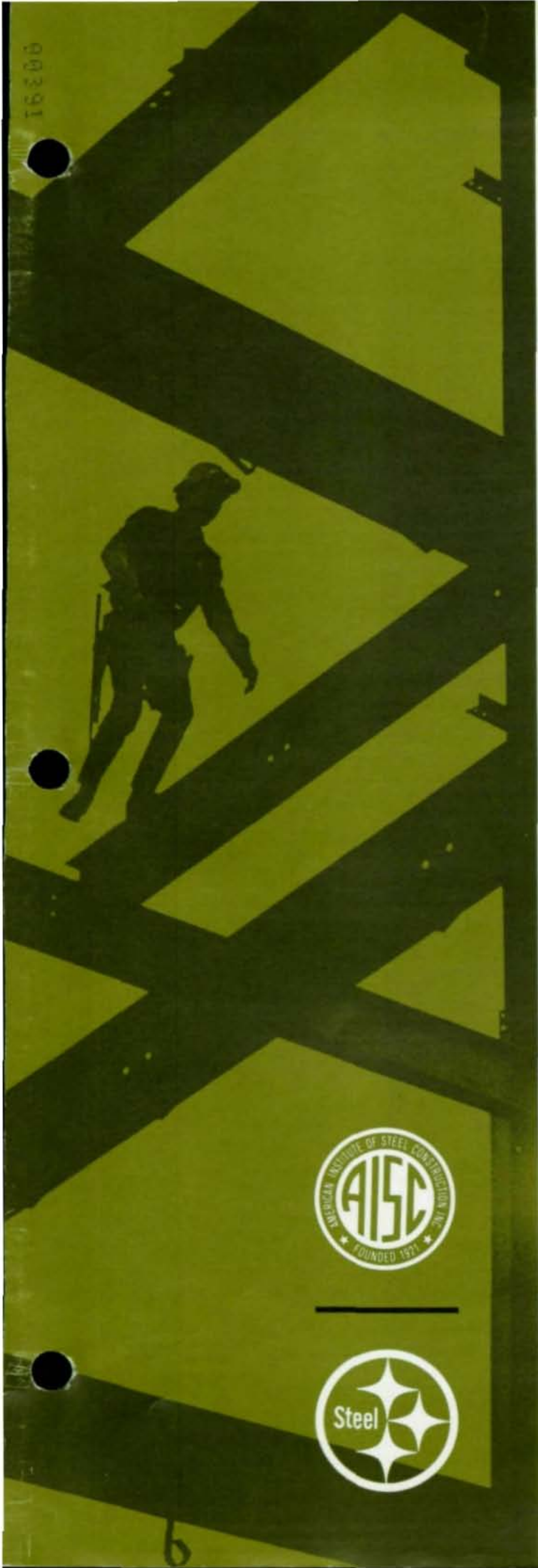
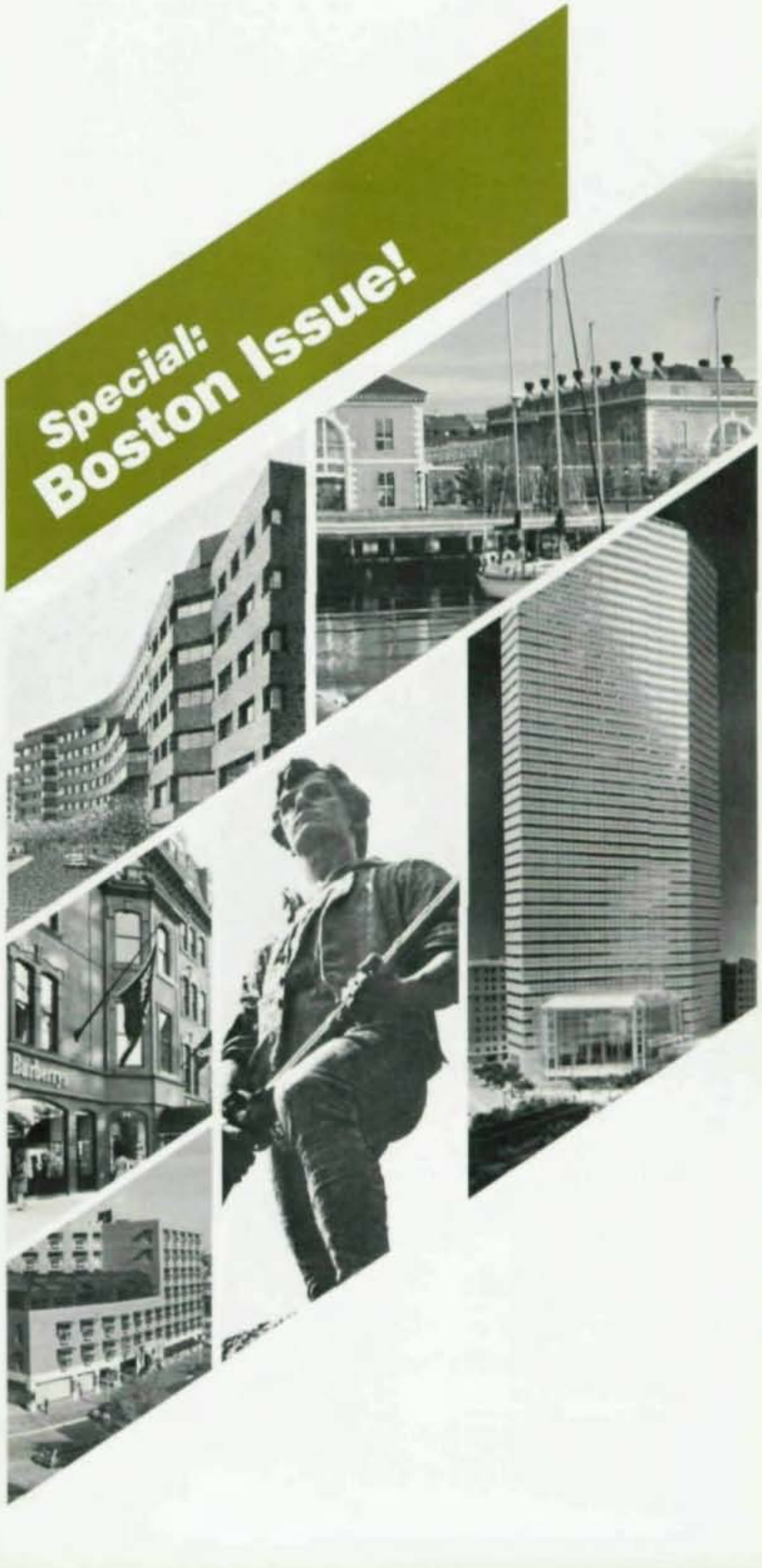
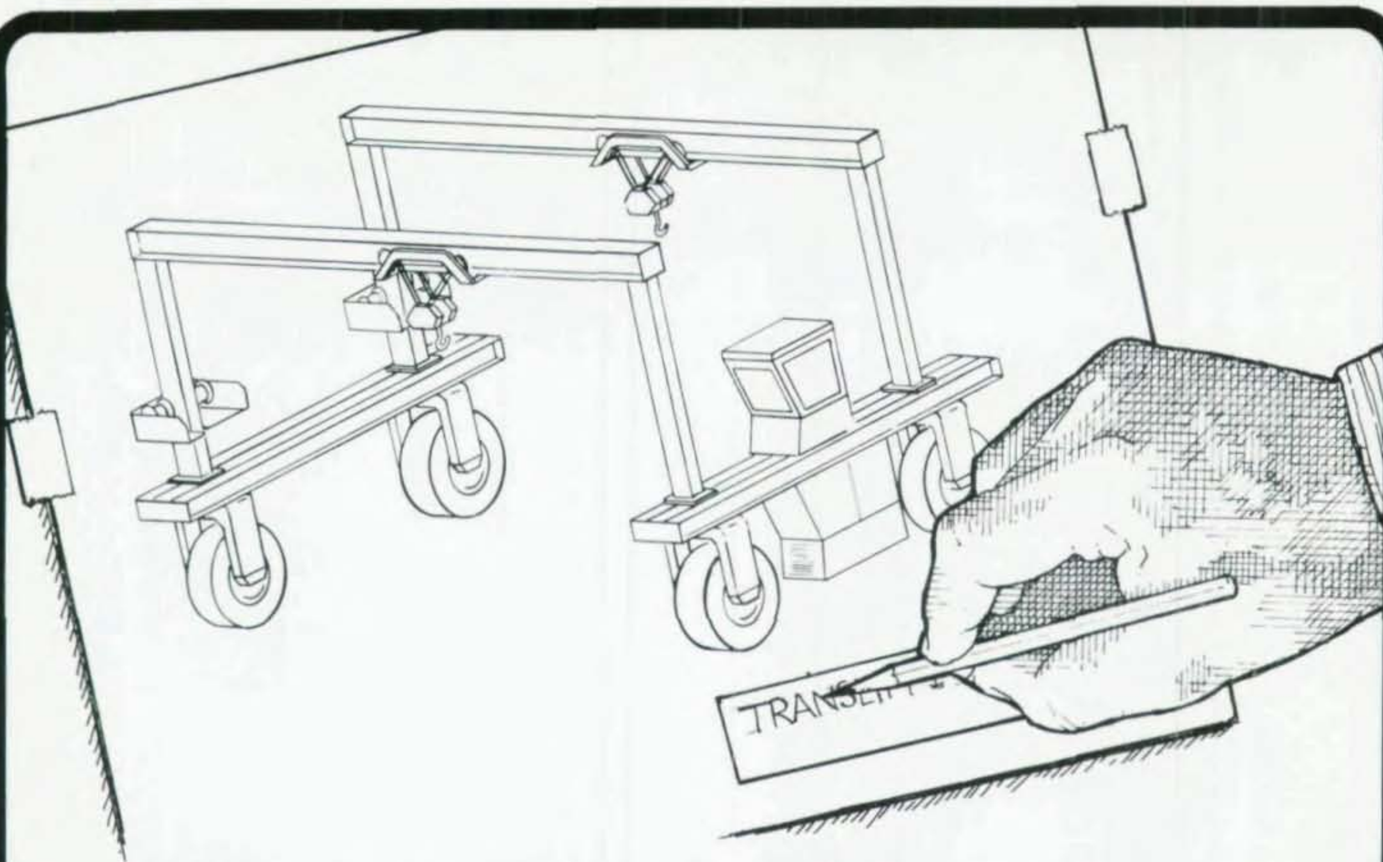


VOLUME XXIII NUMBER 1/FIRST QUARTER 1983

MODERN STEEL CONSTRUCTION

Special: Boston Issue!

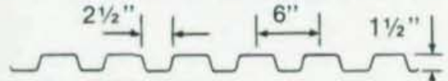
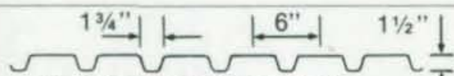
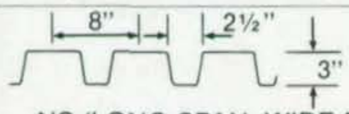




DECK DESIGN DATA SHEET

NO. 2

MAXIMUM ROOF DECK SPANS

UNITED STEEL DECK, INC. ROOF DECK PROFILE	DESIGN METAL THICKNESS	GA.	MAXIMUM SPAN		
			SINGLE SPAN	MULTIPLE SPAN	CANTILEVER SPAN
 B (WIDE RIB)	0.0295"	22	5'-10"	6'-11"	2'-0"
	0.0358"	20	6'-7"	7'-9"	2'-4"
	0.0474"	18	7'-11"	9'-5"	2'-10'''
	0.0598"	16	9'-0"	10'-8"*	3'-0"
 F (INTERMEDIATE RIB)	0.0295"	22	5'-1"	6'-1"	1'-6"
	0.0358"	20	5'-9"	6'-9"	1'-9"
	0.0474"	18	6'-11"	8'-2"	2'-3"
 NS (LONG SPAN, WIDE RIB)	0.0295"	22	11'-6"*	13'-6"*	4'-0"
	0.0358"	20	13'-0"*	15'-4"*	4'-7"
	0.0474"	18	15'-9"*	18'-7"*	5'-5"
	0.0598"	16	18'-3"*	21'-6"*	6'-0"

*Exceeds normal applications

NOTES:

All maximum spans are center to center and are based on SDI loading criteria and United Steel Deck, Inc. roof deck sections.

1.) Regular spans (not cantilever) are governed by a maximum stress of 26600 psi and a maximum deflection of 1/240 with a 200 pound concentrated load at midspan on a 1'-0" wide section of deck.

2.) Cantilever spans are based on:

a.) construction load of 10 psf on adjacent span and cantilever, plus 200 pound load at end of cantilever - stress limit is 26600 psi; or

b.) service load of 45 psf on adjacent span and cantilever, plus 100 pound load at end of cantilever -stress limit is 20000 psi and cantilever deflection limit is 1/120.

c.) maximum, and less than maximum, adjacent spans were used to find the cantilever spans; the governing shorter spans are shown in the table.

3.) Check any applicable insurance requirements (Underwriters Laboratories and Factory Mutual) as they may require smaller spans.

4.) Uniform loads are shown in the U.S.D. catalog for spans greater than the maximums shown in this table. Frequently deck is used in applications other than roofs - siding, temporary structures, shelving, etc., and load data is desired.

5.) Reprints available on request.

NICHOLAS J. BOURAS, INC.
P.O. BOX 662, 475 SPRINGFIELD AVE.,
SUMMIT, NEW JERSEY 07901 (201) 277-1617

MODERN STEEL CONSTRUCTION

Published by

American Institute of Steel Construction

The Wrigley Building
400 North Michigan Avenue
Chicago, Illinois 60611

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CONTENTS

21st AISC ARCHITECTURAL AWARDS OF EXCELLENCE ANNOUNCED

AISC again sponsors its Architectural Awards of Excellence Competition—our 21st. The contest seeks to recognize and honor the most outstanding buildings in the U.S., both technically and aesthetically, completed during 1981–1982—using fabricated steel framing.

Winning structures will be featured in a special section of the October Architectural Record. *Also, a representative of each winning firm will be an honored guest of the steel industry at AISC's prestigious Annual Awards Banquet on November 1.*

This year's distinguished panel of judges includes:

Gunnar Birkerts, FAIA, *Gunnar Birkerts & Associates, Birmingham, Michigan*
Wayne R. Bishop, AIA, *Ellerbe Associates, Minneapolis, Minnesota*
Stanley D. Lindsey, Ph.D., *Stanley D. Lindsey and Associates, Nashville, Tennessee*
George M. Notter, Jr., FAIA, *Anderson Notter Finegold, Washington, D.C.*
George Schipporeit, *AIA, Illinois Institute of Technology, Chicago, Illinois*

Entries will be judged on June 7, 1983. Entries must be postmarked by May 15. Further details and entry forms may be secured from: Awards Committee, AISC, 400 N. Michigan Ave., Chicago, IL 60611. 312/670-2400.

NEW LIGHTWEIGHT 8TH EDITION MANUAL RELEASED

Not quite pocket size—but the new lightweight version of the Manual of Steel Construction *fits easily into briefcase or tote bag—perfect for field trips or travel. Light, flexible cover, and printing on "bible" paper cuts its weight down to 1 lb.–5½ oz. and its thickness to ⅞-in. Same number of pages, same type size, same contents as the standard version—and the same price—$36. Order your copy today!*

Steel Construction—Rising to the Occasion in Boston

by Emile W. J. Troup

This landmark issue of *Modern Steel Construction*, the largest ever published, is a celebration of the rejuvenation and growth of one of the country's oldest, most unique and exciting cities. It is a celebration of effective solutions orchestrated for recycled and new construction by public and private agencies, owners, developers, designers and builders. And, it is a celebration of the contributions made by the structural steel industry to the successful framing of many challenging projects.

Soliciting articles for this issue required scrutiny of more than 75 important steel-frame projects in Boston and Cambridge, recently completed or under construction. With this kind of inventory, it was hardly possible to expand consideration to the suburbs, within a 30-mile radius, which would have added hundreds more worthy projects to an already lengthy list.

Dozens more exciting downtown projects, from $5 to $500 million, will break ground during 1983 and 1984, and will be candidates for future issues of *MSC*, for example:

- BOSCOM, the $100-million conversion of Commonwealth Pier exhibition space into a 1-million sq ft marketplace for the information industry.
- East Cambridge Riverfront along the Charles River, a $180-million public/private development of perhaps the most desirable property in the area, with an assortment of some 20 new and recycled buildings.
- Lafayette Place, a $150-million parking/commercial/hotel complex in the heart of Boston, featuring the city's first staggered-truss structure, the 22-story Intercontinental Hotel.
- 399 Boylston Street, a block-long redevelopment involving recycling of the historic Warren Chambers Building, adjacent to a new 13-story retail/office building.

Emile Troup, P.E., AISC's regional engineer, is a life-long resident of the Boston area. He holds nothing back in his enthusiasm for the future of Boston, and for his good fortune of being in the thick of the most exiting transformation in the city's recent history.

- Hynes Auditorium expansion, perhaps one of the more important projects, which, in concert with a doubling of hotel space, will put major conventions on notice.

Billion a Year Expansion

The rate of construction in Boston since 1981, and for at least the next few years, is on the order of $1 billion dollars per year. Steel-frame projects included in this issue represent about one-half billion dollars of investment. They range in size from $1½ to $100 million; from one to 46 stories; and from 10,000 to over 1 million sq ft.

The phenomenal achievement of the redevelopment and construction program is a result of many factors. There has been an appreciation of, and response to, the region's unique history of events and architecture. Also, concentration of architect/engineer talent in the Boston/Cambridge area is perhaps the highest of any city.

