

Architectural Engineering Senior Thesis

Tuesday, April 7, 2009



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Construction Management Option
Faculty Consultant: Dr. Anumba
Spring 2009

Constitution Center

400 7th Street SE, Washington, DC 20024

NATALIE L. BRYNER

CONSTRUCTION MANAGEMENT OPTION

CONSTITUTION CENTER

400 7TH STREET SE, WASHINGTON, DC 20024



BUILDING STATISTICS

- Size: 1,500,000-SF base building and 600,000-SF parking garage
- Number of Stories: Three-level underground parking garage, 10 stories + Pent House
- Occupancy Type: Class A Office Space
- Cost: \$246 Million GMP
- Construction Dates: July 2007 - November 2009
- Delivery Method: Design-Bid-Build
- LEED Gold Project



MECHANICAL & ELECTRICAL

- Centralized Plant in the Penthouse Housing:
 - Two 800 h.p. Boilers
 - One 350 h.p. Boiler
 - Three 1200 ton Trane Chillers
 - Eight 30,000 CFM Trane Air Handlers
 - Eight 30,000 CFM Semco Energy Recovery Units
 - Four 1200 ton Cooling Towers utilizing 6,700 Active Chilled Beams
- Power distribution system of 13.8 kVA feed from four primary switchgear connected to Pepco feeders
- 10 secondary 4000A transformers within the garage and Pent House levels
- Two 1000 kilowatt generators are roof mounted to provide power back-up to the critical building systems during a power outage
- Two dedicated chiller/purifier drinking water systems that continuously circulate water throughout the building
- Custom made Chilled-Beam System from Germany

PROJECT TEAM

- Owner/Developer: David Nassif Associates
- General Contractor: James G. Davis Construction Corporation
- Owners Representative: Kramer Consulting
- Architect: SmithGroup, Inc.
- MEP Engineer: SmithGroup, Inc.
- Civil Engineer: Wiles Mensch Corporation
- Structural Engineer: SK&A

STRUCTURAL

- Precast panels found at all four corners of the building, which frame the spandrel glass
- Blast resistant curtainwall throughout at Streetscape and Courtyard, with floor two being the most resistant including an air barrier system
- Metal panel on the Pent House level to conceal the MEP equipment
- Blast protection in garage tenant space, entrance ramp, internal ramps, electrical rooms, telecom rooms, elevator shafts, egress stairs, and exposed columns
- Two-way waffle slab on all floors except the Pent House

ARCHITECTURE

- Renovation of an existing building, originally constructed in 1976 and occupied by the Department of Transportation (DOT)
- 4 separate, but integrated quadrants that have their own elevator, stairs ways, bathrooms, electrical closets, communication closets
- One acre of courtyard that is a private, secure green space with fountain, seating areas, sculpture, and 32 Honey Locust Shade Trees that are 11'-15' tall
- White Marble and Jerusalem Limestone are located around the first level of the building, creating a boarder for the spandrel glass located at the storefront entrances
- Built-up roofing system and metal panels used to conceal the MEP equipment on the Pent House level



RENDERINGS PROVIDED BY SMITHGROUP, INC. AND STUDIO CHRISTEN

EXECUTIVE SUMMARY

Information about the renovation of Constitution Center, located in Washington, DC, can be found throughout the following document. In the first section, one can find project background, including information on why the building is being renovated. Also, the project team is outlined, along with the client, David Nassif Association. Next, there is data about the project delivery system and how it played a part in the selection of the subcontractors. An overview of the building systems is discussed, along with a summary of the project schedule. Finally, the section is concluded with an evaluation of the project costs.

Analysis: Chilled Beams & Commissioning

The first analysis deals with the chilled beam system being installed. This is the largest system being installed in the United States and provided an area to gain knowledge to a system that may become widely used in future buildings. This analysis also provided an area for a critical industry research and a mechanical breadth. Both of these topics dealt with the commissioning requirements for Constitution Center. In this section, one can find information about the three different types of chilled beams and a recommendation on which one would be most cost efficient to use on the project. Additionally, a study of the commissioning outlines the lessons learned about the requirements on numerous projects.

Analysis: Parking Garage Waffle Slab

The second analysis incorporates a structural breadth for a redesign of the parking garage waffle slab. During the renovation process, quadrants of the parking garage were completely shut down in order for the floors to be updated. The redesign will focus on a two-way reinforced concrete system. After the redesign, a recommendation on which system would be best to use based on studying both the schedule and the cost requirements.

Analysis: Curtain Wall Installation

The third analysis incorporates the MAE Graduate-Level component of *CE 533 - Construction Productivity Analysis and Performance Evaluation*. The research focused around the curtain wall installation procedures and how they impacted both the schedule and the site logistics. The section is concluded with an overview on how productive the installation was throughout the project.

Analysis: Pedestrian Safety

The final analysis studied the safety requirements for the pedestrians about Constitution Center. Since the L'Enfant Metro Station Entrance was within the construction site, it was a problematic feature to keep the pedestrians safe, but not limiting the use of the metro or the work taking place on the construction site. One can find an overview of how DAVIS implemented special safety techniques in order to keep everyone safe. Finally, the section is concluded with survey results on how companies are applying safety to their jobsites.

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- Bill Moyer
- Yolanda Nelson
- James Pacala
- Nestor Santos
- T.J. Sterba
- Meghan Ulrich



David Nassif Associates

- Timothy Jaroch



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- Melissa Brown
- David Varner



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- Suzanne Chupp
- Chris Lawrence



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- Dan Donaghy



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- Tod Krauss



Enclos Corp.

- Paul Sullivan



The Pennsylvania State University

- Chimay Anumba
- Robert Holland
- Kevin Parfitt



PACE Industry Members

Fellow Architectural Engineering Students

- Joe Wilcher (Structural)

PROJECT OVERVIEW

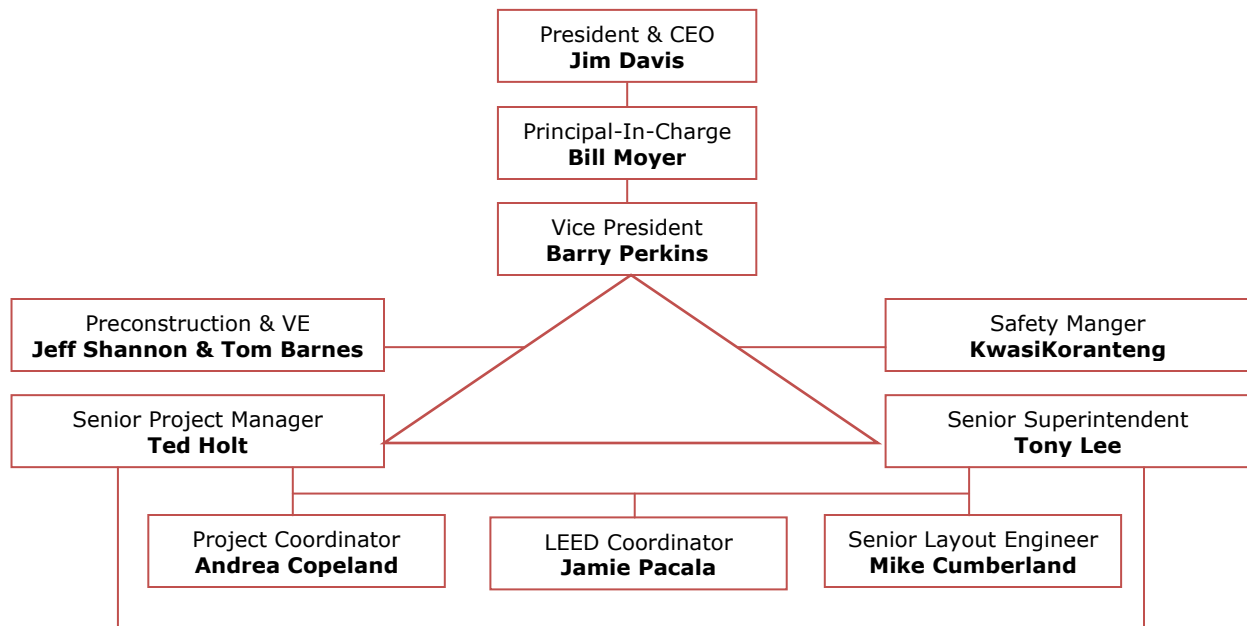
Constitution Center is a renovation of an existing building, located a few blocks south of the National Mall, originally constructed in 1976. It was formerly occupied by the Department of Transportation (DOT). It is located between 6th and 7th Street and D and E Street in SW DC. The building takes up an entire city block, with 3 levels of parking below grade, which is approximately 15 acres in size. Additionally, there are 10 levels above grade with a penthouse for MEP equipment. There is an open, landscaped courtyard (approximately 1 acre in size) at the center of the site with a decorative fountain. The building is not yet leased, but is designed as offices for a potential government tenant, with Level IV security rating. Constitution Center is striving to attain LEED Gold Certification.



Figure 1: Map of the Central DC showing the location of Constitution Center.



The structure of the general contractor, DAVIS, on Constitution Center is a typical hierarchy. Please see Figure 2 for a visual description of the hierarchy at Constitution Center. Jim Davis, the President and CEO oversees all DAVIS projects. Bill Moyer, Principal-In-Charge, manages multiple projects at DAVIS. The Vice President, Barry Perkins, is responsible for several projects; however he spends most of his time overseeing Constitution Center. Both Ted Holt, Senior Project Manager, and Tony Lee, Senior Superintendent, work onsite of Constitution Center daily and provide guidance to the progress of the project. Under their leadership, the project is divided into five main areas: Site, Demolition, & Plaza Coordination; Structure, Blast & Masonry; Façade & Division 7; MEP & Elevators; and Interiors & Finishes. Each of these areas has a Project Manager, Project Superintendent, Assistant Project Manager, and a summer intern to insure the project is being built it the correct specifications.



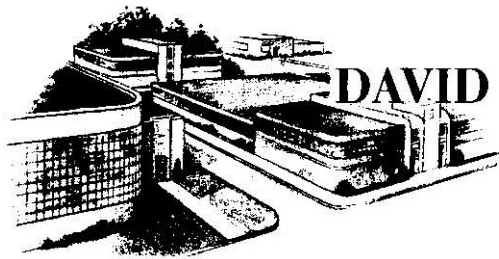
Site, Demolition & Plaza Coordination		Structure, Blast, & Masonry		Façade & Div. 7		MEP& Elevators		Interiors & Finishes	
Project Manager, LEED Brad Cordek	Project Superintendent Tim Swanson	Project Manager, LEED TJ Sterba	Project Superintendent Dan Gowin	Project Manager, LEED Meghan Ulrich	Project Superintendent Doug Bolden	Project Manager Bill Bundens	Project Superintendent Drew Broglie	Project Manager, LEED Greg Ghent	Project Superintendent Tim Swanson
Assistant Project Manager Jamie Pacalla		Assistant Project Manager Frank Lefler		Assistant Project Manager Jesse May		Assistant Project Manager Ihsan Gin, Nestor Santos, Omega Tadesse		Assistant Project Manager Jamie Pacalla	
Intern Natalie Bryner		Intern Natalie Bryner		Intern Desmon Hayden		Intern Natalie Bryner		Intern -	

Figure 2: Hierarchy of the general contractor, James G. Davis Construction Corporation

Client Information

David Nassif Associates are the owners of Constitution Center. They originally built the building back in the 1970's, and have operated and leased the building since then. The company thrives on owning a smaller number of larger buildings, like Constitution Center. This will be the largest privately owned office building in Washington, DC and owning it is one of the goals of the ownership. The building, like many others built in the 1970s, are ready for renovations. Additionally, they saw this moderation as an excellent opportunity to bring a newly updated and renovated LEED building to the DC area.

David Nassif Associates want the best in cost, quality, schedule, and safety for Constitution Center. They expect the highest quality work possible, within the schedule of the project. Additionally, they have extremely high safety expectations, as they have the onsite nursing staff for drug testing and any injuries. One of their strategies with the cost is to "bend but not break."¹ They are willing, unlike most owners, to pay more for items that actually warrant extra money. It is believed that this strategy will help them get a better quality product in the end. David Nassif Associates have provided numerous free things for the subcontractors. Some examples include the parking that is available in the garage and trips with the subcontractors to look at the curtain wall, stone, trees, and chilled beams. As one can tell, they have spent a lot of money on travel to ensure they have the best product.



DAVID NASSIF ASSOCIATES

Pioneers in Property Development

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The main sequencing issue that is of interest to the owners is that the building is completed in the correct sequences, so that the appropriate quadrant is released at the projected time. With this, there are no occupancy requirements, other than turning the quadrants over on time. In order for Constitution Center to be completed to the owner's satisfaction, they would like to make sure that the punch lists are done for the majority of the items installed to ensure that they are getting the highest quality they are expecting.

¹ (Cordek)

Project Delivery System

Constitution Center is being delivered as a design-bid-build project. This means that the owner holds the contracts for both design and construction. The reason the owner chose this type of contract was because the project is so large that they wanted to manage the contracts for the different phases and be involved throughout the entire renovation. Please see the organizational chart, Figure 3, for the other key contracts. There is a guaranteed maximum price (GMP) contract between David Nassif Associates and DAVIS, which states that the owner is not obligated to compensate DAVIS for any amount beyond the contract price. DAVIS holds all of the subcontracts, which are all lump sum contracts, except for the Abatement Subcontractor, Aceco, Inc., which is a unit rate. The reason DAVIS chose to do a unit rate contract with Aceco is because they had to add and deduct rates for different abatement quantities. David Nassif Associates holds lump sum contracts with everyone that is involved in the design phase. These two types of contractors are very common in most construction projects and they are very appropriate for this large job.

DAVIS selected the subcontractors, which are listed to the right, by weighing the cost proposals against the performance strategies. The primary subcontractor had a meeting with the ownership to discuss their planning strategies, prior to decisions being made. DAVIS was selected in a similar manner; they provided their estimate, along with the planning strategies.

The project requires a Contractor Controlled Insurance Program (CCIP), which provides coverage for all enrolled subcontractors. A typical CCIP provides coverage in the following three areas: Workers' Compensation / Employer's Liability, Commercial General Liability, and Excess Liability.

Major Subcontractors:

- Government Agency (Power) – Pepco
- Government Agency (Gas) – Washington Gas
- Government Agency (Metro) – Washington Metropolitan Area Transit Authority
- Survey & Layout – William H. Gordon Associates
- Demolition – Aceco, LLC, The Berg Corporation
- Site Concrete – GT Contracting Corporation
- Site Signage – All State Striping & Sealing Co.
- Landscaping – Ruppert Nurseries
- Cast In Place Concrete – Brothers Concrete Construction, Inc.
- Concrete Restoration – Concrete Restoration Services
- Masonry – Genco Masonry Inc, Worcester Eisenbrant
- Stone – Rugo Stone
- Metals – Extreme Steel
- Miscellaneous Metals – Superior Iron Works
- Ornamental Metal – Louis Hoffmann
- Waterproofing – Eastern Waterproofing & Restoration
- Sprayed On Fireproofing – Diamond Engineering
- Manufactured Roof & Wall Panels – A.C. Dellovade
- Roofing – Gordon Contractors
- Doors, Frames & Hardware – C.H. Edwards
- Glass & Glazing – Enclos Corporation
- Drywall & Acoustical Ceiling – C.J. Coakley
- Painting & Wallcovering – Brien Miller Painting Company
- Elevators – Mid-American Elevator
- Plumbing & HVAC – Pierce Associates
- HVAC Controls – Facility Dynamics Engineering
- Electrical – J.E. Richards

Project Team

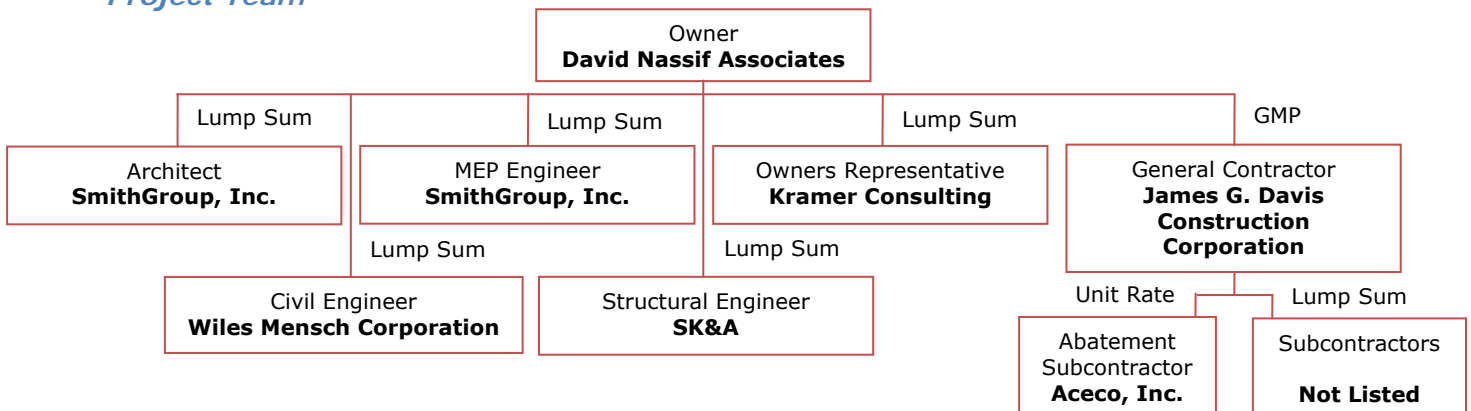


Figure 3: Hierarchy of the design-bid-build delivery system, including the major project team members.

Site Plan and Existing Conditions

The site plan of existing conditions can be found on page 13. It includes the footprint of Constitution Center, along with the buildings that surround it. Additionally, it depicts the patterns for both traffic and pedestrians. Fire hydrants and metro grate locations are included on the plan. As one can tell, the north sidewalk is for the L'Enfant Plaza metro entrance, which is open Monday through Friday. Even though the metro entrance is within the site, overhead protection is not necessary, since the north face of the curtain wall was previously installed before the reopening in July 2008. Parking for the workers of Constitution Center can be found on the three levels below the building in the parking garage. There is one access road into the site, which can be found at the south of the building. This road is used to get into the parking garage and where deliveries occur. There is storage found around the site, in the areas between the side-walks and the driving lanes that are temporarily shut down. Additional storage areas are in the parking garage areas. Since the site is so large, the utility locations can be found on a separate drawing, which is Figure 4. This drawing depicts where the existing water, gas, and communication locations were found. The offices of Constitution Center can be found on the south side of the second and third floors. DAVIS' office is located on the second floor; SmithGroup, David Nassif Associates, and Kramer Consulting are all on the third floor; and subcontractors can be found on both floors.

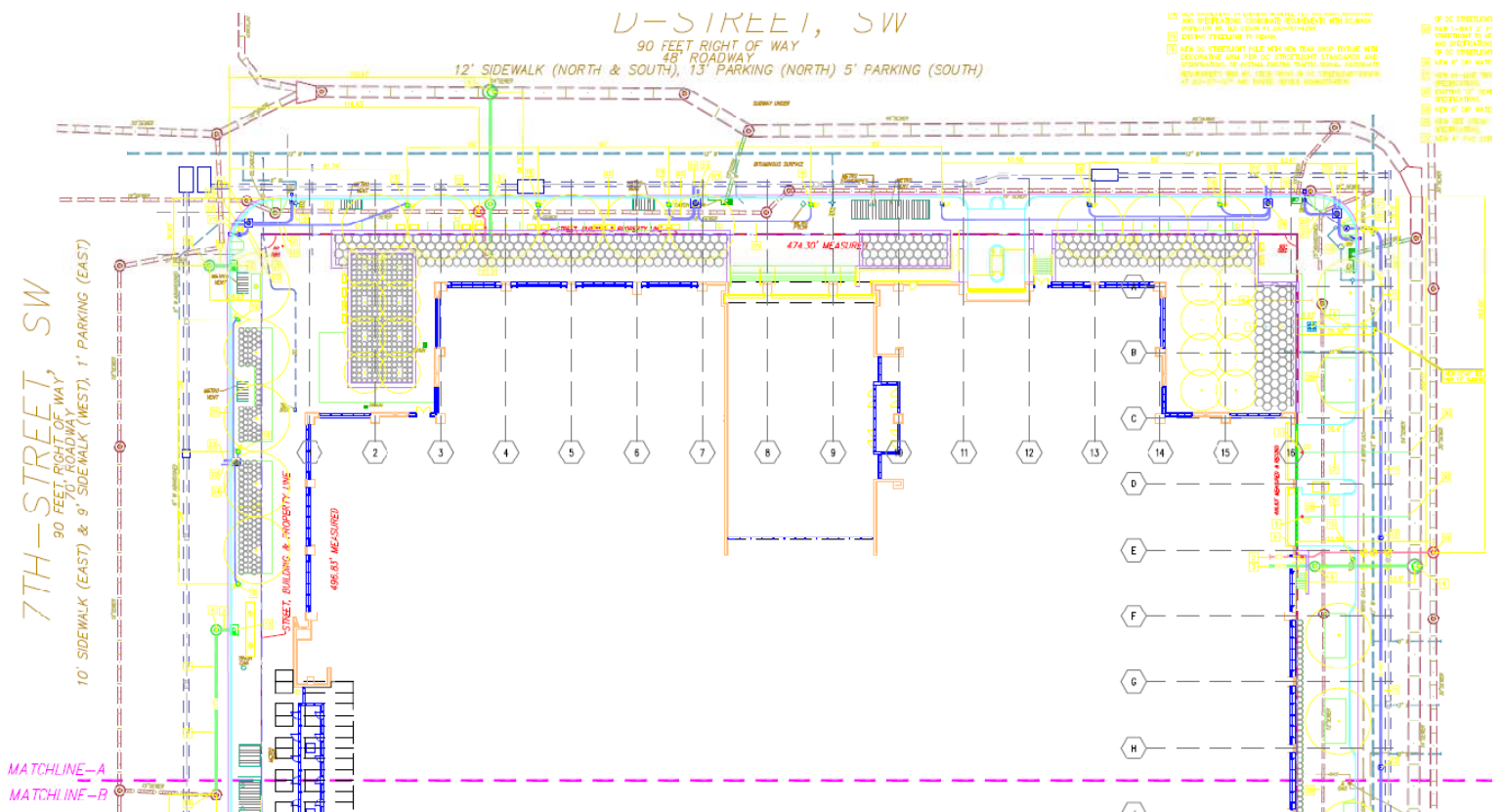
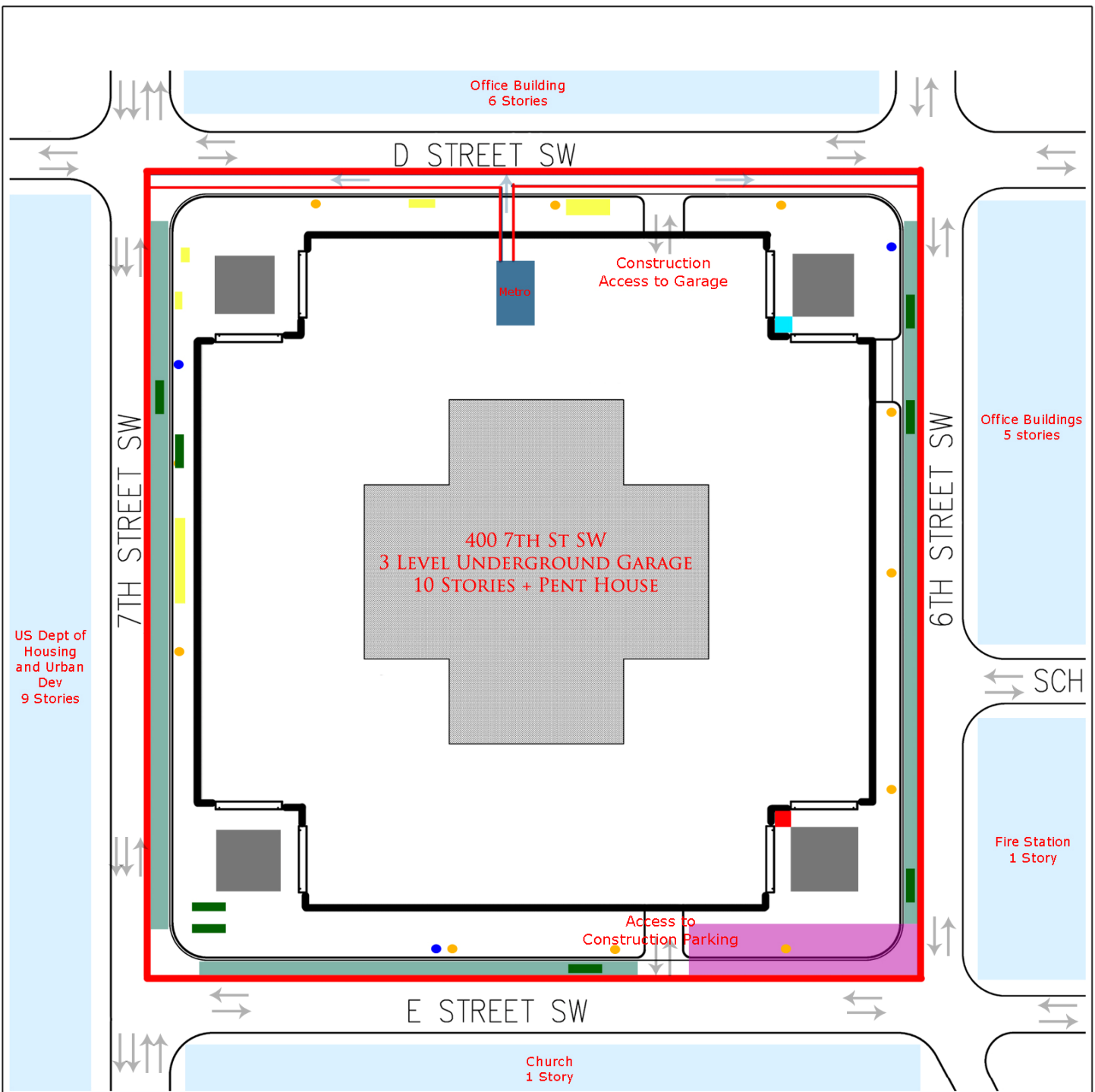


Figure 4: Site Utility Locations



CONSTITUTION CENTER

400 7TH STREET SE, WASHINGTON, DC 20024

Legend:

- Jersey Barriers and Fences, indicating Construction Boundaries
- ← Traffic Flow
- ← Pedestrian Flow
- Tower Cranes (Four)
- Metro Grates
- Metro Entrance
- Delivery Area
- Material Storage
- Material Hoist
- Person Hoist
- Dumpsters
- Light Poles
- Fire Hydrants



NATALIE BRYNER

TECHNICAL ASSIGNMENT ONE
SEPTEMBER 29, 2008

SITE PLAN
EXISTING CONDITIONS

The preferred method of construction in Washington, DC is the use of concrete. The reason for this method is because there is a height restriction in Washington, DC. "In 1899, Congress passed the Heights of Buildings Act ... but it was amended in 1910 to the width of the adjacent street plus 20 feet."² Therefore, when Constitution Center was built in 1976, they used a two-way waffle slab for the floors and concrete columns to create 30' by 30' bays to maximize the floor to floor height, staying within the height restriction.



Figure 5: Sample of the parking arrangements for August 2008 at Constitution Center. The colored blocks indicate parking spaces per subcontractor.



At Constitution Center, there are currently 350 parking spaces available to the workers. The spaces are in the three level controlled access parking garage, which will have 1,500 spaces when construction is complete. DAVIS has given each particular subcontractor a limit to the amount of people that receive parking passes and have a guard on duty throughout the day checking the passes. The spaces alternate between the levels, depending on where work is taking place at the time. Figure 5 shows how the parking spaces are divided on parking level one. If the workers were not provided with parking arrangements, Constitution Center has direct access to four of the five L'Enfant Plaza metro entrances, the Virginia Rail Station, and 14 bus lines. Overall, parking has not been a problem for the workers of Constitution Center.

Since Constitution Center is striving for LEED Gold Certification, the site has a total of eight dumpsters; five belong to DAVIS, two trash, one metal, one block, and one wood while the other three are the responsibility of the subcontractors, ACECO, Brothers, and CRS. The wood and trash dumpsters are emptied every day, while the metal and blocks are removed every three to four days. Additionally, ACECO pulls theirs three times a day and Brothers and CRS empties them every four to six days. The initial cost of the dumpsters was about \$500 and they have a tipping fee of about \$130. Overall, dumpsters play a very large part in the site receiving LEED Certification; therefore DAVIS has an assistant project manager responsible for tracking the percentage of material that is being recycled.








Constitution Center is a renovation of the existing David Nassif Building, therefore soil and subsurface water conditions did not play a large role in the construction. However, since there is a three level parking garage under the building, which is not the same footprint as the building, proper shoring was necessary with the mobile cranes used for the installation of the curtain wall.

² (Grunwald)

Building Systems Summary

Table 1: Summary of the key aspects of the design and construction of Constitution Center

Yes	No	Work Scope	Information
x		Demolition Required?	<p>The demolition subcontractor, Aceco, was responsible for the removal of asbestos, lead based paint, Polychlorinated biphenyls (PCB) & mercury, hazardous chemicals, and biological elements. Some of the asbestos was the cementitious surfacing materials, the duct connectors and gaskets, the elevator door packing, exhaust mufflers, etc. Examples of the lead based paint were in the mechanical motor units, the ceramic wall tile, the metal wall flashing, etc. PCB and mercury were in the light ballasts, the fluorescent light tubs, and the mercury contained bulbs and thermostats. Petroleum liquids and glycol coolant are the hazardous chemicals. Finally, the biological elements were the avian and rodent excreta, mold impacted abatement, and surfaces that needed to be disinfected.</p> <p>The building demolition included removing everything from the building, expect for the floor slabs and columns. The picture below shows how much demolition occurred.</p> <div style="display: flex; justify-content: space-around;">   </div> <div style="display: flex; justify-content: space-around; margin-top: 10px;"> August 29, 2007 July 30, 2008 </div>
	X	Structural Steel Frame	N/A
x		Cast in Place Concrete	<p>The cast in place concrete included new concrete blast reinforcement, which was installed with items such as blast walls, blast hardening, etc. There were also newly installed topping slabs and raised slabs at some areas that required elevation changes. Formwork was standard stick built on-site by the concrete subcontractor, Brothers Concrete. Concrete placement methods included by tower cranes, boom truck, and buggies.</p>

x		Precast Concrete	<p>Decorative precast concrete was installed at the four corners of the building with welded steel connections. Coordination issues with the building roof overhang occurred therefore the steel was erected from a mobile crane, as opposed to the tower cranes.</p> 
x		Mechanical System	 <p>The mechanical rooms are located on the Pent House level. The building mechanical system consists of AHU's, Chillers and Boilers. Ductwork feeds the chilled beam systems that will be installed in the office spaces.</p> <p>The sprinkler system varies from dry to wet, depending on the location of the pipe runs.</p>
x		Electrical System	<p>The power distribution system of 13.8 kVA is feed from four primary switchgears connected to Pepco feeders. It is then distributed to 10 secondary 4000A transformers within the garage and penthouse levels. Two 1000-kilowatt generators are roof mounted to provide power back up to the critical building systems during a power outage.</p>
x		Masonry	<p>Constitution Center does not have veneer brick, however it does have CMU partition walls and blast walls. The connections are typical for masonry work in all areas of the building. They are utilizing the typical scaffold, which makes the work area fairly straightforward, especially since it is not in hard to access areas.</p>
x		Curtain Wall	 <p>The curtain wall system is composed of composite glass and aluminum panels. These structures are prefabricated offsite and erected a panel at a time. The overhang was an issue; so mobile cranes have been used to set these pieces. The design of the curtain wall, although outlined by the architect, fell mostly into the subcontractor's engineer's responsibility.</p>
	x	Support of Excavation	N/A

Project Schedule Summary

One of the main concerns of the ownership of Constitution Center is that the project be completed on time; therefore the schedule plays a major part in the construction. Figure 6, summarizes the schedule to make it easy to tell what phases are taking place during a specific month.

