast from the fifth floor to the roof parapets. The building, topped out November 25, 1980, was occupied by Philip Morris in January, 1982.

Stock Exchange Project Tough

The job at the New York Stock Exchange may have been smaller, dollar-wise, than the Philip Morris headquarters, but the problems were just as tough, if not more so. Most of the credit for the success of the project goes to the project manager, Thomas Link, and his team.

The project had two main parts. One was the reconstruction of the New York Stock Exchange's main trading floor and installation of new trading posts—which contain sophisticated electronic communications equipment.

The second was to construct and install an expansive steel space frame over the trading floor to carry communications and cooling lines. And all of this had to be done without interrupting the Exchange's daily business. This meant only weekend work—14 long weekends.

Obviously, the job was loaded with unknowns. Nobody knew what we would find after we demolished the old posts. There were contingencies for our contingencies. For example, at all times there were 50 extra workmen there, just in case.

Working within the cramped confines of the small winding streets of the financial district, threading large steel trusses through narrow windows, plus having to build the new trading posts with their intricate wiring systems, on platforms suspended over the trading floor—one can well imagine how critical the geometry was. We worked the geometry out in advance on scale models.

The 100 ft x 80 ft space frame was shipped in five sections. Each section was rigged through windows with tolerance of no more than three inches. Temporary supports for each truss were individually designed to handle the conditions above the floor. The first truss took 48 hours of continuous rigging to get it into place. We were finished barely two hours before trading began.

The new trading posts each consisted of a base unit and an overhead section. The overheads were assembled on 20-ton-capacity temporary platforms. At the same time, base units were constructed in an adjoining room.

Despite all the variables, the New York Stock Exchange always opened for business every Monday morning we were on the job. □

Steel space frames serve trading posts on remodeled New York Stock Exchange's main floor. Frames carry communications/cooling lines to sophisticated electronic equipment. Original trading floor shown (r.).

Philip Morris, Inc. Project

Architect
Ulrich Franzen & Associates
New York, New York

Structural Engineer
Weiskopf & Pickworth
New York, New York

Construction Manager/Consultant
Morse/Diesel, Inc.
New York, New York

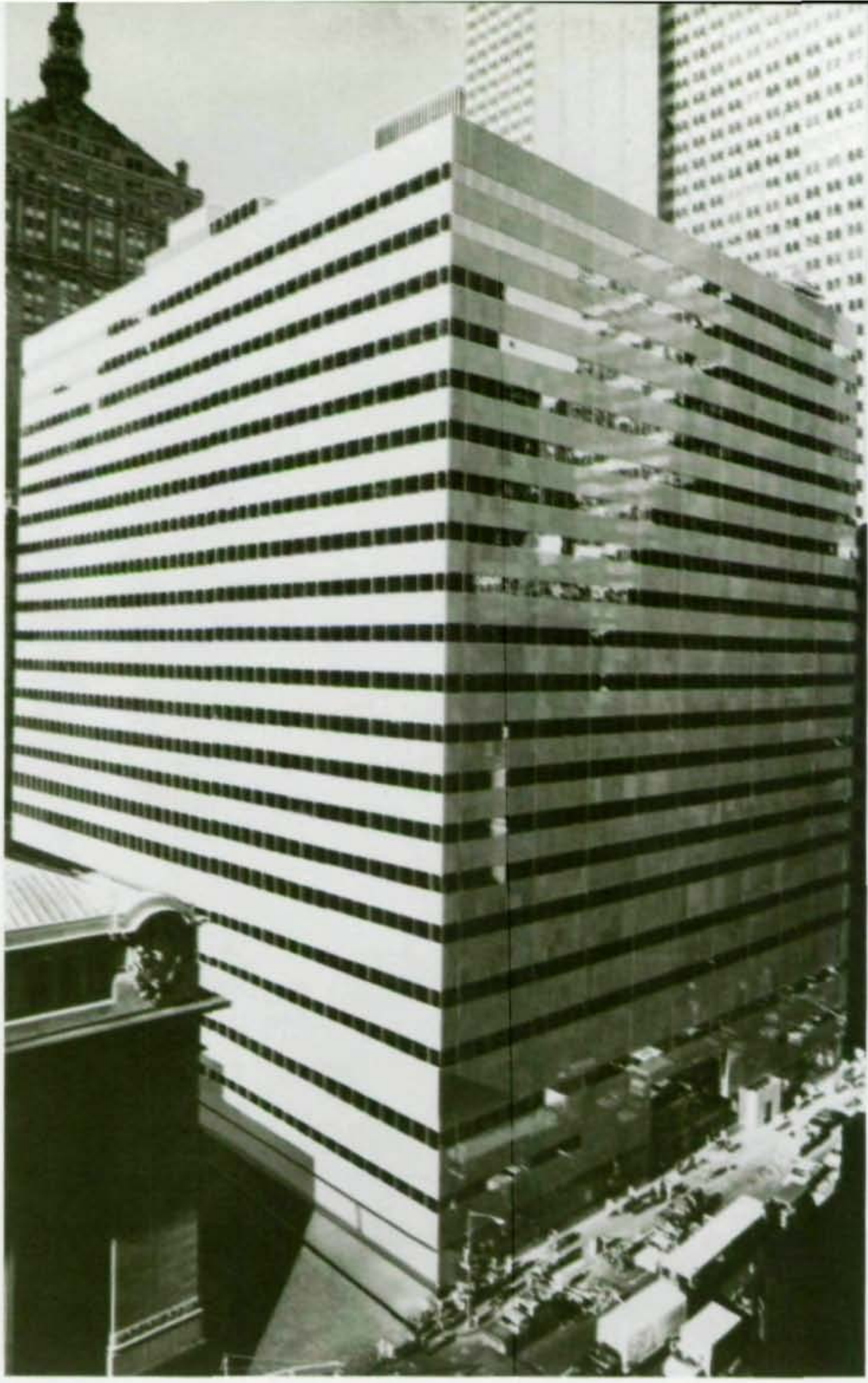
Steel Fabricator
Standard Erecting Co., Inc.
Newington, Connecticut

New York Stock Exchange Project

Architect
Bonsignore, Brignati & Mazzotta
New York, New York

Structural Engineer
Weiskopf & Pickworth
New York, New York

Construction Manager/Consultant
Morse/Diesel, Inc.
New York, New York



Largest remodeling of its kind in New York, Park Avenue Atrium added five floors, spacious new atrium. Before photo (r.) is opposite corner view at 46th and Lexington.

Park Avenue Atrium: The Chemistry of Recycling

In the face of today's costs for new construction, often the question is, "remodel or rebuild?"

The building in question was the Park Avenue Atrium building in midtown Manhattan. The site was occupied by a 16-story building completed in 1912, and expanded in 1920 to a total of 650,000 sq ft.

The owner's requirements were to create approximately 850,000 sq ft of highly desirable commercial and retail space—highlighted by a major interior atrium. The architects were charged with the responsibility to develop options which considered the merits of demolition and new construction versus renovation and reconstruction. After various cost profiles and building envelopes were considered, the owner selected the option for redevelopment, with a new addition to the original building.

The new Park Avenue Atrium Building would have all its area completely renovated, and a new building of about 80,000 sq ft added to it. The existing central courtyard would be redesigned as a major interior space to unify the two commercial structures. This was the largest renovation of its type in New York City.

