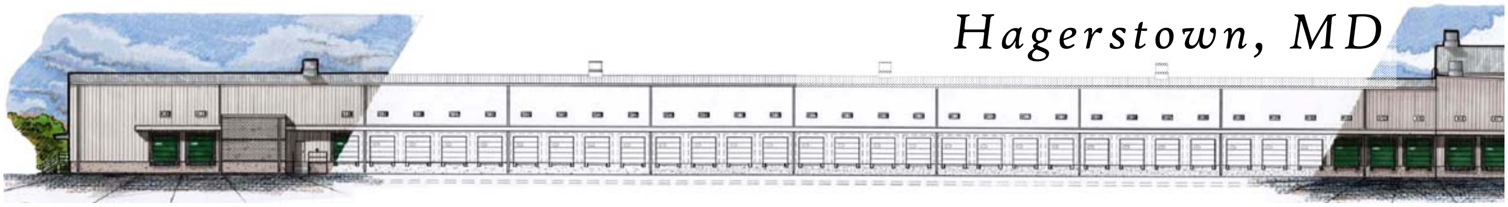
FedEx Ground Distribution Hub

Hagerstown, MD



Construction Management Senior Thesis

2005

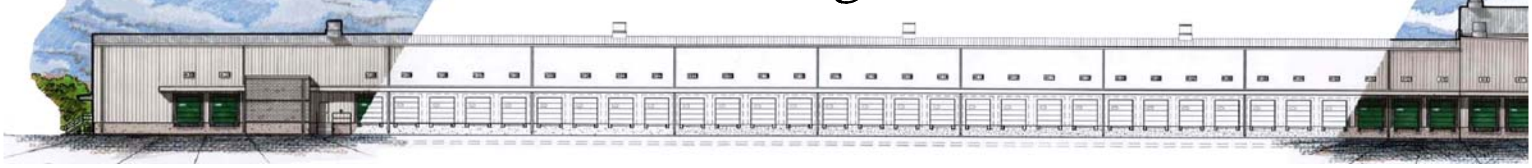
by Lucas Klock

FedEx Ground

The Pennsylvania State University
Architectural Engineering Department

FedEx Ground Distribution Center

Hagerstown, MD



OWNER
~ FedEx Ground ~

ARCHITECT / ENGINEERS
~ The Osborn Engineering Company ~

PRIME CONTRACTORS
~ Gilbane Building Company ~
~ Butler Construction ~
~ HK Systems Uhs ~

ELECTRICAL SYSTEM
- (2) ~ 15kV transformers with 480/277V at 2500 kVa
- Main Distribution Switchboard: 4000A, 480/277V, 3Ø, 4W
- (1) ~ Diesel powered emergency generator with an output of 480/277V, 3~phase at 250kVa
- (2) ~ 18kVa Uninterruptible Power Supplies:
- Static uninterruptible power supply will be three phase, on~line, static~type, complete with transient voltage surge suppression and input harmonics reduction

LIGHTING SYSTEM
- Site lighting consists of 15, 1000W, 480V metal halide lighting fixtures plus 8, 400W, 480V metal halide light fixtures
- Interior lighting consists of high pressure~sodium lamps with an auxiliary, instant on, quartz system

PROJECT STATISTICS
- Lot Size: 114 Acres
- One main structure with five additional outbuildings
- Main Building Size: 475,000 s.f.
- Est. Project Cost: $75,000,000
- Delivery Method: Multiple Prime
- Actual Begin: Oct. 1, 2003
- Fully Operational: 2006

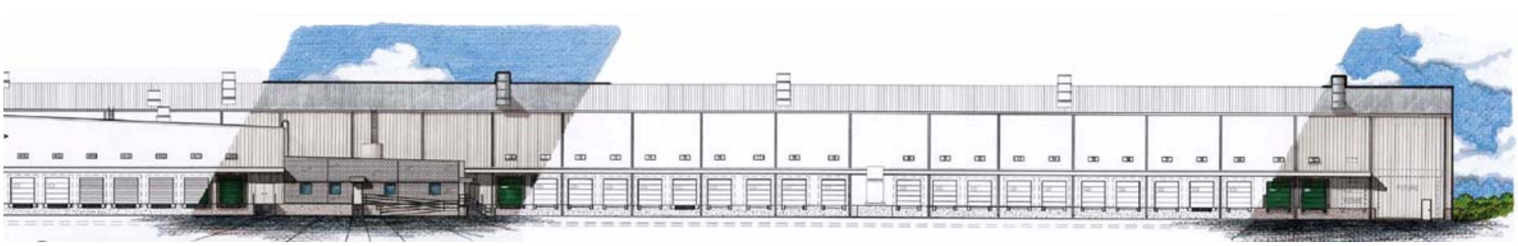
STRUCTURAL SYSTEM
- Foundation system utilizes both continuous and isolated footings
- 4000 psi slab~on~grade installed in the unload / load areas, corridor and local city area
- Pre~engineered steel structure
- Service platform utilizes ADA compliant steel grating in conjunction with slab~on~deck

CONVEYING SYSTEM
- State of the art conveying system will be designed and installed by HK Systems

PROJECT BACKGROUND
As part of a $1.8 billion network expansion plan to nearly double average daily hub package volume capacity in North America, FedEx Ground, an operating unit of FedEx Corporation, has chosen a 114~acre site in Hagerstown, MD as the location for a new 475,000 square~foot distribution hub to be opened by 2006.

The site for the new Hagerstown hub was chosen for its proximity to customers' distribution centers and major highways as well as its access to a strong local employee base. The facility will initially process about 30,000 packages an hour and is expected to house a workforce of 400 full~ and part~time employees and independent contractors when it opens in 2006. At full capacity, the new hub will process up to 45,000 packages per hour and could employ more than 1,000 workers.

FIRE PROTECTION SYSTEM
- Fire suppression system is a dry pipe system including a mechanical smoke exhaust system with heat vents and draft curtains.
- Smoke detection system includes photoelectric detectors, ionization detectors and duct smoke



Lucas Klock
Construction Management
www.arche.psu.edu/thesis/2005/lok101

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THESIS INTRODUCTION

1.1. *Executive Summary*

The following report is a key component of an Architectural Engineering senior thesis project at The Pennsylvania State University. Thesis is a comprehensive study and analysis of a recent or on going construction project. The initial assessment occurred during the fall 2004 semester, involving the analysis of existing construction conditions, analysis of key construction features, and alternate system methods and analysis. The spring segment of the thesis project is focused on the development and analysis of key construction issues.

As part of a $1.8 billion network expansion plan to nearly double average daily hub package volume capacity in North America, FedEx Ground, an operating unit of FedEx Corporation, has chosen a 114-acre site in Hagerstown, Maryland as the location for a new 475,000 square-foot distribution hub to be fully operational by 2006. The high tech distribution facility will cost in excess of $100,000,000. The chosen project delivery method is multiple prime which divided the project into a general trades package, superstructure package, and a conveying system package.

As per FedEx Ground's request, analyses have been developed to investigate the use of a tilt-up concrete wall system in lieu of the pre-engineered exterior wall structure. These analyses will focus on the construction management aspects of the project by analyzing the feasibility, adaptability, cost and schedule impacts of a tilt-up wall system. Additionally, an advanced model of the distribution facility will be developed in order to facilitate the communications between the owner and future contractors.

Ultimately, analysis has proven that the proposed tilt-up wall system is feasible and the corresponding structural components are easily adapted to accept the tilt-up system. Overall project costs will increase by approximately $845,000 without extending the current project schedule. To demonstrate the diversity of Pennsylvania State University architectural engineering students, a structural analysis was performed on a tilt-up panel during the lifting process.

Existing Construction Conditions

2.1. *Executive Summary*

FedEx Ground Distribution Hub in Hagerstown, Maryland is a small piece of a billion dollar network of distribution hubs to be built across the United States. The Hagerstown Hub is a 475,000 sq. ft. distribution center which will cost approximately $100 million to complete. The site is located at 16730 Halfway Boulevard, Hagerstown, Maryland. Hagerstown was chosen for its accessibility to contractors, availability of local labor, and access to major shipping routes. Local site conditions are going to be very challenging, requiring approximately 1,000,000 cubic yards of excavation through various types of clays and rock.

FedEx Ground chose Osborn Architects/Engineers as the primary architects and engineers. In order for FedEx Ground to receive the best price for construction, the project has been divided into 3 separate bid packages which include: Sitework and General Trades, Structure and Enclosure, and Conveying Systems. FedEx Ground prefers a multiple prime organizational structure with a minimum of three bidders per work package. This project will take approximately 20 months to complete, starting with ground breaking in October of 2003 and full operation by 2006. There are 7 milestone dates, some with liquidated damages and incentives, associated with the schedule to support in the completion of the project on time.

The structural system chosen for this project is a pre-engineered steel structure and the enclosure system was developed and installed by Butler Construction. Gilbane Building Company is responsible for the general trades and sitework package, while HK Systems is responsible for the conveying systems.

The major building systems are basic in nature except for electrical and telecommunications systems because these systems are the backbone of a highly efficient distribution hub. In order to prevent potential complications with these systems, there have been redundant systems built into the design of each. Over specified/engineered systems have been designed and installed in the main building for future expansion.

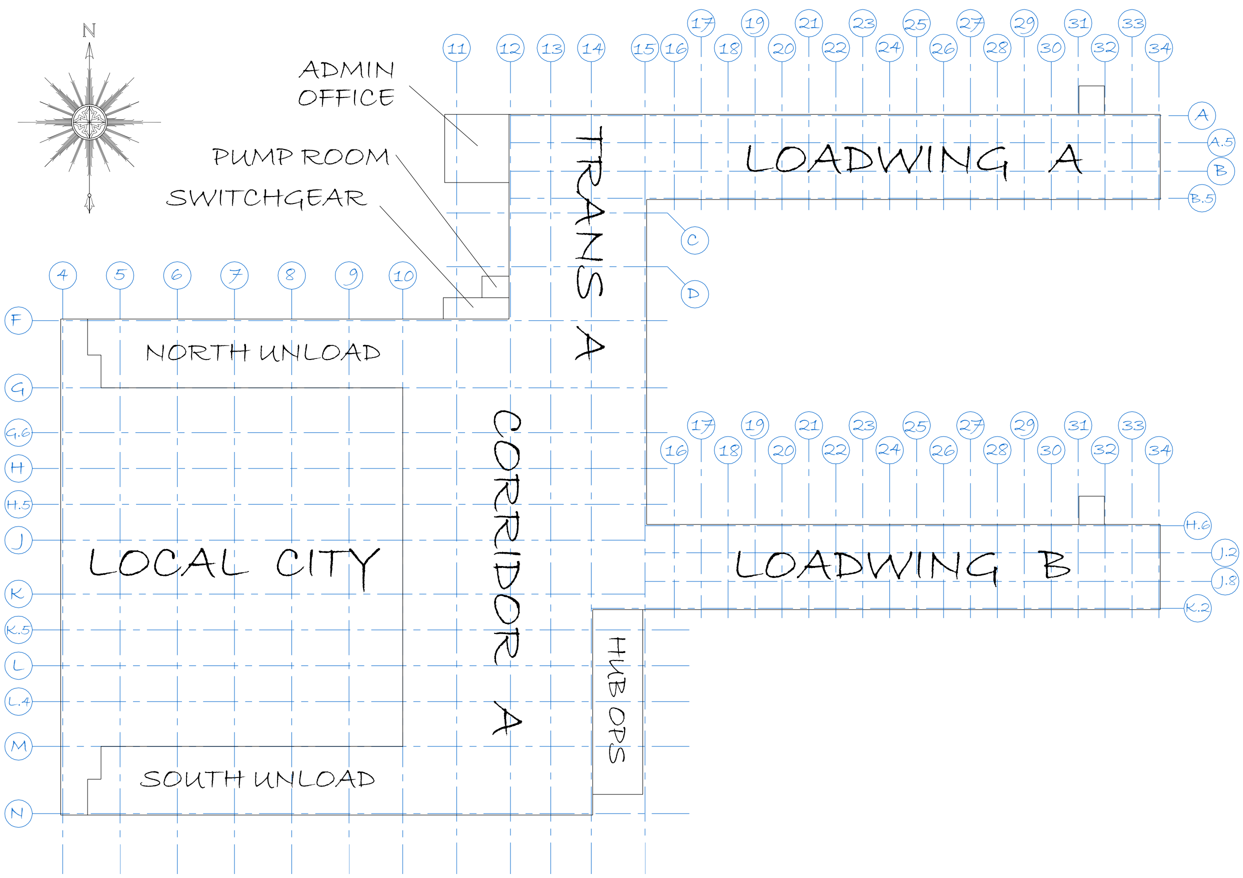


Figure 1: FedEx Ground Distribution Center

2.2. *Project Delivery System*

The project delivery method for the project is complex. FedEx Ground is in the process of building two identical structures as part of a pilot program for their future network of distribution hubs. FedEx Ground's intentions are to construct the two buildings simultaneously while utilizing the identical sets of plans, drawings, and specifications. This strategic approach is intended to increase the number of people whom review and correct the drawings ultimately yielding a master set of plans and specifications that will be used to streamline construct of the remainder of the distribution facilities.

FedEx Ground has developed a competitive bidding process, which is primarily used on their construction projects. FedEx Ground requires a minimum of three bidders for each bid package developed within a project. The Hagerstown Distribution Hub was divided into three separate bid packages: site development and general trades, building structure / enclosure, and conveying systems. The building structure / enclosure and conveying system contracts are lump sum and the general trades and site development bid package is cost plus a fee with lump sum general conditions.

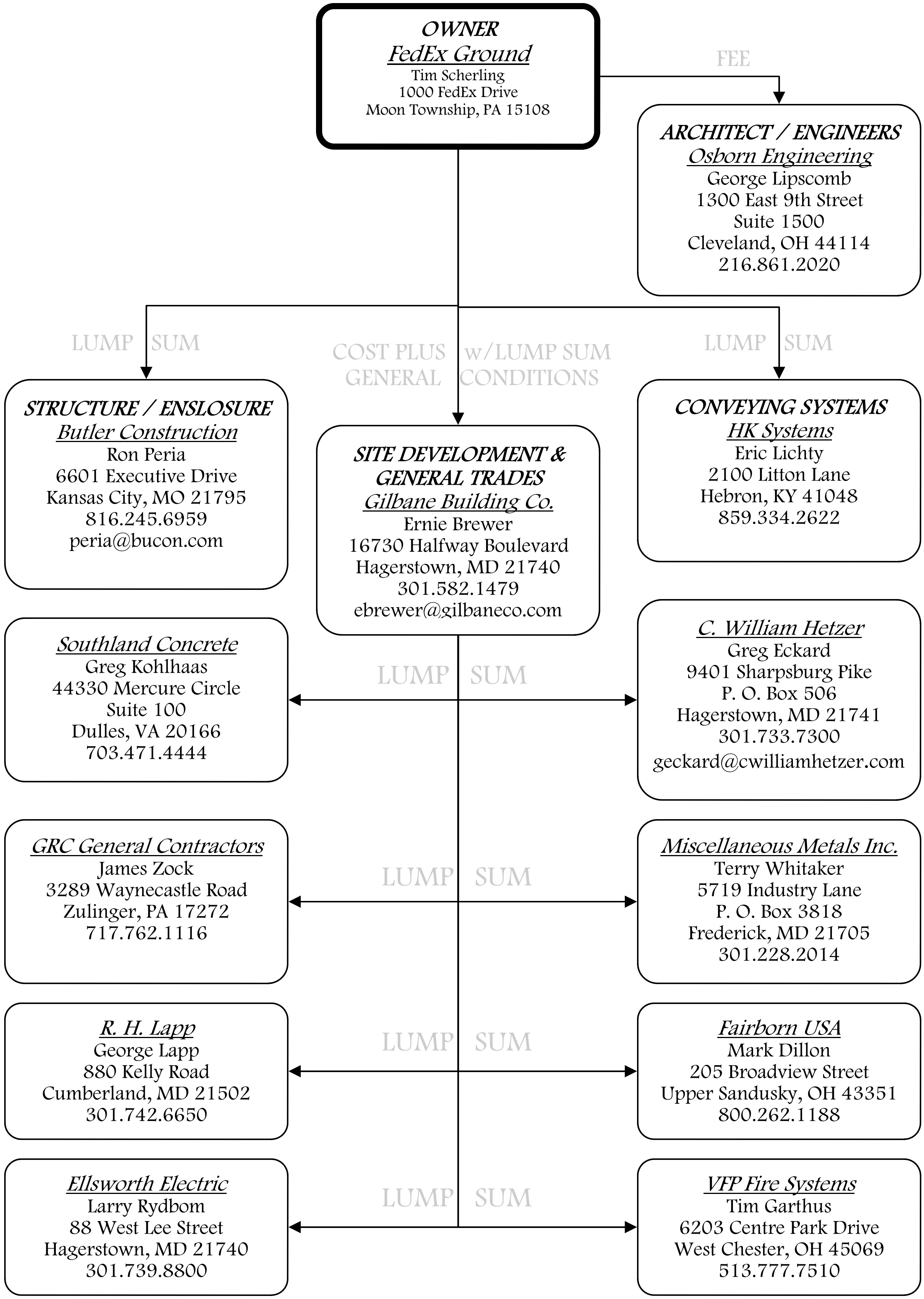


Figure 1: Project Organizational Chart

2.3. *Project Schedule*

The construction schedule for this project is unique due to the massive area the building covers. The building is divided into several smaller more manageable areas. See appendix A for a detailed construction schedule of the FedEx Ground Distribution Hub.

STRUCTURE

Initially, mass excavation takes place first followed by the concrete contractor. Within the building structure, all of the column footings are formed and placed while simultaneously preparing all of the conduits and underground components. Once the column footings reached the target strength, the steel erectors will begin erecting the superstructure. When all of the underground work is completed in an area, the concrete contractor prepares for installation of the concrete slabs. During the steel erection phase, additional erection crews were installing Skyweb, insulation, and metal roofing. A finishing crew followed behind them installing roof curbs, gutters, and downspouts.

GENERAL TRADES

The main areas of the building were finished as they became available, but the office areas were closely monitored because of the close work conditions and accelerated schedule. Initially the masons were in the area first and laid the necessary block. If the office were on the exterior of the building, a roofing crew installed the steel joists and bituminous roofing. Once the area was water tight, the general trades' contractor followed the masons, installing all of the electrical and HVAC distribution equipment, plumbing, metal studs and framing, and drywall. Prior to wall enclosure, an enclosure inspection was completed and photographs were taken in order to document that all of the specified systems and equipment were installed as per project specifications. Upon completion of the walls, the general trades contractor would paint, install flooring materials, install all lighting and electrical outlets/fixtures, and plumbing fixtures.

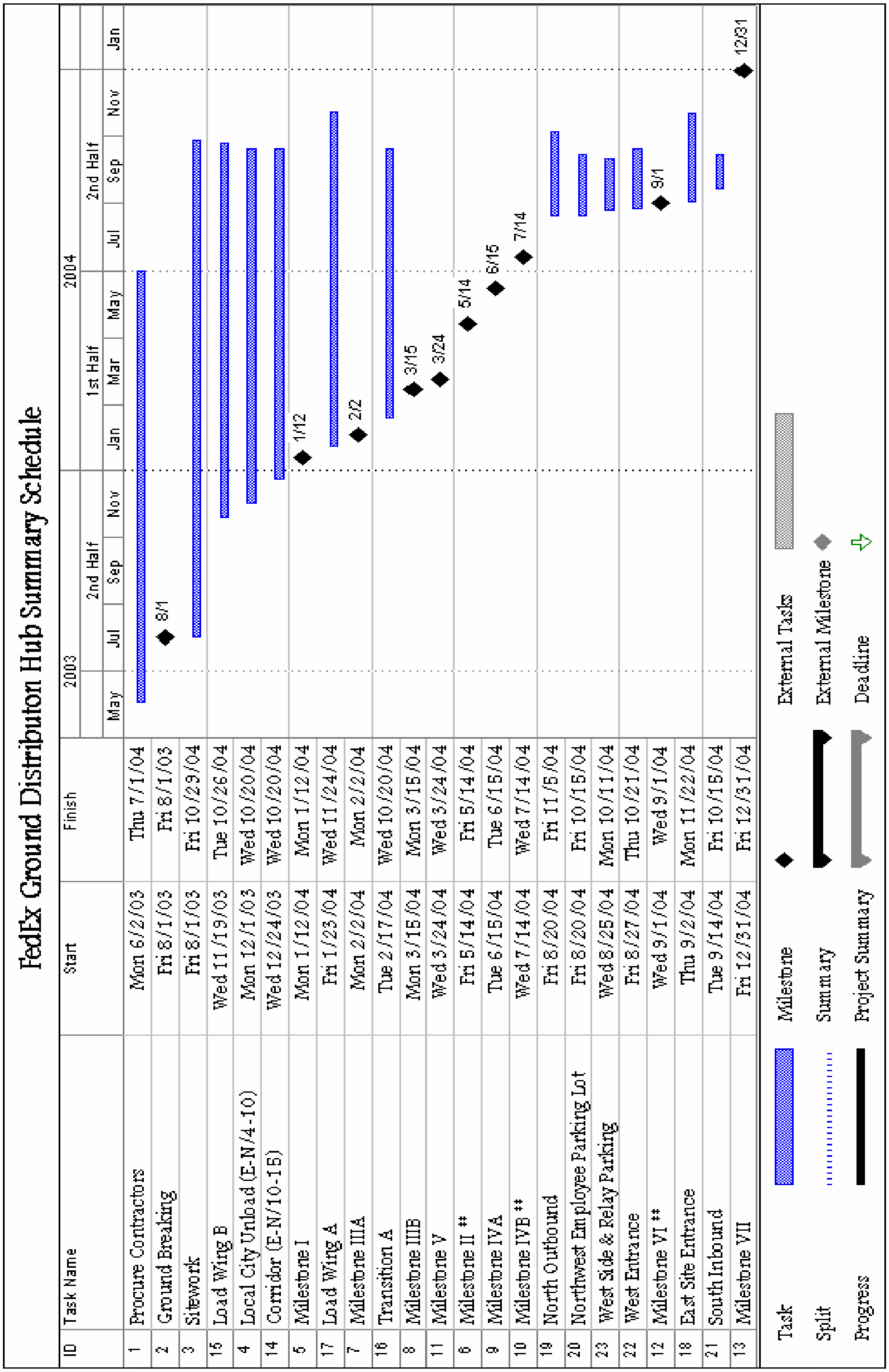


Figure 3: FedEx Ground Distribution Hub Summary Schedule

MILESTONE DATES

Milestone	Definition	Date
I	Local City / Unload Wings - Ready for Butler Column Lines 4 to 10 and E to N	1/12/04
II **	Local City / Unload Wings - Ready for MH Column Lines 4 to 10 and E to N	5/14/04
III A	Corridor - Ready for Butler Column Lines 10 to 15 and E to N	2/2/04
III B	Loadwing B - Ready for Butler Column lines 15 to 34 and K.2 to H.6	3/15/04
IV A	Corridor - Ready for Material Handling Column Lines 10 to 15 and E to N	6/15/04
IV B **	Loadwing B - Ready for Material Handling Column lines 15 to 34 and K.2 to H.6	7/14/04
V	Loadwing A - Ready for Butler Column lines 12 to 34 and A to E	3/24/04
VI **	Loadwing A - Ready for Material Handling Column lines 12 to 34 and A to E	9/1/04
VII	Project Completion except for Conveying Systems	12/31/04

** Liquidated Damages and Incentives are associated with these Milestone Dates.

2.4. *Building Systems Summary*

STRUCTURAL FRAMING

Type of Bracing – All connections are moment connections. Girders have been installed for horizontal bracing and diagonal braces have designed into the system as wind braces.

Composite Slab – None

Type/Size of Crane – (2) 100 ton mobile cranes and (1) 200 ton mobile crane

Location of Crane – varies

CAST IN PLACE CONCRETE

Horizontal Formwork Type – stick built formwork, metal deck/grade

Vertical Formwork Type – stick built formwork

Placement Method – direct chute, pump, crane and bucket, power buggy

MECHANICAL SYSTEM

Mechanical Room Location – None

System Type – Co-Ray-Vac and roof mounted mechanical units

Types of Distribution Systems – Radiant heat

Types of Fire Suppression – dry pipe system with pre-action sprinkler heads

ELECTRICAL SYSTEM

Size – Main distribution, 480/277V, 3Ø, 4W

Capacity – 4000A

Redundancy – Two redundancy systems will be installed in the main building: a diesel generator and two uninterrupted power supply systems. Also, future plans are designed for two independent service feeds to the building.

MASONRY

Load Bearing – varies

Veneer – Trendwyth Trendstone Plus, Colors: Manchester and Ravenstone

Connection Details – free standing with masonry ties

Scaffolding – hand built and jack scaffolds

2.5. *Project Cost Evaluation*

CONSTRUCTION COSTS

Projected Building Cost = $22,000,000 Cost / SF = $46.32

* excludes mechanization equipment, distribution equipment, land costs, sitework, permitting, etc.*

TOTAL PROJECT COSTS

Total Project Cost = $32,000,000 Cost / SF = $67.36

* excludes mechanization and distribution equipment*

DESIGN COSTS

Due to the nature of the project, design costs are not able to be determined. Typically the design cost is approximately 8% of the total project cost.

Total Project Cost = $32,000,000 Design Cost = $2,560,000

* Design Cost shown above does not represent the actual design cost for this project *

BUILDING SYSTEM COSTS

Building systems costs are confidential as per Gilbane Building Company's request.

This estimate was developed using D4 cost estimating software.

	CSI Division	%	Sq. Ft. Cost	Projected Cost
01	General Requirements	8.07	4.05	1,923,918
02	Site Work	0.00	0	0
03	Concrete	13.41	6.73	3,195,536
04	Masonry	1.45	0.73	345,264
05	Metals	15.16	7.61	3,613,092
06	Wood & Plastics	0.14	0.07	33,524
07	Thermal & Moisture Protection	4.35	2.18	1,037,250
08	Doors & Windows	2.40	1.2	572,059
09	Finishes	9.06	4.55	2,160,128
10	Specialties	0.99	0.49	234,922
11	Equipment	0.97	0.49	230,676
12	Furnishings	0.16	0.81	40,213
13	Special Construction	0.00	0	0
14	Conveying Systems	0.00	0	0
15	Mechanical	16.59	8.33	3,955,324
16	Electrical	11.25	5.65	2,682,385
D4 Total Building Costs		**84.00**	**$42.24**	**$20,062,351**

SQUARE FOOT ESTIMATE USING R.S. MEANS

Reference: R.S. Means Construction Cost Data (2004), 62nd Annual Edition

Assumptions:
1. Building Type: Warehouse and Office combination
2. Median unit cost data was used: $47.00/sf
3. Size Modifier: 15.00 ∴ Cost Multiplier = 0.90
4. Location Adjustment = 0.881 (weighted average)
5. No adjustment was taken for time

Calculation:

Building Size		475,000 sf
Cost per Square Foot	x	$ 47.00 /sf
Unadjusted Total		$22,325,000
Location Adjustment	–	$2,232,500
Size Adjustment	–	$2,656,675
R.S. Means Total		**$17,435,825**

Estimate Comparison

Several estimates of the FedEx Ground Distribution Hub were compiled using various available resources which include: D4 Cost estimating software and R.S. Means Construction Cost Data. Differences in the building cost estimates can be significantly affected by many factors such as environmental conditions, economic factors and owner specified constraints.

	Sq. Ft. Cost	Projected Cost	Variation From Projected	Deviation From Projected
D4 Cost Estimate	$42.24	$20,062,351	$1,937,649	8.81%
R.S. Means Estimate	$36.71	$17,435,825	$4,564,175	20.75%
Projected Building Cost	$46.32	$22,000,000		

D4 Cost estimating software used the smart average of three warehouse and distribution projects. These projects were chosen for their simplicity in structure, electrical and mechanical systems. The estimated square footage was adjusted to 475,000 resulting in an approximate project cost of $20,062,351. This estimated cost was within approximately 9 % of the projected building cost. The difference between costs cannot be attributed to sitework because sitework was taken out of the D4 estimate. This difference could be a resultant of economic conditions such as the current increase in steel and concrete costs. Also, this project is fast-tracked and the structure is to be turned over to the owner within 12 months. Fast-tracking a project such as this can contribute to increased projected building costs.

R.S. Means Construction Cost Data for 2004 was used to perform another estimate which yielded a deviation of over 20 %. This method of estimating a project is only applicable for the building itself. Specialty systems within the building such as redundant electrical systems and fiber optic data communication systems are not included. Also, economic factors and owner constraints are not accountable. The same factors that affected the D4 estimate are also viable reasons for the difference between the R.S. Means value and the actual projected cost.

2.6. Site Plan of Existing Conditions

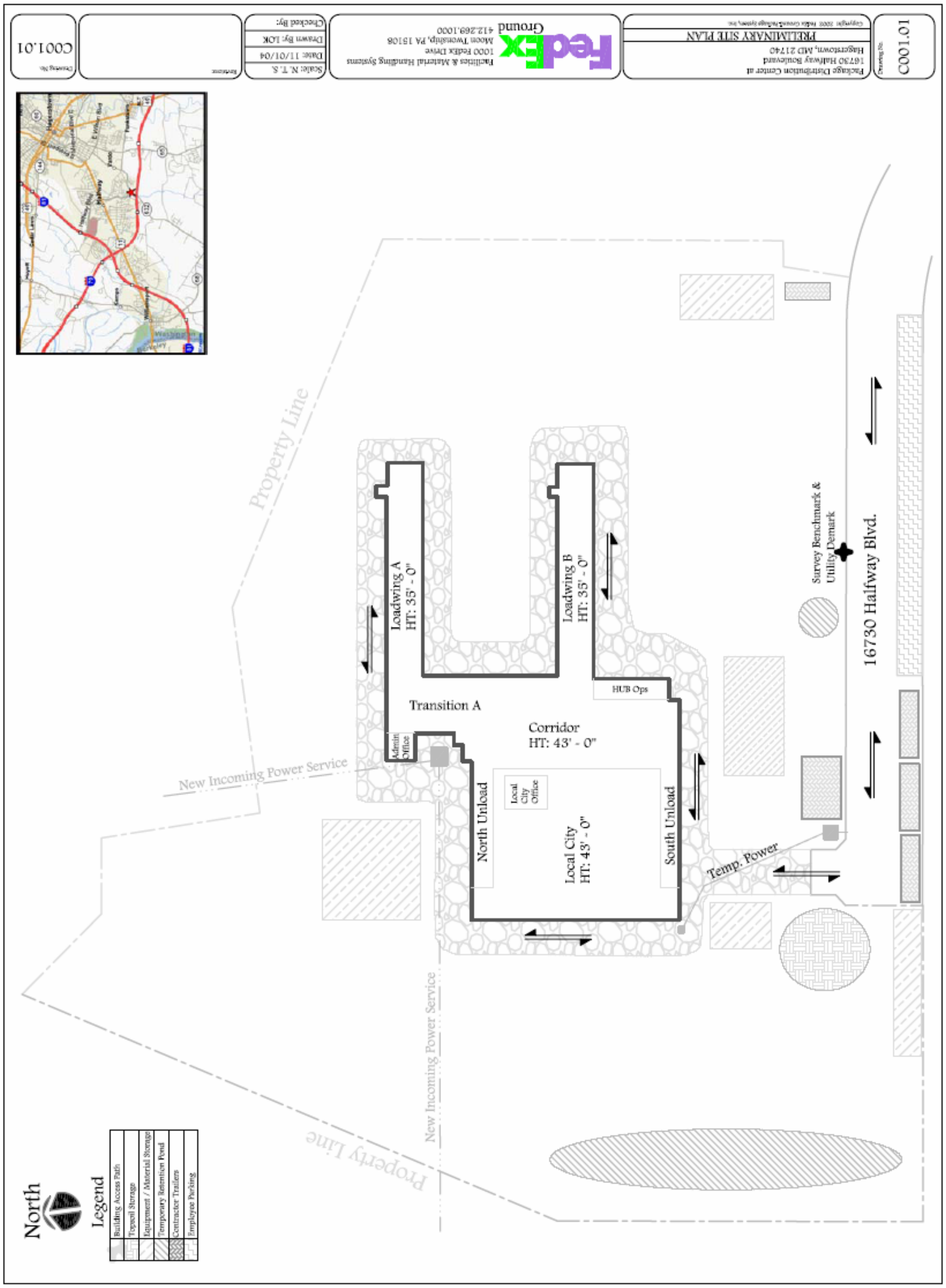


Figure 4: Initial Site Utilization Plan

2.7. *Local Conditions*

The future site for the distribution center is located at the I-70 / I-81 interchange in Hagerstown, Maryland. This is a typical trucking route for commercial vehicles. Initially there was access to the site via Halfway Boulevard due to future planning. The 114 acre plot was obtained from Tiger Developers. Initially the site was zoned as agricultural and will be rezoned to commercial use.

Along Halfway Boulevard, parallel to the site, there is ample parking. The road currently is a dead end until New Gate Road is constructed. Within a half mile of the site is an AC&T truck stop with waste removal and recycling capabilities large enough to service the construction site during full operation.

The labor conditions in the Hagerstown area are very rich resulting in a surplus of available contractors, laborers and materials. The majority of the subcontractors of are within 50 miles of the jobsite and the construction equipment and materials are readily accessible.

Figure 5: Initial Site Conditions

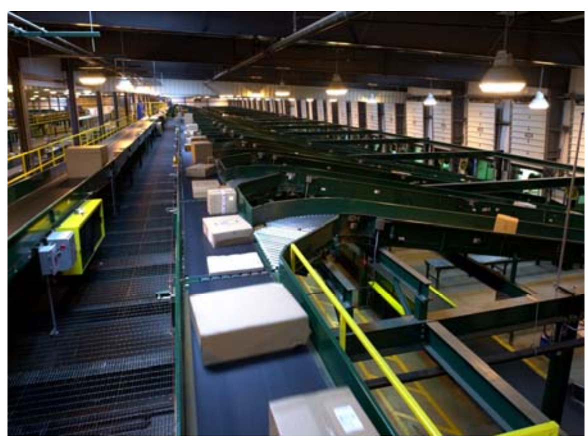
An initial geotechnical engineering study was conducted by Hillis-Carnes Engineering Associates. The exploration principal exploration method consisted of 83 Standard Penetration Test (SPT) borings.

General site geology in Hagerstown consists of a parent bedrock formation which includes limestones of the Rockdale Run Formation. The topsoil generally ranged from 4± to 12± inches in thickness. The majority of the borings identified decomposed rock which as determined by the depth of augur refusal. The average depth of refusal was determined to be approximately 6 feet below the existing surface. Between the rock and topsoil layers, the soils identified ranged from low-plasticity clays to sandy silt materials of varying densities. The existing groundwater table was approximately 18 feet below the surface.

2.8. Client Information

FedEx Ground is a subsidiary company of FedEx Corporation, comprised of FedEx Ground US, International and FedEx Home Delivery. FedEx Ground is currently North America's second largest small-package carrier, with an extensive network of pick-up and delivery terminals located throughout, providing business-to-business and residential deliveries within the United States, Mexico and Canada.

As part of a $1.8 billion network expansion plan, the Mid-Atlantic region was targeted by FedEx Ground for its rich concentration of manufacturers and businesses. FedEx Ground has chosen the 114-acre site in Hagerstown, Maryland for its accessibility to major interstates as well as access to a strong local workforce. The facility will initially process about 30,000 packages an hour and is expected to employee more than 400 employees in 2006. At full capacity, the new hub will process up to 45,000 packages per hour and will possibly employ over 1,000 workers. The new 475,000 square-foot distribution hub is scheduled to be opened by 2006.



The fully operational distribution hub will cost approximately $100 million and will take about 20 months to complete. The skeleton of the building is pre-engineered metal structure which is a low cost alternative to a design build system. In order to reach the 20 month, fully operational, goal, the building will have to be completed in 12 months including all major sitework. To ensure the building is constructed in a timely manor, there are seven major milestone dates, three with liquidated damages equal to $5000 per day. Quality is not a major concern for the main distribution center due to the nature of the operations which will be taking place within the facility but the office and customer service areas require higher standards. In order to maintain quality standards initially set by FedEx Ground, a full time representative is onsite, continuously observing daily operations.

ANALYSIS OF KEY CONSTRUCTION FEATURES

3.1. *Executive Summary*

Analyzing the key construction features of a project is necessary for completion in a timely manner within the specified budget. The project schedule within this section, is an accurate schedule of general trades activities throughout the building during construction. Since there are intermediate milestone dates with associated liquidated damages of $5000 per day, it is imperative to closely monitor and update the general trades schedule.

An Assemblies Estimate has been developed for the substructure and foundation system. The total estimated cost, including materials, labor, and overhead required to complete the scope of work, is approximately $2.5 million. The accuracy of this type of estimate is plus or minus 15 %. This estimate is helpful to the owner, when trying to develop an initial budget during the design phase of construction.

There are several contract types held by FedEx Ground with several entities on the distribution hub project. Contract types range from cost plus a fee to lump sum to strictly fee based. Due to the nature of a multiple prime hierarchy, Gilbane holds contracts with all general trade contractors in order to improve the integration of the contractors. Gilbane's management staff were hand selected for this project due to intense coordination of trade contractors during construction. The overall experience of the team is well suited for this project, offsetting the limited number of management personnel assigned to the Hagerstown project.

Annually, Penn State University hosts the PACE Roundtable Seminar, were industry members, faculty and students gather to discus leading industry issues. This year's theme is "Innovation and Leadership in Changing Construction Markets". The ideas and opinions are expressed by all parties are recorded and examined over the next few month. In the spring of the following year, PSU hosts a PACE Research Seminar in order to discuss research findings of the faculty and students.

3.2. Assemblies Estimate

Brief Overview

A fast and effective estimate needed for the planning phase of a project is a "Systems" or "Assemblies" estimate. The Assemblies method is a sequential approach to estimating, which represents how the building is to be constructed. One great advantage of an Assemblies Estimate is the ability to substitute one system for another during design development with the ability to quickly determine the cost difference between the two systems. An Assemblies estimate does not require much detail, but estimators must have a solid working knowledge of construction materials and methods used. An Assemblies Estimate is best used as a budgeting tool in the planning stages of a project because the accuracy of the estimate is typically plus or minus 15 %.

Foundation Assemblies Estimate Summary

	Concrete Required (CY)	Local In-Place Cost ($/CY)	Total Cost	Cost per Sq. Ft. ($)
Column Footings	3,087	$250	$771,785	$1.62
Column Piers	206	$300	$61,880	$0.13
Wall Footings	236	$250	$59,110	$0.12
Walls	417	$300	$125,131	$0.26
Slab on Grade	7,639	$200	$1,527,778	$3.22
Total Foundation & Substructure Cost			**$ 2,545,683**	**$5.36**

Assumptions

The Hagerstown Hub is currently in construction, rendering an Assemblies estimate non-feasible. The design of the foundation system and the site conditions led to the non-typical column and pier footing shapes. These shapes are not in the assemblies estimating book. The load design of the footings was not available making an Assemblies Estimate extremely difficult. Industry members were contacted and a more useful estimate was developed using local in-place costs. In-place costs include all labor and materials required to complete the specified task

3.3. *Design Coordination*

MEP Coordination

According to each contractor's contract with Gilbane, the contractor will provide and maintain a project schedule in accordance with the general conditions section of the specifications. Phasing of the work shall be constructed in such a manner to satisfy the milestone requirements of the contract documents.

During construction Gilbane is responsible for conducting construction coordination meetings. Attendees shall include Gilbane, superintendents or project managers from all subcontractors working on site, the testing laboratory, and owner's representatives. By contract these meeting shall be conducted as a minimum of once every two weeks. Due to the fast-tracked nature of the project, Gilbane conducts contractor coordination meetings once a week. Meeting minutes will be taken by Gilbane and published within three business days. Special Meetings shall be conducted as required in order to ensure the timely completion of the work.

Coordination Challenges

The Hagerstown Distribution Hub is a large distribution center containing minimal MEP systems. There are no defined mechanical rooms, but there are several offices located within the main distribution facility. The administrative and local city offices contain very intensive electrical and telecommunication systems. As the offices are enclosed all of the MEP subcontractors need access to each of the areas. Coordination efforts in these areas have been increased in order to maintain the project schedule and to keep the subcontractors busy. Since the drawings are not as well developed as desired, there are an increased number of coordination issues that need to be addressed in the field.

