Seven World Trade Center, New York, Fabrication and Construction Aspects

by John J. Salvarinas

John J. Salvarinas received his B.A.Sc. and M.A.Sc. degrees in Civil Engineering from the University of Toronto. His master's research programme was one co-funded by the Canadian Steel Construction Council, involving the full-scale testing of hollow structural steel sections as columns. From 1977 to 1983, Mr. Salvarinas continued his interest in steel serving in various capacities with the Canadian Institute of Steel Construction, attaining the position of Regional Manager Ontario in 1980.

Since joining Frankel Steel Limited in 1983, Mr. Salvarinas has been responsible for several projects, including bridge, mill and office structures and is currently Project Manager for the Seven World Trade Center in New York City. His professional affiliations include the Association of Professional Engineers of Ontario, The Engineering Institute of Canada and The Canadian Society for Civil Engineering.
SUMMARY
When completed in 1987, the Seven World Trade Center will become the final phase of the World Trade Complex in New York City. The structural steel skeleton will be clad in red granite, and contain approximately 1,800,000 square feet (167,225 m²) on 47 floors. This paper deals with the fabrication and erection of the 26,000 tons (23,640 metric tonnes) of material required for the superstructure. Emphasis is placed on the construction solutions for the design constraints imposed by the site conditions. These include:
(a) accommodation of an arrangement of caissons installed in 1967 for a different structure to the one under consideration;
(b) spanning a shipping/receiving ramp leading to the World Trade Center, occupying one-third of the site;
(c) cantilevering over and tying into a Consolidated Edison substation serving lower Manhattan, occupying one-quarter of the site; and,
(d) connecting the new tower to the World Trade Center over a four-lane arterial roadway, during erection of the structural steel. Also covered, are general fabrication decisions made to facilitate steel erection; construction sequencing and field equipment; and, scheduling.

SOMMAIRE
Le Seven World Trade Center constituera, à son achèvement en 1987, la dernière étape du complexe World Trade Center de la ville de New York. L'ossature d'acier, recouverte de granit rouge, englobera à peu près 1 800 000 pieds carrés (167 225 m²) répartis sur 47 planchers.
L'exposé traite de la fabrication et du montage de 26 000 tonnes (23 640 tonnes métriques) d'acier nécessaires à sa réalisation. L'exposé traite plus spécifiquement des solutions de constructions rendues nécessaires par les contraintes imposées par les conditions de l'emplacement. Ces contraintes comprennent, entre autres:
a) la nécessité de s'accommoder de la présence de caissons construits en 1967 pour la construction d'un autre ouvrage;
b) la nécessité d'enjamber une rampe d'expédition/réception menant au World Trade Center et occupant un tiers de l'emplacement;
c) construction en porte-à-faux et raccordement au poste électrique de la Consolidated Edison desservant une partie de Manhattan et occupant un quart de l'emplacement; et,
d) raccordement de la nouvelle tour au World Trade Center au-dessus d'une artère de circulation de quatre voies, pendant le montage de la charpente d'acier.
L'exposé aborde également les grandes décisions de fabrication prises dans le but de faciliter le montage de l'acier; échelonnement de la construction et matériel de chantier; et ordonnancement.
SEVEN WORLD TRADE CENTER, NEW YORK
FABRICATION AND CONSTRUCTION ASPECTS

INTRODUCTION

The seventh and final phase of the World Trade Center in New York, will be a forty-seven storey, 1,868,000 square foot office tower. Its red granite facade will be a striking contrast to the white, silver and black World Trade plaza.

This new structure is located on a block of land north of the main complex, and separated from it by a four-lane arterial roadway. Its link to the World Trade plaza will be by means of two pedestrian bridges spanning the roadway from number Seven's 3rd floor. The site has other interesting features with which the designers had to contend (see Figure 1). The easterly portion of the site contains a 5,200 square foot shipping/ramp used by the entire World Trade complex. The northern half, approximately, houses a Consolidated Edison (Con Ed) substation, supplying electrical power to this quadrant of lower Manhattan. The remaining 23,625 square feet of land, forms part of the foundations for the 41,575 square foot structural floors above the Con Ed roof.