And what about the role of structural steel? Is it the key framing material in Boston during the 80's? Consider the following:

- Three luxury hotels opened during 1982. The Bostonian (five stories), Marriott Long Wharf (nine stories), and the Back Bay Hilton (25 stories). Totals: 917 rooms, $73 million, *all* framed with steel.
- During 1983, two multi-level, steel-framed superblock shopping malls (Lafayette Place, Copley Place), will add more than 200 stores to those in the traditional shopping districts.
- Five mid-rise office buildings (17 to 23 stories) are under construction in 1983, totaling $165 million, *all* steel-framed. Both high-rise office buildings due to top out this year will total 95 stories, with over 2 million sq ft of steel framed space.
- Two major new health care facilities opened in 1982 were both framed with steel and totaled $54 million. Several other hospital expansions in steel are underway during 1983.

At the outset, several framing materials are usually, and rightly, investigated for each project. Some challenges of Boston/Cambridge construction projects are: an irregular footprint; constricted, tight sites; unfavorable soil conditions; underground obstructions (old utilities, subways, tunnels, etc.); historical/architectural significance of adjacent or nearby structures; future expansion considerations; modifications to existing buildings, and encountering the unexpected.

Unquestionably, fabricated structural steel is the *problem-solver* among the various framing materials. And when this fact is combined with the local expertise in design, fabrication and erection, it becomes clear why steel has ultimately been the choice for most projects. In New England, over 200 structural engineers are well-informed, Professional Members of AISC, and at least 80 to 90% of the steel fabricating capacity rests with AISC Active Members. And we have not even alluded here to steel's many traditional advantages—speed of construction, flexibility, economy, efficiency and the opportunity for winter construction.

From one to 46 stories, fabricated structural steel rises to the occasion in Boston. It does the job it was made to do: provide owners with flexible, durable, attractive and rapidly constructed buildings at the best cost. These buildings rise now, but they represent the future of Boston. This memorable issue, the result of the great interest and diligence of its authors, hopefully records a significant chapter of an astounding rejuvenation.

So—read on—and let the celebration begin! □

A New Boston— Vibrant, Dynamic— Sheds Its Skin

by Robert J. Ryan

Twenty-five years ago, Boston was often referred to in the past tense. Its future as a viable city was openly questioned. The gloom-and-doom prophets had only to point to an eroding economic base to buttress their pessimistic forecasts. Boston, it was said, had never recovered from the 1929 Depression. Worse still, the process of suburbanization which followed World War II lured jobs and people from the city to the outer reaches of the metropolitan area. The city once called "Hub of the Universe" was hard-pressed to maintain its role as economic and cultural capital of New England.

Today, of course, Boston has emerged as one of the most exciting and dynamic cities in the country. It is one of the few urban centers weathering the national economic recession. At the same time, our city is experiencing development activity that is without parallel in its long history. A remarkable comeback from economic stagnation and physical deterioration is the story of concerted public-private sector cooperation, or more specifically, a public investment strategy which created the underpinnings for private sector growth.

Boston, in the 1960's, launched a program of renewal that was both ambitious and far-reaching. A new agency, the Boston Redevelopment Authority (which had absorbed the powers of the City Planning Board) was able to tap Federal funding for showcase projects such as Government Center and the Downtown-Waterfront project, as well as neighborhood renewal efforts in Charlestown, Washington Park and a number of other residential areas.

The Prudential Center began to take shape on 24 acres of abandoned railyards in the Back Bay, thanks to legislation which allowed for Chapter 121A limited dividend corporations. Under the new law, enacted in 1960, a 121A development was exempted from real estate taxes but paid an in-lieu tax levy based on percentage of growth income. Chapter 121A provided new developments some relief from Boston's historically high property tax rate.

Chapter 121A also signaled the city administration's willingness to provide private investors with various incentives if they were willing to build in Boston. Additionally, massive public improvements targeted under the urban renewal program upgraded the physical environment of downtown—and also set the stage for improving the Boston investment climate.

Of equal importance, the BRA, by using Federal funds to acquire rundown and blighted buildings, then deliver sites to developers at a "writedown," paved the way for rebuilding the downtown area.

Scollay Square, an area of honky-tonk bars, tatoo parlors and burlesque houses, was cleared. In its place—almost as soon as demolition was completed—foundation work began on a number of government buildings. Centerpiece of the 50-acre project was New City Hall, a building whose stark, modernistic design symbolized the new era, the new spirit of Boston.

Nearby, on Boston's historic waterfront, an area filled with under-utilized warehouses and decaying piers and sheds, the city's renewal agency was creating a new residential neighborhood. A mix of commercial uses and regional attractions, such as the New England Aquarium, was bringing new life to the area, re-establishing Boston's historic ties to the sea.

The city's aggressive intervention in the process of development and growth began to bear fruit as one after another of the large banks, insurance companies and financial institutions announced plans for new high-rise towers. The business community was responding to the improved investment climate in the city.

Boston business was also in the forefront of the dramatic change taking place in the American economy. The segment of the national economy which began to grow most rapidly in the 1960's was high-grade service activities. Consequently, the rate of job growth increased dramatically in banking, insurance, finance, higher education and medical research, all areas of economic activity which had been traditional Boston

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Robert J. Ryan is director of the Boston Redevelopment Authority and deputy mayor for development for the City of Boston.

Dynamic Boston area sprouts new buildings at $1 billion a year rate. Half-billion dollar Copley Place (c.) is superimposed on aerial view.

strengths. Suddenly, a city suffering from the steady loss of blue-collar jobs found itself developing an employment base consisting of white-collar jobs.

The city, which had seen little private investment between 1930 and 1960, began to catch up with itself.

The story, of course, is writ large on our skyline. New office buildings—more than half of the city's office space has been built since 1960—spelled out the transformation and growth of Boston's economy.

Moreover, beginning in the late 1960's, the city refocused its renewal and development efforts in its neighborhoods. Having restored some semblance of health and activity to its downtown, the city was trying to strengthen confidence in its neighborhoods by providing new public facilities. The social turmoil generated by school busing in the early 1970's undermined some progress, but by 1976, Boston displayed a sparkling new face when the nation's attention turned to this old city for the bicentennial celebration.

The Fourth of July extravaganza on the Charles River Esplanade, the visit of the Tall Ships and Queen Elizabeth II, the opening of the new park on Boston's refurbished waterfront, and the Faneuil Hall Marketplace attracted thousands of visitors. Those who did not visit watched TV coverage of these events, and became aware of the remarkable rebuilding which was taking place.

The public perception of us as a city caught up in the backwash of suburbanization began to fade away. Boston became a city where people wanted to visit, to live, to shop, to work. By 1980, after two decades of development activity, there was a shortage of hotel space and of office space. The spectacular success of Faneuil Hall Marketplace had revitalized Boston's retail district. Evidence of this became evident when construction began on Copley Place, a combined retail-hotel-office center which represents the largest private investment in the history of the city. In addition, Lafayette Place, another development featuring a retail and hotel complex, is under construction on Washington Street, in the heart of the retail district.

In 1983, Boston is experiencing the third year in succession where private investment is moving at $1 billion a year.

Major office towers underway include million-sq ft office buildings at Dewey Square (near South Station), a joint venture of Rose Associates of New York and Metropolitan Life Insurance Company, and Exchange Place on State Street, being developed by Olympia-York Co.

With an office vacancy rate standing at 3% for Class A space, a number of medium-sized buildings are being developed, both in the Back Bay and in the city's financial district. In all, about 4 million sq ft of space is under construction.

Boston, with an inventory of 7,000 hotel rooms, ran into problems in attracting sizable conventions. But in the past two years, the city has seen the opening of the Long Wharf Marriott (400 rooms), the Hotel Meredien (300 rooms), the Ritz Carlton addition (80 rooms), the Hotel Bostonian (155 rooms), and the Back Bay Hilton (350 rooms). In addition, construction is now underway on the 250-room Four Seasons Hotel, the 700-room Westin Hotel and a 1,200-room Marriott, the last two a part of Copley Place.

Having encouraged a significant expansion of hotel space, the city, working with the newly created Massachusetts Convention Center Authority, is about to begin reconstruction of the Hynes Auditorium, Boston's major convention facility. The Hynes expansion, to be completed in 1986, doubles the size of that facility and enhances Boston's capacity to attract larger conventions.

Moreover, with all this development activity underway, the city is formulating development plans for another generation of growth. In the spring, construction will begin on a $75-million federal office building in North Station, the first phase of a development that will see the creation of a new residential complex on an island in the Charles River. At the Charlestown Navy Yard, abandoned by the U.S. Navy in 1974, the BRA is creating another residential community on Boston Harbor. Here again the new apartments and condominiums will consist of warehouse and manufacturing buildings recycled for a new use.

In addition, the city is marketing the larger buildings at the Navy Yard for light industrial or office uses. And South Station, once the hub of rail, as well as intercity and commuter bus operations, takes on a new life. Later, air-rights over the track area of South Station will be developed by BRA for office and hotel use. And across the Fort Point Channel, plans have been announced for a major hotel/condominium complex to be built by Anthony Athanas and Hyatt Hotels.

Today's Boston has little in common with the slumbering towns of the mid-1950's. Today's Bostonian might not insist on calling this old city the Hub of the Universe, but the city has reclaimed its title as the leading provider of goods and services in New England. It is a city which has shed its skin, but not lost its soul, a city which has a development agenda that will ensure growth and expansion into the 21st century. □

Key to Boston convention growth is Hynes Auditorium, soon to be expanded to match area business/tourism explosion.

Back Bay Hilton:
The Team Cheers "Go Steel!"

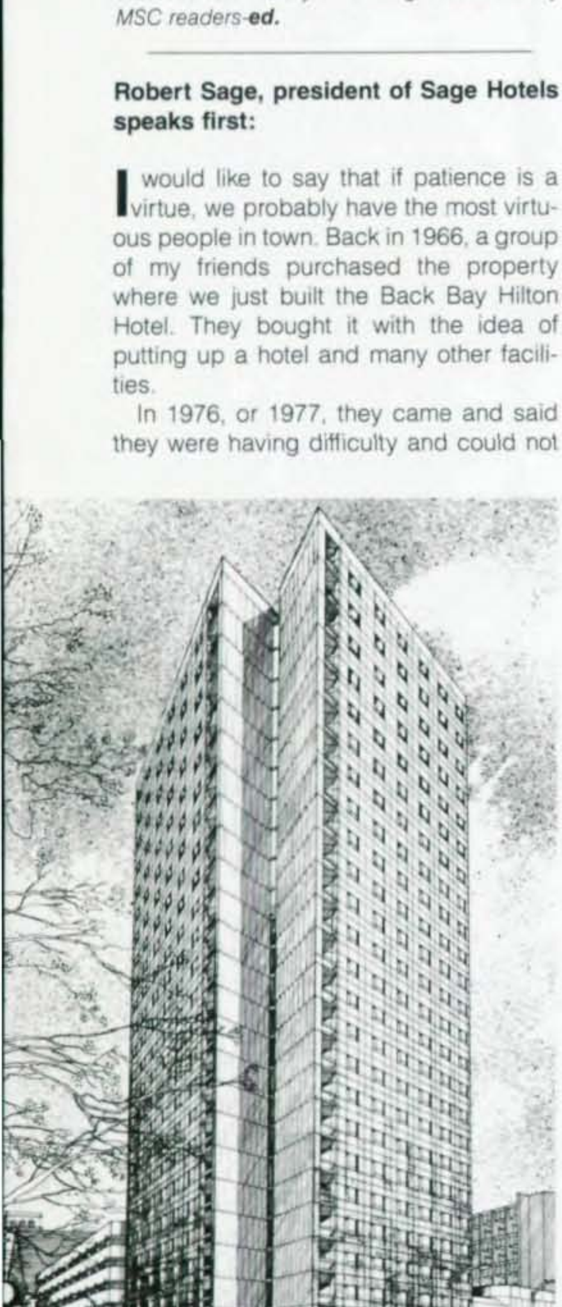
*At a Breakfast Meeting (late 1981) of the Structural Steel Fabricators of New England, an owner/developer and a noted structural engineer say some potent things about structural steel that are worthy of sharing with our many MSC readers-**ed.***

Robert Sage, president of Sage Hotels speaks first:

I would like to say that if patience is a virtue, we probably have the most virtuous people in town. Back in 1966, a group of my friends purchased the property where we just built the Back Bay Hilton Hotel. They bought it with the idea of putting up a hotel and many other facilities.

In 1976, or 1977, they came and said they were having difficulty and could not get this project off the ground, and asked if I would be interested. We made some feasibility studies and went forward. We found out this was a great location and deserved the type of hotel we would like to put in this particular location. But we had certain problems to overcome. Our piece of land totaled about an acre. On that acre there were 30,000-plus sq ft of land, and we had to go over the Boston Edison sub-station to pick up another 12 or 13,000 sq ft.

As far as I am concerned, only one person could answer that problem—and it was Irving Salsberg. Irving designed the first hotel for us back in 1959, so we have a relationship of over 22 years. As a result of what we have done, we tried to be as innovative as possible—I don't think that any of our six hotels look alike. We think we blend very well into the communities where these hotels were built.



Property Use Vital to Plans

First, we tried to decide which was the best way to build a new Back Bay Hilton. With a little bit of macho in every one of us, we did not want to be subordinate to any other hotels in the area.

Frankly, I am very, very impressed with the utilization of the property. We have a 25-story tower, a seven-story garage in the back and a three-story public facility to the side to give it more dimension. It does not look as if we covered every inch of space, when in fact we have. But, what is more important, we gave some dimension to it. From an architectural standpoint, I think we can put this up against any hotel in town. It is outstanding.

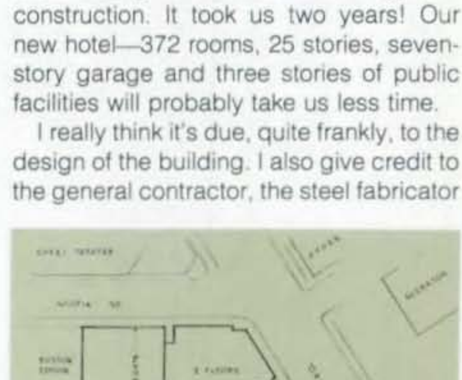
What we did at that point was to decide the most efficient and best way to build a hotel. As a result, we had in the back of our minds a fast track, in other words, the ability to formulate our plans, move forward and erect this hotel in the fastest time possible. Of course, who knew then that interest rates were going to 20 to 22%. We didn't have that in our crystal ball.

As a result, Irving and I sat down with Bill LeMessurier and decided on a plan—probably the most open plan I have ever seen. I never worked with people so receptive to new ideas. We decided we would invite a general contractor to sit down with us to go over the plans, and determine in a team effort exactly what this would do for us. As a result, we sat down with the Vappi Company, the engineers and architects and came up with the idea to erect a steel hotel. It was the first experience we have ever had with steel. I'm the fellow who has to pay the bills and do not know much about the technical aspects of building a hotel. I relied upon people with expertise in other fields. As a result, we decided to move forward.

Moving Right Along!

Now, I can just tell you what this means to us, as an owner and developer of a hotel. First of all, if everything goes well, we hope to open in the fall of 1982. Since we started construction last January, that is less than two years! Interestingly enough, we built this 15-story, 205-room hotel we are meeting in with a different type of construction. It took us two years! Our new hotel—372 rooms, 25 stories, seven-story garage and three stories of public facilities will probably take us less time.

I really think it's due, quite frankly, to the design of the building. I also give credit to the general contractor, the steel fabricator



New steel-framed Back Bay Hilton was designed for tight site, speed of construction. Floor plan (r.) shows difficult site plan.

and the erector. No matter what plans we accomplished, nothing would have worked without their cooperation. It was really a team effort.

Ripple Effect Important

The other thing I should bring to your attention is, as the owner, what it means to get a hotel up this fast. There is a ripple effect. The ripple effect is that if the steel-workers can erect the hotels quickly, it helps the other sub-contractors. First, in the construction business, like in our business, the faster you get in, the faster you get out. That's when contractors have the opportunity to make some money. Secondly, if sub-contractors are trying to figure what the material and labor costs are, the faster they get in, the faster they get out. It's very helpful to them, so from that standpoint it's like a two-way street. It helps us get the building built faster, but it also helps the rest of the trades, and everybody else on the job.

The other thing, which is very important, is interest rates. Basically, as it is right now, every month we save at the end of a job, we are talking about saving, just in interest alone, between $250,000–$300,000. That's an awful lot of money. As a matter of fact, I was just thinking, that if we save $600,000, I think that is what it cost us to build our first motel in 1959. When you try to relate to those figures, it is really frightening.

The other thing which is very important to us as an owner and operator is the fact there will be 4,000 new hotel rooms coming to Boston between now and 1985. Quite frankly, we want our share of the market. The faster we can open our hotel, the faster we can solidify our position as far as our customers are concerned. It's very important to us to get in as fast as we can from the standpoint of staffing and developing new business.

Furthermore, I think that with the hotels opening up right now, or will be within the next few years, you are talking about an average construction cost of $100–$140,000 per room. How that relates to our business is frightening. Years ago, I remember reading that for every $1,000 in construction cost, it was like a dollar for room rate. So if you are talking about a hotel which cost $140,000 per room, you have to charge an average of $140 per night. We forecast on this project that the total price per room will probably be around $81 to $82,000, which means our average room rate will be about $82 to $85 per night. That is very important from a standpoint of being competitive. If you buy right you can sell right. As far as we are concerned, we feel very strong in the market at that price.

So for these many reasons, it's very, very important that we are very happy we went along with this system. If you are looking for an endorsement for steel, you certainly have our vote.

William LeMessurier, chairman of SCI sums up:

It is quite remarkable that this is a steel building. Architect Irving Salsberg, in my opinion, is one of the most talented designers of concrete in the country.

When I first was shown the design for what is now the Back Bay Hilton, I said, "Well, he's done it again; a wonderful concrete building." He had built a model and the conception in concrete terms was quite clear. The building is on an amazingly difficult site. The street pattern led to a triangular building. And it is not just some architect's whim, it is an elegant and practical solution to an extremely difficult site problem.

So, when we began to study this building, I don't think it was very much appreciated when we suggested, as a matter of policy, we should look at steel as well. I think it a cliche in every designer's mind that common widom dictates you always build housing and hotels out of concrete. But things are a little different these days, especially in Boston. I do not think we have the teams who know how to build concrete as fast as other places in the country. We do have good steel fabricators. We have terrible site conditions in the Back Bay which means that weight saving is an advantage.