Enter Chemistry

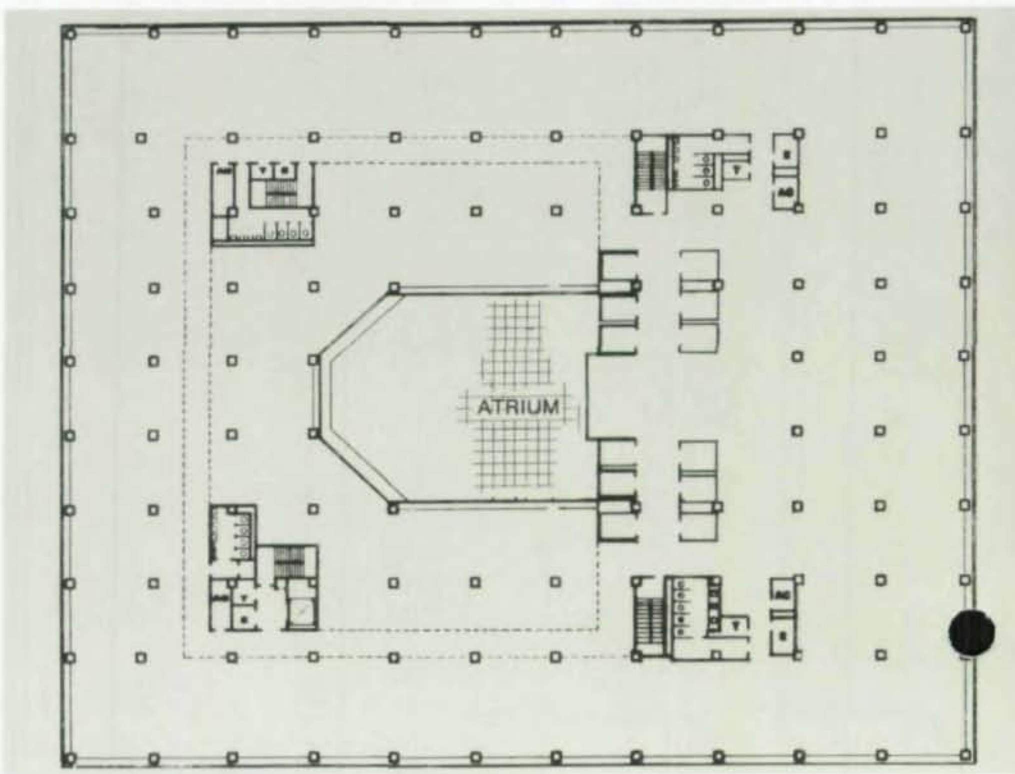
The framing of the original building was steel, including the massive girders built-up to span critical areas of huge dimensions over the Grand Central Station's tracks and platforms. Renovating and reconstructing the structural system involved the redesign of certain parts of the existing frame as well as supplementary framing systems—all in steel. Steel was selected as the highly adaptable and flexible system which could most easily complement the existing building frame.

Recycling a steel frame built in the early 1900s posed a unique structural problem. First, the type of steel used then had to be determined and its chemistry researched to determine its load-bearing characteristics. Secondly, adding five stories meant that most of the existing frame had to be reinforced. Further, connections had to be strengthened for lateral loads at the same time that masonry walls were demolished, requiring strict timing and coordination during construction.

Research on the steel used in the building in 1916 yielded this information:

The steel framing was open-hearth steel rolled to AREA specifications, the same quality as bridge steel. Testing over 40 coupons revealed a yield of over 36,000 psi although the original design met the lower New York City building code requirements of the time. Chemical testing showed that E70 electrodes for welding the new work would be compatible with existing steel. Many of the original shop drawings were available, since the New York Central Railroad made it a practice to preserve them.

Major design feature of remodeled building, 300-ft atrium adds visual spark of life with glass elevators, extensive landscaping, eliminates interior offices with no natural light. Floor plan below.



Ground and first floors in handsome atrium house stores, restaurants.

Innovative Ideas of Special Interest

Major design feature of the newly renovated building is its 300-ft high skylit atrium that incorporates glass elevators and extensive interior landscaping. This atrium concept eliminates interior offices without natural light. As an interior focus, the atrium also promotes contact between employes and gives new life to the building. And, at the same time, the atrium does not sacrifice an inordinate amount of rentable floor space —net rentable area is 82%.

Reconstruction of the 65-year old building fell into six categories:

1. Reinforcing many of the steel columns with heavy steel plates to carry the additional floors, and to resist wind moments. The original building depended on exterior and interior masonry walls for wind

resistance. These were removed, and an entire new system of wind bents were created using existing columns and beams as well as new beams. Temporary steel knee braces were used during transition.

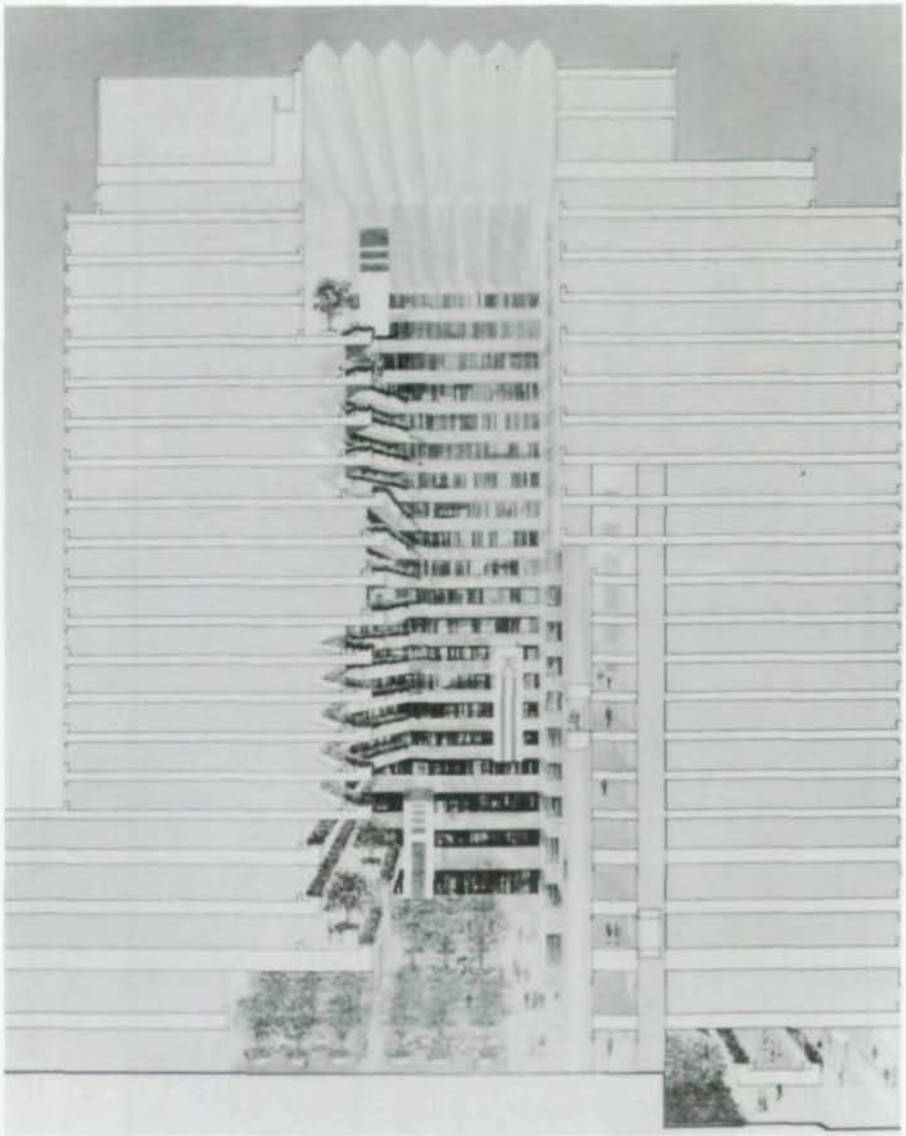
2. Installing new moment connections for the new wind bents between existing columns and beams. Since the existing columns were made of plates and angles, these new connections were custom-made to fit each column point.
3. Placing "in fill" steel for new stairs, washrooms, elevators, new cantilevers into atrium space within existing floors.
4. Erecting new built-up girders for the base of the new atrium elevator core, and for new truck/pedestrian entrances to the building. Girders in the atrium were needed to transfer new loads to existing columns that pass through the train space. No new columns or footings were installed in the train space. The girders at the entrance (three) were above the new entrances so that existing columns could be jacked and the load transferred to adjacent columns. This created wider bays for entrances and eliminated existing transfer girders at street level that were inverted in the old masonry walls, but would prevent people from walking in the new entrances.
5. Installing new elevator columns and framing in the atrium.
6. Installing a steel spandrel system around the perimeter of the existing frame for carrying the new precast curtain wall.

The rehabilitated Park Avenue Atrium conforms to the newly enacted New York State Energy Code. The exterior facade is granite spandrel panels and solar insulated glass. The building also features individual tenant metering and incremental air conditioning. □

Architect
Edward Durell Stone Associates
Emory Roth & Sons (Associate)
New York, New York

Structural Engineer
Office of James Ruderman
New York, New York

General Contractor/Owner
Olympia and York
New York, New York



Model cutaway details atrium with first interior glass elevators in New York City.

Alley behind Park Avenue Atrium Building is landscaped extension of commercial space inside.