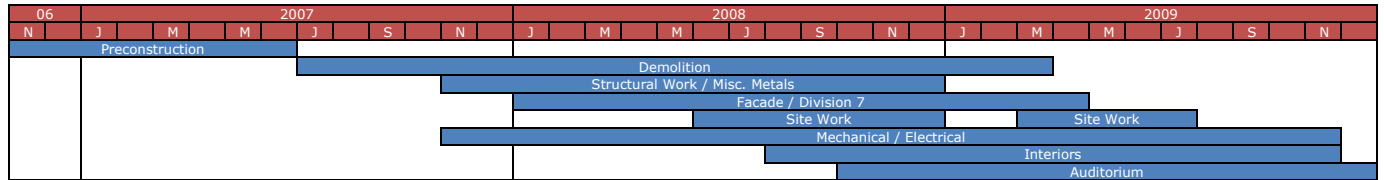


Figure 6: Simple schedule that is used to show when each general phases is being constructed.

Figure 7 shows a project schedule summary, which includes pre-construction, demolition, and actual construction milestones. Each of these phases is then broken into the key elements that must occur in order for that phase of construction to be completed. The finishes take approximately 206 days to complete, therefore this is a main phase in the construction progress. The first key element for the finish sequence of the garage is the construction of the elevator shaft walls. After this is completed, the erection of the CMU blast walls occur, followed by the hardening of the concrete walls. The next element is the rough-in of the MEP, along with the hardening of the columns. To finish the parking garages, the raised slabs must be constructed, the lights installed, and the finishes applied. For the typical floors, there are five main elements that much occur before the finish sequence. First, the steel columns and beams must be installed. Then the expansion joints need to be removed. Next the slabs need to be in-filled and the MEP rough-in has to take place. Finally the shaft walls need to be constructed then the finishes are applied.

Preconstruction started in November of 2006. This phase includes both mobilization and critical procurement of 7 elements. After the preconstruction, demolition started in July 2007 and may last until March 2009. Finally construction started in September 2007 and the building will be turned over in 4 quadrants. The sequence is the northeast on May 1, 2009, the northwest on July 1, 2009, the southwest on September 1, 2009 and the southeast on November 1, 2009. Finally the project close-out will last until December 2009, which includes commissioning.

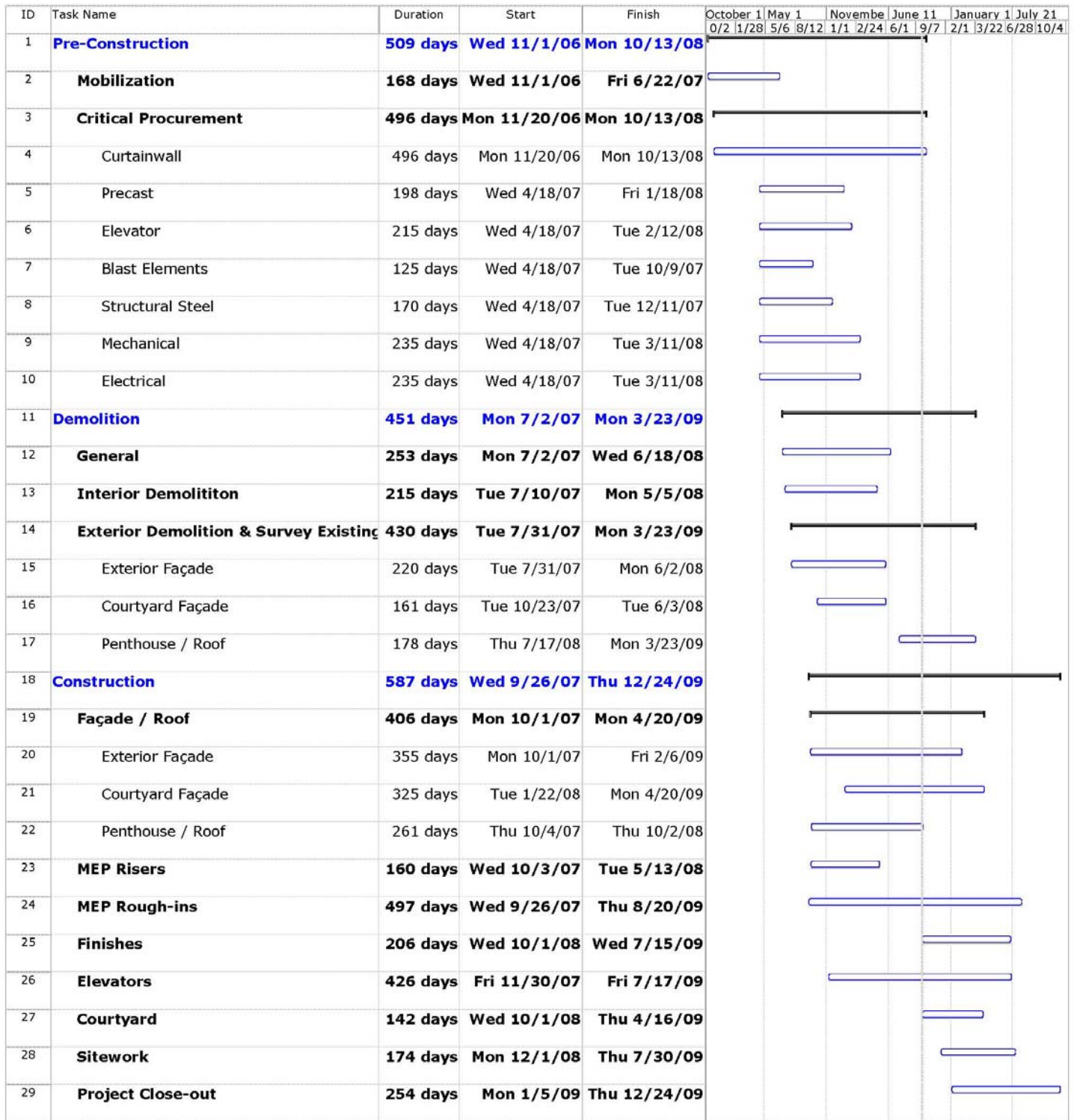


Figure 7: Project Summary Schedule produced in Microsoft Project

Project Cost Evaluation

The project cost of Constitution Center was evaluated several different ways. First, Table 2 shows the building construction cost, as one can see it is \$211,191,150 or \$140.70/SF. Next the total project cost is outlined in Table 3, showing that the cost is \$244,700,033 or \$163.13/SF. Table 4 shows the major building systems costs and the cost per square foot for each of the systems. After evaluation, it is determined that the mechanical system is the most expensive, being around \$52 million.

Building Construction Cost (CC)	
Construction Cost	\$211,191,150
Cost per Square Foot	\$140.79

Table 2: Building Construction Cost Breakdown

Total Project Cost (TC)	
Construction Cost	\$244,700,033
Cost per Square Foot	\$163.13

Table 3: Total Project Cost Breakdown

Table 4: Building Systems Costs

Division	Title	Cost	Cost/SF
Division 02	Existing Conditions	\$17,717,242	\$11.81
	Selective Demolition	\$12,310,000	\$8.21
	HAZMAT Abatement	\$1,514,316	\$1.01
	Surveying	\$49,900	\$0.03
	Site Utilities: water, san, storm	\$643,040	\$0.43
	Asphalt Paving	\$218,000	\$0.15
	Restriping/Pavement Marking	\$22,900	\$0.02
	Concrete Site Work	\$544,000	\$0.36
	Site Furnishings	\$200,000	\$0.13
	Exterior Plants w/ Irrigation	\$1,253,000	\$0.84
	Retractable Bollards	\$422,141	\$0.28
	Parking Equipment	\$100,000	\$0.07
	Site Development	\$439,945	\$0.29
Division 03	Concrete	\$23,142,494	\$15.43
	Cast-in-Place Concrete	\$9,408,124	\$6.27
	Structural Precast Concrete	\$48,392	\$0.03
	Architectural Precast Concrete	\$1,975,834	\$1.32
	Cementitious Underlayment	\$3,538,710	\$2.36
	Fiber Reinforced Polymer	\$3,768,402	\$2.51
	Concrete Repair & Traffic Coat	\$4,403,032	\$2.94
Division 04	Masonry	\$5,043,908	\$3.36
	Tuckpointing	\$990	\$0.00
	Masonry	\$1,393,173	\$0.93
	Masonry Coating (Polyurea)	\$183,910	\$0.12
	Stone	\$3,465,835	\$2.31

Division 05	Metals	\$14,521,856	\$9.68
	Structural Steel	\$2,445,660	\$1.63
	Miscellaneous	\$6,481,564	\$4.32
	Curtain wall Anchors	\$2,729,113	\$1.82
	Steel Jackets	\$2,361,538	\$1.57
	Ornamental Metals	\$286,806	\$0.19
	Expansion Joints	\$217,175	\$0.14
Divison 06	Wood, Plastics, and Composites	\$1,590,627	\$1.06
	Carpentry	\$745,609	\$0.50
	Millwork	\$845,018	\$0.56
Division 07	Thermal and Moisture Protection	\$6,757,989	\$4.51
	Hot Fluid Applied Waterproofing	\$770,800	\$0.51
	Cementitious Waterproofing	\$70,000	\$0.05
	Crystalline Waterproofing	\$11,977	\$0.01
	Traffic Coatings	\$180,149	\$0.12
	Metal Wall Panels & Louvers	\$2,783,500	\$1.86
	Roofing, Hot Fl. & Membrane	\$2,234,937	\$1.49
	Applied Fireproofing	\$499,455	\$0.33
	Joint Sealants	\$207,171	\$0.14
Division 08	Openings	\$47,918,829	\$31.95
	Doors, Frames, Hardware	\$630,787	\$0.42
	Coiling Doors	\$80,767	\$0.05
	Exterior Curtain wall	\$46,697,203	\$31.13
	Interior Glass & Glazing	\$510,072	\$0.34
Division 09	Finishes	\$6,350,845	\$4.23
	Drywall	\$4,412,130	\$2.94
	Ceramic Tile	\$528,320	\$0.35
	Carpet and Resilient	\$136,469	\$0.09
	Painting	\$1,273,926	\$0.85
Division 10	Specialties	\$551,329	\$0.37
	Toilet Compartments	\$156,930	\$0.10
	Louvers & Vents	\$93,701	\$0.06
	Exterior & Interior Signage	\$156,023	\$0.10
	Fire Protection Specialties	\$31,675	\$0.02
	Toilet Accessories	\$113,000	\$0.08
Division 11	Equipment	\$212,682	\$0.14
	Window Washing Systems	\$212,682	\$0.14
Division 12	Furnishings	\$519,489	\$0.35
	Foot Grilles	\$160,107	\$0.11
	Horiz. Louver Blinds	\$359,382	\$0.24
Division 13	Special Construction	\$446,862	\$0.30
	Waterfeatures / Fountains	\$446,862	\$0.30
Division 14	Conveying Equipment	\$8,862,503	\$5.91
	Elevators	\$8,862,503	\$5.91
Division 15	Mechanical	\$52,523,331	\$35.02
	HVAC / Plumbing	\$49,517,031	\$33.01
	Sprinkler	\$3,006,300	\$2.00
Division 16	Electrical	\$24,725,667	\$16.48
	Electrical	\$24,725,667	\$16.48

ANALYSIS 1: CHILLED BEAM SYSTEM

Critical Issue Research Method and Mechanical Breadth

Background

The first analysis deals with the chilled beam system being installed. This is the largest system being installed in the United States and provides an area to gain knowledge to a system that may become widely used in future buildings. This analysis also provides an area for a critical industry research and a mechanical breadth. Both of these topics will deal with the commissioning requirements for Constitution Center.

Problem/Opportunity Statement

The chilled beam system being installed in Constitution Center started as a construction management issue due to the size of the plenum space. This system was then redesigned in order to fit into the space and utilize a system that is widely used in Europe. The chilled beams provide an opportunity for research in a field that is increasing in the United States. This research will allow for increased knowledge of the system, along with an understanding on why the project team decided upon the system. The chilled beam system also allows for the evaluation of how the system affects cost, schedule, and site logistics. Finally, this system presents a construction management issue that can be incorporated into a mechanical breadth.

Mechanical Breadth

While analyzing the chilled beam system, the chance to evaluate the commissioning requirements for the mechanical systems will provide an opportunity for a mechanical breadth as well as a critical industry issue. With a project the size of Constitution Center, the commissioning requirements are very detailed. After evaluating the requirements, if necessary an updated or new system of tracking the commissioning will be proposed.

Research Steps

1. Travel to Atlanta, Georgia to TROX USA, Inc. in order to see firsthand how the chilled beam systems, both passive and active, work. The CEO & President has activities planned to provide me with an understanding of how the system works in order to continue my research.
2. Evaluate publications on the chilled beams.
3. Interview the DAVIS project team in order to see how the schedule, cost, and site logistics were affected by the chilled beam systems.
4. Interview SmithGroup to find out why they chose the chilled beam system and if the design of the building has changed because of their use.
5. Interview Pierce Associates to determine how they have familiarized themselves with the system in order to properly install it.
6. Research the typical costs of an HVAC system that would be installed in a building similar to Constitution Center and compare the costs.
7. Interview DAVIS for commissioning requirements
8. Research current commissioning systems
9. Send out interview/survey questions to industry members
10. Compile interview/survey questions and analyze
11. Finalize Chilled Beam Research

Interview/Survey Questions

1. How many employees does your company employ?
2. What market(s) does your company typically work in?
3. Does your company utilize commissioning?
4. Does your company have full time staff that completes commissioning?
5. Does your company use a specific program for commissioning?
 - a. If so, what program(s)?
6. What is one suggestion to make commissioning easier?

Expected Outcome

The expected outcome of this research is to become familiar with the chilled beam system. Also, the goal is to understand why the system was chosen to be utilized at Constitution Center. Finally, the impacts that the system will have on the cost, schedule, and site logistics will be outlined.

Analysis

Traveling to Atlanta Georgia, to the TROX Technik Inc. factory, provided the opportunity to increase the knowledge of the chilled beams air handling system. Heinrich Trox founded the TROX Company in 1951. Since then, the company has grown to over 2,700 employees worldwide and 12 production plants in 10 countries. The company has completed work in numerous types of buildings, such as:

- Office Buildings
- Hotels
- Concert and Theatre Halls
- Shopping Centers
- Recreation Centers
- Hospitals
- Exhibition and Congress Halls
- Sports Facilities
- Universities
- Airports
- Train Stations
- Tunnels
- Ships
- Laboratories
- Clean Rooms
- Data Centers
- Automotive Sites
- Oil Production
- Food Processing Industry
- Power Stations
- Chemical and Pharmaceutical Industry

Through their research and development, TROX was able to create chilled beams. These beams are not actually beams, however they are "finned chilled water heat exchanger cooling coils. These coils are capable of providing 200 to 900 BTUH of sensible cooling per foot of length and are designed to take advantage of the significantly higher cooling efficiencies of water."³ Figure 8 shows the comparison of a typical air duct size to a water pipe used in chilled beams. As one can see, this will provide much more free space to work with if a water pipe was used instead of an air duct. "(Chris) Lawrence says the system can use a 1-inch-diameter water pipe to transport the same cooling energy as an 18-square-inch air duct."⁴

³ (TROX Technik)

⁴ (Washington Contractor)

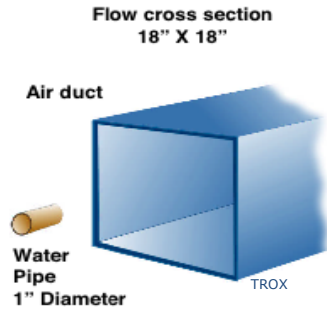


Figure 8: Comparison of Air Duct to Water Pipe

Through their work in a variety of buildings, TROX was able to create two specific types of chilled beams. The first is a passive chilled beam. Passive chilled beams do not use fans or other components, instead they re-circulate air. Figure 9 represents how the passive beam functions. Here one can see that the warm air naturally rises into the plenum space, causing it to flow through the coils. As it does, the heat is removed, causing it to fall back into the space since cool air is less buoyant than warm air.

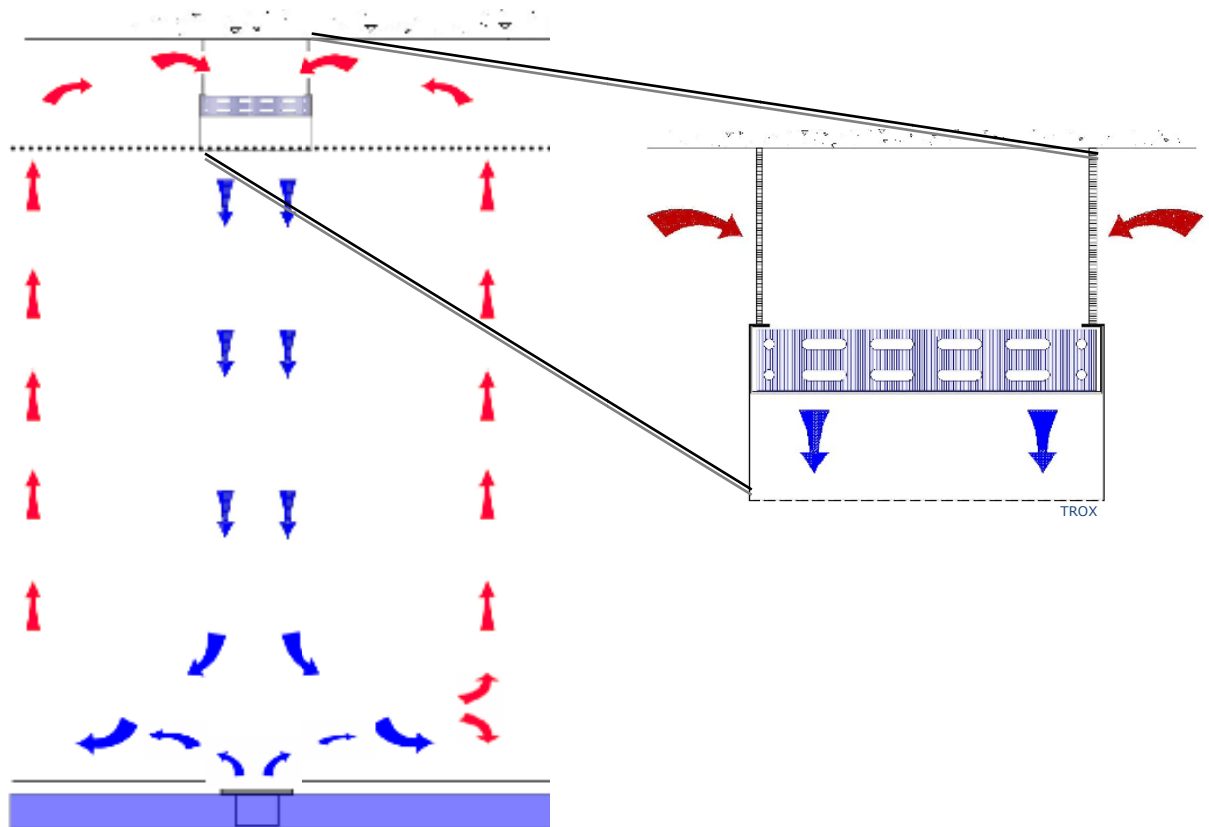


Figure 9: Representation of Passive Chilled Beams

The second type of chilled beams that TROX manufactures is called the active chilled beam. These beams are similar to the passive; however, they utilize a ducted air supply. This supply air is pretreated from a central air-handling unit and typically is injected through

nozzles inside the beams. As one can see from Figure 10, the nozzles supply the air, which then circulates throughout the space. After it heats up, just like the passive beams, the hot air raises and passes through the coils to be cooled and sent back into the space. "Because the active introduction of ventilation air magnifies the natural induction effect, active chilled beams are also commonly referred to as induction diffusers. This induction effect gives active chilled beams much higher cooling or heating capacities than pass chilled beams."⁵

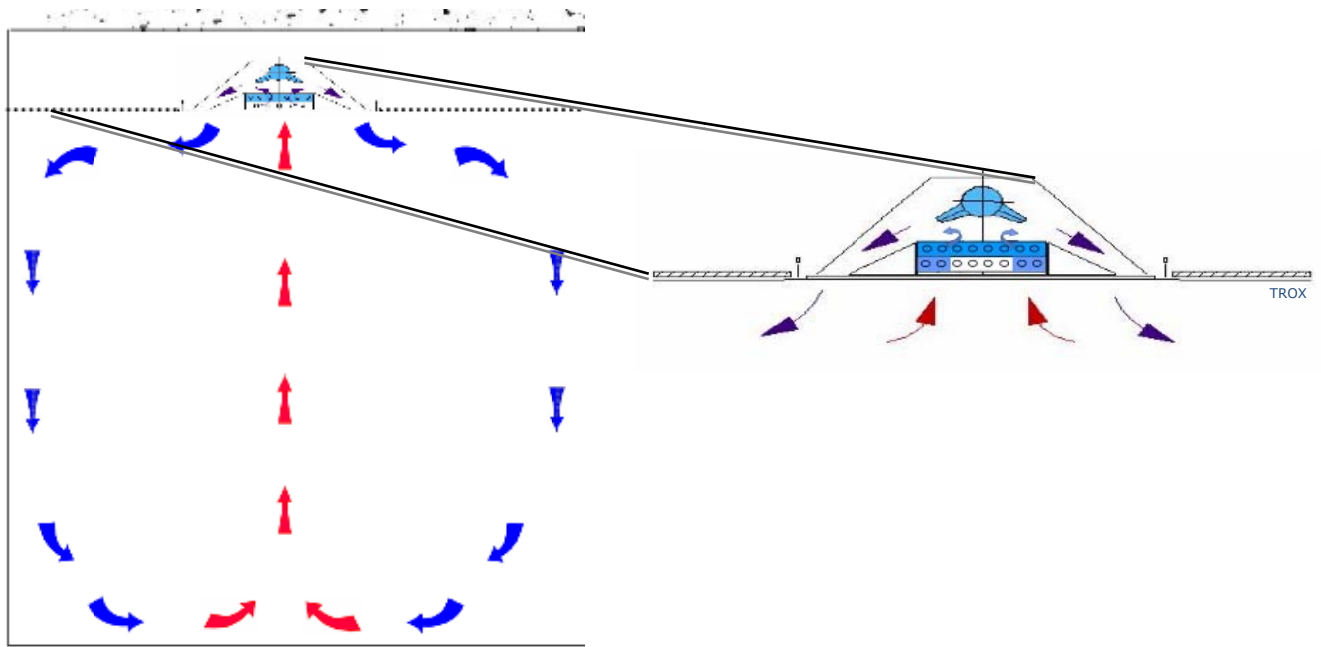


Figure 10: Representation of Active Chilled Beams

Similar to both passive and active chilled beams, TROX has incorporated building features in an integrated system known as multi-service chilled beams. These beams have numerous services built into them at the factory in order to arrive at the site in a "just-in-time" fashion. Figure 11 illustrates some of the services that can be included in the system including:

- Lighting fixtures and control circuits
 - Direct and/or indirect
- Public address speakers
- Occupancy sensors
- Fire and smoke sensors and alarms
- Passive infra-red detectors
- Acoustic insulation
- Sprinklers
- Fresh air supply
- Cooling and heating

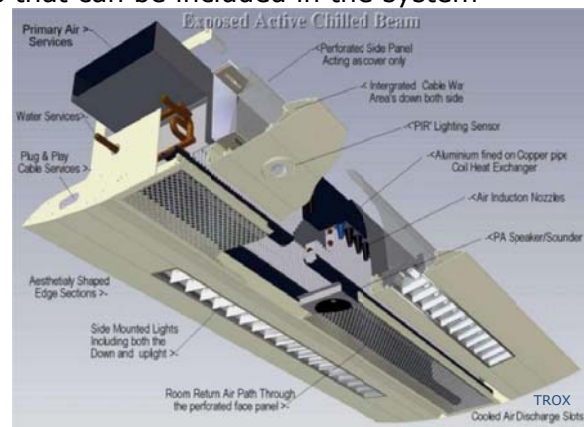


Figure 11: Diagram showing some of the services of a Multi Service Chilled Beam

One special feature about these beams is that the exterior frames can be customized in order to meet the owners' desires. Additionally, the services can be customized in order to meet the requirements that are in the design specifications. After these features are installed at the factory, the final steps are to ship them to the site, mount them, and connect all of the systems.

⁵ (TROX Technik)

Since the services are factory installed, testing can be completed prior to the arrival on the site. Additionally, the coordination between trades can be reduced onsite since most of the services will be installed. Also, the units provide a common system for all the services and allow for easy maintenance and commissioning. Since the architects and engineers will be needed to decide the appropriate services, coordination will be established early in the design process. Figure 12 illustrates some of the multi-service chilled beams that have been implemented into numerous buildings.

Throughout research of the multi-service beams used in the United Kingdom, it was determined that "building construction time has been reduced by 25 to 30 percent."⁶ Also, it is documented that "construction schedule reductions of ten to fifteen percent result in significant cost savings."⁷ These savings have been found in the communication and utility services, sanitation services, equipment rentals, and insurance costs.



Figure 12: Examples of Multi-Service Chilled Beams

After the visit to TROX, Inc., further research was conducted. DAVIS, SmithGroup, and TROX provided publications that featured chilled beams. One outlined the advantages of having chilled beams installed in the building, the advantages are the following:

Advantages
Shorter construction periods
Reduced ceiling void heights
Easier installation (plug and play)
Quicker amortization of investments
Clear reduction of interfaces
Less maintenance and operating costs
Energy savings
More flexible refurbishment
Intelligent control through the connection to building BMS
Lower wiring costs
Higher operational security
Maximum flexibility of configuration and technology

Table 5: Advantages of using Trox air handling systems.⁸

⁶ (TROX Technik)

⁷ (TROX Technik)

⁸ (TROX Technik)

After becoming familiar with what chilled beams were, David Varner from SmithGroup was interviewed in order to determine why they chose to use the new system in Constitution Center. The primary reason was because of the limited ceiling plenum. As one can see from Figure 13, they wanted to achieve an 8'-4" ceiling height, which would only give them 2'-0" to work with, which included the 1'-0" waffle slab. TROX worked with SmithGroup in order to customize the chilled beams to only be 7.5" high and 2' wide by 8' long. With this customization, they were able to give the owner's exactly what they were looking to be "consistent with what our commercial office market in downtown Washington prefers for Class-A space."⁹

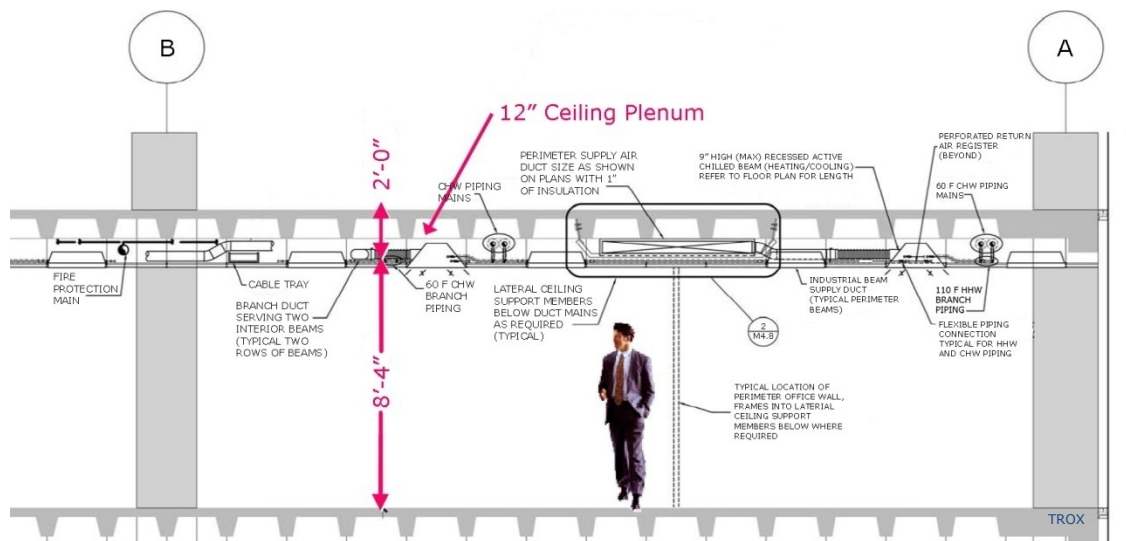


Figure 13: Diagram showing how the plenum space is utilized.

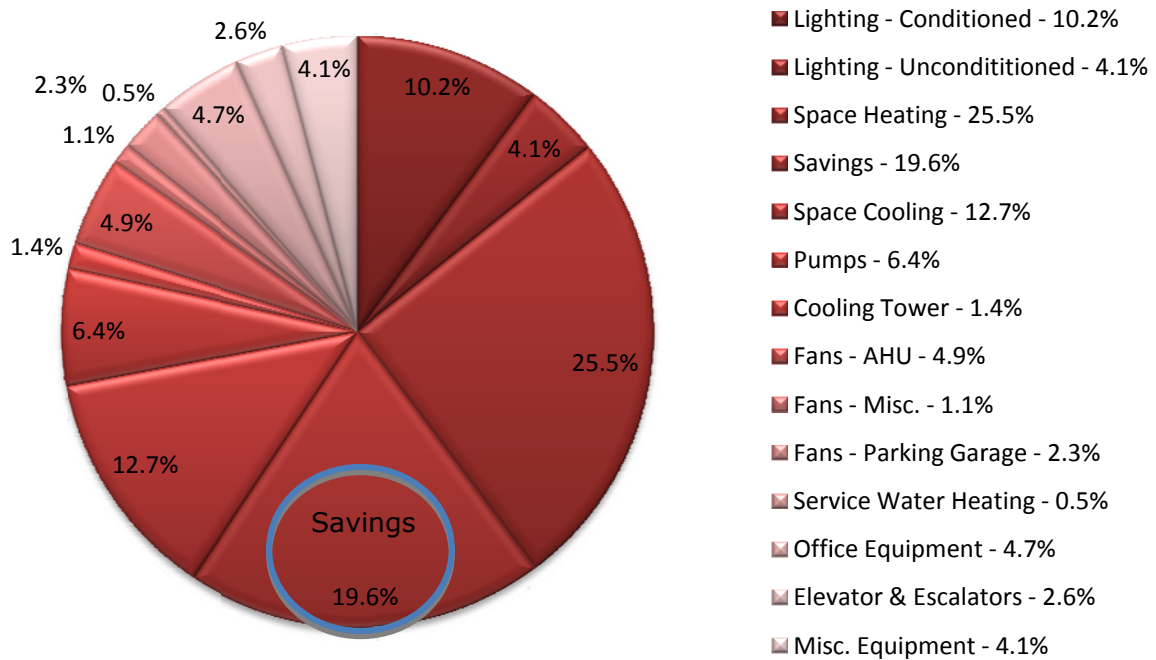
Another reason why SmithGroup chose to utilize chilled beams is because they "had the least impact to the usable office space on typical office floors."¹⁰ Since the beams reduce the size of the ductwork, they are able to provide more area for the tenants in case they need to change the formation of their office space. Additionally, until they find a tenant, the chilled beams will not be installed in order to make sure they meet the tenants' needs.