MEP Coordination Enforcement

To counteract the increased number of laborers and subcontractors on site, Gilbane placed two highly experienced superintendents on the project. Both of the senior superintendents track the progress of the subcontractors. If any problems arise in the field, a meeting takes place to address the problem as quickly and efficiently as possible in order to maintain the project schedule. Gilbane holds contracts with all of the MEP subcontractors in order to assist in the enforcement of coordination efforts.

Current MEP Field Conflicts

One major field conflict has developed due to the delayed of the superstructure erection. Many of the subcontractors are behind their proposed schedules as developed prior to the beginning of construction. Extra coordination efforts are in place to address the increased coordination of subcontractors in the office areas. A strict schedule of each conflict area has been developed and is updated daily in order to monitor the work efforts. To enhance the efficiency within the office areas, select subcontractors have offset work hours to reduce the number of laborers in a work space at any given time.

3.4. *Critical Industry Issues*

The PACE Roundtable Meeting is an annual event in which industry members, students and faculty members join together to discuss leading issues plaguing the construction industry. This year's theme is "Innovation and Leadership in Changing Construction Markets". Interactive sessions were held throughout the day focusing on topics such as Integrated Design Management I – The Role of the CM in Design, Integrated Design Management II – Constructability and VE in Design, and Leadership Jump-Start for Entry Level Employees.

The Role of the CM in Design

One of the key motivators for construction managers as part of the design team is due to the reduced quality of construction drawings and specifications. There is a continuously declining trend to minimize Architect's design fees. Reducing the fee for architects causes a multitude of problems to occur such as reduced construction details and limited number of responses to RFI's. Many Construction Managers are finding themselves developing solutions to engineering problems and producing construction details which are to be utilized in the field. CM firms are finding themselves purchasing Errors & Omission Insurance on projects.

The CM role on this project is a direct result from reduced design fees. FedEx Ground is trying to save money by reducing Osborn's design fee, resulting in several hardships. The current construction drawings have been compiled from two similar projects developed by two different design firms. The integration of both sets of construction drawings were intended to develop a master set, which will be used to reproduce this building several times. One problem with the current drawing set is the over engineering of select systems. One of the projects was in designed for a facility in Texas, where there is a large factor of safety for uplift of the building due to tornados and strong winds. Money was not allotted for Osborn to redesign the uplift component of the structural system resulting in an extremely over-engineered system, which has increased construction costs due to additional labor and material.

Another problem that has occurred is the number of Requests for Information (RFI's) that will be answered. FedEx Ground is simultaneously constructing two identical buildings in an effort to reduce architect's fees. The number of RFI's being asked has increased significantly due to the multitude of people looking at the construction drawings. Osborn has set a maximum number of RFI's that will be answered. As a result, many of the RFI's are being answered by the CM firm.

Constructability and VE in Design

Value engineering (VE) and constructability are closely related on many projects. Constructability reviews are usually conducted after a set of drawings is released. Value engineering efforts are cost cutting ideas or reductions in scope. Value engineering is divided into two subcategories: cost savings and value added. Typically to add value to a project, select systems, typically mechanical or HVAC, are analyzed and Life Cycle Costs and Return on Investment costs are evaluated for alternate systems. Determining these costs will help owners and engineers choose systems, which will be both energy and cost efficient.

The collegiate definition of value engineering is increasing the value of a system without increasing project costs. I was surprised to discover that owners and CMs analyze the construction drawings and specifications, trying to discover "low hanging fruit". Low hanging fruit was described as something that was blatantly obvious such as cable tray specifications. Recently, a project manager saved an owner several thousand dollars on cable trays. The cable trays specified for a central telecommunications room was the same type and size as a single cable that needed to run over one thousand feet. Over three thousand feet of cable tray was reduced to accommodate the single strand of LAN cable resulting in cost savings of several thousand dollars per run. I was amazed to discover that architects and engineers are not developing systems that are the most efficient but systems that are the easiest to draw. Architects are supposed to act on behalf of the owner not themselves.

Value engineering and cost savings are the responsibility of the owner, architect, construction managers, and sub-contractors. Ellsworth Electric, the electrical subcontractor on the project, continuously analyzes equipment and devices before installation for over engineering or over specification. Many architects are unaware of identical or comparable products. Ellsworth Electric is responsible for saving FedEx Ground several thousand dollars.

Cost reduction alternatives have been developed and implemented by Gilbane. The continuously rising price of steel has been negatively affecting many projects. As a cost savings idea Gilbane suggested fiber reinforced concrete to be substituted for steel reinforced concrete. The availability of fiber reinforced concrete was a plausible alternative to steel reinforced concrete, which saved vital project time and reduced the overall project costs.

Site Planning And General Conditions Estimate

4.1. *Executive Summary*

The pre-construction phase of a project is one of the most critical aspects related to the success of a project. There are several key elements that need to be analyzed prior to mobilization, such as Site Logistics and Planning, Temporary Utilities requirements, and General Conditions Estimate.

Gilbane Building Company is acting as the overall site coordinator and logistics planner. The excavation plan is critical on this project due to the massive amount of excavation. The superstructure and finish logistics plans are based upon the milestone schedule developed by FedEx Ground. Coordination throughout each phase is critical and all contractors are responsible for settling minor coordination issues while Gilbane is responsible for the overall coordination of trade contractors.

The availability or unavailability of temporary utilities has an impact on the constructability of the distribution facility. Gilbane is responsible for procuring and maintaining basic requirements such as dumpsters, chemical toilets, and site safety and signage. The Hagerstown site is undeveloped and Tiger Developers will not have any utilities available to the site until approximately 50% completion of the project.

The development of a general conditions estimate is related to the potential profit on a project. Gilbane has a lump sum general conditions contract which dictates the amount of funds are available for unforeseen costs and conditions. The estimated general conditions cost for the general trades portion of the project will be approximately $1,000,000.

Research is the key driver for the majority of the preliminary research and investigations. The findings help to develop plausible thesis research ideas such as: Virtual Prototyping and Structural System Substitution will be developed, analyzed, and compiled for future reference.

4.2. *Site Layout Planning*

Excavation Plan

Refer to appendix B for an excavation site plan. The Hagerstown site contains about 1,000,000 cubic yards of excavation. The red region depicts regions that need to be removed and the blue represents fill areas, darker regions designate a greater cut or fill depth. The total differential in excavation elevation is approximately 70'. In order to expedite the construction of the foundation system, the building footprint and access areas are excavated first. The main building excavation will begin in the southwest corner of the building and will work toward the north east corner. During all phases of construction a travel path must be maintained due to the direction of the local fire marshal. The work flow of the cut area started near the middle of the site and extended toward the western property line and similarly, the fill started from approximately the middle of the site and worked toward the western property line. Excavation will continue throughout the majority of the project duration and dust control will be mandatory for the excavation contractor to maintain. See appendix B for a preliminary excavation site plan.

Superstructure Plan

Refer to appendix B for a superstructure plan. The superstructure workflow will follow the completion of the foundation system. The slab-on-grade areas will be poured after the erection of the structural system in order to allow access for cranes. Large sections of the roof were constructed on the ground allowing workers easier access and control. Two 200 ton mobile cranes were used to lift the heavy sections into place. Another 200 ton mobile crane was used to lift and place steel members ahead of the roof structure. The cranes were able to travel through the building's foundation system along with the access path around the structure. Materials were staged behind the cranes as they moved throughout the site, reducing the pick and swing time. Once the structural system was substantially complete, the erection crew began installing the roof insulation, decking and water runoff system. Lastly, the exterior skin and trim will be installed. See appendix B for a preliminary site plan.

Finish Plan

The building was divided into phases according to milestone dates set forth by FedEx Ground. Primary work flow directions are indicated on the preliminary finish trade plan, but due to the large number of laborers within the building some trades will start at various locations through out the areas and weekly contractor coordination meetings will be conducted. During this phase of construction, clean-up is mandatory and two laborers will be provided in order to assist in the clean-up initiative. See appendix B for a finish site coordination plan.

4.3. *Temporary Utilities*

Temporary utilities for the superstructure of the building have a large impact of the erection of the structure. The following are some of the general requirements the overall project as well as the superstructure phase of the project.

Access Roads

Access to the site is critical on almost all construction sites. This project in particular has excavation continuing through out the majority of the project. As part of the excavation bid package, the contractor must maintain an all-weather temporary stone access road suitable for tractor-trailer traffic from the beginning of material handling till the completion of the permanent pavement. As per fire code, a temporary access road around the perimeter of the main building must be maintained at all times during construction till the fire suppression system is installed and operational.

Water

Temporary water is not available to the site, so each contractor must pay for their own water consumption during the project. Due to the increased cost and slow installation of temporary water by the local authorities, Gilbane has provided temporary water for the contractors to use on the project.

Electricity and Lighting

The electrical contractor shall provide all circuit and branch wiring including distribution boxes for the main distribution facility. The electrical contractor shall also provide electrical service to their own on-site trailer and the owner's trailer. Lighting will also be provided by the electrical contractor according to local code.

Telecommunications

All telecommunications are the responsibility of the contractor, including the installation and payment for services rendered.

Toilet Facilities and Rubbish Removal

These services are necessary in order to maintain a clean and safe work environment. These temporary services are provided and maintained by the general contractor on site.

Barriers and Signage

Barricades are required by the owner in order to maintain site safety and to deter unauthorized personnel from entering the site. This temporary requirement is to be provided and maintained by the general contractor.

Field Offices

Maintaining an adequate field office is an essential task related to onsite construction. The field office is the headquarters for the superintendent and must accommodate the necessary field personnel, project documents, job meetings, and construction drawings. The field office must be furnished, finished, equipped, and conditioned in addition to required office equipment such as: heat, wiring, telephone, fax machine, and copy machine. Gilbane and the Owner's representative are sharing a double wide trailer which will contain security filing cabinets for construction documents, private offices for each of the management staff furnished with desks and chairs, drawing table, drawing rack and other support equipment.

4.4. *General Conditions Estimate*

Description	Duration	Unit Cost	Projected Final Cost	% of Estimate
Field Labor				
Project Manager	Project	$125,000	$125,000	12.37 %
General Superintendent	Project	$115,000	$115,000	11.38 %
Project Engineer	Project	$105,000	$105,000	10.39 %
Office Engineer	Project	$60,000	$60,000	5.94 %
Assistant Officer Engineer	As Needed	$12,500	$12,500	1.24 %
Sub-Total			$417,500	41.32 %

Description	Duration	Unit Cost	Projected Final Cost	% of Estimate
Regional Labor				
Project Executive	Project	$15,000	$15,000	1.48 %
Home Office Overhead	Project	$50,000	$50,000	4.95 %
Sub-Total			$65,000	6.43 %

Description	Duration	Unit Cost	Projected Final Cost	% of Estimate
On-Site Support				
Field Office				
On-Site Trailer	Project	$20,000	$20,000	1.98 %
Field Office Setup	Project	$8,000	$8,000	0.79 %
Office Furniture	Project	$5,000	$5,000	0.49 %
Trailer Maintenance	14 Months	$750	$10,500	1.04 %
Electric, Water, Sewer	14 Months	$250	$3,500	0.35 %
Stationary & Supplies	14 Months	$500	$7,000	0.69 %
Postage & Shipping	14 Months	$2,000	$28,000	2.77 %
Fax Equipment	Project	$1,000	$1,000	0.10 %
Telephone Equipment	Project	$1,500	$1,500	0.15 %
Telephone Service	14 Months	$750	$10,500	1.04 %
Computer Equipment	Project	$10,000	$10,000	0.99 %
Fractional T-1 Access	Project	$10,000	$10,000	0.99 %
Copier and Supplies	14 Months	$12,500	$175,000	17.32 %
Software				
Prolog	Project	$3,500	$3,500	0.35 %
Sure Trek	Project	$1,500	$1,500	0.15 %
Blueprinting	Project	$25,000	$25,000	2.47 %
OSHA Safety	Project	$1,500	$1,500	0.15 %
Job Travel & Mileage	Project	$5,000	$5,000	0.49 %
First Aid Supplies	Project	$1,000	$1,000	0.10 %
Small Tools	Project	$2,500	$2,500	0.25 %
Sub-Total			$330,000	32.66 %

Site Services				
Chemical Toilets	56 Weeks	$500	$28,000	2.77 %
Project Signage	Project	$1,500	$1,500	0.15 %
Rubbish Removal	56 Weeks	$1,500	$84,000	8.31 %
Permitting	Project	$25,000	$25,000	2.47 %
Field Office Security	14 Months	$500	$7,000	0.69 %
Fire Extinguishers	Project	$3,500	$3,500	0.35 %
Project Vehicle	Project	$35,000	$35,000	3.46 %
Fuel & Maintenance	14 Months	$1,000	$14,000	1.39 %
Sub-Total			**$198,000**	**19.59 %**

LUMP SUM GENERAL CONDITIONS COSTS	**$1,010,500**	**100.00 %**

Figure 6: General Conditions Estimate for the FedEx Ground Distribution Facility

Advanced Modeling

In

Construction

5.1. *Analysis Overview*

In the construction industry, design and modeling tools add unparalleled value to construction projects. As buildings grow in size and complexity, there is increased need for advanced modeling tools and techniques. The FedEx Ground Distribution center is part of a billion dollar network of distribution hubs to be built across the U.S. and advanced modeling could prove to be beneficial to the overall efficiency and productivity of the project. As the modeling techniques advance from 2D drawings to Building Information Models, the ability to visualize the construction process and to develop useful information from the models increase.

As an owner of a distribution facility, the cost and schedule of the project are primary concerns, but as a project increases in size and the construction schedule is accelerated, the amount of required coordination increases. The FedEx Ground Distribution facilities are currently constructed and coordinated from a set of 2D drawings. Developing a basic 3D model of the foundation and structure would enable the construction management team to increase the effectiveness of overall communications between all project members. Due to the high repeatability of the distribution facility, the effectiveness of advanced models would prove to be beneficial.

5.2. *Basic Modeling Overview*

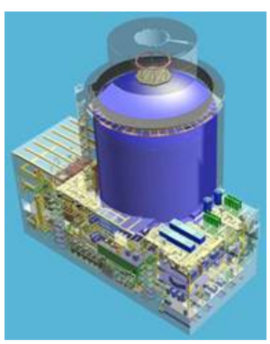
Building modeling is an integral part of construction, and developing useful models is integral to the success of a project. Basic modeling begins as 2D drawings and progresses to 4D models, which include time as a fourth dimension. Size, building complexity and available funding are some of the key determining factors for choosing the amount of modeling for a project.

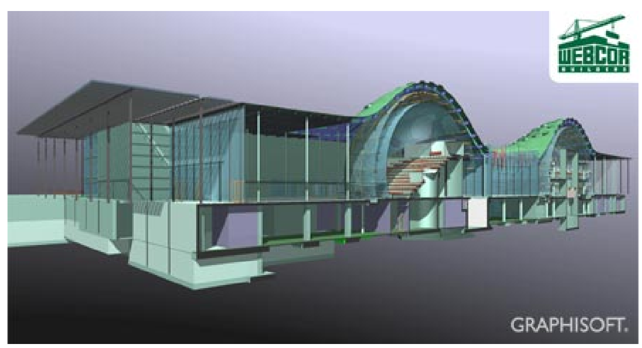
2D Drawings

As the need for advanced modeling techniques advances, two dimensional drawings are the backbone for the majority of construction projects. 2D drawings are simple, easy, and fast to develop. Over the past 30 years there have been significant advancements in 2D drawing applications, but there are several inefficiencies such as misalignment of drawing elements and incorrect dimensioning which plague the construction world. These inefficiencies lead to poor communications between architects and field personnel, lost time fixing incorrectly installed building components, and increased project costs.

3D Models

As buildings become more complex, 3D modeling is a necessity for improving contractor trade coordination. 3D models allow users to develop a better understanding of how buildign systems are integrated together and conflicts within the building systems are easier to identify during the modeling process. Developing these models can be very time consuming and cost more than 2D drawings, but the long term benifints from utilizing a 3D model will outweigh the disadvantages.

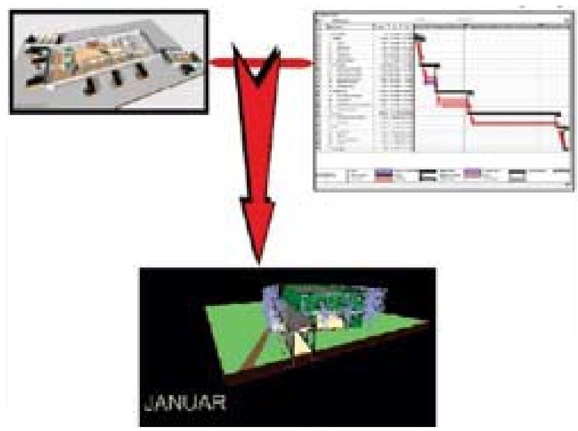




4D Models

4D models focus on visualizing the construction process over the life of the project. The two basic elements of a 4D model is a critical path schedule and a 3D CAD model. Combining these two elements together, results in a 4D model which provides project planners with the ability to visualize the construction sequence resulting in potential savings of both time and cost over 2D drawings. 4D models help project members to:

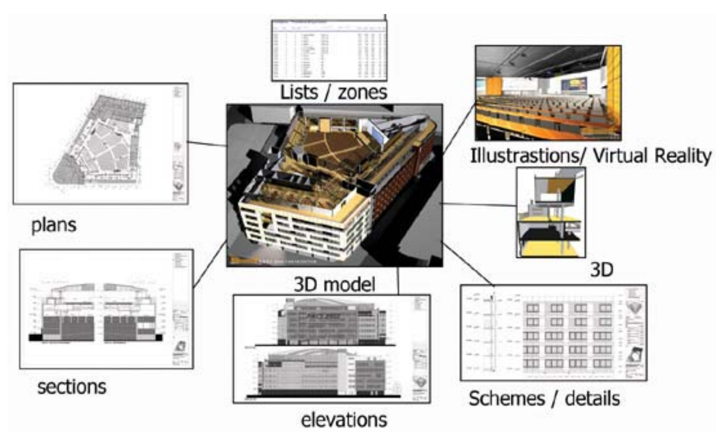
- Understand the relationship between construction activities
- Understand the use of work areas, access, and staging areas over time
- Identify and improve spatial relationships between trade contractors
- Improve overall communication between other project members



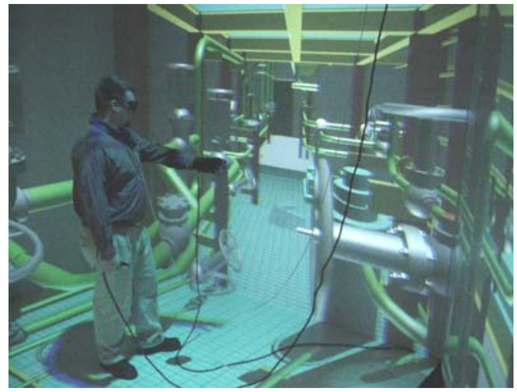
5.3. *Advanced Modeling*

B U I L D I N G   I N F O R M A T I O N   M O D E L I N G   (B I M)

Building information models are essentially advanced 3D model that includes information about the elements within the model. The model is constructed using parametric elements which carry essential information with each element such weight, shear and moment capacity for steel members, lumen output and density for light fixtures, and other detailed information about furniture and fixtures. BIMs are also able to keep track of objects such as rooms, components, fixture, and equipment, not only through the design and construction phase but throughout the life of the project. If a BIM model was developed using Industry Foundation Classes (IFC), then the model can be used for consistency checks, quantity takeoffs, collision detection, energy analysis, environmental hazard studies, and 4D visualization models.



VIRTUAL PROTOTYPING



Through the advancement of computer technology and modeling ability, virtual facility prototyping is gaining increased recognition throughout the building industry. Virtual prototyping utilizes 4D or BIM models and adds the ability for designers, construction personnel and owners to view the project at a one-to-one scale in a virtual reality environment. Although a virtual prototype model requires a lot of time and effort, highly complex projects can fully appreciate the benefits of viewing the facility prior to construction. Virtual prototype models can be extremely beneficial for users and maintenance personnel to help identify areas problem areas such as the incorrect placement of a valve or control locations. Theses types of models are currently being developed for nuclear power plants, off-shore oil rigs and other highly complex facilities which have very little or no tolerance for errors in design.

5.4. *FedEx Ground Distribution Facility Model*

The development of useful models is important in the construction industry. Different modeling applications result in very diverse results. Autodesk Revit is a building information modeling application. Using a component based modeling tool allows users to develop highly integrated models. Two models have been developed for the distribution facility, one using Autodesk Revit and the other using Autodesk AutoCAD 2004. Even though there are many uses for advanced models, the distribution facility model was primarily created to illustrate the visual differences between modeling applications. The models would also prove to be helpful during coordination meetings and design review session, but the use of a model has to be a collaborative effort of all members of the construction team in order to utilize the full potential of advanced modeling. See appendix C for pictures and illustrations of various modeling applications.

5.5. *Conclusion & Recommendation*

Choosing the appropriate amount of modeling for a project can be a difficult task. There are many elements that need to be considered while choosing modeling tools. Cost is typically one of the primary factors that owners use, while field personnel value communication and trade coordination aspects of drawings and models to be highly valuable. Developing advanced models such as building information models (BIM) are slowly becoming popular. The development of BIM models allows designers to alter one model which will correlate the information to the building schedules, quantity takeoffs, and construction drawings. For smaller, less complex projects simple 2-D drawings are quicker and easier to develop while more complex or repeated projects can utilize the benefits of advanced modeling techniques.

The simplicity of the distribution facility does not warrant the development of advanced models for the structural, mechanical or electrical systems. The size of the facility allows for minor field changes without requiring system redesign, but the conveying system is highly complex where errors can slow construction while increasing costs. Developing a 3D model of the conveying system would allow designers and FedEx Ground to identify conflicts between structural elements and conveying equipment prior to final placement.

TILT-UP PLANNING

&

ANALYSIS

6.1. *Tilt-Up Construction Overview*

The following section has been developed for FedEx Ground and other owners in order to provide a basic overview of the feasibility, pre-planning and constructability of a tilt-up project. Providing the owner with sufficient knowledge about tilt-up construction will allow them to make a sound decision when choosing or comparing structural systems.

TILT-UP BACKGROUND INFORMATION

Tilt-up received its name from the method of constructing the vertical surfaces. Initially, concrete panels are formed horizontally and set (tilt-up) into their final position. The major cost savings comes from using concrete slabs as casting surfaces, reducing the need for extensive formwork. This method of construction has been utilized for over 50 years in the United States and is commonly found throughout the world. Tilt-up construction is primarily used in low rise structures but is not limited to only single story buildings. Buildings range in size from 5,000 s.f. homes to over 1,600,000 s.f. warehouses and distribution facilities. Tilt-up construction is limited only by the equipment placing the panels. Figure 7, illustrates examples of the most extreme uses of tilt-up construction.

Description	Building	Attribute
Largest Building (Footprint)	IKEA Distribution Center	1,704,748 sq ft
Largest Building (total floor area)	Eddie Bauer Distribution	1,750,000 sq ft
Largest Wall Area (including windows)	Old Navy Distribution Center	1,400,000 sq ft
Most Panels (single building)	El Paso County Detention Facility	1,310 panels
Most Panels (entire project)	El Paso County Detention Facility	1,300 panels
Largest Panel	Carson-Tahoe Replacement Hospital	2,742 sq ft
Tallest Panel	Seven Rivers Presbyterian Church	92' - 10 3/4"
Heaviest Panel	Distribution Center (Ontario, Ca)	310,000 lbs
Widest Panel	City Kia	69' - 3 1/4"
Tallest Cantilever Wall	Pearson Education / Rockefeller Group	52' - 4"
Largest Spandrel Panel	Public Safety Building (Orlando, Fl)	74' - 0"

Figure 7: Top 10 Tilt-Up Examples

TYPES OF TILT-UP PANELS

Non-insulated

Non-insulated panels are standard reinforced concrete panels. These panels are efficient and can be used under various loading conditions. Typically, non-insulated panels are used as retaining walls, barriers, and general enclosures that would hide items such as dumpsters and generators. These panels vary in size from 4" upwards of 10" depending on their intended use.

Insulated

Insulated panels are primarily used in colder climates or in cold storage facilities where heating or cooling costs are substantial. There are several ways of achieving an insulated tilt-up panel. One of the easiest ways to insulate the panels is to apply a rigid insulation or to install a furring system with batt insulation. Another method of creating insulated panels is to embed the insulation within the panel. "Sandwich" panels consist of two layers of concrete separated by a typical 2" layer of rigid insulation. These "sandwich" panels take advantage of the insulation while providing the durability of a standard tilt-up panel. As a load bearing panel the typical panel is comprised of an exterior wythe of concrete approximately 1 ½" to 2". The interior wythe of concrete varies from 4" up to 12" depending on the load requirements and is tied to the exterior wythe of concrete.

6.2. *Feasibility Review*

Determining the feasibility is the first step in planning a tilt-up building. Ideally, the perfect tilt-up building would be a large warehouse with basic highly repeatable walls where there would be ample room to form and cast the panels. Additionally, there should be enough room for the delivery, movement, and storage of materials. Figure 9 below illustrates some of the key questions that need to be analyzed prior to choosing tilt-up construction.

	Yes	No
Are the exterior surfaces essentially flat ?	☒	☐
Do they make up at least 50% of the total wall surface ?	☒	☐
Will most of the wall panels rest on the foundation as opposed to elevated lintel panels ?	☒	☐
Will most of the wall panels overall height be less than 30 feet ?	☐	☒
Can there be highly repeatable panels, in order to improve the efficiency of panel erection ?	☒	☐
Is there enough floor area available to provide a casting surface for the panels ?	☒	☐
Can the walls be divided into panels whose weight does not exceed the crane capacity ?	☒	☐

Figure 8: Tilt-Up Feasibility Questionnaire for the FedEx Ground Distribution facility

The above questions are designed to help identify if tilt-up is the right type of construction for the building. The feasibility questionnaire was filled out for the FedEx Ground Distribution Facility and the results determine that the building is capable of utilizing the benefits of tilt-up construction even though the typical height of the wall panels will be over 30 feet.

6.3. Tilt-Up Construction Sequence

The construction sequence for a tilt-up building is slightly different from the construction schedule of a metal wall system. One of the major differences is the sequence of activities for the erection of the roof and walls. The typical sequence of activities for constructing a tilt-up system is as follows:

1. Mass excavation and subgrade preparation
2. Form, Reinforce & Pour interior footings
3. Excavate and Place exterior foundations
4. Install all necessary underslab MEP conduits and equipment
5. Form, Reinforce, Pour & Cure floor slabs
6. Construct leveling pads on the perimeter footings
7. Set & Brace wall panels
8. Grout between footing and panel
9. Install roof
10. Remove wall bracing
11. Form & Pour closure strip

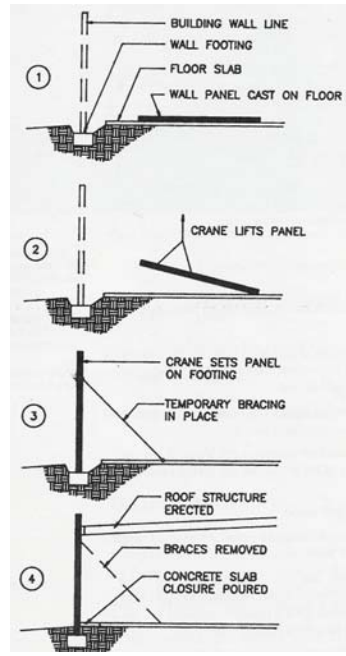


Figure 9: Tilt-Up Process

From the beginning of panel formation to the setting of the tilt-up panels, takes approximately 4-5 weeks. Enclosing the building as quick as possible allows other trades to gain access to the spaces in order to perform weather sensitive activities earlier. Ultimately, tilt-up structures maintain their appearance, structural integrity, and value.

The construction work flow for a tilt-up building is different than a typical steel structure. A typical steel erection sequence will start in one corner of a building or along a wall and work toward another specified location. Tilt-up workflows are based on the locations of the panels. The distribution facility is large enough to cast the panels on the exterior slabs and set them from inside the building. In order to accelerate the construction schedule the steel erector will have to start erection during the tilt-up process. The steel erector will begin erection near the center of the building and work toward the exterior walls. Once the walls are set, the steel erector must go between the tilt-up panels and install the remaining structural members. The roof system will typically follow the steel erection sequence until the tilt-up panels are connected to the roof structure. See appendix D for examples of the original and modified steel erection sequences.

6.4. Site Analysis

Site analysis is a critical aspect of the tilt-up process. The Hagerstown site is over 100+ acres of land. So, there is ample room to utilize tilt-up construction. The property is undeveloped and there are no overhead utilities or obtrusions on the site prior to construction. During construction, 360° access to the building is a required by the local fire marshal. Therefore, access for delivery trucks, cranes and other equipment is acceptable.

6.5. Foundation Analysis

The foundation system for the distribution facility consists of spread footings, wall footings and piers. The current system is easily adapted to accept tilt-up panels. If the panels are non-load bearing the foundation walls and piers will be require modification to be able to accept the tilt-up panels. Prior to setting the panels, leveling pads will need to be installed at locations where the edges of the panel will be placed. After the panels are set and shimmed, non-shrink grout will be installed in order to provide a continuous bearing surface for the panels. Figure 10, illustrates the locations of the leveling pads and grout placement for both pad footings and continuous footings.

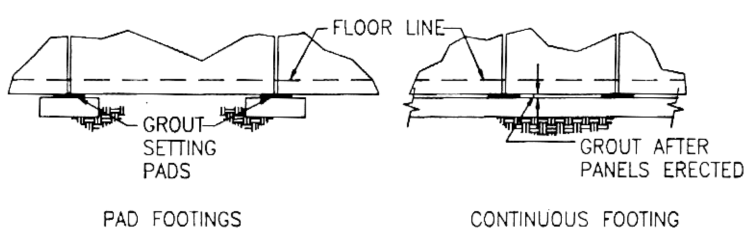


Figure 10: Panel Foundation Elevation

The foundation walls of the distribution facility are comprised of a 12" reinforced wall supported by a spread wall footing. The wall footings will require structural analysis to determine if the footings have sufficient load bearing capacity to withstand the additional weight of the tilt-up panels.

6.6. *"Panelizing" the Building*

One of the most important steps in the design of a tilt-up building is determining the where the panels will be divided, the shape of the panels, and where the joints will occur. Several aspects of the panels would be taken into consideration when dividing, "panelizing", the panels such as:

- Where members frame into the panels
- Location of window and door openings
- Avoid lintels longer than 40 feet
- Approximate weight of the panel should not exceed 40 tons
- Leave at least 18" between panel openings
- The bottom of the panel should be at least 8" below the floor
- The types of corners (mitered or overlapped)

These are the most important considerations during the panelization of the structure. See Appendix E for panelized drawings of the distribution facility. Once the building's exterior façade has been panelized, a panel schedule is developed in order to facilitate future activities. See Appendix F for a panel schedule of the distribution facility divided by area and elevation.

6.7. *Analyzing the Casting/Lifting Surfaces*

Typically the floor slabs act as the casting surfaces for the tilt-up panels so additional analysis is required in order to check the structural integrity and design of the existing slabs. As a 'rule of thumb' the total surface area of the panels should not exceed 80% of the usable floor area. Usually the heaviest loads ever imposed on a slab are during the construction of the building. A 140 ton, eight wheeled truck mounted crane lifting a tilt-up panel can apply loads in excess of 200,000 lbs per tire on the floor slabs. Most industry designers/constructors recommend a 6" reinforced slab due to its increased load carrying capacity. If a 4" or 5" slab is used, it is recommended that the slabs are thickened along the travel path of the crane and concrete trucks. Additionally, the subgrade plays a major role in the load bearing capacity of the slabs. The subgrade should be comprised of a granular, non-expansive soil compacted to at least 90%. Tilt-up contractors claim that the applied crane loads are able to be carried by a 6" reinforced slab with a properly designed and installed subgrade.

The subgrade and floor slabs of the distribution facility meet or exceed the industry recommendations. All of the interior slabs are 6" reinforced concrete with 6" of compacted aggregate subgrade and the exterior slabs are 8" reinforced concrete with 8" of compacted aggregate subgrade. Slab surface tolerances should be limited to F_F25/F_L30, which is the generally accepted standard. Currently the interior and exterior slabs do not comply with the general criteria due to the slab drainage design, but can be easily redesigned to meet the drainage requirements and slab surface tolerances. Figure 12 below is a section detail of the exterior concrete slabs.

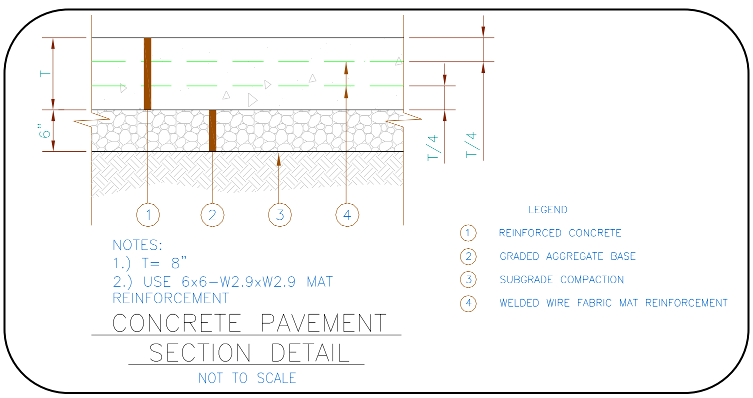


Figure 11: Exterior Concrete Section

6.8. *Panel Layout*

Planning the layout and forming sequences of the panels are fundamental components of the tilt-up construction process. Initially the tilt-up panels should not occupy more than 75%-80% of the total floor area. This allows for machinery, equipment and workers space to maneuver around the area. If tilt-up is to be used for a project where the panel area exceeds the floor area there are a couple of planning options that will allow for the use of tilt-up such as:

- Casting the panels outside the building on temporary casting slabs
- Stacking the panels (casting one panel on top of another)
- Perform multiple casts from the same casting area
- Cast panels on top of one another

Panels are typically cast exterior face down allowing architectural finishes to be applied to the panels easier. Casting panels from outside of the building takes more time because the panels would have to be rotated 180° in the air placing the rigging equipment out of view of the crane operator.

Determining where to cast the panels takes a great deal of planning and should include the general superintendent, the crane subcontractor, the tilt-up contractor and the crane operator. Together each team member will be able to help identify problem areas and develop an efficient solution. Developing an efficient layout will take several iterations but the benefits will be apparent when the casting and lifting process begins.

6.9. *Panel Forming*

Planning the panel forming is the next step in the tilt-up construction process. The physical act of forming, reinforcing and pouring the panels should be performed by a reputable tilt-up contractor. Once the panels are poured, fixing careless errors will negatively affect the budget as well as the schedule. Developing and using forming and pre-pour checklist will ensure good quality control. Average contractors can form, reinforce and pour between 8 and 12 panels per 8 hour period.

6.10. Lifting, Setting & Bracing Panels

The day the life occurs is considered ”the day of truth” because any errors in overall panel dimensions will become readily apparent. Dimensional errors at this stage of the process slow down or even stop erection and eventually increase costs due to the reduced productivity.

CRANE SELECTION

Selecting the right equipment for the job is an integral part of the construction process. The most common type of crane used for tilt-up erection is a 140 ton truck mounted crane. The lifting capacity of the crane should be rated for two times the weight of the heaviest panel. Using the panel schedule for the FedEx Ground facility, the heaviest panel is 40.1 tons and utilizing the factor of safety the minimum lifting capacity of the crane should be at minimum of 80.2 tons. A typical 100 ton crane is capable of lifting and setting all of the panels for the distribution facility, although a larger crane will allow for an extended working radius. Using a crane of this size will not overstress the 6” interior slabs or the 8” exterior slabs.

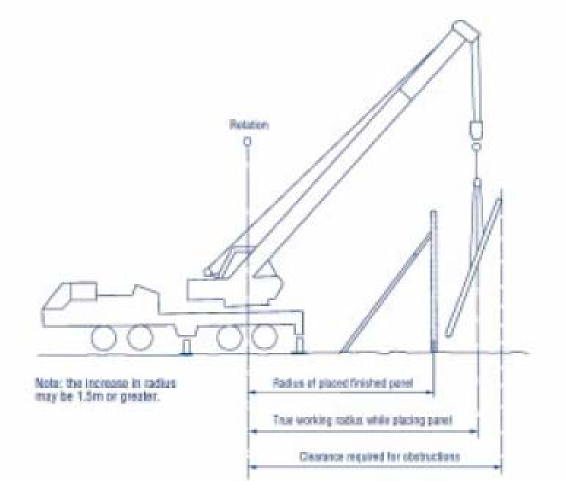


Figure 12: Crane Lifting Parameters

LIFTING, SETTING & BRACING

Lifting and setting the panels should be performed by an experiences rigging and setting crew. During the lifting process the crane operator will utilize a variety of lifts such as tandem picks, suitcase picks and a reverse picks that facilitate the lifting process. Each lift has its own specific use. The preferred typical lifting method will allow the up side of the panel to be in view of the crane operator at all times. The lifting schedule should cater to this type of lift for quick and efficient erection. Once the panel is lifted, it needs to be set into its final position. Typically the panel will be placed without remobilizing the crane but sometimes it is necessary to "walk" the panel to its final destination. This process is time consuming and dangerous and should be avoided whenever possible. Before the crane releases the set panels, temporary braces must be installed in order to prevent the panels from blowing down during high winds and to hold the panels in position until the roof is installed.

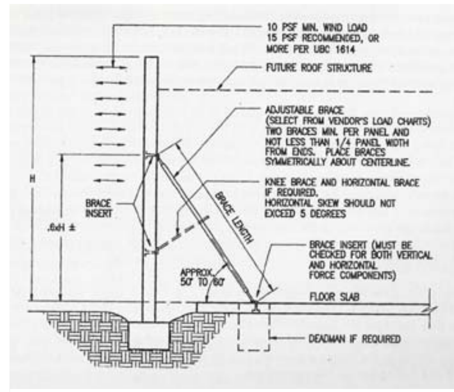


Figure 13: Panel Bracing Example

6.11. *Conclusion & Recommendation*

This analysis was a preliminary investigation into the use of tilt-up construction in lieu of a pre-engineered metal wall system. Initial research analyzed the following:

- Basic tilt-up system overview
- Feasibility Review
- Construction schedule overview
- Site analysis
- Foundation analysis
- Casting and lifting surface analysis
- Basic panel layout and forming

The current building and site parameters allow for easy adaptability of a tilt-up system. As a recommendation, tilt-up is a feasible alternative system and further analysis is required to determine the cost and schedule impacts of the proposed system.

Pre-Engineered Steel Structure vs Tilt-Up Concrete Construction

7.1. *Analysis Overview*

During the initial planning phases of a project, the owner, architect and various engineers have to develop the design parameters of the facility. One of the major decisions is determining the appropriate structural system. The structural system chosen for the building is a pre-engineered steel system with a metal wall panel exterior facade. The key determinants for choosing this type of system were the minimal costs of the structure and the overall speed of erection.

7.2. *Pre-Engineered Wall System Overview*

Pre-engineered building systems use standardized metal components which are designed to maximize the structural properties of the material. The system has been designed for maximum efficiency resulting in minimized material.

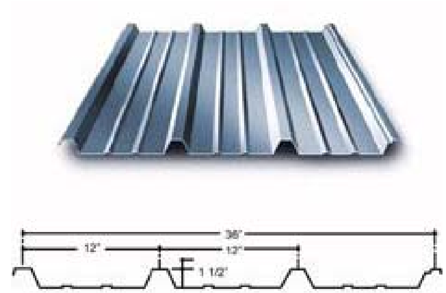
STRUCTURAL MEMBERS

The existing structural system is pre-engineered steel structure. The system is primarily composed of W 12 x 26, W14 x 43, W 14 x 61, and W 14 x 90 columns spaced along the exterior wall for the Local City, Corridor and Transition areas. Throughout Loadwings A & B the structural steel has been designed as a brace frame to counteract the large horizontal forces generated by wind. All steel members shall conform to ASTM A570 or A572 and all connections utilize A325 high strength, torsion control bolts.