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00465

A CM Looks at Structural Analysis and New York's Greatest-Ever Building Boom

by Daniel Koch

Daniel A. Koch, P.E., is vice president, Tishman Construction Corp. of New York and chief structural engineer, Tishman Realty & Construction Co., Inc., New York, New York.

Introduction

In New York, Chicago, Los Angeles and other major U. S. cities, the name Tishman is synonymous with high-rise construction, much of which is steel. In fact, the firm's corporate logo is a horizontal steel beam atop a wide-flange column, forming a structural "T." In more than 80 years as an owner-builder, Tishman Realty & Construction Co., Inc. has been in the vanguard of building innovation, including construction management and fast-track scheduling, new building materials and energy conservation design.

Tishman landmark projects include the twin towers of the World Trade Center in lower Manhattan, the Century City Theme Towers in Los Angeles and the 100-story John Hancock Center in Chicago—all steel-framed buildings.

The firm's present New York City backlog includes nine major structures, six of which boast steel framing.

In the following article, Daniel A. Koch discusses his firm's role in the greatest building boom in New York's history.

Structural steel goes up on 520 Madison Avenue Building in New York City.

Not too many years ago, high-rise office building framing was a no-choice decision in New York. It was steel all the way. Then, reinforced concrete technology literally got off the ground, giving structural designers a practical alternative in terms of cost, strength and serviceability.

Yet, structural steel still rules the day in New York. Of nine projects (totaling nearly 7 million sq ft) in Manhattan for which Tishman is construction manager (CM), six are of structural steel framing. It is not out of bias or sentiment that such decisions are made. When recommending steel, the CM is simply fulfilling his primary mission: to deliver to the owner in each particular instance the most efficient building of the highest quality for the most economical price. In many cases, our analyses show that structural steel does just that.

How a CM Analyzes Structural Steel

Before deciding on a structural system at Tishman, our top-level staff generally examines anywhere from three to 20 different schemes per project. We start out looking at three basic systems: all-steel, all-reinforced concrete, and a combination of the two. From there on, everything is a calculation of subsystems. The variables are such that there is no unyielding formula for determining the most efficient way to go. In addition, there are owners' preferences, based on such diverse factors as financing, aesthetics and market/tenant demand. Each building or project has its own cost determinants, and they are unique; no set of data can be transferred from one site to another.

For example, we are presently analyzing a 45-story office tower for a relatively small parcel, considered some of the most valuable land in mid-Manhattan. Our initial structural estimates of the square-foot cost show all three systems within 5% of one another. At this early stage of budgeting, we would call that even.

To meet the owners' goal of approximately 600,000 sq ft, the completed building will have to be unusually high for its depth. While these are the exigencies of Manhattan real estate economics, such conditions do not make for maximum construction cost efficiency. So, we have to be all the more careful in selecting materials as we get further into design to make the building as cost-efficient as possible.

When costing out reinforced concrete, you normally deal with one trade and essentially two materials: concrete and rebar. Estimating structural steel systems is more complicated. Besides the steel, you have to factor in the cost of metal floor decking, the concrete for the floor, and the spray fireproofing material. When considering a combination structure, add the cost of the structural concrete for the stairwells and elevator cores.

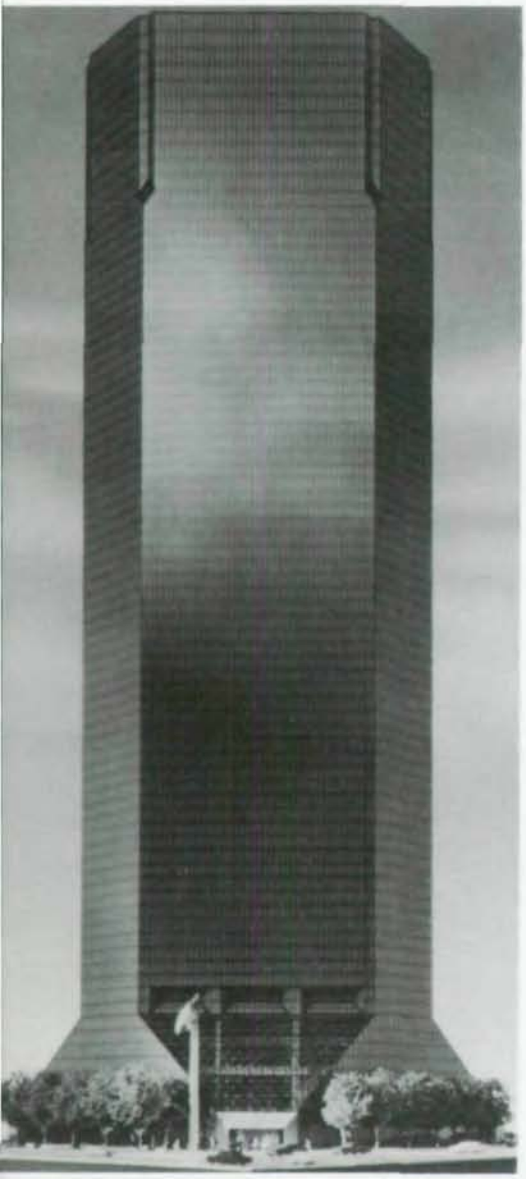
More system components mean more subcontractors, and it takes considerable expertise to weigh the variables and come up with costs that will hold up through completion of the project. That's where the CM plays his most crucial role. Besides reconciling price with value, he must target costs and time schedules and then hit those targets, not within parameters—but right through the bull's-eye. If a CM can't deliver cost figures within the time he projects, the project may falter, and the owner will be irritated, understandably.

The Structure of the CM's Role

Until the 1960s, the CM concept as we know it today barely existed. The owner seldom got the benefit of the contractor's expertise when it could be the most valuable—during the preconstruction stage. Before CM, the prime contractor either bid or negotiated an award based on a fully completed set of plans and specifications. The only opportunity to cut his (or the owner's) costs was within the narrow framework of the contract documents, which were pretty much carved in stone prior to his arrival.

Now, when a contractor takes on the mantle of a CM, his ability to apply value-engineering principles increases exponentially. He's on board with the architect and the structural engineer from the time that project is merely a gleam in the owner's eye. Out of this pooling of talents emerged the idea of fast-track scheduling, a development that changed the entire process of construction contracting. Being able to take the bare bones of a schematic design and proceed full-speed ahead on a project requires a tremendous amount of teamwork from day one. Of course, all fast-track

The Continental Center



Tishman Realty's Current New York Projects (steel-framed)

Project	Type	Size	Completion
Continental Center	Office	1,200,000 sq ft	January, 1983
Portman-Marriott Times Square Hotel	Hotel	2,000,000 sq ft	May, 1984
520 Madison Avenue	Office	912,000 sq ft	April, 1983
1155 Avenue of the Americas	Office	660,000 sq ft	April, 1983
38 East 61st Street	Residential	98,000 sq ft	May, 1982
Tower 49	Office	550,000 sq ft	January, 1984

projects don't have a CM. But fast-tracking without a CM is something like fielding an army without a general. It can be done, but the end result is likely to be less than desirable.

If Tishman didn't invent fast-track, it has done as much as any contractor to perfect the technique. Good fast-tracking demands anticipation, and when we execute the final contract, we must anticipate what is not yet on the final drawings so we can work out fair agreements with the subcontractors. We have to sit down with the architect and the structural engineer and ascertain what will be on the final plans, so the owner's exposure to possible claims is limited. The subcontractors must know fully what to expect, and to cover their costs accordingly.

While this applies to all trades, it is most *important when pricing the structural steel*, because it is one of the first trades we have to buy. And, the structural engineer probably has the least amount of time to prepare drawings. Thus, the gaps left in the early drawings are greater than when the first-stage plans come out on the mechanicals or the facade, for example. There's simply less time for modification.

Asking penetrating questions of the architect and structural engineer means more illuminating answers. The better the CM's information, the better he can forecast, making it easier to buy properly. Buying properly means buying to protect your owner—the client—as much as possible, and making sure that the subcontractors leave nothing uncovered in their bids. It is a CM's obligation to protect the owner, and in order to do so properly, we have to protect both parties. With fast-tracking you are constantly negotiating with subcontractors as the job moves along. But, if we anticipate properly, we limit negotiations.

The Value of Preconstruction Services

Based on our record, we like to think we're great builders, and once we start digging a hole we'll get a building up as fast or faster than anyone in the business. But where we really believe we can make a difference is in the design phase. The depth of our in-house expertise makes it possible for us to evaluate and select structural, mechanical and architectural systems most effectively, since we keep extremely close tabs on the market.