Although there is a higher initial cost, the lower operating costs quickly offset them. While completing the design for Constitution Center, SmithGroup completed research on the energy usage of the building. This research was to show how much of a saving there would be if the chilled beam system was implemented into the building. As one can see from the graph below, there is a saving of 19.6% on energy usage.

⁹ (Varner)

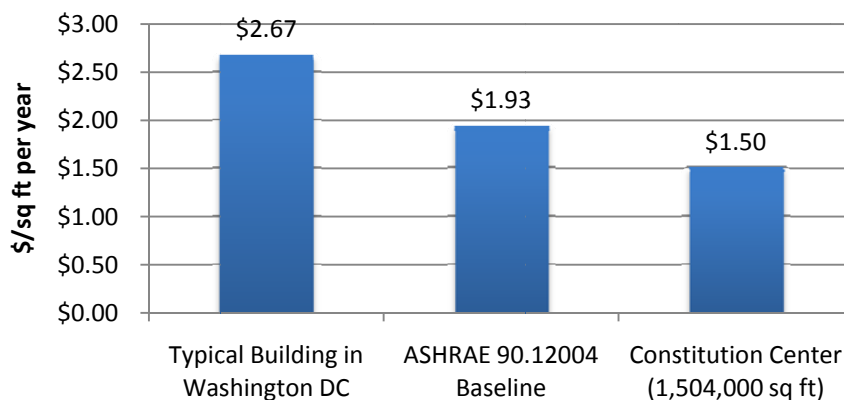
¹⁰ (Varner)

Constitution Center Energy Usage (according to SmithGroup's Research)



SmithGroup also did a comparison on the Energy Cost. The graph below shows how the cost per square foot per year would be \$0.49 lower than the ASHREA standard and \$1.17 cheaper than a standard Washington, DC office building because of the installation of the chilled beams.

Energy Cost Comparison (according to SmithGroup's Research)



The fact that chilled beams are attractive and do not detract from the appearance is another reason for their installation into Constitution Center. These beams were designed to fit into the drywall ceiling; therefore will more than likely not stand out and be noticeable. Figure 14 shows the numerous configurations that chilled beams can come in.

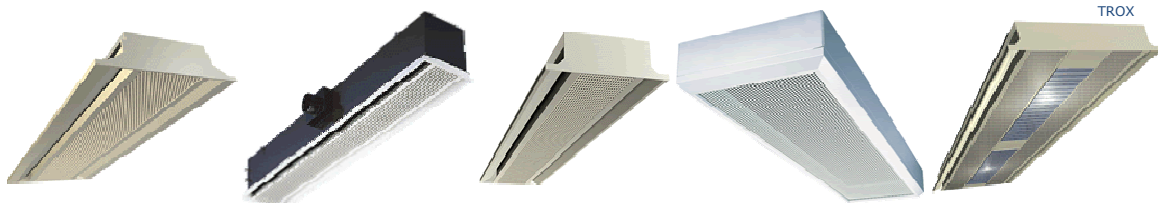


Figure 14: Examples of chilled beams

A concern of the ownership was that the finished office space “not be unduly compromised by innovative technology.”¹¹ Working with TROX, they were able to design a product of high quality and that blends very well with the ceiling. Figure 15 is a rendering from SmithGroup that shows how the chilled beams will be incorporated into the ceiling grid and will not stand out very much. Another benefit of chilled beams was their superior acoustical performance. The reason for this performance is because they are not fan-powered making them very quiet. The “ownership believed that this might be one factor in attracting a major tenant to the building.”¹²



Figure 15: Rendering showing how the chilled beams will be incorporated into the ceiling grid.

¹¹ (Varner)

¹² (Varner)

Although the chilled beams will not be installed into Constitution Center until a tenant is established, Pierce has familiarized themselves with them. Pierce Associates is the mechanical contractor on Constitution Center. During the bidding process, they initially familiarized themselves through information provided by both SmithGroup and DAVIS. They also used “the three beams referenced in the contract drawings as leaping off points to contact various manufacturer representatives on their beams and pricing...”¹³ As they compared pricing, they learned the differences between them and were able to supply this information to the design team. Since the ownership wanted to use the chilled beams, Pierce was invited into the design discussion, which allowed them to have “a comprehensive understanding of the beams and their variety of capacities.”¹⁴ With this knowledge they have had the opportunity to pursue future work using the chilled beam technology. Additionally, they were able “to build an in-shop chilled beam mock-up to promote the product, and they have developed in-house information packets to assist in educating other members of the industry in acclimating to the beams emergence in our market.”¹⁵

Specifically, Pierce used the following steps to familiarize themselves with the chilled beam technology:¹⁶

1. Worked with vendors to introduce ourselves to the products and to review sample beams
2. Met with Ownership and designers to assist in desired customization
3. Provided pricing from multiple vendors with differences clearly delineated
4. Attended Chilled Beam Symposium offered by Trox and Nassif
5. Finalized customized beam order and requested samples for inspection
6. Traveled to England to inspect Trox’s production and storage activities

Along with the installation of the chilled beams, the mechanical system commissioning plays a large part in the construction. Commissioning is also a critical industry issue since most companies are now incorporating it into the construction process. According to ASHRAE, commissioning is “a quality-oriented process for achieving, verifying, and documenting that the performance of facilities, systems, and assemblies meets defined objectives and criteria.”¹⁷ There are several benefits in utilizing commissioning. First, the facility is both safe and helpful. Also, it optimizes energy use and the operating costs are reduced. Additionally, it ensures the operation and maintenance staff has proper orientation and training. Finally, commissioning is said to improve the documentation of the installed building systems.

Since Constitution Center is striving for a LEED Gold rating, it is required to have Fundamental Commissioning of the Building Energy Systems for the Energy & Atmosphere LEED points. In order to achieve this point, the project team must:

1. Designate an individual as the Commissioning Authority (CxA) to lead, review and oversee the completion of the commissioning process activities.
 - a. The CxA shall have documented commissioning authority experience in at least two building projects.
 - b. The individual serving as the CxA shall be independent of the project’s design and construction



Figure 16: LEED Gold Award

¹³ (Donaghy)

¹⁴ (Donaghy)

¹⁵ (Donaghy)

¹⁶ (Donaghy)

¹⁷ (WBDG Project Management Committee)

- management, though they may be employees of the firms providing those services. The CxA may be a qualified employee or consultant of the Owner.
- c. The CxA shall report results, findings and recommendations directly to the Owner.
 2. The Owner shall document the Owner's Project Requirements (OPR). The design team shall develop the Basis of Design (BOD). The CxA shall review these documents for clarity and completeness. The Owner and design team shall be responsible for updates to their respective documents.
 3. Develop and incorporate commissioning requirements into the construction documents.
 4. Develop and implement a commissioning plan.
 5. Verify the installation and performance of the systems to be commissioned.
 6. Complete a summary commissioning report.

In order to meet these requirements, DAVIS has divided Constitution Center into four phases for the commissioning:

- Phase 1 - Hot Water System
- Phase 2- CHW/CW & North AHU system
- Phase 3 - SW AHU System, Fuel Oil System, Emergency Power System, and Power Monitoring System
- Phase 4- SE AHU System, FA System, BMS System, and conclude with Endurance Period

Although the chilled beams are not being installed until a tenant is selected, research was conducted on what needs to occur for the commissioning process. First, the pipe work needs to be cleared of all the air that may be trapped in the water circuit. This can be done by pushing water through the system, using vents that are located on the header of the coils inside the beams. After this is complete, measuring and balancing valves will be adjusted in order for the chilled water flow rate to be at the designed valve. Another way to test the system is by checking the airflow rate by measuring the static pressure of the pressurized entry plenum. After this, it needs to be compared with calibration charts provided by the manufacturer. The final step is to connect a measuring gauge to the integral pressure tap in order to get a final reading.

While the commissioning of the chilled beams is fairly straight forward, other parts of the building systems will take more time. For Constitution Center, there are numerous steps that must be followed before each system is signed off. First, a factory representative performs equipment start-ups. Then they "continue with Testing & Balancing of the water, and air sides, then the controls subcontractor will put the system under control and check the sequence of operation for the equipment in the system"¹⁸ Once these steps are finished, functional testing is completed by the commissioning agent, Facility Dynamics. During this testing, they verify that the equipment is operating properly and complete several other tests. Additionally, the review all of the completed paperwork is preformed to ensure that everything was documented properly. After this, if all of the equipment passes the test, then the system is signed off.

After the systems are signed off, the final functional testing is preformed. For this testing, the building management system controls the entire building. This testing typically takes about two weeks to test, once this is completed and it is approved, the final step can occur. The final phase is called the endurance period. The ownership has 30 days to operate the

¹⁸ (Santos)

equipment and verify that it operates properly. Once this is proved to be successful, the commissioning of the building is complete.

In order to aid in the commissioning process, DAVIS uses a computer portal called ComIT. This program is used to "track deficiency items, post information such as schedules, submittals, and start-up forms."¹⁹ Additionally, all of the functional tests are documented on the portal.

Although the survey that was sent to industry members did not have very many people complete it, several things were learned from performing the research. The first is that all of the companies utilize commissioning on their projects. Additionally, that only half of them have full time staff that completes the commissioning. When asked what specific programs are used for commissioning the only response was that they used formats from the Building Commissioning Association. In order to make commissioning easier, two topics were discussed. First, "identify the commissioning needs and program requirements early in the design stage so all team members can understand and set their strategies to meet the project goals." Additionally, "Make sure all parties know what is required for commissioning as soon in the project as possible (Communications is key)."

Outcome

After completing the research on chilled beams, it is recommended that a multi-service chilled beam be used in Constitution Center. The reason for this recommendation is because it has been proven that both the construction costs and schedules can be reduced with the additional of multi-service chilled beams.

Additionally, it was learned that if there is a full time staff member on site assisting with commissioning it is easier to stay organized in order to meet the requirements. Also, it reiterated that communication is the key to having commissioning successfully be completed.

¹⁹ (Santos)

ANALYSIS 2: STRUCTURAL INTEGRITY OF THE PARKING GARAGE WAFFLE SLABS

Structural Breadth

Problem/Opportunity Statement

The structural integrity of the parking garage waffle slabs was a construction management topic that incorporates a structural breadth. There were areas of the parking garage that had to be supported, the selection torn out, and a new area poured. Because of these areas, quadrants of the three level parking garage were closed for months at a time. These closures provided less construction parking and less onsite storage.

Structural Breadth

Analysis of the structural system will be conducted in order to determine the renovation requirements of the waffle slab. If necessary, an updated or new system will be proposed. There are two options for a redesign: a two-way reinforced concrete system or a flat plate, drop panel with column capitals. Both of these redesigns will have to have a detailed analysis on loads, cost, and schedule and will provide a structural breadth to be applied to the construction management issue.

Potential Solution(s)

A potential solution is to determine if there are other ways to renovate the slab without hindering the use of the quadrant for both construction parking and material storage.

Research Steps

1. Research how the waffle slabs were renovated.
2. Determine what qualified a section to be renovated.
3. Interview DAVIS project team in order to determine the schedule requirements of the renovation of the waffle slabs.
4. Interview the subcontractor in order to determine the steps necessary for the renovation.
5. Research other means of fixing the waffle slabs.
6. Determine if there are schedule acceleration options available and used on other sites.

Expected Outcome

By conducting this research, the outcome that I expect to find is if there are other ways to renovate the waffle slab, without taking away the structural integrity.

Analysis

Throughout the three levels of the parking garage, there were sections that needed to be updated structural in order to insure they would not only hold the weight of the parking garage, but also support the floors above, including the additional of a Pent House level. In order to determine if a section needed to be updated, there were several tests that were preformed. First, a few occasions were recommendations of the engineers, even when the concrete looked sound. One type of test that was completed was using "sounding" to test every area of the garage to see if it was sound. This test consisted of listening to the tones of the reverberations caused by dragging heavy chains over the concrete. To know if an "area (contained) bad concrete, the sound became hollow."²⁰ The second type of test that was performed was using a hammer or pole to check the overhead parts of the waffle slab. This test produced the same hollow sounds if a section contained bad concrete. Additionally, manual inspection was complete in order to replace exposed and/or corroded rebar, along with visual spalled sections. Figure 17 provides an example of a spalled section.



Figure 17: Section of the waffle slab that was contained spalling concrete with rebar exposure.

After a section was identified by the engineer as an area that was in need of repair, they marked the section with spray paint in order to easily recognize the areas that were not sound. Then the subcontractor, Concrete Restoration Services (CRS) began to chip away at the concrete with a jackhammer. The size of the jackhammer depended on the section; however it was typically a nine to 15 pound device. They continue to chip away at the section until one of the following occurred: 1. Reached sound concrete, which is difficult to chip 2. Corroded rebar was fully exposed 3. Clean non-deteriorated rebar was found. After this, the next step was to either clean the rebar or remove it completely. To clean the rebar, the subcontractor used sand blasting, grind wheel, or a wire brush, depending on the severity of the damage. After cleaning it, the rebar would then be coated with a corrosion inhibitor. If rebar was found with more than 20% loss of section, then it would have to be removed and replaced. New rebar would be installed that is epoxy coated. Shortly after, the subcontractor forms one side of the section and has the engineer inspect the work. After approval, 5,000psi concrete was poured back into place. The shoring which was used to hold the formwork "in place until the concrete test cylinders broke at 100% of the design strength."²¹



Figure 18: Photo showing the poly-wall used in the parking garage

While all of the above steps were taking place, the area of the parking garage that they were repairing would be completely sectioned off. This meant that no other construction could take place in the area. Poly-walls (Figure 18) were used to contain the dust created in this area and prevent people from walking on a weakened section. The areas were also sectioned off due to the risk of falling debris, open holes, dust, and sound controlled. A safety requirement for the CRS employees is that respirators were required and that the shoring had to remain in place until the concrete was at 100% strength.

²⁰ (Lefler)

²¹ (Lefler)

The schedule requirements for the concrete repairs of the waffle slabs depended on the overall condition of the concrete. Typically one quadrant, which included all three levels, was sectioned off for a period of time. DAVIS predicts that about "150,000sqft of garage was repaired every 4 months."²² Below, Table 6 outlines the estimated schedule of the repairs. It is estimated that about 35-45% of the concrete was completely replaced.

Quadrant	Time Frame
Northeast	November 2007 – February 2008
Southeast	February 2008 – May 2008
Southwest	May 2008 – August 2008
Northwest	August 2008 – November 2008

Table 6: Schedule of waffle slab repairs

When a section was being repaired, it took away numerous things that the area could be used for. One particular thing was for storage used by several different subcontractors. Additionally, the parking garage was used for construction parking; therefore the entire level could not be used for parking. Additionally, the columns of the garage were being wrapped in steel jackets, which would have to be schedule around both the waffle slab repairs and the parking sequences. The addition of another elevator in all the quadrants had to also be scheduled around the repairs. The existing elevator concrete walls were to be hardened; therefore this was something else that played a part in the scheduling of the repairs. Overall, the schedule of the repairs interfered with numerous construction related activities, therefore it had to be planned to have the least impact on the construction progress.

Direct Design for a Two Way Reinforced Concrete System

It was determined that the parking garage waffle slab could also be repaired by replacing it with a two-way reinforced concrete system. An analysis of the system was performed in order to verify if both the cost and the schedule requirements would be better for the overall construction of Constitution Center.

First the parking garage was broken up into 4 sections. The four sections are Frame A, Frame B, Frame C, and Frame D. Frames A and C are interior frames, which Frames B and D are end frames. Please see Figure 19 for a visual representation of the areas that the frames cover. After determining the frames, we know that each of the bays are 30' by 30' and the columns are 26" by 26". The other given information can be found in Appendix F. After all the given information was determined, the values were imported into an excel spreadsheet made to calculate the number of rebar needed for each frame. These spreadsheets can also be found in Appendix F. Table 7 is a summary of the tables, which shows how many pieces of #8 rebar are needed.

Design Reinforcement for CS		Design Reinforcement for MS	
Frame A	11	Frame A	8
Frame B	5	Frame B	5
Frame C	14	Frame C	8
Frame D	5	Frame D	5

Table 7: Summary of the number of pieces of rebar needed for each frame type

²² (Lefler)

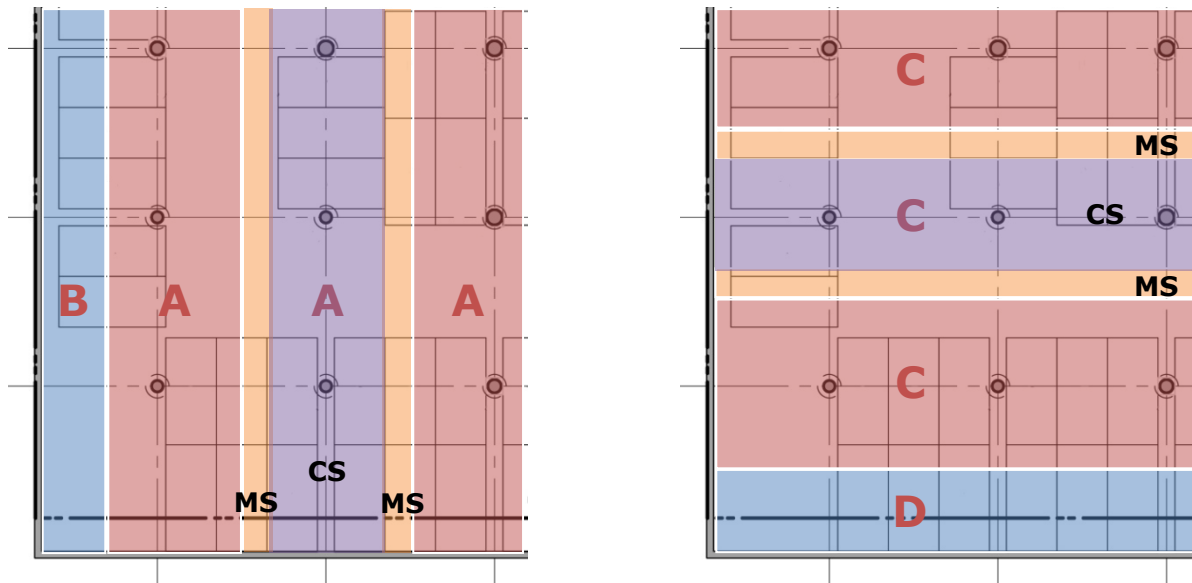


Figure 19: Diagram showing the frames used for the calculations

The footprint of each level of Constitution Center’s parking garage is 202,500sqft and the slab is 12 inches thick. Therefore 202,500 cubic feet of concrete or 7,500 cubic yards is needed for each level. The total amount of concrete needed is 22,500 cubic yards. Using #8 rebar (which is assumed to come in 30’ sections), Table 19 shows how many pieces of rebar are needed for each section. Since there are two Frame B and two Frame D, there will need to be a total of 20 rebar per bay (300 #8 rebar). For Frame A, 19 pieces are needed per bay (285 #8 rebar) and for Frame C, 22 pieces are needed per bay (330 #8 rebar). Therefore for each level, there needs to be 915 pieces of #8 rebar, for a total of 2,745 #8 rebar (915 are Slab on Grade).

Below, Table 8 outlines the cost of the Two Way Reinforced Concrete System. As one can see the total cost of this system redesign is slightly over \$3.5 million. From Table 4, the concrete repairs and traffic coating costs \$4,403,032. This total is higher, however it contains traffic coating for all three levels of the parking garage, therefore the two-way reinforced concrete system is more expensive than the basic repairs CRS performed. Additionally, the two-way reinforced concrete system is replacing all of the existing concrete and does not include the demolition cost which would make this system even more expensive.

	Quantity	Unit	Extended Total	Extended Total O & P
Structural Concrete, Ready Mix, Normal Weight, 4,000psi	22,500	CY	\$1,040,875	\$3,356,500
Reinforcing steel, in place, elevated slab, #8	74	Ton	\$107,418.4	\$136,207.36
Reinforcing steel, in place, Slab on Grade, #8	37	Ton	\$54,063.29	\$70,008.44
Total			\$3,202,356.69	\$3,562,765.80

Table 8: Cost of Two-Way Reinforced Concrete System

Table 9 gives a brief overview of the schedule requirements for the two-way reinforced concrete system. As one can see it is roughly 171 days, which is about 9 months of work. However, the calculations below do not take in account that multiple levels can be worked on at the same time. Also, it does not factor in the schedule for demolition. If it did, it would for sure take longer than the one year that is scheduled for the repairs that CRS is currently performing.

	Quantity	Unit	Daily Output	Total (Days)
Structural Concrete, Ready Mix, Normal Weight, 4,000psi, elevated slab, pumped	15,000	CY	180	84
Structural Concrete, Ready Mix, Normal Weight, 4,000psi, slab on grade, pumped	7,500	CY	185	41
Reinforcing steel, in place, elevated slab, #8	74	Ton	2.30	33
Reinforcing steel, in place, Slab on Grade, #8	37	Ton	2.90	13
Total				171

Table 9: Schedule of Two-Way Reinforced Concrete System

Outcome

After performing this analysis, it was determined that the current way that CRS is repairing the parking garage waffle slab is the most efficient. The cost would be much more to do the proposed two-way reinforced concrete system because they would have to do demolition work on the entire garage, not just sections with bad concrete and rebar. Additionally, the cost would increase due to formwork needed to properly place the concrete. Although the schedule mentioned above has the work being completed before the repairs that are currently taking place, the schedule does not take into account the demolition. Overall, it is suggested that the renovations of the parking garage waffle slab be performed the same way as planned.

ANALYSIS 3: CURTAIN WALL INSTALLATION PROCEDURES

MAE Graduate-Level Component

Problem/Opportunity Statement

The curtain wall of Constitution Center is another construction management issue that will provide an area for research. The installation of the façade played a major role in how the exterior site work was phased and researching the installation will allow the productivity to be tracked.

MAE Graduate-Level Component

With this research, *CE 533 – Construction Productivity Analysis and Performance Evaluation* graduate class will be incorporated into the thesis research. Within this class, productivity measurements, control, and forecasting were addressed, along with the factors affecting productivity and the methods for improving the productivity. All of these elements play an important role in the installation of the curtain wall.

Potential Solution(s)

A potential solution to the installation of the curtain wall is to use a prefabricated system instead of installing each piece separately. This may have potential schedule and cost saving impacts that affect the overall construction of Constitution Center.

Research Steps

1. Research the panel descriptions (dimensions, weight, etc.) and become familiar with the installation requirements.
2. Determine how the panels were shipped and how often.
3. Determine where the panels were stored and if there were any restrictions.
4. Determine if preparation was needed before the panels were installed.
5. Determine what type of equipment was needed to install the panels.
6. Interview the DAVIS project team to see if they kept a record of how many people worked on the installation each day and how many pieces were installed on that particular day
7. Determine if weather was a factor in the installation process.
8. Determine the Rules of Credit using R.S. Means
9. Using CE 533 information, calculate:
 1. Expected and Actual Productivity
 2. Expected Performance Factor
 3. Planned and Actual Manning
 4. Actual Percent Complete
 5. Control Budget
10. If any delays occurred, determine the factors for the delays.
11. Compare this data to the data collected from the CE 533 semester project of the Dickinson School of Law to determine if the installation procedure is productive.

Expected Outcome

The expected outcome of this research is to familiarize myself with the curtain wall installation procedures. After that I will be able to apply my knowledge learned in CE 533 to

determine the productivity of the installation. If it does not meet a satisfactory productivity I will determine other productive ways to install the curtain wall.

Note: Although an analysis of the actual curtain wall panels are not permitted due to security reasons, a study of the façade from a constructability perspective will take place and will not be affected by the security requirements.

Analysis

On the site of Constitution Center, there are nearly 5,000 curtain wall panels that need to be installed. The subcontractor that is responsible for their installation is Enclos Corp. This company is based out of Eagan, Minnesota and has completed over 145 custom curtain wall systems. Some examples include the Newseum and Federal Triangle based out of Washington, DC, Children's Hospital of Philadelphia, PA, and the Gannett/USA Today Headquarters in McLean, VA.

Constitution Center is another custom system that Enclos has been brought on to install. The overall cost of the exterior curtain wall is \$46,697,203 or \$31.13/SF. This price is 19% of the total cost of the building. Additionally, it was determined the each curtain wall panel is \$9,626/panel. The curtain wall panels are different sizes depending on their location on the building. Figure 20 represents a mock up of the streetside curtain wall. For example, the plaza level storefront panels are 5' by 12' to 13' weighing about 1,100 to 1,300 pounds. However, levels 2 to 7 are 5' by 23' and weigh 2,300 to 2,500 pounds. Finally, levels 8 to 10 are 5' by 10' and weigh only 500 to 600 pounds. Figure 22 shows the majority of the different curtain wall pieces that need to be installed. As one can see, for this particular section there are ten different types of curtain wall panels. Since the panels are different sizes and weighs, the manpower for them may vary. Additionally, the training to install each type is similar, but different depending on the equipment needed to do the setting of the panels. For the streetside curtain wall, a crane was used to set levels two through eight. However, the courtyard curtain wall was installed using a monorail. Figure 15 is a photograph of the Enclos crew using the monorail to install the curtain wall panel. As you can see from there picture, there are 3 people working on the installation, while another person is putting the finishing touches on the previous piece. One the other hand, the storefront panels "they have used multiple types of equipment pending the existing conditions found."²³

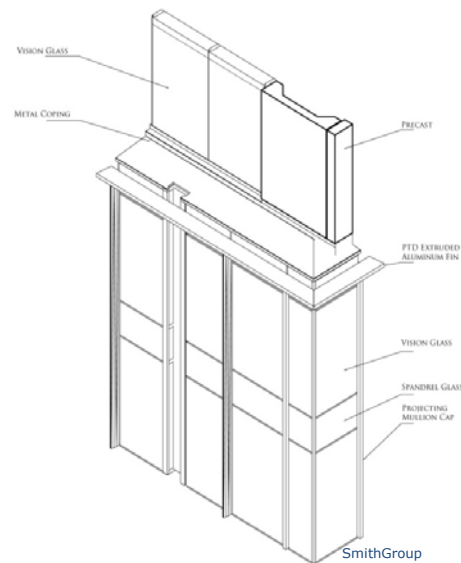


Figure 20: Streetside Laboratory Mock Up



Figure 21: Photograph showing the installation of a curtain wall panel

²³ (Ulrich)



- | | |
|--|--|
| <ol style="list-style-type: none"> 1. Precast Concrete Panels 2. Penthouse: Metal Panels & Louvers 3. Vision Glass – (30" of frit)
GL-3 (2nd and 3rd Floors)
GL-5 (4th Floor and up) 4. Spandrel Glass
GL-3S (2nd and 3rd Floors)
GL-5S (4th Floor and up) 5. Vertical Aluminum Mullion | <ol style="list-style-type: none"> 6. Vision Glass – (30" of frit)
GL-4 (2nd and 3rd Floors)
GL-6 (4th Floor and up) 7. Spandrel Glass
GL-4S (2nd and 3rd Floors)
GL-6S (4th Floor and up) 8. Metal Panel 9. Vision Glass – GL-2 10. Spandrel Glass – GL-2S (at Plaza Only) |
|--|--|

Figure 22: Street Facade Glazing Rendering

The installation of the panels started on March 21, 2008 on the north side of the building. The reason why they started with this is area is because the northeast quadrant will be the turned over first. Additionally, the L'Enfant metro station entrance was scheduled to be reopened on July 1, 2008 and there were safety concerns, therefore the north façade needed to be completely installed before its opening. Table 10 is a summary of the sequence for the curtain wall demolition and installation. As one can see, the curtain wall is scheduled to be completed at the end of April 2009.

Task	Duration	Start	Finish
Exterior Façade	366	10/1/2007	2/23/2009
North	328	10/1/2007	12/31/2008
Fabrications for Slab Extensions	32	10/1/2007	11/13/2007
Demo & Shoring 2nd Floor at Blast Beams	10	11/6/2007	11/19/2007
Slab Extensions	1	12/17/2007	12/17/2007
Encase Perimeter Columns at Blast Beams	1	12/5/2007	12/5/2007
F,R&P Blast Beams	1	1/18/2008	1/18/2008
Fab Anchors & Plates for Curtain wall	1	1/21/2008	1/21/2008
Install Anchors & Plates for Curtain wall	1	3/12/2008	3/12/2008
Erect Curtain wall	91	2/22/2008	6/27/2008
Erect Metal Panels	20	7/28/2008	8/22/2008
Erect Exterior Storefront	17	11/12/2008	12/4/2008
Erect Exterior Stone	17	12/9/2008	12/31/2008
East	311	10/1/2007	12/8/2008
West	266	1/22/2008	1/27/2009
South	272	2/8/2008	2/23/2009
NE Corner - Erect Precast	24	1/31/2008	3/4/2008
NW Corner - Erect Precast	21	4/23/2008	5/21/2008
SE Corner - Erect Precast	21	5/22/2008	6/19/2008
SW Corner - Erect Precast	21	6/20/2008	7/18/2008
Courtyard Façade	332	1/22/2008	4/29/2009
North	232	1/22/2008	12/10/2008
Fab Anchors & Plates for Ctyd Curtain wall	25	1/22/2008	2/25/2008
Install Anchors & Plates for Curtain wall	21	4/11/2008	5/9/2008
Erect Structural Steel & Deck	16	5/12/2008	6/2/2008
Erect Curtain wall	26	8/26/2008	9/30/2008
Erect Metal Panels	1	10/13/2008	10/13/2008
Erect Storefront	12	11/25/2008	12/10/2008
East	207	2/8/2008	11/24/2008
West	163	5/12/2008	12/24/2008
South	247	5/20/2008	4/29/2009

Table 10: Summary of the Façade Sequence

According to Enclos, the steps of the installation are as follows:²⁴

1. Boot span between frames at sill starter chicken head
2. Hook up lifting lug to picking bar
3. QC unit (check that gaskets are installed, gaskets are long enough, all access holes are sealed, ab clips are installed and not damaged)
4. Lift frame vertically and wait for top half of crew is ready for installation
5. Align frame male leg of set frame and female leg of frame being installed.
6. Snap female leg and male leg together
7. Make sure ab clips did not snap on the outside of the female leg
8. Slide frame over the two alignment bars (stab bars)
9. Shoot the frames height and engage the set screw to maintain the frame height.

These steps are important to the productivity of the installation. If one of the steps is not completed, then the entire setting has to be redone. Also, if the crew is not properly trained in how each panel needs to be installed then the productivity will decrease. Typically, the only preparation work needed was to unwrap the panels from the delivery. Table 11 gives a breakdown of how many people were on a typical crew size for the installation depending on its location and equipment needed to install the panels. A breakdown of how many people Enclos had onsite can be found in Table 12 and Appendix A. Depending on the day, there

²⁴ (Sullivan)

were usually an engineer, foreman, helper, mechanic, worker, project manager, and/or apprentice on the site for Enclos. Additionally, four more people were needed to unload the delivery of the panels. These people were separate from the crew setting the panels. The deliveries were arranged in advance in order to ensure the proper number of people were onsite to handle the installation and deliveries. For the units spanning two floors (streetside levels 2 – 8), typically a delivery consisted of 12 panels. However, for the single span units (courtyard), there are usually 18 to 24 panels on the trucks. After the panels were delivered, they were then stored on the proper floor in order to ensure a quick installation once the crew made it to that floor. One of the requirements for the storage was that they had to be in the center of the building, close to the columns so that the floor did not have any problems holding a large amount of additional weight.