WALL FRAMING

The lateral bracing for the exterior wall panels is comprised of purlins or "Z" girts at various elevations in order to act as connecting points for the exterior wall panels. The "Z" girts conform to ASTM A570 at a minimum of 55 ksi.

WALL PANELS

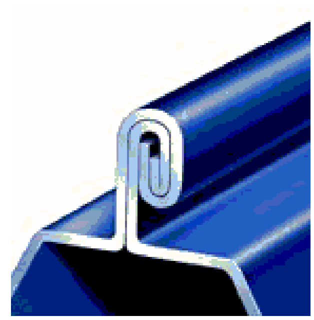


The exterior wall panels are precision roll-formed Butlerib® II panels. The panels are 26 gage galvanized panels which conform to ASTM A525. The insulating layer is a 2" semi-rigid insulation. Insulation is a commercially odorless glass fiber blanket which shall have a flame spread rating of 25.

INTERIOR WALL SYSTEM

The interior wall system consists of 8' tall liner panels comprised of ¾" CDX fire retardant treated plywood. The plywood will be primed on both sides and 2 coats of paint will be applied to the exposed face.

ROOF SYSTEM



The roof system is a MR-24® Standing Seam Roof System designed and installed by Butler Manufacturing and Butler Construction. All insulation shall be blanket fiberglass insulation with a minimum thickness of 2" for MR-24® roofing applications.

ADVANTAGES OF PRE-ENGINEERED BUILDINGS

The metal wall system is a very quick and efficient system to put in place. The simplicity of the system makes it very versatile, requiring no specialized labor to properly install the system. Pre-engineered buildings reduce the need for on-site labor by performing as much of the cutting and welding operations in a factory environment. Because most of the work is completed in a factory, weather interruptions and delays are reduced. Expanding a metal building performed easily and quickly. If designed properly, it is as simple as removing wall panels adding new framework and connecting into the existing wall and roof panels.

Pre-engineered structural systems are very cost efficient because the design of the structure takes advantage of the material properties of the elements. This type of design reduces the extra costs by minimizing waste and excess materials. Pre-engineered buildings have lower initial costs. Reducing design costs is a predominant feature of pre-engineered buildings because previous structures are easily modifiable which leads to the owner's ability to see the building prior to beginning construction.

Disadvantages of Pre-engineered Buildings

Pre-engineered metal buildings have many disadvantages. The typical life-cycle of metal building is approximately 20-30 years according to steel manufacturers, but the building's paint fades quickly and the building easily becomes damaged and dented. Because of the wear on the interior and exterior facades, the future value of the building is greatly decreased. Also, the aesthetic appearance decreases quickly. In order to maintain the building, continuous monitoring and a regularly scheduled maintenance is necessity.

7.3. *Tilt-Up Wall System Overview*

Developing a structural estimate for the proposed systems will be very useful. Initially, several assumptions need to be as well as descriptions of the systems that will be incorporated into the tilt-up system.

Foundation System

The foundation system was not altered during the analysis of the tilt-up system. Tilt-up panels are non-load bearing, so the current wall footings will be utilized as structural components carrying the additional weight of the tilt-up panels. The foundation walls and piers will be maintained due to the use of structural steel along the exterior facades to carry the roof loads for the distribution facility. These structural members will also act as connection points for the lateral support system. The panels will rest directly on the foundation walls and will be structurally tied into the foundation wall system and columns.

Tilt-Up Panels

For this system estimate an 8" insulated panel will be used. The 8" panel thickness is needed to structurally support its own weight while maintaining the current R-value. This is the minimum thickness of panel required to span a distances of approximately 32'. Currently a tilt-up panel of this type will cost approximately $15 per square foot installed. This cost includes all labor and equipment costs needed to form, set, grout, and brace the panels.

Roof Adaptation

The existing Butler MR-24® Standing Seam Roof System was designed to be compatible with both the pre-engineered system and a tilt-up wall system. So, the existing roof can be used but there will need to be alterations to the exterior edges of the roof structure. The roof-to-wall connections will need to be adapted to the tilt-up panel system.

Advantages of Tilt-Up

Constructing a building of tilt-up panels is advantageous only when the given locale and project conditions favor it. Many of the advantages of tilt-up make this type of construction very competitive in the construction industry. The cost advantages of tilt-up construction spawn from the minimized use of formwork required to construct the panels. Building maintenance costs over the lifetime of a building can be very demanding, but tilt-up has very low maintenance costs when compared to other types of construction. Typical building maintenance consists of applying a new coat of paint every 6 to 8 years. When tilt-up buildings are coupled with an EPDM membrane roof held in place with ballast rock, the overall heating and cooling costs are greatly reduced. Tilt-up concrete walls offer increased fire resistance over other types of construction which in turn can potentially lower insurance costs.

Tilt-Up panels can be designed as load bearing or non load bearing structures. Load bearing capabilities can support long-span roof members and intermediate floor levels. When used in conjunction with pre-cast concrete structures, long, clear spans of up to 110' are obtainable. Tilt-up panels provide a smooth, durable finish that reduces the amount of damaged caused by trucks, forklifts, and other heavy equipment. They are easily cleanable ensuing in a cleaner, healthier work environment. Tilt-up provides an increased level of security over metal buildings by restricting forced entry to door and window openings.

Disadvantages of Tilt-Up

In the construction industry there are many ways to enclose a building. Tilt-up has many appealing advantages, but there are also disadvantages to this type of construction. The site can very easily limit or restrict the use of tilt-up. Project sites located in remote areas with limited resources can have a negative effect on the productivity of tilt-up. Tilt-up construction yields higher up front costs and these costs are incurred because of the increased number of construction activities which must be completed prior to the casting of the panels. Typically, the management staff should have experience with this type of construction in order to make it beneficial. Fixing minor mistakes can be very time consuming and costly. Planning is critical in order for this type of construction to be beneficial. The building size it typically restricted to low-rise buildings less than 50' tall. There are exceptions to the limitations, but they can quickly increase costs. Tilt-up does not adapt well to unusual building designs and is very susceptible to weather delays.

7.4. Cost Analysis

PRE-ENGINEERED WALL SYSTEM COST ESTIMATE

Initially, Pre-engineered steel structure is the cheapest method of enclosing a structure. Pre-engineered wall systems cost approximately $6.00 per square foot installed. This cost includes all miscellaneous hardware, insulation, framing members and equipment required to properly install the wall sheets. The FedEx Ground Distribution center contains approximately 104,500 sq. ft. of exterior façade which will be covered by the wall sheeting system. The structural steel estimate was based on weight. The amount of steel was developed for the exterior walls only. The current approximate industry standard for steel installed is $1600 per ton of material taking into account for minor fluctuations in steel prices. Figure 14 below illustrates the cost breakdown by area and component for the wall system. All costs are approximate in place costs and include procuring all materials, shipping costs, wasted materials and installation labor.

Activity Description / **Area**	Local City / Unload (4-10 / E-N)	Corridor (10-15 / E-N)	Loadwing A & Trans (15-34 / H.6-K.2)	Loadwing B (12-34 / A-E)	Loadwing Restrooms	Admin. Office	HUB Ops	Switchgear / Pump Room	**Total**
Concrete Footings	359.5	228.5	214.3	208.7	6.3	8.9	23.1	5.2	**1,054.4**
Concrete Foundation Walls / Piers	304.0	166.4	223.5	190.2	24.0	28.6	24.0	10.6	**971.3**
Structural Steel	69.4	23.0	82.9	55.0					**230.3**
Wall Sheeting System	217.7	44.2	207.8	152.6					**622.3**
Plywood Liner Panels	10.9	9.7	10.9	10.9					**42.4**
CMU Walls & Masonry Veneer					61.5	91.1	61.5	63.4	**277.4**
Total	**961.5**	**471.8**	**739.4**	**617.3**	**91.7**	**128.6**	**108.6**	**79.1**	**3,198.0**

* All costs are in thousands of dollars

Figure 14: Metal Wall Panel System Cost Estimate

Tilt-Up Wall System Cost Estimate

The use of tilt-up concrete enclosure system will have increased costs due to the basic components that make up the system. The wall system will utilize the existing spread footings, wall footings and piers. The use of non-load bearing panels will also require the need for structural steel around the perimeter. The recommended wall panel will be an 8" insulated system. Estimated panel costs as of February 2005 are approximately $15 per square foot installed. This cost estimate includes all lifting hardware, connecting embeds, formwork, labor, equipment, and a basic finish required to completely install the system. Figure 15 depicts the approximate cost of the tilt-up system for the FedEx Ground distribution facility. The costs are divided by area and system and include all material, labor, and equipment costs required to install each system.

Activity Description / Area	Local City / Unload (4-10 / E-N)	Corridor (10-15 / E-N)	Loadwing A & Trans A (15-34 / H.6-K.2)	Loadwing B (12-34 / A-E)	Loadwing Restrooms	Admin. Office	HUB Ops	Switchgear / Pump Room	Total
Concrete Footings	359.5	228.5	214.3	208.7	6.3	8.9	23.1	5.2	1,054.4
Concrete Foundation Walls / Piers	304.0	166.4	223.5	190.2	24.0	28.6	24.0	10.6	971.3
Tilt-Up Panels	544.3	110.7	519.3	381.5	54.9	63.5	68.8	44.7	1,787.7
Structural Steel	69.4	23.0	82.9	55.0					230.3
Wall Sheeting System									
Plywood Liner Panels									
Total	1,277.2	528.6	1,040.0	835.4	85.2	101.0	115.9	60.5	4,043.7

* All costs are in thousands of dollars

Figure 15: Tilt-Up Exterior Wall System Cost Estimate

7.5. Cost Comparison

The existing pre-engineered system costs approximately $3,198,000 and the tilt-up enclosure system costs approximately $4,043,700. When comparing these two systems, the tilt-up system is an overall increase of 26.4% over the current wall system. The difference between the two systems results in an increased enclosure cost of approximately $845,700. Both of the estimated system costs are in-place costs resulting in a viable cost comparison.

7.6. Construction Schedule Analysis

Pre-Engineered Wall System Estimate

The initial construction schedule was redeveloped utilizing the original activity durations in order to have an appropriate schedule for comparison. The schedule has been simplified for a structural system analysis. The schedule was developed by the project management team which conformed to the milestone dates set forth by FedEx Ground. These milestone dates are in place to ensure the project schedule will be maintained. Appendix G is the simplified schedule for the pre-engineered structural system.

Tilt-Up Wall System Estimate

The initial schedule developed for the pre-engineered was modified for the proposed tilt-up wall system. The major activities were adapted to a tilt-up construction process. The actual durations were maintained for the foundations, backfill, underslab rough-ins, and roof installation. The structural steel durations were developed to install the non-required pieces and subtracted from the construction schedule. The total tilt-up construction process takes approximately 45 days per panel and an average forming crew can form, reinforce and pour 8-12 panels per day. It was assumed that a panel forming crew could form 10 panels per day. Also, it was assumed that multiple erection crews were installing the tilt-up panels and all activities could be overlapped in order to fast-track the schedule to meet the milestone dates. Appendix H is the simplified construction schedule for the tilt-up structural system.

7.7. *Schedule Comparison*

Both of the schedules conform to the milestone dates that were developed by FedEx Ground. The proposed wall system will take longer to completely enclose the facility. This is attributed to the time required to form, reinforce and cure the panels.

7.8. *Conclusion & Recommendation*

The proposed tilt-up wall system costs approximately $4,043,700 which is substantially higher than the current pre-engineered wall system by $845,700. This difference is minimal when compared to the overall project cost in excess of $100 million. Also, the construction schedule of the tilt-up wall system will be able to conform to the milestone dates previously set by FedEx Ground. As a recommendation, tilt-up exterior wall system is more valuable than the pre-engineered wall system the durability and aesthetic advantages concrete structures.

Designing a Tilt-Up Panel

for

Lifting Conditions

8.1. *Design Analysis Overview*

The structural design of the tilt-up panels is the primary responsibility of the structural engineer. From a construction management point of view, one of the most important aspects of the tilt-up process is the lifting activity. Having a basic working knowledge of the lifting process and basic lift design will help prevent costly errors and potential schedule loss due to poor planning. Additionally, a quick analysis of the lifting inserts can facilitate the prevention of lifting hardware failure potentially resulting in injured personnel, damaged equipment or damaged in-place work.

8.2. *Lifting Tilt-Up Panels*

PRIOR TO LIFTING

Lifting preparation is a very important aspect of the lifting process. Prior to lifting there are several precautions that should take place prior to lifting panels into place. Prior to lifting any of the panels, each tilt-up panel should be checked for the following:

- Overall panel dimensions
- Locations of panel openings
- Proper concrete strength
- Inspect panels for surface defects (cracks, spalling, exposed rebar, ect.)
- Accessibility and location of embedded objects such as lifting anchors
- Test lifting hardware for minimum lifting capacity
- Verification of final panel positioning
- Crane path requirements (underground utilities, clear travel path, ect.)
- Required foundations are installed

The list above is some of the major inspection requirements that should be checked before and after the casting of the panels in addition to checking them prior to setting the panels.

A suspended tilt-up panel is essentially a large sail when exposed to wind, so the weather conditions are extremely important during the tilt-up process. Panels can be erected during a light breeze but should be avoided when windy conditions exist. Checking the weather conditions prior to setting the panels is a necessity.

During the Lift

During the lift, safety is the main concern. The rigging and setting crews are the only personnel allowed in the lift and swing area. It is necessary that management personnel hold safety meetings on the mornings that lifts will be taking place in order to make other contractors aware of the lifting areas.

After the Lift

Once the panels are set into place, it is necessary to properly brace the panels prior to releasing the crane. Bracing holds the panel in place and keeps the panel from blowing down until the supporting structure is in place. The industry standard for bracing factor of safety is 1.5 times the applied wind and seismic load. Typically inner costal regions of the mid-Atlantic require a minimum of two braces to be installed. After the panels are properly braced, a crew follows behind grouting the panel between the foundation surface and the bottom of the panel. Once the panel is fully supported by the structure, the bracing can be removed and the panel is completed with the exception of installing the closure strip and applying the desired finish.

8.3. Lifting Hardware & Rigging

Lifting Hardware

Lifting hardware is an essential part of tilt-up panel design. Tilt-up panels are constructed in a numerous variety of configurations and specifying effective and efficient lifting hardware is vital to the overall costs of a tilt-up system. Lifting hardware ranges from a few dollars per insert to over seventy five dollars per insert. See appendix J for several different types of lifting inserts and their respective structural attributes and configuration information.

PANEL RIGGING CONFIGURATIONS

Designers should have a basic knowledge of the typical rigging configurations in order to try to reduce the number of different lifting configurations on the project. Changing rigging configurations during lifting sequences reduced the efficiency of the crane and labor utilization ultimately resulting in increased costs. The illustration to the right shows the use of various spreader bars and sheaves used to maintain equal load on each of the lift points. It is extremely necessary that he center of gravity is maintained in the horizontal direction in order to eliminate the panel's tendency to roll to the left or right during the lifting process. The number of inserts required to lift the panel depends upon the weight and size of the panel as well as the strength of the concrete.

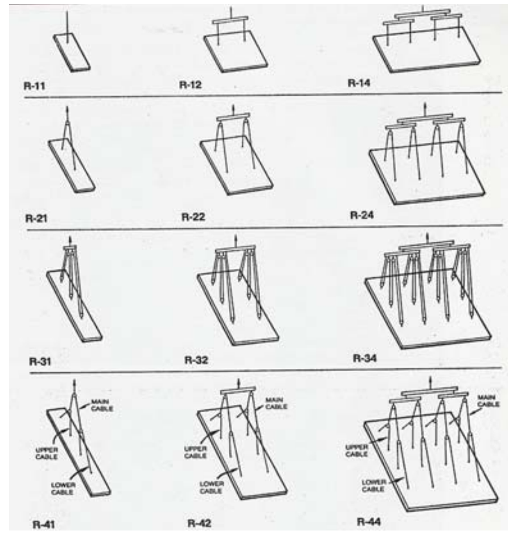


Figure 16: Panel Rigging Configurations

8.4. General Crane Requirements

Selecting the right crane for the job is essential for a quick and efficient setting process. An experienced project team will involve the crane operator during pre-planning and panel layout. Typically the minimum factor of safety for lifting tilt-up panels is 2.0 times the heaviest panel, but experienced tilt-up contractors will use evaluate the lifting capacity as well as the working radius of the crane in order to maximize efficiency.

8.5. *Panel Design Analysis for Lifting Condition*

Basic Panel Parameters

Panel Height	32' – 6"
Panel Width	25' – 6"
Overall Panel Thickness	0' – 7 1/2"
Insulation Thickness	0' – 1 ½"
Net Concrete Thickness	0 – 6"
Reinforced Concrete Weight	150 psf

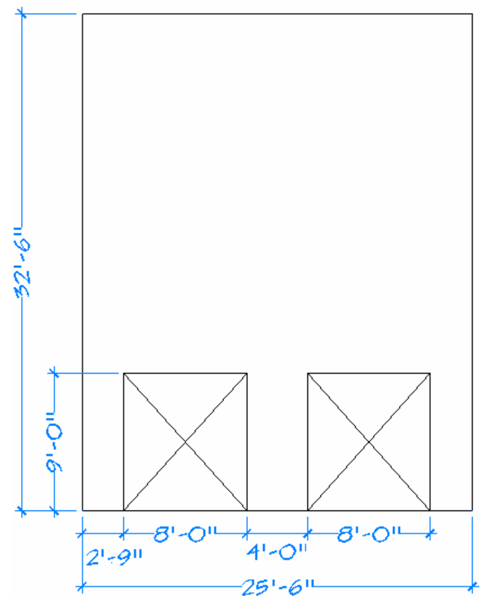


Figure 18: Initial Design Sketch

Design Calculations

Gross Panel Area	832.0 sq ft
Void Area	144.0 sq ft
Net Panel Area	688.0 sq ft
Weight of Panel	51,600 lbs

# of Lift Points = Panel Weight * Suction Factor of 1.3 / Insert Lifting Capacity

# of Lifting Points = 51,600 lb (1.3) / 8,333 lb = 8.05 , Use 8 inserts

Specified lift inserts are ductile ferrule inserts, part number NCFF158, designed for increased load carrying capacity. The factor of safety has been modified from 4:1 to 3:1 and the Universal Form Clamp Company allows for the modification upon confirmation with UFC.

MOMENT CAPACITY

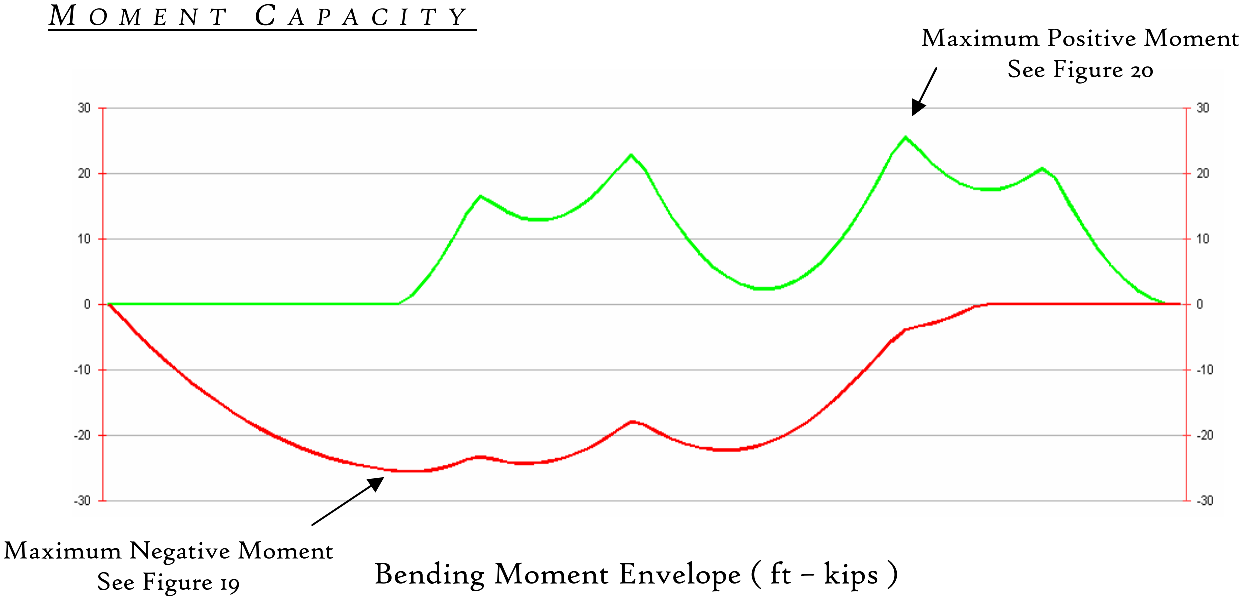


Figure 17: Tilt-Up Panel Moment Diagram

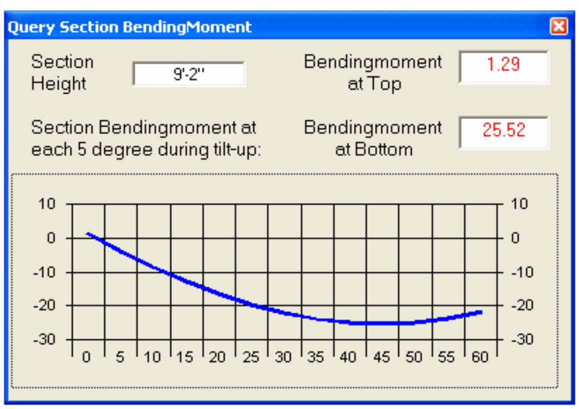


Figure 19: Maximum Negative Bending Moment during Erection

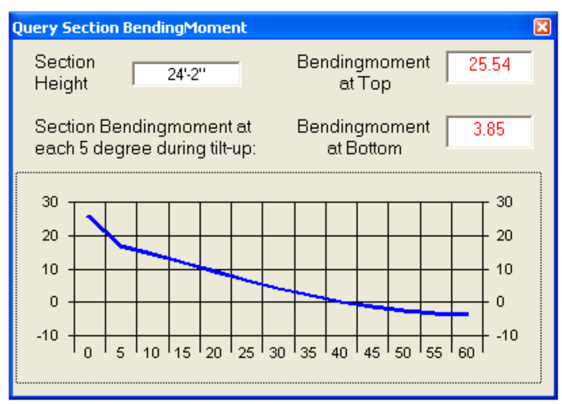


Figure 20: Maximum Positive Bending Moment during Erection

Allowable Bending Stress = $6\sqrt{f'c} = 6\sqrt{3{,}000} = 328$ psi

Maximum Bending Stress Imposed = Maximum Moment / Section Modulus

= 25.54 ft-kip (12 in/ft) (1000 lb/kip) / 2609 in^4

= 117.5 psi < 328 psi $\therefore$ OK

PANEL DESIGN SUMMARY

Point	X	Y
CG	12' – 9"	18' – 11 ½"
LP 1	5' – 3"	28' – 6"
LP 2	20' – 3"	28' – 6"
LP 3	5' – 3"	21' – 1"
LP 4	20' – 3"	21' – 1"
LP 5	5' – 3"	15' – 11"
LP 6	20' – 3"	15' – 11"
LP 7	5' – 3"	11' – 2"
LP 8	20' – 3"	11' – 2"

**All points are measured from the bottom left corner of the panel.

Figure 21: Center of Gravity and Lift Point Locations for Local City Tilt-Up Panel

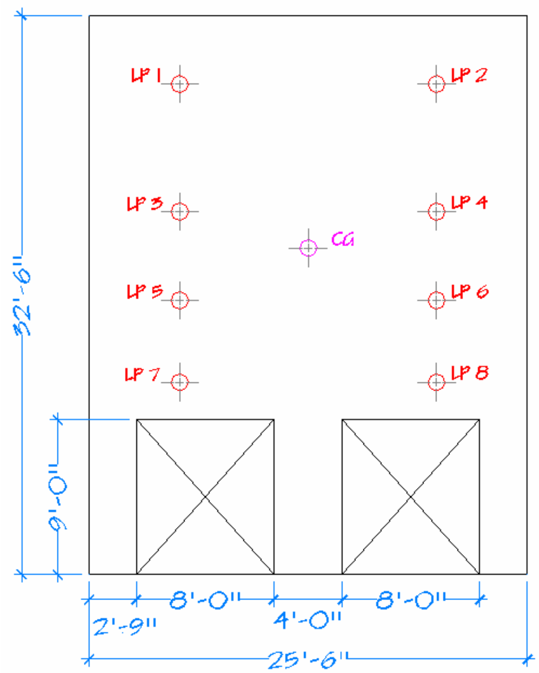


Figure 22: Local City Tilt-Up Panel Design along F & N Line

ACKNOWLEDGEMENTS & REFERENCES

9.1. Acknowledgements

FedEx Ground

Eric Adamczyk

Tim Scherling

Gilbane Building Company

Andy Faber

John LaRow

Ernie Brewer

Butler Construction

Ron Peria

Robert Treadway

Penn State University

Dr. David Riley

Dr. John Messner

Dr. Michael Horman

Dr. Linda Hannagan

Friends & Family

John & Rebecca Klock

Elizabeth Schaut

Sam Klock

Fellow AE associates

Others

Richard Taylor, Autodesk Revit

Sam Lee, TiltMAX

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APPENDIX A

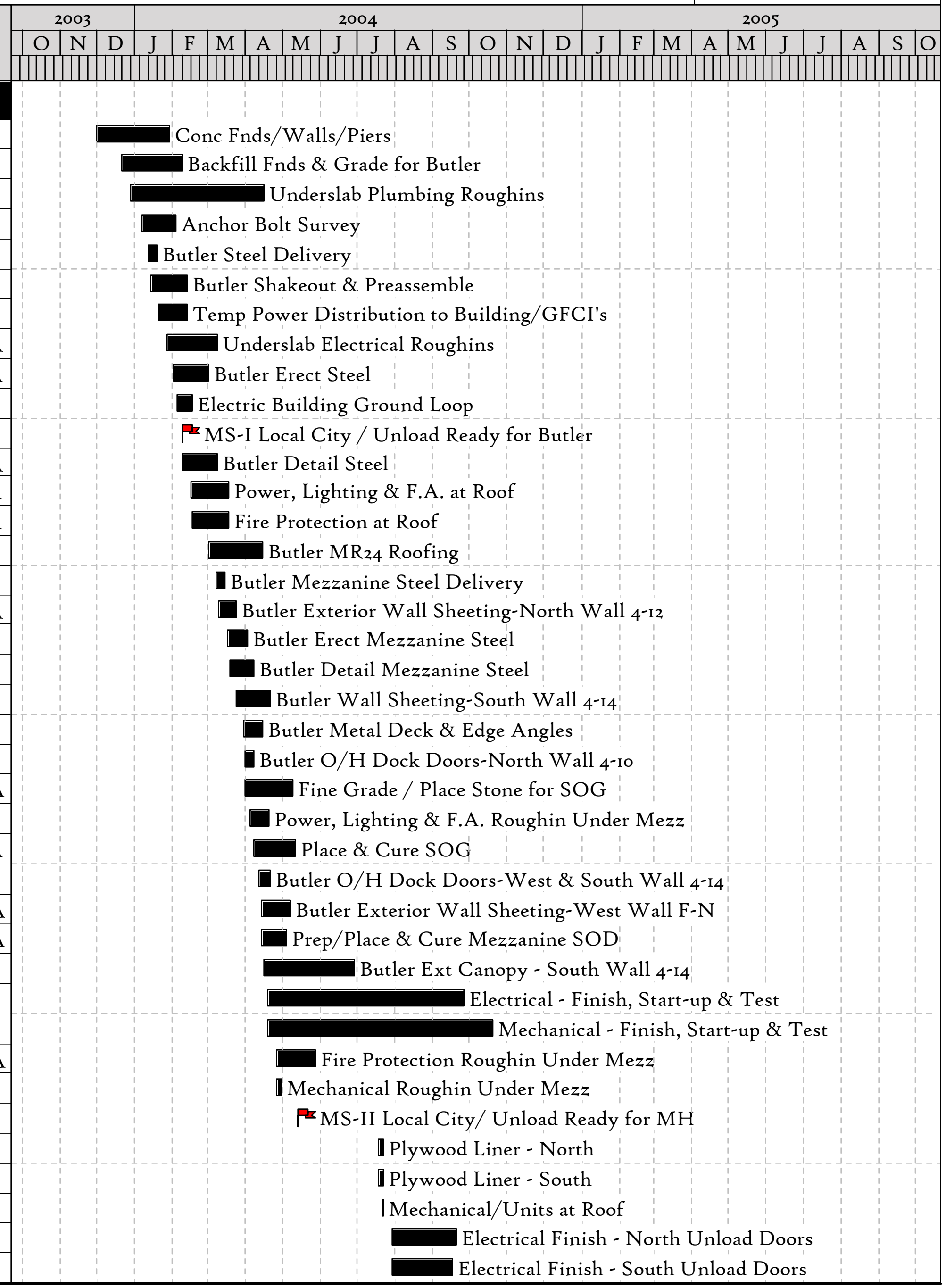
FEDEX DISTRIBUTION FACILITY DETAILED CONSTRUCTION SCHEDULE

Early bar
Start milestone point
Finish milestone point

FedEx Distribution Center - Project Schedule

Local City / Unload (E-N/4-10)

Act ID	Activity Description	Orig Dur	Early Start	Early Finish
2010	Conc Fnds/Walls/Piers	49	01DEC03 A	30JAN04 A
2020	Backfill Fnds & Grade for Butler	28	22DEC03 A	09FEB04 A
2040	Underslab Plumbing Roughins	10	29DEC03 A	16APR04 A
2070	Anchor Bolt Survey	2	07JAN04 A	04FEB04 A
2100	Butler Steel Delivery	10	12JAN04 A	19JAN04 A
2050	Butler Shakeout & Preassemble	6	14JAN04 A	13FEB04 A
2000	Temp Power Distribution to Building/GFCI's	11	20JAN04 A	13FEB04 A
2045	Underslab Electrical Roughins	10	28JAN04 A	09MAR04 A
2110	Butler Erect Steel	18	02FEB04 A	02MAR04 A
2030	Electric Building Ground Loop	10	05FEB04 A	17FEB04 A
2090	MS-I Local City / Unload Ready for Butler	0	09FEB04 A	
2120	Butler Detail Stee	32	09FEB04 A	09MAR04 A
2230	Power, Lighting & F.A. at Roof	24	16FEB04 A	18MAR04 A
2220	Fire Protection at Roof	24	17FEB04 A	18MAR04 A
2130	Butler MR24 Roofing	30	02MAR04 A	15APR04 A
3510	Butler Mezzanine Steel Delivery	7	08MAR04 A	15MAR04 A
2135	Butler Exterior Wall Sheeting-North Wall 4-12	5	10MAR04 A	24MAR04 A
3520	Butler Erect Mezzanine Steel	19	17MAR04 A	03APR04 A
3530	Butler Detail Mezzanine Steel	19	19MAR04 A	08APR04 A
2150	Butler Wall Sheeting-South Wall 4-14	4	24MAR04 A	21APR04 A
3540	Butler Metal Deck & Edge Angles	19	30MAR04 A	15APR04 A
2160	Butler O/H Dock Doors-North Wall 4-10	8	01APR04 A	08APR04 A
2270	Fine Grade / Place Stone for SOG	22	01APR04 A	10MAY04 A
3570	Power, Lighting & F.A. Roughin Under Mezz	20	05APR04 A	20APR04 A
2280	Place & Cure SOG	20	08APR04 A	12MAY04 A
2170	Butler O/H Dock Doors-West & South Wall 4-14	10	12APR04 A	21APR04 A
2140	Butler Exterior Wall Sheeting-West Wall F-N	6	14APR04 A	07MAY04 A
3550	Prep/Place & Cure Mezzanine SOD	23	14APR04 A	05MAY04 A
2200	Butler Ext Canopy - South Wall 4-14	7	16APR04 A	29JUN04 A
2320	Electrical - Finish, Start-up & Test	40	19APR04 A	27SEP04 *
2330	Mechanical - Finish, Start-up & Test	40	19APR04 A	20OCT04 *
3560	Fire Protection Roughin Under Mezz	20	26APR04 A	28MAY04 A
3580	Mechanical Roughin Under Mezz	20	26APR04 A	30APR04 A
2300	MS-II Local City/ Unload Ready for MH	0	14MAY04 A	
2290	Plywood Liner - North	3	19JUL04 A	23JUL04 A
2294	Plywood Liner - South	3	19JUL04 A	23JUL04 A
2250	Mechanical/Units at Roof	15	22JUL04 A	23JUL04 A
2180	Electrical Finish - North Unload Doors	5	30JUL04 A	20SEP04
2185	Electrical Finish - South Unload Doors	5	30JUL04 A	17SEP04



Early bar
Start milestone point
Finish milestone point

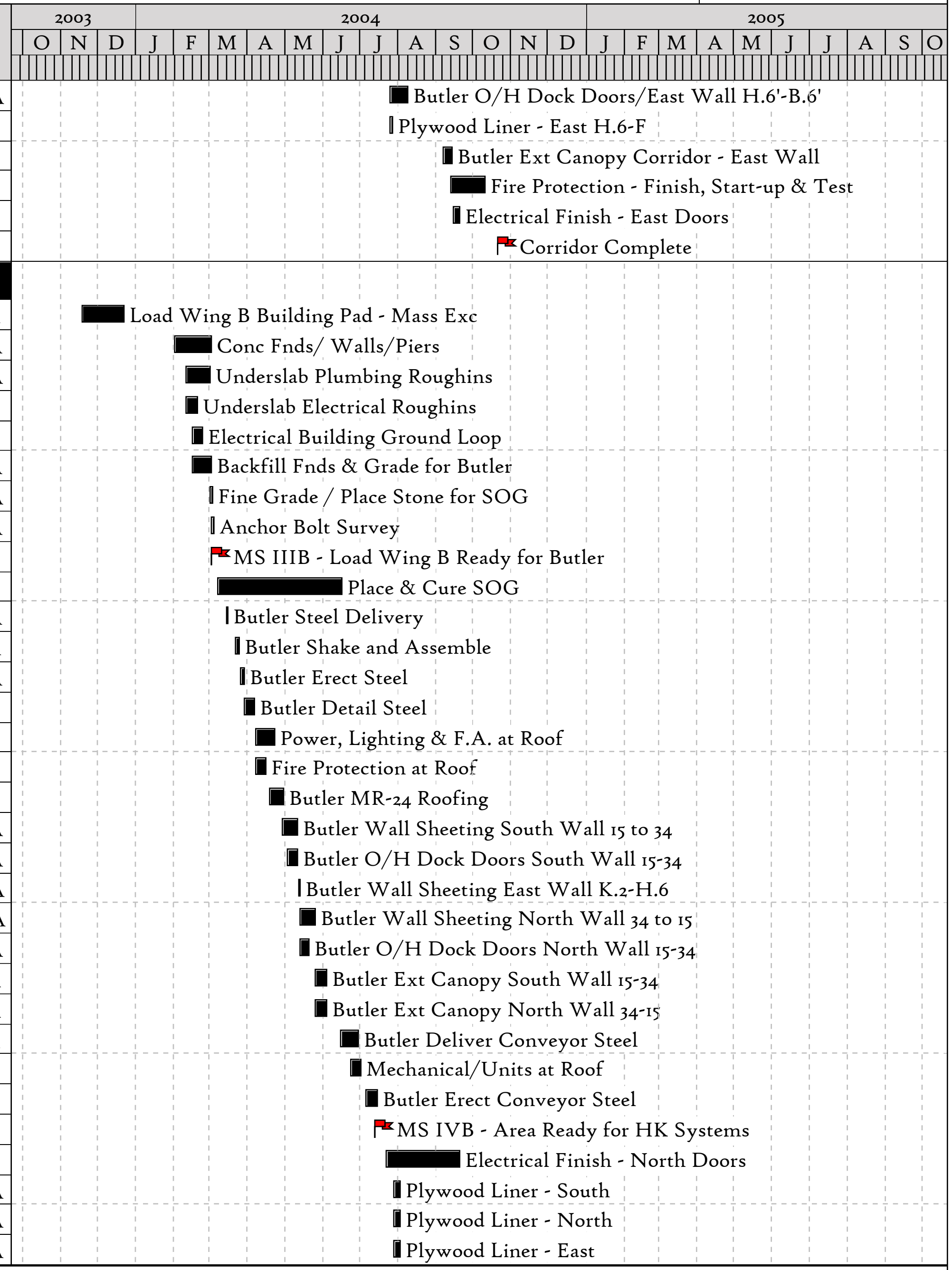
FedEx Distribution Center - Project Schedule

Act ID	Activity Description	Orig Dur	Early Start	Early Finish
2292	Plywood Liner - West	4	30AUG04 A	10SEP04
2190	Butler Ext Canopy - North Wall 4-10	7	07SEP04 *	14SEP04
2310	Fire Protection - Finish, Start-up & Test	25	13SEP04 A	27SEP04
2340	Gas Service Available	0		08OCT04 *
2335	Local City/Unload Complete	0		20OCT04
Corridor (E-N/10-15)				
3410	Underslab Plumbing Roughins	10	24DEC03 A	30MAR04 A
3405	Backfill Fnds & Grade for Butler	16	02JAN04 A	12FEB04 A
3400	Conc Fnds/Walls/Piers	46	07JAN04 A	11FEB04 A
3415	Underslab Electrical Roughins	6	04FEB04 A	30MAR04 A
3420	Electrical Building Ground Loop	7	04FEB04 A	12FEB04 A
3435	Anchor Bolt Survey	2	05FEB04 A	16FEB04 A
3440	MS IIIA - Corridor Ready for Butler	0	12FEB04 A	
3445	Butler Deliver Steel	3	12FEB04 A	13FEB04 A
3430	Butler Shakeout & Preassemble	5	16FEB04 A	05MAR04 A
3450	Butler Erect Steel	12	23FEB04 A	08MAR04 A
3455	Butler Detail Steel	23	09MAR04 A	30MAR04 A
3465	Power, Lighting & F.A. at Roof	17	10MAR04 A	07APR04 A
3460	Fire Protection at Roof	17	23MAR04 A	06APR04 A
3475	Butler Deliver Platform Steel	8	29MAR04 A	08APR04 A
3480	Butler Erect Service Platform Steel/Joists	11	13APR04 A	07MAY04 A
3490	Butler MR-24 Roofing	13	16APR04 A	14MAY04 A
3505	Butler Wall Sheeting/East Wall N-K.2	4	21APR04 A	28APR04 A
3485	Butler Platform Deck/Grating	14	26APR04 A	07MAY04 A
3635	Fine Grade/ Place Stone for SOG	12	10MAY04 A	09JUN04 A
3495	Butler Wall Sheeting/South Wall 10-15	3	14MAY04 A	20APR04 A
3640	Place & Cure SOG	17	14MAY04 A	11JUN04 A
3486	Prep/Place & Cure SOD M-N/12-14	3	20MAY04 A	27MAY04 A
3487	Prep/Place & Cure SOD K.2-H.6/11-15	5	20MAY04 A	27MAY04 A
3488	Prep/Place & Cure SOD G-F/12-14	4	27MAY04 A	03JUN04 A
3515	Butler Wall Sheeting/East Wall H.6'-F	4	27MAY04 A	24JUN04 A
3655	Electrical - Finish, Start-up & Test	23	28MAY04 A	06OCT04 *
3660	Mechanical - Finish, Start-up & Test	23	28MAY04 A	20OCT04 *
3625	Power, Lighting & F.A. Roughin Under Platform	16	07JUN04 A	24JUN04 A
3630	Mechanical Roughin Under Platform	16	07JUN04 A	24JUN04 A
3620	Fire Protection Roughin Under Platform	16	28JUN04 A	03AUG04 A
3670	MS IVA - Corridor Ready for MH	0	29JUN04 A	
3470	Mechanical/Units at Roof	17	22JUL04 A	23JUL04 A
3645	Plywood Liner - South 10-14	5	23JUL04 A	26JUL04 A