DESIGN BACKGROUND

In conjunction with the construction of the Con Ed substation in 1967, the Port Authority of New York and New Jersey took the first step in the completion of the World Trade Center, by installing caissons for a future office structure. It was to be called number Seven, and contain some 600,000 square feet on twenty-five floors. Since then, the present owners of the new structure, Seven World Trade Company - Silverstein Development Corporation, General Partner, have elected to construct a much larger building in both height and floor area. As a result, the designers have incorporated not only the existing foundations, but also some very different design parameters to those originally contemplated (see Figure 2).

STRUCTURAL FRAMING OVERVIEW

When one reviews the framing plans for Seven World Trade Center, one is left with the impression that it is two separate structures, one atop the other. From the 8th floor to the 46th, the floor plan is typical (see Figures 4 & 5). Long-span composite beams carry the loads from the core areas to the
perimeter, in conjunction with an electrified composite floor slab. Except for a belt truss between the 22nd and 24th floors, there is no bracing in this upper portion of the structure. All lateral loads are resisted by means of perimeter moment frames along all four exterior walls (see Figure 6).

From the 7th floor down, lateral loads are resisted by a combination of bracing and moment frames both in the core and around the perimeter (see Figures 7, 8, 9 & 10). The floor framing is similar to that for the typical floors above, except that formed slabs are utilized in portions of the structure in lieu of a composite deck, and an electrified floor slab is not used throughout.

Fifth Floor Diaphragm

Since caissons already existed on site, the designers incorporated them as part of the structure's foundations. However, the original structure contemplated in 1967 was much smaller in size than the one currently under construction. The smaller, lighter structure would require smaller caissons.

As a result, the 5th floor was developed into a diaphragm, by means of embedding T-sections within a 14 inch reinforced concrete slab (see Figures 11 & 12). Its purpose is to distribute the required loads equitably between new and existing caissons, eliminating the possibility of caisson yielding. In fact, this diaphragm is a dual system, with either the embedded T-sections or the reinforced concrete slab being capable of resisting the loads independently.

Consolidated Edison Substation

The Con Ed substation occupies a major portion of the site (see Figure 1.) The roof of the substation is at the same elevation as Seven World Trade Center's 3rd floor. With the size of floor plate under construction, it is inevitable that a number of framing members, especially columns, become attached to existing steelwork (see Figures 2, 8 & 9). Although the methods used were by no means revolutionary, they will be discussed later in the paper.

Pedestrian Bridges

In order that Seven World Trade Center be recognized as part of the main complex, it must somehow be linked to it. This link will be achieved by the construction of two pedestrian bridges. They will span 95 feet over the arterial roadway separating number Seven and the plaza from the structure's
3rd floor (see Figure 13). The larger of the two bridges, the Plaza Bridge, has a plan area of about 11,000 square feet. When completed, it will support a landscaped approach to the main entrance of the tower.

An additional, smaller pedestrian bridge is also being contemplated. At the time of the preparation of this paper, the only details available were that it would also span across the roadway, possibly be fabricated as a 100 foot long single box girder, and become enclosed within a stainless steel cylinder.

FABRICATION AND CONSTRUCTION

Introduction

The topics of fabrication and construction are usually considered as separate entities. The impact that each aspect has on the other, however, requires that they be considered jointly. The final in-place cost of a piece of structural steel, is the method by which their respective impacts are gauged.

When the cost of field labour, in New York city, is compared to Canadian direct shop labour costs, it becomes quickly apparent that economies must be achieved in construction. Although fabrication remains an important element, it is sometimes outweighed by construction as the key parameter to consider.