Location	Level	Crew Size	Equipment
Streetside	2 – 8	6	Crane
Streetside	9 – 10	4	Crane
Courtyard	2 – 10	6*	Monorail
Storefront	1	4 – 6	Multiple Types

Table 11: Crew and Equipment Breakdown for the Exterior Curtain wall
 * 4 people used for the monorail installation, and two would follow behind for the sealants and/or boot

Total Crew Size

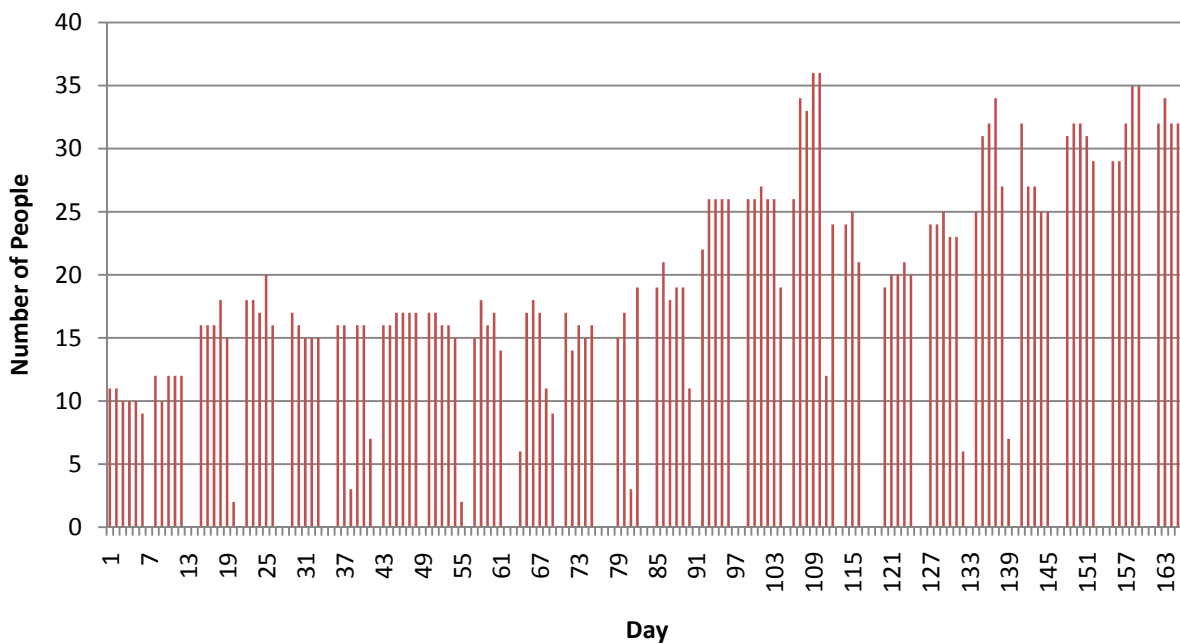


Table 12: The daily crew size for Enclos Corp.

A typical crew for the streetside curtain wall averaged between 20 to 30 panels per day. However, 35 to 40 panels for the courtyard could be installed a day. The reason for the setting difference is because the streetside panels spanned two floors, while the courtyard panels were only single spans. As one can see from Table 13, the installation of the panels varied depending on the location. Additionally, please note that there are numerous days where they did not install any panels. Most of these days are on weekends when they did not work. The only time they worked on weekends was if they fell behind schedule.

Installation

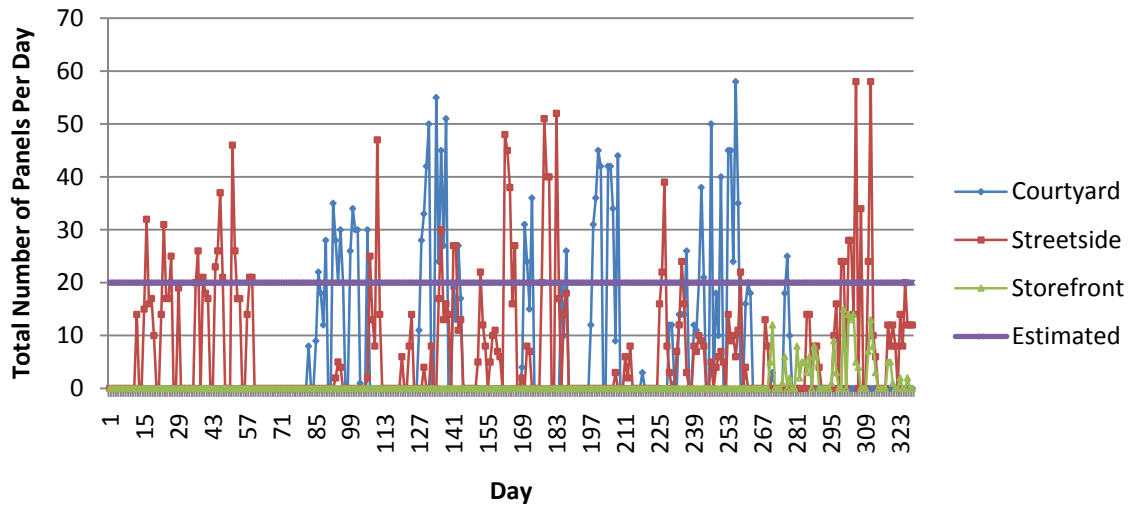


Table 13: Actual number of panels installed per day

Throughout *CE 533 – Construction Productivity Analysis and Performance Evaluation*, the steps of productivity were outlined in order to determine if a project had good productivity. The first step was to determine the Rules of Credit. However, since the curtain wall panels require little preparation, there is not a need to have Rules of Credit. The next step is to determine the expected and actual productivity of the installation. To do this, the total manpower was divided by the total number of panels. The numbers used for this calculation can be found in Appendix A, Appendix B, Appendix C, and Appendix D. Table 14 represents these calculations in a table format. As one can see, the estimated productivity is around 2.22 and the majority of the actual productivity is much lower than the estimated. Please note that from August of 2008 to March of 2009 the manpower was not provided.

Actual Productivity

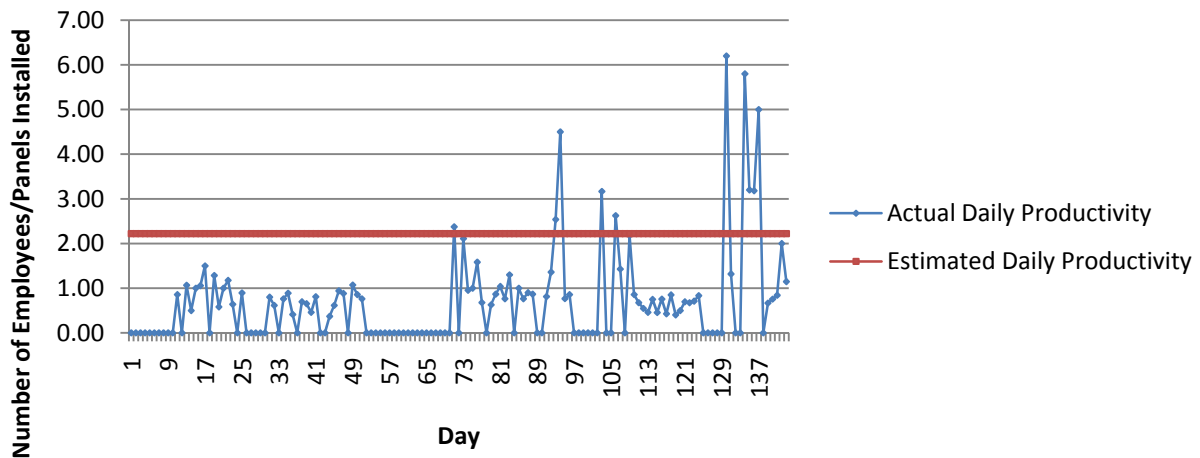


Table 14: Actual and Estimated Daily Productivity

After the productivity was calculated, the expected performance factors were established. In order to do this calculation, the estimated number of panels per day is divided by the actual number of panels per day. This information can be found in Appendix B, Appendix C, and Appendix D. Again, as one can see, the estimated performance is one and most of the actual performance is slightly above one.

Performance Factor

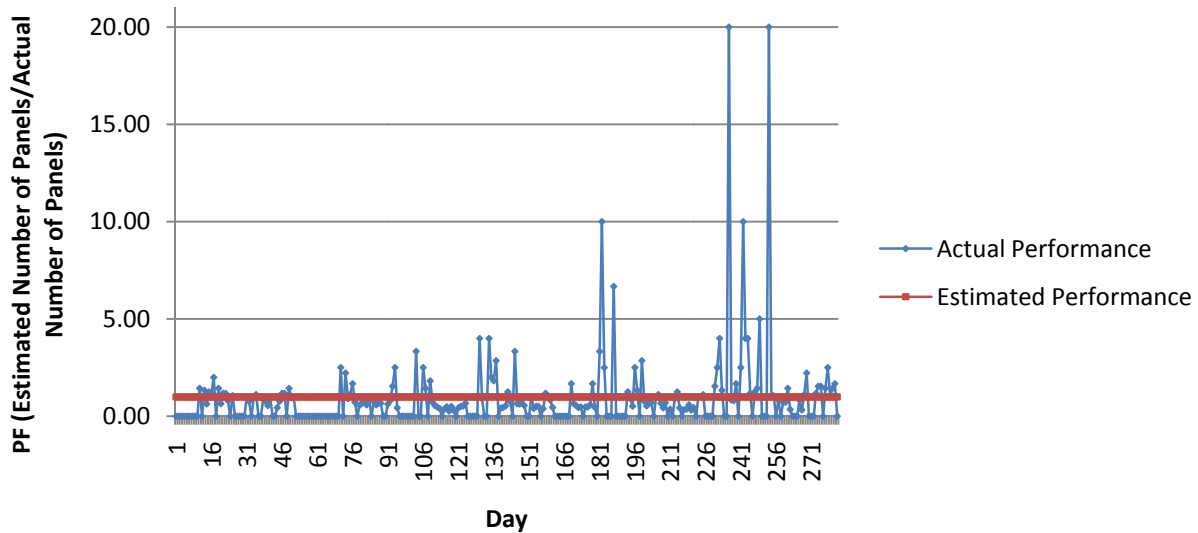


Table 15: Actual and estimated curtain wall installation performance

After calculating the performance factor, the planned and actual manning needs to be compared. As discussed on page 41, the planned manning depends on which curtain wall pieces were being installed (please see Table 11 for more information). The actual manning is shown both in Table 12 and Table 16. As one can see from the table, the most employees onsite were workers who were actually doing the labor of installing the panels.

Total Number of Enclos Employee

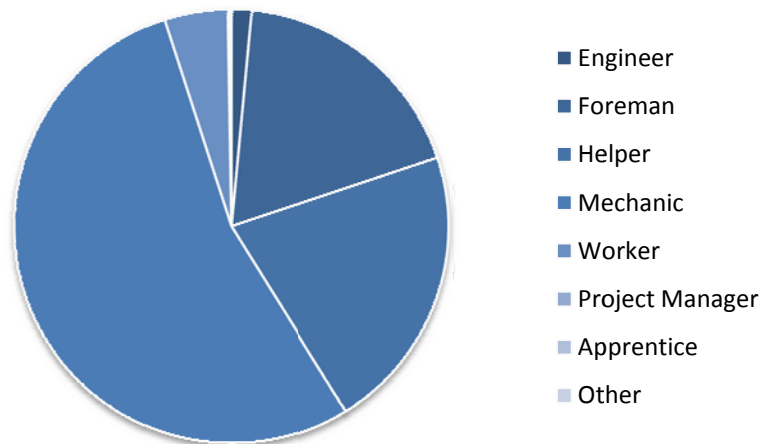


Table 16: Total Number of Enclos Employees

Additionally, the actual percent complete must be determined. In order to do this, the cumulative number of panels was compared for both the actual and the estimated number of panels per day. Table 17 shows the comparison of the two data. As one can see, the actual number was constantly lower than the estimated number of panels per day.

Percent Complete

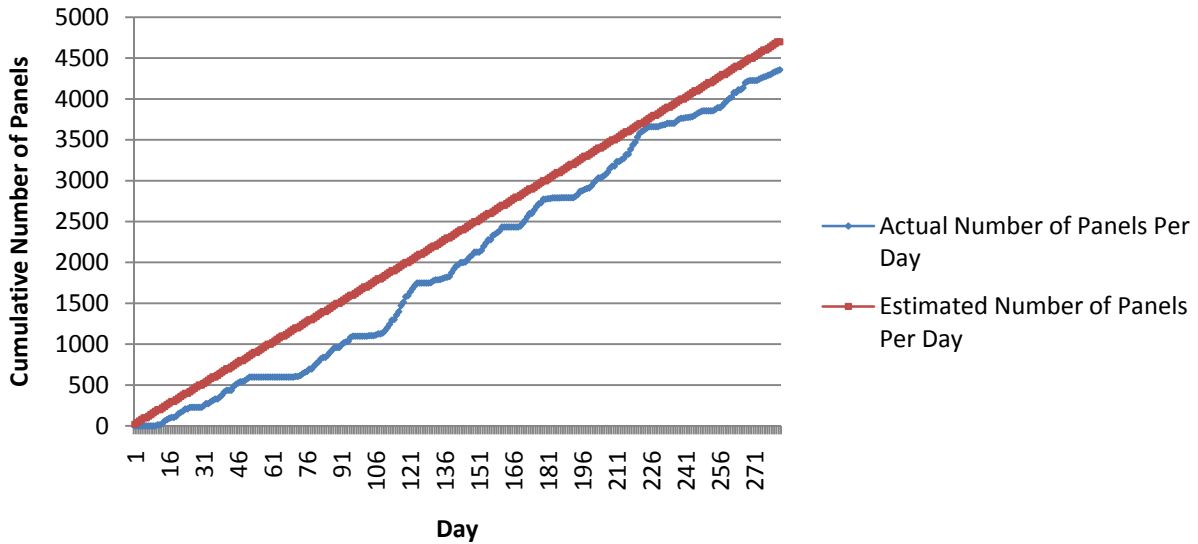


Table 17: Percent complete for curtain wall installation

Therefore the final step was to determine the control budget of the project. Since it was determine that each panel had a cost of \$9,626/panel, the control budget is cumulatively adding the cost of the panels compared to the number of panels installed per day. Table 18 shows the control budget of the period of time the curtain wall was being installed. This information helps the contractor and owner determine the amount of money needed to be paid based on the actual number of panels installed.

Control Budget

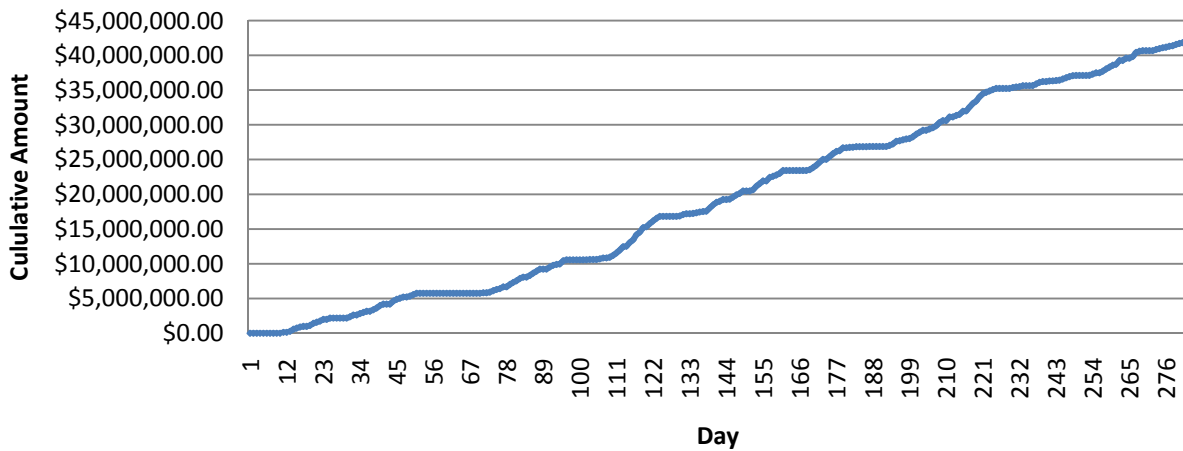


Table 18: Control budget for the cumulative number of panels installed per day

Average Temperature

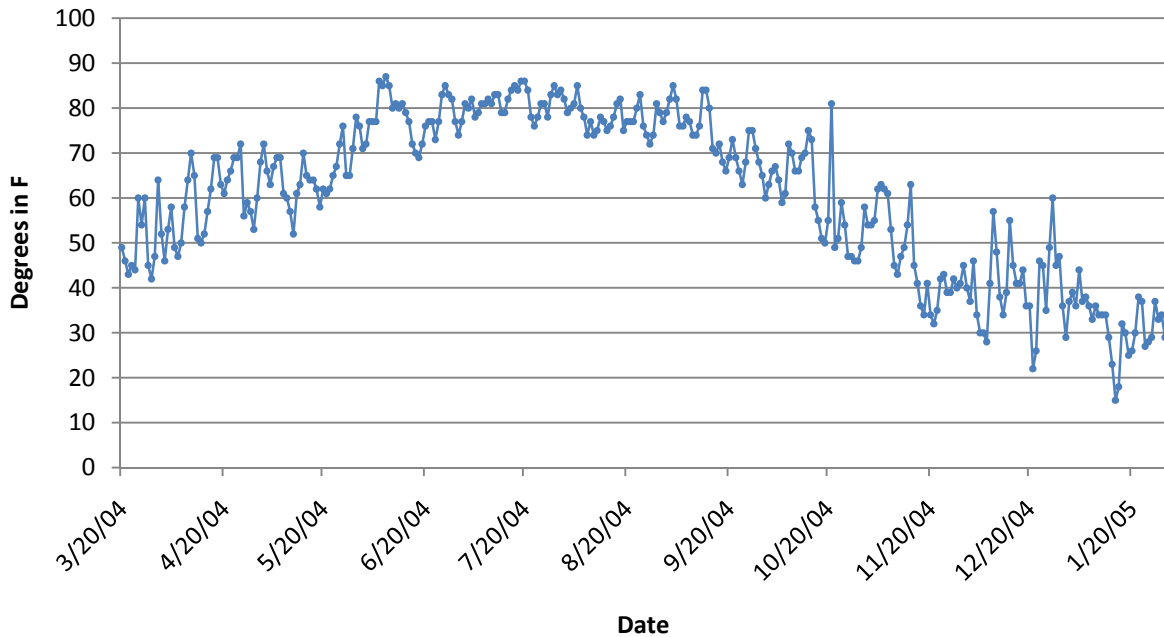


Table 19: Average temperature for the curtain wall installation

After all of the above information was collected, it was necessary to determine if the installation was actually productive. Overall, one can tell from Tables 14, 15, and 17 that it is slightly below the estimated values. There are several reasons why this may have occurred. First, weather could have played a large part in the delays. Appendix E contains the weather data that was researched. Table 19 illustrates the average temperature, while Table 20 shows both the daily high and low temperatures. Additionally, along with the



Figure 23: Curtainwall panel's anchors

actual temperature, precipitation and wind were a factor for delay. Both of these delays can be found in Tables 21 and 22. Overall, weather is typically a factor for delay in any construction project. Another delay was when rebar interfered with the anchors that had to be updated to support the panels. Since the waffle slabs have tensioned rebar from the original construction, it was a concern when rebar was struck during the installation of the new anchors. These anchors are shown in Figure 20 to the right. As one can see, there are typically two bolts need to secure the anchors, however, if rebar was encountered, then three or more bolts would be necessary to properly fasten the anchors. Another typical delay on projects is when other trades are working in the

same area. Since the panels were stored in the middle of the building, in order to move them to the exterior, the pathway needs to be cleared of all other trades. Typical trade interference included the MEP contactors. A final factor for delay is when a frame was found to be deficient. If this occurred, then the installed would be slowed to allow time to fix the problem. Typically, since the building is almost identical on the mirrored side, a panel could be barrowed in order to not delay the installation that long.

Daily High and Low Temperatures

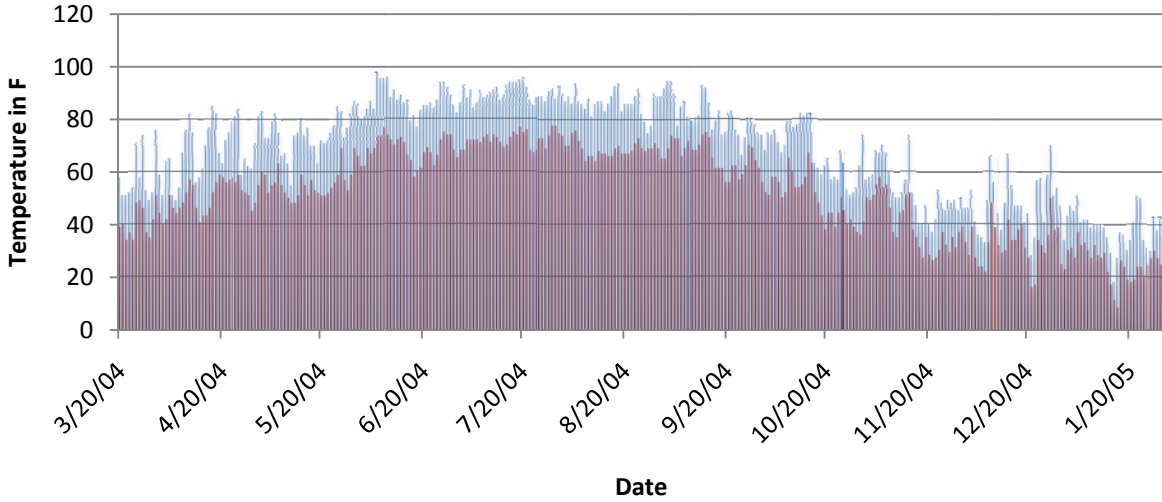


Table 20: Daily high and low temperatures for the curtain wall installation

Precipitation

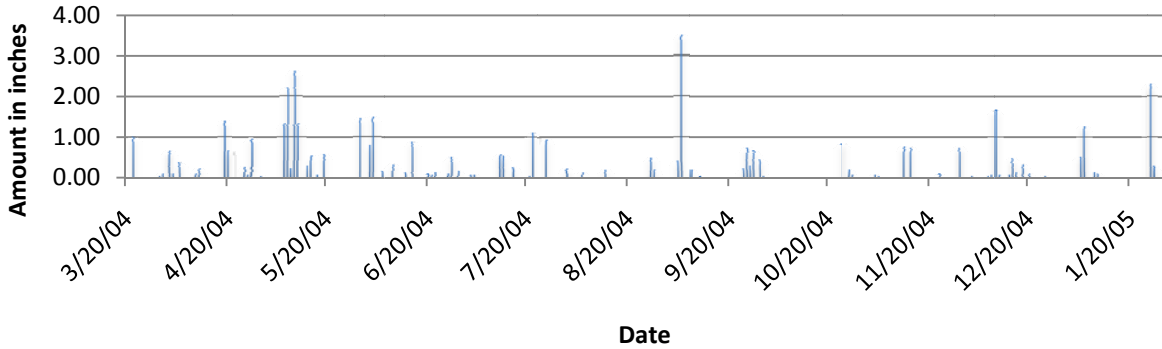


Table 21: Precipitation during the curtain wall installation

Daily Wind Speed

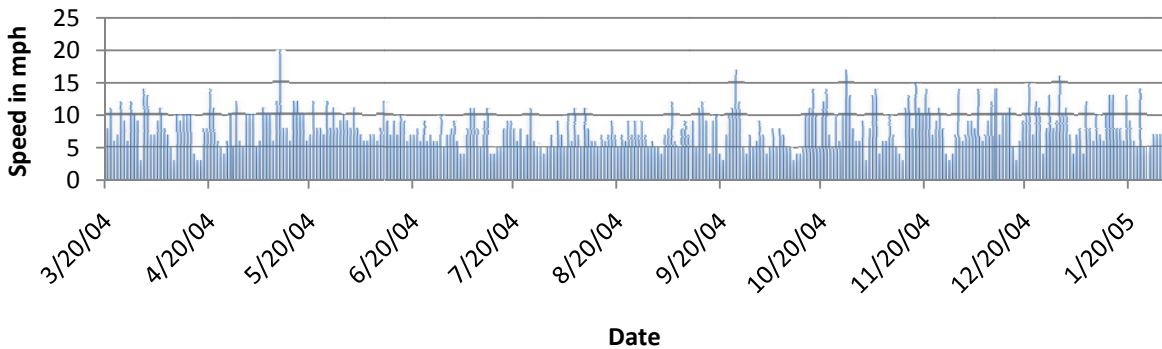


Table 22: Daily wind speed during the curtain wall installation

Outcome

Overall, it was learned that the productivity of the curtain wall installation was slightly under the estimated productivity. However, in order to get back on schedule there are several areas they could accelerate in. First, as long as the deliveries could be pushed ahead, they have the opportunity to work on weekends in order to put in 16-20 additional hours of installation. If these types of shifts are use, then the site will more than likely be less congested and quieter. Also, if possible, Enclos could bring in double the manpower in order to have two (or more) crews installing the panels. However, with this option, there will be a need for more tools and equipment. Overall, there were several factors that played a part in reducing the productivity, if Enclos feels it is necessary, there are areas where they can accelerate the installation if necessary.

ANALYSIS 4: PEDESTRIAN SAFETY

Critical Issue Research Method

Problem/Opportunity Statement

The critical industry issue, which also is a construction management issue, was the requirements for safety on jobsites. Since the L'Enfant Metro Station Entrance was within the construction site, it was a problematic feature to keep the pedestrians safe, but not limiting the use of the metro or the work taking place on the construction site. Safety is one of the biggest factors on jobsites, I would like to increase my knowledge on how companies are initiating the efforts to make their sites safer. The general audience and benefactor of this research are the companies that are managing jobsites.

Research Steps

1. Determine what the safety requirements are on the entire Constitution Center site.
2. Determine the OSHA requirements for areas within a construction site that are also open to the public.
3. Interview the DAVIS project team in order to determine if there were any special safety techniques that were unique to the site.
4. Create a survey to be sent to industry members to determine their site safety requirements.
5. Compile the results into a useful format in order to determine how companies are implementing safety procedures on their sites.

Survey Questions

1. How many employees does your company employ?
2. What market(s) does your company typically work in?
3. Does your company have a safety department?
4. Does your company have a full time safety manager on your site?
5. Does your company require specific safety training?
6. What types of consequences are enforced on your sites for not following safety procedures?
7. Do your sites have a full time nursing staff?
8. Does your company require a drug test before starting work on your sites?
9. Does your company have any sites that require special safety requirements?

Expected Outcome

The expected outcome of this research is to determine what safety requirements are implemented on job sites today and to determine if there were other ways to protect the pedestrians using the L'Enfant Metro Station.

Analysis

Constitution Center has the L'Enfant Plaza metro station entrance is directly beneath the building. One issue with this area was that the metro did not permit the entrance to be closed for the full duration of the project. The only time frame they allowed it to be closed was during the overhead curtain wall work along D Street. One stipulation for the closure was that it had to be fully reopened by the July 4th holiday since the National Mall is two blocks away. Therefore, from October 2007 till June 2008, the metro escalator was shut

Figure 24: Photo showing the escalator ceiling work.



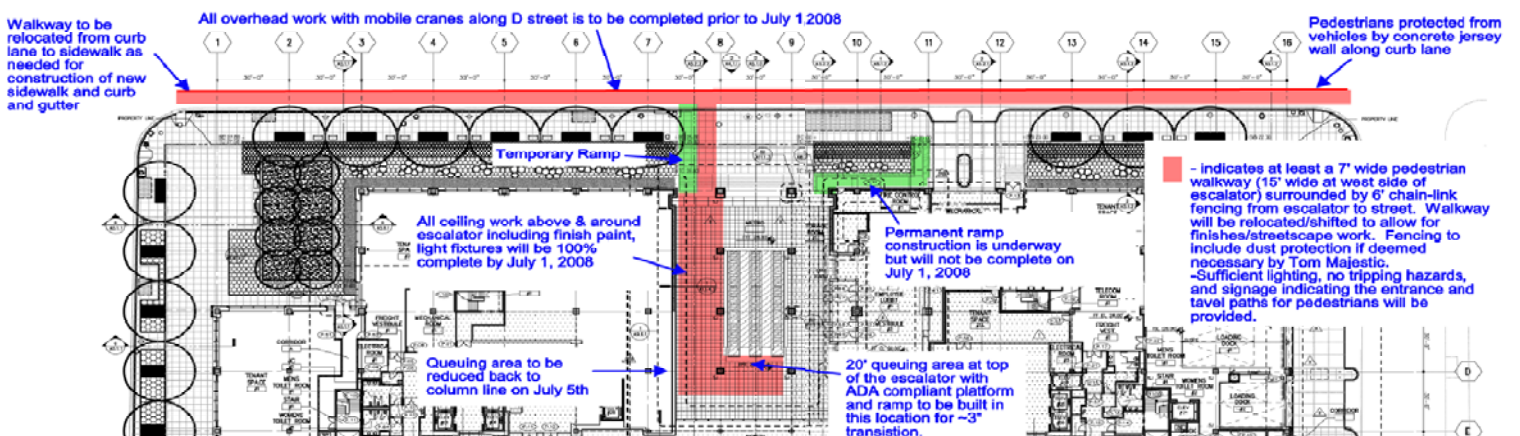
down and the curtain wall installation took place along D Street and the ceiling work directly above the escalators was completed. Figure 24 shows the ceiling work taking place over the metro escalator. From the start of the project, overhead protection was in place in order to protect pedestrians while demolition was taking place. Finally, the metro entrance was reopened on July 1, 2008 and overhead protection was eliminated since all overhead work was complete. Additionally, special measures were implemented to protect pedestrians while the remaining work along the streetscape and lobby are being completed.

Some of the special measures were:²⁵

- All ceiling work above and around the escalator is in the finishing stages – finish paint, final light fixtures, etc. will be completed by July 1, 2008.
- All overhead work involving mobile cranes along D Street will be completed by July 1, 2008.
- Construction of an ADA compliant platform and ramp at the escalator entrance to accommodate for the ~3" transition until the finish stone can be installed
- 6' high chain link fence surrounding the perimeter of the pedestrian pathway – dust protection will be provided if deemed necessary by site conditions and WMATA.
- Although the original metro easement did not include a ramp from the sidewalk to the escalator entrance, DAVIS constructed the new final ramp. While this construction was underway, it was not be completed by July 1, 2008.

Figure 25 is the plan that was executed in order to have the L'Enfant Metro entrance reopened by July 1, 2008.

Figure 25: Metro entrance protection plan.



After learning about DAVIS' safety techniques, it was researched the OSHA requirements that are the same for every project. It is necessary that the employer must initiate and maintain accident prevention both on and around the site. In order to do so, there should be an established safety training and education program. Additionally, general housekeeping must be followed in order to keep everyone safety, including pedestrians that would be passing by. Since the construction site was shutting down one of the entrances to the metro, there had to be an established plan with the metro in case of an emergency would occur in the tunnel. This plan was then documented and hung around both the construction site and the metro area to make everyone aware of what to do in case of an emergency. Subpart G of the OSHA Standard for the Construction Industry outline the sign and barricade requirements. Figure 26 provides examples of what the signs should look like.