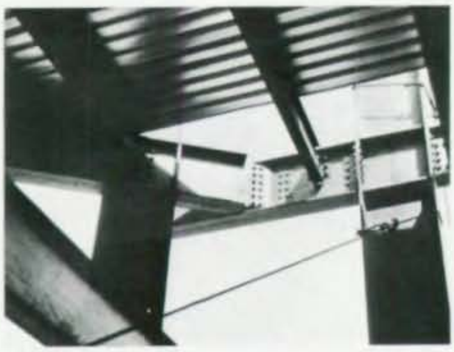
Steel, with No Regrets

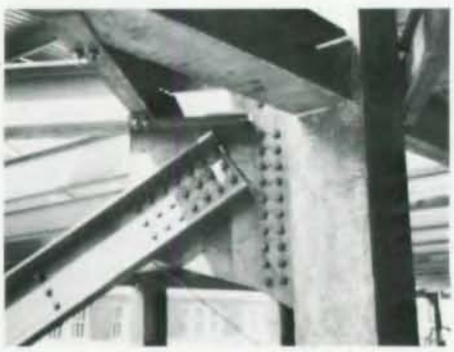
We went through this, however, looking at concrete and steel very, very carefully. I must admit I shuddered when I thought of trying to figure out how to do a steel frame in this particular arrangement. But when you do it in detail and talk to some of our builders around here for advice you find some serious problems. What about those concrete shear walls? There are a lot of them and they take a long time to form. They do not really work in terms of energy, because when you put them up, you really have to insulate the outside. Then you have to cover the insulation with something. If you insulate the inside in a tall building you will get differential temperature movements tearing things apart. And the earthquake problems are just amplified with heavier buildings.

So we went through a fairly conscientious preliminary study and then got counsel from builders on the time and the cost. Together with Irving and Mr. Sage, we made the decision to go steel. I don't think anyone has any regrets.

We ended up framing this building with what could be called a tube. The idea is to mobilize all of the exterior walls into a continuous system. Where there are windows, and balconies in some cases, the framing is conventional moment-resisting frames—almost conventional, with a few exceptions. But when it came to the corners, where the original design already was arranged without windows, these were natural places to put diagonal bracing. So, the building in conception is a plan which has three walls on the three sides of a triangle, framed with moment-resisting beams and columns, and the corners in all faces framed with diagonally braced shear panels. These are shear walls in steel as the way to think about them.

Let's start at the foundation. One of the peculiarities of a steel building is it is so lightweight that even though you mobilize the whole building, in this case to resist lateral forces, you sometimes run out of resistance to overturning capacity. So we have some piles here that are quite long: 14-in. precast piles with all this steel sticking up to engage them in tension to hold the building down. That will never happen at design load levels, but to achieve the proper load factor, you do need to have some tension anchors. Because of our requirements for seismic design in Massa-





Typical connections at reentrant corners (top); typical connection at bracing detail (bott. photo).

Architect
Irving Salsberg & Associates, Inc.
Brookline, Massachusetts

Structural Engineer
LeMessurier Associates/SCI
Cambridge, Massachusetts

General Contractor
Vappi & Co.
Cambridge, Massachusetts

Steel Fabricator
West End Iron Works
Cambridge, Massachusetts

Steel Erector
Daniel Marr & Son Co.
Boston, Massachusetts

Owner/Developer
Sage Hotel Corporation
Boston, Massachusetts

chusetts now, we tie all of the footings (pile caps in this case) together with tie beams to give a good foundation, which unites the building as a whole right at the ground level.

It is a nice overlap when you have a pile foundation to support steel framing for two reasons: one is that steel is a lighter load. Secondly, there is always the time necessary to fabricate the steel and get a backlog. So, if a certain time has to be spent in the ground putting in piles, doing excavation, that time can be used to fabricate the steel. When you start erection, you have a good backlog and can go very fast.

The The Drama of Steel Framing

A closer look at some of the framing—the re-entrant corner is really a difficult problem. We have a diagonally braced shear wall in each of the two planes leading into the corner. But right in the middle—right in the very inside corner—there is a strip of windows. This will all be glazed, and the drama of this emerges as the building is enclosed. The building is diagonally braced, and a series of beams with moment connections connect the the two braced bays together.

Now let's consider the lateral load resistance. We had to design here not only for wind but also for earthquake. To face these problems, this building would be a case of taking K=1 in the earthquake system. We have shear walls in steel combined with moment-resisting frames. That combination with the moment-resisting frame part gives the extra boost in ductility which is highly desirable in earthquake design. But it still is not quite the case where we could use K=8, because these shear walls are not capable of taking all of the over-turning forces by themselves, so it is a K=1 building.

The weight of this superstructure is 13.4 psf. We have kind of a target goal. It says that if you have a steel building (it is such a loose formula it covers all high-rise steel buildings), a target for the designer is to divide the number of stories by three. You get a number which is lbs. per sq ft; then add six to that. For a 25-story building, you divide by three, to get 8.3 psf. Add six and you get 14.3 psf. In 13.4 psf for the Back Bay Hilton we beat our target. You can prove the formula yourself. Obviously, there are so many variables left out that it is rather crude. But it is a pretty good guide which we use all the time, particularly to extrapolate. If someone asks you what a 30-story building costs compared to a 25-story building, use the formula.

Sometimes people wonder how to design for lateral load. We designed this building for Boston code wind loads. In the middle of Back Bay, we went for the lightest wind load. With that, we used a drift limit of 1/450.

There are some peculiar conditions in this building. In some cases, when we brought the frame down to the ground, we needed to open up the framing at the bottom. To transfer the shear out of the frame in the bottom story, some diagonal bracing shows up in odd places. That allows some freedom in openings elsewhere in the wall.

With regard to the typical floor framing, the ceiling goes up after the fireproofing is on the floor beams, up tight so that the depth of the construction is about as thin as you can get it in steel. The total sandwich, including the slab, is 1 ft-6 in. All the floor beams, and the girders into which they frame on the inside of the building, are 12 in. Bar joists would have been deeper. Normally, in a hotel there is not much need to inter-penetrate beams with ductwork. The air usually goes vertically in chases, exhausts, etc. So, the ceiling up tight against the steel is pretty feasible. We really did not waste much story height here.

In summary, this building went up fast. They started putting up steel in June 1981. I was busy all summer, and later I said, "Where are they in the steel?" I was told, "Oh, they're topping out next week." So I missed the whole thing. That speaks for itself.

We're working on another project in Dallas, and the same story of time is the whole secret in building in steel. We studied two different designs in considerable detail. In terms of raw dollars, concrete came out cheaper on the 75-story building. But when you have interest costs for somewhere between four and seven months extra construction time—forget it. You go steel! □

Dewey Square Tower: Drama at Historic South Station

What do you do with a 1.23 acre historic wedge-shaped site in the heart of Boston's transportation hub? The answer: Dewey Square Tower, a 46-story office building with a dramatic atrium entrance and public facilities to enliven the streetscape near historic South Station. The complex was conceived as a significant link between the developing Fort Point Channel area and Boston's Financial District by New York-based developers, Rose Associates.

Architects and engineers were faced with two existing physical constraints: a ramp for the Central Artery and a Department of Public Works building remaining on the site. Conceived with six parallel sides, the tower encloses the DPW Building and adjoins the Central Artery. Although the plan configuration was arrived at early in the design, the building's maximum height remained undetermined until agreement was obtained from all public agencies. The tower's structural system was planned to be adaptable to a building from 30-to 50-stories high.

Dramatic Entry

Entry to Dewey Square Tower is through a unique, glass-enclosed atrium. For this 90-ft high space, designers selected a cost-effective steel truss system. The atrium roof frame is an unusual design for covering a column-free triangular area measuring 80 × 120 ft. Drywall-clad steel trusses are set at a 45° angle to form a coffered ceiling with a skylight above. Three columns near each corner support the triangular roof truss system and exposed steel members along the perimeter brace the glass walls. Joints at the intersection of the trusses' top and bottom chords are moment-connected with splice plates. All structural steel for roof trusses is clad with architectural finishes. The glazed window wall system is made of horizontal structural steel mullions at a spacing of 12 ft-6 in., supported on W27 vertical mullions that span 90 ft vertically, and braced by the atrium roof.

Dewey Square Tower graces heart of Boston's transportation hub. Model by Architects Jung/Brannen Associates and Pietro Belluschi, Inc.

Dewey Square Tower is the only structure in Boston clad with a precast concrete rain screen system. This system, developed in Canada, uses the pressure equalization principle to minimize water penetration. Each rain screen consists of an exterior and interior precast panel with air space and insulation board sandwiched between. Specially designed anchors secure one panel to the other. Thus, the exterior panel is free to expand and contract within a determined margin.

Alternate Systems Examined

After examining many alternate systems, the project designers concluded that a steel structure with a rigid frame around the perimeter was most economical and would resolve the requirements for integrating the structure with the curtain wall. Resistance to wind and seismic forces is provided by the framed tube which forms the tower perimeter. The tube is created by rigid connections between columns and beams. To economize on field work, particularly field welding, spandrel units consist of trees with columns and welded stub girders. Field connections of the girders at the center line between columns are bolted shear connections.

Column spacing is a unique feature of Dewey Square Tower. The building is designed on a 30-ft square structural grid to optimize interior floor layouts; perimeter columns are spaced 15 ft o.c. The center line of the structural steel is held back 2 ft-6 in. from the facade to permit uninterrupted expression of horizontal window bands, and greater window area in tenant spaces.

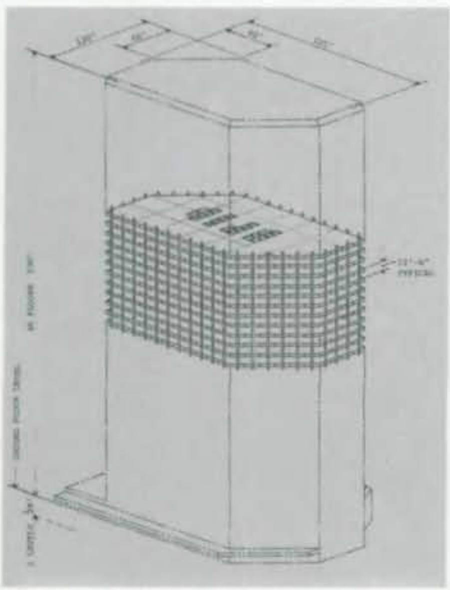
Since all of the structure's lateral stiffness is provided around the perimeter, all interior beam-to-beam connections are of the simple shear type. Spandrel girders on typical floors are generally 45 in. deep, varying from a minimum of 39 in. at the top of the building to 49 in. at the bottom. Columns are built-up members 30 in. deep along the building face, except where rolled sections are used above the 33rd floor. Perimeter columns are arranged to provide open corners. That is, the ladder section always ends with a beam stub at the corner. This scheme avoids the complication of three-dimensional corner columns with welded stubs going in two directions, as well as the biaxial bending problem of a corner column.

Designers selected a variety of steels to use throughout the structure: exterior columns and interior floor framing are of A36 steel. Girders and interior columns are A572 Grade 50, except built-up interior columns are Grade 42. High-strength steels were chosen where the design was governed by strength considerations. Where the design is primarily governed by deformation criteria, as for exterior columns, lower strength steels were used.

The tower has a structural depth of 120 ft, with a height-to-depth ratio of almost 5 to 1. This, coupled with its unusual shape, suggested the use of a wind-tunnel test to verify both the magnitude and the local variations of wind forces. Test results very closely matched the overall forces required under Massachusetts code. Local hot spots were found to exist particularly at the intersection between the tower and the atrium.

Useful Future Information

Analysis of the structure for lateral forces yielded information useful for future projects. It is well known that the effect of shear deformation becomes magnified with an increase in the depth-span ratio of the beam. Since, in a frame such as this, the depth-span ratio is on the order of 1 to 5, shear deformations contribute a large part of the total lateral deformation of the structure. Specifically, in this case, the



Steel-framed Dewey Square (l.) nears top out. Above, isometric shows perimeter steel framing.

Architects
Pietro Belluschi, Inc.
and
Jung/Brannen Associates, Inc.
Boston, Massachusetts

Structural Engineer
Weidlinger Associates
New York, New York, Cambridge, Massachusetts

Construction Manager
Morse Diesel Inc.
Boston, Massachusetts

Steel Fabricator
The Standard Structural Steel Company
Newington, Connecticut

Owner (a joint venture)
Metropolitan Life Insurance Co.
and
Rose Associates
Boston, Massachusetts

lateral deflection of drift of the building can be attributed in roughly equal parts to:

- Overall deformations of the frame (shear deflections)
- Column shortening (bending deflection)
- Shear deformation of beams and columns.

Since girder webs are relatively thin compared to column web thicknesses, the major portion of the shear deformation is attributable to the beam web.

The steel fabricators used both automatic and semi-automatic welding on the exterior columns, almost all of which are built-up from steel plates, as opposed to standard rolled sections. Wherever possible in the established program, the fabricator elected to substitute fillet welding for the connection between the spandrel girder flanges and the perimeter columns. This was chosen over the specified full-penetration weld.

Also, whenever the erection equipment would allow, the fabricator used two-story tiers for exterior columns. These consisted of the full 25-ft column, with two spandrel girder stubs on each side. The spandrel girders were then bolted together at mid span. This method kept field welding to a minimum and expedited erection as well.

In erecting the steel tower, three self-climbing tower cranes were used, in lieu of the more conventional two. This insured maximum erection speed and facilitated the erection of the precast panels, also part of the steel contractor's work. Dewey Square Tower is granite-clad on the lower two floors with precast, rain-screen panels from the third floor to the sloped glass crown of the 46th story. Continuous bands of tinted reflective glass alternate with bands of exposed granite aggregate set in white cement. Structural connections for the panels were developed with input from both the panel fabricator and the steel contractor. The typical panel is attached by two load-bearing connections and two lateral connections shop-welded to the perimeter columns.

The vertical load is transferred to the perimeter columns through a W10×30 outrigger, while the lower lateral load is taken by struts to the spandrel girder. The top flange of the outriggers is above the floor level. Thus, the floors are poured completely without providing pockets in the floor for precast connection. Floor construction consists of 2-in. composite deck with a 3¼-in. lightweight concrete topping. The tower starts on a concrete mat two stories below grade and rises 590 ft. The 6-to 8-ft thick mat rests on hardpan, providing an economical foundation. The area of the building surrounding the tower has columns resting on spread footings and incorporates an underdrain system below the sub-basement slab.

Tower fire protection includes full sprinkler system, fire alarm, stair pressurization and smoke-detector systems. The atrium has a complete fire suppression and independent smoke evacuation system. All structural steel members are protected with either concrete encasement, concrete block, drywall or spray fireproofing. Stair and elevator shafts are protected with drywall construction within the tower and encased in block on lower levels. Structural beams and perimeter steel are protected with mineral fiber spray fireproofing. The steel in the lower garage levels is treated with hard-coat spray fireproofing.

The overall economy of this project is clear from the fact that the average steel used is 21 lbs./sq ft. Following a fast-track design schedule, steel erection began in May 1982, with initial occupancy slated for the end of 1983. □

Burberrys Limited: A "Gem" Rises from the Ashes

When does it make sense to restore a badly fire-damaged building, rather than build a new one? When the client is Burberrys Limited of London, a company internationally famous for its quality rainwear and leisure clothing. And, when the building is a historic townhouse located in the heart of Boston, a city where quality and tradition are completely in keeping with the client's image.

Having planned to expand their operation to Boston, Burberrys undertook an investigation of existing commercial building stock in the city. They settled on a building at the corner of Arlington and Newbury Streets, in Boston's Back Bay. Originally designed by William Preston in the late 1800's, the building had been the focus of tragic attention as a result of a fire, which took the lives of two Boston firefighters in January 1981.

With its interior damaged, and even its outer walls structurally unstable, it posed an architectural and engineering challenge. The architect, working with the consulting engineer, devised an approach to rebuilding the structure based on the idea of a "building within a building."

Several challenges confronted the design team early on. The building is located on a filled area of Back Bay, so there was a need for a completely new dry foundation to support the new structure. To minimize the impact of noise in the neighborhood and risk to the frail building, it was decided to drill rather than drive foundation piles. Forty-six Fondedile piles, each of 50-ton capacity, were drilled to a depth of 80 ft. The client, anxious to establish a presence in Boston, set a short schedule for occupancy and called for fast-track construction.

Structural steel was the ideal material to accommodate this accelerated construction schedule. A steel erection methodology was employed to ease phasing of construction in a limited erection area. The existing wooden structure left standing after the fire was literally holding the building together. Due to its flexibility in staging and assembly, the structural steel frame could be erected in three stages to function as bracing for the existing walls as the interior was completely gutted.

During early stages of construction, it was discovered that one of the outer walls was buckling, and it required tying back to the steel. A system of ties, set with epoxy into the old masonry wall, bolted to steel bracing angles and fastened back to the structural frame, was ideal to resolve this problem.

To meet the client's program needs, and gain additional square footage in the building, the architects made effective use of the basement space, added a full sixth floor to the building by creating a double-height mansard roof and added a bay to the Newbury Street side. This plan, adopted with the approval of the Back Bay Architectural Commission, is in keeping with the historic quality of the Back Bay Historic District.

Fast-tracking the design and construction was inevitable, given the October 1982 opening deadline. Bruner/Cott & Associates, Inc. worked closely with the general contractors to organize the complicated scheduling of construction, ordering of long-lead items, and the search for and selection of appropriate materials to be used to resurface the building exterior.

The badly damaged brownstone on the building was patched and restored with a pigmented cement. Where total replacement was necessary, latex molds were taken of the existing window surrounds. Plaster casts were then poured and sculpted by Rudco's artists. Finally, precast concrete replacements were made to replace the severely damaged brownstone. In addition, enough salvaged brick was saved from the crumbling, fire-damaged walls to face the portion of the new bay at the rear of the building facing onto Newbury Street.