Early bar	
Start milestone point	
Finish milestone point	

FedEx Distribution Center - Project Schedule

Act ID	Activity Description	Orig Dur	Early Start	Early Finish
3615	Butler O/H Dock Doors/East Wall H.6'-B.6'	7	26JUL04 A	09AUG04 A
3665	Plywood Liner - East H.6-F	5	26JUL04 A	28JUL04 A
3835	Butler Ext Canopy Corridor - East Wall	7	07SEP04	14SEP04
3650	Fire Protection - Finish, Start-up & Test	25	13SEP04 *	11OCT04
3845	Electrical Finish - East Doors	5	15SEP04	20SEP04
3830	Corridor Complete	0		20OCT04
Load Wing 'B'				
4185	Load Wing B Building Pad - Mass Exc	55	19NOV03 A	23DEC03 A
4005	Conc Fnds/ Walls/Piers	25	02FEB04 A	03MAR04 A
4015	Underslab Plumbing Roughins	5	11FEB04 A	02MAR04 A
4020	Underslab Electrical Roughins	10	11FEB04 A	20FEB04 A
4025	Electrical Building Ground Loop	10	16FEB04 A	25FEB04 A
4030	Backfill Fnds & Grade for Butler	15	16FEB04 A	03MAR04 A
4100	Fine Grade / Place Stone for SOG	10	02MAR04 A	04MAR04 A
4045	Anchor Bolt Survey	2	03MAR04 A	05MAR04 A
4055	MS IIIB - Load Wing B Ready for Butler	0	03MAR04 A	
4105	Place & Cure SOG	18	08MAR04 A	17JUN04 A
4060	Butler Steel Delivery	3	15MAR04 A	16MAR04 A
4195	Butler Shake and Assemble	4	22MAR04 A	25MAR04 A
4065	Butler Erect Steel	8	26MAR04 A	30MAR04 A
4070	Butler Detail Steel	12	29MAR04 A	07APR04 A
4075	Power, Lighting & F.A. at Roof	24	08APR04 A	23APR04 A
4080	Fire Protection at Roof	24	08APR04 A	16APR04 A
4095	Butler MR-24 Roofing	12	19APR04 A	30APR04 A
4110	Butler Wall Sheeting South Wall 15 to 34	6	29APR04 A	12MAY04 A
4125	Butler O/H Dock Doors South Wall 15-34	11	03MAY04 A	12MAY04 A
4115	Butler Wall Sheeting East Wall K.2-H.6	1	13MAY04 A	14MAY04 A
4120	Butler Wall Sheeting North Wall 34 to 15	6	14MAY04 A	26MAY04 A
4130	Butler O/H Dock Doors North Wall 15-34	14	14MAY04 A	21MAY04 A
4135	Butler Ext Canopy South Wall 15-34	9	26MAY04 A	04JUN04 A
4137	Butler Ext Canopy North Wall 34-15	10	26MAY04 A	04JUN04 A
4160	Butler Deliver Conveyor Steel	10	16JUN04 A	30JUN04 A
4085	Mechanical/Units at Roof	20	24JUN04 A	02JUL04 A
4165	Butler Erect Conveyor Steel	18	06JUL04 A	15JUL04 A
4170	MS IVB - Area Ready for HK Systems	0	14JUL04 A	
4190	Electrical Finish - North Doors	10	23JUL04 A	20SEP04
4205	Plywood Liner - South	5	29JUL04 A	03AUG04 A
4215	Plywood Liner - North	5	29JUL04 A	03AUG04 A
4225	Plywood Liner - East	2	29JUL04 A	03AUG04 A



Early bar
Start milestone point
Finish milestone point

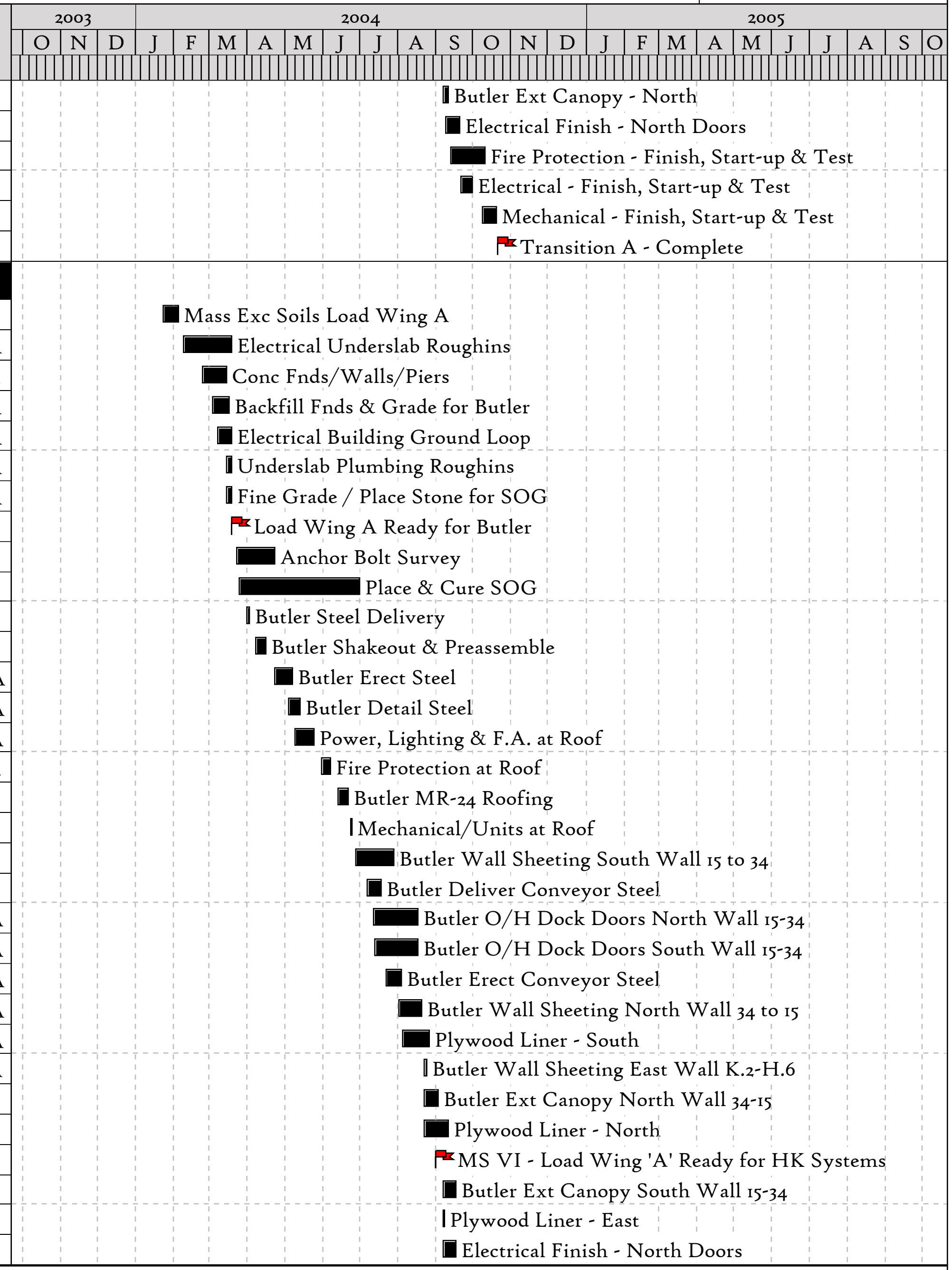
FedEx Distribution Center - Project Schedule

Act ID	Activity Description	Orig Dur	Early Start	Early Finish
4200	Electircal Finish - South Doors	10	30JUL04 A	27SEP04
4140	Fire Protection - Finish, Start-up & Test	25	13SEP04 *	11OCT04
4210	Co-Ray-Vac Change Order (HK Constrained Start)	30	15SEP04 *	19OCT04
4150	Mechanical - Finish, Start-up & Test	25	27SEP04 *	25OCT04
4145	Electrical - Finish, Start-up & Test	25	28SEP04 *	26OCT04
4175	Load Wing "B" Complete	0		26OCT04
Load Wing 'A' Transition				
5111	Mass Excavation	1	29SEP03 A	19NOV03 A
5006	Conc Fnds/Walls/Piers	15	17FEB04 A	08MAR04 A
5051	Underslab Plumbing Roughins	5	26FEB04 A	05MAR04 A
5061	Backfill Fnds & Grade for Butler	10	01MAR04 A	12MAR04 A
5056	Underslab Electrical Roughins	5	08MAR04 A	05MAR04 A
5131	MS V - Load Wing 'A' Ready for Butler	0	12MAR04 A	
5121	Anchor Bolt Survey	2	15MAR04 A	23MAR04 A
5101	Fine Grade / Place Stone for SOG	5	17MAR04 A	19MAR04 A
5016	Butler Steel Delivery	3	24MAR04 A	07APR04 A
5141	Butler Shakeout & Preassemble	4	17MAY04 A	26MAY04 A
5116	Butler Deliver Platform Steel	2	18MAY04 A	19MAY04 A
5011	Butler Erect & Detail Steel	17	04JUN04 A	15JUN04 A
5106	Place & Cure SOG	10	17JUN04 A	24JUN04 A
5031	Butler Wall Sheeting East Wall	4	21JUN04 A	30JUL04 A
5021	Butler MR-24 Roof	5	28JUN04 A	02JUL04 A
5036	Butler Wall Sheeting North Wall	2	28JUN04 A	02JUL04 A
5076	Fire Protection at Roof	25	28JUN04 A	16JUL04 A
5081	Power, Lighting & F.A. at Roof	25	28JUN04 A	16JUL04 A
5046	Butler O/H Dock Doors North	5	13JUL04 A	24AUG04 A
5126	Butler Shakeout & Preassemble	4	14JUL04 A	19JUL04 A
5086	Butler Erect & Detail Platform	10	16JUL04 A	04AUG04 A
5091	Butler Platform Decking	5	21JUL04 A	04AUG04 A
5026	Mechanical/Units at Roof	10	22JUL04 A	23JUL04 A
5096	Pre/Place & Cure SOD	9	27JUL04 A	30JUL04 A
5136	Fire Protection Under Platform	10	27JUL04 A	20AUG04 A
5146	Mechanical Under Platform	10	27JUL04 A	20AUG04 A
5156	Power, Lighting & F.A. Under Platform	10	27JUL04 A	20AUG04 A
5181	Plywood Liner - West	3	02AUG04 A	06AUG04 A
5161	Plywood Liner - East	3	03AUG04 A	05AUG04 A
5041	Butler Wall Sheeting West Wall	4	09AUG04 A	13AUG04 A
5171	Plywood Liner - North	2	16AUG04 A	08SEP04
5151	Trans 'A' Ready for HK Systems	0	01SEP04 A	

Early bar
Start milestone point
Finish milestone point

FedEx Distribution Center - Project Schedule

Act ID	Activity Description	Orig Dur	Early Start	Early Finish
5071	Butler Ext Canopy - North	5	07SEP04	11SEP04
5166	Electrical Finish - North Doors	10	09SEP04	20SEP04
5191	Fire Protection - Finish, Start-up & Test	25	13SEP04 *	11OCT04
5211	Electrical - Finish, Start-up & Test	10	21SEP04	01OCT04
5201	Mechanical - Finish, Start-up & Test	10	09OCT04 *	20OCT04
5221	Transition A - Complete	0		20OCT04
Load Wing 'A'				
5066	Mass Exc Soils Load Wing A	17	23JAN04 A	05FEB04 A
5014	Electrical Underslab Roughins	10	09FEB04 A	19MAR04 A
5001	Conc Fnds/Walls/Piers	25	25FEB04 A	15MAR04 A
5024	Backfill Fnds & Grade for Butler	15	04MAR04 A	17MAR04 A
5019	Electrical Building Ground Loop	10	08MAR04 A	19MAR04 A
5009	Underslab Plumbing Roughins	10	15MAR04 A	19MAR04 A
5095	Fine Grade / Place Stone for SOG	10	15MAR04 A	19MAR04 A
5049	Load Wing A Ready for Butler	0	19MAR04 A	
5039	Anchor Bolt Survey	2	23MAR04 A	23APR04 A
5100	Place & Cure SOG	18	25MAR04 A	01JUL04 A
5054	Butler Steel Delivery	4	01APR04 A	02APR04 A
5180	Butler Shakeout & Preassemble	2	08APR04 A	16APR04 A
5060	Butler Erect Steel	8	23APR04 A	07MAY04 A
5065	Butler Detail Steel	11	05MAY04 A	14MAY04 A
5070	Power, Lighting & F.A. at Roof	22	10MAY04 A	25MAY04 A
5075	Fire Protection at Roof	7	31MAY04 A	08JUN04 A
5090	Butler MR-24 Roofing	13	14JUN04 A	22JUN04 A
5080	Mechanical/Units at Roof	20	24JUN04 A	25JUN04 A
5105	Butler Wall Sheeting South Wall 15 to 34	6	28JUN04 A	29JUL04 A
5160	Butler Deliver Conveyor Steel	13	07JUL04 A	19JUL04 A
5125	Butler O/H Dock Doors North Wall 15-34	13	12JUL04 A	18AUG04 A
5120	Butler O/H Dock Doors South Wall 15-34	12	13JUL04 A	18AUG04 A
5165	Butler Erect Conveyor Steel	17	23JUL04 A	04AUG04 A
5115	Butler Wall Sheeting North Wall 34 to 15	6	02AUG04 A	20AUG04 A
5185	Plywood Liner - South	5	05AUG04 A	27AUG04 A
5110	Butler Wall Sheeting East Wall K.2-H.6	1	23AUG04 A	25AUG04 A
5135	Butler Ext Canopy North Wall 34-15	9	23AUG04 A	03SEP04 A
5205	Plywood Liner - North	5	23AUG04 A	11SEP04
5170	MS VI - Load Wing 'A' Ready for HK Systems	0	01SEP04 A	
5130	Butler Ext Canopy South Wall 15-34	10	07SEP04 A	17SEP04
5195	Plywood Liner - East	2	07SEP04	08SEP04
5225	Electrical Finish - North Doors	10	07SEP04	17SEP04

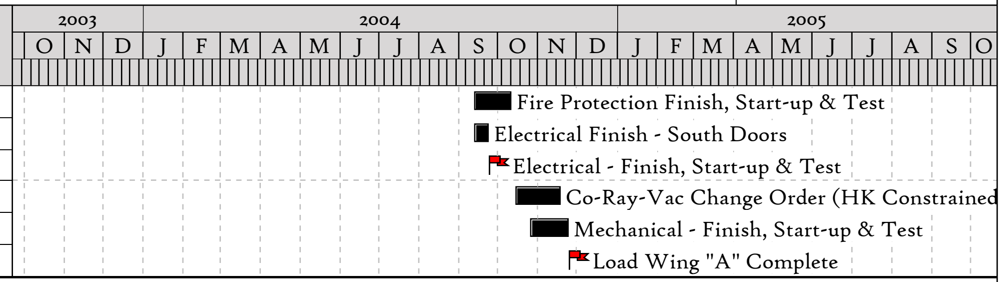


Early bar
Start milestone point
Finish milestone point

FedEx Distribution Center - Project Schedule

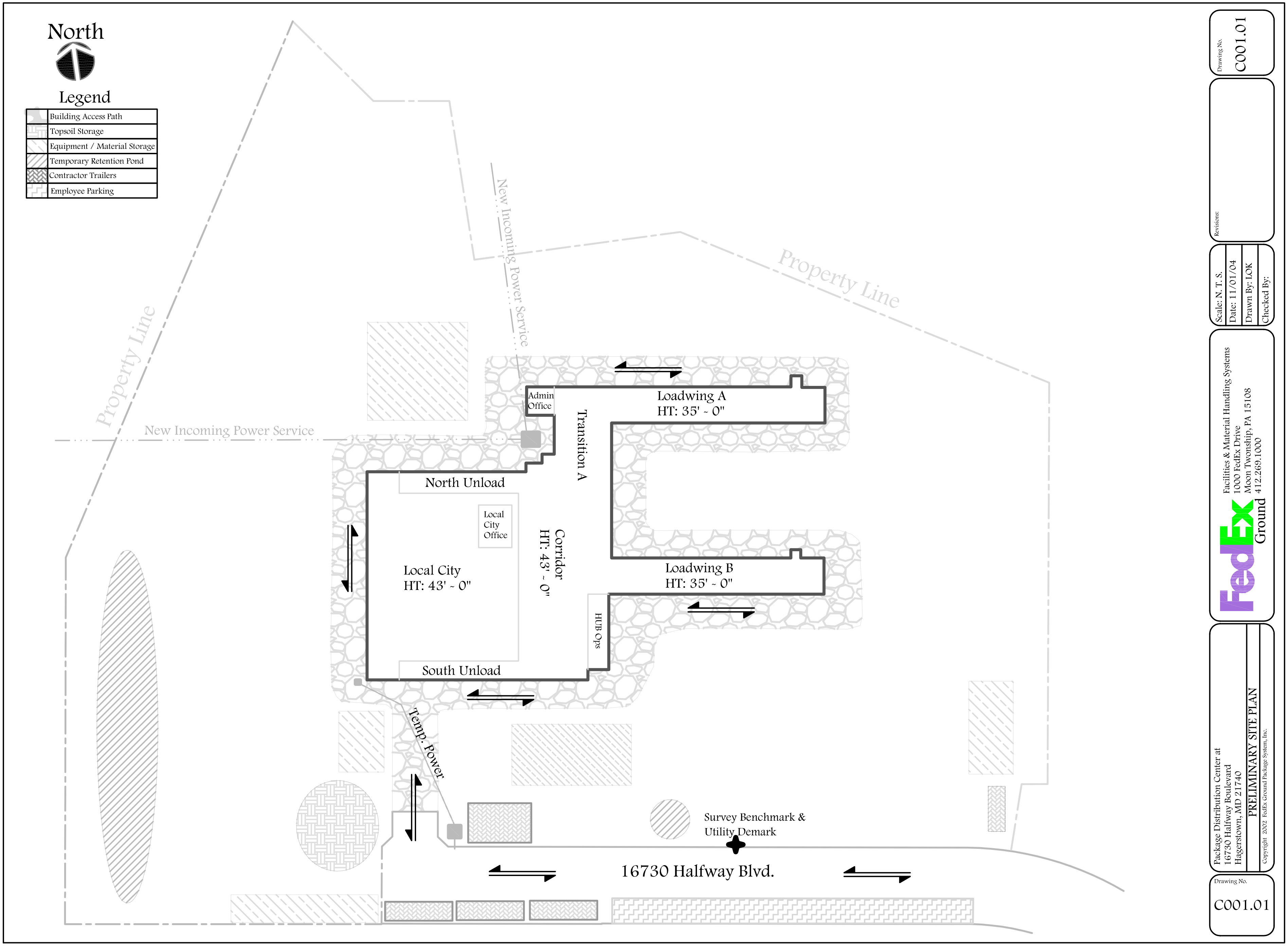
Page number 6A
Page count 6A

Act ID	Activity Description	Orig Dur	Early Start	Early Finish
5140	Fire Protection Finish, Start-up & Test	25	13SEP04 *	11OCT04
5215	Electrical Finish - South Doors	10	13SEP04	23SEP04
5145	Electrical - Finish, Start-up & Test	0		23SEP04
5190	Co-Ray-Vac Change Order (HK Constrained Start)	30	15OCT04 *	18NOV04
5150	Mechanical - Finish, Start-up & Test	25	27OCT04 *	24NOV04
5175	Load Wing "A" Complete	0		24NOV04

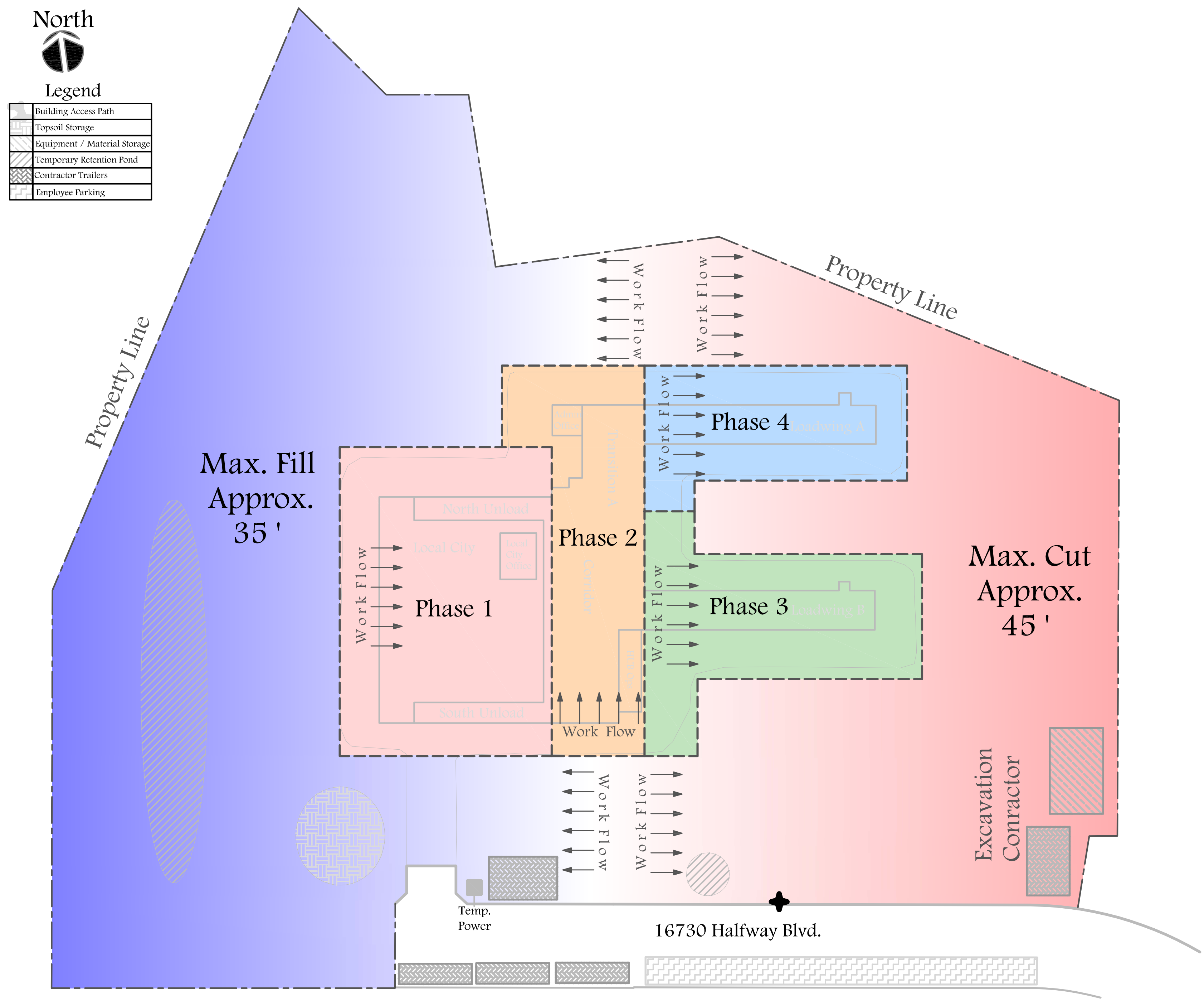


APPENDIX B

SITE PLANS



North
Legend
Building Access Path
Topsoil Storage
Equipment / Material Storage
Temporary Retention Pond
Contractor Trailers
Employee Parking
Property Line
Property Line
New Incoming Power Service
New Incoming Power Service
Admin Office
Transition A
Loadwing A
HT: 35' - 0"
Loadwing B
HT: 35' - 0"
North Unload
Local City Office
Local City
HT: 43' - 0"
Corridor
HT: 43' - 0"
HUB Ops
South Unload
Temp. Power
Survey Benchmark &
Utility Demark
16730 Halfway Blvd.
Drawing No.
C001.01
Revisions:
Scale: N. T. S.
Date: 11/01/04
Drawn By: LOK
Checked By:
FedEx Ground
Facilities & Material Handling Systems
1000 FedEx Drive
Moon Twonship, PA 15108
412.269.1000
Package Distribution Center at
16730 Halfway Boulevard
Hagerstown, MD 21740
PRELIMINARY SITE PLAN
Copyright 2002 FedEx Ground Package System, Inc.
Drawing No.
C001.01



Drawing No.
C001.03

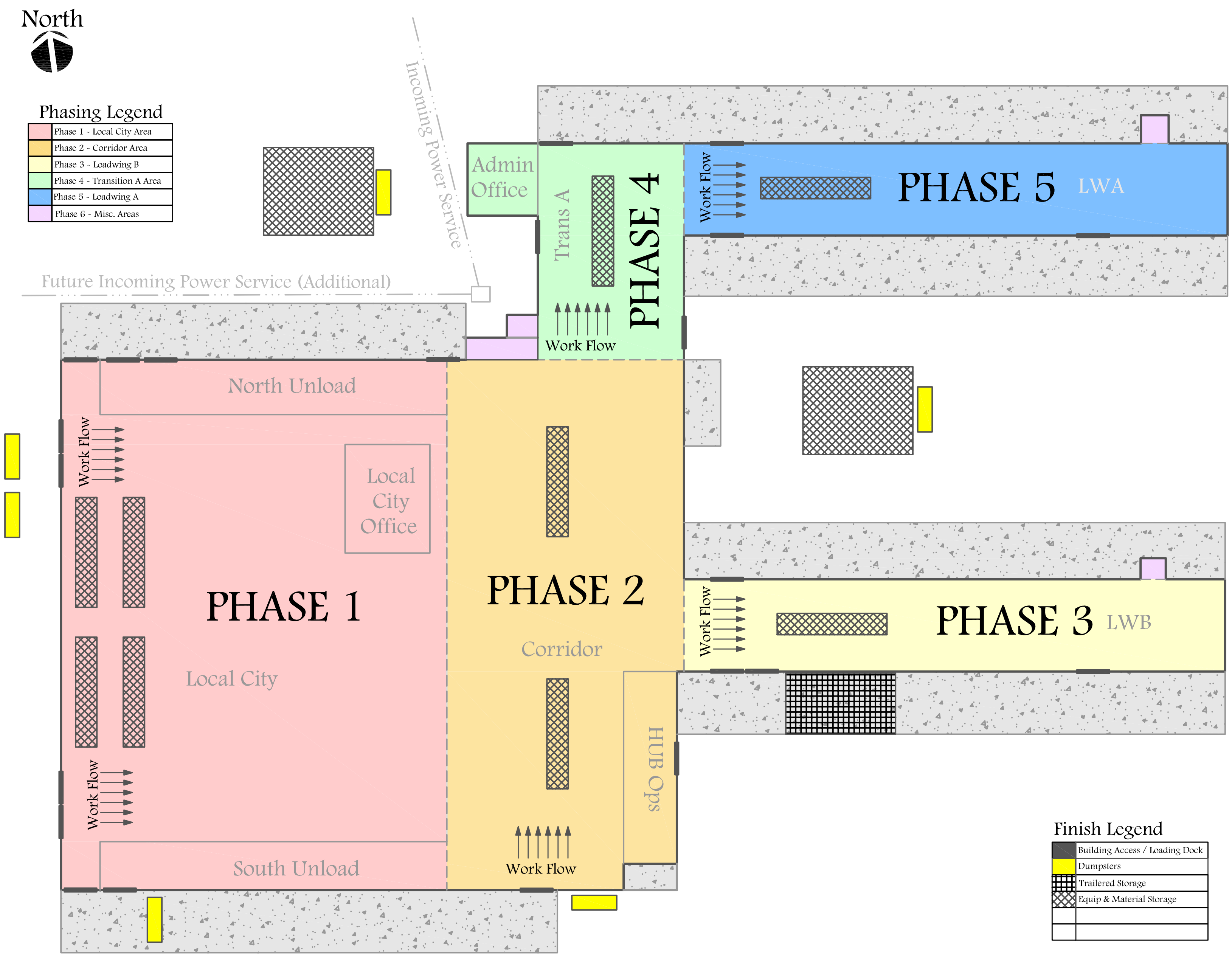
Revisions:

Scale: N. T. S.
Date: 11/01/04
Drawn By: LOK
Checked By:

FedEx Ground
Facilities & Material Handling Systems
1000 FedEx Drive
Moon Twonship, PA 15108
412.269.1000

Package Distribution Center at
16730 Halfway Boulevard
Hagerstown, MD 21740
PRELIMINARY EXCAVATION SITE PLAN

Drawing No.
C001.03



Drawing No. C001.04

Revisions:

Scale: N. T. S.
Date: 11/01/04
Drawn By: LOK
Checked By:

FedEx Ground
Facilities & Material Handling Systems
1000 FedEx Drive
Moon Twonship, PA 15108
412.269.1000

Package Distribution Center at
16730 Halfway Boulevard
Hagerstown, MD 21740

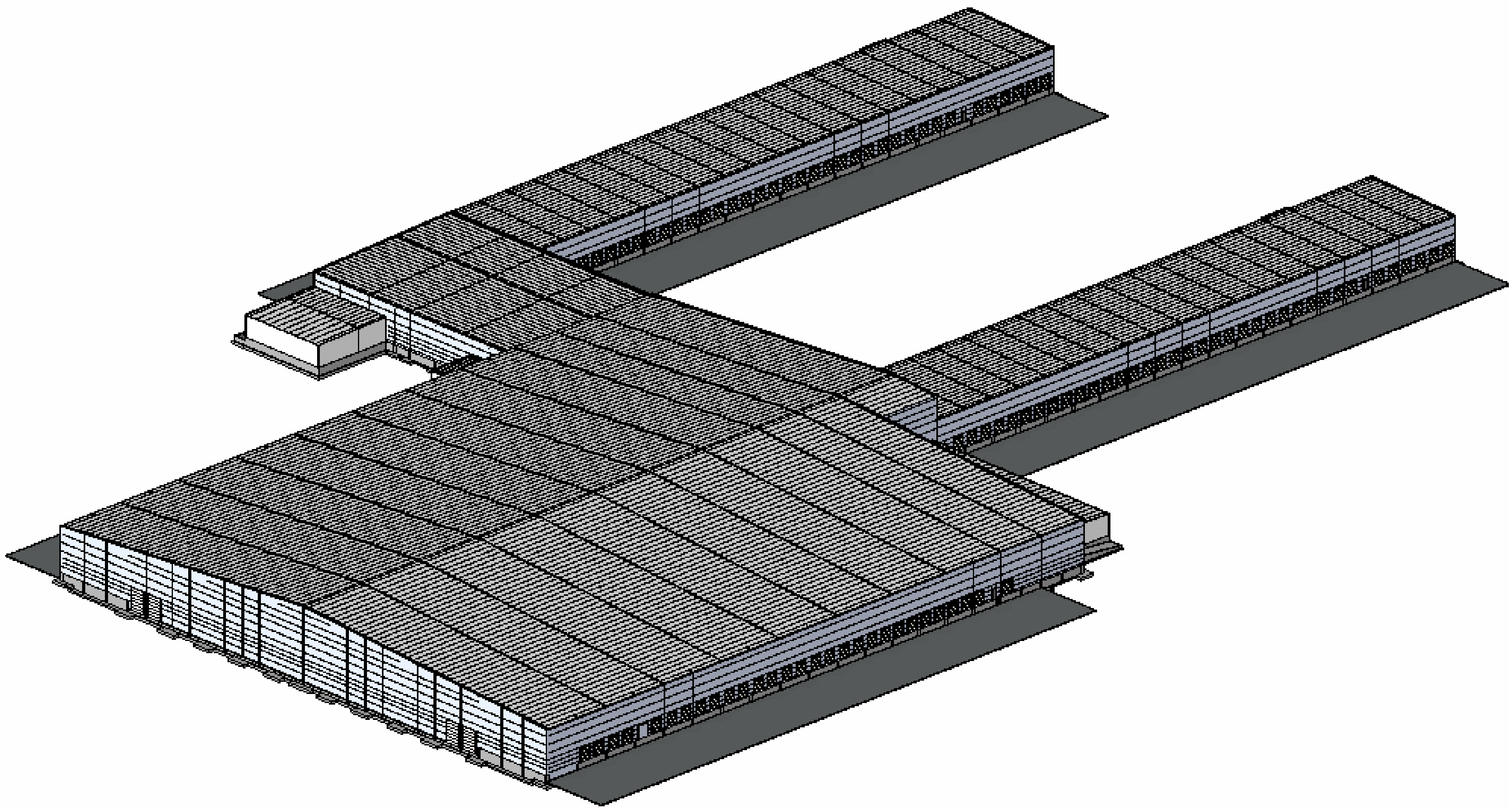
PRELIMINARY FINISH TRADES PLAN

Drawing No. C001.04

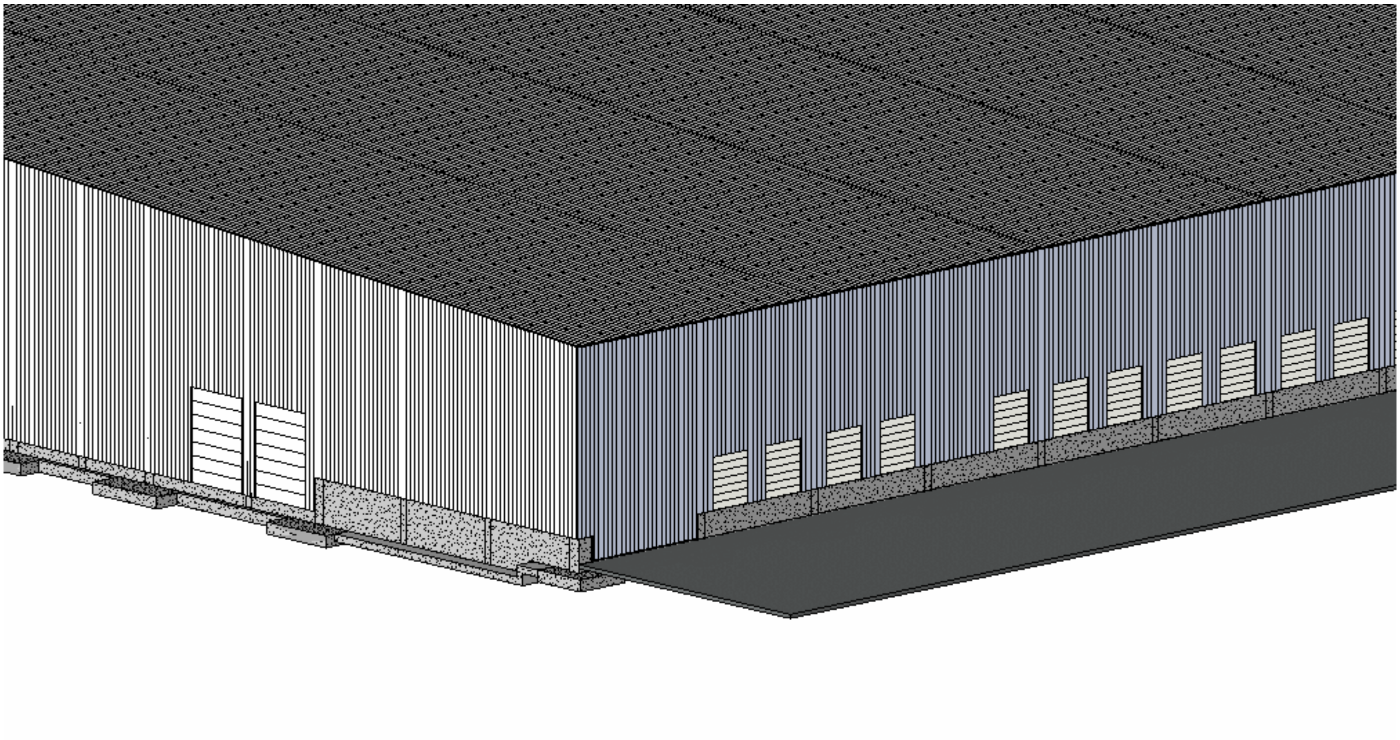
APPENDIX C

FEDEX DISTRIBUTION ADVANCED MODELS

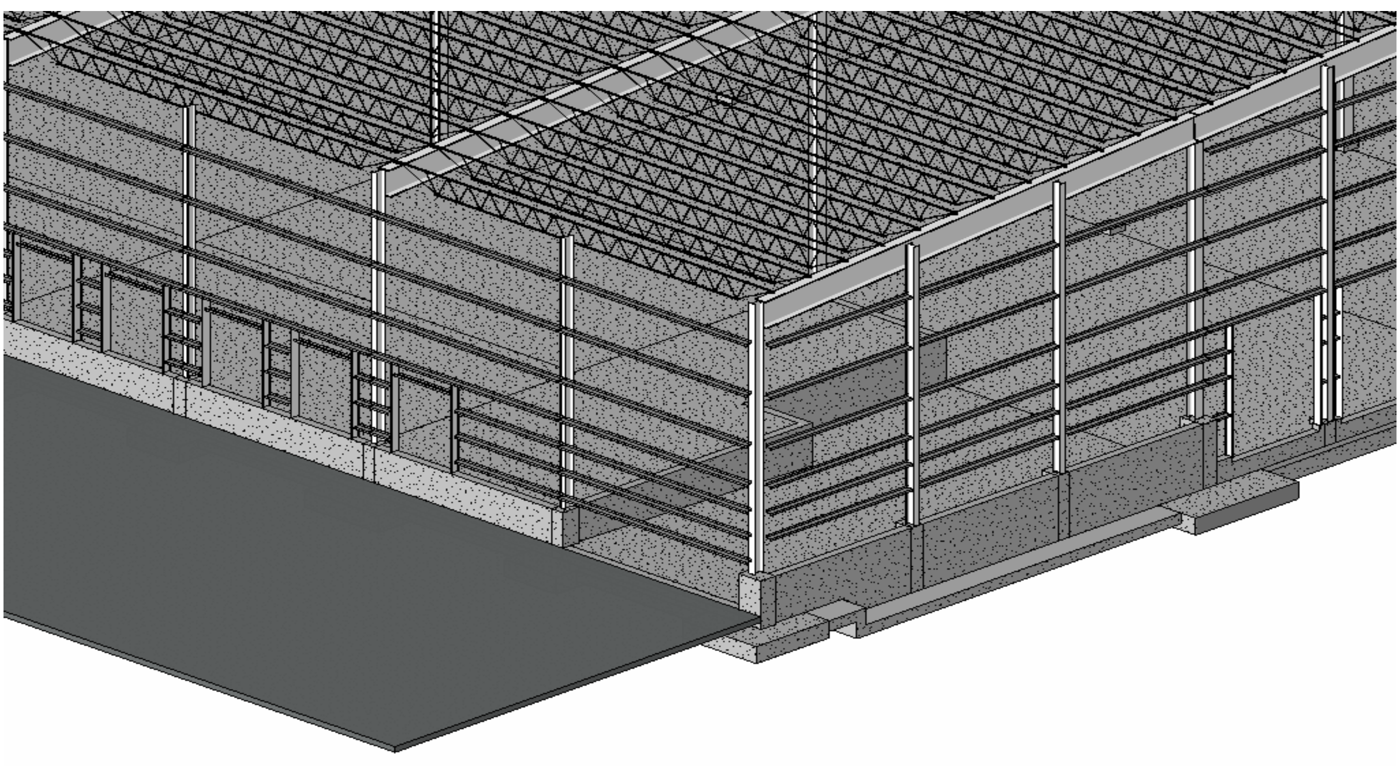
FedEx Ground Distribution Hub Building Information model and images using Autodesk Revit