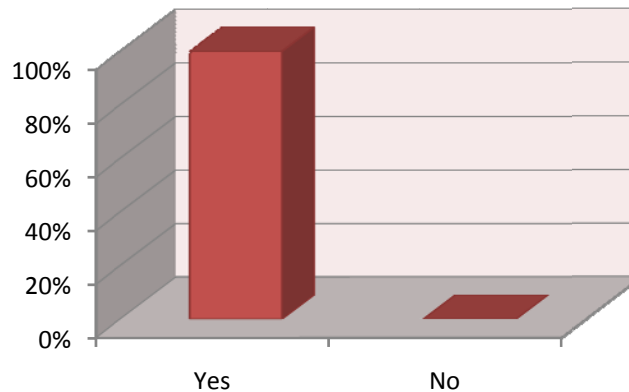
Figure 26: Examples of the Danger and Caution signs used according to Subpart G

Additionally, because not all of the curtain wall was installed before the metro was open, safety arrangements had to be made in order to finish the curtain wall of the north façade. In order to not have to install overhead protection, Enclos only worked on weekends in order to install the panels. Luckily the L'Enfant Plaza metro station entrance was not open on weekend; therefore no special arrangements had to be made.

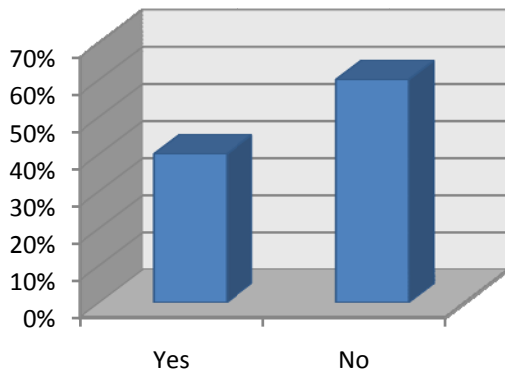
In order to learn more about site specific safety requirements, a survey was sent out to industry members. The results for the survey, although not many, came back exactly how expected. The first thing that was learned from this survey was that all of the companies that participated had a safety department. Additionally, only 60% of the companies have a full time safety manager onsite. The comments lift by the industry members mentioned that it depended on the specific site if full time coverage was required. If it was not full time, then most of the sites had periodic visits by someone involved in the safety department. All of the industry members noted that they require safety training. Some of the examples of the training include:

- 1st Aid/CPR certified
- Minimum 10 OSHA certified
- Department Of Labor, Division of PenSafe certified annually.
- OSHA 30 First aid

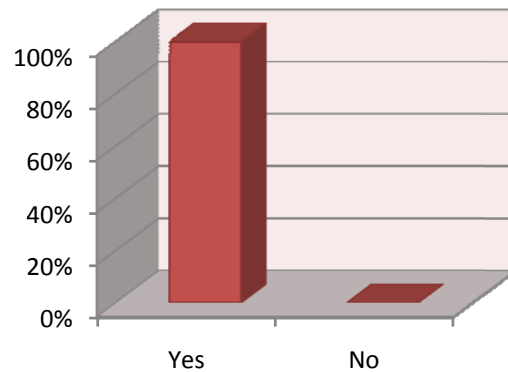
Safety Department



Full Time Safety Manager Onsite



Specific Safety Training



Each site has job specific consequences that are enforced for not following safety procedures. One particular company utilizes the "3 strikes and you're out rule" while another has a zero-tolerance rule that requires a monetary fine or temporary removal from the site if mine items occur. It was discovered that not all project require drug testing, with a note that a company only requires them for government contracts.

Finally, it was asked if any of their sites require special safety requirements. Several companies noted that Owner Controlled Insurance Plans and Contractor Controlled Insurance Plans require additional safety requirements compared to general OSHA requirements. Additionally, one company has project specific orientation plans for every project. At their meetings, they go over basic safety standards, along with calling out any specific working conditions.

Outcome

Overall, by conducting the research on safety requirements, it was determined that each site will have to conduct their own safety plan. However, OSHA has special programs in order to assist project teams with the safety requirements.

SUMMARY AND CONCLUSIONS

After performing research in several different key areas associated with the renovation of Constitution Center, several outcomes have transpired. First, going into detail about the project brought an understanding on why the owner, David Nassif Association decided to renovate the existing Department of Transportation building. Additionally, outlining and the project teams and the basic systems of the project increased the knowledge of construction. Furthermore, doing an evaluation of the project costs allowed one to see where the majority of the cash is going and if there are any ways to value engineer the systems without hindering the overall design.

After completing the research on chilled beams, it is recommended that a multi-service chilled beam be used in Constitution Center. The reason for this recommendation is because it has been proven that both the construction costs and schedules can be reduced with the additional of multi-service chilled beams. Additionally, it was learned that if there is a full time staff member on site assisting with commissioning it is easier to stay organized in order to meet the requirements. Also, it reiterated that communication is the key to having commissioning successfully be completed.

After performing the parking garage waffle slab analysis, it was determined that the current way that CRS is repairing the parking garage waffle slab is the most efficient. The cost would be much more to do the proposed two-way reinforced concrete system because they would have to do demolition work on the entire garage, not just sections with bad concrete and rebar. Additionally, the cost would increase due to formwork needed to properly place the concrete. Although the schedule mentioned above has the work being completed before the repairs that are currently taking place, the schedule does not take into account the demolition. Overall, it is suggested that the renovations of the parking garage waffle slab be performed the same way as planned.

It was learned that the productivity of the curtain wall installation was slightly under the estimated productivity. However, in order to get back on schedule there are several areas they could accelerate in. First, as long as the deliveries could be pushed ahead, they have the opportunity to work on weekends in order to put in 16-20 additional hours of installation. If these types of shifts are use, then the site will more than likely be less congested and quieter. Also, if possible, Enclos could bring in double the manpower in order to have two (or more) crews installing the panels. However, with this option, there will be a need for more tools and equipment. Overall, there were several factors that played a part in reducing the productivity, if Enclos feels it is necessary, there are areas where they can accelerate the installation if necessary.

Overall, by conducting the research on safety requirements, it was determined that each site will have to conduct their own safety plan. However, OSHA has special programs in order to assist project teams with the safety requirements.

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APPENDIX A: TWO-WAY REINFORCED CONCRETE REDESIGN

The tables below were used during the two-way structural redesign on the parking garage waffle slab. The information was taken from AE 431 Advance Concrete. Table 7 corresponds with the information below.

Given Information	
l_1 (ft)	30
l_2 (ft)	30
t_{slab} (in)	12
γ_c (pcf)	150
f'_c (psi)	4000
f_y (psi)	60000
Column Size (in) l_2, l_1	26
w_{SDL} (psf)	15
w_{DL} (psf)	150
w_{LL} (psf)	50
w_u (psf)	278
Φ_{bar} (in)	1
A_{bar} (in ²)	0.79

13.6.3.2 — In an interior span, total static moment, M_o , shall be distributed as follows:

Negative factored moment.....0.65

Positive factored moment0.35

13.6.3.3 — In an end span, total factored static moment, M_o , shall be distributed as follows:

	(1)	(2)	(3)		(4)	(5)
	Exterior edge unrestrained	Slab with beams between all supports	Without edge beam	With edge beam	Exterior edge fully restrained	
Interior negative factored moment	0.75	0.70	0.70	0.70	0.65	
Positive factored moment	0.63	0.57	0.52	0.50	0.35	
Exterior negative factored moment	0	0.16	0.26	0.30	0.65	

ρ	$f_y = 40,000$ psi				$f_y = 60,000$ psi			
	f'_{cr} psi				f'_{cr} psi			
	3000	4000	5000	6000	3000	4000	5000	6000
0.0005	20	20	20	20	30	30	30	30
0.0010	40	40	40	40	59	59	60	60
0.0015	59	59	60	60	88	89	89	89
0.0020	79	79	79	79	117	118	118	119
0.0025	98	99	99	99	146	147	147	148
0.0030	117	118	118	119	174	175	176	177
0.0035	136	137	138	138	201	204	205	206
0.0040	155	156	157	157	229	232	233	234
0.0045	174	175	176	177	256	259	261	263
0.0050	192	194	195	196	282	287	289	291
0.0055	211	213	214	215	309	314	317	319
0.0060	229	232	233	234	335	341	345	347
0.0065	247	250	252	253	360	368	372	375
0.0070	265	268	271	272	385	394	399	403
0.0075	282	287	289	291	410	420	426	430
0.0080	300	305	308	310	435	446	453	457
0.0085	317	323	326	329	459	472	479	485
0.0090	335	341	345	347	483	497	506	511
0.0095	352	359	363	366	506	522	532	538
0.0100	369	376	381	384	529	547	558	565
0.0105	385	394	399	403	552	572	583	591
0.0110	402	412	417	421	575	596	609	617
0.0115	419	429	435	439	597	620	634	643
0.0120	435	446	453	457	618	644	659	669
0.0125	451	463	471	476	640	667	684	695
0.0130	467	480	488	494	661	691	708	720
0.0135	483	497	506	511	681	714	733	746
0.0140	499	514	523	529	702	736	757	771
0.0145	514	531	540	547	722	759	781	796
0.0150	529	547	558	565	741	781	805	821
0.0155	545	563	575	582	760	803	828	845
0.0160	560	580	592	600		825	852	870
0.0165	575	596	609	617		846	875	894
0.0170	589	612	626	635		867	898	918
0.0175	604	628	642	652		888	920	942
0.0180	618	644	659	669		909	943	966
0.0185	633	660	676	686		929	965	989
0.0190	647	675	692	703		949	987	1013
0.0195	661	691	708	720		969	1009	1036
0.0200	675	706	725	737		988	1031	1059

Transverse Distribution of Longitudinal Moments										
		Negative Moment					Positive Moment			
Frame	l_2/l_1	a_2/l_1	% To CS	M In CS	% To MS	M in MS	% To CS	M In CS	% To MS	M in MS
	1.00	0	75	-424.00	25	-141.33	60	251.98	40	167.98
B	1.00	0	100 (Ext.)	-104.99	0	0.00	60	125.99	40	83.99
	1.00	0	75 (Int.)	-212.00	25	-70.67				
	1.00	0	75	-424.00	25	-141.33	60	251.98	40	167.98
D	1.00	0	100 (Ext.)	-104.99	0	0.00	60	125.99	40	83.99
	1.00	0	75 (Int.)	-212.00	25	-70.67				

Frame	Total Width (ft)	CS (ft)	MS (ft)	Total - Moment	CS (-M)	MS (-M)	Total + Moment	CS (+M)	MS (+M)
A	30	15	15	-565.33	-424.00	-141.33	419.96	251.98	167.98
B	15	7.5	7.5	-104.99	-104.99	0.00	209.98	125.99	83.99
				-282.67	-212.00	-70.67			
C	30	15	15	-565.33	-424.00	-141.33	419.96	251.98	167.98
D	15	7.5	7.5	-104.99	-104.99	0.00	209.98	125.99	83.99
				-282.67	-212.00	-70.67			

Frame Moments				
Frame	A	B	C	D
M _o (ft-Kip)	807.62	403.81	807.62	403.81
Positive & Negative Moments	-565.33	-104.99	-565.33	-104.99
	419.96	209.98	419.96	209.98
	-565.33	-282.67	-565.33	-282.67

Torsional Constant	
* Use .5 of I ₁ or I ₂ (Whichever is greater)	
c (in ⁴)	99325

Table A.5a	
ρ	f'c (4000psi)
0.001	59
0.0015	89
0.002	118
0.0025	147
0.003	175
0.0035	204
0.004	232
0.0065	368
0.007	394

For Frame A Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-424.00	251.98	
2	b (in)	154.00	154.00	
3	d (in)	11.50	11.50	
4	M _n = M _u /0.9 (ft-Kip)	-471.11	279.97	
5	R = M _n /bd ²	277.58	164.96	
6	ρ [Table A.5a]	0.00	0.00	
7	A _{st} = ρ bd (in ²)	8.43	4.96	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	10.67	6.28	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame A Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-141.33	167.98	
2	b (in)	154.00	154.00	
3	d (in)	9.50	9.50	
4	M _n = M _u /0.9 (ft-Kip)	-157.04	186.65	
5	R = M _n /bd ²	135.59	161.15	
6	ρ [Table A.5a]	0.00	0.00	
7	A _{st} = ρbd (in ²)	3.37	4.03	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	4.27	5.10	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame B Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-104.99	125.99	-212.00
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	-116.66	139.99	-235.56
5	R = M _n /bd ²	100.72	120.87	203.38
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	2.49	3.00	5.10
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75

For Frame B Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	0.00	83.99	-70.67
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	0.00	93.32	-78.52
5	R = M _n /bd ²	0.00	80.58	67.79
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	0.00	1.99	1.68
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75

For Frame C Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-424.00	251.98	
2	b (in)	154.00	154.00	
3	d (in)	9.50	9.50	
4	M _n = M _u /0.9 (ft-Kip)	-471.11	279.97	
5	R = M _n /bd ²	406.76	241.73	
6	ρ [Table A.5a]	0.01	0.00	
7	A _{st} = ρbd (in ²)	10.60	6.11	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	13.42	7.73	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame C Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-141.33	167.98	
2	b (in)	154.00	154.00	
3	d (in)	9.50	9.50	
4	M _n = M _u /0.9 (ft-Kip)	-157.04	186.65	
5	R = M _n /bd ²	135.59	161.15	
6	ρ [Table A.5a]	0.00	0.00	
7	A _{st} = ρbd (in ²)	3.37	4.03	
8	A _{st,min} = 0.002bt	3.70	3.70	
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	
10	N _{min} = width _{strip} /2t	7.50	7.50	

For Frame D Design Reinforcement For CS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	-104.99	125.99	-212.00
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	-116.66	139.99	-235.56
5	R = M _n /bd ²	100.72	120.87	203.38
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	2.49	3.00	5.10
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75

For Frame D Design Reinforcement For MS (Will Use #8 Bars)				
Item	Description	Span		
		M ⁻	M ⁺	M ⁻
1	M _u (ft-Kip)	0.00	83.99	-70.67
2	b (in)	154.00	154.00	154.00
3	d (in)	9.50	9.50	9.50
4	M _n = M _u /0.9 (ft-Kip)	0.00	93.32	-78.52
5	R = M _n /bd ²	0.00	80.58	67.79
6	ρ [Table A.5a]	0.00	0.00	0.00
7	A _{st} = ρbd (in ²)	0.00	1.99	1.68
8	A _{st,min} = 0.002bt	3.70	3.70	3.70
9	N = #7 or #8 (Greater)/A _{bar}	4.68	4.68	4.68
10	N _{min} = width _{strip} /2t	3.75	3.75	3.75

APPENDIX B: ENCLOS MANPOWER

The table below was used for the curtain wall productivity analysis. This information was provided to by both DAVIS and Enclos in order to determine the manpower needed to properly install the curtain wall panels. Additionally, this information was used to determine if the manpower caused any delays on the project. Finally, the information was used to create Table 12 and 16.

Day	Date	Engineer	Foreman	Helper	Mechanic	Worker	Project Manager	Apprentice	Other	Total
Monday	3/10/08	0	3	2	6	0	0	0	0	11
Tuesday	3/11/08	0	3	2	6	0	0	0	0	11
Wednesday	3/12/08	0	3	2	5	0	0	0	0	10
Thursday	3/13/08	0	3	2	5	0	0	0	0	10
Friday	3/14/08	0	3	2	5	0	0	0	0	10
Saturday	3/15/08	0	2	2	5	0	0	0	0	9
Sunday	3/16/08	0	0	0	0	0	0	0	0	0
Monday	3/17/08	0	4	2	6	0	0	0	0	12
Tuesday	3/18/08	0	4	2	4	0	0	0	0	10
Wednesday	3/19/08	0	4	2	6	0	0	0	0	12
Thursday	3/20/08	0	4	2	6	0	0	0	0	12
Friday	3/21/08	0	4	2	6	0	0	0	0	12
Saturday	3/22/08	0	0	0	0	0	0	0	0	0
Sunday	3/23/08	0	0	0	0	0	0	0	0	0
Monday	3/24/08	0	4	4	8	0	0	0	0	16
Tuesday	3/25/08	0	4	4	8	0	0	0	0	16
Wednesday	3/26/08	0	4	4	8	0	0	0	0	16
Thursday	3/27/08	0	4	4	9	0	1	0	0	18
Friday	3/28/08	0	2	4	9	0	0	0	0	15
Saturday	3/29/08	0	1	0	1	0	0	0	0	2
Sunday	3/30/08	0	0	0	0	0	0	0	0	0
Monday	3/31/08	0	4	4	9	0	1	0	0	18
Tuesday	4/1/08	0	4	4	9	0	1	0	0	18
Wednesday	4/2/08	0	4	4	9	0	0	0	0	17
Thursday	4/3/08	2	4	3	8	3	0	0	0	20
Friday	4/4/08	0	4	3	9	0	0	0	0	16
Saturday	4/5/08	0	0	0	0	0	0	0	0	0
Sunday	4/6/08	0	0	0	0	0	0	0	0	0
Monday	4/7/08	0	4	4	9	0	0	0	0	17
Tuesday	4/8/08	0	4	2	9	0	1	0	0	16
Wednesday	4/9/08	0	4	2	9	0	0	0	0	15
Thursday	4/10/08	0	4	2	9	0	0	0	0	15
Friday	4/11/08	0	4	2	9	0	0	0	0	15
Saturday	4/12/08	0	0	0	0	0	0	0	0	0
Sunday	4/13/08	0	0	0	0	0	0	0	0	0
Monday	4/14/08	0	4	2	10	0	0	0	0	16
Tuesday	4/15/08	0	4	2	10	0	0	0	0	16
Wednesday	4/16/08	0	1	0	1	0	0	1	0	3
Thursday	4/17/08	0	4	2	10	0	0	0	0	16
Friday	4/18/08	0	4	2	10	0	0	0	0	16
Saturday	4/19/08	0	2	2	3	0	0	0	0	7
Sunday	4/20/08	0	0	0	0	0	0	0	0	0
Monday	4/21/08	0	4	2	10	0	0	0	0	16
Tuesday	4/22/08	0	4	2	10	0	0	0	0	16
Wednesday	4/23/08	0	4	2	11	0	0	0	0	17
Thursday	4/24/08	0	4	2	11	0	0	0	0	17
Friday	4/25/08	0	4	2	11	0	0	0	0	17
Saturday	4/26/08	0	4	2	11	0	0	0	0	17
Sunday	4/27/08	0	0	0	0	0	0	0	0	0
Monday	4/28/08	0	4	2	11	0	0	0	0	17
Tuesday	4/29/08	0	4	2	11	0	0	0	0	17
Wednesday	4/30/08	0	4	2	10	0	0	0	0	16
Thursday	05/01/08	0	4	2	10	0	0	0	0	16
Friday	05/02/08	0	3	2	10	0	0	0	0	15
Saturday	05/03/08	0	0	0	0	2	0	0	0	2

Day	Date	Engineer	Foreman	Helper	Mechanic	Worker	Project Manager	Apprentice	Other	Total
Monday	05/05/08	0	3	3	9	0	0	0	0	15
Tuesday	05/06/08	0	4	3	11	0	0	0	0	18
Wednesday	05/07/08	0	4	3	9	0	0	0	0	16
Thursday	05/08/08	0	4	4	9	0	0	0	0	17
Friday	05/09/08	0	2	4	8	0	0	0	0	14
Saturday	05/10/08	0	0	0	0	0	0	0	0	0
Sunday	05/11/08	0	0	0	0	0	0	0	0	0
Monday	05/12/08	0	3	2	1	0	0	0	0	6
Tuesday	05/13/08	0	3	4	10	0	0	0	0	17
Wednesday	05/14/08	0	4	4	10	0	0	0	0	18
Thursday	05/15/08	0	4	4	9	0	0	0	0	17
Friday	05/16/08	0	3	3	5	0	0	0	0	11
Saturday	05/17/08	0	1	3	5	0	0	0	0	9
Sunday	05/18/08	0	0	0	0	0	0	0	0	0
Monday	05/19/08	0	3	4	10	0	0	0	0	17
Tuesday	05/20/08	0	3	4	7	0	0	0	0	14
Wednesday	05/21/08	0	3	3	10	0	0	0	0	16
Thursday	05/22/08	0	2	3	10	0	0	0	0	15
Friday	05/23/08	0	2	4	10	0	0	0	0	16
Saturday	05/24/08	0	0	0	0	0	0	0	0	0
Sunday	05/25/08	0	0	0	0	0	0	0	0	0
Monday	05/26/08	0	0	0	0	0	0	0	0	0
Tuesday	05/27/08	0	2	3	10	0	0	0	0	15
Wednesday	05/28/08	0	4	3	10	0	0	0	0	17
Thursday	05/29/08	0	1	0	2	0	0	0	0	3
Friday	05/30/08	0	4	5	10	0	0	0	0	19
Saturday	05/31/08	0	0	0	0	0	0	0	0	0
Sunday	06/01/08	0	0	0	0	0	0	0	0	0
Monday	06/02/08	0	4	5	10	0	0	0	0	19
Tuesday	06/03/08	0	4	5	12	0	0	0	0	21
Wednesday	06/04/08	0	4	5	9	0	0	0	0	18
Thursday	06/05/08	0	4	5	10	0	0	0	0	19
Friday	06/06/08	0	4	5	10	0	0	0	0	19
Saturday	06/07/08	0	3	3	5	0	0	0	0	11
Sunday	06/08/08	0	0	0	0	0	0	0	0	0
Monday	06/09/08	0	4	5	13	0	0	0	0	22
Tuesday	06/10/08	0	4	7	15	0	0	0	0	26
Wednesday	06/11/08	0	4	7	15	0	0	0	0	26
Thursday	06/12/08	0	4	7	15	0	0	0	0	26
Friday	06/13/08	0	4	7	15	0	0	0	0	26
Saturday	06/14/08	0	0	0	0	0	0	0	0	0
Sunday	06/15/08	0	0	0	0	0	0	0	0	0
Monday	06/16/08	0	4	7	15	0	0	0	0	26
Tuesday	06/17/08	0	5	8	13	0	0	0	0	26
Wednesday	06/18/08	0	5	7	15	0	0	0	0	27
Thursday	06/19/08	0	5	6	15	0	0	0	0	26
Friday	06/20/08	0	5	6	15	0	0	0	0	26
Saturday	06/21/08	0	4	4	11	0	0	0	0	19
Sunday	06/22/08	0	0	0	0	0	0	0	0	0
Monday	06/23/08	0	5	7	14	0	0	0	0	26
Tuesday	06/24/08	2	5	7	14	6	0	0	0	34
Wednesday	06/25/08	2	5	6	14	6	0	0	0	33
Thursday	06/26/08	2	5	8	17	4	0	0	0	36
Friday	06/27/08	2	5	8	17	4	0	0	0	36
Saturday	06/28/08	0	3	3	6	0	0	0	0	12
Sunday	06/29/08	0	6	5	13	0	0	0	0	24
Monday	06/30/08	0	0	0	0	0	0	0	0	0
Tuesday	07/01/08	0	6	5	13	0	0	0	0	24
Wednesday	07/02/08	0	6	6	13	0	0	0	0	25
Thursday	07/03/08	0	3	5	13	0	0	0	0	21
Friday	07/04/08	0	0	0	0	0	0	0	0	0
Saturday	07/05/08	0	0	0	0	0	0	0	0	0
Sunday	07/06/08	0	0	0	0	0	0	0	0	0
Monday	07/07/08	0	2	4	13	0	0	0	0	19
Tuesday	07/08/08	0	3	4	13	0	0	0	0	20
Wednesday	07/09/08	0	3	4	13	0	0	0	0	20
Friday	07/11/08	0	4	4	12	0	0	0	0	20

Day	Date	Engineer	Foreman	Helper	Mechanic	Worker	Project Manager	Apprentice	Other	Total
Sunday	07/13/08	0	0	0	0	0	0	0	0	0
Monday	07/14/08	0	5	6	13	0	0	0	0	24
Tuesday	07/15/08	0	5	6	13	0	0	0	0	24
Wednesday	07/16/08	0	5	6	14	0	0	0	0	25
Thursday	07/17/08	0	4	6	13	0	0	0	0	23
Friday	07/18/08	0	4	6	13	0	0	0	0	23
Saturday	07/19/08	0	2	0	4	0	0	0	0	6
Sunday	07/20/08	0	0	0	0	0	0	0	0	0
Monday	07/21/08	0	3	7	15	0	0	0	0	25
Tuesday	07/22/08	2	3	6	16	4	0	0	0	31
Wednesday	07/23/08	2	3	7	16	4	0	0	0	32
Thursday	07/24/08	2	3	6	18	5	0	0	0	34
Friday	07/25/08	0	3	6	18	0	0	0	0	27
Saturday	07/26/08	0	2	1	4	0	0	0	0	7
Sunday	07/27/08	0	0	0	0	0	0	0	0	0
Monday	07/28/08	2	4	6	18	0	0	0	2	32
Tuesday	07/29/08	0	4	7	16	0	0	0	0	27
Wednesday	07/30/08	0	4	7	16	0	0	0	0	27
Thursday	07/31/08	0	4	7	14	0	0	0	0	25
Friday	08/01/08	0	4	7	14	0	0	0	0	25
Saturday	08/02/08	0	0	0	0	0	0	0	0	0
Sunday	08/03/08	0	0	0	0	0	0	0	0	0
Monday	08/04/08	2	4	7	13	5	0	0	0	31
Tuesday	08/05/08	2	4	7	14	5	0	0	0	32
Wednesday	08/06/08	2	4	7	14	5	0	0	0	32
Thursday	08/07/08	2	4	7	14	4	0	0	0	31
Friday	08/08/08	2	2	7	13	5	0	0	0	29
Saturday	08/09/08	0	0	0	0	0	0	0	0	0
Sunday	08/10/08	0	0	0	0	0	0	0	0	0
Monday	08/11/08	0	4	7	13	5	0	0	0	29
Tuesday	08/12/08	0	4	7	14	4	0	0	0	29
Wednesday	08/13/08	0	4	7	14	7	0	0	0	32
Thursday	08/14/08	2	4	7	16	6	0	0	0	35
Friday	08/15/08	2	4	7	16	6	0	0	0	35
Saturday	08/16/08	0	0	0	0	0	0	0	0	0
Sunday	08/17/08	0	0	0	0	0	0	0	0	0
Monday	08/18/08	2	3	6	15	6	0	0	0	32
Tuesday	08/19/08	2	4	6	16	6	0	0	0	34
Wednesday	08/20/08	2	3	6	15	6	0	0	0	32
Thursday	08/21/08	0	4	6	16	6	0	0	0	32
Friday	08/22/08	0	4	6	15	6	0	0	0	31
Saturday	08/23/08	0	0	0	0	0	0	0	0	0
Sunday	08/24/08	0	0	0	0	0	0	0	0	0
Monday	08/25/08	0	0	0	0	0	0	0	0	0
Tuesday	08/26/08	0	0	0	0	0	0	0	0	0
Wednesday	08/27/08	0	0	0	0	0	0	0	0	0
Thursday	08/28/08	0	0	0	0	0	0	0	0	0
Friday	08/29/08	0	0	0	0	0	0	0	0	0
Saturday	08/30/08	0	0	0	0	0	0	0	0	0
Sunday	08/31/08	0	0	0	0	0	0	0	0	0
Monday	09/01/08	0	0	0	0	0	0	0	0	0
Tuesday	09/02/08	0	0	0	0	0	0	0	0	0
Wednesday	09/03/08	0	0	0	0	0	0	0	0	0
Thursday	09/04/08	0	0	0	0	0	0	0	0	0
Friday	09/05/08	0	0	0	0	0	0	0	0	0
Saturday	09/06/08	0	0	0	0	0	0	0	0	0
Sunday	09/07/08	0	0	0	0	0	0	0	0	0
Monday	09/08/08	0	0	0	0	0	0	0	0	0
Tuesday	09/09/08	0	0	0	0	0	0	0	0	0
Wednesday	09/10/08	0	0	0	0	0	0	0	0	0
Thursday	09/11/08	0	0	0	0	0	0	0	0	0
Friday	09/12/08	0	0	0	0	0	0	0	0	0
Saturday	09/13/08	0	0	0	0	0	0	0	0	0
Sunday	09/14/08	0	0	0	0	0	0	0	0	0
Tuesday	09/16/08	0	0	0	0	0	0	0	0	0
Wednesday	09/17/08	0	0	0	0	0	0	0	0	0
Friday	09/19/08	0	0	0	0	0	0	0	0	0

Day	Date	Engineer	Foreman	Helper	Mechanic	Worker	Project Manager	Apprentice	Other	Total
Saturday	09/20/08	0	0	0	0	0	0	0	0	0
Sunday	09/21/08	0	0	0	0	0	0	0	0	0
Monday	09/22/08	0	0	0	0	0	0	0	0	0
Tuesday	09/23/08	0	0	0	0	0	0	0	0	0
Wednesday	09/24/08	0	0	0	0	0	0	0	0	0
Thursday	09/25/08	0	0	0	0	0	0	0	0	0
Friday	09/26/08	0	0	0	0	0	0	0	0	0
Saturday	09/27/08	0	0	0	0	0	0	0	0	0
Sunday	09/28/08	0	0	0	0	0	0	0	0	0
Monday	09/29/08	0	0	0	0	0	0	0	0	0
Tuesday	09/30/08	0	0	0	0	0	0	0	0	0
Wednesday	10/01/08	0	0	0	0	0	0	0	0	0
Thursday	10/02/08	0	0	0	0	0	0	0	0	0
Friday	10/03/08	0	0	0	0	0	0	0	0	0
Saturday	10/04/08	0	0	0	0	0	0	0	0	0
Sunday	10/05/08	0	0	0	0	0	0	0	0	0
Monday	10/06/08	0	0	0	0	0	0	0	0	0
Tuesday	10/07/08	0	0	0	0	0	0	0	0	0
Wednesday	10/08/08	0	0	0	0	0	0	0	0	0
Thursday	10/09/08	0	0	0	0	0	0	0	0	0
Friday	10/10/08	0	0	0	0	0	0	0	0	0
Saturday	10/11/08	0	0	0	0	0	0	0	0	0
Sunday	10/12/08	0	0	0	0	0	0	0	0	0
Monday	10/13/08	0	0	0	0	0	0	0	0	0
Tuesday	10/14/08	0	0	0	0	0	0	0	0	0
Wednesday	10/15/08	0	0	0	0	0	0	0	0	0
Thursday	10/16/08	0	0	0	0	0	0	0	0	0
Friday	10/17/08	0	0	0	0	0	0	0	0	0
Saturday	10/18/08	0	0	0	0	0	0	0	0	0
Sunday	10/19/08	0	0	0	0	0	0	0	0	0
Monday	10/20/08	0	0	0	0	0	0	0	0	0
Tuesday	10/21/08	0	0	0	0	0	0	0	0	0
Wednesday	10/22/08	0	0	0	0	0	0	0	0	0
Thursday	10/23/08	0	0	0	0	0	0	0	0	0
Friday	10/24/08	0	0	0	0	0	0	0	0	0
Saturday	10/25/08	0	0	0	0	0	0	0	0	0
Sunday	10/26/08	0	0	0	0	0	0	0	0	0
Monday	10/27/08	0	0	0	0	0	0	0	0	0
Tuesday	10/28/08	0	0	0	0	0	0	0	0	0
Wednesday	10/29/08	0	0	0	0	0	0	0	0	0
Thursday	10/30/08	0	0	0	0	0	0	0	0	0
Friday	10/31/08	0	0	0	0	0	0	0	0	0
Saturday	11/01/08	0	0	0	0	0	0	0	0	0
Sunday	11/02/08	0	0	0	0	0	0	0	0	0
Monday	11/03/08	0	0	0	0	0	0	0	0	0
Tuesday	11/04/08	0	0	0	0	0	0	0	0	0
Wednesday	11/05/08	0	0	0	0	0	0	0	0	0
Thursday	11/06/08	0	0	0	0	0	0	0	0	0
Friday	11/07/08	0	0	0	0	0	0	0	0	0
Saturday	11/08/08	0	0	0	0	0	0	0	0	0
Sunday	11/09/08	0	0	0	0	0	0	0	0	0
Monday	11/10/08	0	0	0	0	0	0	0	0	0
Tuesday	11/11/08	0	0	0	0	0	0	0	0	0
Wednesday	11/12/08	0	0	0	0	0	0	0	0	0
Thursday	11/13/08	0	0	0	0	0	0	0	0	0
Friday	11/14/08	0	0	0	0	0	0	0	0	0
Saturday	11/15/08	0	0	0	0	0	0	0	0	0
Sunday	11/16/08	0	0	0	0	0	0	0	0	0
Monday	11/17/08	0	0	0	0	0	0	0	0	0
Tuesday	11/18/08	0	0	0	0	0	0	0	0	0
Wednesday	11/19/08	0	0	0	0	0	0	0	0	0
Thursday	11/20/08	0	0	0	0	0	0	0	0	0
Saturday	11/22/08	0	0	0	0	0	0	0	0	0
Sunday	11/23/08	0	0	0	0	0	0	0	0	0
Monday	11/24/08	0	0	0	0	0	0	0	0	0
Tuesday	11/25/08	0	0	0	0	0	0	0	0	0
Thursday	11/27/08	0	0	0	0	0	0	0	0	0