Connections - General

The selection of field bolting or field welding is a decision which varies from region to region. Many factors affect this selection: speed of one operation vs the other; climactic constraints at time of construction; available workforce; and, personal preference, are but a few such factors. Within our organization, we attempt to shop weld and field bolt wherever possible, as a general rule. Due to applied loads, joint geometries or material availability, situations do occur where field welding would be the least costly alternative.

As a standard beam-to-beam connection, we opted for the one-sided, single-shear plate. Although seated beam-to-column connections were used around the perimeter of the structure (see Figure 14), and some double-angle and end-plate beam-to-beam and beam-to-column connections were used in the interior, our standard connection allowed for quicker installations over the other solutions noted. This results from less time taken to manoeuvre a piece into position, combined with the need for fewer temporary bolts.

In order that we would not be penalized for selecting a one-sided, single-shear connection as a standard, the use of a 7/8" @ ASTM A325 bolt
was adopted for all interior floor framing connections. At perimeter and interior moment frames, column splices and bracing connection points, we elected to use 1" ø ASTM A490 bolts. This combination of diameter and connection type allowed us to reduce the number of fasteners required for the project, when compared to 3/4" ø ASTM A325 bolts commonly used.

**Moment Connections**

As was indicated earlier, lateral loads in this structure are resisted by a combination of perimeter and interior moment frames to the 7th floor, and by means of perimeter moment frames and a belt truss above (see Figures 6, 7, 8, 9 & 10).

Along the east and west elevations, the centre-to-centre column spacings are for the most part, less than 10 feet. This dimension falls well within an acceptable shipping maximum. As a result, column “trees” were fabricated at these locations. A column tree is a single tier column, with the perimeter beam made into stubs, prepared, and fully welded to the column flanges (see Figure 14). All field connections occur at the centre of the span between columns, requiring about one-half of the fasteners when compared to a bolted connection made at the column flanges. One-sided lap plates were used for both flange and web connections.

Along the north and south elevations, and within the core up to the 7th floor, the spans are in the order of 28 feet. At these locations, conventional moment frame construction was carried out (see Figure 14). Prepared top and bottom flange plates, and one-sided web shear plates were shop welded to column flanges. The beams are then slid into the connection from one side, and fastened by means of bolts.

**Column Splices**

Most of the columns on this project were not required to resist tension forces through their splices. This facilitated the use of American Institute of Steel Construction (AISC) standard bolted column splices which we located 3.5 feet above the floor (see Figure 16).

However, many of the columns, up to the 7th, were fabricated built-up sections incorporating a jumbo column shape (W14x455 to 730), and two plates, with thicknesses of up to 10 inches, welded between the flanges to complete the required cross-section (see Figure 15). Here, either a non-prepared connection was used, utilizing side plates shop welded to the column shaft below and field welded to the one above, or a partially prepared
upper shaft for field welding was provided (see Figure 16). In either case, temporary "rabbit-ear" bolted splices were also provided so that construction could continue without the necessity of completing the welded joint immediately (see Figure 17).

**Bracing Connections**

The majority of the bracing members are double shapes. Their connection to the structure was accomplished by means of a single gusset plate welded to either columns, beams or a combination of these two. The members themselves, were fabricated with intermediate spacers, so that they could be positioned easily (see Figure 18).

Where the forces were such that double members could not be efficiently substituted, or where architectural constraints governed, a single wide flange cross-section was used. These single members were connected to the structure by means of web and flange plates, similar to those used in the moment frames (see Figure 18). Along the east and west wall elevations, some of the members also reached jumbo column cross-sections. Since these members, especially diagonals, could not be easily handled in the field with large connection plates at one end, "nodes" were developed as a separate entity. These nodes incorporated the large connection plates, joining columns and bracing together (see Figure 19).

**Con Ed substation Roof Connections**

As was noted earlier, several column and floor framing members required attachment to the Con Ed substation (see Figure 2). The floor framing was attached by means of brackets, welded to the existing columns in the field. The base plates of the new columns were field welded to the tops of the existing Con Ed columns, once the reinforced concrete roof was locally removed. In order that any misalignments not affect either structure, column cover plates were field installed, boxing the section, and assisting in achieving an even bearing (see Figure 20).