It takes a skill all its own to select systems and materials that are most appropriate to the owner's requirements. That doesn't mean we always choose what is least expensive. If you work with an institutional owner who wants a higher-grade building, you go with that client's wishes. Planning an investment office building takes a whole different set of imperatives; that owner will make some trade-offs for the sake of economy, and we have to tilt our recommendations toward that kind of program.

By having a finger on the pulse of every major trade, we can guide the architect, the structural engineer or the mechanical engineer in selecting the system or components that best fit the project. The construction management concept calls for better-than-average subcontractors, and *our modus operandi requires the best in the* business.

The CM-Owner Partnership

We find that during the preconstruction stage, a building's structural system gets more attention from the owner than any other of the building's systems. Whenever we deal with clients, they participate more readily in planning the structural elements than, say, the electrical, air conditioning or other mechanicals. Why? Probably because it is the most visible during the construction stage, and most easily understood by a non-engineer. Then there is the psychological factor. Somehow, the sight of steel going up is more thrilling to an owner, and the general public, than air conditioning ducts going in.

The framework can also be the job's most critical system in determining its final cost. Among the many high-rise projects now underway in New York, structural designs run anywhere from 18.5 psf to 43 psf. Give an identical problem to three structural engineers and you always come up with three different answers, each one technically correct. Disparities do not mean faulty design—the designers are undoubtedly meeting the needs of the project—but drastic differences do have a tremendous impact on cost. By rule of thumb, the steel framing should approximate 20 to 25% of a high-rise building's total cost.

In the decade since the last great surge of high-rise building in New York, many changes have swept the construction in-

1155 Avenue of the Americas Building

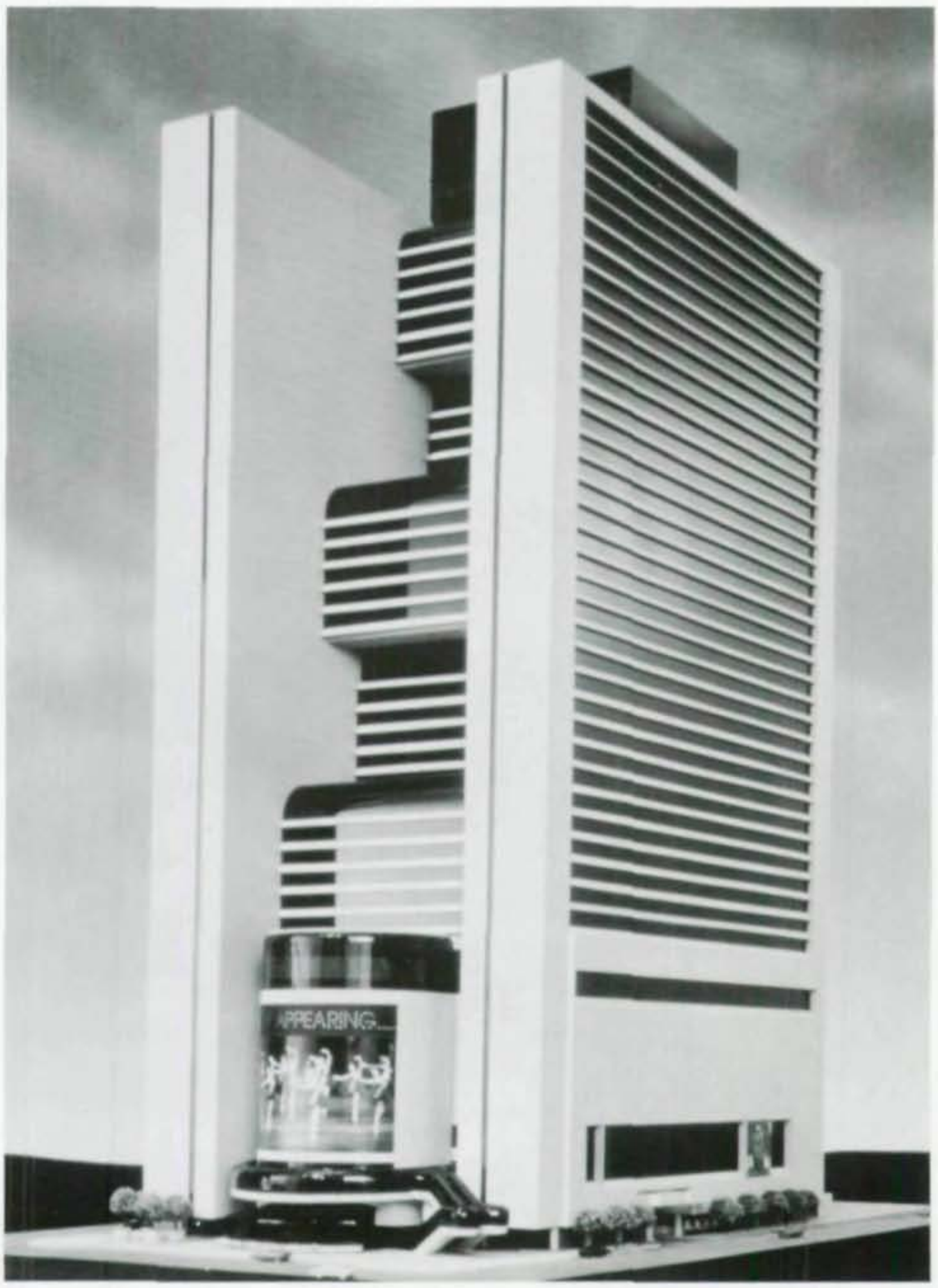
dustry, and the world. Environmental concerns, energy crises and a turbulent economy have brought us face-to-face with a whole new set of challenges that we never foresaw 20 years ago.

No building boom was ever quite like this. Material costs were never higher, labor more expensive nor financing costs as great. Nevertheless, against this prohibitive background, our industry is delivering the finest products that construction technology has ever produced. These splendid towers of the 1980s are not only architecturally superior to anything we have seen before, but also the methods and materials we meld produce the most energy-efficient buildings ever constructed. And, we accomplish all this at a cost with which society can live.

The history of construction in New York has been a series of challenges met and conquered. It was here the high-rise structure evolved to meet the challenge of limited land space, versus an unlimited need for space where great masses of people can live and work efficiently and comfortably.

To meet the challenges such as we face today is construction's reason for being—to shape the earth's forces to meet the needs of mankind. □

Portman-Marriott Times Square Hotel



How to Fasten Steel Deck

by Richard B. Heagler

Almost all steel-framed buildings use steel deck somewhere in their makeup, either on the roof or the floor, or both. Although the deck can be used in many ways, usually it is a substrate for a built-up roof; as a stay-in-place concrete form; or, as composite form that furnishes the slab reinforcement for positive bending.

Unfortunately, information about fastening deck to the frame, and fastening deck-to-deck at side laps, is scattered through many references. And, there is much practical information which is not published at all. Questions about fastenings frequently come up because many job problems are, in one way or another, related to fastening. Deck fastening is important—not just for the obvious reason of holding the deck in place, but also to stabilize the compression flange of beams (or joists)[1]; and, to provide diaphragm strength and stiffness which helps to brace the building against lateral forces.[2, 3] Insurance considerations[4] and fire ratings[5] may impose requirements which the designer should check.

The 1980 American Iron and Steel Institute Specifications (AISI)[6] and those of the American Welding Society (AWS) present similar methods for calculating shear strengths of arc spot (puddle) welds used to attach deck to the structural frame. The Steel Deck Institute (SDI) provides minimum spacing patterns for floor deck, roof deck and centering[8]. In the SDI *Diaphragm Design Manual*, strength and stiffness calculations and data

Richard B. Heagler, P.E., is director of engineering for the firm of Nicholas J. Bouras, Inc., New York, New York and Summit, New Jersey

Table 1: Design Strengths of 0.5-in. Welds, Sheet-to-Structure, with and without Washers, Lbs.

Deck Thickness (in.)	Gage	No Washers Single Sheet	No Washers Double Sheet	With Welding Washers
0.0295	22	600	950	650
0.0358	20	700	850	600
0.0474	18	900	600	500
0.0598	16	950	400	400

Table values have been rounded to the nearest 50 lbs.
Based on formulas from Reference 7.

are shown which include welds, screws, pneumatically driven pins and powder-driven fasteners. The AWS and the SDI give methods to test the quality of the welds holding the deck to the structure. Shear studs through the deck can be used as all or part of the deck fastening requirements; and, the AWS *Structural Welding Code*[9] gives a method for field testing stud welds.