The engineer's staging schedule for erection was well orchestrated by the general contractor. At one point, foundations were being drilled, structural steel was being erected, steel decking being installed, tying back the exterior masonry wall was underway and the new roof was being framed out—simultaneously.

The end result, which was finished on schedule, provides Burberrys with an elegant showcase to display their quality merchandise. Uncompromising attention to detail resulted in a building renovation that has been widely acclaimed as a gem. □

Burberrys Limited rose from ruins (l.). View above shows ravages of fire.

Architect
Bruner/Cott & Associates, Inc.
Cambridge, Massachusetts

Structural Engineer
Wayne L. Weaver & Associates
Boston, Massachusetts

General Contractor
Barkan Construction Company
Chestnut Hill, Massachusetts

Steel Fabricator
A. O. Wilson Structural Co., Inc.
Cambridge, Massachusetts

Owner
Burberrys Limited
Boston, Massachusetts

Copley Place: Complex is the Word for It!

by Michael J.A.H. Jolliffe

In the heart of Boston's Back Bay business district, Copley Place represents a $460-million development. The site for this largest mixed-use development in Boston's history was originally cleared during the construction of the Massachusetts Turnpike Extension into Boston—and subsequently occupied by the Turnpike interchange, two railroad lines and the city street network.

Many attempts were made over a 15-year period to develop plans for the air-rights use of the area, one which would produce a financially feasible project. The final plan for Copley Place was developed by the master planners for the project—The Architects Collaborative (TAC) and Zaldastani Associates, Inc. Both were also responsible for the design of the Central Area, which differed from previous plans in that it proposed relocation of portions of the Turnpike ramps and the city street network. The plan produced sites of sufficient area for two major hotels, which were not penalized by air-rights considerations, and concentrated the air-rights portion of the construction into the Central Area. This approach reduced the overall cost premium for the work.

The Central Area construction comprises over 1,600,000 sq ft of floor area, including 845,000 sq ft of offices, 386,000 sq ft of retail, restaurant and theater, parking for over 600 cars, a central mechanical facility and a service area. The complex is built above part of the eastbound lane and a major exit ramp of the Turnpike and a railroad line.

Extremely Complex Constraints

The project was complicated by the severe physical constraints of building above a number of tunnel-like easements of complex three-dimensional geometry on filled land. In addition, it was further restrained by the massing and siting of components required by the Boston Redevelopment Authority and the Community Review Committee.

The structural design had to consider a large number of unusual and demanding constraints: the need for a deep pile foundation; occupancy of the site by the Turnpike and its ramps, the railroad and the trucking portions of the service area; the need to transfer seismic and wind loads to the ground; and the differential thermal effects of a structure maintained at internal temperature on the upper levels but exposed to external temperature at the Turnpike, parking and service levels below. The undertaking was extremely complex, both structurally and geometrically.

These constraints, along with the need to erect rapidly the structure, both to provide early completion and to minimize interruption of normal Turnpike circulation, led to the selection of a structural steel frame for the major portion of the building. Advantages of this selection were numerous: the light weight of the floors limited loads which had to be transferred above the transportation corridors, requiring fewer piles; the ability to provide transfer systems which carried dramatically different levels of loadings at spans varying from 23 ft to 102 ft; the ability to erect the main floor of the mall 50 ft above the foundation prior to erection of the flat-slab garage below; and the ability to provide a method of resisting lateral loads which interfered least with the facility's function.

Upper portions of the central area structure are relatively conventional. The office floors, with an area of over 100,000 sq ft per floor, are framed on 30-ft sq bays.

Half-billion "clams" are going into construction of complex One Copley Place—a literal maze of buildings, ramps and underpasses. Steel framing played vital role in solving complicated constraints.

Michael Jolliffe is vice president and principal-in-charge for Zaldastani Associates, Consulting Engineers, Boston, Massachusetts.

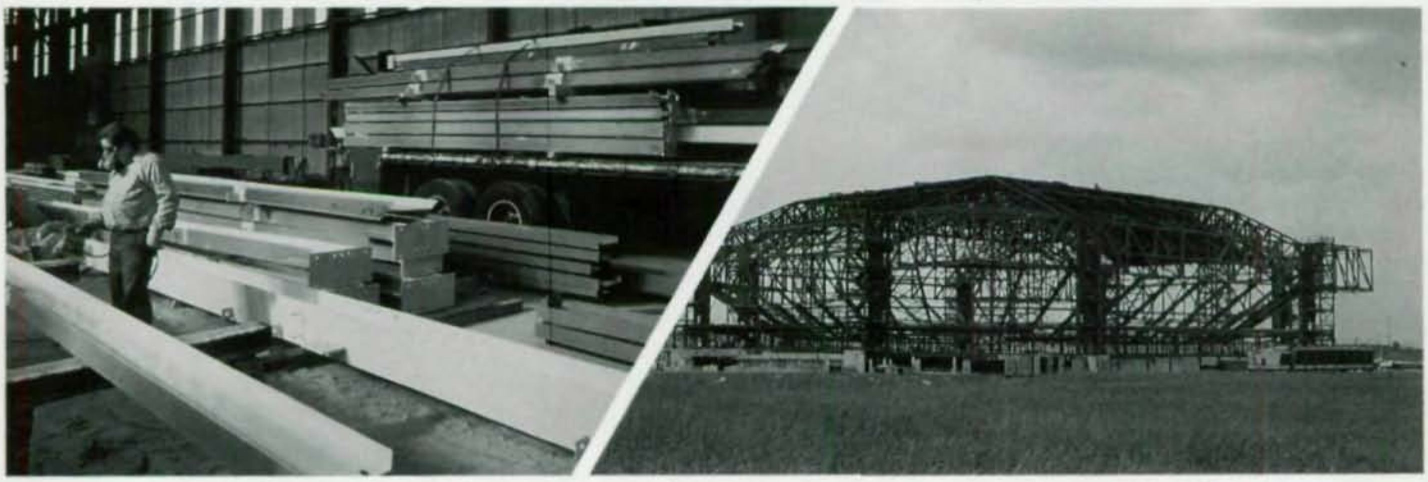
These floors will be exposed to the cityscape at the outside perimeter and to a high, interior atrium. Lateral loads are resisted by a perimeter moment resisting frame, with columns at 15 ft o.c., which extends around the entire building. The 510-ft long building is divided into two sections by an expansion joint capable of accommodating over seven inches of movement from seismic loading at the upper levels.

Floor-to-floor height of office floors is 12'-6". At the retail mall floors below, that height increases up to 20'. For economical reasons, and the severe restraint on locations at which lateral load resisting elements may be introduced, lateral loads below the office level are resisted by braced frames or shear walls.

Greatest Constraint at Lower Levels

At the lower retail mall floor, and below, the greatest structural constraints occur. This level represents the lowest level at which a complete floor can be established over the entire site. At this level, the majority of the floor is subject to external temperature which habitually may reach −10° F, while the structure above is maintained at 60–70° F. Below this level, the tubular easements of the Turnpike ramps and their associated site lines, the railroad and the large clear spans for truck circulation at the service area occur. The geometry, complex not only in the horizontal plane but also in the vertical plane, limits the depth of potential transfer systems above the transportation rights of way.

Aerial view of Copley Place portrays complexities of site and underground easements.



Cross section (l.) shows numerous levels to be accommodated. Huge girders (r. and below) transfer loads over ramps.

The effects of temperature required introduction of an added expansion joint at the lowest mall floor and below. To eliminate the need for an expansion joint above, the lateral loads from the upper floors of the structure on one side of that expansion joint are transferred through a horizontal truss on the upper mall floor to a braced frame on the other side of that expansion joint. The structural system between the upper and lower mall floors is designed with sufficient flexibility so that unacceptable stresses are not introduced. The "released" structure below is independently braced to the foundation level.

Below the office towers, 66 of the column loads had to be transferred above the transportation corridors. Elsewhere, 32 of the column loads had to be transferred, despite extreme care in arranging the building grid to minimize interference. Sixty four plate girders were used to transfer 86 columns. The rest were transferrred by trusses, which usually were also part of the bracing system. Plate girders varied from 23 ft to 102 ft long and weighed up to 120 tons. Approximately 2,000 tons of ASTM A572 and A588 steel were used to fabricate these girders, none of which were identical in design. Most girders were restricted in depth by the vertical clearance required from the roadway ramps or future railroad or truck dock, so that girders varied in depth from 3 ft-10 ft.

Two Types of Connections Selected

A major issue related to the design of plate girders was selection of a method of connection of plate girders to supporting columns, and connection of columns being transferred at girders. Because of the magnitude of end reaction (up to 2,000^k), and because of the deflection and rotation of the girders which occurred as each floor was added, framing angle connections could not be used in most cases.

After a thorough examination, two types of connections were selected by the designers. Where plate girders are supported on long, slender columns, the girder is bolted to a column cap plate, creating a moment connection. Moments up to 2,100 ft kips are developed in the connections. Where plate girders are resting on shear walls or very short and stiff column stubs, a spherical bearing was selected.

Spherical bearings were also used below columns supported on plate girders in locations where plate girder rotation would result in a very large moment in the column and large additional unbalanced horizontal forces, which would have to have been resisted by the building's bracing system. The spherical bearing consists of two parts; the lower part is a convex plate with polished stainless steel spherical surface and a concave plate on top with woven Teflon. But, where horizontal movement was required, an additional sole plate with a sliding surface is added. The bearings are small in size, the largest, of 3,600^k capacity, is 25" × 25" and fit on columns as cap plates. They provide minimum eccentricity and easy erection. A total of 101 bearings were used, with capacity varying from 500^K to 3,600^K.

The site is located on land filled in the latter part of the 19th century. The nature of subsoil required installation of deep piles to reach bedrock. Where density of the piles and the proximity to existing bridge piers required, piles were preaugered to reduce disturbance to the underlying clay stratum prior to the installation of 14- and 16-in. prestressed piles. □

Architect/Office and Retail
The Architects Collaborative, Inc. (TAC)
Cambridge, Massachusetts

Principal Designers/Garage, Service and Turnpike Levels
Zaldastani Associates, Inc.
Boston, Massachusetts

Structural Engineer
Zaldastani Associates, Inc.

Civil Engineer
Parsons, Brinckerhoff, Quade & Douglas, Inc.
Boston, Massachusetts

Steel Fabricator
Owen Steel Company, Inc.
Columbia, South Carolina

Owner
Urban Investment and Development Co.
Boston, Massachusetts

The Transportation Building: Designed for a Perfect "Fit"

by Spiros G. Pantazi

A recent editorial in the *Boston Sunday Globe*, referring to the many buildings under construction in the Boston area, stated: "Hard hats are at work all over Boston, altering the skyline, changing the streetscape. They are knocking down old buildings and putting up new ones. . . . Some of it, like the new Transportation Building in Park Square . . . fits the city."

It is gratifying that this unique government building should already receive such favorable reviews, even before completion.

Since 1974, when the first feasibility studies were commissioned by the Commonwealth of Massachusetts concerning the scattered locations and poor working conditions of many transportation agencies (with the possibility of bringing them together under one roof), Boston Architects Goody, Clancy & Associates, Inc. (GC&A) committed their resources not only to architectural design, but also to an awareness of the effect such a building would have on the surrounding neighborhood. From the 20 sites investigated and evaluated by the architect, the Commonwealth selected a site for the new Transportation Building which would revitalize an important downtown area and stimulate public and private development and construction. The site, in the Park Plaza Urban Renewal Area, is near the historic Boston Common and Public Garden, and in the heart of Boston's famed theater district, itself in need of revitalization.

Spiros G. Pantazi, AIA, is the Transportation Building project architect for Goody, Clancy & Associates, Inc., Boston, Massachusetts.

Close Community Cooperation

The building was planned in close cooperation with the surrounding community—business, cultural and neighborhood groups—through their participation in a Civic Advisory Committee.

The Commonwealth passed special legislation to allow commercial uses on the street level so that rather than the somber "9-to-5" facade usually associated with government buildings, a retail arcade with shops and restaurants would enliven the area day and night.

The Boston Redevelopment Authority, the Civic Advisory Committee and community groups assisted in the preparation of the final Environmental Impact Report, a document which imposed a number of limitations on the building's design. Height maximums were established to prevent the new construction from overwhelming the scale of the historic buildings in the immediate area. The irregular site was shaped to preserve many older structures.

Steel Plays Role in Design Decisions

An early decision was made to design the structure around a steel frame. Precast and prestressed concrete frames for the building were considered by the architect and structural engineer, but were deemed inappropriate for a number of reasons: earthquake design requirements are such that needed special joints would be difficult and costly to construct; there would be limited competition for public bidding; site restrictions would make field erection difficult; future modifications would be difficult; and, finally, there appeared to be no particular advantage in cost or construction time.

Giant Transportation Building (l.) "fits" surroundings in historic theater district. Bird's-eye view and site plan (below) show how massive steel-framed building was designed to match area needs.

Of the remaining two systems considered, a steel frame was deemed to be superior to concrete in earthquake-resistant detailing and control of construction. It offered a considerable cost advantage and, with an early award of the structural steel subcontract, also provided substantial savings in time.

The architect wanted an "open, airy" building. This was achieved by utilizing triangular pipe-framed trusses to span a multi-story atrium. The atrium marks the *intersection of a pedestrian way (once a* dead-end theater street) and a diagonal path to nearby hotels. This space, overlooked by the transportation agencies' offices and common facilities, creates a meeting place for workers, shoppers and theater-goers.

Basic Steel Frame

The basic structural system is a two-way ductile moment frame chosen for its redundancy and economy in irregular layouts.

Schemes involving bracing were ruled out because of architectural requirements for open planning. Moment connections and column splices in the design which evolved are field welded. Standard connections are bolted with tension control bolts for "automatic" torquing.

Floor framing is typically uncambered partial-composite A36 steel, which meets stringent floor vibration criteria. Supporting girders are raised 3 in. into the slab to permit increased space for mechanical ductwork. The slab is a blended 3-in. electrified cellular steel deck with 2-½ in. topping.

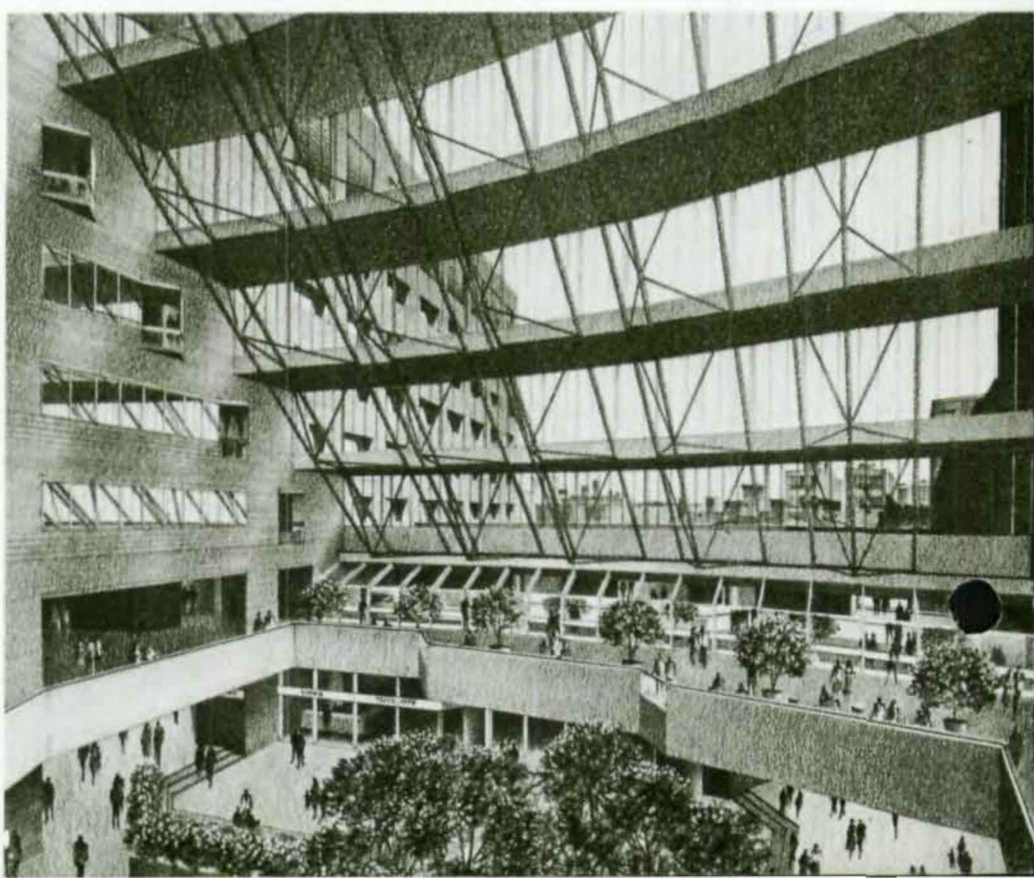
Due to its 700-ft length, the 880,000-sq ft building is divided by expansion joints into four structurally independent buildings. The need for double columns at these expansion joints was eliminated by slide bearings mounted on column brackets. These bearings allow movement perpendicular to the joint, but restrain movement parallel to the joint. Restraint parallel to the joint is required to keep the build*ings in tune with each other and to prevent* damage to the brick cladding.

Erection Handled From Curbside

Structural steel (5,800 tons of it) was shipped from the fabricator to a Boston area marshalling yard, and from there the job was supplied on an as-needed basis.

The bulk of the steel erection was handled from curbside by truck-mounted cranes, including one rigged with a 310-ft boom. Even with that boarding house reach, a Kodiak climber was needed to rig the atrium trusses, to handle the center section of the sprawling building. The five 13-ton, 126-ft long trusses were hoisted from streetside and swung over the roof of the eighth floor by the Kodiak in their final inclined posture—one end positioned to bear at the third floor level and the upper tips at the ninth floor.