**Shipping / Receiving Ramp**

The easterly quarter of the site contains a shipping/receiving ramp servicing the entire World Trade complex (see Figure 1). Due to truck clearances required along the north elevation, and the grade of the ramp itself, the first level to completely cover the ramp is the 3rd floor. The 2nd floor is hung from the 3rd, over a portion of the ramp (see Figure 1, unshaded portion south of ramp).
Since the floor framing spans the distance between columns located along each face of the ramp (see Figure 4), construction of this area was not a complicated matter. The sequencing of this portion is covered in the following section.

**CONSTRUCTION EQUIPMENT AND SEQUENCING**

**Introduction**

The Contract Documents clearly stated a preferred method of construction, as well as suggested equipment. Up to and including the 5th floor, structural steel and deck were to be erected by means of street cranes. Due to the sizes and weights of the members in this area of the structure, some up to 52 tons, the reach required to position these heavy pieces, and, the scheduling constraints, we elected to use two Manitowoc crawler cranes. The first, a 4100W with 60 tons of counterweight and a capacity of 200 tons; the second, a 4100W Series 2, with an additional 42 tons of counterweight and a 230 ton capacity.

From the 6th floor to the roof, the documents suggested the use of three or more guy derricks, or similar pieces of construction equipment. Upon a closer investigation of the parameters involved, it was decided that three guy derricks would adequately service the project. This resulted from: a lower initial cost or rental when compared to other equipment; less structural reinforcement, and only on every other floor; and, familiarity within the city of New York with the use of guy derricks in high-rise construction. All three derricks have 123 feet of mast, and 110 feet of boom. Two (derricks A & B), are 50 ton capacity American No. 4's, with the third being a 30 ton capacity American No. 3.

**Low-Rise Sequencing**

The two Manitowoc street cranes used initially on this project, were phased so that each could perform certain lifts within the structure. The larger capacity machine, remained to assist in the installation of the guy derricks, and to perform joint lifts with the center derrick. The first to arrive, and the last to leave the site, had the 230 ton capacity (crane A). The 200 ton capacity crane (crane B), arrived approximately two weeks after crane A had commenced erection.

The sequencing was as follows (see Figure 22):

1. Crane A erects the core area up to the 5th floor (area 1A), followed by
the floor framing south of the core to the perimeter, also to the 5th floor (area 2A).

2. Crane A moves to a location within area 3B, to erect area 3A. At this time, Crane B has come on site, and erects the westerly portion of the ramp steel the the 5th floor (area 1B).

3. Crane A moves onto the street adjacent to the east side of the site, to continue work over the ramp (area 4A). Due to the number of vehicles using this ramp on a daily basis, this work was scheduled on a weekend up to the 3rd floor.

While Crane A erects the 4th and 5th floors over the ramp, Crane B moves to the westerly street next to the site, and erects the west wall to the 5th floor, and fills in the block between 1A, 2A and the west wall (area 2B).

4. The 200 ton crane moves onto the southern street, and completes its work with area 3B.

5. Finally, Crane A situates itself on the northern street, and while reaching over part of the Con Ed roof, moves east to west completing area 5A. During this operation, the three derricks are installed on the 5th floor. It remains to assist the centre derrick in lifting eight 52 ton transfer girders (see Major Transfer Structures).

This sequencing allowed the construction of some 1700 pieces of structural steel, weighing a total 3,350 tons, the lifting of all required floor deck, and installation of the three guy derricks ready to receive steel, all within a three month period, start to finish.