One of the frequently asked questions is when to use, or not to use, welding washers. The AWS, AISI and the SDI all advise that washers be used when the deck metal thickness is less than 0.028 in. (minimum 22 ga.). The SDI goes further and recommends that washers *not* be used on material thicker than 0.028 in. When the strength calculation formulas provided by the AWS are followed, it can be seen that 22 ga. is the thickness where stronger welds start to occur without washers. Table 1 shows the calculated (AWS) design strengths of welds with and without washers. These values for washers should be considered as approximate, since the distance from the hole to the edge of a typical washer doesn't meet specification requirements.

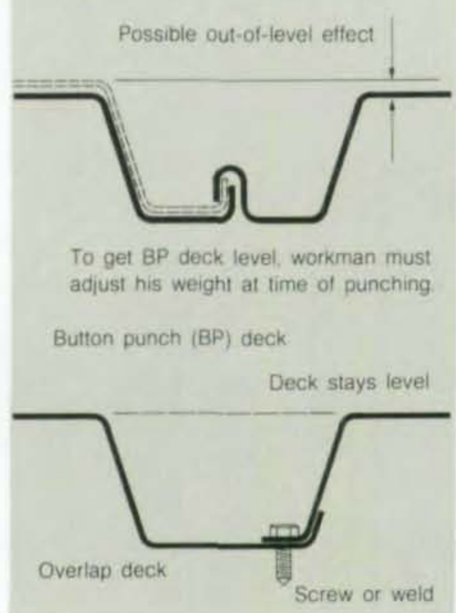
Although there is substantial information about fastening the deck to the structural steel, the SDI is the only source for fastening side laps (deck to deck). There are three methods commonly used for side lap fastening—screws, welds and button punches.

1. **Side lap screws:** These are usually self-drilling, self-tapping sheet metal screws commonly in #10, #12 and #14 sizes. Diaphragm data are published on #12s and #14s.

   The screws are very easy to install, with little skill required to consistently obtain good connections. The self-drilling screws drill their own holes and cut threads in the top and bottom sheet; the bottom sheet is drawn tightly against the top with no effort on the part of the operator, and the deck remains level across the joint (see Figure 1). Overtorquing is prevented by using a tool with a depth-limiting nosepiece and a clutch. Generally, the shear strength provided by a single screw is less than the strength of a single weld, and the screw connection is more flexible. So, on a one-to-one basis and neglecting weld quality control problems, screwed connections will result in a weaker and more flexible diaphragm than if welded. Of course, the strength and stiffness of the screw connected diaphragm can be increased by installing more screws along the seam.

   One very big advantage of screwed side laps is the appearance of the finished job. The underside of the deck does not show burn marks, the finish of the deck is left intact, and there are no holes. Screw points coming through the deck are not noticed with normal ceiling heights. If the bottom side of the deck is to be exposed, screwed side laps are definitely recommended.

Figure 1



   For roof deck thickness less than 0.045 in. (minimum 18 ga.) Factory Mutual calls for screwed side laps rather than welds.

2. **Welded side laps:** Welds, when properly done, provide the strongest and stiffest connections. As with screwed side laps, the deck is held level across the lap; in fact, the overlapping metal must be in intimate contact for the weld to be made (see Figure 1). Good side-lap "tack" welds do not take a long time to do if the welder is experienced. In fact, an inexperienced welder may take too much time and simply burn a bigger hole.

Table 2: Ultimate Strength of Side-Lap Fasteners, Lbs.

Deck Thickness (in.)	Gage	Ultimate Strength (lbs.) ½ in. Welds* F_y=33 ksi**	½ in. Welds* F_y=40 ksi**	Screws #12	Screws #14
0.0295"	22	900	1100	550	550
0.0358"	20	1150	1350	700	850
0.0474"	18	1300	1900	1100	1400
0.0598"	16	2100	2500	1450	2000

Note: All strength values based on data and formulas from Reference 2. The values are rounded to the nearest 50 lbs.

*Field observations indicate that ½ in. is the most common side-lap weld size; larger sheet to sheet welds and seam welds are harder to obtain.

**Deck material. Yield strength (F_y) of 33 ksi is the most often specified design yield-strength; in reality, very little deck is furnished with a yield-strength of less than 40 ksi. In Luttrell's data, both the weld strength and the screw-strength values were determined by using material with greater than 40 ksi yield-strength. Since most screw failures in light gage material are sheet failures, for comparison purposes it would be more accurate to relate the 40 ksi weld strengths to the screw strengths.

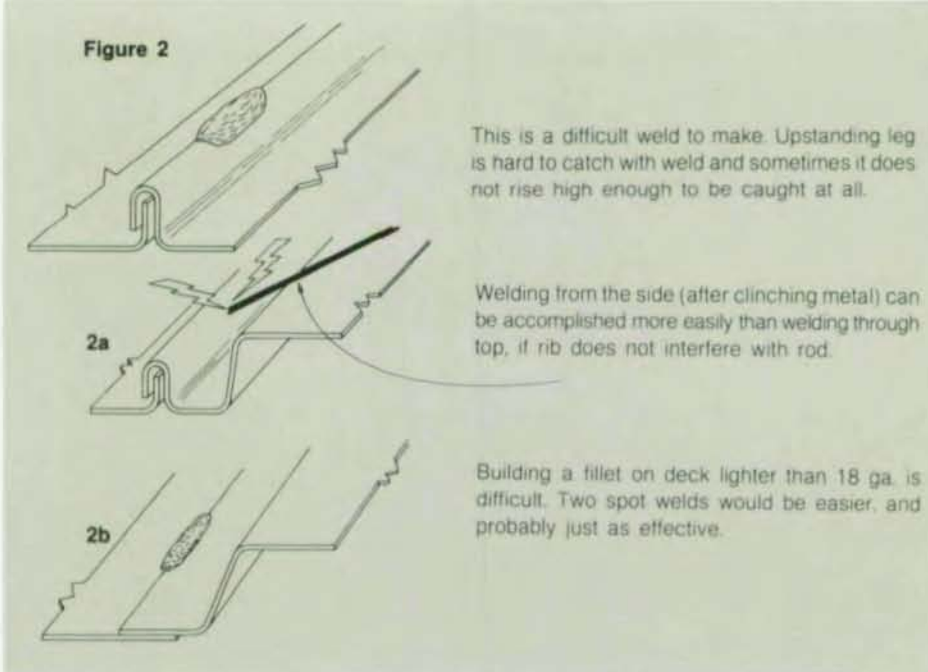
Burn holes are the rule rather than the exception, and an inspector should not be surprised to see them in the deck. The weld does almost all of its work by holding at the perimeter; a good side-lap weld will have about 75% of its perimeter working. The thicker the metal the easier it is to make a good side-lap weld.

Table 2 is based on Dr. Luttrell's tests as reported in the SDI *Diaphragm Manual*, and shows predicted *ultimate* shear strengths. When comparing the strengths of welds and screws, a higher safety factor should, of course, be used on welds since it is harder to maintain consistent quality on the welds.

On most jobs, the roof deck is to be used as the structural base for a built-up roof, and the deck is not intended as a water-tight cover. Floor deck will usually have a suspended ceiling below it or have fireproofing sprayed on it. In these cases, burn holes are not important. Appearance, of course, is affected by the burn holes. So, if the deck is to be exposed to view, then side-lap welding should not be done and much care should be exercised to prevent burn marks if welds are used at the supports.

Sometimes side-lap welds are specified which are very difficult, if not impossible, to make. Figure 2 shows seam welds of this type. It is, of course, absolutely necessary that there is metal-to-metal contact if a weld is to be made. Figures 2a and 2b show attempts at welding the "interlocking" rib type of side lap. Metal-to-metal contact is not assured with the interlocking rib, and it is likely there is not enough contact to achieve an adequate weld.