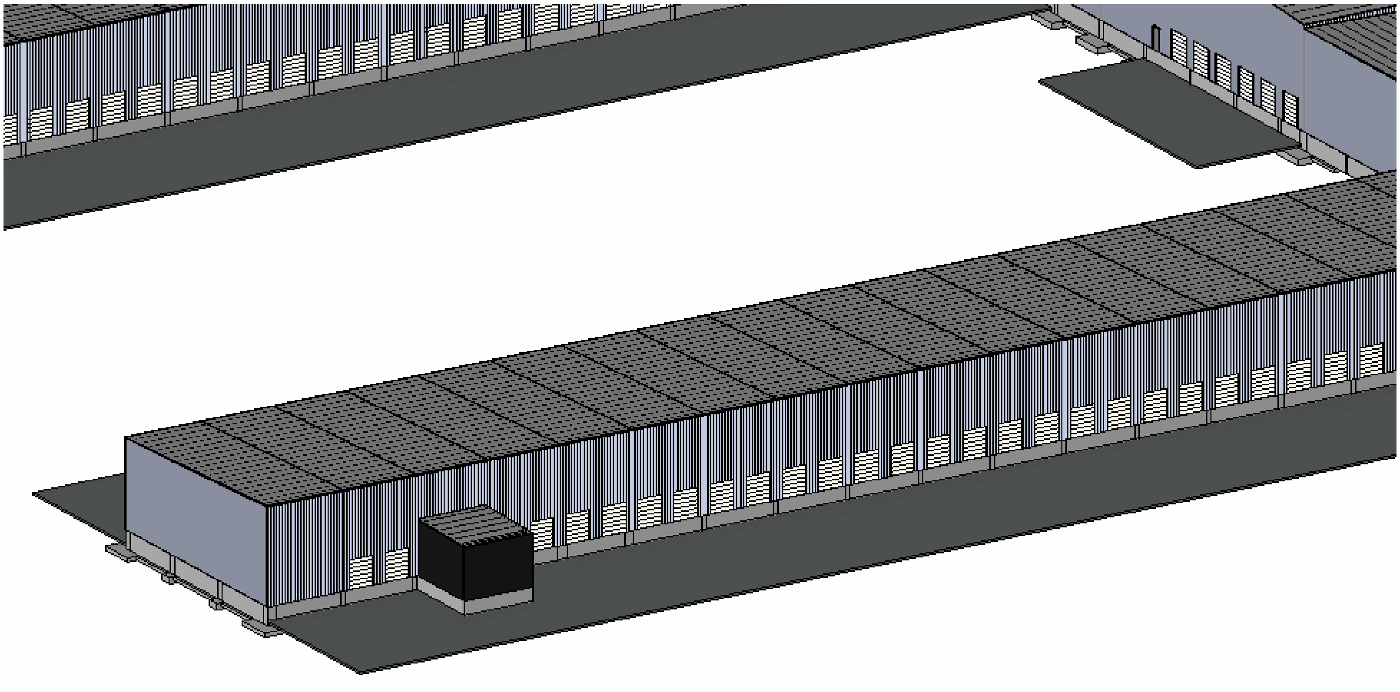
Distribution Hub Complete



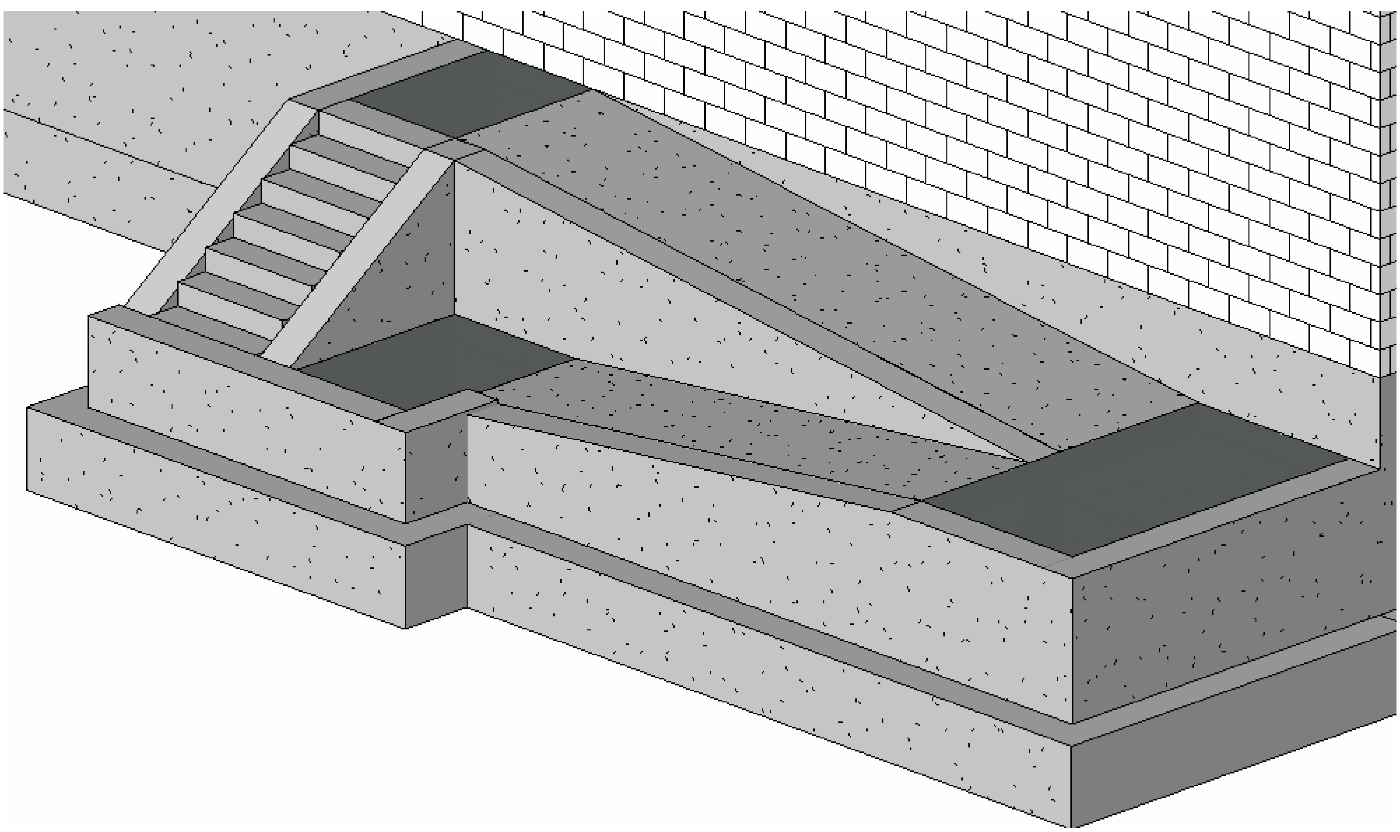
Local City Southwest View



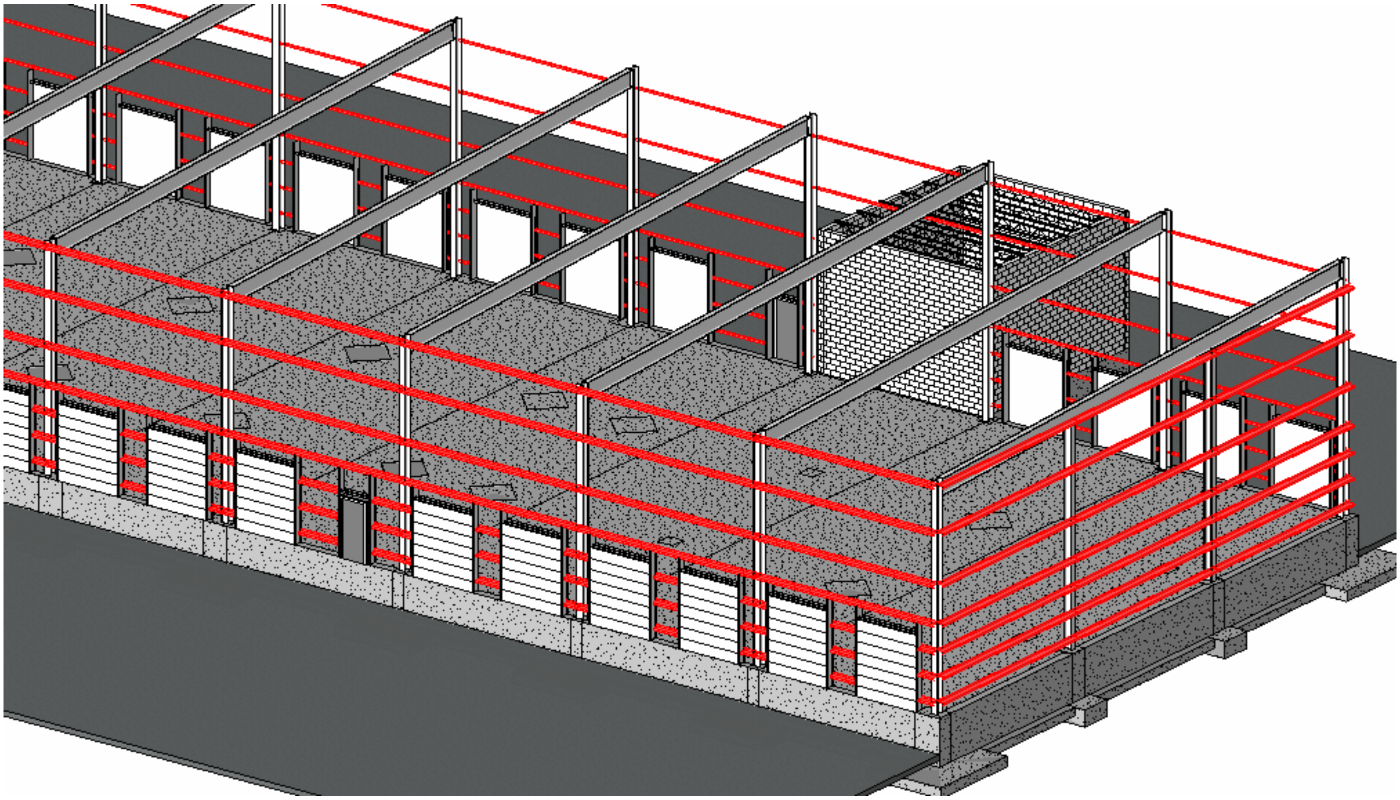
Local City Structural Steel Complete
Northwest View



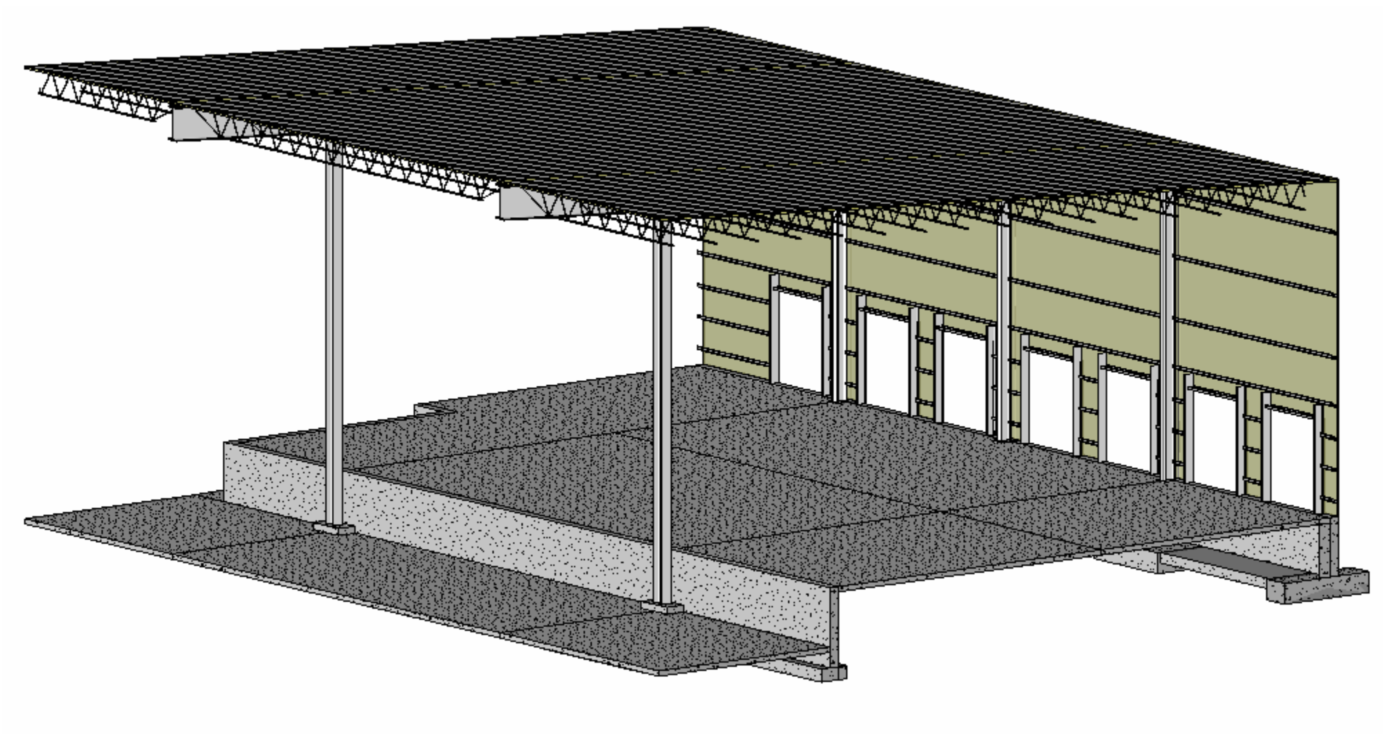
Typical Loadwing Northeast View



Stairs and Ramp for Administration
Office Entrance

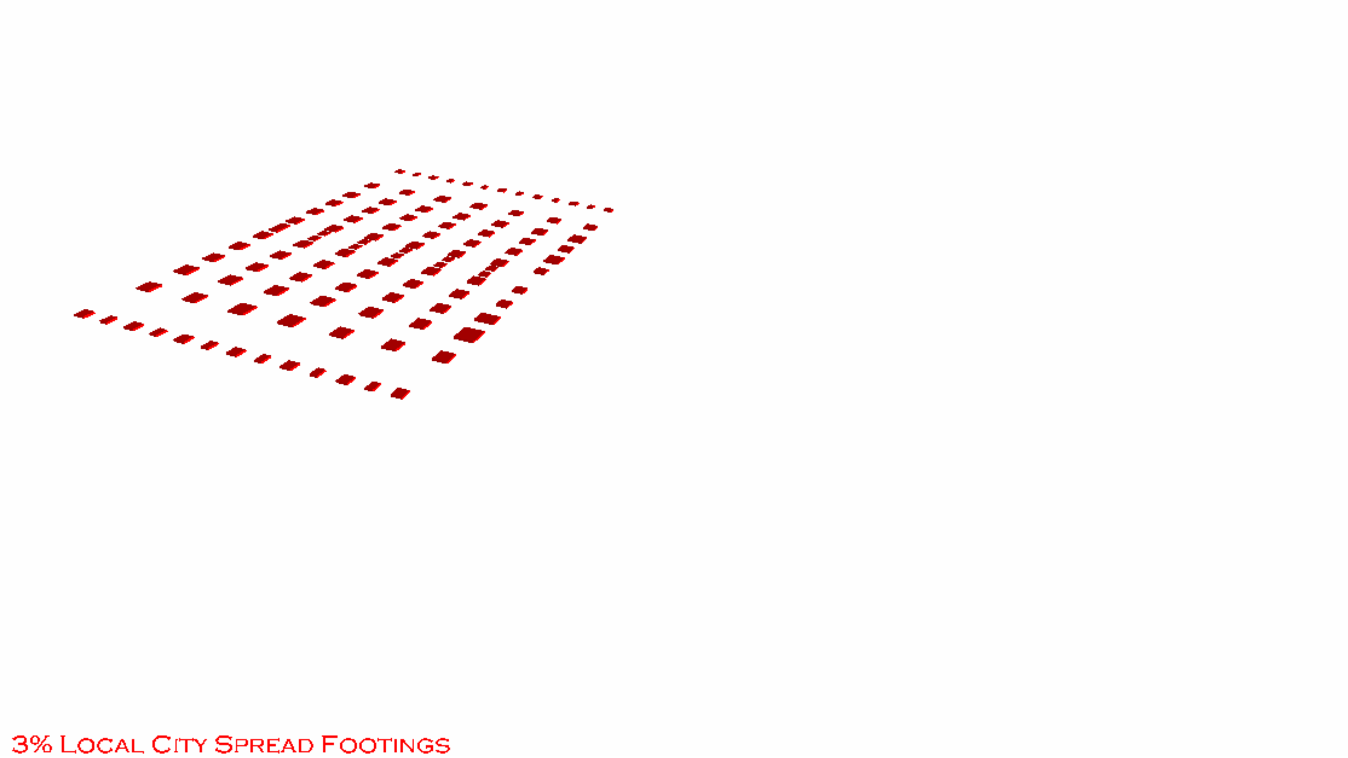


Loadwing B Metal Wall Backup System Isolated

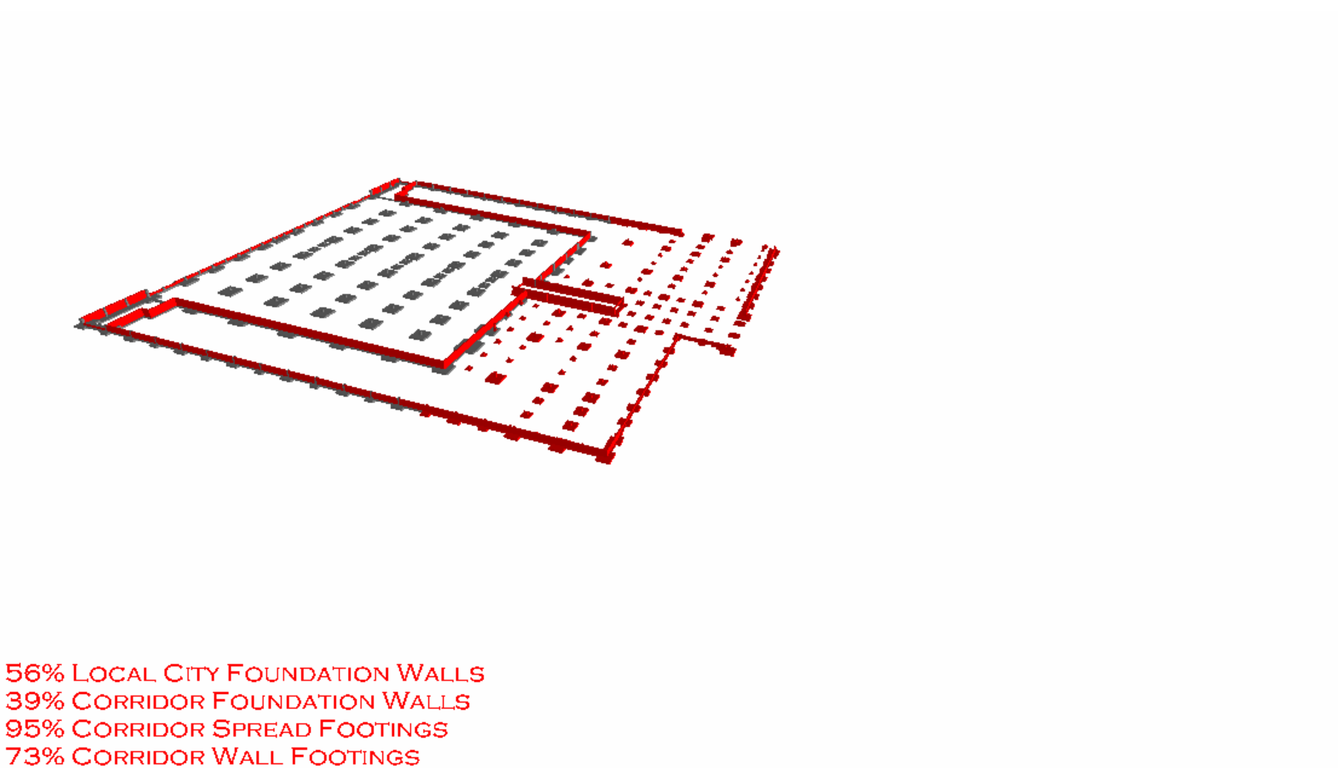


Local City Unload Typical Bay Section

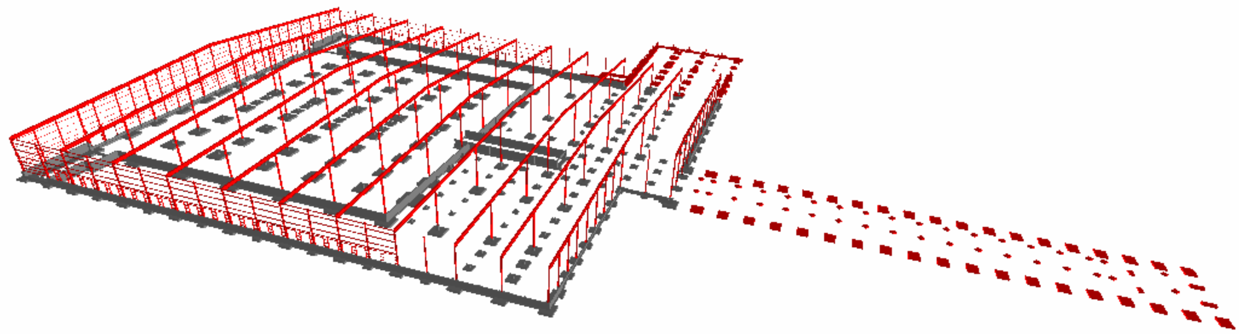
4D Model
using a
3d AutoCAD Model
and an
initial project schedule



December 1, 2003

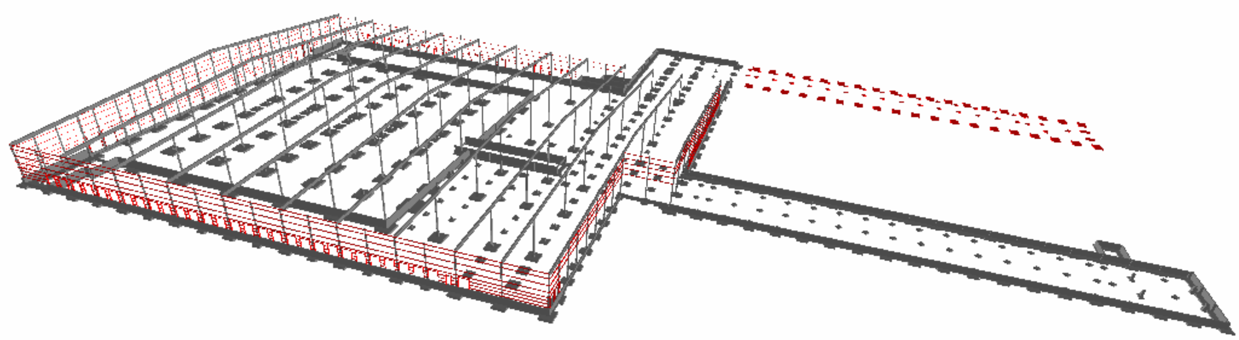


January 1, 2004



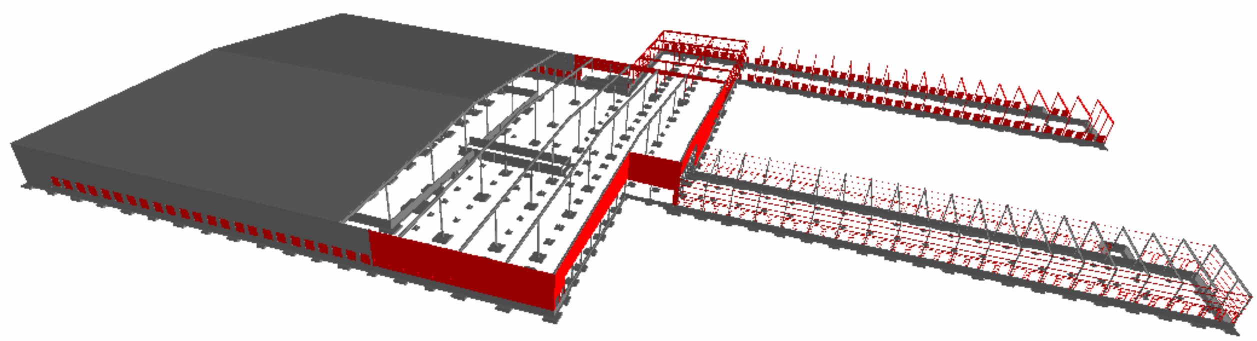
83% Trans Spread Footings
73% Local City Structural Steel
50% LWB Spread Footings
16% Trans Wall Footings
21% Local City Framing
4% Corridor Structural Steel

February 1, 2004



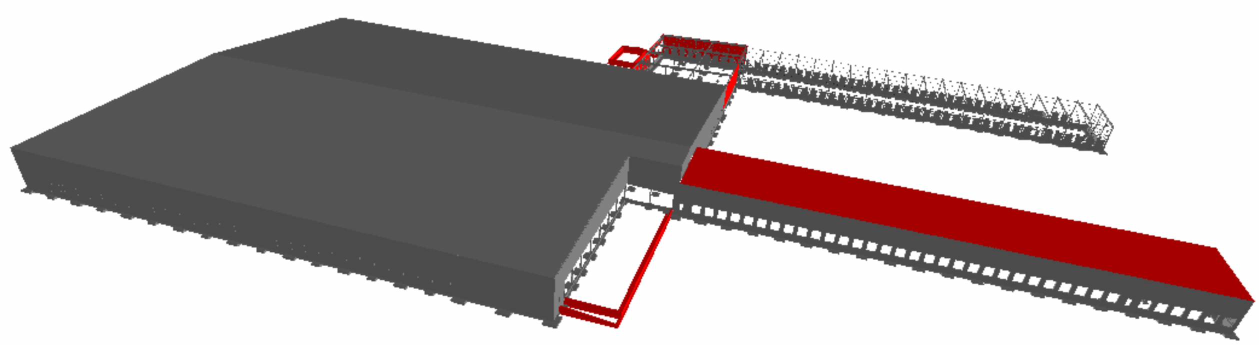
33% LWA Spread Footings
46% Corridor Framing
97% Local City Framing

March 1, 2004



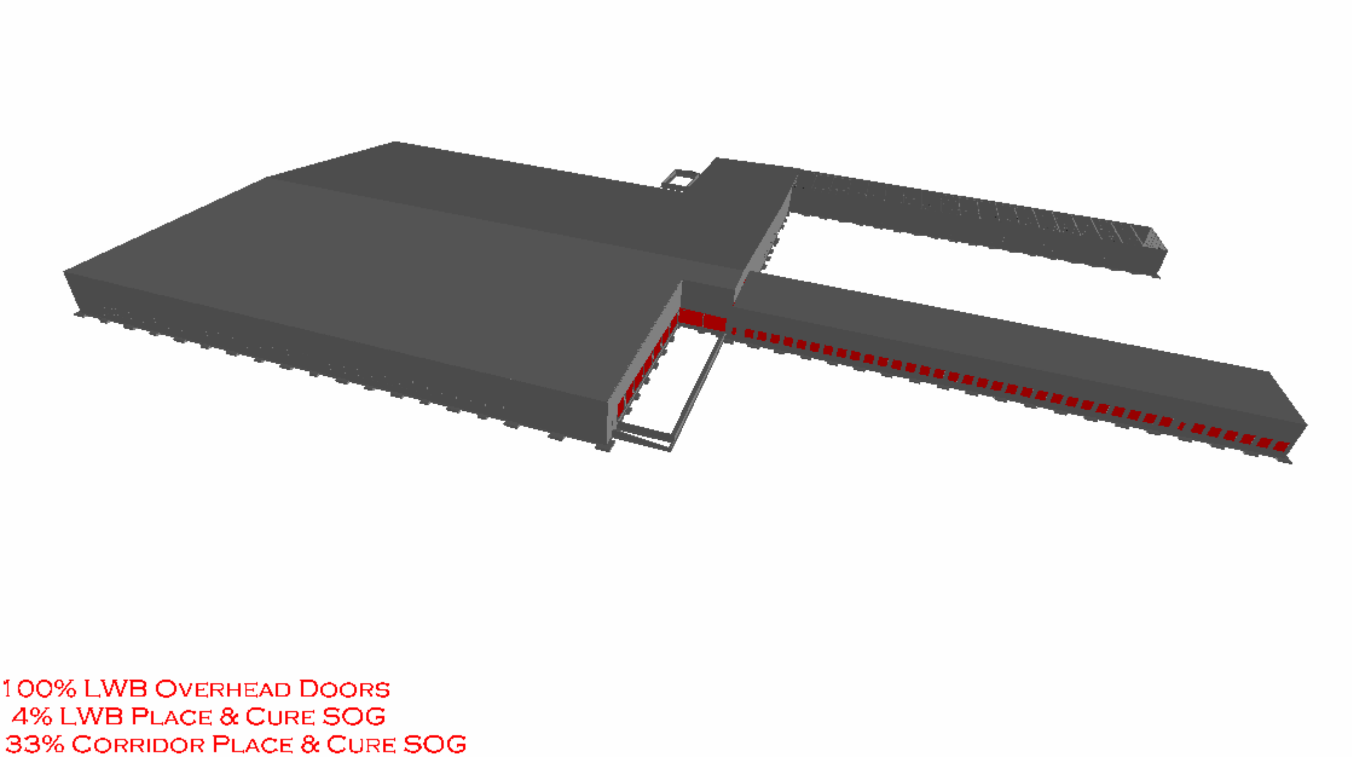
36% Trans Overhead Doors
5% LWA Structural Steel
33% Corridor Wall Sheeting
32% Trans Structural Steel
17% LWA Overhead Doors
47% Local City Overhead Doors
5% Trans Framing
7% LWB Framing

April 1, 2004

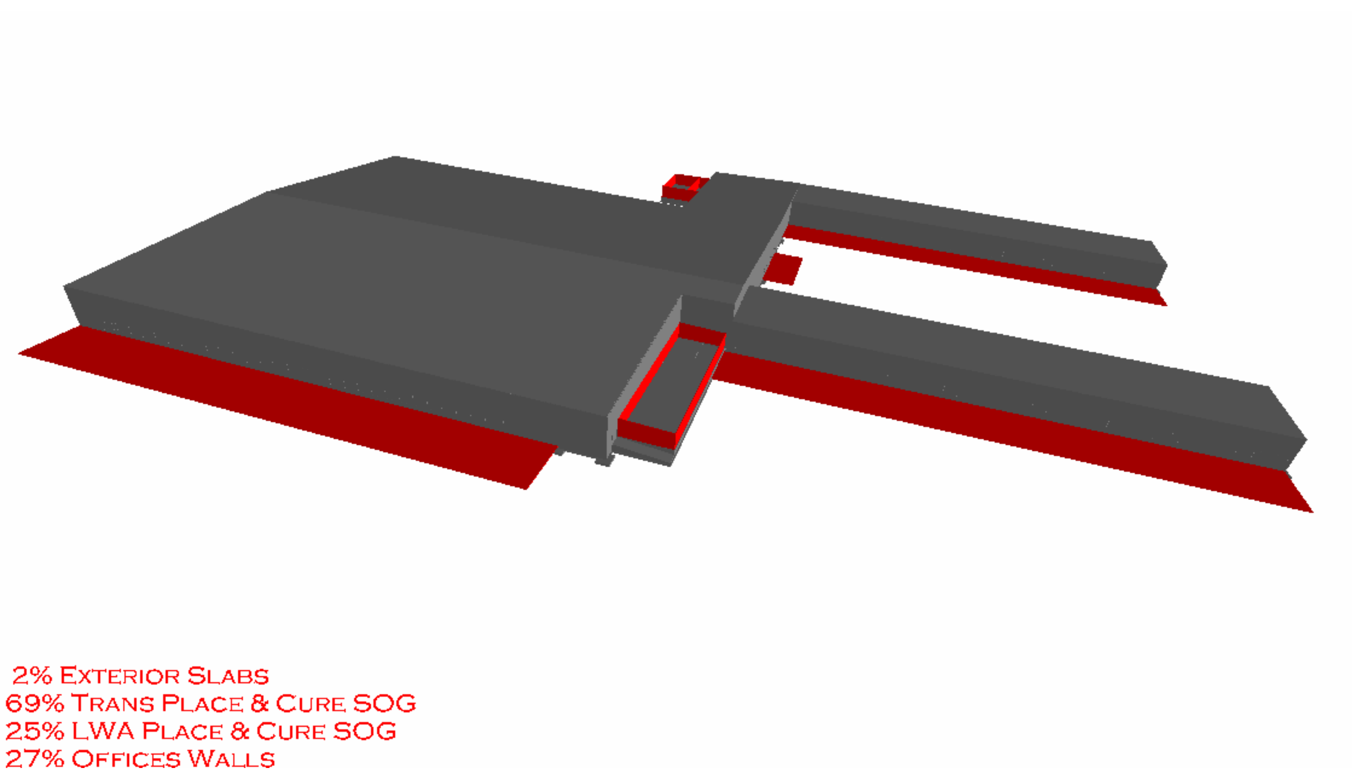


100% Offices Wall Footings
78% LWB MR-24 Roof Installation
6% Offices Foundation Walls
25% Trans Wall Sheeting
37% Local City Place & Cure SOG

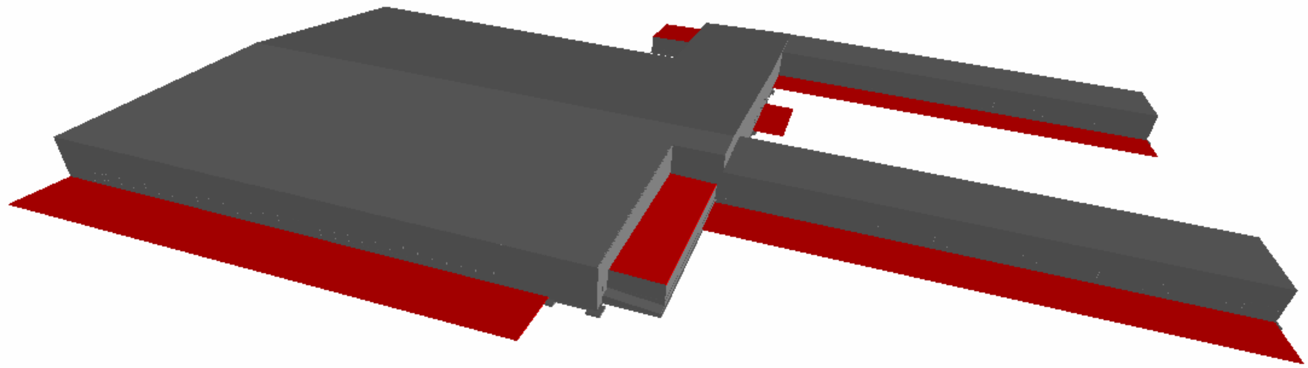
May 1, 2004



June 1, 2004

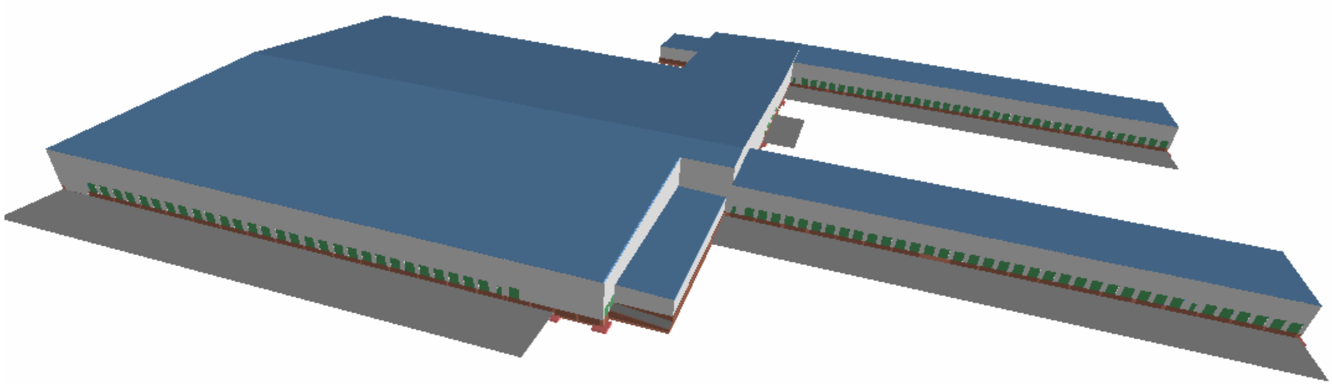


July 1, 2004



71% Exterior Slabs
28% Offices MR-24 Roof Installation
84% Offices Joists

August 1, 2004

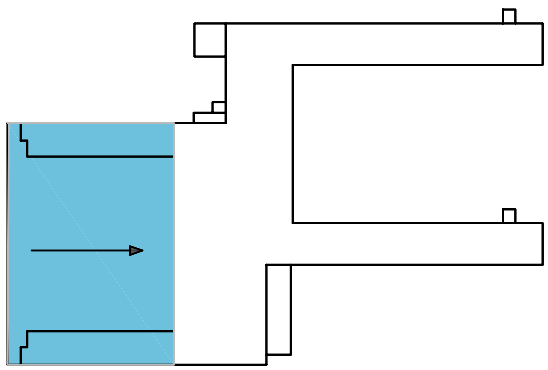


Building Structure & Enclosure Complete

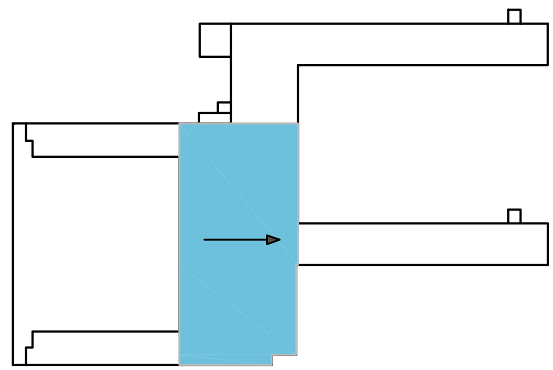
Appendix D

Steel Erection Sequences

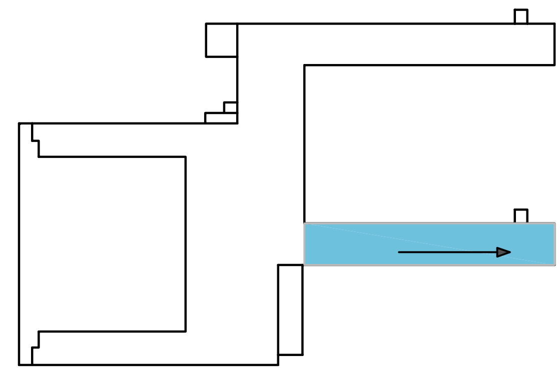
INITIAL STEEL PHASE SEQUENCING AND WORKFLOW



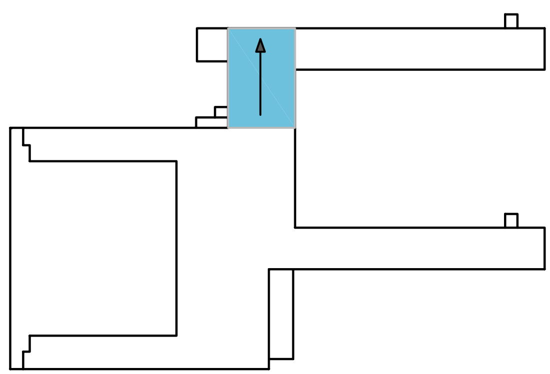
STEEL ERECTION PHASE 1



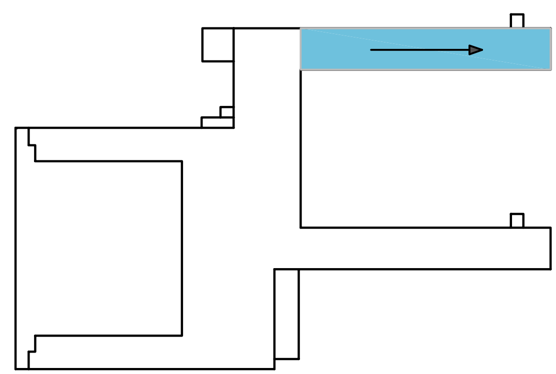
STEEL ERECTION PHASE 2



STEEL ERECTION PHASE 3

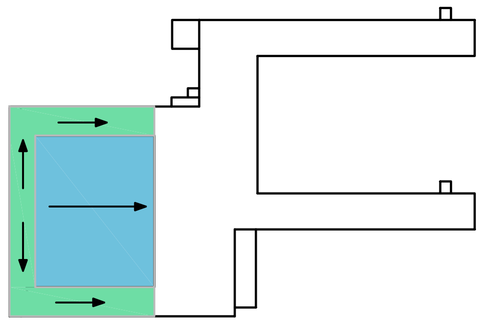


STEEL ERECTION PHASE 4

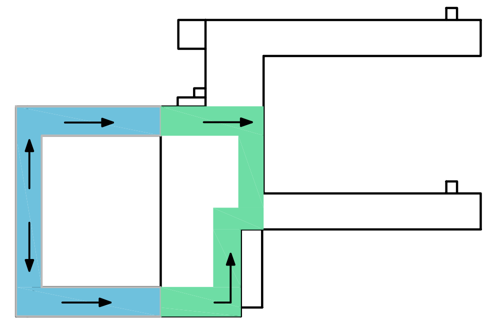


STEEL ERECTION PHASE 5

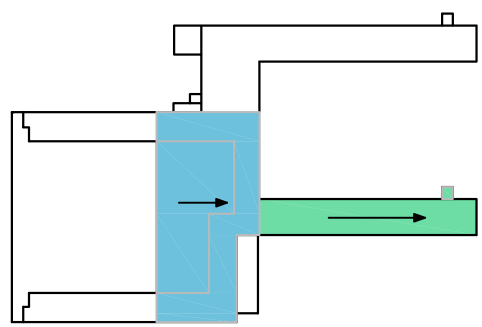
MODIFIED STEEL PHASE SEQUENCING AND WORKFLOW