Day	Date	Engineer	Foreman	Helper	Mechanic	Worker	Project Manager	Apprentice	Other	Total
Friday	11/28/08	0	0	0	0	0	0	0	0	0
Saturday	11/29/08	0	0	0	0	0	0	0	0	0
Sunday	11/30/08	0	0	0	0	0	0	0	0	0
Monday	12/01/08	0	0	0	0	0	0	0	0	0
Tuesday	12/02/08	0	0	0	0	0	0	0	0	0
Wednesday	12/03/08	0	0	0	0	0	0	0	0	0
Thursday	12/04/08	0	0	0	0	0	0	0	0	0
Friday	12/05/08	0	0	0	0	0	0	0	0	0
Saturday	12/06/08	0	0	0	0	0	0	0	0	0
Sunday	12/07/08	0	0	0	0	0	0	0	0	0
Monday	12/08/08	0	0	0	0	0	0	0	0	0
Tuesday	12/09/08	0	0	0	0	0	0	0	0	0
Wednesday	12/10/08	0	0	0	0	0	0	0	0	0
Thursday	12/11/08	0	0	0	0	0	0	0	0	0
Friday	12/12/08	0	0	0	0	0	0	0	0	0
Saturday	12/13/08	0	0	0	0	0	0	0	0	0
Sunday	12/14/08	0	0	0	0	0	0	0	0	0
Monday	12/15/08	0	0	0	0	0	0	0	0	0
Tuesday	12/16/08	0	0	0	0	0	0	0	0	0
Wednesday	12/17/08	0	0	0	0	0	0	0	0	0
Thursday	12/18/08	0	0	0	0	0	0	0	0	0
Friday	12/19/08	0	0	0	0	0	0	0	0	0
Saturday	12/20/08	0	0	0	0	0	0	0	0	0
Sunday	12/21/08	0	0	0	0	0	0	0	0	0
Monday	12/22/08	0	0	0	0	0	0	0	0	0
Tuesday	12/23/08	0	0	0	0	0	0	0	0	0
Wednesday	12/24/08	0	0	0	0	0	0	0	0	0
Thursday	12/25/08	0	0	0	0	0	0	0	0	0
Friday	12/26/08	0	0	0	0	0	0	0	0	0
Saturday	12/27/08	0	0	0	0	0	0	0	0	0
Sunday	12/28/08	0	0	0	0	0	0	0	0	0
Monday	12/29/08	0	0	0	0	0	0	0	0	0
Tuesday	12/30/08	0	0	0	0	0	0	0	0	0
Wednesday	12/31/08	0	0	0	0	0	0	0	0	0
Thursday	01/01/09	0	0	0	0	0	0	0	0	0
Friday	01/02/09	0	0	0	0	0	0	0	0	0
Saturday	01/03/09	0	0	0	0	0	0	0	0	0
Sunday	01/04/09	0	0	0	0	0	0	0	0	0
Monday	01/05/09	0	0	0	0	0	0	0	0	0
Tuesday	01/06/09	0	0	0	0	0	0	0	0	0
Wednesday	01/07/09	0	0	0	0	0	0	0	0	0
Thursday	01/08/09	0	0	0	0	0	0	0	0	0
Friday	01/09/09	0	0	0	0	0	0	0	0	0
Saturday	01/10/09	0	0	0	0	0	0	0	0	0
Sunday	01/11/09	0	0	0	0	0	0	0	0	0
Monday	01/12/09	0	0	0	0	0	0	0	0	0
Tuesday	01/13/09	0	0	0	0	0	0	0	0	0
Wednesday	01/14/09	0	0	0	0	0	0	0	0	0
Thursday	01/15/09	0	0	0	0	0	0	0	0	0
Friday	01/16/09	0	0	0	0	0	0	0	0	0
Saturday	01/17/09	0	0	0	0	0	0	0	0	0
Sunday	01/18/09	0	0	0	0	0	0	0	0	0
Monday	01/19/09	0	0	0	0	0	0	0	0	0
Tuesday	01/20/09	0	0	0	0	0	0	0	0	0
Wednesday	01/21/09	0	0	0	0	0	0	0	0	0
Thursday	01/22/09	0	0	0	0	0	0	0	0	0
Friday	01/23/09	0	0	0	0	0	0	0	0	0
Saturday	01/24/09	0	0	0	0	0	0	0	0	0
Sunday	01/25/09	0	0	0	0	0	0	0	0	0
Monday	01/26/09	0	0	0	0	0	0	0	0	0
Tuesday	01/27/09	0	0	0	0	0	0	0	0	0
Wednesday	01/28/09	0	0	0	0	0	0	0	0	0
Thursday	01/29/09	0	0	0	0	0	0	0	0	0
Friday	01/30/09	0	0	0	0	0	0	0	0	0

APPENDIX C: COURTYARD AND STREETSIDE CURTAIN WALL PANEL INSTALLATION

The information below was provided by Enclos in order to calculate the curtain wall installation productivity. As one can see, the building was divided into 8 different sections, 4 courtyard sides and 4 exterior sides. After this information as collected, Appendix E and Table 13 were calculated from the data.

Day	Date	Total	Courtyard East	Courtyard North	Courtyard West	Courtyard South	Streetside North	Streetside East	Streetside West	Streetside South	Streetside Leaveout
Monday	3/10/08	0	0	0	0	0	0	0	0	0	0
Tuesday	3/11/08	0	0	0	0	0	0	0	0	0	0
Wednesday	3/12/08	0	0	0	0	0	0	0	0	0	0
Thursday	3/13/08	0	0	0	0	0	0	0	0	0	0
Friday	3/14/08	0	0	0	0	0	0	0	0	0	0
Saturday	3/15/08	0	0	0	0	0	0	0	0	0	0
Sunday	3/16/08	0	0	0	0	0	0	0	0	0	0
Monday	3/17/08	0	0	0	0	0	0	0	0	0	0
Tuesday	3/18/08	0	0	0	0	0	0	0	0	0	0
Wednesday	3/19/08	0	0	0	0	0	0	0	0	0	0
Thursday	3/20/08	0	0	0	0	0	0	0	0	0	0
Friday	3/21/08	14	0	0	0	0	14	0	0	0	0
Saturday	3/22/08	0	0	0	0	0	0	0	0	0	0
Sunday	3/23/08	0	0	0	0	0	0	0	0	0	0
Monday	3/24/08	15	0	0	0	0	15	0	0	0	0
Tuesday	3/25/08	32	0	0	0	0	32	0	0	0	0
Wednesday	3/26/08	16	0	0	0	0	16	0	0	0	0
Thursday	3/27/08	17	0	0	0	0	17	0	0	0	0
Friday	3/28/08	10	0	0	0	0	10	0	0	0	0
Saturday	3/29/08	0	0	0	0	0	0	0	0	0	0
Sunday	3/30/08	0	0	0	0	0	0	0	0	0	0
Monday	3/31/08	14	0	0	0	0	14	0	0	0	0
Tuesday	4/1/08	31	0	0	0	0	31	0	0	0	0
Wednesday	4/2/08	17	0	0	0	0	17	0	0	0	0
Thursday	4/3/08	17	0	0	0	0	17	0	0	0	0
Friday	4/4/08	25	0	0	0	0	25	0	0	0	0
Saturday	4/5/08	0	0	0	0	0	0	0	0	0	0
Sunday	4/6/08	0	0	0	0	0	0	0	0	0	0
Monday	4/7/08	19	0	0	0	0	19	0	0	0	0
Tuesday	4/8/08	0	0	0	0	0	0	0	0	0	0
Wednesday	4/9/08	0	0	0	0	0	0	0	0	0	0
Thursday	4/10/08	0	0	0	0	0	0	0	0	0	0
Friday	4/11/08	0	0	0	0	0	0	0	0	0	0
Saturday	4/12/08	0	0	0	0	0	0	0	0	0	0
Sunday	4/13/08	0	0	0	0	0	0	0	0	0	0
Monday	4/14/08	20	0	0	0	0	0	20	0	0	0
Tuesday	4/15/08	26	0	0	0	0	0	26	0	0	0
Wednesday	4/16/08	0	0	0	0	0	0	0	0	0	0
Thursday	4/17/08	21	0	0	0	0	0	21	0	0	0
Friday	4/18/08	18	0	0	0	0	0	18	0	0	0
Saturday	4/19/08	17	0	0	0	0	0	17	0	0	0
Sunday	4/20/08	0	0	0	0	0	0	0	0	0	0
Monday	4/21/08	0	0	0	0	0	0	0	0	0	0
Tuesday	4/22/08	23	0	0	0	0	0	23	0	0	0
Wednesday	4/23/08	26	0	0	0	0	0	26	0	0	0
Thursday	4/24/08	37	0	0	0	0	0	37	0	0	0
Friday	4/25/08	21	0	0	0	0	0	21	0	0	0
Saturday	4/26/08	0	0	0	0	0	0	0	0	0	0
Sunday	4/27/08	0	0	0	0	0	0	0	0	0	0
Monday	4/28/08	0	0	0	0	0	0	0	0	0	0
Tuesday	4/29/08	46	0	0	0	0	0	46	0	0	0
Wednesday	4/30/08	26	0	0	0	0	0	26	0	0	0
Thursday	05/01/08	17	0	0	0	0	0	17	0	0	0
Friday	05/02/08	17	0	0	0	0	17	0	0	0	0
Saturday	05/03/08	0	0	0	0	0	0	0	0	0	0
Sunday	05/04/08	0	0	0	0	0	0	0	0	0	0
Monday	05/05/08	14	0	0	0	0	14	0	0	0	0
Tuesday	05/06/08	21	0	0	0	0	21	0	0	0	0
Wednesday	05/07/08	21	0	0	0	0	21	0	0	0	0
Thursday	05/08/08	0	0	0	0	0	0	0	0	0	0
Friday	05/09/08	0	0	0	0	0	0	0	0	0	0
Saturday	05/10/08	0	0	0	0	0	0	0	0	0	0

Day	Date	Total	Courtyard East	Courtyard North	Courtyard West	Courtyard South	Streetside North	Streetside East	Streetside West	Streetside South	Streetside Leaveout
Monday	05/12/08	0	0	0	0	0	0	0	0	0	0
Tuesday	05/13/08	0	0	0	0	0	0	0	0	0	0
Wednesday	05/14/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/15/08	0	0	0	0	0	0	0	0	0	0
Friday	05/16/08	0	0	0	0	0	0	0	0	0	0
Saturday	05/17/08	0	0	0	0	0	0	0	0	0	0
Sunday	05/18/08	0	0	0	0	0	0	0	0	0	0
Monday	05/19/08	0	0	0	0	0	0	0	0	0	0
Tuesday	05/20/08	0	0	0	0	0	0	0	0	0	0
Wednesday	05/21/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/22/08	0	0	0	0	0	0	0	0	0	0
Friday	05/23/08	0	0	0	0	0	0	0	0	0	0
Saturday	05/24/08	0	0	0	0	0	0	0	0	0	0
Sunday	05/25/08	0	0	0	0	0	0	0	0	0	0
Monday	05/26/08	0	0	0	0	0	0	0	0	0	0
Tuesday	05/27/08	0	0	0	0	0	0	0	0	0	0
Wednesday	05/28/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/29/08	0	0	0	0	0	0	0	0	0	0
Friday	05/30/08	8	8	0	0	0	0	0	0	0	0
Saturday	05/31/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/01/08	0	0	0	0	0	0	0	0	0	0
Monday	06/02/08	9	9	0	0	0	0	0	0	0	0
Tuesday	06/03/08	22	22	0	0	0	0	0	0	0	0
Wednesday	06/04/08	18	18	0	0	0	0	0	0	0	0
Thursday	06/05/08	12	12	0	0	0	0	0	0	0	0
Friday	06/06/08	28	28	0	0	0	0	0	0	0	0
Saturday	06/07/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/08/08	0	0	0	0	0	0	0	0	0	0
Monday	06/09/08	35	35	0	0	0	0	0	0	0	0
Tuesday	06/10/08	30	28	0	0	0	2	0	0	0	0
Wednesday	06/11/08	25	20	0	0	0	5	0	0	0	0
Thursday	06/12/08	34	30	0	0	0	4	0	0	0	0
Friday	06/13/08	20	20	0	0	0	0	0	0	0	0
Saturday	06/14/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/15/08	0	0	0	0	0	0	0	0	0	0
Monday	06/16/08	26	26	0	0	0	0	0	0	0	0
Tuesday	06/17/08	34	34	0	0	0	0	0	0	0	0
Wednesday	06/18/08	30	30	0	0	0	0	0	0	0	0
Thursday	06/19/08	30	30	0	0	0	0	0	0	0	0
Friday	06/20/08	1	1	0	0	0	0	0	0	0	0
Saturday	06/21/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/22/08	0	0	0	0	0	0	0	0	0	0
Monday	06/23/08	32	30	0	0	0	2	0	0	0	0
Tuesday	06/24/08	25	0	0	0	0	25	0	0	0	0
Wednesday	06/25/08	13	0	0	0	0	13	0	0	0	0
Thursday	06/26/08	8	0	0	0	0	8	0	0	0	0
Friday	06/27/08	47	0	0	0	0	47	0	0	0	0
Saturday	06/28/08	14	0	0	0	0	14	0	0	0	0
Sunday	06/29/08	0	0	0	0	0	0	0	0	0	0
Monday	06/30/08	0	0	0	0	0	0	0	0	0	0
Tuesday	07/01/08	0	0	0	0	0	0	0	0	0	0
Wednesday	07/02/08	0	0	0	0	0	0	0	0	0	0
Thursday	07/03/08	0	0	0	0	0	0	0	0	0	0
Friday	07/04/08	0	0	0	0	0	0	0	0	0	0
Saturday	07/05/08	0	0	0	0	0	0	0	0	0	0
Sunday	07/06/08	0	0	0	0	0	0	0	0	0	0
Monday	07/07/08	6	0	0	0	0	6	0	0	0	0
Tuesday	07/08/08	0	0	0	0	0	0	0	0	0	0
Wednesday	07/09/08	0	0	0	0	0	0	0	0	0	0
Thursday	07/10/08	8	0	0	0	0	8	0	0	0	0
Friday	07/11/08	14	0	0	0	0	14	0	0	0	0
Saturday	07/12/08	0	0	0	0	0	0	0	0	0	0
Sunday	07/13/08	0	0	0	0	0	0	0	0	0	0
Monday	07/14/08	11	0	11	0	0	0	0	0	0	0
Tuesday	07/15/08	28	0	28	0	0	0	0	0	0	0
Wednesday	07/16/08	37	0	33	0	0	4	0	0	0	0
Thursday	07/17/08	42	0	42	0	0	0	0	0	0	0
Friday	07/18/08	50	0	50	0	0	0	0	0	0	0
Saturday	07/19/08	8	0	0	0	0	8	0	0	0	0
Sunday	07/20/08	0	0	0	0	0	0	0	0	0	0
Monday	07/21/08	55	0	55	0	0	0	0	0	0	0
Tuesday	07/22/08	41	8	16	0	0	7	10	0	0	0

Day	Date	Total	Courtyard East	Courtyard North	Courtyard West	Courtyard South	Streetside North	Streetside East	Streetside West	Streetside South	Streetside Leaveout
Thursday	07/24/08	40	12	15	0	0	6	7	0	0	0
Friday	07/25/08	67	18	33	0	0	11	5	0	0	0
Saturday	07/26/08	14	0	0	0	0	14	0	0	0	0
Sunday	07/27/08	0	0	0	0	0	0	0	0	0	0
Monday	07/28/08	46	0	19	0	0	15	12	0	0	0
Tuesday	07/29/08	40	0	13	0	0	13	14	0	0	0
Wednesday	07/30/08	38	0	27	0	0	0	11	0	0	0
Thursday	07/31/08	30	14	3	0	0	0	13	0	0	0
Friday	08/01/08	0	0	0	0	0	0	0	0	0	0
Saturday	08/02/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/03/08	0	0	0	0	0	0	0	0	0	0
Monday	08/04/08	0	0	0	0	0	0	0	0	0	0
Tuesday	08/05/08	0	0	0	0	0	0	0	0	0	0
Wednesday	08/06/08	0	0	0	0	0	0	0	0	0	0
Thursday	08/07/08	5	0	0	0	0	5	0	0	0	0
Friday	08/08/08	22	0	0	0	0	0	22	0	0	0
Saturday	08/09/08	12	0	0	0	0	0	12	0	0	0
Sunday	08/10/08	8	0	0	0	0	0	8	0	0	0
Monday	08/11/08	0	0	0	0	0	0	0	0	0	0
Tuesday	08/12/08	5	0	0	0	0	0	0	5	0	0
Wednesday	08/13/08	10	0	0	0	0	0	10	0	0	0
Thursday	08/14/08	11	0	0	0	0	0	11	0	0	0
Friday	08/15/08	7	0	0	0	0	0	7	0	0	0
Saturday	08/16/08	6	0	0	0	0	0	6	0	0	0
Sunday	08/17/08	0	0	0	0	0	0	0	0	0	0
Monday	08/18/08	48	0	0	0	0	0	0	48	0	0
Tuesday	08/19/08	45	0	0	0	0	0	0	45	0	0
Wednesday	08/20/08	38	0	0	0	0	0	0	38	0	0
Thursday	08/21/08	16	0	0	0	0	0	0	16	0	0
Friday	08/22/08	27	0	0	0	0	0	0	27	0	0
Saturday	08/23/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/24/08	0	0	0	0	0	0	0	0	0	0
Monday	08/25/08	6	0	4	0	0	0	2	0	0	0
Tuesday	08/26/08	31	0	31	0	0	0	0	0	0	0
Wednesday	08/27/08	32	4	20	0	0	0	8	0	0	0
Thursday	08/28/08	22	15	0	0	0	0	7	0	0	0
Friday	08/29/08	36	36	0	0	0	0	0	0	0	0
Saturday	08/30/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/31/08	0	0	0	0	0	0	0	0	0	0
Monday	09/01/08	0	0	0	0	0	0	0	0	0	0
Tuesday	09/02/08	20	0	0	0	0	0	3	17	0	0
Wednesday	09/03/08	51	0	0	0	0	0	16	35	0	0
Thursday	09/04/08	40	0	0	0	0	0	11	29	0	0
Friday	09/05/08	40	0	0	0	0	0	16	24	0	0
Saturday	09/06/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/07/08	0	0	0	0	0	0	0	0	0	0
Monday	09/08/08	52	0	0	0	0	0	9	43	0	0
Tuesday	09/09/08	17	0	0	0	0	0	0	17	0	0
Wednesday	09/10/08	19	0	19	0	0	0	0	0	0	0
Thursday	09/11/08	24	0	10	0	0	0	0	14	0	0
Friday	09/12/08	44	0	26	0	0	0	0	18	0	0
Saturday	09/13/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/14/08	0	0	0	0	0	0	0	0	0	0
Monday	09/15/08	0	0	0	0	0	0	0	0	0	0
Tuesday	09/16/08	0	0	0	0	0	0	0	0	0	0
Wednesday	09/17/08	0	0	0	0	0	0	0	0	0	0
Thursday	09/18/08	0	0	0	0	0	0	0	0	0	0
Friday	09/19/08	0	0	0	0	0	0	0	0	0	0
Saturday	09/20/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/21/08	0	0	0	0	0	0	0	0	0	0
Monday	09/22/08	12	0	0	12	0	0	0	0	0	0
Tuesday	09/23/08	31	0	0	31	0	0	0	0	0	0
Wednesday	09/24/08	36	0	0	36	0	0	0	0	0	0
Thursday	09/25/08	45	0	0	45	0	0	0	0	0	0
Friday	09/26/08	42	0	0	42	0	0	0	0	0	0
Saturday	09/27/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/28/08	0	0	0	0	0	0	0	0	0	0
Monday	09/29/08	42	0	0	42	0	0	0	0	0	0
Tuesday	09/30/08	42	0	0	42	0	0	0	0	0	0
Wednesday	10/01/08	34	0	0	34	0	0	0	0	0	0
Thursday	10/02/08	12	0	0	9	0	0	3	0	0	0
Friday	10/03/08	44	0	2	42	0	0	0	0	0	0

Day	Date	Total	Courtyard East	Courtyard North	Courtyard West	Courtyard South	Streetside North	Streetside East	Streetside West	Streetside South	Streetside Leaveout
Sunday	10/05/08	0	0	0	0	0	0	0	0	0	0
Monday	10/06/08	6	0	0	0	0	6	0	0	0	0
Tuesday	10/07/08	2	0	0	0	0	2	0	0	0	0
Wednesday	10/08/08	8	0	0	0	0	8	0	0	0	0
Thursday	10/09/08	0	0	0	0	0	0	0	0	0	0
Friday	10/10/08	0	0	0	0	0	0	0	0	0	0
Saturday	10/11/08	0	0	0	0	0	0	0	0	0	0
Sunday	10/12/08	0	0	0	0	0	0	0	0	0	0
Monday	10/13/08	3	0	0	0	3	0	0	0	0	0
Tuesday	10/14/08	0	0	0	0	0	0	0	0	0	0
Wednesday	10/15/08	0	0	0	0	0	0	0	0	0	0
Thursday	10/16/08	0	0	0	0	0	0	0	0	0	0
Friday	10/17/08	0	0	0	0	0	0	0	0	0	0
Saturday	10/18/08	0	0	0	0	0	0	0	0	0	0
Sunday	10/19/08	0	0	0	0	0	0	0	0	0	0
Monday	10/20/08	16	0	0	0	0	0	5	6	0	5
Tuesday	10/21/08	22	0	0	0	0	0	0	9	0	13
Wednesday	10/22/08	39	0	0	0	0	0	5	5	0	29
Thursday	10/23/08	8	0	0	0	0	0	0	0	0	8
Friday	10/24/08	15	0	0	12	0	0	0	3	0	0
Saturday	10/25/08	12	0	0	12	0	0	0	0	0	0
Sunday	10/26/08	1	0	0	1	0	0	0	0	0	0
Monday	10/27/08	7	0	0	0	0	0	0	0	0	7
Tuesday	10/28/08	26	0	0	14	0	0	0	4	0	8
Wednesday	10/29/08	38	0	0	14	0	0	0	0	0	24
Thursday	10/30/08	30	0	0	14	0	0	0	0	0	16
Friday	10/31/08	29	0	0	26	0	0	0	3	0	0
Saturday	11/01/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/02/08	0	0	0	0	0	0	0	0	0	0
Monday	11/03/08	20	0	0	12	0	0	0	8	0	0
Tuesday	11/04/08	18	0	0	0	11	0	0	7	0	0
Wednesday	11/05/08	30	0	0	0	20	0	0	10	0	0
Thursday	11/06/08	47	0	0	0	38	0	0	9	0	0
Friday	11/07/08	29	0	0	0	21	0	0	8	0	0
Saturday	11/08/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/09/08	0	0	0	0	0	0	0	0	0	0
Monday	11/10/08	55	0	0	0	50	0	0	5	0	0
Tuesday	11/11/08	0	0	0	0	0	0	0	0	0	0
Wednesday	11/12/08	22	0	0	0	18	0	0	4	0	0
Thursday	11/13/08	16	0	0	0	10	0	0	6	0	0
Friday	11/14/08	47	0	0	0	40	0	0	7	0	0
Saturday	11/15/08	5	0	0	0	0	0	0	5	0	0
Sunday	11/16/08	0	0	0	0	0	0	0	0	0	0
Monday	11/17/08	59	0	0	0	45	0	4	10	0	0
Tuesday	11/18/08	54	0	0	0	45	0	0	9	0	0
Wednesday	11/19/08	34	0	0	0	24	0	0	10	0	0
Thursday	11/20/08	64	0	0	0	58	0	0	6	0	0
Friday	11/21/08	46	0	0	0	35	0	0	11	0	0
Saturday	11/22/08	22	0	0	0	0	0	0	22	0	0
Sunday	11/23/08	0	0	0	0	0	0	0	0	0	0
Monday	11/24/08	20	0	0	16	0	0	4	0	0	0
Tuesday	11/25/08	20	0	0	20	0	0	0	0	0	0
Wednesday	11/26/08	18	0	0	18	0	0	0	0	0	0
Thursday	11/27/08	0	0	0	0	0	0	0	0	0	0
Friday	11/28/08	0	0	0	0	0	0	0	0	0	0
Saturday	11/29/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/30/08	0	0	0	0	0	0	0	0	0	0
Monday	12/01/08	0	0	0	0	0	0	0	0	0	0
Tuesday	12/02/08	13	0	0	0	0	0	4	9	0	0
Wednesday	12/03/08	8	0	0	0	0	0	0	8	0	0
Thursday	12/04/08	5	0	0	0	0	0	0	0	0	0
Friday	12/05/08	15	0	0	0	3	0	0	0	0	0
Saturday	12/06/08	0	0	0	0	0	0	0	0	0	0
Sunday	12/07/08	0	0	0	0	0	0	0	0	0	0
Monday	12/08/08	0	0	0	0	0	0	0	0	0	0
Tuesday	12/09/08	1	0	0	0	0	0	0	0	0	0
Wednesday	12/10/08	24	0	0	0	18	0	0	0	0	0
Thursday	12/11/08	25	0	0	0	25	0	0	0	0	0
Friday	12/12/08	12	0	0	0	10	0	0	0	0	0
Saturday	12/13/08	0	0	0	0	0	0	0	0	0	0
Sunday	12/14/08	0	0	0	0	0	0	0	0	0	0
Monday	12/15/08	8	0	0	0	0	0	0	0	0	0

Day	Date	Total	Courtyard East	Courtyard North	Courtyard West	Courtyard South	Streetside North	Streetside East	Streetside West	Streetside South	Streetside Leaveout
Wednesday	12/17/08	5	0	0	0	0	0	0	0	0	0
Thursday	12/18/08	5	0	0	0	0	0	0	0	0	0
Friday	12/19/08	17	0	0	0	0	0	0	0	14	0
Saturday	12/20/08	20	0	0	0	0	0	0	0	14	0
Sunday	12/21/08	0	0	0	0	0	0	0	0	0	0
Monday	12/22/08	16	0	0	0	0	0	0	0	8	0
Tuesday	12/23/08	14	0	0	0	0	0	0	0	8	0
Wednesday	12/24/08	4	0	0	0	0	0	0	0	4	0
Thursday	12/25/08	0	0	0	0	0	0	0	0	0	0
Friday	12/26/08	0	0	0	0	0	0	0	0	0	0
Saturday	12/27/08	0	0	0	0	0	0	0	0	0	0
Sunday	12/28/08	0	0	0	0	0	0	0	0	0	0
Monday	12/29/08	1	0	0	0	0	0	0	0	0	0
Tuesday	12/30/08	19	0	0	0	0	0	0	0	10	0
Wednesday	12/31/08	19	0	0	0	0	0	0	0	16	0
Thursday	01/01/09	0	0	0	0	0	0	0	0	0	0
Friday	01/02/09	24	0	0	0	0	0	0	0	24	0
Saturday	01/03/09	33	0	0	0	0	0	0	0	24	0
Sunday	01/04/09	0	0	0	0	0	0	0	0	0	0
Monday	01/05/09	28	0	0	0	0	0	0	0	28	0
Tuesday	01/06/09	28	0	0	0	0	0	0	0	28	0
Wednesday	01/07/09	14	0	0	0	0	0	0	0	14	0
Thursday	01/08/09	58	0	0	0	0	0	0	0	58	0
Friday	01/09/09	0	0	0	0	0	0	0	0	0	0
Saturday	01/10/09	34	0	0	0	0	0	0	0	34	0
Sunday	01/11/09	0	0	0	0	0	0	0	0	0	0
Monday	01/12/09	0	0	0	0	0	0	0	0	0	0
Tuesday	01/13/09	24	0	0	0	0	0	0	0	24	0
Wednesday	01/14/09	62	0	0	0	0	0	0	0	58	0
Thursday	01/15/09	18	0	0	0	0	0	0	0	10	0
Friday	01/16/09	9	0	0	0	0	0	0	0	6	0
Saturday	01/17/09	0	0	0	0	0	0	0	0	0	0
Sunday	01/18/09	0	0	0	0	0	0	0	0	0	0
Monday	01/19/09	0	0	0	0	0	0	0	0	0	0
Tuesday	01/20/09	0	0	0	0	0	0	0	0	0	0
Wednesday	01/21/09	17	0	0	0	0	0	0	0	12	0
Thursday	01/22/09	13	0	0	0	0	0	0	0	8	0
Friday	01/23/09	13	0	0	0	0	0	0	0	12	0
Saturday	01/24/09	8	0	0	0	0	0	0	0	8	0
Sunday	01/25/09	0	0	0	0	0	0	0	0	0	0
Monday	01/26/09	14	0	0	0	0	0	0	0	14	0
Tuesday	01/27/09	8	0	0	0	0	0	0	0	8	0
Wednesday	01/28/09	20	0	0	0	0	0	0	0	20	0
Thursday	01/29/09	14	0	0	0	0	0	0	0	12	0
Friday	01/30/09	12	0	0	0	0	0	0	0	12	0
Saturday	01/31/09	12	0	0	0	0	0	0	0	12	0
Actual Total		4367	494	496	494	474	560	560	560	500	110
Estimated Total		4851	494	496	494	474	560	560	560	560	222

APPENDIX D: STOREFRONT CURTAIN WALL PANEL INSTALLATION

The information below was provided by Enclos in order to calculate the curtain wall installation productivity. As one can see, the storefront curtain wall was divided into 10 different sections. After this information as collected, Appendix E and Table 13 were calculated from the data.