A factor which has not yet been noted, is that within the Con Ed roof plan outside the Seven World Trade Center building line, are eight electrical transformers, each approximately 30 feet wide. Since the steel for a large portion of the structure must be lifted over these transformers, measures were taken to reduce the impact of small objects falling from above. The Construction Manager erected a falsework over this part of the Con Ed roof for this purpose (see Figure 20, upper photo, right-hand side). We, of course, exercised great care in lifting pieces over this area. The transformers were not a factor in erecting steel for the tower above the 7th floor, due to the location of our pick points (see Figure 23).
High-Rise Sequencing

Except for the erection of eight transfer girders and the 7th floor level, the three guy derricks erected all members from the 6th floor to the roof. The building was zoned into 18 divisions, with each derrick erecting approximately one third.

The equipment was situated in such a way, so as to allow the derricks to pass material back and forth, as well as reaching all portions of the structure within a derrick block. All three hoist engines were positioned along the south elevation on the 3rd floor, and were repositioned once to the 21st floor, where they will remain for the duration of the erection schedule.

The derricks are fed as shown in Figure 23. Usually, derrick A is the first to erect steel for a tier, followed on consecutive days by derricks B and C. When beginning a cycle, derrick A commences at the north-east corner of its block, erecting the north wall towards the west, then progressing south along the west wall. The areas to the north and to the east of the derrick are then filled in. This allows derrick B to start its cycle at its north-east corner as well, working towards the west. When it comes time to link steel, all columns and girders erected by the first derrick are now in position. Derrick C starts its cycle in a similar manner.

Within a short period of time, the three derricks have erected the entire north wall, from one end to the other, and a portion of the framing immediately to the south. Once aligned, this north wall serves as the datum to maintain all other columns within prescribed erection tolerances.

The erection of pieces continues in a pattern to allow each derrick access to its unloading point. This accomplished by utilizing a "U" pattern, which allows a portion of a wall to be left open, until all steel and deck have been received and hoisted for the tier in progress. Once the wall has been closed in, and a minimum amount of deck has been spread and welded to the framing, the derrick is "jumped" to the next tier.

Since a guy derrick is a relatively light piece of equipment for the function it performs, the reinforcement of the structural framing is minimized. In addition, the derrick jumps two floors at a time, thus, only half of the supporting beams need be considered for reinforcement. Out of the six framing members supporting the three derricks, only four needed reinforcement in order to carry the resulting forces. In lieu of reinforcing, we elected to replace these members with larger adequate cross-sections. Sitting atop the framing are four derrick beams, distributing the forces to the
structure, and assisting in the derrick jumps.

The normal practice used to connect the wire rope guys to the structure, is to wrap them around the appropriate beam-to-column connection. This practice results in a large number of openings left in the deck on each working floor. This is costly in terms of both time and money. As an alternative, we provided plates, shop welded between column flanges, at each location to which the guys were attached (see Figure 24). This not only allows the deck to proceed in an efficient manner, it also reduces the time taken to jump the derrick to the next tier.

Excluding lifts made for stairs and other trades, we achieved the erection of a typical tier, with about 600 pieces, plus the required lifts of deck, in a period of 7 working days. The jumping of each derrick took about 3-4 hours in the process. Table 1, provides an overview of the massing of the structure by areas.

<table>
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<tr>
<th>Floors</th>
<th>Approx. Area (ft²)</th>
<th>Steel Qty (tons)</th>
<th>(lbs/ft²)</th>
<th>(kg/m²)</th>
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</thead>
<tbody>
<tr>
<td>2nd - 5th</td>
<td>115,000</td>
<td>3,350</td>
<td>58.3</td>
<td>284.2</td>
</tr>
<tr>
<td>6th &amp; 7th</td>
<td>83,150</td>
<td>2,250</td>
<td>54.1</td>
<td>263.9</td>
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<tr>
<td>8th - 45th</td>
<td>1,579,850</td>
<td>18,900</td>
<td>23.9</td>
<td>116.6</td>
</tr>
<tr>
<td>46th - roof</td>
<td>91,000</td>
<td>1,200</td>
<td>26.4</td>
<td>128.8</td>
</tr>
<tr>
<td></td>
<td>1,668,000</td>
<td>25,700</td>
<td>27.5</td>
<td>134.2</td>
</tr>
<tr>
<td></td>
<td>(173 540 m²)</td>
<td>(23 315 tonnes)</td>
<td></td>
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</table>

**MAJOR TRANSFER STRUCTURES**

**Introduction**

In any structure of this magnitude, situations arise which can not be accommodated by "simple" framing methods. Complicating this situation for Seven World Trade Center, is a site, of which half is occupied by a substation, and a quarter by a ramp. Incorporating these two features, especially the substation, has resulted in some interesting solutions. This section does not attempt to review all of the transfer structures which have been incorporated into the project, but does cover the major transfers (see Figure 25).