The width of each truss tapers to fit the radial geometry of the atrium, but the layout enabled all five trusses to be geometrically identical, which simplified fabrication. Building movement between the



3rd and 9th floors is accommodated by attaching the trusses at the 3rd floor, but allowing the other three sides to float freely on slide bearings. All wind shear is thus delivered to the 3rd-floor supports.

Light Metal Framing to New Level

Over the years, the steel and construction industries have combined their expertise in developing structural light metal framing (LMF) techniques and applications. These were refined and brought to a new level in the Transportation Building.

Most, if not all, earlier LMF applications, with which designers were familiar, used 18-, 16-, or 14-ga. C-section steel studs as infill framing between floors at a building's edge. Using LMF, the weight imposed on building edges is reduced drastically when compared to the weight of the usual concrete block backup wall. The LMF system lends itself admirably to panelized shop prefabrication for additional cost savings. In this instance, the LMF provides not only backup but also actually supports the brick masonry skin.

In the Transportation Building, the principal plane of LMF framing is placed outboard of, but still anchored to, the slab edges. Secondary LMF members are used to frame the rather deep recesses desired for solar control and architectural articulation at windows. All LMF connections are welded.

Design of the LMF panels is akin to the Vierendeel truss in which there is no diagonal bracing. Notable in the design is the absence of "kicker" braces, leaving the ceiling space uncluttered. As noted previously, the system is designed to enable shop fabrication of C-shaped panels with rigid connections at points "A" (see Fig. 1). Field-applied studs at B were not required to furnish moment capacity.

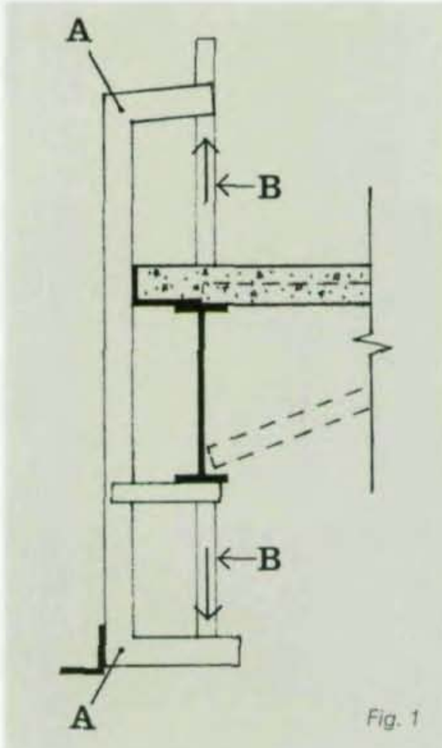
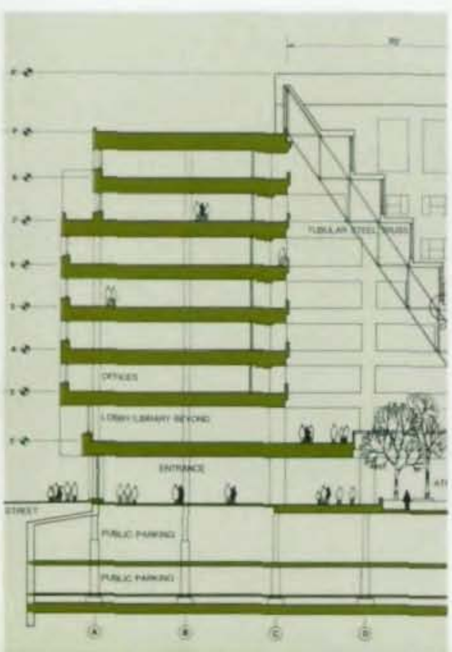
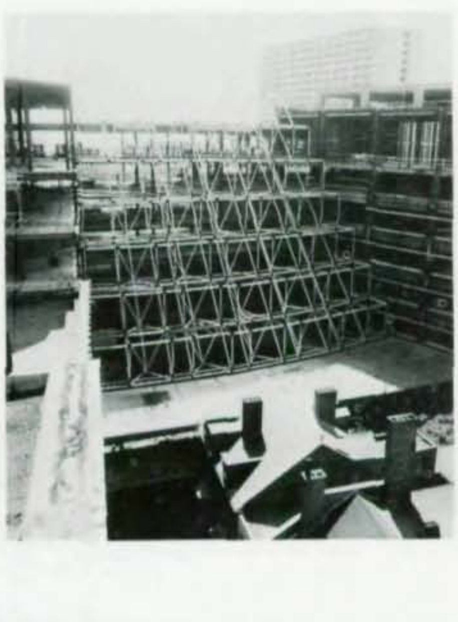


Fig. 1

For the most part, fireproofing of structural steel is accomplished with sprayed-on, non-asbestos mineral fiber/cementitious material. Steel is not primed, but has been permitted to oxidize to a "sugar" coating to achieve a good bond with fireproofing. In the garage areas, steel columns vulnerable to auto traffic are encased. In the water tank construction required as part of the unique energy system, columns are both bitumen-coated and concrete-encased.

Soaring atrium lends airy feeling to meeting place for shoppers, employees and theater-goers. Plan and open steel framework below show intricate design.





Energy Conservation Sets Standards

One of the mandated goals for the project was to set standards for energy conservation. A heating system was designed which requires no purchase of outside heat or steam. It is based on recovery and storage of ambient and process heat—the former derived from the 2,000 occupants and 15,000 lighting fixtures, the latter drawn primarily from three-heat recovery chillers. The heart of the heat recovery system is a 750,000-gallon water storage tank consisting of three two-story 250,000-gallon cells. During the peak heating season, all three cells will provide heat when the building is unoccupied. Proportionately, they will unload to chilled water storage to provide cooling during the peak season.

A 4,000-sq ft array of solar collectors generates 85% of the building's annual domestic hot water requirements.

By the close of 1983, Boston's residents, downtown shoppers, theater goers and tourists will have discovered and welcomed the remarkable renaissance of the theater district brought about by this major new construction.

The value of this effort is evidenced by the present spurt of major new construction and rehabilitation in the area inspired by this first bold step—a building that "fits the city." □

Architect
Goody, Clancy & Associates, Inc.
Boston, Massachusetts

Structural Engineer
LeMessurier Associates/SCI
Cambridge, Massachusetts

General Contractor
Volpe, Dimeo, O'Connell & Gutierrez (joint venture)
Malden, Massachusetts

Geotechnical Consultant
Haley & Aldrich, Inc.
Cambridge, Massachusetts

Construction Consultant
Falk Associates
Boston, Massachusetts

Steel Fabricator
Bristol Steel & Iron Works, Inc.
Richmond, Virginia

Steel Erector
Daniel Marr & Son Co.
Boston, Massachusetts

Owner
Commonwealth of Massachusetts

Bostonian Hotel: Posh Amongst the Pushcarts

by Pat Kolber

The problem was how to build a modern luxury 155-room European-style hotel on a small site—and preserve the historical integrity of the site. Creative planning, design and development combined to solve the problem in a unique way.

The $18-million Bostonian Hotel occupies the Blackstone Block, the heart of 17th-century Boston's commercial center. Historic red-brick buildings adjacent to the hotel, neighboring Faneuil Hall Marketplace and the presence of Haymarket's colorful pushcart vendors preserve the colonial flavor which pervades the historic locale. The unique efforts of the developer, the architect and members of Boston's Landmarks Commission and the Massachusetts Historical Commission culminated in a fine blend of old and new. The architect incorporated the historic buildings into the predominantly modern structure. The developer contributed $5,000 to an archeological dig that produced rare artifacts now on display in the hotel lobby. The winding alleys and tiny courtyards of Blackstone Block remain intact, as does the ambiance of the entire area.

Central atrium is highlight design feature of new luxury Bostonian Hotel.

The structure of the new atrium-style Bostonian Hotel combines the traditional with the modern in a brick facade with glass and steel beams. The brick, with its granite ground floor, matches the materials of the old buildings that surround the hotel. The seven-story structure reduces to four where the hotel approaches these old buildings. A glass-enclosed granite bridge spans a narrow brick alley to join 40 rooms housed in the intact 19th-century Harkness Building. Small balconies and bright awnings at each hotel window relieve the larger scale of the building and match the festivity of Faneuil Hall Marketplace. This modern 20th-century hotel captures and reflects the city's heritage and expresses the commitment of developer and architect to Boston's historical integrity.

20th-Century Construction—with Steel

The construction of the Bostonian, however, reflects 20th-century considerations of time, cost and flexibility.

"A steel frame was selected to supply flexibility and clear spans required by the architectural design," said David Berg, structural engineer of the project, "keeping in mind economy of materials and time of construction." The relatively small size of the site and its very unstable subsoil were also factored into the decision to use steel.

Ease of adaptability was another major consideration. "The constricted site was a factor in our decision to use steel," said Berg, "plus adaptations for future expan-

Pat Kolber is account executive with Averil Lashley Company, Boston, Massachusetts.

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Unique $18-million Bostonian Hotel (l.) occupies heart of historic commercial district, fine blend of old and new. Top photo defines original structure of new steel-framed hotel.

sion were built in half-way through the project. We decided to use a steel skeleton because of ease of adaptability."

Story-height trusses create the central atrium, the important design feature of the Bostonian structure. One truss supports the seven-story wing; two others support the glass-enclosed Seasons Restaurant housed atop the four-story section of the building.

The steel frame used Grade A36 steel for the majority of the beams in the structure and steel conforming to ASTM Grade A572 for the story-height trusses that create the atrium, as well as for columns. To reduce depth at construction, yet maintain sound attenuation and reduce vibration in the floors, a composite steel joist and concrete slab system was used for floor framing. Gravity and lateral forces are carried by intersecting steel frames—in the longitudinal direction of the wings are rigid frames, in the transverse direction three hinged arches.

Moment connections in the rigid frames and hinged arches were typically made with end-plate connections shop-welded to the beams and bolted to the columns with high strength bolts. Shear connections were normally one sided "slap plate."

The Bostonian is protected by a highly sophisticated fire alarm system, with smoke detectors and three separate sprinkler heads in each room. In addition, the hotel's highest point (70 ft) is well within the range of fire-fighting equipment.

The cost-efficient "energy management system" is a part of the hotel's heat/pump system. As guests enter their rooms, the system monitors body temperature and turns on or off to consistently maintain comfort and conserve energy.

The Bostonian Hotel is a unique example of innovative planning and design reflecting the dedication of developer and architect to construct a building in concert with the needs of a historic city. □

Architect
Mintz Associates Architects/Planners
Boston, Massachusetts

Structural Engineer
David M. Berg, Inc.
Needham, Massachusetts

General Contractor
Perini Corporation
Framingham, Massachusetts

Steel Fabricator
General Iron & Steel Works, Inc.
Lawrence, Massachusetts

Owner/Developer
Winn Development Company
Boston, Massachusetts

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155 Federal Street: Molding Today to Yesterday

by Jonathan Buhl

From the beginning, and all through the design period, the 155 Federal Street project required a tremendous amount of communication and coordination between owner, architect and consultants. There had to be a lot of give and take on everyone's part to get this building designed and in the ground.

On a number of occasions, the architect and owner met with the Boston Redevelopment Authority to develop a building which is harmonious with the existing ones in the immediate South Station area. The Authority wanted the new 155 Federal Street Building to be compatible with the adjacent 10 High Street Building. The new office building was to connect with the existing building at 10 High Street. Thus, the sill and window head condition of the new 155 Federal Street was to line up with 10 High Street. This was achieved. In addition, the arcade design apparent on the existing High Street Building is repeated, thus the 28 ft-high column at street level. Also, the rhythm of the facade of the new office building is similar to 10 High Street.

Design Constraints

The 155 Federal Street Building is 18 stories, with an overall height of 210 ft above grade. The aspect ratio, or height-to-width ratio, averages slightly over 2:1. The building site includes about 10,000 sq ft of building area, with the western limit abutting on an existing 11-story building (10 High Street).

The first design constraint faced was that virtually 100% of the building site had to be included as rentable space in the tower floor plan. This meant that the service core—which contained elevators, stairways and toilet rooms—had to be located elsewhere.

Secondly, since the final occupants of the building were unknown at the time of design, the facade and floor plan had to have a maximum degree of flexibility. The building had to be structured to cause minimal interference from columns and a lateral support system.

A third major design constraint required floor levels at the new tower to match those of 10 High Street. This resulted in a typical floor-to-floor height of only 10 ft-9 in. for the first 11 floors. Further complicating matters, architectural requirements required 7-ft high punched window openings at the tower perimeter. The head and sill elevations matched those at 10 High Street. The owner's requirement for an 8 ft-6 in. ceiling left only a 2 ft-3 in. sandwich to accommodate the structure, HVAC ducts, sprinklers, fireproofing, lighting fixtures and the ceiling grid.

Jonathan Buhl is a principal in the structural engineering firm of Souza and True, Inc., Cambridge, Massachusetts.

The 18-story 155 Federal Street Building had to "match" existing 10 High Street in historic area. Unusual steel framing details did job while tenants remained in building.

Alternate Schemes Considered

When the design team first looked at the 10 ft-9 in. floor-to-floor height requirement and the complex building geometry, a concrete flat-plate structure looked like a very clean structural solution. But when they took a closer look at this and other concrete systems, some problems became evident from a design standpoint.

The two-way flat plate solution does provide a relatively shallow floor structure. But here the system broke down somewhat, due to varying span conditions and a lack of continuity. The dead load of a concrete structure would have been over double that of a steel structure, which would have had two major impacts on design:

First, the seismic requirements for a concrete structure would be far greater than for a steel structure. Since shear walls and bracing could not be tolerated in the floor plan or facade, moment frames would be required for either steel or concrete systems. In the concrete structure, the resulting beams would have created an unacceptable depth of structure. Secondly, the heavier concrete structure would have required an expensive mat foundation, as opposed to the spread footings which were adequate for the structural steel. Other factors, more construction related, made reinforced concrete a less attractive solution. Among these were the complexities involved in the service core construction, the extremely tight building site and schedule considerations, which are always critical.

The team also studied a number of structural steel schemes initially. Among these were bar joists with steel beams, the stub girder system, precast plank on steel beams and non-composite steel beams with steel deck. These systems were all eliminated due to inability to accommodate mechanical requirements, or because of excessive structural depth. However, through a collective effort, they arrived at a structural solution which reasonably satisfied everyone's design requirements. Structural steel was the answer to all the problems.

Unusual Framing Details

The basic floor structure is a 3¼-in. lightweight concrete slab on a 1½-in. composite steel deck. All floor beams and girders are 16-in. deep composite steel wide-flange members, resulting in a total structural depth of 21 in. The typical girder span is 23 ft-9 in., while beams generally span 28 ft-6 in. or more. The existing floor-to-floor height, to be matched in the new construction, was only 10 ft-9 in. The owner wanted 8 ft-6 in. for rental purposes. Another 21 in. for the structure left a 6-in. space in which everyone else had to work. What ultimately happened was that almost every beam was penetrated for HVAC ducts and sprinkler piping. The 6-in. space was adequately taken care of by conduit, fireproofing, lighting fixtures and ceiling grid. At the upper floors, above 10 High Street, the floor-to-floor height was increased to 11 ft-4 in. to give everyone seven more inches of breathing room.

To provide complete flexibility within the tower floor area, moment frames were located around the building perimeter to resist lateral loads. The plan view of the moment frames was generated by computer. The frames are discontinuous at the north and south extremes of the Federal Street side, since the architectural feature is rounded corners in these locations. Also, at the west frame, a gap was provided to allow passage of mechanical services from the mechanical room in the core to each floor.

As mentioned before, one of the initial design constraints was for the rentable tower area to envelop virtually 100% of the building. This constraint was satisfied by constructing the core completely within the limits of the existing building. A 60-ft × 35-ft by 11 story high section of 10 High Street was demolished to accommodate the new core construction. The original building remained occupied just beyond the limits of this work, all through demolition and construction phases. Fortunately, an existing 30-ft square light well from the third floor to the roof helped to reduce the amount of demolition necessary.

A larger scale typical structural plan of the service core area will show that the floor structure is essentially the same as in the tower, but columns are generally located closer together, on an irregular grid. Bracing bents at the north and south core walls resist east-west lateral loads. Also at these lines, support has been provided for the remaining sections of the 10 High Street floor slabs at levels one to 12. Above that, there is all new construction.

The core is structurally separated from the tower by a movement joint that is 2 in. wide at lower levels, increasing to 4 in. at the 12th floor and above.

Below the tower perimeter moment frames, a continuous spread footing was provided to minimize differential settlements. A full basement level was provided, which matches the elevation of the 10 High Street basement. A cantilevered soldier pile and wood lagging system, which braced the excavation, was located directly on the property line. In fact, the lagging was used as the outside foundation wall form.

Complex Service Core Geometry

Demolition began with removal of exterior walls. All walls and concrete floor slabs were removed to a point about 15 ft away from each edge of the light well. The owner had previously provided temporary closure walls in anticipating this work. Since the existing floor slab was not cut off at a column line, the remaining section had to be supported by the new structure. The first step was to bring in 10-in. deep steel header beams and place them on the floors. These headers were then hoisted up and attached to the underside of the existing slab.

Once all the header beams were in place, they were shored with 8-in. × 14-in. timbers, from the roof to the second floor. At the second floor, a 24-in. deep girder transferred all loads to four 8-in. steel columns. These columns were in turn supported by heavy 14-in. deep girders which sat slightly up off the first floor, and transferred the loads to the existing columns. When the shoring system was completely in place, all of the demolition could then be completed, with the exception of the first floor. By transferring all the loads at the first floor, the contractor kept the area free directly below, so new foundation work could begin.

After the foundation work along the shoring lines was completed, three columns on each line were delivered to the site to be erected. Each column was lowered through a hole cut in the first floor and bolted into place on a new foundation pier. After they were installed, the first tier frame was completed. The 24-in. deep header at the second floor was connected to the frame, and cut loose from the four steel columns. The first floor structure was then removed, and work started on the balance of the foundations.