3. **Button punched side laps:** Button punching is the most unreliable method of the three methods of fastening laps. The strength of the attachment depends on the care and physical strength of the workman, and on the quality of the tool that he uses. Fastening deck that is out of level at the side joints is possible (see Figure 1). If the deck is a concrete form, button-punched side laps may open during the pouring operation. Two advantages of button punching are that the underside appearance is not affected, and it is a rapid method of connection. But, under even the best of conditions, it is of questionable value. Table 3 shows a qualitative comparison of the side-lap attachment methods. The table is, of course, based on the writer's opinions, but it does illustrate that more than one factor should be considered before allowing, or excluding any method of attachment. □



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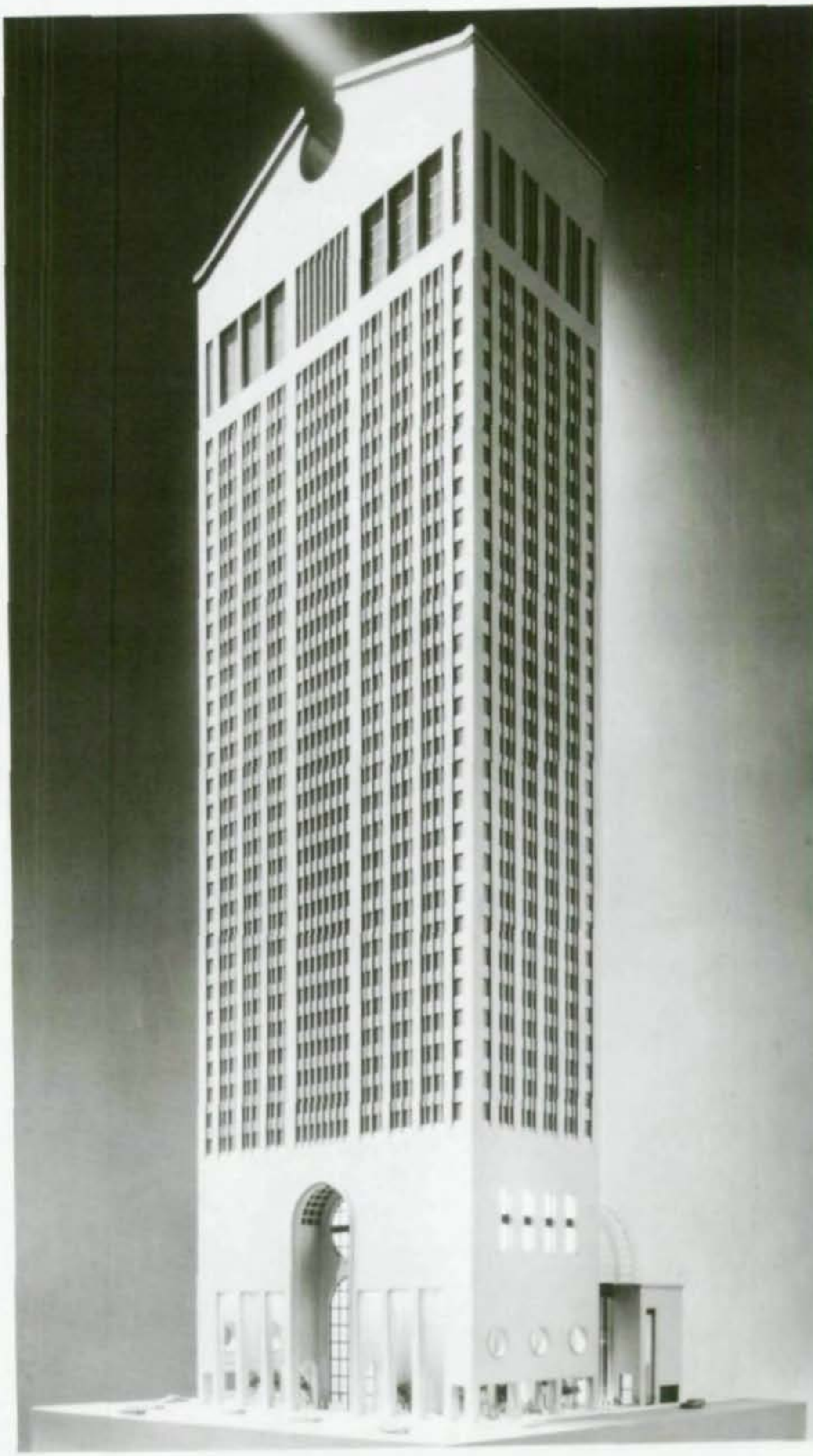
9. *Structural Welding Code—Steel* AWS D1.1-79 American Welding Society, Inc., Miami, Fla., 1979.

Table 3: Qualitative Comparison Chart of Side Lap Fasteners*

Attribute	Welds	Screws	Button Punches	Note
Strength	3	2	1	
Stiffness	3	2	1	
Consistency of quality	2	3	1	The SDI *Diaphragm Design Manual* shows suggested amperage settings for welding
Underside appearance	1	3	3	
Skill required for installation	2	3	3	
Availability of tools	2	2	1	A button punch tool is not always available. A screw gun with a clutch and nosepiece is recommended for the screws.
Factory Mutual (roof deck)	1	2	2	For FM-insured roof deck installation material lighter than 18 ga. should not be welded at side laps.
Underwriters Labs. (floor deck)	3	1	2	More rated floor assemblies are welded than button-punched. The author does not know of any screw-connected floor assemblies.
Deck cost	2	2	1	A premium is usually charged for the button-punched deck; shipping and installation costs may also be higher.

*Scale is 1 to 3 with 3 being the most desirable. This table is based on the author's opinions.

AT&T Headquarters: Culmination of a Life's Work



A striking departure from the "glass box" design of many high-rise office buildings is evidenced in the new $110-million AT&T corporate headquarters now under construction in New York City.

Via use of an innovative structural steel framing system, a host of challenging architectural and engineering requirements have been met for the 36-story, 800,000-sq ft project on Madison Avenue (between 55th and 56th Streets) in midtown Manhattan.

Construction of the new headquarters began in December 1978 and is expected to be completed by the first quarter of 1983.

Architect Philip Johnson has called the AT&T building his "'capolavoro'—the culmination of my life's work." Structural Engineer Leslie E. Robertson speaks just as highly of the building's notable design. His firm prepared the structural design in association with Consulting Engineer LeRoy Callender.

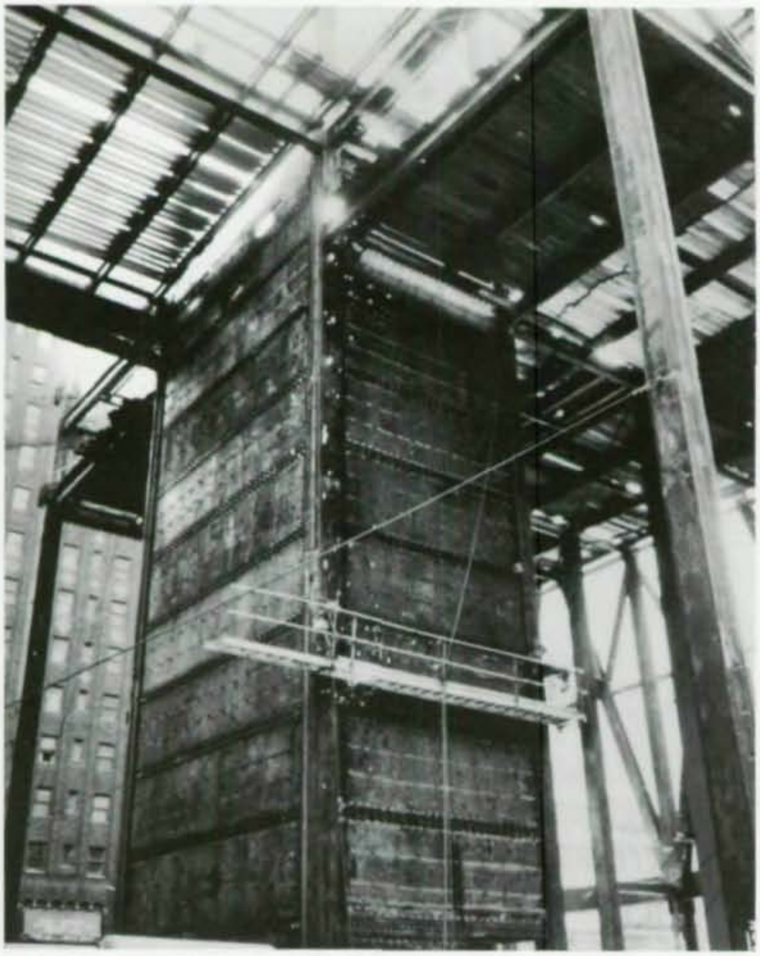
Stanley W. Smith, chairman of the 195 Broadway Corporation, an AT&T subsidiary, said of the new headquarters, "In addressing the kind of building we wanted, we asked the design team to give us a headquarters that reflects a proud tradition and one that typifies a dynamic, progressive organization.