**Trusses Nos. 1 & 2**

Truss No. 1 is located along a line in the north-east corner of the core area (see Figure 25). It is a two storey structure, between the 5th and 7th floors,
and is required as a result of a column arrangement above the 7th floor which does not match the location of columns tied in through the Con Ed roof. Thus, two columns terminate, as one begins (see Figure 26). The latter section, carries the load of some 41 levels to this two-dimensional truss.

In one plane, the truss consists of two jumbo column shape diagonals, forming an apex where the new column above begins. The diagonals are supported by a continuous column serving the entire building on the west, and by a double-web, 36.5 ton built-up girder on the east at the 5th floor. Tying this structure together at its base, between column and built-up girder, is another 22 ton built-up section.

The main feature of this truss is the 36.5 ton double-web girder. In order that the column connections be made easier, stubs were provided through the girder. This results in a column splice occurring both above and below the girder, at each end. The splices above are standard bolted splices, while the two below the girder have been partially prepared for field welding.

Truss No. 2 is also a two storey deep structure, located near the first (see Figure 25). It was constructed for the same reason, and is similar in appearance. However, the difference between the two is that both of the diagonals are connected directly to columns. At each column, a large node has been provided since both the diagonals and the built-up tie girder are field welded.

**Truss No. 3**

At the westerly end of the core area, is another two storey deep transfer structure between the 5th and 7th floors (see Figure 25). Truss No. 3 also transfers the loads from columns above to columns below. The difference between this and the other two trusses, is that the upper column shaft is not supported between the locations of the two lower shafts. The new upper column also carries 41 floors of load, but is "hung" to one side (see Figure 27). The loads are transferred by a two bay wide series of bracing, back to the foundation columns.

The truss system was fabricated in five main pieces, so that it could be erected utilizing its two support columns. The diagonals between, were provided with erection connections in their webs, and fully prepared flanges for subsequent field welding.
Transfer Girders

There are a total of eight transfer girders located between the core area and the north elevation at the 7th floor. Their purpose, is to transfer the building column loads above the 7th, back to a line of building columns through the Con Ed substation roof, a distance of 6'-9 (see Figures 2, 20 & 25). In addition, they form part of a truss along the north elevation between the 5th and 7th, which transfers other column loads.

The girders weigh a total of 420 tons (52 to 52.7 tons each, 52.4 tons average), span 46'-0 from core to supports, and cantilever an additional 7'-7 from the centre of support to their ends. At one end, they are 9'-0 deep, at the other, 4'-6 deep, with a transition in between (see Figure 28).

Due to their physical parameters, and to the fact that they were erected over the line of transformers in the substation, their installation was specially engineered as a tandem lift between the 230 ton Manitowoc street crane, and the centre 50 ton guy derrick.

The erection procedure was as follows:

1. The street crane lifts the girder alone and rests the deeper end on a falsework tower (see Figure 28).

2. While the girder is supported by the crane and the falsework, the centre derrick is attached to the girder near the shallow end transition (see Figure 29).

3. In Tandem, the street crane and derrick manoeuvre the girder into its final position (see Figure 30).

4. The girder is secured by tying it into previously erected framing.

This procedure was repeated for each of the eight girders, averaging from 30 to 45 minutes to complete. At most, three girders were positioned in one day, which included filling in the framing between.