Day	Date	Storefront Metro	Storefront Courtyard North	Storefront Streetside North	Storefront Courtyard East	Storefront Streetside East	Storefront Courtyard West	Storefront Streetside West	Storefront West Entrance	Storefront Courtyard South	Storefront Streetside South
Monday	3/10/08	0	0	0	0	0	0	0	0	0	0
Tuesday	3/11/08	0	0	0	0	0	0	0	0	0	0
Wednesday	3/12/08	0	0	0	0	0	0	0	0	0	0
Thursday	3/13/08	0	0	0	0	0	0	0	0	0	0
Friday	3/14/08	0	0	0	0	0	0	0	0	0	0
Saturday	3/15/08	0	0	0	0	0	0	0	0	0	0
Sunday	3/16/08	0	0	0	0	0	0	0	0	0	0
Monday	3/17/08	0	0	0	0	0	0	0	0	0	0
Tuesday	3/18/08	0	0	0	0	0	0	0	0	0	0
Wednesday	3/19/08	0	0	0	0	0	0	0	0	0	0
Thursday	3/20/08	0	0	0	0	0	0	0	0	0	0
Friday	3/21/08	0	0	0	0	0	0	0	0	0	0
Saturday	3/22/08	0	0	0	0	0	0	0	0	0	0
Sunday	3/23/08	0	0	0	0	0	0	0	0	0	0
Monday	3/24/08	0	0	0	0	0	0	0	0	0	0
Tuesday	3/25/08	0	0	0	0	0	0	0	0	0	0
Wednesday	3/26/08	0	0	0	0	0	0	0	0	0	0
Thursday	3/27/08	0	0	0	0	0	0	0	0	0	0
Friday	3/28/08	0	0	0	0	0	0	0	0	0	0
Saturday	3/29/08	0	0	0	0	0	0	0	0	0	0
Sunday	3/30/08	0	0	0	0	0	0	0	0	0	0
Monday	3/31/08	0	0	0	0	0	0	0	0	0	0
Tuesday	4/1/08	0	0	0	0	0	0	0	0	0	0
Wednesday	4/2/08	0	0	0	0	0	0	0	0	0	0
Thursday	4/3/08	0	0	0	0	0	0	0	0	0	0
Friday	4/4/08	0	0	0	0	0	0	0	0	0	0
Saturday	4/5/08	0	0	0	0	0	0	0	0	0	0
Sunday	4/6/08	0	0	0	0	0	0	0	0	0	0
Monday	4/7/08	0	0	0	0	0	0	0	0	0	0
Tuesday	4/8/08	0	0	0	0	0	0	0	0	0	0
Wednesday	4/9/08	0	0	0	0	0	0	0	0	0	0
Thursday	4/10/08	0	0	0	0	0	0	0	0	0	0
Friday	4/11/08	0	0	0	0	0	0	0	0	0	0
Saturday	4/12/08	0	0	0	0	0	0	0	0	0	0
Sunday	4/13/08	0	0	0	0	0	0	0	0	0	0
Monday	4/14/08	0	0	0	0	0	0	0	0	0	0
Tuesday	4/15/08	0	0	0	0	0	0	0	0	0	0
Wednesday	4/16/08	0	0	0	0	0	0	0	0	0	0
Thursday	4/17/08	0	0	0	0	0	0	0	0	0	0
Friday	4/18/08	0	0	0	0	0	0	0	0	0	0
Saturday	4/19/08	0	0	0	0	0	0	0	0	0	0
Sunday	4/20/08	0	0	0	0	0	0	0	0	0	0
Monday	4/21/08	0	0	0	0	0	0	0	0	0	0
Tuesday	4/22/08	0	0	0	0	0	0	0	0	0	0
Wednesday	4/23/08	0	0	0	0	0	0	0	0	0	0
Thursday	4/24/08	0	0	0	0	0	0	0	0	0	0
Friday	4/25/08	0	0	0	0	0	0	0	0	0	0
Saturday	4/26/08	0	0	0	0	0	0	0	0	0	0
Sunday	4/27/08	0	0	0	0	0	0	0	0	0	0
Monday	4/28/08	0	0	0	0	0	0	0	0	0	0
Tuesday	4/29/08	0	0	0	0	0	0	0	0	0	0
Wednesday	4/30/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/01/08	0	0	0	0	0	0	0	0	0	0
Friday	05/02/08	0	0	0	0	0	0	0	0	0	0
Saturday	05/03/08	0	0	0	0	0	0	0	0	0	0
Sunday	05/04/08	0	0	0	0	0	0	0	0	0	0
Monday	05/05/08	0	0	0	0	0	0	0	0	0	0
Tuesday	05/06/08	0	0	0	0	0	0	0	0	0	0
Wednesday	05/07/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/08/08	0	0	0	0	0	0	0	0	0	0
Friday	05/09/08	0	0	0	0	0	0	0	0	0	0

Day	Date	Storefront Metro	Storefront Courtyard North	Storefront Streetside North	Storefront Courtyard East	Storefront Streetside East	Storefront Courtyard West	Storefront Streetside West	Storefront West Entrance	Storefront Courtyard South	Storefront Streetside South
Sunday	05/11/08	0	0	0	0	0	0	0	0	0	0
Monday	05/12/08	0	0	0	0	0	0	0	0	0	0
Tuesday	05/13/08	0	0	0	0	0	0	0	0	0	0
Wednesday	05/14/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/15/08	0	0	0	0	0	0	0	0	0	0
Friday	05/16/08	0	0	0	0	0	0	0	0	0	0
Saturday	05/17/08	0	0	0	0	0	0	0	0	0	0
Sunday	05/18/08	0	0	0	0	0	0	0	0	0	0
Monday	05/19/08	0	0	0	0	0	0	0	0	0	0
Tuesday	05/20/08	0	0	0	0	0	0	0	0	0	0
Wednesday	05/21/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/22/08	0	0	0	0	0	0	0	0	0	0
Friday	05/23/08	0	0	0	0	0	0	0	0	0	0
Saturday	05/24/08	0	0	0	0	0	0	0	0	0	0
Sunday	05/25/08	0	0	0	0	0	0	0	0	0	0
Monday	05/26/08	0	0	0	0	0	0	0	0	0	0
Tuesday	05/27/08	0	0	0	0	0	0	0	0	0	0
Wednesday	05/28/08	0	0	0	0	0	0	0	0	0	0
Thursday	05/29/08	0	0	0	0	0	0	0	0	0	0
Friday	05/30/08	0	0	0	0	0	0	0	0	0	0
Saturday	05/31/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/01/08	0	0	0	0	0	0	0	0	0	0
Monday	06/02/08	0	0	0	0	0	0	0	0	0	0
Tuesday	06/03/08	0	0	0	0	0	0	0	0	0	0
Wednesday	06/04/08	0	0	0	0	0	0	0	0	0	0
Thursday	06/05/08	0	0	0	0	0	0	0	0	0	0
Friday	06/06/08	0	0	0	0	0	0	0	0	0	0
Saturday	06/07/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/08/08	0	0	0	0	0	0	0	0	0	0
Monday	06/09/08	0	0	0	0	0	0	0	0	0	0
Tuesday	06/10/08	0	0	0	0	0	0	0	0	0	0
Wednesday	06/11/08	0	0	0	0	0	0	0	0	0	0
Thursday	06/12/08	0	0	0	0	0	0	0	0	0	0
Friday	06/13/08	0	0	0	0	0	0	0	0	0	0
Saturday	06/14/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/15/08	0	0	0	0	0	0	0	0	0	0
Monday	06/16/08	0	0	0	0	0	0	0	0	0	0
Tuesday	06/17/08	0	0	0	0	0	0	0	0	0	0
Wednesday	06/18/08	0	0	0	0	0	0	0	0	0	0
Thursday	06/19/08	0	0	0	0	0	0	0	0	0	0
Friday	06/20/08	0	0	0	0	0	0	0	0	0	0
Saturday	06/21/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/22/08	0	0	0	0	0	0	0	0	0	0
Monday	06/23/08	0	0	0	0	0	0	0	0	0	0
Tuesday	06/24/08	0	0	0	0	0	0	0	0	0	0
Wednesday	06/25/08	0	0	0	0	0	0	0	0	0	0
Thursday	06/26/08	0	0	0	0	0	0	0	0	0	0
Friday	06/27/08	0	0	0	0	0	0	0	0	0	0
Saturday	06/28/08	0	0	0	0	0	0	0	0	0	0
Sunday	06/29/08	0	0	0	0	0	0	0	0	0	0
Monday	06/30/08	0	0	0	0	0	0	0	0	0	0
Tuesday	07/01/08	0	0	0	0	0	0	0	0	0	0
Wednesday	07/02/08	0	0	0	0	0	0	0	0	0	0
Thursday	07/03/08	0	0	0	0	0	0	0	0	0	0
Friday	07/04/08	0	0	0	0	0	0	0	0	0	0
Saturday	07/05/08	0	0	0	0	0	0	0	0	0	0
Sunday	07/06/08	0	0	0	0	0	0	0	0	0	0
Monday	07/07/08	0	0	0	0	0	0	0	0	0	0
Tuesday	07/08/08	0	0	0	0	0	0	0	0	0	0
Wednesday	07/09/08	0	0	0	0	0	0	0	0	0	0
Thursday	07/10/08	0	0	0	0	0	0	0	0	0	0
Friday	07/11/08	0	0	0	0	0	0	0	0	0	0
Saturday	07/12/08	0	0	0	0	0	0	0	0	0	0
Sunday	07/13/08	0	0	0	0	0	0	0	0	0	0
Monday	07/14/08	0	0	0	0	0	0	0	0	0	0
Tuesday	07/15/08	0	0	0	0	0	0	0	0	0	0
Wednesday	07/16/08	0	0	0	0	0	0	0	0	0	0
Thursday	07/17/08	0	0	0	0	0	0	0	0	0	0
Friday	07/18/08	0	0	0	0	0	0	0	0	0	0
Saturday	07/19/08	0	0	0	0	0	0	0	0	0	0
Sunday	07/20/08	0	0	0	0	0	0	0	0	0	0

Day	Date	Storefront Metro	Storefront Courtyard North	Storefront Streetside North	Storefront Courtyard East	Storefront Streetside East	Storefront Courtyard West	Storefront Streetside West	Storefront West Entrance	Storefront Courtyard South	Storefront Streetside South
Tuesday	07/22/08	0	0	0	0	0	0	0	0	0	0
Wednesday	07/23/08	0	0	0	0	0	0	0	0	0	0
Thursday	07/24/08	0	0	0	0	0	0	0	0	0	0
Friday	07/25/08	0	0	0	0	0	0	0	0	0	0
Saturday	07/26/08	0	0	0	0	0	0	0	0	0	0
Sunday	07/27/08	0	0	0	0	0	0	0	0	0	0
Monday	07/28/08	0	0	0	0	0	0	0	0	0	0
Tuesday	07/29/08	0	0	0	0	0	0	0	0	0	0
Wednesday	07/30/08	0	0	0	0	0	0	0	0	0	0
Thursday	07/31/08	0	0	0	0	0	0	0	0	0	0
Friday	08/01/08	0	0	0	0	0	0	0	0	0	0
Saturday	08/02/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/03/08	0	0	0	0	0	0	0	0	0	0
Monday	08/04/08	0	0	0	0	0	0	0	0	0	0
Tuesday	08/05/08	0	0	0	0	0	0	0	0	0	0
Wednesday	08/06/08	0	0	0	0	0	0	0	0	0	0
Thursday	08/07/08	0	0	0	0	0	0	0	0	0	0
Friday	08/08/08	0	0	0	0	0	0	0	0	0	0
Saturday	08/09/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/10/08	0	0	0	0	0	0	0	0	0	0
Monday	08/11/08	0	0	0	0	0	0	0	0	0	0
Tuesday	08/12/08	0	0	0	0	0	0	0	0	0	0
Wednesday	08/13/08	0	0	0	0	0	0	0	0	0	0
Thursday	08/14/08	0	0	0	0	0	0	0	0	0	0
Friday	08/15/08	0	0	0	0	0	0	0	0	0	0
Saturday	08/16/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/17/08	0	0	0	0	0	0	0	0	0	0
Monday	08/18/08	0	0	0	0	0	0	0	0	0	0
Tuesday	08/19/08	0	0	0	0	0	0	0	0	0	0
Wednesday	08/20/08	0	0	0	0	0	0	0	0	0	0
Thursday	08/21/08	0	0	0	0	0	0	0	0	0	0
Friday	08/22/08	0	0	0	0	0	0	0	0	0	0
Saturday	08/23/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/24/08	0	0	0	0	0	0	0	0	0	0
Monday	08/25/08	0	0	0	0	0	0	0	0	0	0
Tuesday	08/26/08	0	0	0	0	0	0	0	0	0	0
Wednesday	08/27/08	0	0	0	0	0	0	0	0	0	0
Thursday	08/28/08	0	0	0	0	0	0	0	0	0	0
Friday	08/29/08	0	0	0	0	0	0	0	0	0	0
Saturday	08/30/08	0	0	0	0	0	0	0	0	0	0
Sunday	08/31/08	0	0	0	0	0	0	0	0	0	0
Monday	09/01/08	0	0	0	0	0	0	0	0	0	0
Tuesday	09/02/08	0	0	0	0	0	0	0	0	0	0
Wednesday	09/03/08	0	0	0	0	0	0	0	0	0	0
Thursday	09/04/08	0	0	0	0	0	0	0	0	0	0
Friday	09/05/08	0	0	0	0	0	0	0	0	0	0
Saturday	09/06/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/07/08	0	0	0	0	0	0	0	0	0	0
Monday	09/08/08	0	0	0	0	0	0	0	0	0	0
Tuesday	09/09/08	0	0	0	0	0	0	0	0	0	0
Wednesday	09/10/08	0	0	0	0	0	0	0	0	0	0
Thursday	09/11/08	0	0	0	0	0	0	0	0	0	0
Friday	09/12/08	0	0	0	0	0	0	0	0	0	0
Saturday	09/13/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/14/08	0	0	0	0	0	0	0	0	0	0
Monday	09/15/08	0	0	0	0	0	0	0	0	0	0
Tuesday	09/16/08	0	0	0	0	0	0	0	0	0	0
Wednesday	09/17/08	0	0	0	0	0	0	0	0	0	0
Thursday	09/18/08	0	0	0	0	0	0	0	0	0	0
Friday	09/19/08	0	0	0	0	0	0	0	0	0	0
Saturday	09/20/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/21/08	0	0	0	0	0	0	0	0	0	0
Monday	09/22/08	0	0	0	0	0	0	0	0	0	0
Tuesday	09/23/08	0	0	0	0	0	0	0	0	0	0
Wednesday	09/24/08	0	0	0	0	0	0	0	0	0	0
Thursday	09/25/08	0	0	0	0	0	0	0	0	0	0
Friday	09/26/08	0	0	0	0	0	0	0	0	0	0
Saturday	09/27/08	0	0	0	0	0	0	0	0	0	0
Sunday	09/28/08	0	0	0	0	0	0	0	0	0	0
Monday	09/29/08	0	0	0	0	0	0	0	0	0	0
Tuesday	09/30/08	0	0	0	0	0	0	0	0	0	0

Day	Date	Storefront Metro	Storefront Courtyard North	Storefront Streetside North	Storefront Courtyard East	Storefront Streetside East	Storefront Courtyard West	Storefront Streetside West	Storefront West Entrance	Storefront Courtyard South	Storefront Streetside South
Thursday	10/02/08	0	0	0	0	0	0	0	0	0	0
Friday	10/03/08	0	0	0	0	0	0	0	0	0	0
Saturday	10/04/08	0	0	0	0	0	0	0	0	0	0
Sunday	10/05/08	0	0	0	0	0	0	0	0	0	0
Monday	10/06/08	0	0	0	0	0	0	0	0	0	0
Tuesday	10/07/08	0	0	0	0	0	0	0	0	0	0
Wednesday	10/08/08	0	0	0	0	0	0	0	0	0	0
Thursday	10/09/08	0	0	0	0	0	0	0	0	0	0
Friday	10/10/08	0	0	0	0	0	0	0	0	0	0
Saturday	10/11/08	0	0	0	0	0	0	0	0	0	0
Sunday	10/12/08	0	0	0	0	0	0	0	0	0	0
Monday	10/13/08	0	0	0	0	0	0	0	0	0	0
Tuesday	10/14/08	0	0	0	0	0	0	0	0	0	0
Wednesday	10/15/08	0	0	0	0	0	0	0	0	0	0
Thursday	10/16/08	0	0	0	0	0	0	0	0	0	0
Friday	10/17/08	0	0	0	0	0	0	0	0	0	0
Saturday	10/18/08	0	0	0	0	0	0	0	0	0	0
Sunday	10/19/08	0	0	0	0	0	0	0	0	0	0
Monday	10/20/08	0	0	0	0	0	0	0	0	0	0
Tuesday	10/21/08	0	0	0	0	0	0	0	0	0	0
Wednesday	10/22/08	0	0	0	0	0	0	0	0	0	0
Thursday	10/23/08	0	0	0	0	0	0	0	0	0	0
Friday	10/24/08	0	0	0	0	0	0	0	0	0	0
Saturday	10/25/08	0	0	0	0	0	0	0	0	0	0
Sunday	10/26/08	0	0	0	0	0	0	0	0	0	0
Monday	10/27/08	0	0	0	0	0	0	0	0	0	0
Tuesday	10/28/08	0	0	0	0	0	0	0	0	0	0
Wednesday	10/29/08	0	0	0	0	0	0	0	0	0	0
Thursday	10/30/08	0	0	0	0	0	0	0	0	0	0
Friday	10/31/08	0	0	0	0	0	0	0	0	0	0
Saturday	11/01/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/02/08	0	0	0	0	0	0	0	0	0	0
Monday	11/03/08	0	0	0	0	0	0	0	0	0	0
Tuesday	11/04/08	0	0	0	0	0	0	0	0	0	0
Wednesday	11/05/08	0	0	0	0	0	0	0	0	0	0
Thursday	11/06/08	0	0	0	0	0	0	0	0	0	0
Friday	11/07/08	0	0	0	0	0	0	0	0	0	0
Saturday	11/08/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/09/08	0	0	0	0	0	0	0	0	0	0
Monday	11/10/08	0	0	0	0	0	0	0	0	0	0
Tuesday	11/11/08	0	0	0	0	0	0	0	0	0	0
Wednesday	11/12/08	0	0	0	0	0	0	0	0	0	0
Thursday	11/13/08	0	0	0	0	0	0	0	0	0	0
Friday	11/14/08	0	0	0	0	0	0	0	0	0	0
Saturday	11/15/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/16/08	0	0	0	0	0	0	0	0	0	0
Monday	11/17/08	0	0	0	0	0	0	0	0	0	0
Tuesday	11/18/08	0	0	0	0	0	0	0	0	0	0
Wednesday	11/19/08	0	0	0	0	0	0	0	0	0	0
Thursday	11/20/08	0	0	0	0	0	0	0	0	0	0
Friday	11/21/08	0	0	0	0	0	0	0	0	0	0
Saturday	11/22/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/23/08	0	0	0	0	0	0	0	0	0	0
Monday	11/24/08	0	0	0	0	0	0	0	0	0	0
Tuesday	11/25/08	0	0	0	0	0	0	0	0	0	0
Wednesday	11/26/08	0	0	0	0	0	0	0	0	0	0
Thursday	11/27/08	0	0	0	0	0	0	0	0	0	0
Friday	11/28/08	0	0	0	0	0	0	0	0	0	0
Saturday	11/29/08	0	0	0	0	0	0	0	0	0	0
Sunday	11/30/08	0	0	0	0	0	0	0	0	0	0
Monday	12/01/08	0	0	0	0	0	0	0	0	0	0
Tuesday	12/02/08	0	0	0	0	0	0	0	0	0	0
Wednesday	12/03/08	0	0	0	0	0	0	0	0	0	0
Thursday	12/04/08	0	5	0	0	0	0	0	0	0	0
Friday	12/05/08	0	12	0	0	0	0	0	0	0	0
Saturday	12/06/08	0	0	0	0	0	0	0	0	0	0
Sunday	12/07/08	0	0	0	0	0	0	0	0	0	0
Monday	12/08/08	0	0	0	0	0	0	0	0	0	0
Tuesday	12/09/08	0	0	1	0	0	0	0	0	0	0
Wednesday	12/10/08	0	6	0	0	0	0	0	0	0	0
Thursday	12/11/08	0	0	0	0	0	0	0	0	0	0

Day	Date	Storefront Metro	Storefront Courtyard North	Storefront Streetside North	Storefront Courtyard East	Storefront Streetside East	Storefront Courtyard West	Storefront Streetside West	Storefront West Entrance	Storefront Courtyard South	Storefront Streetside South
Saturday	12/13/08	0	0	0	0	0	0	0	0	0	0
Sunday	12/14/08	0	0	0	0	0	0	0	0	0	0
Monday	12/15/08	0	0	8	0	0	0	0	0	0	0
Tuesday	12/16/08	0	0	2	0	0	0	0	0	0	0
Wednesday	12/17/08	0	0	5	0	0	0	0	0	0	0
Thursday	12/18/08	0	0	5	0	0	0	0	0	0	0
Friday	12/19/08	0	0	3	0	0	0	0	0	0	0
Saturday	12/20/08	6	0	0	0	0	0	0	0	0	0
Sunday	12/21/08	0	0	0	0	0	0	0	0	0	0
Monday	12/22/08	8	0	0	0	0	0	0	0	0	0
Tuesday	12/23/08	6	0	0	0	0	0	0	0	0	0
Wednesday	12/24/08	0	0	0	0	0	0	0	0	0	0
Thursday	12/25/08	0	0	0	0	0	0	0	0	0	0
Friday	12/26/08	0	0	0	0	0	0	0	0	0	0
Saturday	12/27/08	0	0	0	0	0	0	0	0	0	0
Sunday	12/28/08	0	0	0	0	0	0	0	0	0	0
Monday	12/29/08	1	0	0	0	0	0	0	0	0	0
Tuesday	12/30/08	9	0	0	0	0	0	0	0	0	0
Wednesday	12/31/08	3	0	0	0	0	0	0	0	0	0
Thursday	01/01/09	0	0	0	0	0	0	0	0	0	0
Friday	01/02/09	0	0	0	0	0	0	0	0	0	0
Saturday	01/03/09	0	0	9	0	0	6	0	0	0	0
Sunday	01/04/09	0	0	0	0	0	0	0	0	0	0
Monday	01/05/09	0	0	0	0	7	7	0	0	0	0
Tuesday	01/06/09	0	0	0	0	8	5	0	0	0	0
Wednesday	01/07/09	0	0	0	0	4	10	0	0	0	0
Thursday	01/08/09	0	0	0	0	5	0	0	0	0	0
Friday	01/09/09	0	0	0	0	4	0	0	0	0	0
Saturday	01/10/09	0	0	0	0	0	0	0	0	0	0
Sunday	01/11/09	0	0	0	0	0	0	0	0	0	0
Monday	01/12/09	0	0	0	0	0	0	0	0	0	0
Tuesday	01/13/09	0	0	0	0	7	0	0	0	0	0
Wednesday	01/14/09	0	4	0	0	9	0	0	0	0	0
Thursday	01/15/09	0	8	0	0	0	0	0	0	0	0
Friday	01/16/09	2	1	0	0	0	0	1	0	0	0
Saturday	01/17/09	0	0	0	0	0	0	0	0	0	0
Sunday	01/18/09	0	0	0	0	0	0	0	0	0	0
Monday	01/19/09	0	0	0	0	0	0	0	0	0	0
Tuesday	01/20/09	0	0	0	0	0	0	0	0	0	0
Wednesday	01/21/09	0	5	0	0	0	0	0	0	0	0
Thursday	01/22/09	0	5	0	0	0	0	0	0	0	0
Friday	01/23/09	0	1	0	0	0	0	1	0	0	0
Saturday	01/24/09	0	0	0	0	0	0	0	0	0	0
Sunday	01/25/09	0	0	0	0	0	0	0	0	0	0
Monday	01/26/09	0	0	0	0	0	2	0	0	0	0
Tuesday	01/27/09	0	0	0	0	0	0	0	0	0	0
Wednesday	01/28/09	0	0	0	0	0	0	0	0	0	0
Thursday	01/29/09	0	2	0	0	0	0	0	0	0	0
Friday	01/30/09	0	0	0	0	0	0	0	0	0	0
Saturday	01/31/09	0	0	0	0	0	0	0	0	0	0
Actual Total		35	49	35	0	44	30	0	0	0	0
Estimated Total		48	66	35	30	53	32	36	48	24	59

APPENDIX E: PRODUCTIVITY CALCULATIONS SPREADSHEETS

Below is the information used to calculate the curtain wall productivity. First the total manpower was taken from the data found in Appendix B and the total number of panels is from appendix. The estimated number of panels per day was provided by both DAVIS and Enclos. The budget was calculated using the total cost of the exterior curtain wall. The actual productivity was calculated by dividing the manpower by the total number of panels. The estimated productivity was calculated the same way; however the estimated number of panels was used in the equation. The actual number of panels per day is the cumulative number of panels that were installed to that date. Also, the estimated number of panels per day is cumulative. Finally, the performance was calculated by dividing the estimated number of panels per day by the actual number of panels. Tables 14, 15, 17, and 18 use the information from the table below.

Day	Date	Total Manpower	Total Number of Panels	Estimated Number of Panels Per Day	Actual Budget	Actual Daily Productivity	Estimated Daily Productivity	Actual Number of Panels Per Day	Estimated Number of Panels Per Day	Actual Perf.	Estimated Perf.
Monday	3/10/08	11	0	20	\$0.00	#DIV/0!	2.22	0	20	#DIV/0!	1
Tuesday	3/11/08	11	0	20	\$0.00	#DIV/0!	2.22	0	40	#DIV/0!	1
Wednesday	3/12/08	10	0	20	\$0.00	#DIV/0!	2.22	0	60	#DIV/0!	1
Thursday	3/13/08	10	0	20	\$0.00	#DIV/0!	2.22	0	80	#DIV/0!	1
Friday	3/14/08	10	0	20	\$0.00	#DIV/0!	2.22	0	100	#DIV/0!	1
Saturday	3/15/08	9	0		\$0.00	#DIV/0!	2.22	0	100	#DIV/0!	1
Monday	3/17/08	12	0	20	\$0.00	#DIV/0!	2.22	0	120	#DIV/0!	1
Tuesday	3/18/08	10	0	20	\$0.00	#DIV/0!	2.22	0	140	#DIV/0!	1
Wednesday	3/19/08	12	0	20	\$0.00	#DIV/0!	2.22	0	160	#DIV/0!	1
Thursday	3/20/08	12	0	20	\$0.00	#DIV/0!	2.22	0	180	#DIV/0!	1
Friday	3/21/08	12	14	20	\$134,768.20	0.86	2.22	14	200	1.43	1
Saturday	3/22/08	0	0		\$134,768.20	#DIV/0!	2.22	14	200	#DIV/0!	1
Monday	3/24/08	16	15	20	\$279,162.70	1.07	2.22	29	220	1.33	1
Tuesday	3/25/08	16	32	20	\$587,204.30	0.50	2.22	61	240	0.63	1
Wednesday	3/26/08	16	16	20	\$741,225.10	1.00	2.22	77	260	1.25	1
Thursday	3/27/08	18	17	20	\$904,872.20	1.06	2.22	94	280	1.18	1
Friday	3/28/08	15	10	20	\$1,001,135.20	1.50	2.22	104	300	2.00	1
Saturday	3/29/08	2	0		\$1,001,135.20	#DIV/0!	2.22	104	300	#DIV/0!	1
Monday	3/31/08	18	14	20	\$1,135,903.40	1.29	2.22	118	320	1.43	1
Tuesday	4/1/08	18	31	20	\$1,434,318.70	0.58	2.22	149	340	0.65	1
Wednesday	4/2/08	17	17	20	\$1,597,965.80	1.00	2.22	166	360	1.18	1
Thursday	4/3/08	20	17	20	\$1,761,612.90	1.18	2.22	183	380	1.18	1
Friday	4/4/08	16	25	20	\$2,002,270.40	0.64	2.22	208	400	0.80	1
Saturday	4/5/08	0	0		\$2,002,270.40	#DIV/0!	2.22	208	400	#DIV/0!	1
Monday	4/7/08	17	19	20	\$2,185,170.10	0.89	2.22	227	420	1.05	1
Tuesday	4/8/08	16	0	20	\$2,185,170.10	#DIV/0!	2.22	227	440	#DIV/0!	1
Wednesday	4/9/08	15	0	20	\$2,185,170.10	#DIV/0!	2.22	227	460	#DIV/0!	1
Thursday	4/10/08	15	0	20	\$2,185,170.10	#DIV/0!	2.22	227	480	#DIV/0!	1
Friday	4/11/08	15	0	20	\$2,185,170.10	#DIV/0!	2.22	227	500	#DIV/0!	1
Saturday	4/12/08	0	0		\$2,185,170.10	#DIV/0!	2.22	227	500	#DIV/0!	1
Monday	4/14/08	16	20	20	\$2,377,696.10	0.80	2.22	247	520	1.00	1
Tuesday	4/15/08	16	26	20	\$2,627,979.90	0.62	2.22	273	540	0.77	1
Wednesday	4/16/08	3	0	20	\$2,627,979.90	#DIV/0!	2.22	273	560	#DIV/0!	1
Thursday	4/17/08	16	21	20	\$2,830,132.20	0.76	2.22	294	580	0.95	1
Friday	4/18/08	16	18	20	\$3,003,405.60	0.89	2.22	312	600	1.11	1
Saturday	4/19/08	7	17		\$3,167,052.70	0.41	2.22	329	600	0.00	1
Monday	4/21/08	16	0	20	\$3,167,052.70	#DIV/0!	2.22	329	620	#DIV/0!	1
Tuesday	4/22/08	16	23	20	\$3,388,457.60	0.70	2.22	352	640	0.87	1
Wednesday	4/23/08	17	26	20	\$3,638,741.40	0.65	2.22	378	660	0.77	1
Thursday	4/24/08	17	37	20	\$3,994,914.50	0.46	2.22	415	680	0.54	1
Friday	4/25/08	17	21	20	\$4,197,066.80	0.81	2.22	436	700	0.95	1
Saturday	4/26/08	17	0		\$4,197,066.80	#DIV/0!	2.22	436	700	#DIV/0!	1
Monday	4/28/08	17	0	20	\$4,197,066.80	#DIV/0!	2.22	436	720	#DIV/0!	1
Tuesday	4/29/08	17	46	20	\$4,639,876.60	0.37	2.22	482	740	0.43	1
Wednesday	4/30/08	16	26	20	\$4,890,160.40	0.62	2.22	508	760	0.77	1
Thursday	05/01/08	16	17	20	\$5,053,807.50	0.94	2.22	525	780	1.18	1
Friday	05/02/08	15	17	20	\$5,217,454.60	0.88	2.22	542	800	1.18	1