"I think this building will do just that."

Architecture Conveys Dignity

The goal of AT&T was to build a structure that conveys a sense of dignity and identity. One feature of the building, which will make it one of the most distinctive additions to the Manhattan skyline since the World Trade Center, is the top of the AT&T headquarters.

Many designs were prepared and studied before it was decided that a gently pitched triangle, split at its peak by a concave hollow, would convey the individual character of this corporate structure. An impressive 112-ft high arch fronting on Madison Avenue presents a grand entrance to the lobby. Large structural columns along the building face form 60-ft high openings into the structure's open street-level public



AT&T Headquarters building (l.) now under construction. Above, shear box on lower level, details below.

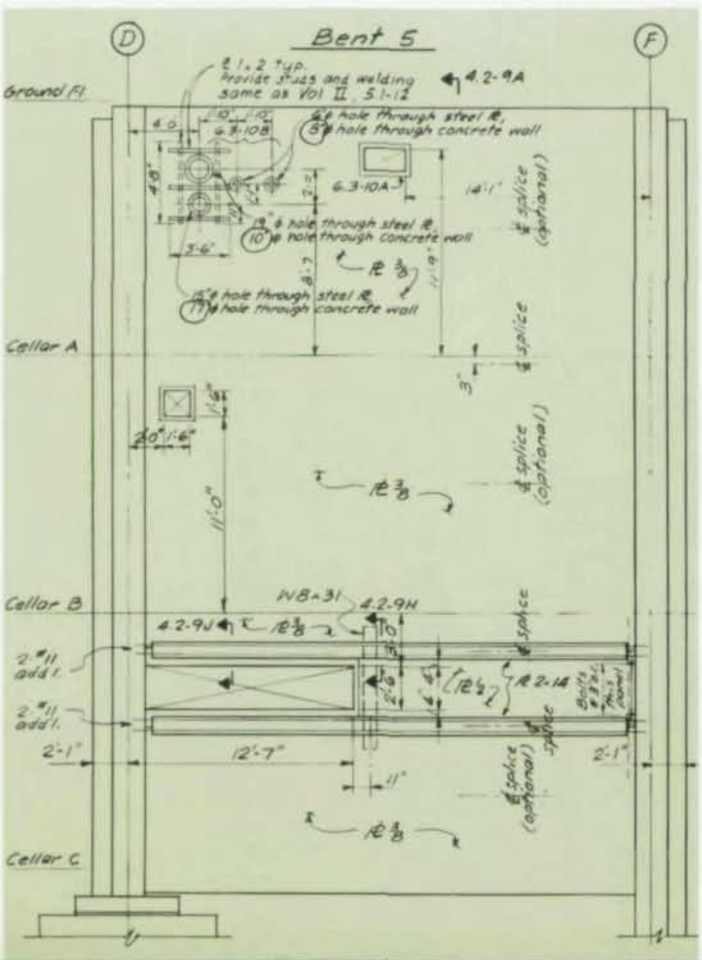
plaza. Twin loggias on the ground floor level feature seating, decorative planters and a variety of retail shops.

Also on the ground floor level will be "Golden Boy." The 24-ft high, 16-ton statue, officially known as the "Spirit of Communications," rested atop AT&T's headquarters at 195 Broadway since 1916. Formed of a bronze case on an inner frame of steel, Golden Boy is currently being refurbished and will ultimately be displayed on a granite pedestal in the main lobby.

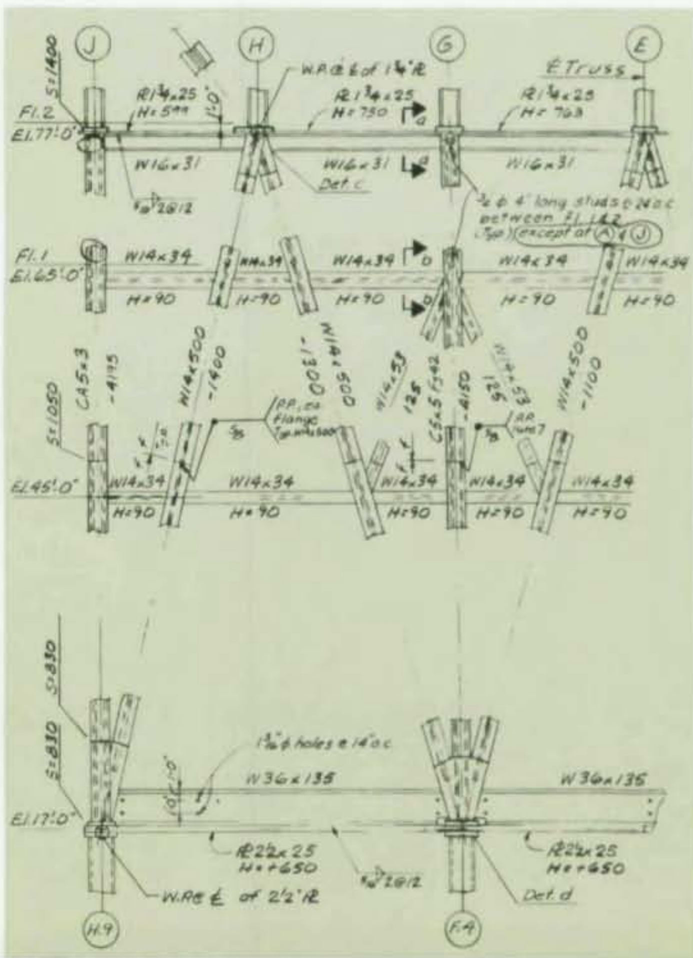
A "through-block" glass-covered arcade link the headquarters to a four-story annex building behind the tower. Except for the main lobby and the annex building, the entire ground floor is open. This area, in fact, will provide more public space than any other commercial facility built recently in New York City.

Housed within the annex building is the Bell System Communicade—an exhibition of communications science and technology for the information age.

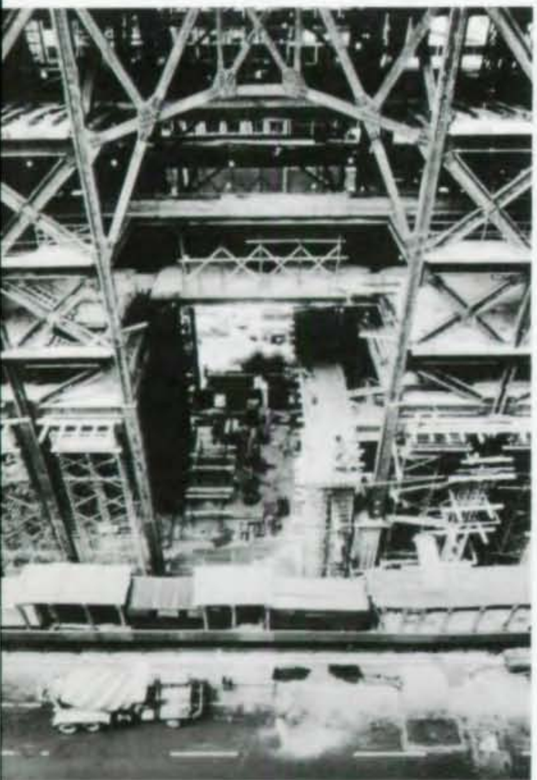
Attractive textured granite panels of a rose-gray hue comprise the exterior facade of the headquarters. A complex of steel angles and tubing superimposed over the frame structure allows each piece of granite to hang independently. Panels are attached in such a way as to minimize thickness of



Shear tube wall details



Truss detail



Early progress photos of steel framing of 112-ft high arch that fronts on Madison Avenue.

joints and to insure safety. Only one third of the AT&T building's exterior will be covered by windows as an energy conservation measure.

Rigid Frame Steel Tube Employed

Architects called for wide-span areas in the building, an important consideration in the design of the structural system. The rigid steel tube comprises the structural frame of the headquarters and represents the most innovative application of steel in the project. A total of 15,800 tons of A36, A572 and A588 F_y 50 grade structural steel was used.