The steel was erected up to the roof level, and then, starting at the roof level, the 10-in. headers were picked up by the new framing and shoring removed, one floor at a time. At each of three columns on the north and south core walls, the headers were supported by a 12-in. stub beam off the column. The header was rigidly connected to the existing slab rib, but was free to slide horizontally on a Teflon bearing below. A 2-in. separation accommodates the expected differential lateral movements between the new 18-story core and 10 High Street.

Handsome lobby/arcade ties old and new together architecturally.

Most Difficult Analysis

The moment frames in the tower, provided to resist wind and earthquake lateral loading, represented a significant portion of the structural design work. They represent probably one of the most difficult analysis problems in the structure. Earthquake loading generally governed the design at the upper stories of the tower. Wind forces became critical at the lower levels, and were based on a Type A exposure. The design of the moment frame was based on stiffness considerations, with the lateral drift being limited to *L*/600. Due to time constraints, a very rigorous hand analysis on the moment frames was done, and drawings issued on the basis of these calculations. A simultaneous computer analysis was performed to check and refine the design as necessary. There were over 1,000 members and 600 joints in the frames, and the computer analysis combined all elements, using a three-dimensional approach.

The computer generated an isometric view of the moment frames. In a gap in the west frame, mechanical services pass from core to tower. This frame begins at the basement level and has beams at every floor level above. Frames on the other three sides start at the first floor, and have no beams until the third floor. For architectural reasons, the second floor perimeter was pulled back and hung from the third floor, resulting in a 26-ft unbraced length for the lower moment frame columns.

Elevations perhaps would show these things a little more clearly. Plenty of beams and columns for stiffness are at the upper levels. After the third floor, one half of the columns are lost, and the second floor is nowhere in sight. The preliminary design had only these main columns, which extend to the base, in the frames. When there were strip windows, the spandrel moment frame beams could be relatively deep. When a requirement for 7-ft high punched window openings was added, a new member had to pick up the limestone between the openings. Also, the spandrel beams were restricted to 18 in. deep. Instead of simply providing false columns between windows, the designer had to make these so-called intermediate columns an integral part of the moment frames, to satisfy stiffness requirements. Even with the added rigidity provided, all of the spandrel beams at the first 11 floors had to be 21 in. deep, and raised up into the floor slab.

Original site condition (top) exposes area of 30-ft sq. light well which became service core. Bird's eye view (bott. photo) midway through steel erection shows moment frame trees to 12th floor, core framing in background.

The same conditions hold at the south elevation. Main columns are typically spaced at 17 ft-4 in. o.c., with one intermediate column midway in between. Things really get rough for the moment frame on the Federal Street side. Because of the main entrance in the center, there is a double-bay condition, with a 34 ft-8 in. column spacing. The first beam at this section of the moment frame is at the fourth floor. The western frames, adjacent to the service core, needed no intermediate columns since there was no limestone to support, and main columns had a smaller average spacing of about 14½ ft.

The computer modeled each floor diaphragm with a grid of finite elements, and combined these with the elevations into one easy-to-understand picture. Both the main and intermediate columns were fabricated in three-story high tree sections, to cut down the number of pieces and field connections. Beam stubs were groove-welded to the main columns at each floor level. At intermediate columns, the beam section was continuous through the joint, with column sections fillet-welded above and below. Flange and web stiffener plates were provided only where required by calculation. In fact, many flange stiffeners at the main columns were eliminated because of the heavy column sections required.

The upper halves of a main tree column and an intermediate column were spliced in the field. Typically, when a tree column approach is used on a building, the main columns are spaced closer together, and the spandrel beam spliced at midspan. In this case, because there are intermediate columns, the spandrel beam is spliced at the quarter-point of the span, in a region of higher stress. As a result, the connections are somewhat heavier than usually expected. If the intermediate columns had not been a part of the moment frame, the tree approach would have been more difficult, and perhaps abandoned. Using tree columns made it possible for the welding to be done in the shop, and for field connections to be bolted. Most all connections on the job, including the tree splices, used snap-off ⅞-in. tension-control bolts.

The most massive connection in the building occurs at a W36×260 beam on the third floor. Here, one of two portal frames supports the entire Federal Street side of the building at the third floor. The 36-in. deep beam spans to columns which weigh 730 psf, the heaviest rolled sections available. The third floor is the only level where spandrel beam depth could exceed 18 in.

There is a very good reason for all the heavy beams and columns in the moment frames at the first to third floors. It has a lot to do with the fact that the second floor has been pulled back, creating a 26-ft high unbraced length condition for the columns. The same drift index at these high bays that are present at the upper levels had to be maintained. The engineer did not want a very stiff structure from the 18th floor all the way down, and then have a flexible, so-called "soft story" at the third floor. This was difficult to overcome, particularly at the main entrance on the Federal Street side.

A typical base detail at a moment frame column called for a 4½-in. thick base plate with 20 1¼-in. dia. anchor bolts. The detail provided a degree of moment fixity for the columns, and resisted uplift forces in some cases.

Floor-to-Floor Height Considerations

The building geometry and the 10 ft-9 in. floor-to-floor height had great impact on the structure. A good place to start is at the recessed, hung second-floor perimeter. The 6-in. wide by 1½-in. thick plate hangers extend to the third floor. They are aligned with, and concealed by the window mullions in the finished building. This would have been more difficult to do in concrete. Some redundancy was designed into each element of the hanging system, to provide an additional safety factor.

Sometimes, things did not go as expected. In this case, the flange of a major girder had to be coped in the field to allow the hanger to pass. A cover plate with a hole for the hanger was provided to reinforce the flange. The most serious impact the 10 ft-9 in. floor-to-floor height had on the structure was that nearly all beams had to be penetrated for HVAC ducts and sprinkler piping. At the break in the moment frame, the floor beams were restricted to an 8-in. maximum depth, to allow 11-in. deep main supply ducts to pass below. A shallow structure here was also desired, so as not to restrict the flow of return air from ceiling plenum to mechanical room.

Speakers at breakfast display 35-lb. plaque, slice of W14×730 (730 lbs./ft) steel column used on building. L. to r.: Albert O. Wilson, Jr., A.O. Wilson Structural Co.; Charles Kenny, C.W. Whittier Co.; George Macomber, Macomber Builders; Eugene Racek, E.R. Racek Associates; and Jonathan Buhl.

In the transition from the moment frame to one of 8-in. deep beams at the gap, the situation was so tight that even the 8-in. beams had to be raised up into the floor slab to provide enough room for ducts. Once the ducts passed under this area of shallow structure, they split into slightly smaller ducts which penetrated the typical 16-in. deep floor beams. The maximum size opening was 31 in. × 8 in. deep, centered on beam depth and beam span, where possible.

The steel fabricator's suggestion, square bar reinforcing, was used on one side of the beam web to reduce shop handling. Design of the reinforcing was based on the composite properties of the steel beam. Using a Vierendeel truss analogy, the designer found consideration of the concrete flange helped in two ways: first, compressive stress at the steel top flange was greatly reduced. Secondly, buckling resistance of the top flange was greatly reduced. Secondly, buckling resistance of the top flange was significantly increased. The final result was that only about 50% of the reinforcing that would have been required was used, had not composite action been considered.

One final area to be considered is the rounded corner framing along the Federal Street side. To frame the corners, an 18-in. deep girder cantilevered from the moment frame at each end of the curve. A simply connected straight beam was provided in between. Tie columns insured compatible deflections of the cantilevers and provided support for limestone panels. Typically, the limestone panels were picked up by seat angles at the floor level. Continuous head and sill angles supported the panels laterally against wind pressures. The design of the limestone supports was based on exposure Type B wind pressures. On the completed limestone work at a rounded corner, the deck edge had to be very carefully layed out so it would not interfere with panel installation.

The building was a most enjoyable project for the design team to take part in—not only because it is an exciting building, but also because of all the other people who were involved with the job. The several "design" sessions held with the BRA to see that their criteria were included in the design of 155 Federal Street paid off. Their impact, along with what the owner wanted to achieve in this new building, came to fruition in a new and exciting office building for Boston. □

Architect
E. R. Racek Associates
Boston, Massachusetts

Structural Engineer
Souza & True
Watertown, Massachusetts

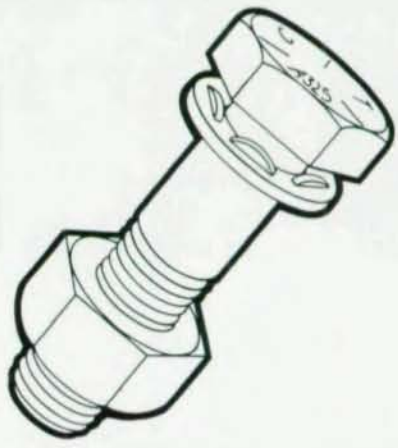
Construction Manager
Macomber Builders
Boston, Massachusetts

Steel Fabricator
A. O. Wilson Structural Co., Inc.
Cambridge, Massachusetts

Steel Erector
Daniel Marr & Son Co.
Boston, Massachusetts

Owner/Developer
Boston Federal Associates
Boston, Massachusetts

Using Coronet Load Indicators saves over $75,000 on PPG Building.



Comparing the bolt inspection costs of two buildings recently erected in Pittsburgh, Pennsylvania, shows how using Coronet Load Indicators can mean significant cost savings.

The high-strength bolts on the Dravo Building were installed using the "turn-of-nut" method. Bolt inspection required an inspector and two ironworkers with a torque wrench at a cost of $9.95 per ton of steel.

The bolts on the PPG Building, however, were installed with Coronet Load Indicators. Bolt inspection required only half of a man's time at a cost of $1.75 per ton of steel plus the cost of load indicators at $4.00 per ton, or a total of $5.75 per ton.

That's a savings of $4.20 per ton over the Dravo Building. With 18,000 tons of steel used to erect the PPG Building, the total savings in bolt inspection is $75,600.

What's more, with Coronet Load Indicators, 100 percent of the bolts were inspected, whereas only 25 percent of the bolts installed by the "turn-of-nut" method were inspected. And because a calibrated torque wrench does not prove that the bolts have been properly tightened, the proper tensioning of even these bolts is not assured.

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PPG Building, Pittsburgh, Pennsylvania. *Owner: Pittsburgh Plate Glass Co. Architect: Johnson/Burgee. Engineer: Skilling, Helle, Christiansen, Robertson. Fabricator: U.S.S. Fabrication, Division of United States Steel Corporation. Erector: American Bridge, Division of United States Steel Corporation.*

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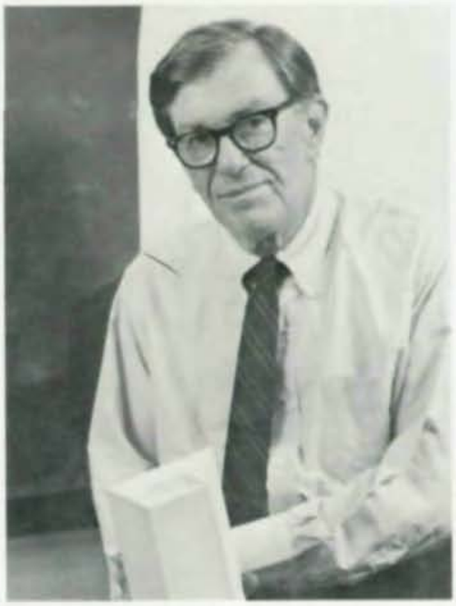
Designs in Steel

by Hugh Stubbins

Hugh Stubbins, FAIA, is president of the architectural firm of Hugh Stubbins and Associates, Cambridge, Massachusetts



Our firm is experienced in a wide range of building types and planning solutions. From beginnings in residential and school architecture in the New England area, we have expanded to include office buildings, theaters, research facilities, hotels, libraries and recreation and transportation facilities throughout the U.S. and overseas. This broadening of architectural scope enlarges our responsibilities as designers and brings us heightened awareness of sound building techniques and materials. Our strong relationship with a structural engineer, William J. LeMessurier of LeMessurier Associates/SCI, has resulted in a successful union of architectural and structural design. Among the most notable and innovative of our collaborations have been those buildings with steel frames.

Beginnings

Even in 1946, we used steel framing for a small house in Newtown, Conn. Located atop a granite hill, and surrounded by cornfields, this brick veneer house was constructed in steel, with a concrete foundation and floor, as a fire precaution and to alleviate anxieties of the owner. From this small structure, we moved on to using steel in elementary school buildings such as the Country School in Weston, Mass., which received the Harleston Parker Gold Medal in 1955 for its innovative design in nestling into the undulating land forms in a residential community. As our practice and the scale of work grew, further opportunities arose for steel structures, and our close relationship with LeMessurier began to evolve. College and university buildings were among the first building types we worked on together. For example, at Jadwin Physical Laboratory, an AISC award-winning building at Princeton University, steel was used to better accommodate large cantilevers and avoid creep commonly experienced in concrete structures. Also, it provided ultimate flexibility for cutting openings in floors to add equipment necessary for different types of research projects.

Tower Designs

Later, combinations of steel and concrete introduced new possibilities for tower design. At MIT's Tang Hall, married-student housing, we used steel for the interior structure connected to a precast concrete exterior wall system. By contrast, our 54-story Singapore Treasury Building, currently under construction, has a slip-formed concrete core from which steel-framed floors are cantilevered 38 ft.

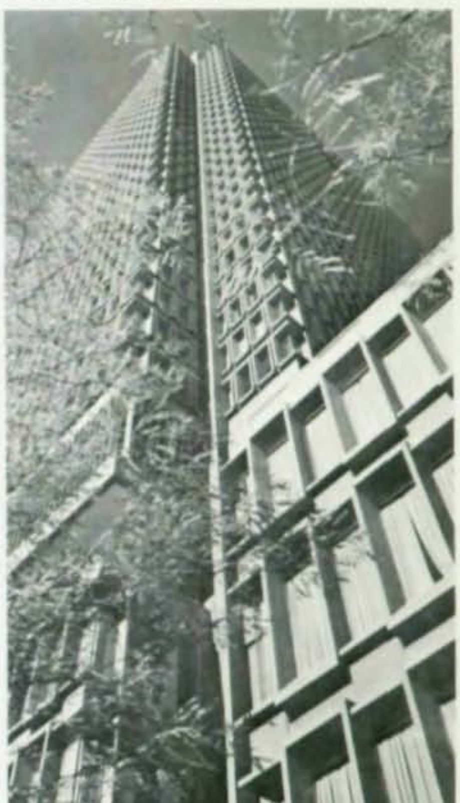
Citicorp Center represents one of the most interesting steel framing concepts devised to date and one of the most economical steel buildings for its 915-ft height. The structure uses a series of chevrons for wind-bracing and the transfer of loads to four large mast columns located at the midpoint of each side of the square tower. These "supercolumns" rise 114 ft from street level to the first tower floor, permitting the siting of Saint Peter's Church at the corner of 53rd and Lexington Avenue, "under" the Citicorp tower. The main sanctuary of the steel-framed, free-standing church is one level below grade. To minimize adjacent subway noise within the church, the frame rests on neoprene pads to absorb vibration.

Close to completion is the 30-story Medical Mutual Center in Cleveland, O. At less than 17½ psf of structural steel, the office tower represents an efficient structural organization. A system of statically determinate trusses in the exterior facade diverts building weight around the open space at the base, concentrates building weight for caisson efficiency, and mobilizes exterior wall weight to resist wind-overturning moments.

Boston and Cambridge

Within Boston and Cambridge, our experience with steel-framed buildings has been diverse. Beginning in 1966 with the AISC award-winning State Street Bank, a joint venture between Hugh Stubbins and Associates, F.A. Stahl and Associates and William J. LeMessurier, steel again offered new design opportunities. The 34-story office tower, with offset corners and 15-ft deep cantilevers on four sides, is distin-

State Street Bank Building



Boston City Hospital Outpatient Dept.

guished from its four-story base which relates to the scale of older neighboring buildings.

Spanning Massachusetts Avenue is the Boston City Hospital Outpatient Building which we designed in partnership with Rex Allen. The structural system consists of a steel frame and precast, prestressed concrete plank. The basic structural element is an 8'-8" deep long-span steel truss. The basic structural bay is a 60-ft square, with secondary trusses located 20 ft o.c. to receive the precast floor planks. This system makes the most efficient use of the depth of the required mechanical space for moment-resisting efficiency and provides maximum free area in this interstitial space for supply systems, mechanical and electrical equipment and personnel.

At the Federal Reserve Bank of Boston near South Station, the building's steel frame is organized so that column loads for 30 floors of the tower are transferred across the large opening near the tower base by massive 36-ft deep twin trusses. Transverse lateral forces are resisted by efficient X-braced "supertrusses" in the end service cores. Typical floor girders and beams are made composite with lightweight concrete deck-supported slab for rigidity.

Federal Building

Initiating the revitalization of Boston's North Station area, the new Federal Building will provide a new image and consolidated quarters for government agency offices previously dispersed throughout the city. In addition to office space, the building offers commercial and retail space at ground level and parking for 260 cars in a one-level underground garage.

Scheduled for construction in early spring, the building is organized in two L-shaped volumes, one eleven stories and the other, five. The interlocking configuration of these forms encloses a central atrium and lobby and creates two distinct types of flexible office space within the building. The large public-service-oriented agencies are housed on the lower five floors which each contain 86,500 gross sq ft of space surrounding the atrium. Smaller, less frequented agencies are located on the six levels above the atrium, on floors providing 42,500 gross sq ft. A street-level arcade provides a covered walkway adjacent to retail space between the two main building entries.

The polychrome exterior of the building is composed of horizontal granite spandrels and strip windows of reflective glass. The flush facade is articulated by a narrow band of polished dark red granite designating floor levels. Warm grey unpolished granite is used for the eleven-story portion of the building and light red granite for the five-story portion, reminiscent of the brick used in neighboring buildings. A design amenity in itself,-the skylighted atrium is also a passive solar collector and contributes to the energy efficiency of the building by substantially reducing exposed exterior surface area. This and other energy-conscious design features result in the very low projected annual energy budget of 37,000 BTUs per sq ft.