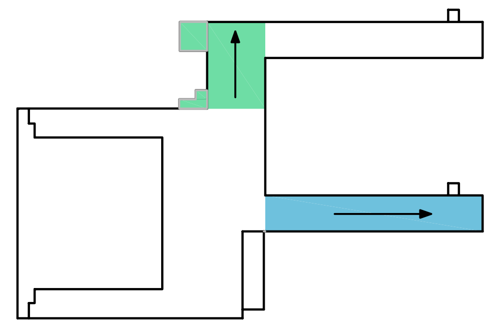
STEEL ERECTION PHASE 1A
TILT-UP CONSTRUCTION PHASE 1



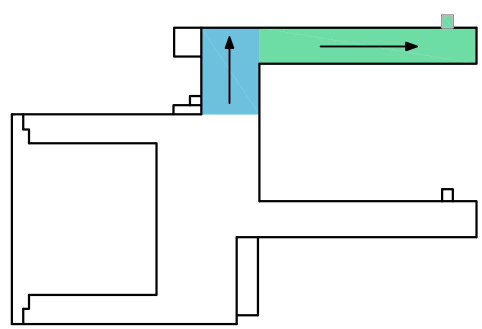
STEEL ERECTION PHASE 1B
TILT-UP CONSTRUCTION PHASE 2



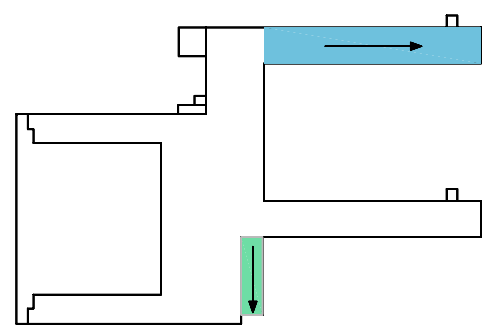
STEEL ERECTION PHASE 2
TILT-UP CONSTRUCTION PHASE 3



STEEL ERECTION PHASE 3
TILT-UP CONSTRUCTION PHASE 4



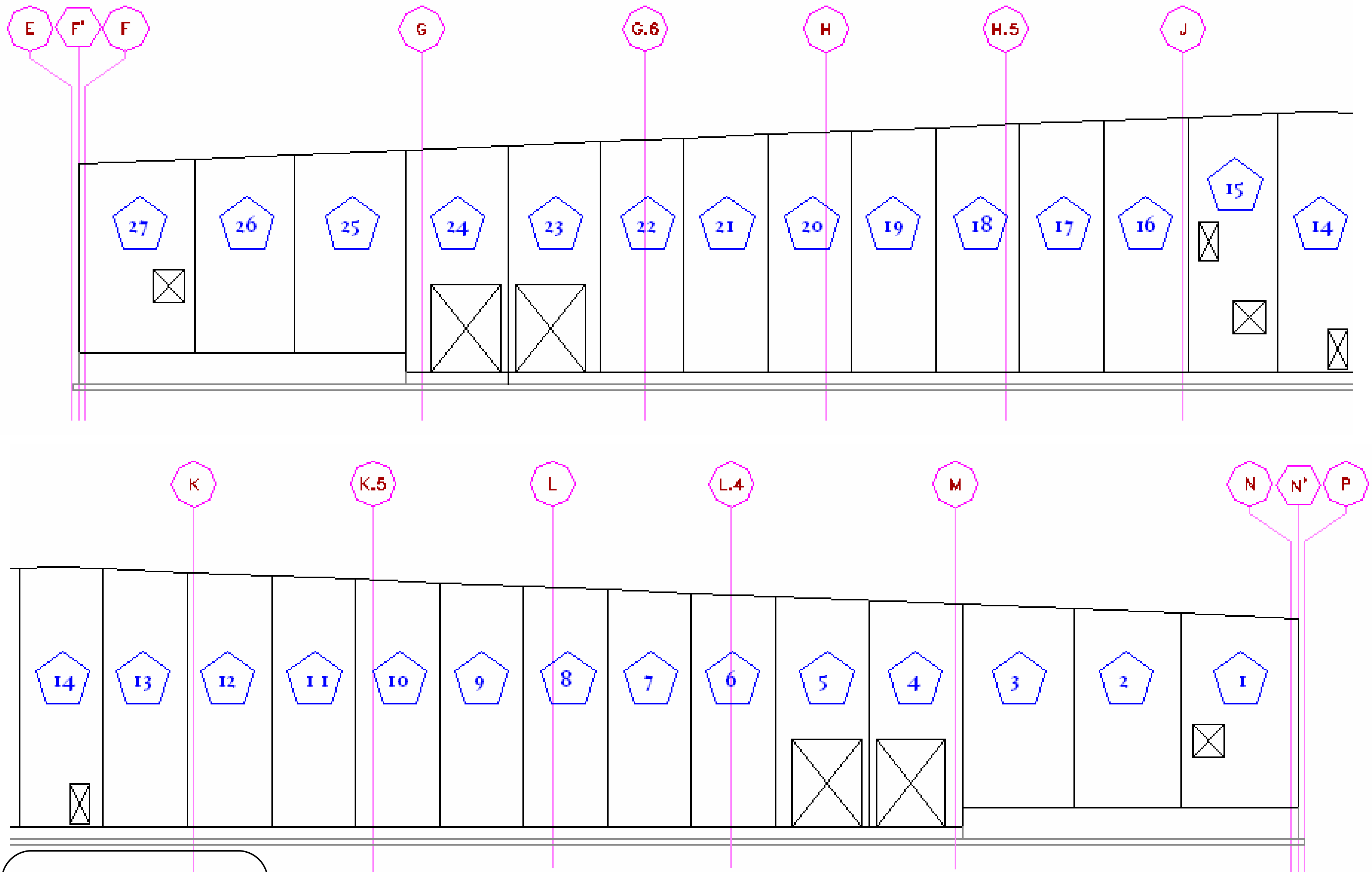
STEEL ERECTION PHASE 4
TILT-UP CONSTRUCTION PHASE 5

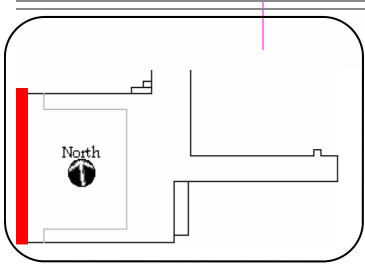


STEEL ERECTION PHASE 5
TILT-UP CONSTRUCTION PHASE 6

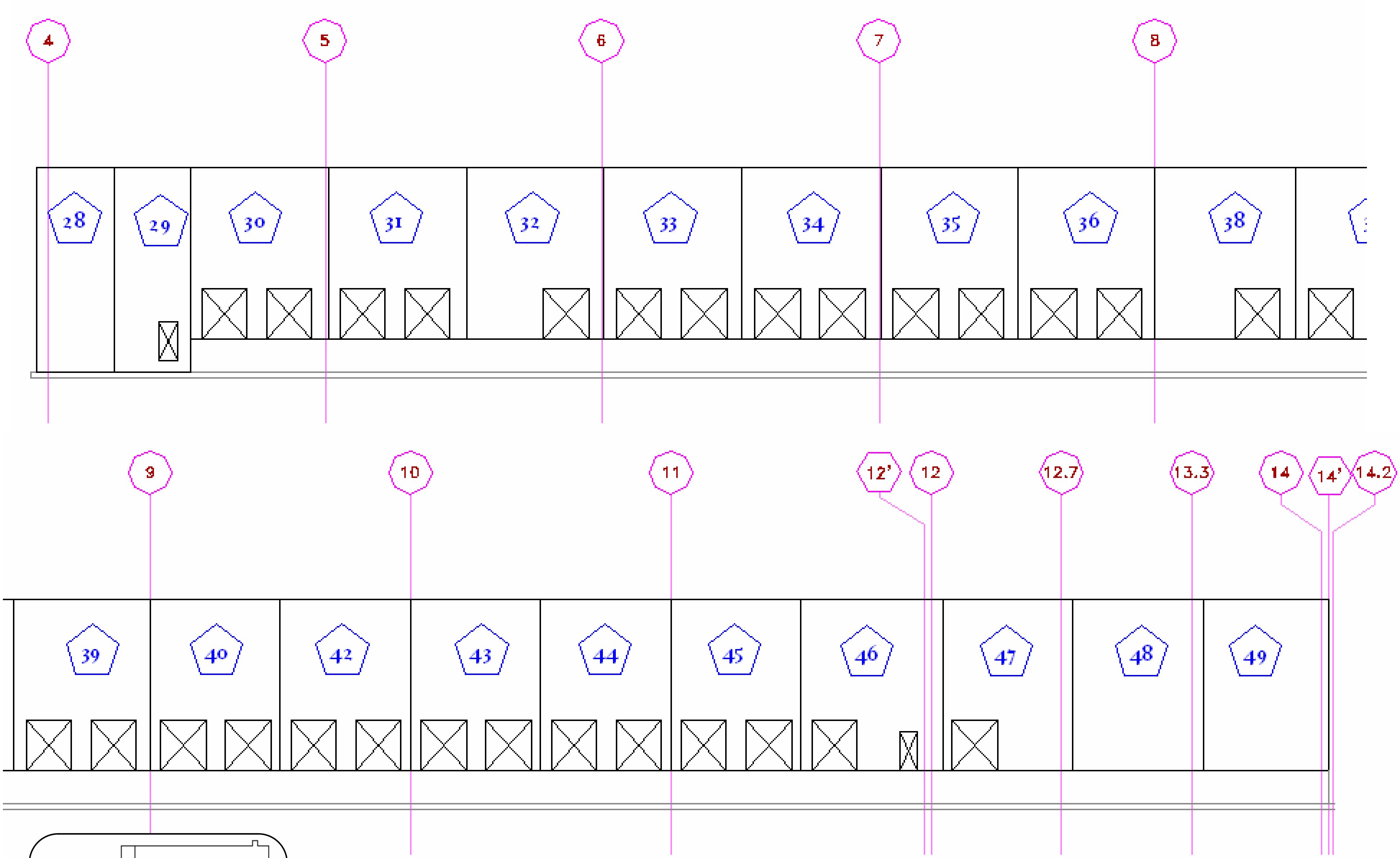
APPENDIX E

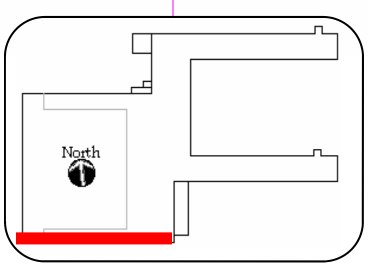
"PANELIZED" DRAWINGS



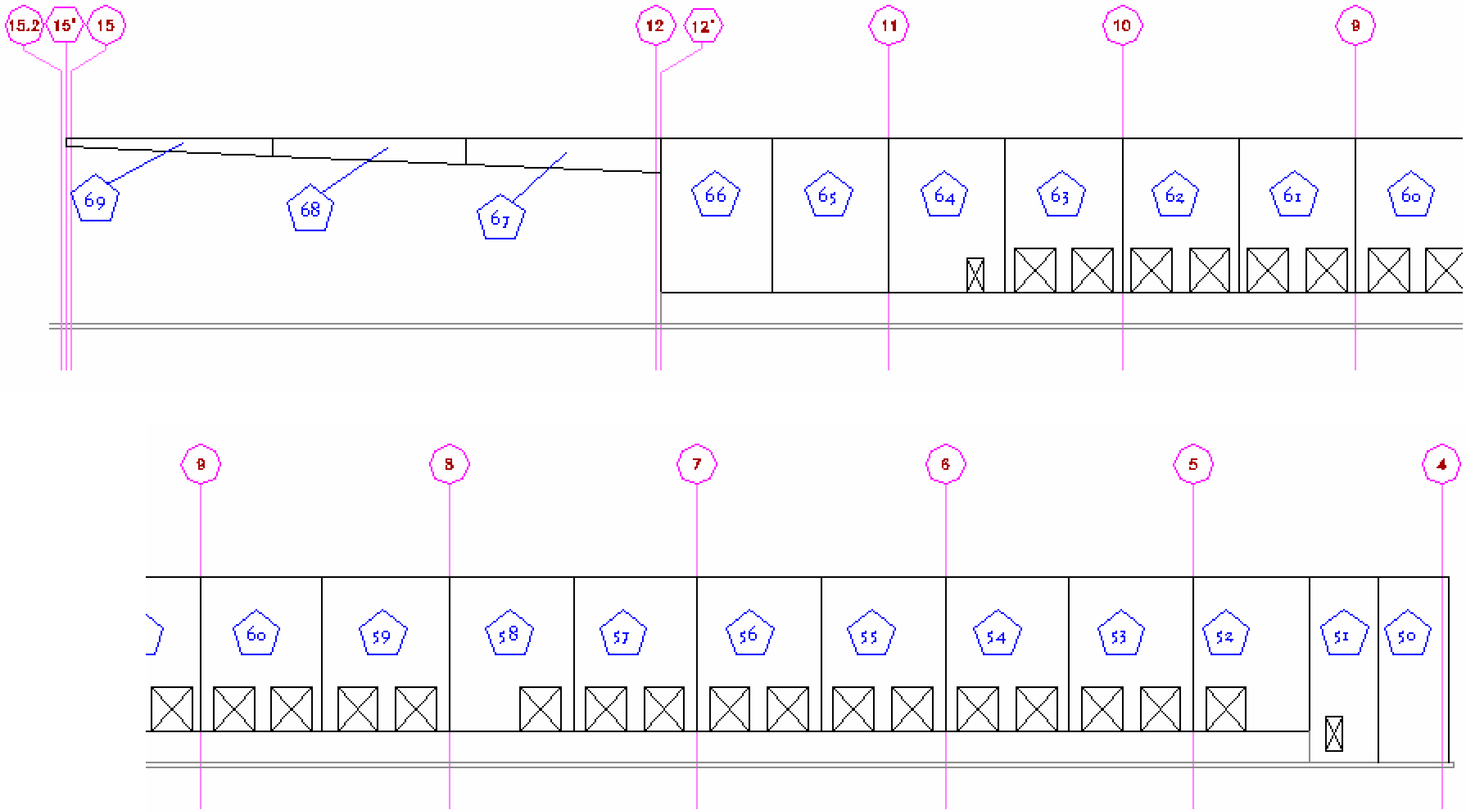


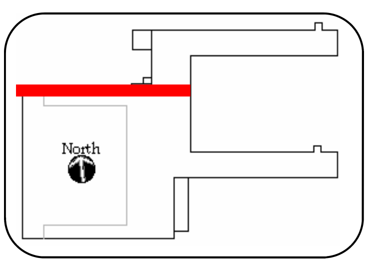
Local City - West Elevation (1 - 27)



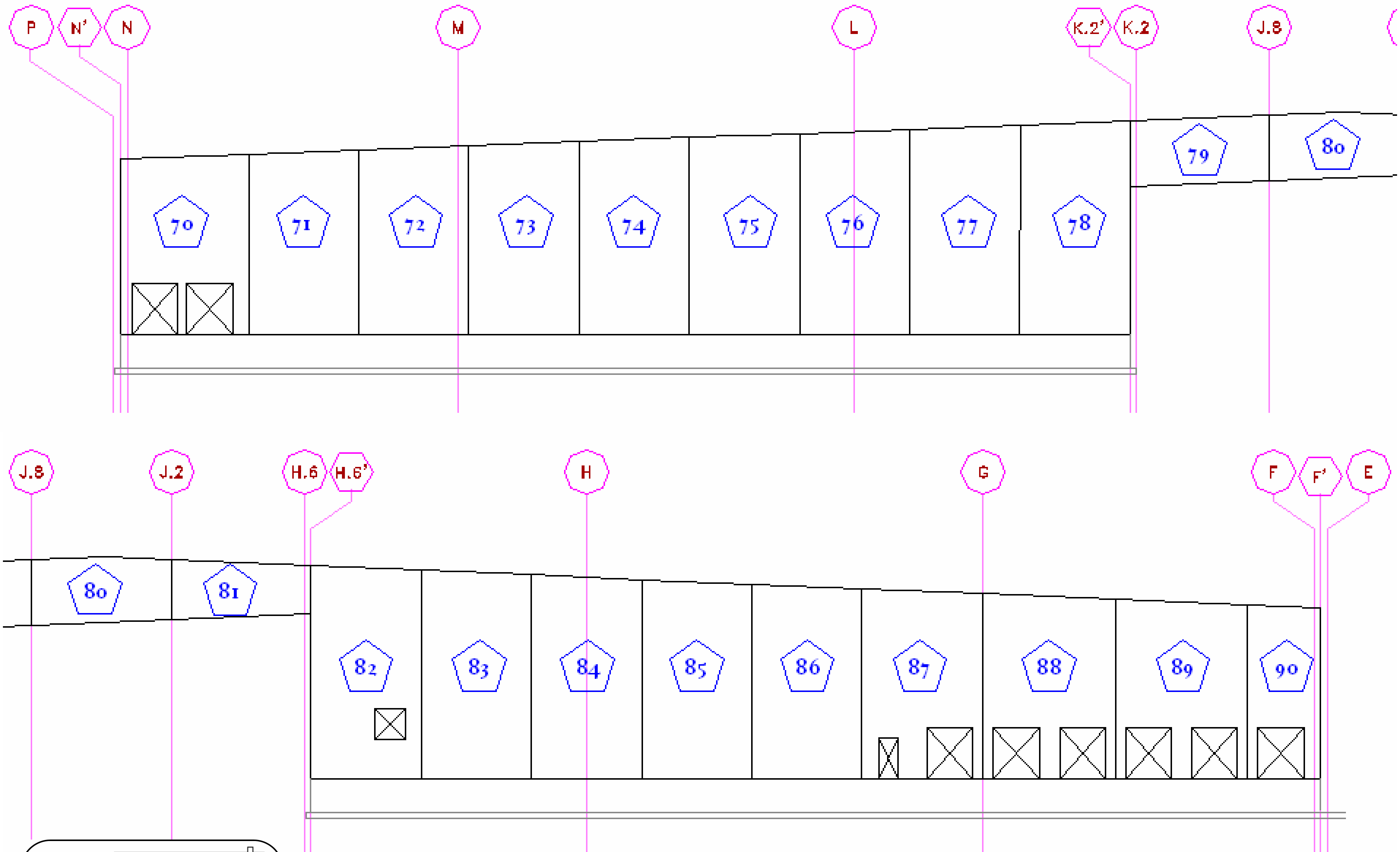


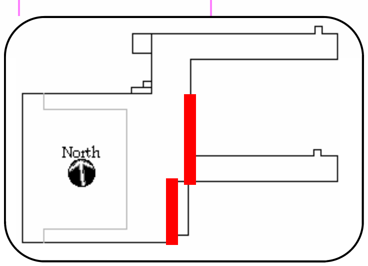
Local City - South Elevation (28 - 49)



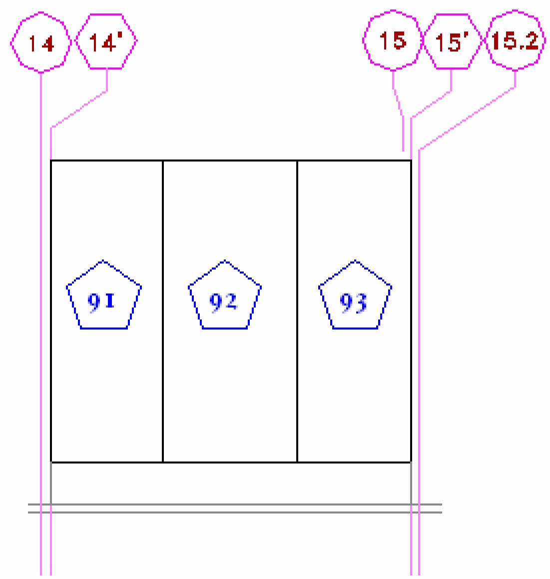


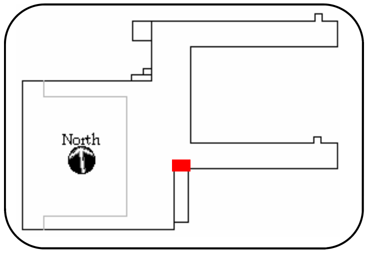
Local City - North Elevation (50 - 69)



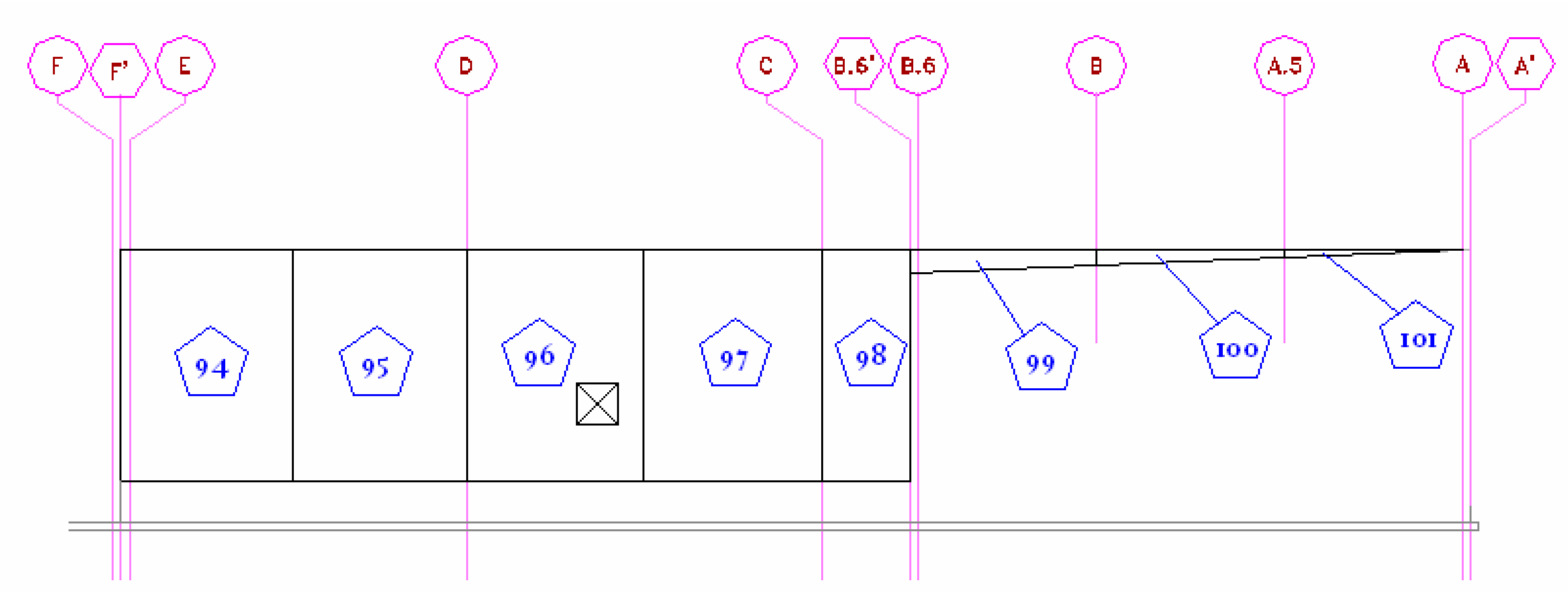


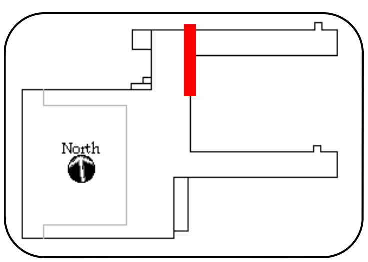
Corridor A - East Elevation (70 - 90)



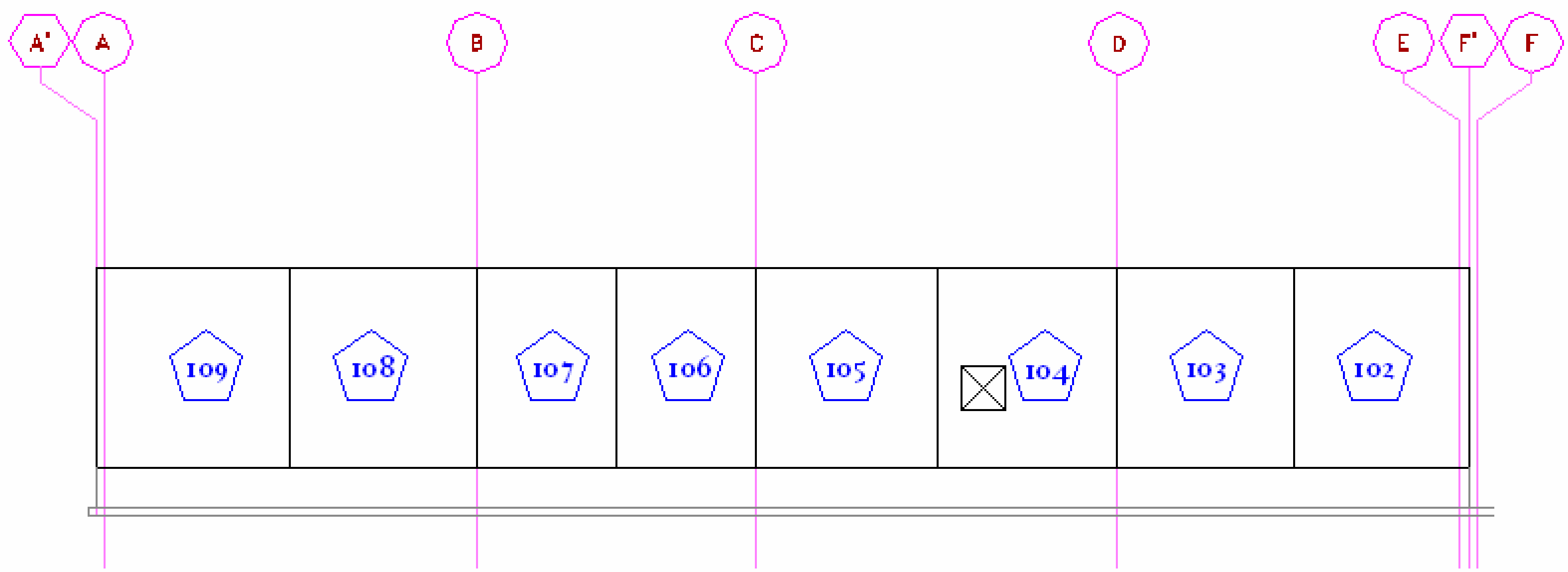


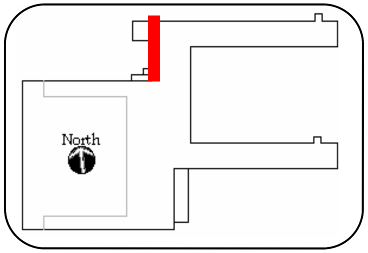
Corridor A - South Elevation (91 - 93)



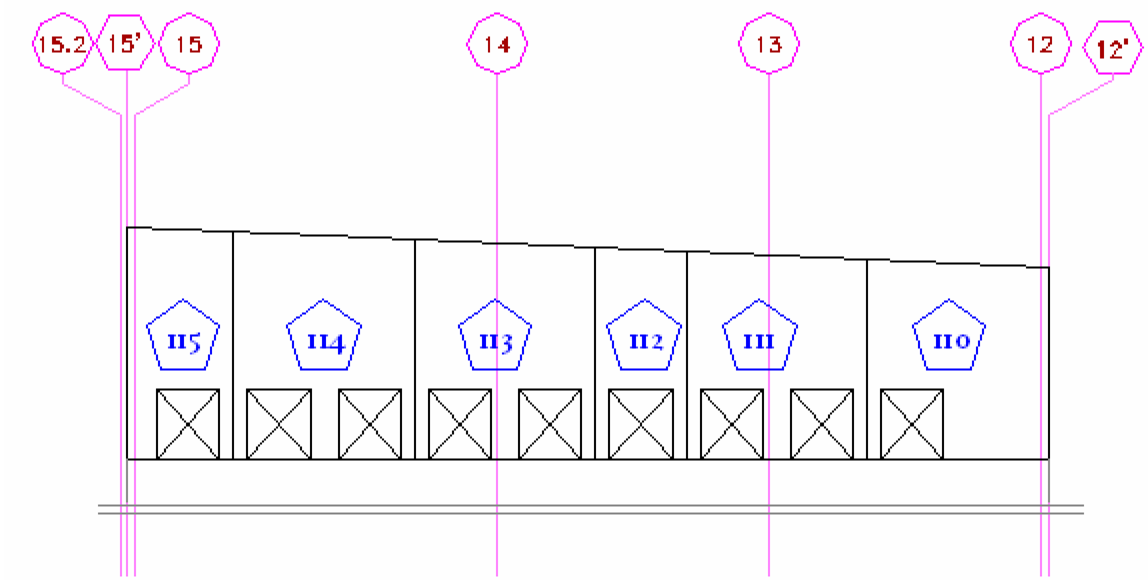


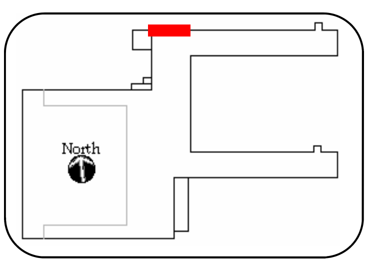
Transition A - East Elevation (94 - 101)



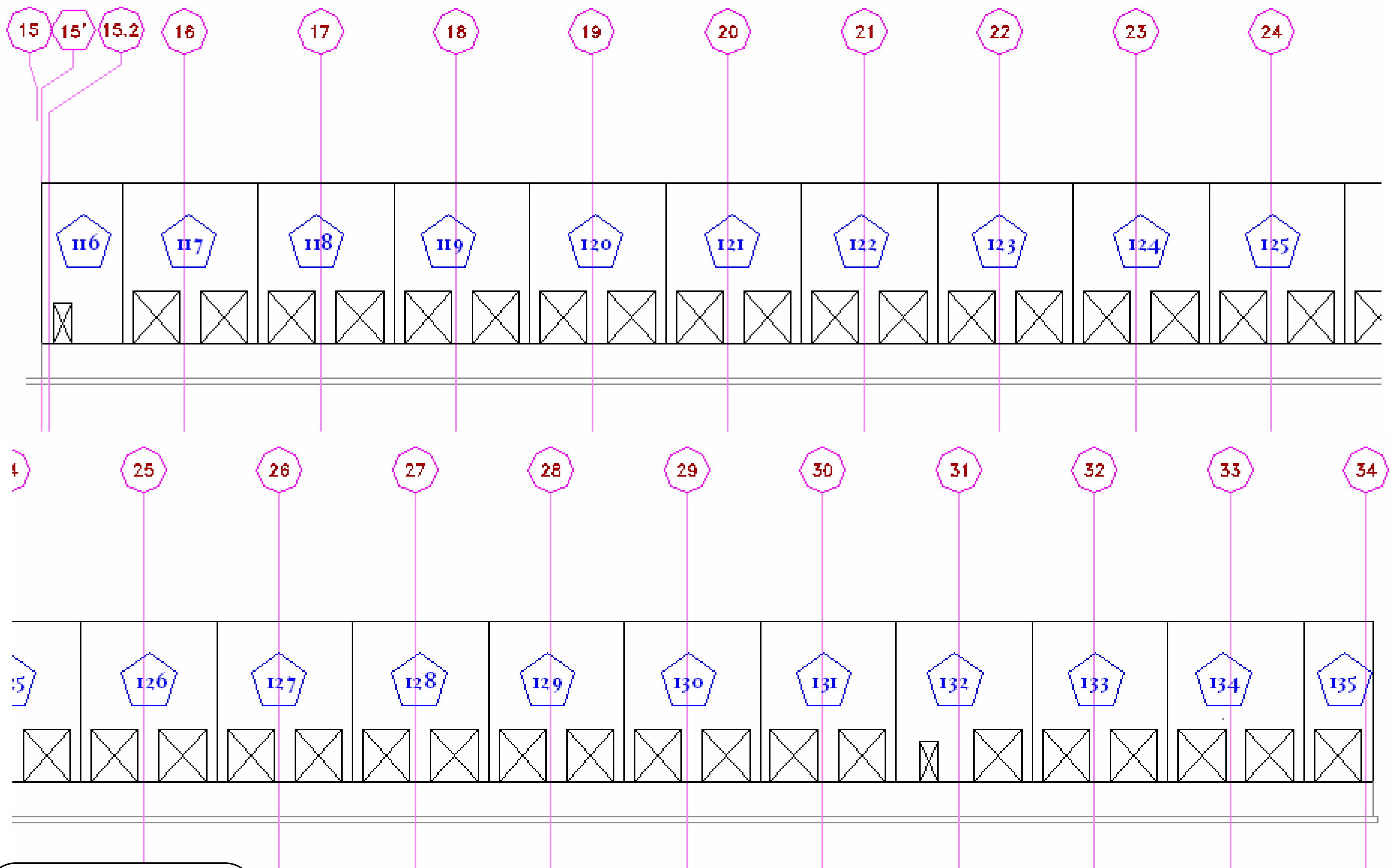


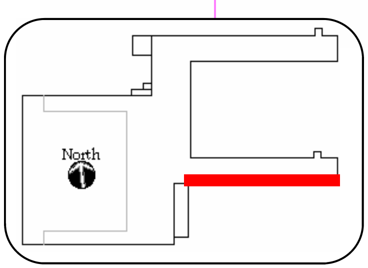
Transition A - West Elevation (102 - 109)



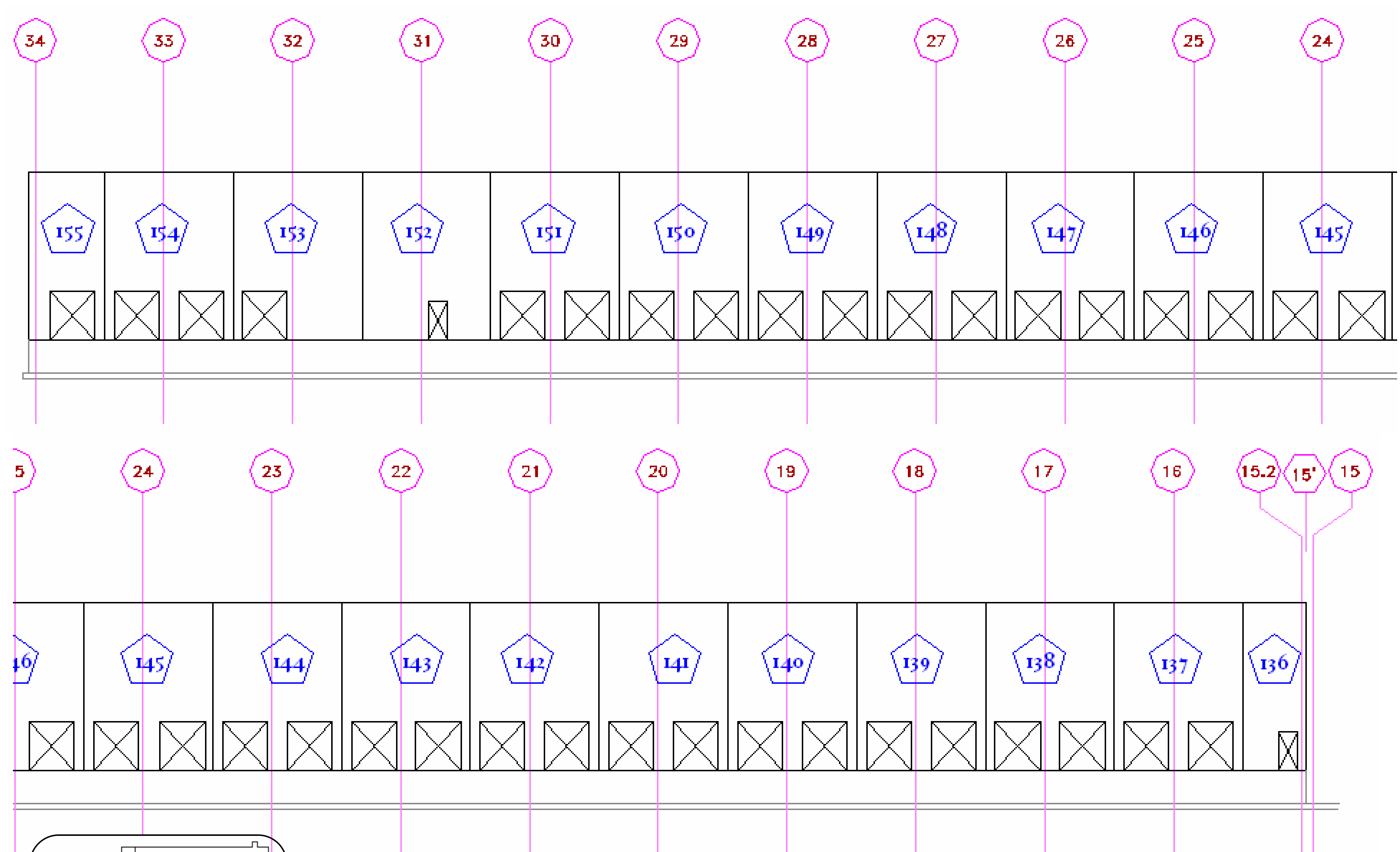


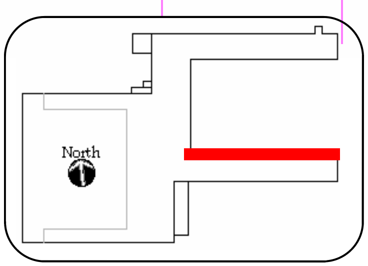
Transition A - North Elevation (110 - 115)



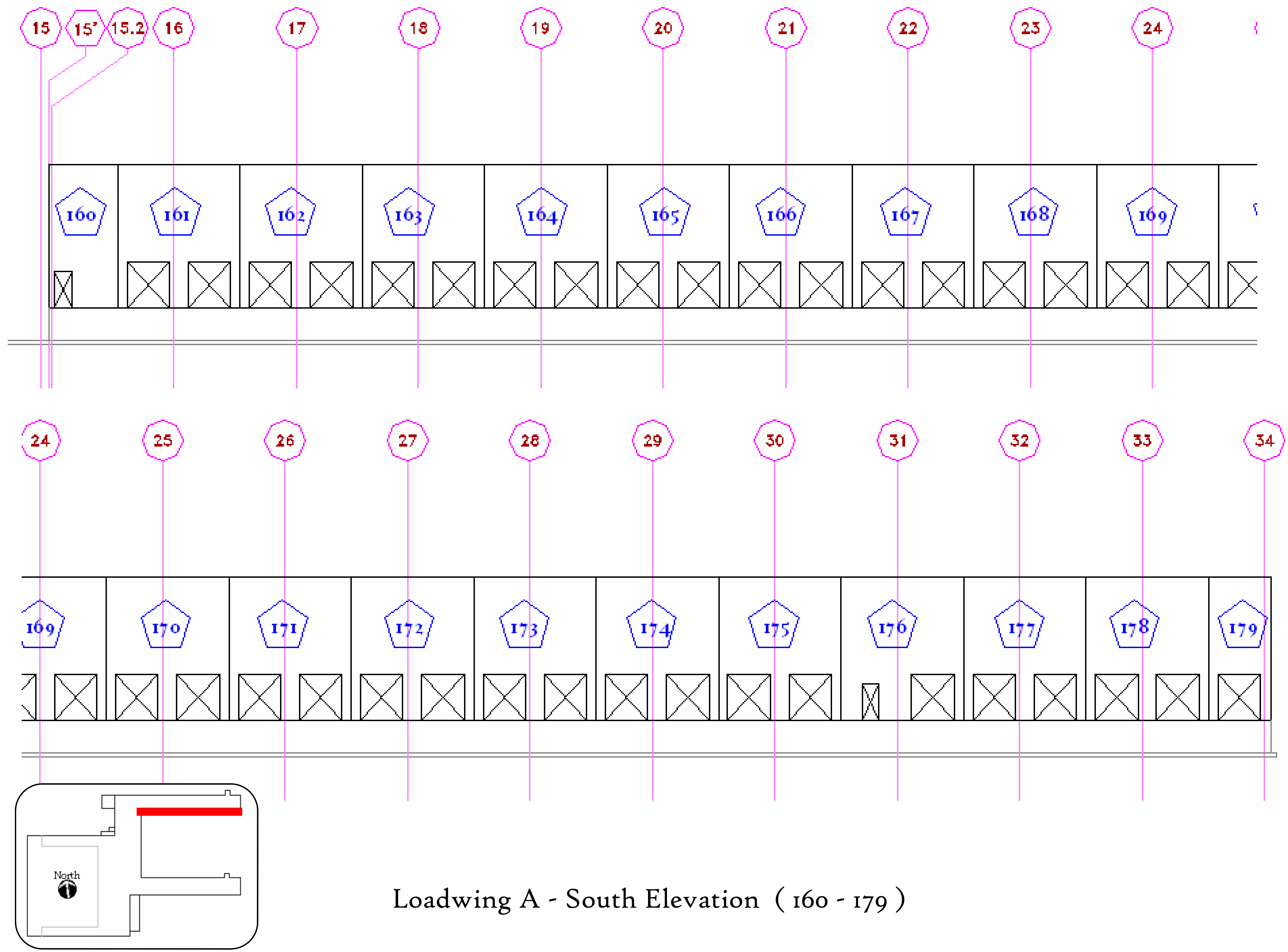


Loadwing B - South Elevation (116 - 135)