Steel was selected for the framing system both for its economy and flexibility. Use of steel enabled the owner to make changes in the design as construction proceeded—changes which would have been costly and difficult to implement if a concrete structural system had been employed. However, reinforced concrete—3,000-4,000 psi—was used in the structural system to provide additional support to steel columns from basement level to ground floor. Concrete was also used for foundation walls, perimeter of the building up to the second floor and for the "cellular" floor system, steel decks topped with concrete.

Essentially, the office part of the AT&T headquarters is "hoisted" some 134 ft off the ground on stilt columns to create an expansive public space. Occupants and visitors to the building take shuttle elevators from the ground level to the building's sky lobby five stories above the public plaza, where they change to elevators that serve the low-rise and high-rise floors.

The frame is actually two series of tubes, the first a lower cross-braced part of the four exterior walls supported by the stilt columns. A second short tube is a cross-braced part at the top. The next series involves two tall vertical tubes that comprise the inner cores of the building, the vertical tubes separated by a 50-ft clear-span space.

At the lower level (fourth floor and below), inner cores are contained within two large shear boxes. Four plates of 3/8-in. thick steel surrounding these boxes house elevator shafts, stairs, ductwork and other mechanical services. The boxes then become architecturally functional elements which conceal the mechanical services, house the 12 columns in the inner cores (six in each core) and act to resist the horizontal shear at the ground level.

Unique Transfer System for Wind Forces

The AT&T building rises on a 36,800-sq ft site. The fact its width is extremely slender—98 ft—presented potential wind problems. The structural engineer's solution involved a network of trusses which transfer lateral wind forces on the building to its exterior columns.

Running the height of the bulding from the second level up is a series of steel trusses located within the inner cores. Every eight floors, steel-plated wind braces with holes (doors) cut out for pedestrian circulation extend out from the cores to the perimeter columns. There will be eight of these assemblies which will form four one-story high trusses at three levels in the tower (floors 12, 20 and 28).

Wind shear forces that accumulate from the top down are transferred to the two shear tubes forming the inner cores. The shear tubes, in turn, dissipate shear forces through the grade slab and basement slabs to the rock at the site perimeter.

According to the structural engineers, it was not necessary to have wind braces on every level—a fact welcomed by AT&T, which wanted as much clear, usable space as possible in the interior. □

Architects
Johnson/Burgee Architects
Harry Simmons, Architect (associate)
New York, New York

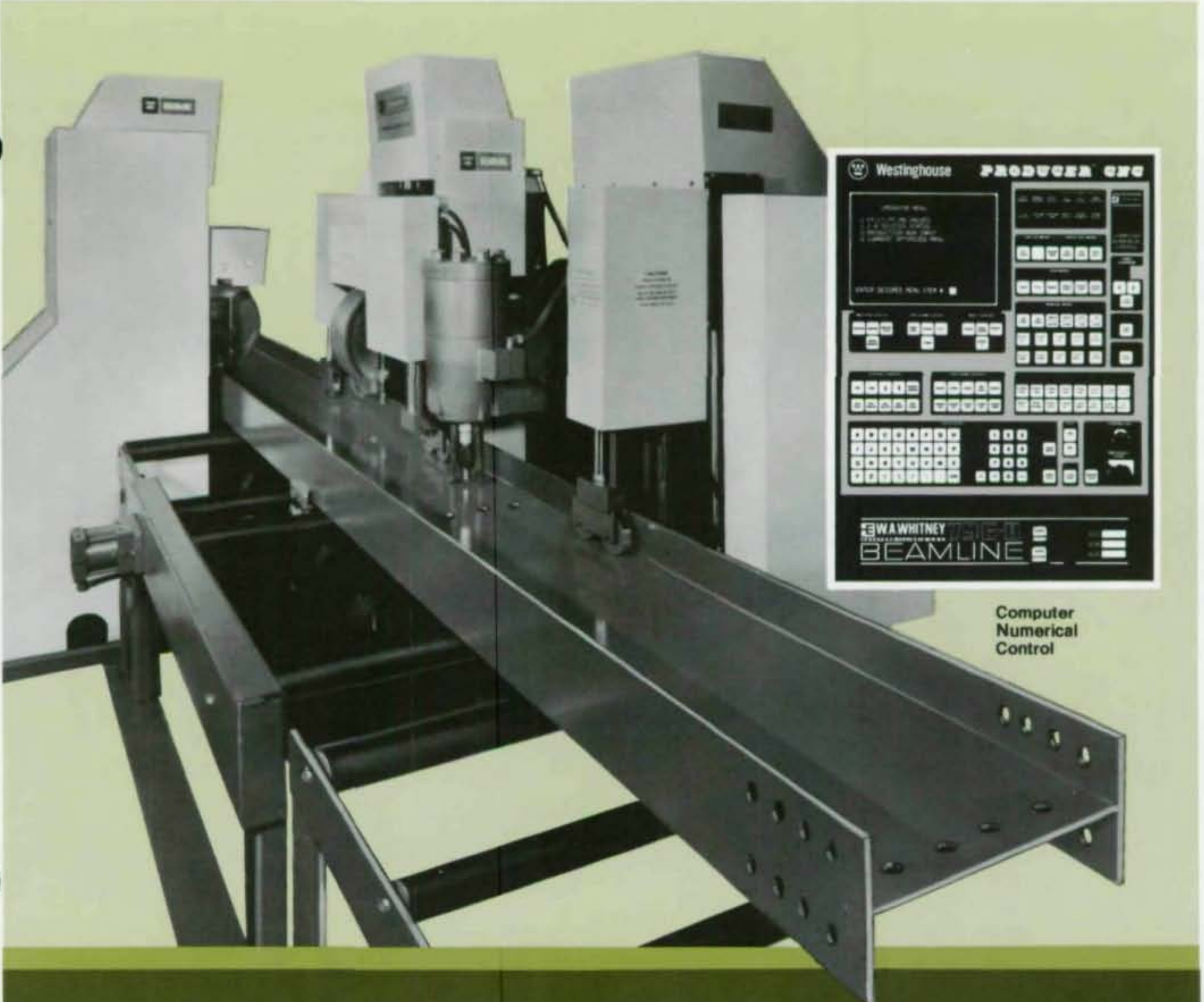
Structural Engineers
Skilling, Helle, Christiansen, Robertson, P.C.
LeRoy Callender, Consulting Engineer (associate)
New York, New York

Construction Manager
Crow-Briscoe (joint venture)
New York, New York

Steel Fabricator
Bethlehem Fabricators, Inc.
Bethlehem, Pennsylvania

Steel Erector
American Steel Erectors, Inc.
South Plainfield, New Jersey

Owner
American Telephone & Telegraph
New York, New York



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Ann Arbor Just "Straddles" Its Problems

Photo courtesy Bethlehem Steel Corporation

The city of Ann Arbor had a problem. A serious parking problem in the downtown area. A heavily used parking deck in the main commercial district became inadequate. The city had to decide whether to build a new facility nearby, or add to the existing four-level deck.

Adding to the existing structure was chosen as the best alternative. Don Todd, the city's project engineer, considered the addition "the more inexpensive way to go in providing the badly needed parking space."

But, enter more problems with that decision to remodel!

First, the concrete foundations and columns on the existing structure could not carry the weight of additional levels. Second, new concrete column penetration through the existing cast-in-place floors was not possible.

And third, adding new concrete columns would cause greater encroachment onto city sidewalks.

An ingenious solution: a steel frame that straddles the existing structure. The addition provides an initial three levels of parking, with provision for a fourth. Its design called for adding 115,000 sq ft to the present 278,000-sq ft deck. Completed, the new deck provides for an additional 388 spaces.

The new straddle structure is supported by 35 10-in. x 10-in. box columns fabricated from 3/8-in. to 5/8-in. steel plates. Exterior columns, up to 65-ft long, were installed parallel to existing columns and are set on spread footings.

Interior columns, W12x152 wide-flange sections, are erected through openings in the decks so the new columns bear on the top of existing columns.

The floor decks of the new levels are composite steel beam and concrete construction. Girders were fabricated from W33x141 structural shapes, and the floor beams are W16x31. All the steel is weathering steel, except for exterior columns which will be painted with polyurethane enamel.

Another important feature of steel construction is that the parking deck was kept open during construction to facilitate the critical parking needs of the area. □

Architect
Richard C. Rich Associates
Southfield, Michigan

Structural Engineer
William Paxton Associates
Detroit, Michigan

Construction Manager
Barton-Malow Company
Detroit, Michigan

Owner
City of Ann Arbor, Michigan