Based on the geotechnical design parameters, pile foundations were required to support the building. With a view toward minimizing the weight of the structure, structural steel framing using either a 30' × 30' or 30' × 25' bay was selected. Vertical-plane diagonal bracing was positioned systematically throughout the plan to provide resistance to lateral loads. Only three-quarters of the number of piles required for an equivalent reinforced concrete framing system were necessary.

Another implication of a lightweight building is the attendant reduction in design seismic forces for which the building was planned. The lower the design seismic forces, directly related to the weight of

Federal Reserve Bank Building

Riverside Place, Cambridge, office building

the building, the less the amount of structural material required to sustain these forces. Thus the lower the design seismic forces, the lower the structural system cost.

Riverside Place

In Cambridge, we have designed a new speculative office building to provide maximum rental space to the developer without sacrificing tenant amenities. Prominently located along the Charles River, the 485,000-sq ft complex, part of the East Cambridge Riverfront Development Program, borders extensive river-edge park improvements.

Above four levels of parking, the building rises in two perpendicular wings to focus interior spaces on views of the river and toward Cambridge and Boston. The seven-story east wing encloses an average of 20,000 sq ft per floor, and the nine-story west wing, 14,000. These wings are connected by a glazed central core and a four-story entry lobby. Along the riverfront side, the building scale is reduced to two-story "townhouse" office space totaling 20,000 sq ft to complement marina and residential development planned for the area. Exterior materials include colored precast concrete spandrels and brick infill with bronze insulating glass.

The structure is a steel frame for the office building and the garage. For the office portion of the building, above and adjacent to the garage, the floor slab construction consists of 3¼-in. lightweight concrete topping composite with 3-in. deep, 21-ga. steel deck spanning 10 ft to composite A36 structural steel filler beams. The corresponding floor construction in the garage is a reinforced concrete slab comprised of 4-in. normal weight concrete topping on 2-in. deep steel deck used as stay-in-place forming. Moment-resisting frames of A572, Grade 50 columns, and A36 girders are designed to accommodate the design lateral loads down to the third level, i.e., first office level. Below this level lateral loads are transmitted through a diagonal bracing system in each principal direction.

260 Franklin Street

Construction of a new 23-story office building, "260 Franklin Street," is scheduled to begin this year. Offering 350,000 sq ft of office space, the building will also have a 5,000-sq ft retail arcade and a sidewalk cafe at ground level. A two-level underground garage accommodates 80 cars. The building design comprises two forms with curved corners, one oriented to the south and one to the north. The different volumes are articulated by vertical slots which run the full height of the building. The building exterior is planned as multi-toned, beige-pink polished granite and insulating glass.

In response to the surrounding context, the lower levels of the facades on Franklin and Oliver Streets will be recessed with the column structure articulated. Setbacks of the glazing at the street - and second-floor levels create the pedestrian arcade opening to the lobby and to retail and cafe uses. Surrounding sidewalks and historic alleys will be provided with appropriate paving materials, lighting and signage.

Structural steel was selected as being the most cost-effective for this particular building configuration. Thirty-three columns are spaced at approximately 15 ft around the building perimeter, and eight columns are positioned at the perimeter of the service core. Typical floor construction consists of 3¼-in. lightweight concrete topping composite with 1½-in. deep steel deck spanning 7′-6″ to composite structural steel filler beams. Lateral design loads associated with wind and seismic forces are resisted by a combination of two moment-resisting exterior frames and four planes of diagonal core bracing in the short direction of the building, and by two planes of diagonal core bracing in the long direction. Code requirements for dead-load resistance to overturning due to wind and economics dictated the use of moment frames in lieu of tie-down anchors under the core columns.

The examples presented here provide a small insight to the versatility and economy of steel construction. We remain committed to investigating innovative design solutions and to exploring techniques of building with steel. □

260 Franklin Street Building

Constitution Quarters: Architectural Integrity Restored

Immobiliare New England was designated by the Boston Redevelopment Authority as the redeveloper for a large part of the historic former Navy Yard. Their interest was in adaptively reusing a number of existing buildings, while preserving their historic and architectural integrity. The master plan for the revitalization of the Navy Yard, also prepared by Architect Anderson Notter Finegold Inc., suggested a mixed use residential/commercial and cultural development.

An economic study confirmed that a complex of existing buildings could be preserved and rehabilitated into condominiums and rental apartments. An imaginative financing program was developed by taking advantage of the tax incentives under the historic provisions of the Tax Reform Act. Key to redevelopment and preservation of the Navy Yard was to establish a neighborhood, initially through housing, with later addition of commercial and cultural facilities. Immobiliare New England established a limited partnership to execute this first stage.

The site at the inner end of Boston Harbor comprises an entire block of about seven acres of the Navy Yard. It is bounded by a number of old industrial shipyard structures, a new city park and part of the waterfront rehabilitated into a marina. The entire block was covered with a structure the Navy had designated Building 42—a complex of a foundry and machine shop to produce major components needed for ship construction.

The task was to recycle the historic foundry and machine shop structures, dating from the 1850's to 1940's, into rental apartments. In the future, these could be sold as condominiums in a price range making them available to buyers of various income levels. The space in the buildings allowed for 367 apartments, including duplex and triplex units.

National Landmark a Challenge

Since the entire 100-acre Navy Yard is a National Historic Landmark, building exteriors were carefully renovated to respect their historic and architectural integrity. Brick and granite surfaces were gently cleaned. Major mullion patterns were retained to preserve the scale and proportion of the industrial windows. New streetscape and courtyard treatments, including retention of a steel truss as an outdoor canopy/trellis, blend the site's industrial heritage with a new residential ambience.

The original full-height space has been preserved and transformed into a spectacular atrium as the internal focal point of the design. The sheer size of this skylit atrium, 60 ft high and nearly 700 ft long, creates a breathtaking environment. The original steel truss/monitor roof is preserved to provide natural lighting.

Glass-enclosed elevator towers and open circulation bridges divide the atrium into smaller bays. A residential scale is achieved with extensive interior plantings, quarry tile floors and wooden entrance platforms and railings. Colorful fabric mobiles, the result of a local artists' competition, float within the atrium bays. Machinery patterns salvaged from the buildings have been creatively redesigned as sculptures and wall murals.

A courtyard was created between the two most historically significant buildings which were linked by an arcade that echoes their most appealing features. Residential development of the first group of buildings will be the initiative to develop the remainder of the shipyard into a neighborhood community.

Structural Details

Project feasibility was based on a structural design which capitalizes on the heavy load capacity of existing galleries, and steel columns with concrete footings to support new construction. Three new floor levels created a total of six residential levels. The gallery levels were widened and open corridors built along their inner edges to overlook the atrium.

The primary structural consideration for this project was to develop a floor system that would economically extend the existing gallery floors by approximately 14 ft, and at the same time have a minimum floor depth so new floors could be added between the existing galleries which had a minimum floor-to-floor height of 17 ft-6 in.

The design chosen consisted of structural steel framing and light gauge metal floor joists. The new floor areas beyond the limits of the existing galleries were framed with W8 beams extending out from existing floor girders. These cantilever over new posts to form a continuous walkway around the atrium at each floor level.

The walkways on either side of the 30-ft atrium are connected with several steel-framed bridges and a glass-enclosed elevator. It was necessary to modify the existing floor girders along the interior edge of the galleries. These built-up and/or rolled girders were originally designed to support a traveling crane and very heavy gallery floor loads. They were not suited for their new use, since the top flange was located above the finished floor and the bottom flange projected into the new apartment areas.

These girders were modified by welding continuous angles to the webs to form a much shallower beam and then removing the original top and bottom flanges. This procedure allowed the contractor to perform his work without shoring the existing galleries and permitted other work to progress simultaneously. With the exception of a few severely corroded roof level spandrels and a fatigue failure of two girder connections which supported the traveling crane, the structural steel was in excellent condition.

The building uses incremental gas heating, with separate systems for each unit. Air-conditioning is also provided. The mechanical system relies on a system of incremental condenser ventilation, carefully designed to be integrated with the fenestration system of the major elevations. To preserve the original masonry facades and historic rooflines, many units have remote condensers located in attic spaces that are mechanically ventilated.

Unique Parking Structure

Also included in this project is a 360-car parking garage built within the limits of a masonry facade from an original historic building. The structural system finally chosen for the garage was precast prestressed plank supported on W24 girders and W12 columns. Girders on both parking levels are cantilevered beyond supporting columns to reduce midspan bending moments—and to eliminate interference between the new and original foundations. The steel framing was rigidly framed with end-plate connections to resist both gravity and seismic induced moments.

This unusual project represents an important commitment by the city and private developers to revitalize a local community. Neighborhood residents were given priority for jobs in construction and management as a measure to boost the local economy and to make the project a part of the community. Most importantly, the project sparks new vitality to the area, without causing any displacement of existing residents. Truly, it transforms obsolete industrial structures to new residential use, yet preserves the integrity of a National Historic Landmark. □

Historic Charlestown Navy Yard building (l. pg.) were transformed into handsome apartments below. Steel framing (l.) permitted extensive structural renovations required.

Architect
Anderson Notter Finegold Inc.
Boston, Massachusetts

Structural Engineer
Brown, Rona Inc.
Boston, Massachusetts

General Contractor
Sydney/Solimando
Newton Highlands, Massachusetts

Steel Fabricator
L. Antonelli Iron Works, Inc.
Quincy, Massachusetts

Owner:
Building 42 Associates
Charlestown, Massachusetts

Northeastern University: Engineered in Steel

Northeastern University is known throughout the U.S. and the world for its College of Engineering. A top-quality education in engineering disciplines is available through both full-time and part-time programs, as well as the well-known cooperative education program. Over the years, tens of thousands of students have participated in these programs, with current enrollment at 5,600. Considering this success, it is incongruous that many of the college's activities are housed in the oldest, most starkly utilitarian quarters on campus. However, this situation will be remedied in September 1983 when the Engineering Center, rising with a grid of steel and precast concrete from the South parking lot, opens its doors.

The Engineering Center will contain 80,000 sq ft on five main floors, plus a roof-top penthouse/teaching unit and observation deck for solar, wind and environmental experiments. Level One, half below grade, includes the "heavy" labs—concrete, structural analysis and hydraulics. Level Two will house classrooms, two slope-floor lecture halls each seating 200 and administrative offices. Levels Three, Four and Five are a mix of administration and faculty offices and laboratory space for the structural, civil, chemical and environmental engineering departments. Construction funding is principally from corporate foundation and individual alumni contributions.

Structural Response to Environment

The exterior design, which departs from Northeastern's traditional white brick, features precast panels with a finish of exposed ¾-in. screen Mount Airy (S.C.) granite. The north facade is composed of flush alternating horizontal bands of solar gray glass and precast. In response to solar orientation, the south facade presents a very different aspect. Here, office windows are protected from solar gain by deep overhangs, while a four-story glass atrium marks the building's entrance. When the MBTA's Orange Line relocation project is complete, this will form an important new gateway to the central campus, via an extension of the underground pedestrian movement system.

The structural engineers considered alternative framing systems, including steel, reinforced concrete and a precast combination. However, a steel system was selected in the early stages of design development for three principal reasons: light weight, speed of design and construction, and adaptability to changes in design even if it were required during construction. Northeastern's campus is in Boston's Back Bay, a filled marsh where the water table rises and falls with harbor tides. The steel framing system yields significantly lighter dead loads, translating into smaller footing requirements on this marginal bearing. Smaller footings in turn mean less excavation and dewatering, lower cost and faster construction.

Speed of construction is a critical factor. From the groundbreaking in May 1982, the contractor was given only 14 months to complete the project for occupancy. Any overrun of this schedule would result in a full semester delay to the facility's planned opening, posing significant scheduling problems to the university. Steel's relatively short design time and speed of erection have allowed the contractor to close in a significant portion of the building prior to severe winter weather —and remain on track with interior partitions, utilities, finishes and equipment.

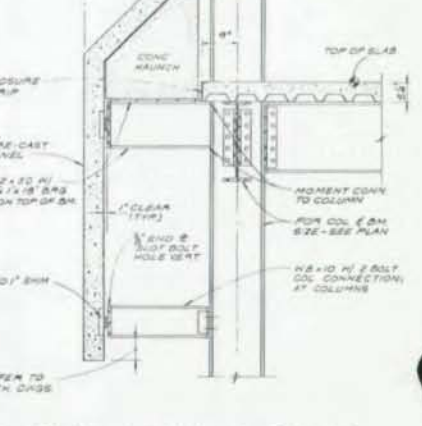
Another method to speed the design and construction process involved the steel to precast cladding connections, which were designed in concept, but not in detail, for the bidding phases of the project. Steel's flexibility allowed the final design of clips and supports to be worked out efficiently to the specific needs of the selected precast and steel subcontractors during the shop drawings phase.

Design for Maximum Flexibility

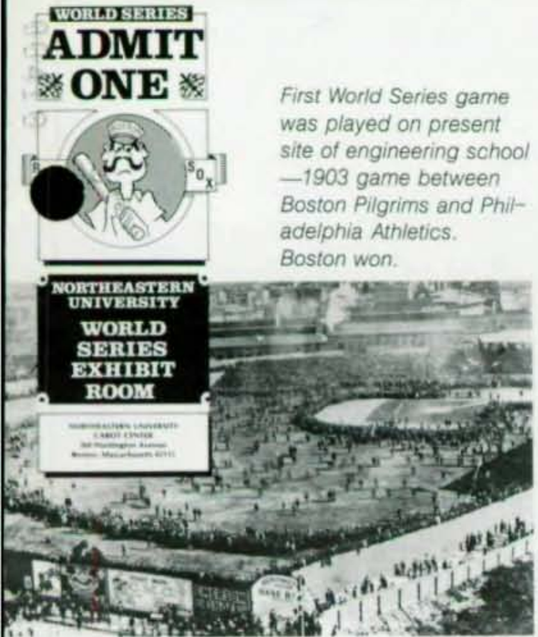
The basic structural frame consists of 650 tons of A36 steel. Design is composite beam/composite deck using ¾-in. × 3-½ in. long shear studs approximately 1 ft-6 in. on center. Total floor slab thickness is 5½ in., with 3½ in. of lightweight concrete fill on 2-in. galvanized metal floor forms, giving a 2-hr. fire rating. Columns and beams are sprayed-on after erection to achieve the same rating. To insure better bonding of the fireproofing material, the structural steel was left unpainted, which also resulted in savings of several thousand dollars. Within the overall structural grid, a rigid frame with moment connections resists wind and seismic loads. In lieu of bracing, this design allows greater freedom of unobstructed window placement and imposes no constraints on future relocation of interior partitions.

The College of Engineering's program includes a wide range of uses—from office space to laboratories to lecture halls. All require maximum flexibility to remain viable during the life of the facility. Steel framing provides the least restrictive envelope. Walls, except at stairs and shaftways, are non-load bearing. Utilities are clustered in four centralized chases for easy access and modification. Classroom, laboratory and office space can be interchanged as program requirements change.

Because the Center abuts the existing Dana Research Center and is connected to it on four levels, floor-to-floor heights are set by Dana's restricted 12 ft-6 in. Added to this constraint are required spans of 52 ft-6 in. over the new lecture halls, plus unusual ceiling plenum space requirements for utility services to laboratories. Depth of structural members therefore be-



Noted Northeastern University School of Engineering building (l.) was framed in steel. Section details connections and facade.



First World Series game was played on present site of engineering school —1903 game between Boston Pilgrims and Philadelphia Athletics. Boston won.

comes severely limited. The engineers designed a structural framing system for this area consisting of W18×71 sections, 5 ft o.c., and precambered to reduce dead-load deflection. For the basic building frame, connections are bolted with A325 load indicator bolts. Moment frame connections are welded with E70XX electrodes.

The Engineering Center is designed not only to house College of Engineering activities, but also to serve itself as a teaching laboratory. Mechanical, electrical and environmental engineering course material will be augmented by the theory, design and operation of actual building systems. As an example, provisions are included to monitor and adapt the functions of the HVAC system as it responds to changing conditions of exterior and interior environment. Also, Northeastern's Office of Learning Resources, under a grant from The Steel Erection and Ornamental Iron Advancement Fund, is photographing and videotaping the entire construction process of this building, with an emphasis on foundations, steel, and steel erection, with plans to design curriculum resource material for courses in structural engineering and general construction practices.□

Architect/Structural Engineer
Keyes Associates
Waltham, Massachusetts

General Contractor
Vappi and Company, Inc.
Cambridge, Massachusetts

Steel Fabricator
General Steel Fabricators, Inc.
Latham, New York

Owner
Northeastern University
Boston, Massachusetts

Seal Harbor Condominiums: Luxury in Panorama

by Dianne M. Ludman

The view is spectacular—a 270° unparalleled panorama of the Boston waterfront stretching from Nahant and Marblehead in the north to the Boston Harbor Islands in the south. The nine-acre site, less than 10 miles from downtown Boston, is a peninsular bluff 20-30 ft above sea level with over 1,800 ft of ocean front.

The marketing vision of the developer/contractor, with 23 years of experience in the housing industry, led him to Seal Harbor, an abandoned U.S. military compound originally known as Fort Heath. Early in 1979, the development team—architect, broker and lender—began an analysis of the site. The eventual program, product of a lengthy study of architectural and marketing options, called for a 246-unit luxury condominium complex with a strong accent on the uniqueness of its harbor location.

Room, and What a View!

"Siting the project was the key," feels the developer, Sanford Kaplan. "It was important to give a direct view of the ocean to every unit, and the architects achieved that." The task was more difficult because, in 1973, Kaplan had built 150 units of rental housing on the landward edge of the site. Providing an ocean view with balcony for each unit of the new development had to be accomplished without disturbing the views and sense of openness of this earlier project.

Dianne Ludman is marketing director for ADD Inc, an architecture/design/development firm in Cambridge, Massachusetts.

The architect met this challenge by grouping the units into two large buildings, each bent at 45° around a central core. These 'chevrons' were then juxtapositioned so that no face of the four wings or the existing structure is parallel to any other. The resultant massing creates a lively interplay of forms and surfaces to emphasize the visual expansiveness of the site and the open sea beyond. The seashore's special quality of light and air is thus invited into every corner of the complex, in spite of the density dictated by economic limitations.