CLADDING CONNECTIONS

The granite cladding for the structure is being mounted on pre-fabricated trussed for attachment to the building. The designers have developed a three-point system in order to accomplish this attachment; one for gravity loads, and two for wind (horizontal) loads. The system takes into account the
contract tolerences for column plumbness, and has been made typical for a major part of the structure.

The gravity load brackets are fabricated stiffened bent plates, with an 11.5 inch outstanding leg as a typical dimension. In the centre of the outstanding leg, is a 5.5 x 11 inch notch, which accommodates not only the end members of the truss, but can also accommodate up to 4 inches column movement from theoretical, in each direction (see Figure 31).

The top and bottom wind ties consist of an angle and a channel shape welded to the column flanges, respectively. Slotted holes are provided in these members to allow for vertical adjustments. Horizontal adjustments are accommodated by the granite trusses themselves.

**CLOSING COMMENTS**

When completed, Seven World Trade Center will become the final phase of a well-known complex in lower Manhattan. Its red granite facade, when viewed with any backdrop of neighbouring buildings, will enhance its impressive stature. Enclosing 1,868,000 square feet on 47 floors, and with a 635 foot overall height, it becomes the largest companion to the twin towers of the World Trade complex.
CONSTRUCTION TEAM

OWNER / DEVELOPER
Seven World Trade Company, Silverstein Development Corp., General Partner

CONSTRUCTION MANAGER
Tishman Construction Corp. of New York

DESIGN ARCHITECT
Emery Roth & Sons, P.C.

STRUCTURAL CONSULTANT
The Office of Irwin G. Cantor, P.C.

MECHANICAL/ELECTRICAL CONSULTANT
Syska & Hennessy, P.C.

STRUCTURAL STEEL FABRICATORS
Frankel Steel Limited & Steel Structures Corp

STRUCTURAL STEEL ERECTOR
Steel Structures Erection, Inc.

STEEL DECK ERECTOR
A.C. Associates

STEEL DECK SUPPLYER
Nicholas J. Bouras Inc.

CONCRETE FOUNDATIONS
Thomas Crimmins Construction Co.

CONCRETE SUPERSTRUCTURE
Century Maxim Construction Corp.

PRE-FABRICATED WALL CLADDING
FEI Limited
Figure 2 – Foundations


Con Ed Substation
Figure 3 – Seven World Trade Center
Figure 6 – High-Rise Lateral Load System

Belt Truss: 2C10 x 33; 2C15 x 33.9 & 50; or 2WT5 x 56 diagonals.
Perimeter Moment Frames: W36 girders; W14 columns.
Figure 7 – Low-Rise Lateral Load System
North Elevation
Girders - W36x210-300
Diagonals - 2C15x50

South Elevation
Girders - W36x210-300 & 2C15x50
Diagonals - 2C12x30, 2C15x50 & 2WT6x68

Transverse Elevations (4)
Girders - W24x76 & 2C15x50
Diagonals - 2C12x25 & 30,
2C15x33.9 & W14x426

Figure 8 – Core Elevations
Figure 9 – Core Bracing
Figure 10 – End Wall Elevations
Figure 12 – Fifth Floor Diaphragm Details
PG1 & 2: 26\" x 6\'-3 x 490 plf; PG3: 8\" x 6\'-3 x 375 plf
W21x44 & W18x35 beams, W14x193 columns
Cross-frames (----) top-bott. bracing L3x3

Figure 13 - Plaza Bridge
Figure 14 – Moment Connections
Figure 15 – Built-Up Columns
Figure 16 - Column Splices
Figure 17 - Temporary Column Splices
Double Members

Single Members

Figure 18 – Bracing Connections
Figure 19 – Bracing Nodes
Figure 20 - Column Cover Plates
Figure 24 – Guy Derrick Column Connections
Figure 26 - Truss No.1
Figure 27 – Truss No. 3
Figure 28 - Transfer Girder Initial Lift
Figure 29 - Tandem Lift
Figure 30 - Final Positioning
Figure 31—Granite Truss Brackets

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