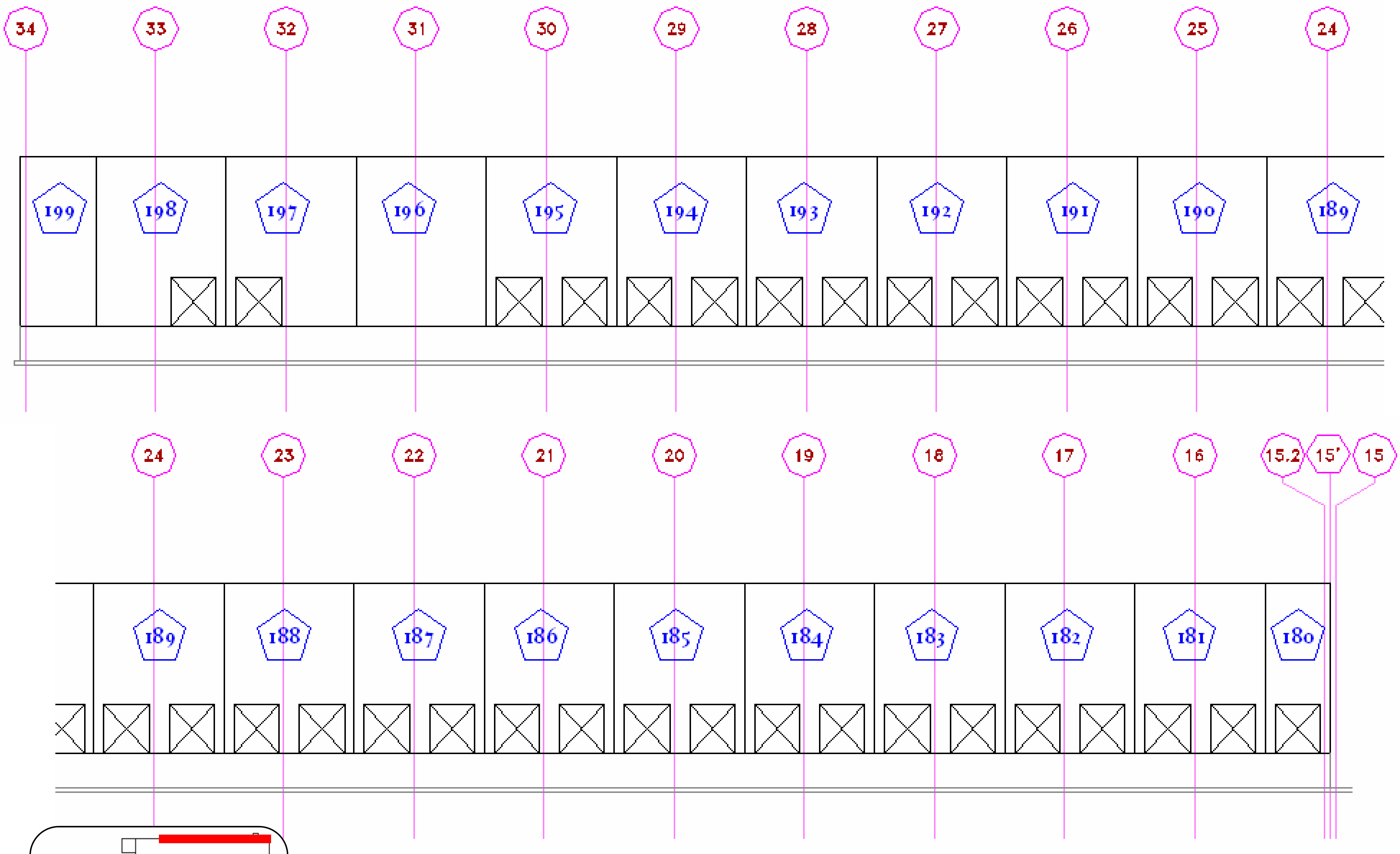


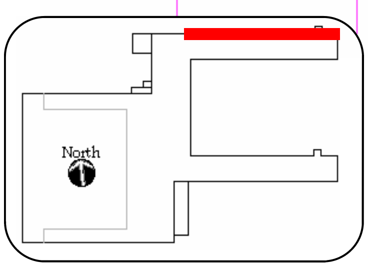


Loadwing B - North Elevation (136 - 155)

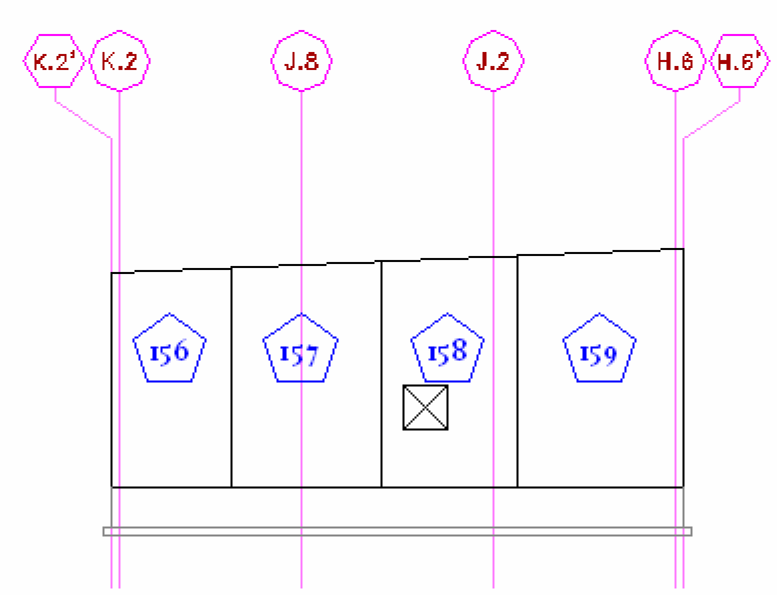


Loadwing A - South Elevation (160 - 179)

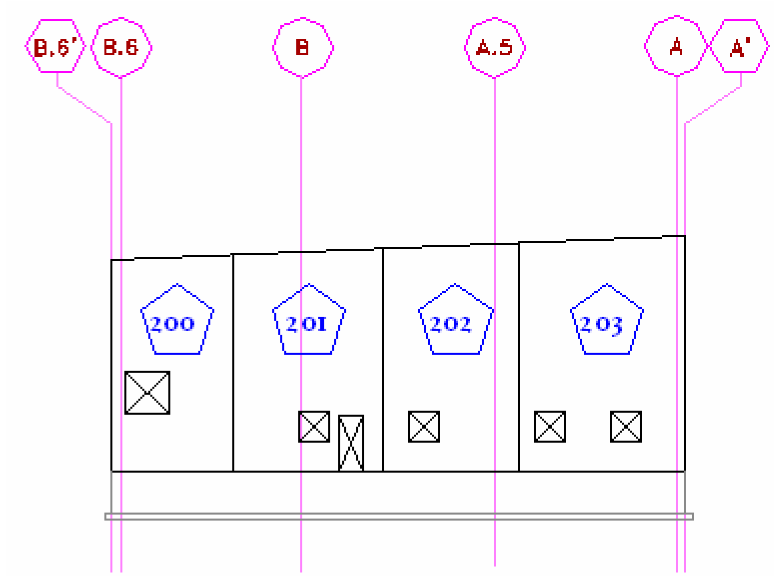




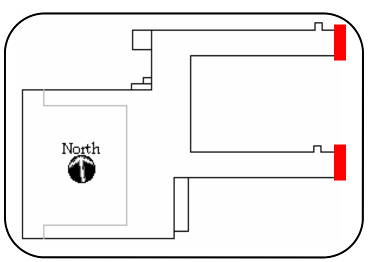
Loadwing A - North Elevation (180 - 199)

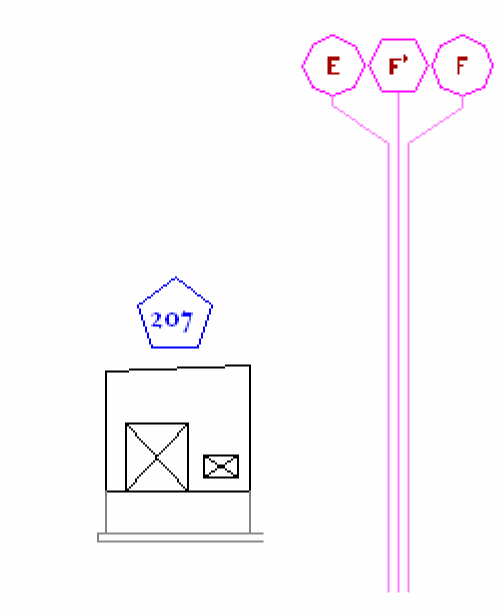


Loadwing B - East Elevation (156 - 159)

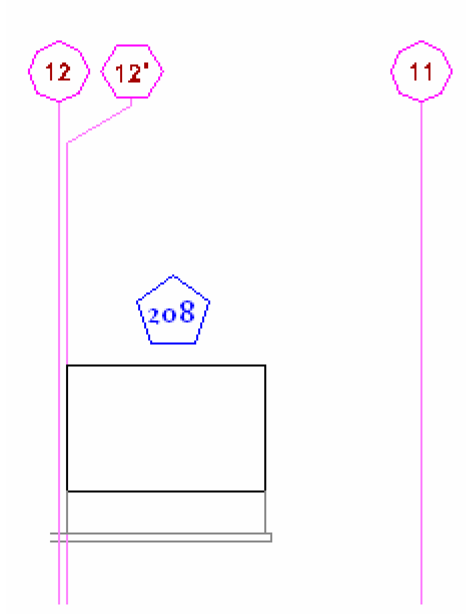


Loadwing A - East Elevation (200 - 203)



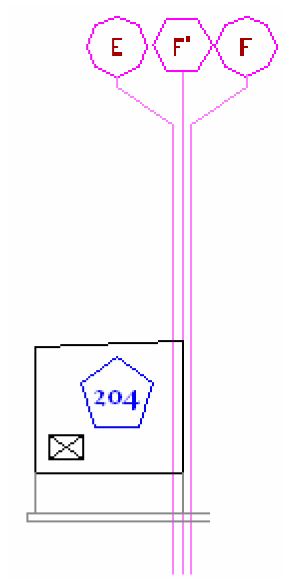


West Elevation

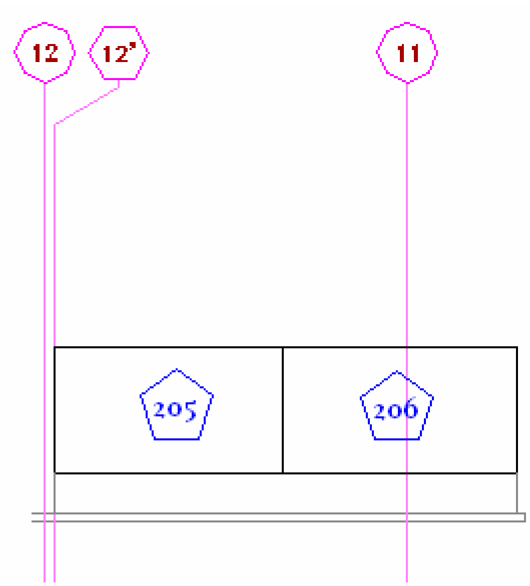


North Elevation

Fire Riser Pump Room (207 - 208)

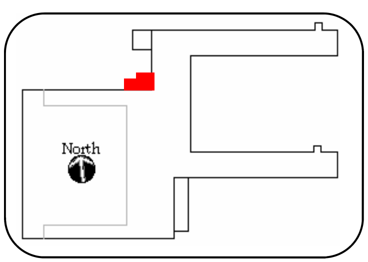


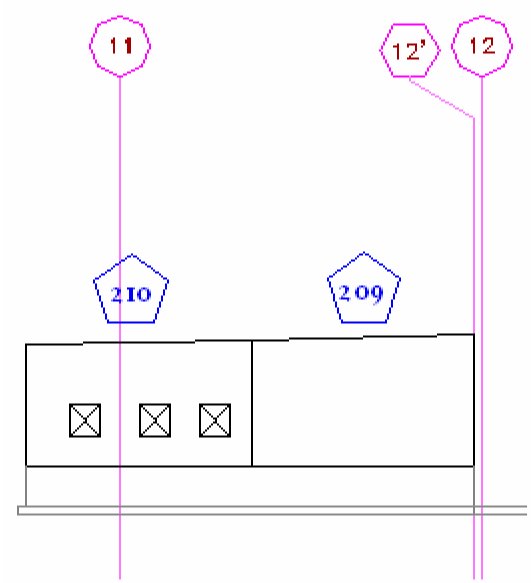
West Elevation



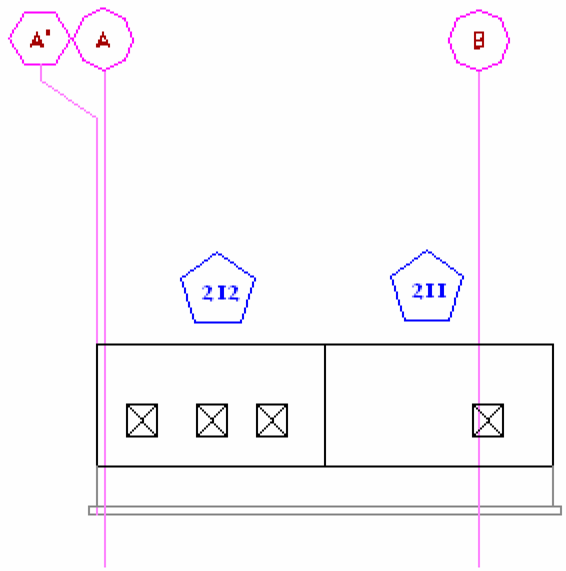
North Elevation

Switchgear Room (204 - 206)

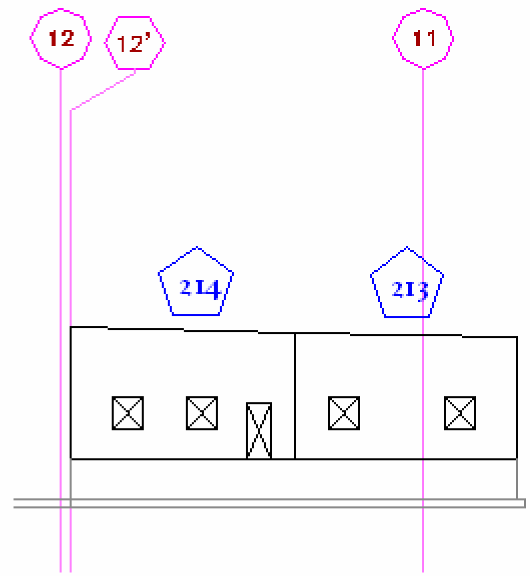




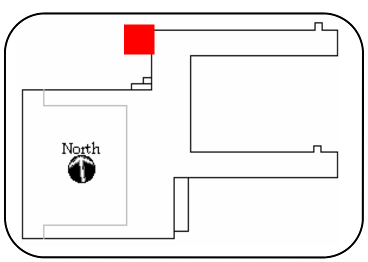
North Elevation



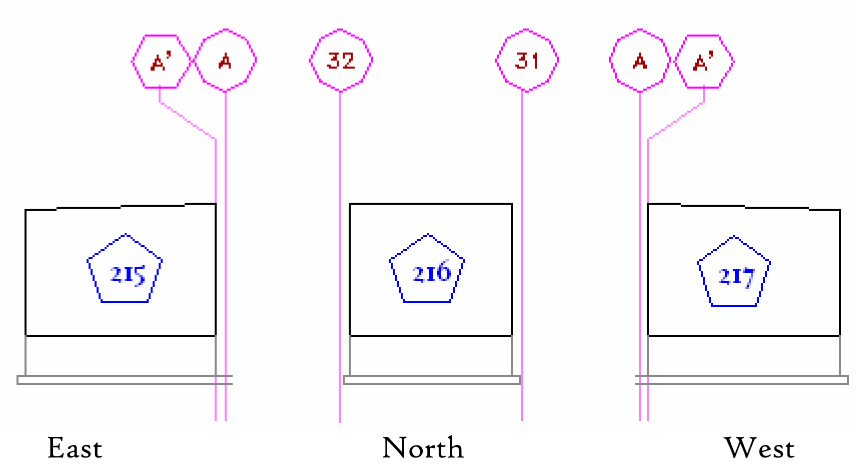
West Elevation



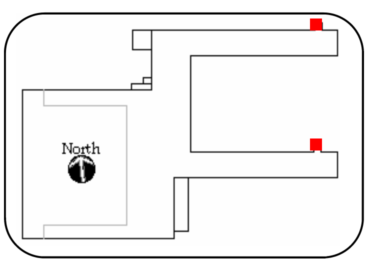
South Elevation

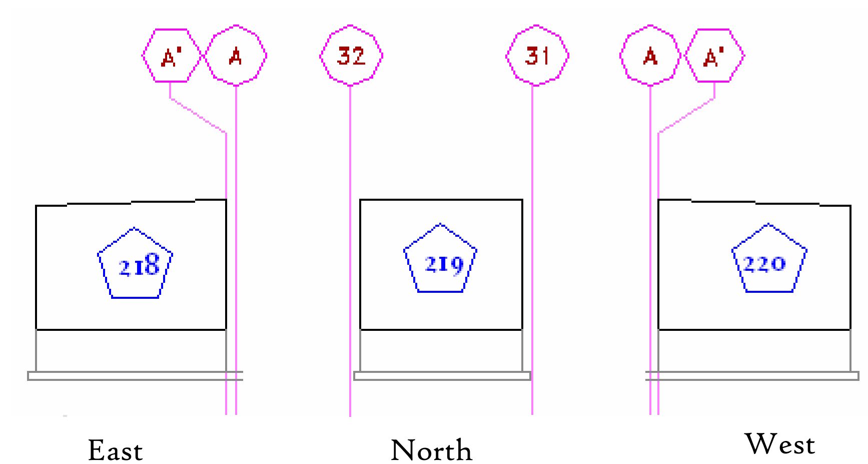


Administration Office (209 - 214)

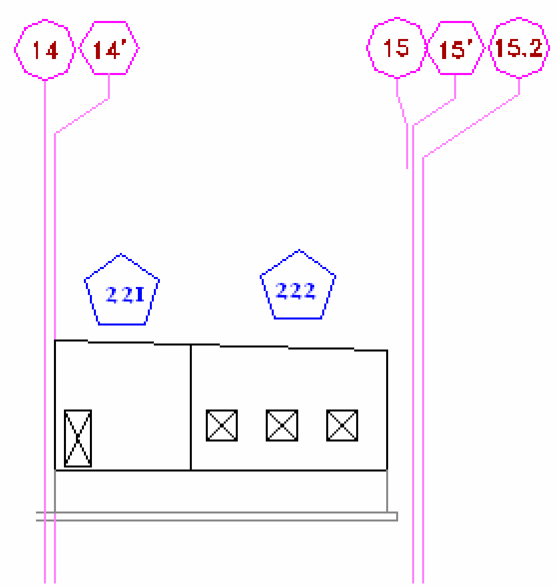


Loadwing A Restroom - Elevations (215 - 217)

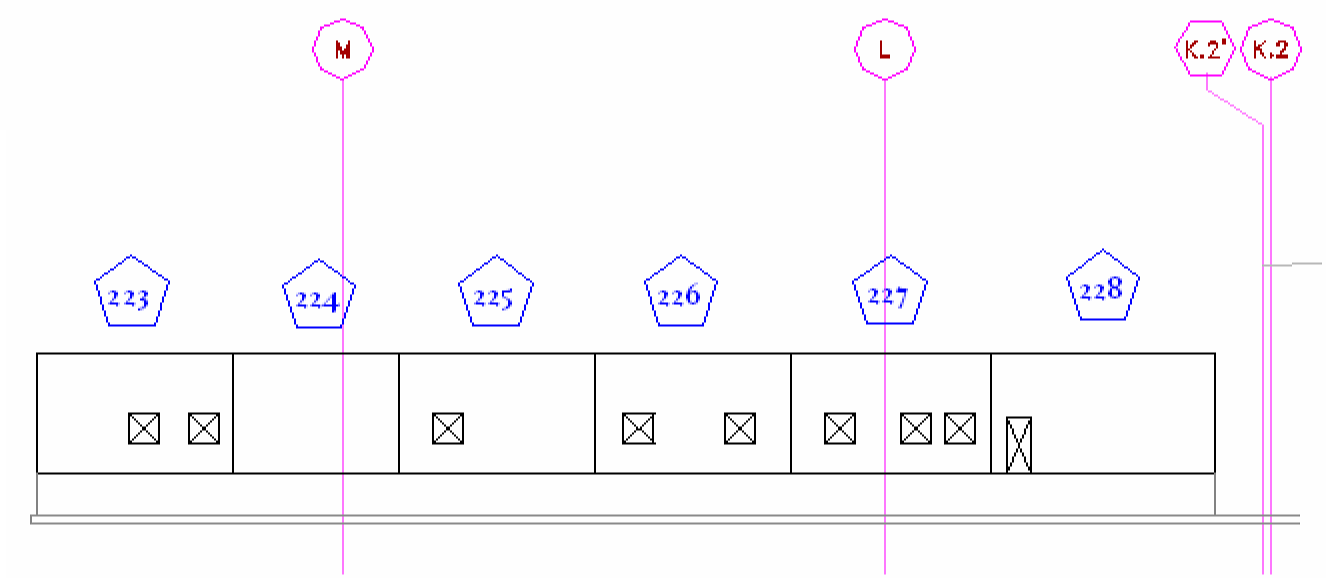




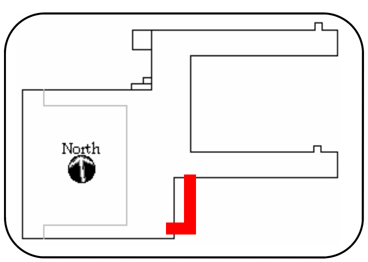
Loadwing B Restroom - Elevations (218 - 220)



South Elevation



East Elevation



Hub Operations / Maintenance (221 - 228)

APPENDIX F

TILT-UP PANEL SCHEDULE

Panel Schedule for FedEx Distribution Facility

Local City - West Elevation (1 - 27)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
1	34.71	20.96	0.50	723.0	32.1	690.9	12.8	51,820	25.9
2	35.50	19.00	0.50	667.1		667.1	12.4	50,030	25.0
3	36.33	20.00	0.50	718.3		718.3	13.3	53,876	26.9
4	40.03	16.67	0.50	662.2	191.8	470.3	8.7	35,276	17.6
5	40.75	16.67	0.50	673.7	191.8	481.9	8.9	36,142	18.1
6	41.33	15.00	0.50	615.4		615.4	11.4	46,153	23.1
7	42.00	15.00	0.50	624.7		624.7	11.6	46,853	23.4
8	42.58	15.00	0.50	634.0		634.0	11.7	47,552	23.8
9	43.25	15.00	0.50	643.3		643.3	11.9	48,251	24.1
10	43.83	15.00	0.50	652.7		652.7	12.1	48,949	24.5
11	44.42	15.00	0.50	662.0		662.0	12.3	49,649	24.8
12	45.08	15.00	0.50	671.3		671.3	12.4	50,348	25.2
13	45.67	15.00	0.50	680.6		680.6	12.6	51,047	25.5
14	46.08	15.00	0.50	688.2	23.9	664.3	12.3	49,826	24.9
15	45.75	16.00	0.50	727.0	34.0	693.0	12.8	51,976	26.0
16	45.08	15.00	0.50	671.9		671.9	12.4	50,391	25.2
17	44.50	15.00	0.50	662.3		662.3	12.3	49,671	24.8
18	43.83	15.00	0.50	653.1		653.1	12.1	48,981	24.5
19	43.25	15.00	0.50	643.7		643.7	11.9	48,276	24.1
20	42.58	15.00	0.50	634.3		634.3	11.7	47,570	23.8
21	42.00	15.00	0.50	624.9		624.9	11.6	46,866	23.4
22	41.33	15.00	0.50	615.5		615.5	11.4	46,161	23.1
23	40.67	16.25	0.50	728.2	191.6	536.5	9.9	40,240	20.1
24	40.00	18.17	0.50	722.8	191.6	531.2	9.8	39,839	19.9
25	36.25	20.00	0.50	717.2		717.2	13.3	53,787	26.9
26	35.42	17.58	0.50	618.7		618.7	11.5	46,404	23.2
27	43.00	20.83	0.50	713.9		713.9	13.2	53,544	26.8

Local City - South Elevation (28 - 49)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
28	32.50	17.25	0.50	560.6		560.6	10.4	42,047	21.0
29	32.50	23.25	0.50	755.6	100.3	655.3	12.1	49,151	24.6
30	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
31	32.50	25.25	0.50	820.6	76.4	744.2	13.8	55,818	27.9
32	32.50	25.67	0.50	834.2	152.8	681.4	12.6	51,104	25.6
33	32.50	25.25	0.50	820.6	152.8	667.8	12.4	50,089	25.0
34	32.50	25.67	0.50	834.2	152.8	681.4	12.6	51,104	25.6
35	32.50	25.25	0.50	820.6	152.8	667.8	12.4	50,089	25.0
36	32.50	25.25	0.50	820.6	76.4	744.2	13.8	55,818	27.9
37	-	-	-	-	-	-	-	-	-
38	32.50	25.75	0.50	836.9	152.8	684.1	12.7	51,307	25.7
39	32.50	24.75	0.50	804.4	152.8	651.6	12.1	48,870	24.4
40	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
41	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
42	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
43	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
44	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
45	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
46	32.50	26.08	0.50	847.7	100.3	747.4	13.8	56,057	28.0
47	32.50	24.00	0.50	780.0		780.0	14.4	58,500	29.3
48	32.50	24.00	0.50	780.0		780.0	14.4	58,500	29.3
49	32.50	11.08	0.50	360.2		360.2	6.7	27,016	13.5

Local City - North Elevation (50 - 69)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
50	32.50	19.83	0.50	644.6		644.6	11.9	48,344	24.2
51	32.50	19.00	0.50	617.5	23.9	593.6	11.0	44,521	22.3
52	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
53	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
54	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
55	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
56	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
57	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
58	32.50	25.50	0.50	828.8	76.4	752.4	13.9	56,427	28.2
59	32.50	25.50	0.50	828.8	152.8	676.0	12.5	50,698	25.3
60	32.50	24.75	0.50	804.4	152.8	651.6	12.1	48,870	24.4
61	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
62	32.50	24.00	0.50	780.0	152.8	627.2	11.6	47,042	23.5
63	32.50	24.00	0.50	780.0	100.3	679.7	12.6	50,979	25.5
64	32.50	24.00	0.50	780.0		780.0	14.4	58,500	29.3
65	32.50	24.00	0.50	780.0		780.0	14.4	58,500	29.3
66	32.50	10.75	0.50	349.4		349.4	6.5	26,203	13.1
67	32.50	39.92	0.50	241.4		241.4	4.5	18,102	9.1
68	32.50	40.00	0.50	173.1		173.1	3.2	12,985	6.5
69	32.50	42.33	0.50	110.0		110.0	2.0	8,248	4.1

Corridor A - West Elevation (70 - 90)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
70	33.17	23.17	0.50	887.3	152.8	734.6	13.6	55,093	27.5
71	34.00	20.00	0.50	782.4		782.4	14.5	58,682	29.3
72	34.75	20.00	0.50	798.6		798.6	14.8	59,894	29.9
73	35.50	20.00	0.50	813.2		813.2	15.1	60,988	30.5
74	36.25	20.00	0.50	828.2		828.2	15.3	62,114	31.1
75	37.00	20.00	0.50	843.9		843.9	15.6	63,290	31.6
76	37.83	20.00	0.50	858.6		858.6	15.9	64,398	32.2
77	38.58	20.00	0.50	874.6		874.6	16.2	65,594	32.8
78	39.33	20.00	0.50	889.3		889.3	16.5	66,700	33.4
79	12.83	25.17	0.50	298.8		298.8	5.5	22,411	11.2
80	11.75	25.42	0.50	293.2		293.2	5.4	21,991	11.0
81	10.75	24.17	0.50	246.1		246.1	4.6	18,456	9.2
82	39.25	20.00	0.50	888.0	32.1	855.9	15.8	64,192	32.1
83	38.42	20.00	0.50	871.3		871.3	16.1	65,347	32.7
84	37.58	20.00	0.50	854.6		854.6	15.8	64,094	32.0
85	36.75	20.00	0.50	837.9		837.9	15.5	62,840	31.4
86	35.92	20.00	0.50	821.2		821.2	15.2	61,587	30.8
87	35.08	22.00	0.50	884.0	100.3	783.7	14.5	58,778	29.4
88	34.17	24.00	0.50	941.3	152.8	788.5	14.6	59,138	29.6
89	33.17	24.00	0.50	917.2	152.8	764.4	14.2	57,333	28.7
90	32.17	13.17	0.50	490.8	76.4	414.4	7.7	31,079	15.5

Corridor A - South Elevation (91 - 93)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
91	40.00	15.00	0.50	600.0		600.0	11.1	45,000	22.5
92	40.00	17.58	0.50	703.3		703.3	13.0	52,750	26.4
93	43.00	20.83	0.50	828.5		828.5	15.3	62,138	31.1

Transition A - East Elevation (94 - 101)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
94	31.33	23.42	0.50	733.6		733.6	13.6	55,023	27.5
95	31.33	23.42	0.50	733.6		733.6	13.6	55,023	27.5
96	31.33	24.00	0.50	751.9	32.1	719.8	13.3	53,986	27.0
97	31.33	24.00	0.50	751.9		751.9	13.9	56,394	28.2
98	31.33	12.00	0.50	376.0		376.0	7.0	28,197	14.1
99	3.17	25.17	0.50	66.6		66.6	1.5	6,092	3.0
100	2.08	25.50	0.50	40.5		40.5	0.9	3,703	1.9
101	1.00	25.25	0.50	12.7		12.7	0.3	1,159	0.6

Transition A - West Elevation (102 - 109)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
102	26.42	23.42	0.50	618.6		618.6	11.5	46,394	23.2
103	26.42	23.42	0.50	618.6		618.6	11.5	46,394	23.2
104	26.42	24.00	0.50	634.0	32.1	601.9	11.1	45,142	22.6
105	26.42	24.00	0.50	634.0		634.0	11.7	47,550	23.8
106	26.42	18.58	0.50	490.9		490.9	9.1	36,818	18.4
107	26.42	18.58	0.50	490.9		490.9	9.1	36,818	18.4
108	26.42	24.00	0.50	634.0		634.0	11.7	47,550	23.8
109	26.42	25.92	0.50	684.6		684.6	12.7	51,347	25.7

Transition A - North Elevation (110 - 115)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
110	27.17	24.17	0.50	778.1	76.4	701.7	13.0	52,627	26.3
111	28.17	24.00	0.50	797.1	152.8	644.3	11.9	48,324	24.2
112	28.67	12.00	0.50	407.8	76.4	331.4	6.1	24,853	12.4
113	29.75	24.00	0.50	833.9	152.8	681.2	12.6	51,088	25.5
114	30.75	24.00	0.50	858.5	152.8	705.7	13.1	52,930	26.5
115	31.33	14.08	0.50	518.0	76.4	441.6	8.2	33,119	16.6

Loadwing B - South Elevation (116 - 135)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
116	28.83	14.08	0.50	406.1	23.9	382.2	7.1	28,664	14.3
117	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
118	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
119	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
120	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
121	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
122	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
123	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
124	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
125	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
126	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
127	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
128	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
129	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
130	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
131	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
132	28.83	24.00	0.50	692.0	100.3	591.7	11.0	44,379	22.2
133	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
134	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
135	28.83	12.17	0.50	350.8	76.4	274.4	5.1	20,581	10.3

Loadwing B - North Elevation (136 - 155)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
136	32.00	11.83	0.50	378.7	23.9	354.8	6.6	26,608	13.3
137	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
138	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
139	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
140	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
141	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
142	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
143	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
144	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
145	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
146	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
147	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
148	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
149	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
150	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
151	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
152	32.00	24.00	0.50	768.0	23.9	744.1	19.8	80,164	40.1
153	32.00	24.00	0.50	768.0	76.4	691.6	18.6	75,360	37.7
154	32.00	24.00	0.50	768.0	152.8	615.2	16.9	68,371	34.2
155	32.00	14.08	0.50	450.7	76.4	374.3	10.2	41,334	20.7

Loadwing B - East Elevation (156 - 159)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
156	28.83	15.92	0.50	543.5		543.5	10.1	40,764	20.4
157	29.67	20.00	0.50	695.0		695.0	12.9	52,125	26.1
158	30.42	18.00	0.50	639.8	32.1	607.6	11.3	45,573	22.8
159	31.33	22.00	0.50	778.8		778.8	14.4	58,407	29.2

Loadwing A - South Elevation (160 - 179)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
160	28.83	14.08	0.50	406.1	23.9	382.2	7.1	28,664	14.3
161	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
162	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
163	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
164	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
165	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
166	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
167	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
168	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
169	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
170	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
171	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
172	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
173	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
174	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
175	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
176	28.83	24.00	0.50	692.0	100.3	591.7	11.0	44,379	22.2
177	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
178	28.83	24.00	0.50	692.0	152.8	539.2	10.0	40,442	20.2
179	28.83	12.17	0.50	350.8	76.4	274.4	5.1	20,581	10.3

Loadwing A - North Elevation (180 - 199)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
180	32.00	11.83	0.50	378.7	76.4	302.3	5.6	22,671	11.3
181	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
182	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
183	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
184	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
185	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
186	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
187	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
188	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
189	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
190	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
191	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
192	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
193	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
194	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
195	32.00	24.00	0.50	768.0	152.8	615.2	11.4	46,142	23.1
196	32.00	24.00	0.50	768.0		768.0	14.2	57,600	28.8
197	32.00	24.00	0.50	768.0	76.4	691.6	12.8	51,871	25.9
198	32.00	24.00	0.50	768.0	76.4	691.6	12.8	51,871	25.9
199	32.00	14.08	0.50	450.7		450.7	8.3	33,800	16.9

Loadwing A - East Elevation (200 - 203)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
200	28.83	15.92	0.50	543.5	32.1	511.4	9.5	38,356	19.2
201	29.67	20.00	0.50	695.0	39.9	655.1	12.1	49,135	24.6
202	30.42	18.00	0.50	639.8	16.0	623.8	11.6	46,783	23.4
203	31.33	22.00	0.50	778.8	31.9	746.8	13.8	56,011	28.0

Switchgear - Elevations (204 - 206)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
204	17.33	19.67	0.50	442.6	13.0	429.6	8.0	32,220	16.1
205	16.67	31.08	0.50	518.1		518.1	9.6	38,854	19.4
206	16.67	30.25	0.50	504.2		504.2	9.3	37,813	18.9

Fire Riser Pump Room - Elevations (207 - 208)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
207	16.67	19.08	0.50	418.5	89.4	329.2	6.1	24,686	12.3
208	16.67	26.17	0.50	436.1		436.1	8.1	32,708	16.4

Admin Office - North Elevation (209 - 214)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
209	15.08	29.33	0.50	663.9		663.9	12.3	49,793	24.9
210	16.67	30.00	0.50	655.2	48.0	607.2	11.2	45,542	22.8
211	16.00	30.33	0.50	485.3	16.0	469.3	8.7	35,200	17.6
212	16.00	30.33	0.50	485.3	48.0	437.3	8.1	32,800	16.4
213	16.67	29.58	0.50	647.6	32.0	615.6	11.4	46,169	23.1
214	17.33	29.67	0.50	667.6	55.9	611.7	11.3	45,879	22.9

Loadwing A - Restroom (215 - 217)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
215	17.33	25.33	0.50	570.0		570.0	10.6	42,750	21.4
216	17.33	21.33	0.50	369.8		369.8	6.8	27,733	13.9
217	17.33	25.33	0.50	570.0		570.0	10.6	42,750	21.4

Loadwing B - Restroom (218 - 220)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
218	17.33	25.33	0.50	570.0		570.0	10.6	42,750	21.4
219	17.33	21.33	0.50	369.8		369.8	6.8	27,733	13.9
220	17.33	25.33	0.50	570.0		570.0	10.6	42,750	21.4

Hub Ops / Maintenance - Elevations (221 - 228)

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
221	17.33	18.17	0.50	409.9	23.9	386.0	7.1	28,950	14.5
222	17.50	26.00	0.50	569.3	48.0	521.3	9.7	39,097	19.5
223	16.00	26.00	0.50	416.0	31.9	384.1	7.1	28,804	14.4
224	16.00	22.00	0.50	352.0		352.0	6.5	26,400	13.2
225	16.00	26.00	0.50	416.0	16.0	400.0	7.4	30,002	15.0
226	16.00	26.00	0.50	416.0	31.9	384.1	7.1	28,804	14.4
227	16.00	26.42	0.50	422.7	47.9	374.8	6.9	28,106	14.1
228	16.00	29.50	0.50	472.0	23.9	448.1	8.3	33,608	16.8

Statistics

Panel Number	Height (Ft.)	Width (Ft.)	Thickness (Ft.)	Area (Sq. Ft.)	Void Area (Sq. Ft.)	Net Area (Sq. Ft.)	Volume (Cu. Yds.)	Weight (Lbs.)	Weight (Tons)
Max	46.08	31.08		941.3		889.3	19.8	80,164	40.1
Min	15.08	10.75		349.4		274.4	5.1	20,581	10.3
Average	31.04	22.03		689.0		607.4	11.7	47,470	23.7
Total						132,423	2555.2	10,348,471	5,174