The two Seal Harbor buildings are connected by a 270-car underground parking garage, with additional parking on grade above. Each building is constructed in two phases of 60-70 units, separated by the central greenhouse—a glazed stack of elevator lobbies. The first phase is stepped from six to eight to ten stories; the second is nine stories. Common areas include an outdoor swimming pool and cabana with kitchen and showers at each building, tennis courts and meeting, game and hobby rooms and health club. Individual living units range in size from 1-bed/1-bath flats to 3-bedroom/2-½ bath duplex penthouses.

Low Cost Steel for Luxury Living

Steel was selected for Seal Harbor because of its low cost, and its ease and speed of construction. Because of openness required by the unit plans and the need to offset columns over the garage and at upper floor setbacks, the structural engineer selected a multi-story rigid frame for the basic framing system. The infill floor system chosen was a regular, mass-produced, composite-steel bar-joist system that neatly incorporates the forms for the floor. This system installs quickly and allows the slabs to be poured closely behind the steel erection so that framing precedes slabs by less than three floors.

Forms for the underside of the slab are held between the joists by temporary subjoists which are removed afterwards from beneath, a method which affords important time savings which translate into cost savings. It is one of the lightest systems available and allows a reduction of 2-4 in. of construction depth per floor, yet provides good airborne and impact sound reduction floor-to-floor.

Flexibility of the joist locations to avoid plumbing/duct conflicts was another important factor. This was accomplished by adjusting the location of the first joist without disturbing the fixed joist spacing. Column and beam framing was primarily done with quick, simple high-strength bolt connections. Moment connections, an integral part of the rigid frame, were welded connections. Wind and seismic lateral forces are resisted by a system of orthogonal bents arranged so that bending occurs only on the strong axis of the wide-flange columns.

Combination of Cantilevers

The architect's design for the building facade employs a combination of two types of cantilevers. Three-ft deep canti-

Seal Harbor Condominiums (l.) on luxury site of Boston Waterfront, once an abandoned army base. Aerial (top) shows magnificent harbor panorama.

levered bays are clad in lightweight synthetic stucco, with a cantilevered slab at each floor. Seven-ft deep cantilevered bays, clad in brick cavity wall construction, are much heavier due to the depth of cantilever and weight of the exterior cladding. These brick-sheathed bays are not supported at each floor; instead, each floor bears on the floor beneath, and the lowest floor of the bay is supported by 24 to 33-in. deep steel cantilevered beams of 36 or 50 ksi steel. To accommodate the depth of the cantilevered beams above the ceiling of the first floor, the first-floor height has been increased to 11 ft, 16 in. greater than the typical 9 ft-8 in. floor-to-floor dimension.

An adjacent government radar dome limited the maximum height of the structure. The composite joist and deck Hambro system helped reduce the overall building height enough to allow 10 stories, while still accommodating the elevator overrun at the top.

Also affecting structural design was the extremely corrosive salt atmosphere of the ocean side. Galvanized steel was used for all relieving angles, which are the most exposed elements of the steel frame. All other steel is painted with a rust-inhibitor.

The high-rise building is fully sprinklered and, classified as type 2B construction, has fire-resistant ratings of 2-hr. enclosure for stairways, elevator shafts and duct shafts; 1-hr. protection for columns, beams and exitway corridors; 1-hr. vertical separation of tenant spaces; and 1-hr. demising partitions between separate dwelling units. All these ratings were met by the chosen system in combination with minimal thicknesses of gypsum wallboard, a particularly clean and economic approach.

All Massachusetts state energy codes limiting of fenestration and requiring minimum R values at walls and roofing have been met. Energy conservation features within the project design include unitized heating and cooling supplied by heat pumps. This system provides the residents with individual control of all HVAC. In addition, a carefully detailed, well-insulated skin minimizes energy loss.

Seal Harbor Condominiums rose quickly and gracefully on its promontory in Boston's fabled outer harbor. □

Multi-story rigid frame provided low cost and ease of construction for luxury condos.

Architect
ADD Inc
Cambridge, Massachusetts

Structural Engineer
David M. Berg, Inc.
Needham, Massachusetts

General Contractor
Sanford Construction Co., Inc.
Needham, Massachusetts

Steel Fabricator
Isaacson Steel
Berlin, New Hampshire

Owner/Developer
Seal Harbor Corporation
Needham, Massachusetts

Tufts Research Center on Aging:
A Challenge in Site and Search

by Dr. Othar Zaldastani
and
Lloyd P. Acton, Jr.

The well-ordered, polite presence of the new 16-story building on the corner of Boston's Washington and Stuart Streets belies the extreme complexity and technical sophistication of the programs, equipment and activities it houses.

Dedicated in November 1982, the U.S. Department of Agriculture's $32-million Human Nutrition Research Center on Aging at Tufts University is the first clinical research unit in the world devoted entirely to the effects of nutrition on the aging process. The Center includes laboratories for 53 scientists and 200 support personnel, extensive animal quarters and administrative/exhibition/auditorium space—as well as comfortable living quarters for 28 volunteers who will live in for testing periods of up to 12 months.

The building occupies a tightly defined, 19,700-sq ft site within the University's downtown campus. Its six-sided rhomboid form responds to the main campus axis and acknowledges the angles of adjacent streets. At the same time, it creates a dramatic new entrance to the campus and the adjoining New England Medical Center. The brick-red precast concrete panels provide a distinctive architectural expression that identifies the Center amidst surrounding white buildings.

The Challenge of a Pioneering Center

To accommodate the different program functions within a unified solution, a system of zoning was designed to create distinct functional layers that are separated by the mechanical floor at the 10th level. Above the building lobby and mezzanine auditorium, a service floor buffers public spaces from the next two floors, which are animal quarters. The third and fourth floors contain environmentally controlled and independently air-handled animal housing for approximately 20,000 rodents and some larger animals, as well as a surgical suite and a special animal nutrition kitchen. Research laboratories on the fifth to eighth floors are adaptable for biochemical, physiological, pathological and behavioral studies. On the ninth floor are the administrative offices and a computer center, which is linked to terminals in each lab.

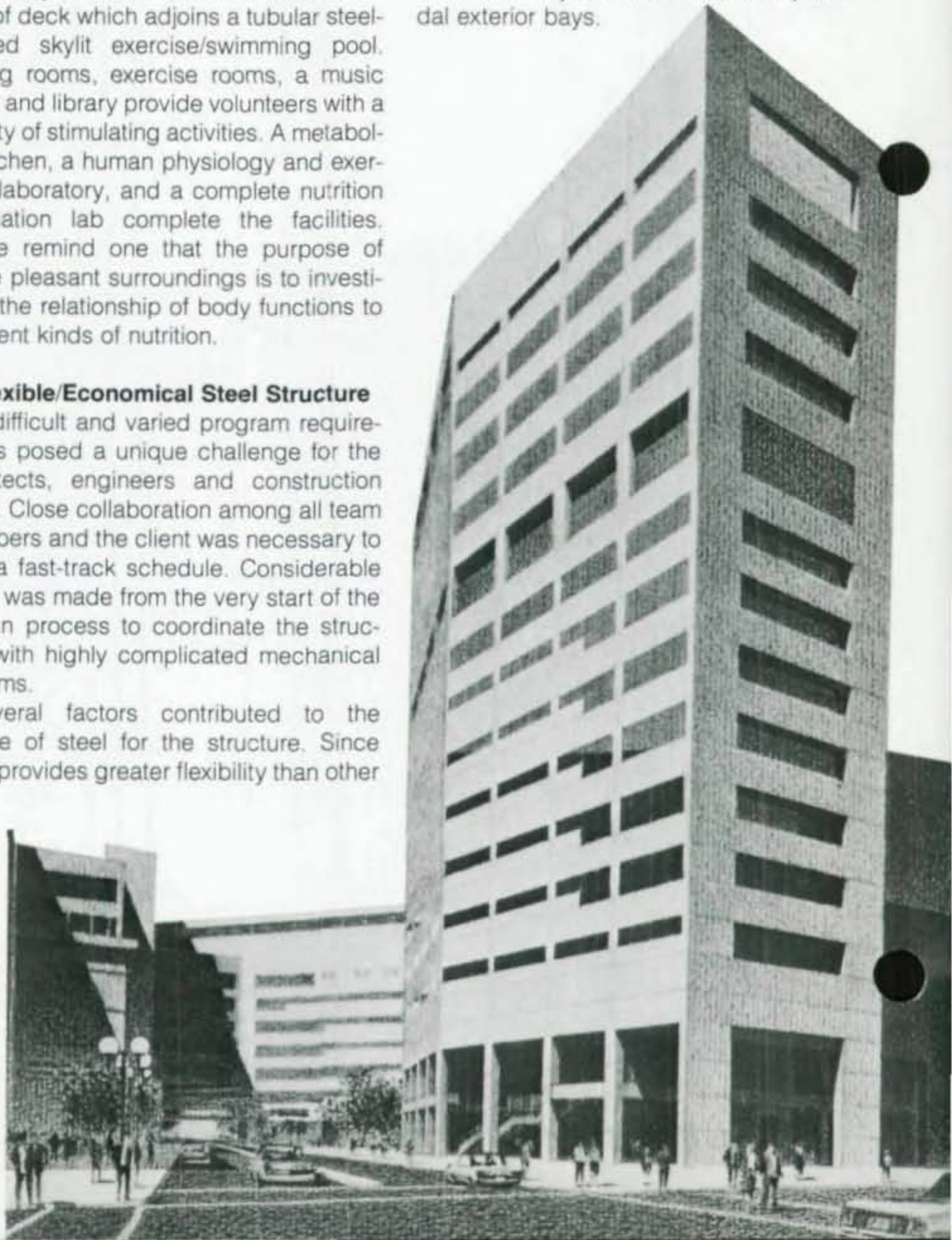
The 10th-floor mechanical space marks the transition from the laboratory to living space. It is strategically located to efficiently service both the research areas below and the clinical center above.

To take best advantage of the views and abundant natural light, volunteers live on the top four floors of the building. Here they have access to a recreational roof deck which adjoins a tubular steel-framed skylit exercise/swimming pool. Dining rooms, exercise rooms, a music room and library provide volunteers with a variety of stimulating activities. A metabolic kitchen, a human physiology and exercise laboratory, and a complete nutrition evaluation lab complete the facilities. These remind one that the purpose of these pleasant surroundings is to investigate the relationship of body functions to different kinds of nutrition.

A Flexible/Economical Steel Structure

The difficult and varied program requirements posed a unique challenge for the architects, engineers and construction team. Close collaboration among all team members and the client was necessary to fulfil a fast-track schedule. Considerable effort was made from the very start of the design process to coordinate the structure with highly complicated mechanical systems.

Several factors contributed to the choice of steel for the structure. Since steel provides greater flexibility than other systems, it is more appropriate in a building that requires installation and maintenance of elaborate, constantly changing equipment and services. In addition, because of the soft blue clay below the site, costly foundations dictated the choice of a light, economical superstructure. Foundations using 120-ton step-tapered steel pipe piles had to be driven to a depth of 120 ft. The building's structural floors are 5½-in. lightweight concrete slabs on 2-in. metal deck, spanning 10 feet between steel beams supported by steel girders. The construction is composite throughout. The shape of the building led to rectangular interior bays of 20-40 ft, and trapezoidal exterior bays.



Dr. Othar Zaldastani, FASCE, is president of Zaldastani Associates, a Boston-based engineering firm.

Lloyd P. Acton, Jr., AIA, is a principal of the Boston architectural firm of Shepley Bulfinch Richardson and Abbott.

Lateral loading resistance is provided by rigid, moment-resisting steel frames in the longitudinal direction, and transverse K-braced frames (vertical trusses) to take wind and seismic loadings.

Computer Analysis Governs Design

Analysis of the structure employed the STRUDL computer program, because of the variety of special conditions from within and without that influenced framing. The bracing systems engage the interior columns to take full advantage of gravity resistance in counteracting uplift forces. The design of the rigid frames was governed by wind-drift criteria. Locating the exercise pool at the top of the building required sophisticated analysis to ensure framing to withstand seismic forces. Moreover, the location of an electron microscope on the fifth floor demanded particular attention to vibration criteria.

Four single-story high transfer trusses within the second floor pick up the exterior columns along the west side of the building and extend the span to permit a loading dock and traffic access beneath. The 10 ft-6 in. transfer trusses also create space for a storage and mechanical floor above the public spaces. The principal mechanical floor is at the 10th level, where it is clearly expressed on the building exterior. In the lobby, diagonal members of transverse K-bracing, exposed as architectural elements, are encased in stainless steel.

A Special Vision

Downtown Boston was selected as an ideal location for the Center because of its large population of older citizens who represent a broad socio-economic spectrum. It also provides an excellent regional base for the public outreach educational programs on food, nutrition and aging that the Center plans to initiate.

On dedication day, visitors were impressed with the humanity and thoughtfulness of the plan, the friendliness of the space and the quality of the detailing—unusual, they seemed to feel, in government architecture. Moreover, Terry Bradford, administrative director of the Center, reports the building works well for the research teams and programs in progress.

Dr. Jean Mayer, renowned nutritionist and president of Tufts, authored the original proposal for the U.S.D.A. Human Nutrition Center, the first partnership between U.S.D.A. and a private university. Drs. Robert McGandy, Stanley Gershoff and Hamish Munro, director of the Center, special appointees in charge of the program, worked most closely with the design team on the evolution of a research center. One which reinforces the vision of Dr. Mayer, who believes, with Hippocrates, "the purpose of medicine is to help one's patients die young—as late as possible." □

Architect
Shepley Bulfinch Richardson and Abbott
Boston, Massachusetts

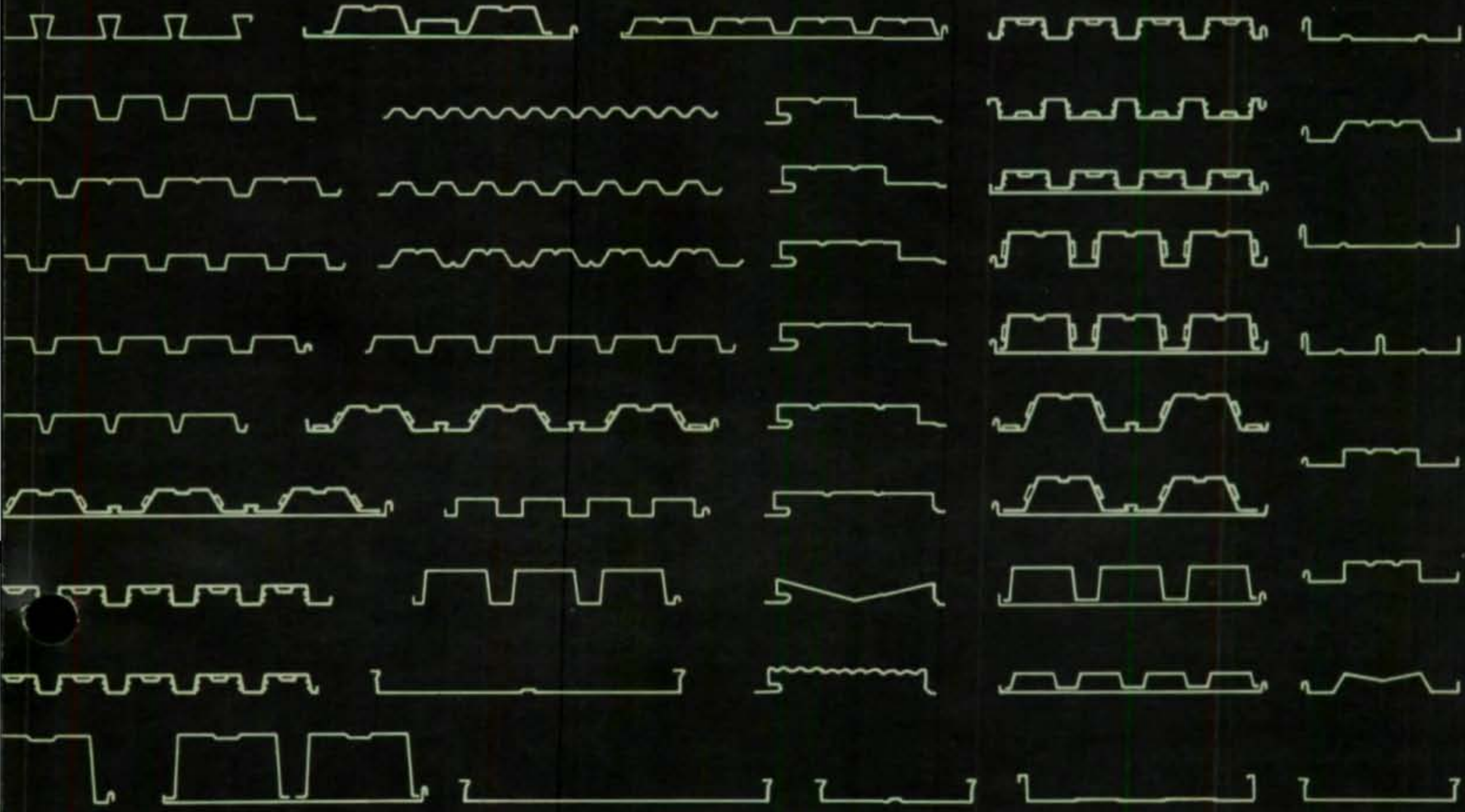
Structural Engineer
Zaldastani Associates
Boston, Massachusetts

General Contractor
Gilbane Building Company
Providence, Rhode Island

Steel Fabricator
West End Iron Works
Cambridge, Massachusetts

Owner
U.S. Department of Agriculture
Tufts University

USDA Human Nutrition Research Center, Tufts University (far l.) meets challenge of tight site. Light steel frame permits constant changes in equipment/services areas.



AMERICAN INSTITUTE OF STEEL CONSTRUCTION
The Wrigley Building, 400 North Michigan Avenue
Chicago, IL 60611

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