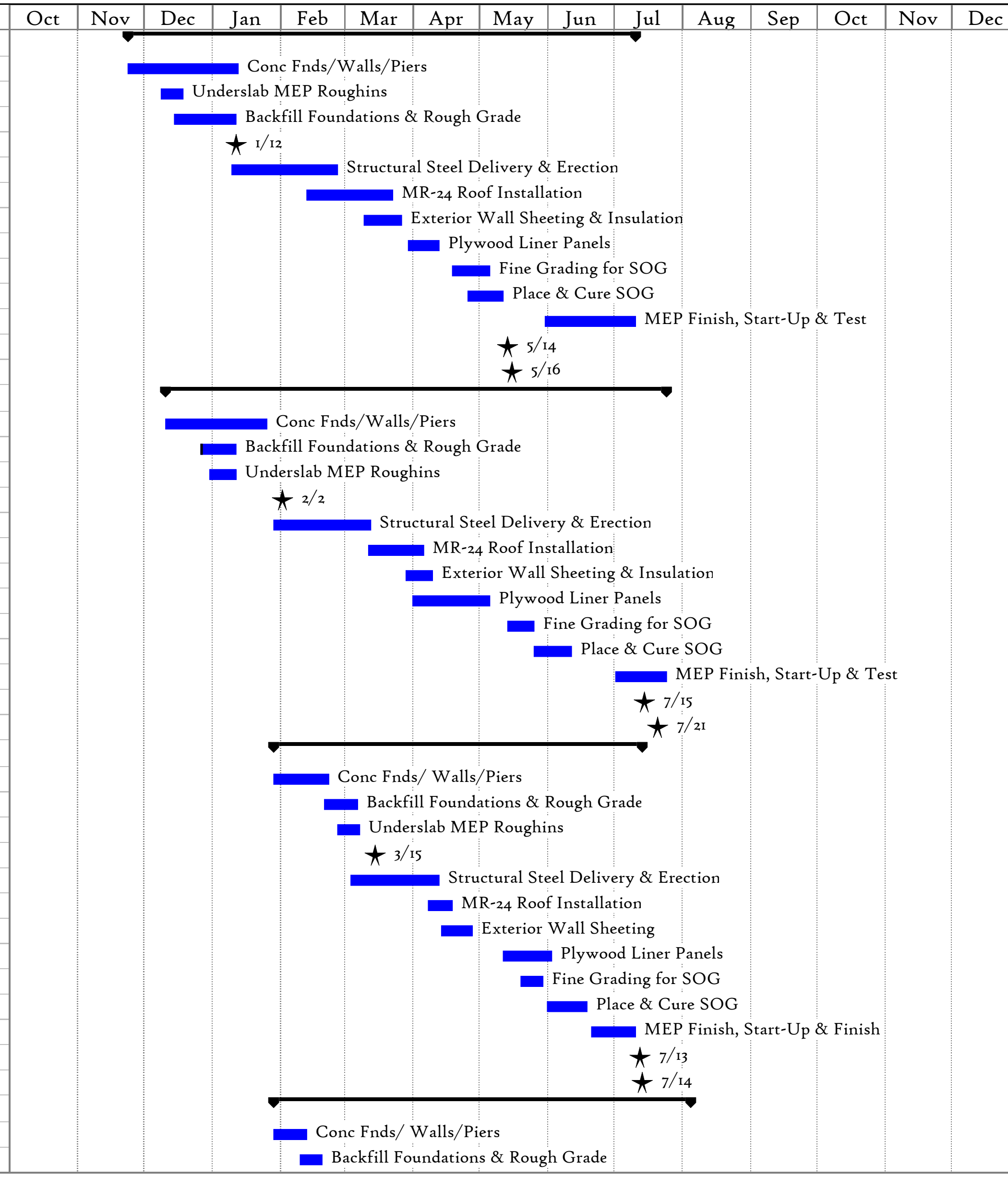
Appendix G

Pre-Engineered Structural System

Simplified Schedule

FedEx Distribution Hub - Pre-Engineered Structural Steel System Simplified Schedule

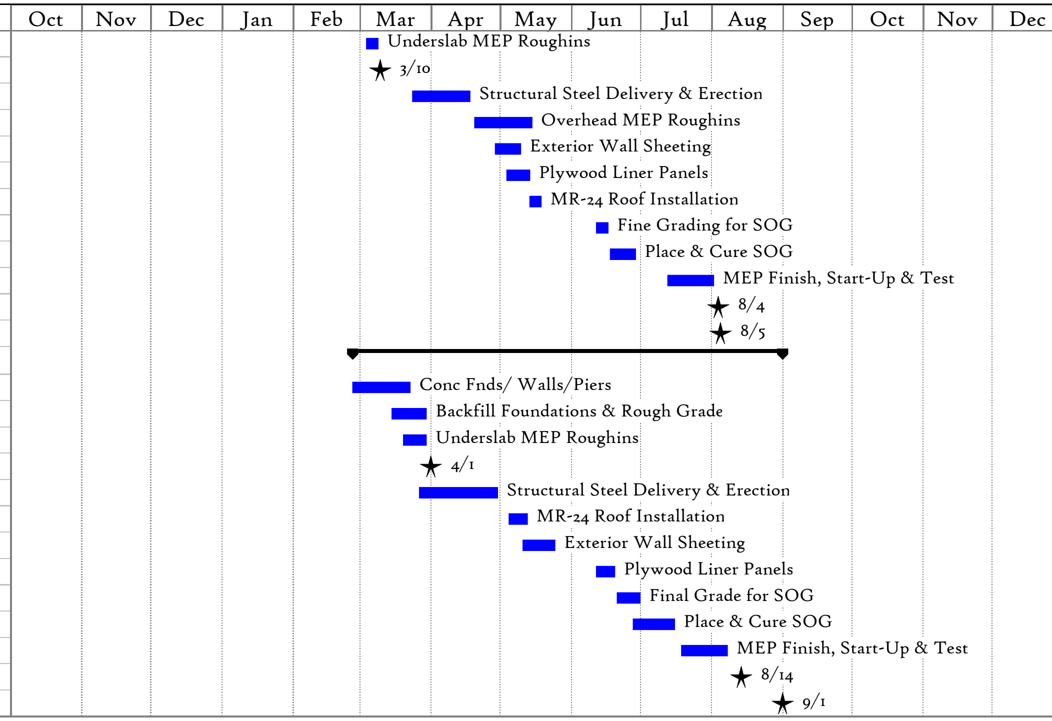
ID	Task Name	Duration	Start	Finish
1	**Local City / Unload (E-N / 4-10)**	**229 d**	**Nov 24**	**Jul 10**
2	Conc Fnds/Walls/Piers	49 d	Nov 24	Jan 12
3	Underslab MEP Roughins	10 d	Dec 9	Dec 18
4	Backfill Foundations & Rough Grade	28 d	Dec 15	Jan 11
5	MS-I Local City / Unload Ready for Butler	0 d	Jan 12	Jan 12
6	Structural Steel Delivery & Erection	48 d	Jan 10	Feb 26
7	MR-24 Roof Installation	39 d	Feb 13	Mar 22
8	Exterior Wall Sheeting & Insulation	17 d	Mar 10	Mar 26
9	Plywood Liner Panels	14 d	Mar 30	Apr 12
10	Fine Grading for SOG	17 d	Apr 19	May 5
11	Place & Cure SOG	16 d	Apr 26	May 11
12	MEP Finish, Start-Up & Test	41 d	May 31	Jul 10
13	MS-II Local City/ Unload Ready for MH	0 d	May 14	May 14
14	Local City/Unload Complete	0 d	May 16	May 16
15	**Corridor (E-N / 10-15)**	**227 d**	**Dec 11**	**Jul 24**
16	Conc Fnds/Walls/Piers	46 d	Dec 11	Jan 25
17	Backfill Foundations & Rough Grade	16 d	Dec 27	Jan 11
18	Underslab MEP Roughins	12 d	Dec 31	Jan 11
19	MS IIIA - Corridor Ready for Butler	0 d	Feb 2	Feb 2
20	Structural Steel Delivery & Erection	44 d	Jan 29	Mar 12
21	MR-24 Roof Installation	25 d	Mar 12	Apr 5
22	Exterior Wall Sheeting & Insulation	12 d	Mar 29	Apr 9
23	Plywood Liner Panels	35 d	Apr 1	May 5
24	Fine Grading for SOG	12 d	May 14	May 25
25	Place & Cure SOG	17 d	May 26	Jun 11
26	MEP Finish, Start-Up & Test	23 d	Jul 2	Jul 24
27	MS IVA - Corridor Ready for MH	0 d	Jul 15	Jul 15
28	Corridor Complete	0 d	Jul 21	Jul 21
29	**Load Wing 'B'**	**167 d**	**Jan 29**	**Jul 14**
30	Conc Fnds/ Walls/Piers	25 d	Jan 29	Feb 22
31	Backfill Foundations & Rough Grade	15 d	Feb 21	Mar 6
32	Underslab MEP Roughins	10 d	Feb 27	Mar 7
33	MS IIIB - Load Wing B Ready for Butler	0 d	Mar 15	Mar 15
34	Structural Steel Delivery & Erection	40 d	Mar 4	Apr 12
35	MR-24 Roof Installation	11 d	Apr 8	Apr 18
36	Exterior Wall Sheeting	14 d	Apr 14	Apr 27
37	Plywood Liner Panels	22 d	May 12	Jun 2
38	Fine Grading for SOG	10 d	May 20	May 29
39	Place & Cure SOG	18 d	Jun 1	Jun 18
40	MEP Finish, Start-Up & Finish	20 d	Jun 21	Jul 10
41	Load Wing B Complete	0 d	Jul 13	Jul 13
42	MS IVB - Area Ready for HK Systems	0 d	Jul 14	Jul 14
43	**Load Wing 'A' Transition**	**189 d**	**Jan 29**	**Aug 5**
44	Conc Fnds/ Walls/Piers	15 d	Jan 29	Feb 12
45	Backfill Foundations & Rough Grade	10 d	Feb 10	Feb 19



Task | Progress | Milestone ★ | Summary

FedEx Distribution Hub - Pre-Engineered Structural Steel System Simplified Schedule

ID	Task Name	Duration	Start	Finish
46	Underslab MEP Roughins	5 d	Mar 4	Mar 8
47	MS V - Load Wing 'A' Ready for Butler	0 d	Mar 10	Mar 10
48	Structural Steel Delivery & Erection	25 d	Mar 24	Apr 17
49	Overhead MEP Roughins	25 d	Apr 20	May 14
50	Exterior Wall Sheeting	11 d	Apr 29	May 9
51	Plywood Liner Panels	10 d	May 4	May 13
52	MR-24 Roof Installation	5 d	May 14	May 18
53	Fine Grading for SOG	5 d	Jun 12	Jun 16
54	Place & Cure SOG	11 d	Jun 18	Jun 28
55	MEP Finish, Start-Up & Test	20 d	Jul 13	Aug 1
56	Transition A - Complete	0 d	Aug 4	Aug 4
57	Trans 'A' Ready for HK Systems	0 d	Aug 5	Aug 5
58	**Load Wing 'A'**	**187 d**	**Feb 27**	**Sep 1**
59	Conc Fnds/ Walls/Piers	25 d	Feb 27	Mar 22
60	Backfill Foundations & Rough Grade	15 d	Mar 15	Mar 29
61	Underslab MEP Roughins	10 d	Mar 20	Mar 29
62	Load Wing A Ready for Butler	0 d	Apr 1	Apr 1
63	Structural Steel Delivery & Erection	34 d	Mar 27	Apr 29
64	MR-24 Roof Installation	8 d	May 5	May 12
65	Exterior Wall Sheeting	14 d	May 11	May 24
66	Plywood Liner Panels	8 d	Jun 12	Jun 19
67	Final Grade for SOG	10 d	Jun 21	Jun 30
68	Place & Cure SOG	18 d	Jun 28	Jul 15
69	MEP Finish, Start-Up & Test	20 d	Jul 19	Aug 7
70	Load Wing A Complete	0 d	Aug 14	Aug 14
71	MS VI - Load Wing 'A' Ready for HK Systems	0 d	Sep 1	Sep 1



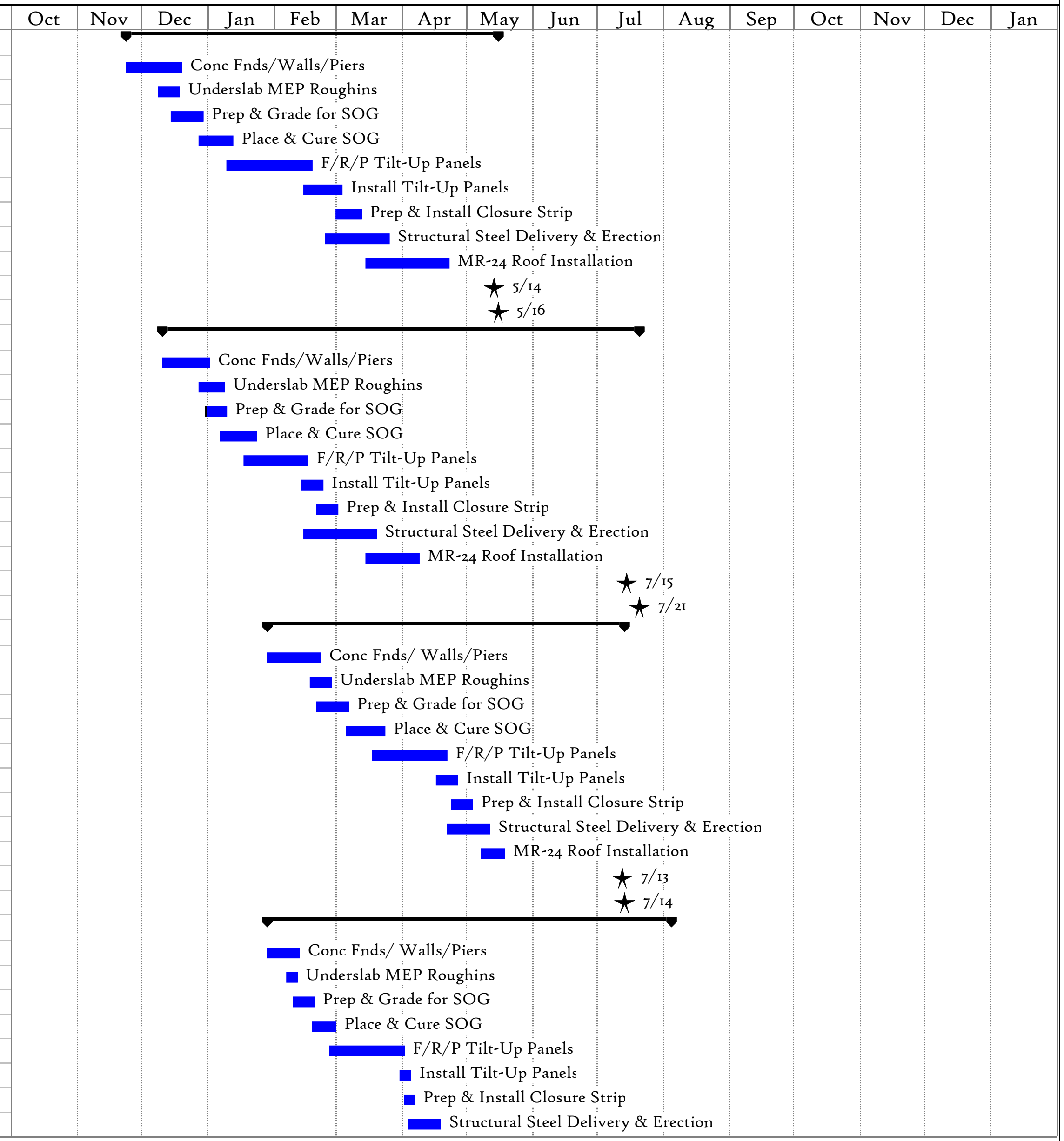
Task | Progress | Milestone ★ | Summary

Appendix H

Tilt-Up Structural System Simplified Schedule

FedEx Distribution Hub - Tilt-Up Concrete Construction Simplified Schedule

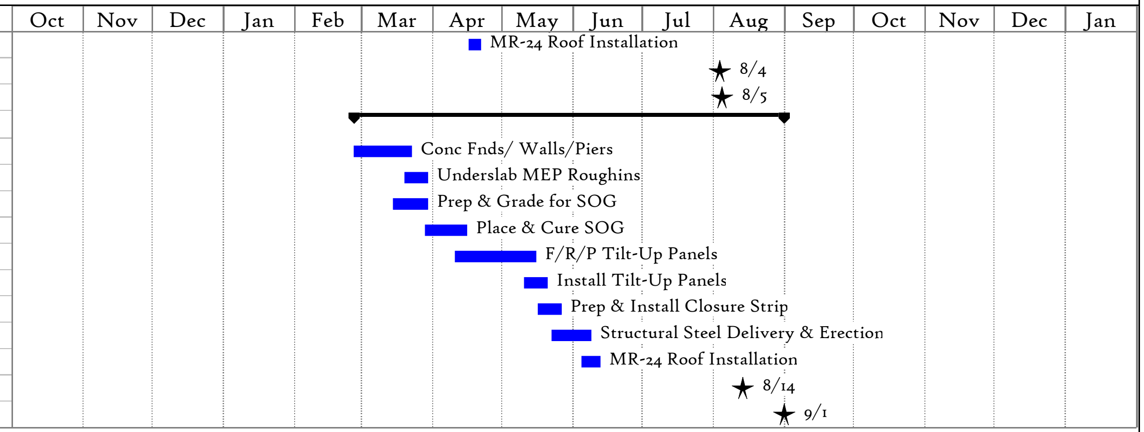
ID	Task Name	Duration	Start	Finish
1	**Local City / Unload (E-N / 4-10)**	**173 d**	**Nov 24**	**May 16**
2	Conc Fnds/Walls/Piers	25 d	Nov 24	Dec 19
3	Underslab MEP Roughins	10 d	Dec 9	Dec 18
4	Prep & Grade for SOG	15 d	Dec 15	Dec 29
5	Place & Cure SOG	16 d	Dec 28	Jan 12
6	F/R/P Tilt-Up Panels	40 d	Jan 10	Feb 18
7	Install Tilt-Up Panels	18 d	Feb 15	Mar 3
8	Prep & Install Closure Strip	12 d	Mar 1	Mar 12
9	Structural Steel Delivery & Erection	30 d	Feb 25	Mar 25
10	MR-24 Roof Installation	39 d	Mar 15	Apr 22
11	MS-II Local City/ Unload Ready for MH	0 d	May 14	May 14
12	Local City/Unload Complete	0 d	May 16	May 16
13	**Corridor (E-N / 10-15)**	**223 d**	**Dec 11**	**Jul 21**
14	Conc Fnds/Walls/Piers	22 d	Dec 11	Jan 1
15	Underslab MEP Roughins	12 d	Dec 28	Jan 8
16	Prep & Grade for SOG	10 d	Dec 31	Jan 9
17	Place & Cure SOG	17 d	Jan 7	Jan 23
18	F/R/P Tilt-Up Panels	30 d	Jan 18	Feb 16
19	Install Tilt-Up Panels	10 d	Feb 14	Feb 23
20	Prep & Install Closure Strip	10 d	Feb 21	Mar 1
21	Structural Steel Delivery & Erection	34 d	Feb 15	Mar 19
22	MR-24 Roof Installation	25 d	Mar 15	Apr 8
23	MS IVA - Corridor Ready for MH	0 d	Jul 15	Jul 15
24	Corridor Complete	0 d	Jul 21	Jul 21
25	**Load Wing 'B'**	**167 d**	**Jan 29**	**Jul 14**
26	Conc Fnds/ Walls/Piers	25 d	Jan 29	Feb 22
27	Underslab MEP Roughins	10 d	Feb 18	Feb 27
28	Prep & Grade for SOG	15 d	Feb 21	Mar 6
29	Place & Cure SOG	18 d	Mar 6	Mar 23
30	F/R/P Tilt-Up Panels	35 d	Mar 18	Apr 21
31	Install Tilt-Up Panels	10 d	Apr 17	Apr 26
32	Prep & Install Closure Strip	10 d	Apr 24	May 3
33	Structural Steel Delivery & Erection	20 d	Apr 22	May 11
34	MR-24 Roof Installation	11 d	May 8	May 18
35	Load Wing B Complete	0 d	Jul 13	Jul 13
36	MS IVB - Area Ready for HK Systems	0 d	Jul 14	Jul 14
37	**Load Wing 'A' Transition**	**189 d**	**Jan 29**	**Aug 5**
38	Conc Fnds/ Walls/Piers	15 d	Jan 29	Feb 12
39	Underslab MEP Roughins	5 d	Feb 7	Feb 11
40	Prep & Grade for SOG	10 d	Feb 10	Feb 19
41	Place & Cure SOG	11 d	Feb 19	Feb 29
42	F/R/P Tilt-Up Panels	35 d	Feb 27	Apr 1
43	Install Tilt-Up Panels	5 d	Mar 31	Apr 4
44	Prep & Install Closure Strip	5 d	Apr 2	Apr 6
45	Structural Steel Delivery & Erection	15 d	Apr 4	Apr 18



Task — Progress — Milestone ★ — Summary

FedEx Distribution Hub - Tilt-Up Concrete Construction Simplified Schedule

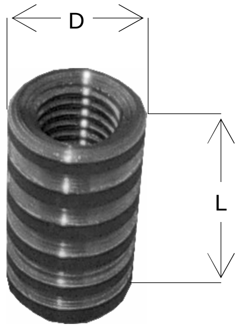
ID	Task Name	Duration	Start	Finish
46	MR-24 Roof Installation	5 d	Apr 17	Apr 21
47	Transition A - Complete	0 d	Aug 4	Aug 4
48	Trans 'A' Ready for HK Systems	0 d	Aug 5	Aug 5
49	**Load Wing 'A'**	**187 d**	**Feb 27**	**Sep 1**
50	Conc Fnds/ Walls/Piers	25 d	Feb 27	Mar 22
51	Underslab MEP Roughins	10 d	Mar 20	Mar 29
52	Prep & Grade for SOG	15 d	Mar 15	Mar 29
53	Place & Cure SOG	18 d	Mar 29	Apr 15
54	F/R/P Tilt-Up Panels	35 d	Apr 11	May 15
55	Install Tilt-Up Panels	10 d	May 11	May 20
56	Prep & Install Closure Strip	10 d	May 17	May 26
57	Structural Steel Delivery & Erection	17 d	May 23	Jun 8
58	MR-24 Roof Installation	8 d	Jun 5	Jun 12
59	Load Wing A Complete	0 d	Aug 14	Aug 14
60	MS VI - Load Wing 'A' Ready for HK Systems	0 d	Sep 1	Sep 1



Task Progress Milestone ★ Summary

Appendix J

Tilt-Up Lifting Hardware



STANDARD FERRULE

The Standard Ferrule is made from solid bar stock 12L14 cold drawn steel and is available in all bolt diameters shown in table. Special length ferrules are available upon request. All ferrules made by Universal Form Clamp have UNC standard thread (Unified National Course). Back end of ferrules are closed to prevent concrete from entering. Minimum bolt engagement for ferrule insert is bolt diameter plus 1/8 inch (3 mm) and maximum bolt engagement is shown in table below.

Ferrules may be substituted in any standard coil product desired. There is no capacity reduction of an insert when this substitution is made. Ferrules and coils (of same diameter) will have the same load carrying capacities.

STANDARD FERRULE

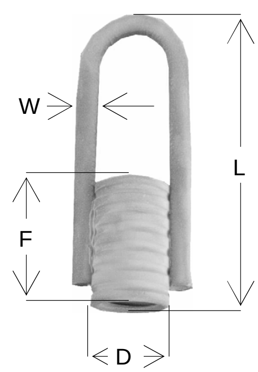
Bolt Diameter		Threads/in.	Maximum Bolt Engagement		Length (L)		Diameter (D)	
in.	mm.	Pitch	in.	mm.	in.	mm.	in.	mm.
3/8	10	16	3/4	19	1-1/4	32	9/16	14
1/2	13	13	1	25	1-3/8	35	11/16	17
5/8	16	11	1-1/8	29	1-5/8	41	7/8	22
3/4	19	10	1-1/8	29	1-5/8	41	1	25
7/8	22	9	1-1/8	29	1-5/8	41	1-3/8	35
1	25	8	1-1/8	29	1-5/8	41	1-3/8	35

No SWL specified for individual ferrules.
Note: Ferrules with an open back end may be ordered. On special ferrules, longer than standard, it may be necessary to leave back end open due to machining requirements.

STRAIGHT LOOP FERRULE INSERT

The various types of ferrule inserts are designed to be used either as a permanent attachment of a precast panel to a building frame or as a mechanical connection of such items as pipes, sprinkler systems or other suspended items. Ferrules accept standard national course (N.C.) threaded bolts or all thread N.C. rod. Bolt lengths are critical in that the ferrules are closed at the bottom end.

Ferrules are available in 1/4", 3/8", 1/2", 5/8", 3/4", and 1" nominal bolt sizes.



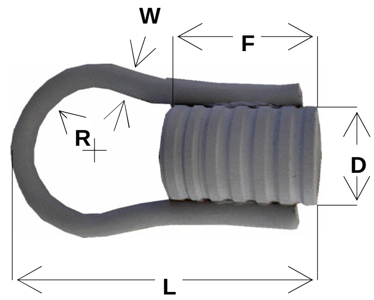
STRAIGHT LOOP FERRULE INSERT

Bolt Diameter		Insert Length (L)		Safe Work Load (Tension)		D		F		W		Minimum Edge Distance	
in.	mm.	in.	mm.	lbs.	kN.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
1/2	13	4-1/8	105	3000	13.3	11/16	17	1-3/8	35	.225	5.7	5	127
1/2	13	6-1/8	155	4000	17.8	11/16	17	1-3/8	35	.306	7.8	8	205
5/8	16	4-1/8	105	3000	13.3	7/8	22	1-5/8	41	.225	5.7	5	127
5/8	16	6-1/8	155	5000	22.2	7/8	22	1-5/8	41	.375	9.5	8	205
3/4	19	4-1/8	105	3000	13.3	1	25	1-5/8	41	.225	5.7	5	127
3/4	19	6-1/8	155	5000	22.2	1	25	1-5/8	41	.375	9.5	9	229
7/8	22	6-1/8	155	5000	22.2	1-3/8	35	1-5/8	41	.375	9.5	9	229
1	25	6-1/8	155	5000	22.2	1-3/8	35	1-5/8	41	.375	9.5	9	229
1	25	8-1/8	205	6000	26.7	1-3/8	35	1-5/8	41	.375	9.5	9	229

- SWL based on 1/2" (13 mm) set-back from concrete surface.
- Minimum concrete compressive strength, f'c = 3000 psi (21 MPa).
- Safety factor is approximately 3:1.
- Not for use as a lifting insert.

FERRULE LOOP INSERT

- used as a connection insert for securing panels and suspension anchors for sprinklers, water pipes and many other types of plumbing fixtures that must be attached to the concrete.
- Safety factor is approximately 3:1
- Not for use as a lifting insert

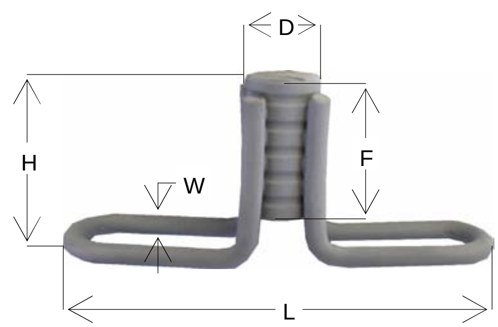


FERRULE LOOP INSERT															
Bolt Diameter		Safe Work Load (Tension)		L		F		D		R		Wire Diameter W		Minimum Edge Distance	
in.	mm.	lbs.	kN.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
3/8	10	2000	8.9	2-3/4	70	1-1/4	32	9/16	14.3	9/16	14.3	.243	6.2	5	125
1/2	13	2000	8.9	2-3/4	70	1-3/8	35	11/16	17.5	9/16	14.3	.243	6.2	5	125
5/8	16	2300	10.2	3-1/2	89	1-5/8	41	7/8	22.2	13/16	20.6	.262	6.7	5	125
3/4	19	2400	10.7	3-1/2	89	1-5/8	41	1	25.0	13/16	20.6	.262	6.7	5	125
7/8	22	5300	23.6	6	152	1-5/8	41	1-1/4	31.8	1-3/8	34.9	.375	9.5	8	200
1	25	5300	23.6	6	152	1-5/8	41	1-3/8	34.9	1-3/8	39.9	.375	9.5	8	200

- SWL based on 1/2" (13mm) set-back from concrete surface.
- Minimum concrete compressive strength, f'c = 3000 psi (21 MPa).

FERRULE WING INSERT

- for use where concrete thickness is limited and other inserts will not fit.
- provides more capacity than the economical insert and is basically the same overall size.



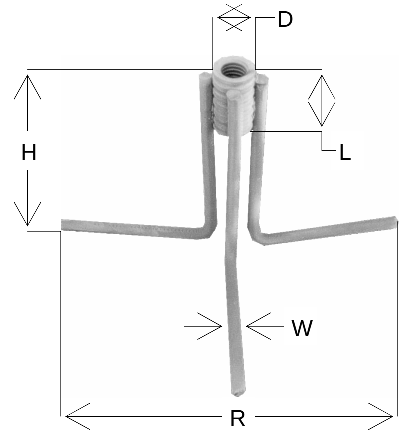
FERRULE WING INSERT															
Bolt Diameter		Insert Height (H)		Safe Work Load (Tension)		Length (L)		Diameter (D)		Ferrule (F)		Wire Diameter (W)		Minimum Edge Distance	
in.	mm.	in.	mm.	lbs.	kN.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
1/2	13	1-5/8	41	1200	5.3	4-1/2	115	11/16	17	1-3/8	35	.225	5.7	5	127
5/8	16	2-3/8	60	2500	11.1	4-3/4	120	7/8	22	1-5/8	41	.306	7.8	6	152
3/4	19	2-3/8	60	2650	11.7	4-7/8	124	1	25	1-5/8	41	.306	7.8	6	152
3/4	19	3-1/2	89	4500	20.0	4-7/8	124	1-3/8	35	1-5/8	41	.306	7.8	8	203
1	25	3-1/2	89	4500	20.0	5-1/8	130	1-3/8	35	1-5/8	41	.375	9.5	6	152
1	25	4-1/2	114	6500	28.9	5-1/8	130	1-3/8	35	1-5/8	41	.375	9.5	9	229

- SWL based on 1/2" (13 mm) set-back from concrete surface.
- Minimum concrete compressive strength, f'c = 3000 psi (21 MPa).
- Safety factor is approximately 3:1.
- Not for use as a lifting insert.

THIN SLAB FERRULE INSERT (4 Strut)

- Connection type insert useful in suspending or hanging various plumbing pipes or securing a panel to a building frame.
- If used as a lifting insert for small precast elements, SWL must be adjusted from 3:1 safety factor to 4:1 safety factor by user.
- SWL based on 1/2" (13 mm) set-back from concrete surface
- Minimum concrete compressive strength, f'c = 3000 psi (21 MPa)
- Safety factor is approximately 3:1

Note: When used as a lifting insert, user must reduce SWL for a 4:1 safety factor

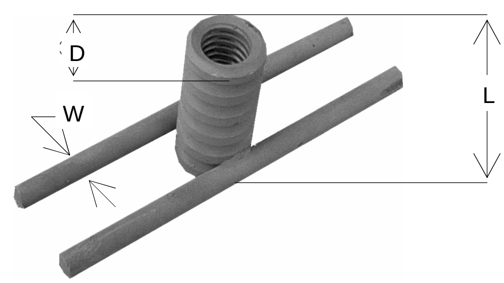


4 STRUT THIN SLAB FERRULE INSERT															
Bolt Diameter		Insert Height (H)		Safe Work Load (Tension)		Diameter (D)		Length (L)		Leg Length (R)		Wire Diameter (W)		Minimum Edge Distance	
in.	mm.	in.	mm.	lbs.	kN.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.
3/4	19	3-1/8	80	3500	15.6	1	25	1-5/8	41	7	175	.306	7.8	7	175
1	25	4-1/8	105	4500	20.0	1-3/8	35	1-5/8	41	9-1/2	241	.306	7.8	9	225

THIN SLAB FERRULE INSERT (2 Strut Parallel)

- Designed for use where concrete thickness is thin and other inserts will not fit.
- Horizontally welded wire 4 inches (100 mm) struts welded to first or second groove from bottom of ferrule.
- In some Universal Form Clamp facilities be supplied with a 4 inch (100 mm) straight wire loop.
- Not for use as a lifting insert.
- Safety factor is approximately 3:1.

Caution: Low and limited capacity and under no circumstances should the user exceed the Safe Work Load shown below in table.

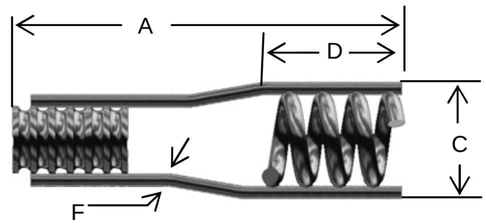


2 STRUT PARALLEL THIN SLAB FERRULE INSERT									
Bolt Diameter		Safe Work Load (Tension)		Length (L)		Diameter (D)		Wire Diameter (W)	
in.	mm.	lbs.	kN.	in.	mm.	in.	mm.	in.	mm.
3/8	10	450	2.0	1-1/4	32	9/16	14	.261	6.7
1/2	13	900	4.0	1-3/8	35	11/16	17	.261	6.7
5/8	16	1000	4.5	1-5/8	41	7/8	22	.261	6.7
3/4	19	1600	7.1	1-5/8	41	1	25	.261	6.7
7/8	22	1600	7.1	1-5/8	41	1-3/8	35	.261	6.7
1	25	1600	7.1	1-5/8	41	1-3/8	35	.261	6.7

- SWL based on 1/2" (13 mm) set-back from concrete surface.
- Minimum concrete compressive strength, f'c = 3000 psi (21 MPa).

OPEN FERRULE INSERT

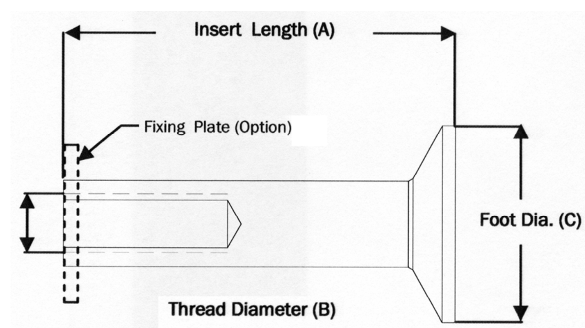
- Designed to develop higher load capacities without increasing depth of insert.
- Adequate vibration is necessary to assure concrete surrounds the open coil.
- Specs based on a 4:1 Safety Factor for lifting



OPEN FERRULE INSERT									
Bolt Diameter	Insert Length A	Safe Work Load		Struts	Wire Diameter (D)	Coil A Diameter (B)	Coil B Diameter (C)	Minimum Edge Distance	Part Number
		Tension	Shear						
in.	in.	lbs.	lbs.		in.	in.	in.	in.	
5/8-NC	4-1/8	3000	3000	2	.225	2	1-1/2	5	58418OCIPL
3/4-NC	4-5/8	4250	4250	2	.375	2-1/8	1-1/2	6	34458OCIPL
7/8-NC	6-1/8	5000	5000	2	.375	2-1/2	2-1/4	7	78618OCIPL
1-NC	5-5/8	6250	6250	2	.440	2-1/2	2-1/4	7	1558OCIPL
1-NC	7-5/8	10000	12000	4	.440	2-3/4	2-3/4	10	1758OCIPL
1-1/4-NC	7-5/8	12000	12000	4	.440	3	2-3/4	10	114758OCIPL
1-1/4-NC	9-5/8	16000	16250	6	.440	3	3-5/8	12	114958OCIPL
1-1/2-NC	9--5/8	16000	16250	6	.440	3-3/8	3-5/8	12	112958OCIPL

DUCTILE FERRULE INSERT

- Designed to give additional load strength in concrete
- Anchors can be used for lifting/handling or fixing and mounting for structural purpose.
- Based of 4:1 Safety Factor, although it factor can be lowered to 3:1 (consult UFC).
- The large foot creates a large shear cone in concrete.



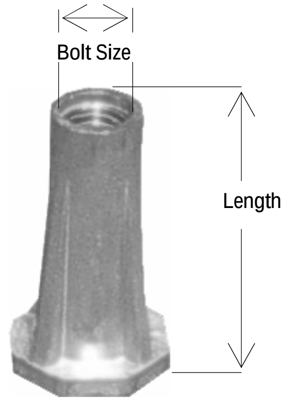
DUCTILE FERRULE INSERT								
Bolt Diameter (B)	Insert Length (A)	Min. Ultimate Strength	SWL 4:1 (Steel)	Foot Dia. (C)	Safe Work Load* (Concrete 4:1)		Minimum Edge Distance in.	Part Number
					Tension	Shear		
in.	in.	lbs	lbs	in.	lbs.	lbs.		
1/2	4.00	19000	4750	2.00	3750	4500	8.00	NCFFI12
5/8	4.50	28000	7000	2.25	6250	7500	8.50	NCFFI58
3/4	5.00	37600	9400	2.75	6000	7200	9.00	NCFFI34
3/4	10	37600	9400	1.80	9000	10800	12.00	NCFFI3410
3/4	12	37600	9400	1.80	9000	10800	12.00	NCFFI3412
7/8	6.00	54000	13500	3.15	9000	10800	10.50	NCFFI78
1	6.50	60000	15000	3.15	10000	12000	10.50	NCFFI1

*Based on 4:1 Safety Factor and minimum capacity strength of 3500 psi with a full shear cone. Concrete Material: 1522

For connecting, the bolt or rod connection must be equal to a Grade 8 or higher.

NC PRECAST CONCRETE INSERT

- Threaded precast insert
- Made from a zinc alloy insert corrosion resistant steel
- Specially designed foot creates a large shear cone in relatively thin concrete panels or walls.
- Available in most bolt sizes



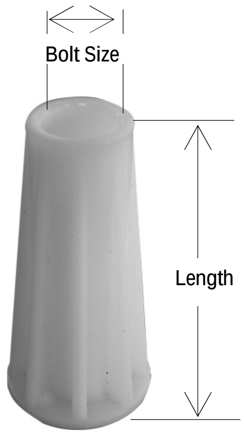
NC PRECAST STEEL INSERTS					
Bolt Size	Length	Threads/in.	Safe Work Load	Weight Per 100	Part Number
in.	in.	Pitch	lbs.	lbs.	#
1/4”	1-1/2”	20	750	4.72	PCI14112
3/8”	1”	16	1200	4.28	PCI381
3/8”	1-3/8”	16	1400	6.84	PCI38138
1/2”	1-1/2”	13	1500	14.72	PCI12112
1/2”	2-7/8”	13	3000	29.90	PCI12278
5/8”	1-11/16”	11	1750	20.96	PCI581116
5/8”	2-7/8”	11	3000	35.80	PCI58278
3/4”	1-11/16”	10	2000	31.60	PCI3411116
3/4”	2-7/8”	10	3500	47.60	PCI34278

*3:1 safety factor

Minimum concrete compression strength 3000 psi.

NC PLASTIC INSERT

- Cost effective
- Threaded insert
- White in color
- Specially designed foot creates a large shear cone in relatively thin concrete panels or walls.
- Available in most bolt sizes



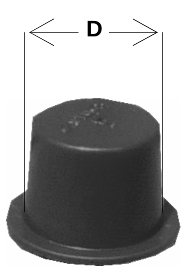
NC PRECAST PLASTIC INSERTS					
Length	Bolt Size (mm)	SWL	Pcs/ctn	Weight/100	Part Number
In.	In. (mm.)	Lbs.	#	Lbs.	#
1”	3/8” (10mm)	1200 lbs.	2000	0.5 lbs.	PCIP38
2-1/2”	1/2” (13mm)	2500 lbs.	1000	0.6 lbs.	PCIP12
3”	5/8” (16mm)	3000 lbs.	500	0.8 lbs.	PCIP58
3”	3/4” (20mm)	3300 lbs.	500	1.0 lbs.	PCIP34

THREADED PLASTIC PLUG

The threaded plastic plug is used similar to plastic cap except it has threads and can be threaded into and out of a ferrule insert previously cast into concrete to keep bolt holes clean.

It is also excellent for installing a ferrule insert on form. A nail hole is provided in center of the plug for ease of attachment.

THREADED PLUGS				
Diameter (D)	Part Number Plastic	Weight Plastic	Part Number Zinc Steel	Weight Zinc Steel
	#	lb/100	#	lb/100
1/4” NC	TPP14	0.4	TSP14	.86
3/8” NC	TPP38	0.5	TSP38	1.58
1/2” NC	TPP12	0.6	TSP12	3.80
5/8” NC	TPP58	0.8	TSP58	7.80
3/4” NC	TPP34	1.0	TSP34	10.40



PLASTIC CAP PLUG

The plastic cap is designed to be inserted in the open end of a ferrule to keep concrete and debris out of the ferrule before use.

It may also be used to attach the ferrule insert to the inside of a form by pre-nailing the plug to the form.

PLASTIC CAP PLUG		
Diameter (D)	Part Number	Weight
	#	lb/100
3/8”	PCP38	0.2
1/2”	PCP12	0.2
5/8”	PCP58	0.3
3/4”	PCP34	0.4
1”	PCP1	0.8