Day	Date	Total Manpower	Total Number of Panels	Estimated Number of Panels Per Day	Actual Budget	Actual Daily Productivity	Estimated Daily Productivity	Actual Number of Panels Per Day	Estimated Number of Panels Per Day	Actual Perf.	Estimated Perf.
Tuesday	05/06/08	18	21	20	\$5,554,375.10	0.86	2.22	577	840	0.95	1
Wednesday	05/07/08	16	21	20	\$5,756,527.40	0.76	2.22	598	860	0.95	1
Thursday	05/08/08	17	0	20	\$5,756,527.40	#DIV/0!	2.22	598	880	#DIV/0!	1
Friday	05/09/08	14	0	20	\$5,756,527.40	#DIV/0!	2.22	598	900	#DIV/0!	1
Saturday	05/10/08	0	0		\$5,756,527.40	#DIV/0!	2.22	598	900	#DIV/0!	1
Monday	05/12/08	6	0	20	\$5,756,527.40	#DIV/0!	2.22	598	920	#DIV/0!	1
Tuesday	05/13/08	17	0	20	\$5,756,527.40	#DIV/0!	2.22	598	940	#DIV/0!	1
Wednesday	05/14/08	18	0	20	\$5,756,527.40	#DIV/0!	2.22	598	960	#DIV/0!	1
Thursday	05/15/08	17	0	20	\$5,756,527.40	#DIV/0!	2.22	598	980	#DIV/0!	1
Friday	05/16/08	11	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1000	#DIV/0!	1
Saturday	05/17/08	9	0		\$5,756,527.40	#DIV/0!	2.22	598	1000	#DIV/0!	1
Monday	05/19/08	17	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1020	#DIV/0!	1
Tuesday	05/20/08	14	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1040	#DIV/0!	1
Wednesday	05/21/08	16	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1060	#DIV/0!	1
Thursday	05/22/08	15	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1080	#DIV/0!	1
Friday	05/23/08	16	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1100	#DIV/0!	1
Saturday	05/24/08	0	0		\$5,756,527.40	#DIV/0!	2.22	598	1100	#DIV/0!	1
Monday	05/26/08	0	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1120	#DIV/0!	1
Tuesday	05/27/08	15	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1140	#DIV/0!	1
Wednesday	05/28/08	17	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1160	#DIV/0!	1
Thursday	05/29/08	3	0	20	\$5,756,527.40	#DIV/0!	2.22	598	1180	#DIV/0!	1
Friday	05/30/08	19	8	20	\$5,833,537.80	2.38	2.22	606	1200	2.50	1
Saturday	05/31/08	0	0		\$5,833,537.80	#DIV/0!	2.22	606	1200	#DIV/0!	1
Monday	06/02/08	19	9	20	\$5,920,174.50	2.11	2.22	615	1220	2.22	1
Tuesday	06/03/08	21	22	20	\$6,131,953.10	0.95	2.22	637	1240	0.91	1
Wednesday	06/04/08	18	18	20	\$6,305,226.50	1.00	2.22	655	1260	1.11	1
Thursday	06/05/08	19	12	20	\$6,420,742.10	1.58	2.22	667	1280	1.67	1
Friday	06/06/08	19	28	20	\$6,690,278.50	0.68	2.22	695	1300	0.71	1
Saturday	06/07/08	11	0		\$6,690,278.50	#DIV/0!	2.22	695	1300	#DIV/0!	1
Monday	06/09/08	22	35	20	\$7,027,199.00	0.63	2.22	730	1320	0.57	1
Tuesday	06/10/08	26	30	20	\$7,315,988.00	0.87	2.22	760	1340	0.67	1
Wednesday	06/11/08	26	25	20	\$7,556,645.50	1.04	2.22	785	1360	0.80	1
Thursday	06/12/08	26	34	20	\$7,883,939.70	0.76	2.22	819	1380	0.59	1
Friday	06/13/08	26	20	20	\$8,076,465.70	1.30	2.22	839	1400	1.00	1
Saturday	06/14/08	0	0		\$8,076,465.70	#DIV/0!	2.22	839	1400	#DIV/0!	1
Monday	06/16/08	26	26	20	\$8,326,749.50	1.00	2.22	865	1420	0.77	1
Tuesday	06/17/08	26	34	20	\$8,654,043.70	0.76	2.22	899	1440	0.59	1
Wednesday	06/18/08	27	30	20	\$8,942,832.70	0.90	2.22	929	1460	0.67	1
Thursday	06/19/08	26	30	20	\$9,231,621.70	0.87	2.22	959	1480	0.67	1
Friday	06/20/08	26		20	\$9,231,621.70	#DIV/0!	2.22	959	1500	#DIV/0!	1
Saturday	06/21/08	19	0		\$9,231,621.70	#DIV/0!	2.22	959	1500	#DIV/0!	1
Monday	06/23/08	26	32	20	\$9,539,663.30	0.81	2.22	991	1520	0.63	1
Tuesday	06/24/08	34	25	20	\$9,780,320.80	1.36	2.22	1016	1540	0.80	1
Wednesday	06/25/08	33	13	20	\$9,905,462.70	2.54	2.22	1029	1560	1.54	1
Thursday	06/26/08	36	8	20	\$9,982,473.10	4.50	2.22	1037	1580	2.50	1
Friday	06/27/08	36	47	20	\$10,434,909.20	0.77	2.22	1084	1600	0.43	1
Saturday	06/28/08	12	14		\$10,569,677.40	0.86	2.22	1098	1600	0.00	1
Monday	06/30/08	24	0	20	\$10,569,677.40	#DIV/0!	2.22	1098	1620	#DIV/0!	1
Tuesday	07/01/08	24	0	20	\$10,569,677.40	#DIV/0!	2.22	1098	1640	#DIV/0!	1
Wednesday	07/02/08	25	0	20	\$10,569,677.40	#DIV/0!	2.22	1098	1660	#DIV/0!	1
Thursday	07/03/08	21	0	20	\$10,569,677.40	#DIV/0!	2.22	1098	1680	#DIV/0!	1
Friday	07/04/08	0	0	20	\$10,569,677.40	#DIV/0!	2.22	1098	1700	#DIV/0!	1
Saturday	07/05/08	0	0		\$10,569,677.40	#DIV/0!	2.22	1098	1700	#DIV/0!	1
Monday	07/07/08	19	6	20	\$10,627,435.20	3.17	2.22	1104	1720	3.33	1
Tuesday	07/08/08	20	0	20	\$10,627,435.20	#DIV/0!	2.22	1104	1740	#DIV/0!	1
Wednesday	07/09/08	20	0	20	\$10,627,435.20	#DIV/0!	2.22	1104	1760	#DIV/0!	1
Thursday	07/10/08	21	8	20	\$10,704,445.60	2.63	2.22	1112	1780	2.50	1
Friday	07/11/08	20	14	20	\$10,839,213.80	1.43	2.22	1126	1800	1.43	1
Saturday	07/12/08	0	0		\$10,839,213.80	#DIV/0!	2.22	1126	1800	#DIV/0!	1
Monday	07/14/08	24	11	20	\$10,945,103.10	2.18	2.22	1137	1820	1.82	1
Tuesday	07/15/08	24	28	20	\$11,214,639.50	0.86	2.22	1165	1840	0.71	1
Wednesday	07/16/08	25	37	20	\$11,570,812.60	0.68	2.22	1202	1860	0.54	1
Thursday	07/17/08	23	42	20	\$11,975,117.20	0.55	2.22	1244	1880	0.48	1
Friday	07/18/08	23	50	20	\$12,456,432.20	0.46	2.22	1294	1900	0.40	1
Saturday	07/19/08	6	8		\$12,533,442.60	0.75	2.22	1302	1900	0.00	1

Day	Date	Total Manpower	Total Number of Panels	Estimated Number of Panels Per Day	Actual Budget	Actual Daily Productivity	Estimated Daily Productivity	Actual Number of Panels Per Day	Estimated Number of Panels Per Day	Actual Perf.	Estimated Perf.
Tuesday	07/22/08	31	41	20	\$13,457,567.40	0.76	2.22	1398	1940	0.49	1
Wednesday	07/23/08	32	75	20	\$14,179,539.90	0.43	2.22	1473	1960	0.27	1
Thursday	07/24/08	34	40	20	\$14,564,591.90	0.85	2.22	1513	1980	0.50	1
Friday	07/25/08	27	67	20	\$15,209,554.00	0.40	2.22	1580	2000	0.30	1
Saturday	07/26/08	7	14		\$15,344,322.20	0.50	2.22	1594	2000	0.00	1
Monday	07/28/08	32	46	20	\$15,787,132.00	0.70	2.22	1640	2020	0.43	1
Tuesday	07/29/08	27	40	20	\$16,172,184.00	0.68	2.22	1680	2040	0.50	1
Wednesday	07/30/08	27	38	20	\$16,537,983.40	0.71	2.22	1718	2060	0.53	1
Thursday	07/31/08	25	30	20	\$16,826,772.40	0.83	2.22	1748	2080	0.67	1
Friday	08/01/08	25	0	20	\$16,826,772.40	#DIV/0!	2.22	1748	2100	#DIV/0!	1
Saturday	08/02/08	0	0		\$16,826,772.40	#DIV/0!	2.22	1748	2100	#DIV/0!	1
Monday	08/04/08	31	0	20	\$16,826,772.40	#DIV/0!	2.22	1748	2120	#DIV/0!	1
Tuesday	08/05/08	32	0	20	\$16,826,772.40	#DIV/0!	2.22	1748	2140	#DIV/0!	1
Wednesday	08/06/08	32	0	20	\$16,826,772.40	#DIV/0!	2.22	1748	2160	#DIV/0!	1
Thursday	08/07/08	31	5	20	\$16,874,903.90	6.20	2.22	1753	2180	4.00	1
Friday	08/08/08	29	22	20	\$17,086,682.50	1.32	2.22	1775	2200	0.91	1
Saturday	08/09/08	0	12		\$17,202,198.10	0.00	2.22	1787	2200	0.00	1
Monday	08/11/08	29	0	20	\$17,202,198.10	#DIV/0!	2.22	1787	2220	#DIV/0!	1
Tuesday	08/12/08	29	5	20	\$17,250,329.60	5.80	2.22	1792	2240	4.00	1
Wednesday	08/13/08	32	10	20	\$17,346,592.60	3.20	2.22	1802	2260	2.00	1
Thursday	08/14/08	35	11	20	\$17,452,481.90	3.18	2.22	1813	2280	1.82	1
Friday	08/15/08	35	7	20	\$17,519,866.00	5.00	2.22	1820	2300	2.86	1
Saturday	08/16/08	0	6		\$17,577,623.80	0.00	2.22	1826	2300	0.00	1
Monday	08/18/08	32	48	20	\$18,039,686.20	0.67	2.22	1874	2320	0.42	1
Tuesday	08/19/08	34	45	20	\$18,472,869.70	0.76	2.22	1919	2340	0.44	1
Wednesday	08/20/08	32	38	20	\$18,838,669.10	0.84	2.22	1957	2360	0.53	1
Thursday	08/21/08	32	16	20	\$18,992,689.90	2.00	2.22	1973	2380	1.25	1
Friday	08/22/08	31	27	20	\$19,252,600.00	1.15	2.22	2000	2400	0.74	1
Saturday	08/23/08	0	0		\$19,252,600.00	#DIV/0!	2.22	2000	2400	#DIV/0!	1
Monday	08/25/08	0	6	20	\$19,310,357.80	0.00	2.22	2006	2420	3.33	1
Tuesday	08/26/08	0	31	20	\$19,608,773.10	0.00	2.22	2037	2440	0.65	1
Wednesday	08/27/08	0	32	20	\$19,916,814.70	0.00	2.22	2069	2460	0.63	1
Thursday	08/28/08	0	22	20	\$20,128,593.30	0.00	2.22	2091	2480	0.91	1
Friday	08/29/08	0	36	20	\$20,475,140.10	0.00	2.22	2127	2500	0.56	1
Saturday	08/30/08	0	0		\$20,475,140.10	#DIV/0!	2.22	2127	2500	#DIV/0!	1
Monday	09/01/08	0	0	20	\$20,475,140.10	#DIV/0!	2.22	2127	2520	#DIV/0!	1
Tuesday	09/02/08	0	20	20	\$20,667,666.10	0.00	2.22	2147	2540	1.00	1
Wednesday	09/03/08	0	51	20	\$21,158,607.40	0.00	2.22	2198	2560	0.39	1
Thursday	09/04/08	0	40	20	\$21,543,659.40	0.00	2.22	2238	2580	0.50	1
Friday	09/05/08	0	40	20	\$21,928,711.40	0.00	2.22	2278	2600	0.50	1
Saturday	09/06/08	0	0		\$21,928,711.40	#DIV/0!	2.22	2278	2600	#DIV/0!	1
Monday	09/08/08	0	52	20	\$22,429,279.00	0.00	2.22	2330	2620	0.38	1
Tuesday	09/09/08	0	17	20	\$22,592,926.10	0.00	2.22	2347	2640	1.18	1
Wednesday	09/10/08	0	19	20	\$22,775,825.80	0.00	2.22	2366	2660	1.05	1
Thursday	09/11/08	0	24	20	\$23,006,857.00	0.00	2.22	2390	2680	0.83	1
Friday	09/12/08	0	44	20	\$23,430,414.20	0.00	2.22	2434	2700	0.45	1
Saturday	09/13/08	0	0		\$23,430,414.20	#DIV/0!	2.22	2434	2700	#DIV/0!	1
Monday	09/15/08	0	0	20	\$23,430,414.20	#DIV/0!	2.22	2434	2720	#DIV/0!	1
Tuesday	09/16/08	0	0	20	\$23,430,414.20	#DIV/0!	2.22	2434	2740	#DIV/0!	1
Wednesday	09/17/08	0	0	20	\$23,430,414.20	#DIV/0!	2.22	2434	2760	#DIV/0!	1
Thursday	09/18/08	0	0	20	\$23,430,414.20	#DIV/0!	2.22	2434	2780	#DIV/0!	1
Friday	09/19/08	0	0	20	\$23,430,414.20	#DIV/0!	2.22	2434	2800	#DIV/0!	1
Saturday	09/20/08	0	0		\$23,430,414.20	#DIV/0!	2.22	2434	2800	#DIV/0!	1
Monday	09/22/08	0	12	20	\$23,545,929.80	0.00	2.22	2446	2820	1.67	1
Tuesday	09/23/08	0	31	20	\$23,844,345.10	0.00	2.22	2477	2840	0.65	1
Wednesday	09/24/08	0	36	20	\$24,190,891.90	0.00	2.22	2513	2860	0.56	1
Thursday	09/25/08	0	45	20	\$24,624,075.40	0.00	2.22	2558	2880	0.44	1
Friday	09/26/08	0	42	20	\$25,028,380.00	0.00	2.22	2600	2900	0.48	1
Saturday	09/27/08	0	0		\$25,028,380.00	#DIV/0!	2.22	2600	2900	#DIV/0!	1
Monday	09/29/08	0	42	20	\$25,432,684.60	0.00	2.22	2642	2920	0.48	1
Tuesday	09/30/08	0	42	20	\$25,836,989.20	0.00	2.22	2684	2940	0.48	1
Wednesday	10/01/08	0	34	20	\$26,164,283.40	0.00	2.22	2718	2960	0.59	1
Thursday	10/02/08	0	12	20	\$26,279,799.00	0.00	2.22	2730	2980	1.67	1
Friday	10/03/08	0	44	20	\$26,703,356.20	0.00	2.22	2774	3000	0.45	1
Saturday	10/04/08	0	0		\$26,703,356.20	#DIV/0!	2.22	2774	3000	#DIV/0!	1

Day	Date	Total Manpower	Total Number of Panels	Estimated Number of Panels Per Day	Actual Budget	Actual Daily Productivity	Estimated Daily Productivity	Actual Number of Panels Per Day	Estimated Number of Panels Per Day	Actual Perf.	Estimated Perf.
Tuesday	10/07/08	0	2	20	\$26,780,366.60	0.00	2.22	2782	3040	10.00	1
Wednesday	10/08/08	0	8	20	\$26,857,377.00	0.00	2.22	2790	3060	2.50	1
Thursday	10/09/08	0	0	20	\$26,857,377.00	#DIV/0!	2.22	2790	3080	#DIV/0!	1
Friday	10/10/08	0	0	20	\$26,857,377.00	#DIV/0!	2.22	2790	3100	#DIV/0!	1
Saturday	10/11/08	0	0		\$26,857,377.00	#DIV/0!	2.22	2790	3100	#DIV/0!	1
Monday	10/13/08	0	3	20	\$26,886,255.90	0.00	2.22	2793	3120	6.67	1
Tuesday	10/14/08	0	0	20	\$26,886,255.90	#DIV/0!	2.22	2793	3140	#DIV/0!	1
Wednesday	10/15/08	0	0	20	\$26,886,255.90	#DIV/0!	2.22	2793	3160	#DIV/0!	1
Thursday	10/16/08	0	0	20	\$26,886,255.90	#DIV/0!	2.22	2793	3180	#DIV/0!	1
Friday	10/17/08	0	0	20	\$26,886,255.90	#DIV/0!	2.22	2793	3200	#DIV/0!	1
Saturday	10/18/08	0	0		\$26,886,255.90	#DIV/0!	2.22	2793	3200	#DIV/0!	1
Monday	10/20/08	0	16	20	\$27,040,276.70	0.00	2.22	2809	3220	1.25	1
Tuesday	10/21/08	0	22	20	\$27,252,055.30	0.00	2.22	2831	3240	0.91	1
Wednesday	10/22/08	0	39	20	\$27,627,481.00	0.00	2.22	2870	3260	0.51	1
Thursday	10/23/08	0	8	20	\$27,704,491.40	0.00	2.22	2878	3280	2.50	1
Friday	10/24/08	0	15	20	\$27,848,885.90	0.00	2.22	2893	3300	1.33	1
Saturday	10/25/08	0	12		\$27,964,401.50	0.00	2.22	2905	3300	0.00	1
Monday	10/27/08	0	7	20	\$28,031,785.60	0.00	2.22	2912	3320	2.86	1
Tuesday	10/28/08	0	26	20	\$28,282,069.40	0.00	2.22	2938	3340	0.77	1
Wednesday	10/29/08	0	38	20	\$28,647,868.80	0.00	2.22	2976	3360	0.53	1
Thursday	10/30/08	0	30	20	\$28,936,657.80	0.00	2.22	3006	3380	0.67	1
Friday	10/31/08	0	29	20	\$29,215,820.50	0.00	2.22	3035	3400	0.69	1
Saturday	11/01/08	0	0		\$29,215,820.50	#DIV/0!	2.22	3035	3400	#DIV/0!	1
Monday	11/03/08	0	20	20	\$29,408,346.50	0.00	2.22	3055	3420	1.00	1
Tuesday	11/04/08	0	18	20	\$29,581,619.90	0.00	2.22	3073	3440	1.11	1
Wednesday	11/05/08	0	30	20	\$29,870,408.90	0.00	2.22	3103	3460	0.67	1
Thursday	11/06/08	0	47	20	\$30,322,845.00	0.00	2.22	3150	3480	0.43	1
Friday	11/07/08	0	29	20	\$30,602,007.70	0.00	2.22	3179	3500	0.69	1
Saturday	11/08/08	0	0		\$30,602,007.70	#DIV/0!	2.22	3179	3500	#DIV/0!	1
Monday	11/10/08	0	55	20	\$31,131,454.20	0.00	2.22	3234	3520	0.36	1
Tuesday	11/11/08	0	0	20	\$31,131,454.20	#DIV/0!	2.22	3234	3540	#DIV/0!	1
Wednesday	11/12/08	0	22	20	\$31,343,232.80	0.00	2.22	3256	3560	0.91	1
Thursday	11/13/08	0	16	20	\$31,497,253.60	0.00	2.22	3272	3580	1.25	1
Friday	11/14/08	0	47	20	\$31,949,689.70	0.00	2.22	3319	3600	0.43	1
Saturday	11/15/08	0	5		\$31,997,821.20	0.00	2.22	3324	3600	0.00	1
Monday	11/17/08	0	59	20	\$32,565,772.90	0.00	2.22	3383	3620	0.34	1
Tuesday	11/18/08	0	54	20	\$33,085,593.10	0.00	2.22	3437	3640	0.37	1
Wednesday	11/19/08	0	34	20	\$33,412,887.30	0.00	2.22	3471	3660	0.59	1
Thursday	11/20/08	0	64	20	\$34,028,970.50	0.00	2.22	3535	3680	0.31	1
Friday	11/21/08	0	46	20	\$34,471,780.30	0.00	2.22	3581	3700	0.43	1
Saturday	11/22/08	0	22		\$34,683,558.90	0.00	2.22	3603	3700	0.00	1
Monday	11/24/08	0	20	20	\$34,876,084.90	0.00	2.22	3623	3720	1.00	1
Tuesday	11/25/08	0	20	20	\$35,068,610.90	0.00	2.22	3643	3740	1.00	1
Wednesday	11/26/08	0	18	20	\$35,241,884.30	0.00	2.22	3661	3760	1.11	1
Thursday	11/27/08	0	0	20	\$35,241,884.30	#DIV/0!	2.22	3661	3780	#DIV/0!	1
Friday	11/28/08	0	0	20	\$35,241,884.30	#DIV/0!	2.22	3661	3800	#DIV/0!	1
Saturday	11/29/08	0	0		\$35,241,884.30	#DIV/0!	2.22	3661	3800	#DIV/0!	1
Monday	12/01/08	0	0	20	\$35,241,884.30	#DIV/0!	2.22	3661	3820	#DIV/0!	1
Tuesday	12/02/08	0	13	20	\$35,367,026.20	0.00	2.22	3674	3840	1.54	1
Wednesday	12/03/08	0	8	20	\$35,444,036.60	0.00	2.22	3682	3860	2.50	1
Thursday	12/04/08	0	5	20	\$35,492,168.10	0.00	2.22	3687	3880	4.00	1
Friday	12/05/08	0	15	20	\$35,636,562.60	0.00	2.22	3702	3900	1.33	1
Saturday	12/06/08	0	0		\$35,636,562.60	#DIV/0!	2.22	3702	3900	#DIV/0!	1
Monday	12/08/08	0	0	20	\$35,636,562.60	#DIV/0!	2.22	3702	3920	#DIV/0!	1
Tuesday	12/09/08	0	1	20	\$35,646,188.90	0.00	2.22	3703	3940	20.00	1
Wednesday	12/10/08	0	24	20	\$35,877,220.10	0.00	2.22	3727	3960	0.83	1
Thursday	12/11/08	0	25	20	\$36,117,877.60	0.00	2.22	3752	3980	0.80	1
Friday	12/12/08	0	12	20	\$36,233,393.20	0.00	2.22	3764	4000	1.67	1
Saturday	12/13/08	0	0		\$36,233,393.20	#DIV/0!	2.22	3764	4000	#DIV/0!	1
Monday	12/15/08	0	8	20	\$36,310,403.60	0.00	2.22	3772	4020	2.50	1
Tuesday	12/16/08	0	2	20	\$36,329,656.20	0.00	2.22	3774	4040	10.00	1
Wednesday	12/17/08	0	5	20	\$36,377,787.70	0.00	2.22	3779	4060	4.00	1
Thursday	12/18/08	0	5	20	\$36,425,919.20	0.00	2.22	3784	4080	4.00	1
Friday	12/19/08	0	17	20	\$36,589,566.30	0.00	2.22	3801	4100	1.18	1
Saturday	12/20/08	0	20		\$36,782,092.30	0.00	2.22	3821	4100	0.00	1

Day	Date	Total Manpower	Total Number of Panels	Estimated Number of Panels Per Day	Actual Budget	Actual Daily Productivity	Estimated Daily Productivity	Actual Number of Panels Per Day	Estimated Number of Panels Per Day	Actual Perf.	Estimated Perf.
Tuesday	12/23/08	0	14	20	\$37,070,881.30	0.00	2.22	3851	4140	1.43	1
Wednesday	12/24/08	0	4	20	\$37,109,386.50	0.00	2.22	3855	4160	5.00	1
Thursday	12/25/08	0	0	20	\$37,109,386.50	#DIV/0!	2.22	3855	4180	#DIV/0!	1
Friday	12/26/08	0	0	20	\$37,109,386.50	#DIV/0!	2.22	3855	4200	#DIV/0!	1
Saturday	12/27/08	0	0		\$37,109,386.50	#DIV/0!	2.22	3855	4200	#DIV/0!	1
Monday	12/29/08	0	1	20	\$37,119,012.80	0.00	2.22	3856	4220	20.00	1
Tuesday	12/30/08	0	19	20	\$37,301,912.50	0.00	2.22	3875	4240	1.05	1
Wednesday	12/31/08	0	19	20	\$37,484,812.20	0.00	2.22	3894	4260	1.05	1
Thursday	01/01/09	0	0	20	\$37,484,812.20	#DIV/0!	2.22	3894	4280	#DIV/0!	1
Friday	01/02/09	0	24	20	\$37,715,843.40	0.00	2.22	3918	4300	0.83	1
Saturday	01/03/09	0	33		\$38,033,511.30	0.00	2.22	3951	4300	0.00	1
Monday	01/05/09	0	28	20	\$38,303,047.70	0.00	2.22	3979	4320	0.71	1
Tuesday	01/06/09	0	28	20	\$38,572,584.10	0.00	2.22	4007	4340	0.71	1
Wednesday	01/07/09	0	14	20	\$38,707,352.30	0.00	2.22	4021	4360	1.43	1
Thursday	01/08/09	0	58	20	\$39,265,677.70	0.00	2.22	4079	4380	0.34	1
Friday	01/09/09	0	0	20	\$39,265,677.70	#DIV/0!	2.22	4079	4400	#DIV/0!	1
Saturday	01/10/09	0	34		\$39,592,971.90	0.00	2.22	4113	4400	0.00	1
Monday	01/12/09	0	0	20	\$39,592,971.90	#DIV/0!	2.22	4113	4420	#DIV/0!	1
Tuesday	01/13/09	0	24	20	\$39,824,003.10	0.00	2.22	4137	4440	0.83	1
Wednesday	01/14/09	0	62	20	\$40,420,833.70	0.00	2.22	4199	4460	0.32	1
Thursday	01/15/09	0	18	20	\$40,594,107.10	0.00	2.22	4217	4480	1.11	1
Friday	01/16/09	0	9	20	\$40,680,743.80	0.00	2.22	4226	4500	2.22	1
Saturday	01/17/09	0	0		\$40,680,743.80	#DIV/0!	2.22	4226	4500	#DIV/0!	1
Monday	01/19/09	0	0	20	\$40,680,743.80	#DIV/0!	2.22	4226	4520	#DIV/0!	1
Tuesday	01/20/09	0	0	20	\$40,680,743.80	#DIV/0!	2.22	4226	4540	#DIV/0!	1
Wednesday	01/21/09	0	17	20	\$40,844,390.90	0.00	2.22	4243	4560	1.18	1
Thursday	01/22/09	0	13	20	\$40,969,532.80	0.00	2.22	4256	4580	1.54	1
Friday	01/23/09	0	13	20	\$41,094,674.70	0.00	2.22	4269	4600	1.54	1
Saturday	01/24/09	0	8		\$41,171,685.10	0.00	2.22	4277	4600	0.00	1
Monday	01/26/09	0	14	20	\$41,306,453.30	0.00	2.22	4291	4620	1.43	1
Tuesday	01/27/09	0	8	20	\$41,383,463.70	0.00	2.22	4299	4640	2.50	1
Wednesday	01/28/09	0	20	20	\$41,575,989.70	0.00	2.22	4319	4660	1.00	1
Thursday	01/29/09	0	14	20	\$41,710,757.90	0.00	2.22	4333	4680	1.43	1
Friday	01/30/09	0	12	20	\$41,826,273.50	0.00	2.22	4345	4700	1.67	1
Saturday	01/31/09	0	12		\$41,941,789.10	0.00	2.22	4357	4700	0.00	1

APPENDIX F: WEATHER

Below are the tables used to analyze the weather for the curtain wall productivity analysis. For the days that have already occurred, the weather was researched on Weather Underground and documented below. As one can see, the average temperature, the high for the day, and the low for the day were used in the tables. Additionally, the total amount of precipitation was used, along with the wind speed, to determine if they were the cause of any of the delays. Tables 19 to 22 were all created using the data below.

Day	Date	Average	High	Low	Perc.	Wind Speed (mph)	Wind Direction	Event	Assumptions
Friday	3/21/08	49	58	39	0.00	8	WNW		
Saturday	3/22/08	46	51	40	0.00	11	NNE		
Sunday	3/23/08	43	51	34	1.00	6	N		
Monday	3/24/08	45	52	37	0.00	7	N		
Tuesday	3/25/08	44	54	34	0.00	12	SSW		
Wednesday	3/26/08	60	71	48	0.00	9	SW		
Thursday	3/27/08	54	58	49	0.01	6	NE	Rain	
Friday	3/28/08	60	74	46	0.00	12	W		
Saturday	3/29/08	45	53	37	0.00	10	N		
Sunday	3/30/08	42	49	35	0.00	9	E		
Monday	3/31/08	47	52	42	0.04	3	ESE	Rain	
Tuesday	4/1/08	64	76	51	0.10	14	SSW	Rain	
Wednesday	4/2/08	52	59	44	0.00	13	NNW		
Thursday	4/3/08	46	51	40	0.66	7	E	Rain	
Friday	4/4/08	53	64	42	0.09	7	SSE	Rain	
Saturday	4/5/08	58	65	51	0.01	9	N		
Sunday	4/6/08	49	51	46	0.37	11	NE	Rain	
Monday	4/7/08	47	49	44	0.01	8	ENE	Rain	Trace=0.01
Tuesday	4/8/08	50	54	46	0.01	7	ENE		Trace=0.01
Wednesday	4/9/08	58	67	48	0.00	5	E		
Thursday	4/10/08	64	76	52	0.00	3	SE	Fog	
Friday	4/11/08	70	82	57	0.09	10	S	Rain	
Saturday	4/12/08	65	75	55	0.23	9	SSW	Rain, Thunderstorm	
Sunday	4/13/08	51	56	46	0.01	10	NW		
Monday	4/14/08	50	58	41	0.01	10	N	Rain	
Tuesday	4/15/08	52	61	43	0.00	10	NNE		
Wednesday	4/16/08	57	70	43	0.00	4	SSE		
Thursday	4/17/08	62	77	46	0.00	3	SSE		
Friday	4/18/08	69	85	52	0.00	3	S		
Saturday	4/19/08	69	82	56	0.00	8	SSE		
Sunday	4/20/08	63	67	59	1.40	8	SE	Fog, Rain, Thunderstorm	
Monday	4/21/08	61	63	58	0.67	14	ENE	Rain, Thunderstorm	
Tuesday	4/22/08	64	72	56	0.01	11	ENE	Rain	Trace=0.01
Wednesday	4/23/08	66	75	57	0.00	6	E		
Thursday	4/24/08	69	79	58	0.00	5	NE		
Friday	4/25/08	69	81	56	0.00	4	ESE		
Saturday	4/26/08	72	84	59	0.26	6	ENE	Rain, Thunderstorm	
Sunday	4/27/08	56	59	53	0.06	10	NE	Rain	
Monday	4/28/08	59	65	52	0.96	5	N	Rain	
Tuesday	4/29/08	57	62	51	0.01	12	NW	Rain	Trace=0.01
Wednesday	4/30/08	53	61	45	0.01	6	NW	Rain	Trace=0.01
Thursday	05/01/08	60	71	48	0.04	5	SE	Rain	
Friday	05/02/08	68	81	55	0.00	10	S		
Saturday	05/03/08	72	83	60	0.01	10	S	Rain	Trace=0.01
Sunday	05/04/08	66	73	59	0.00	10	NNW		
Monday	05/05/08	63	73	52	0.00	5			
Tuesday	05/06/08	67	79	55	0.00	6	WNW		
Wednesday	05/07/08	69	82	56	0.00	11	S		
Thursday	05/08/08	69	75	63	1.32	10	SSW	Rain, Thunderstorm	

Day	Date	Average	High	Low	Perc.	Wind Speed (mph)	Wind Direction	Event	Assumptions
Friday	05/09/08	61	66	55	2.22	10	N	Fog, Rain, Thunderstorm	
Saturday	05/10/08	60	67	52	0.22	6	N	Rain	
Sunday	05/11/08	57	63	50	2.63	12	ENE	Rain	
Monday	05/12/08	52	55	48	1.32	20	N	Rain	
Tuesday	05/13/08	61	74	48	0.00	8	NNW		
Wednesday	05/14/08	63	75	51	0.00	8	S		
Thursday	05/15/08	70	80	59	0.29	6	SW	Rain	
Friday	05/16/08	65	74	55	0.53	12	SW	Rain	
Saturday	05/17/08	64	77	51	0.01	12	W		
Sunday	05/18/08	64	70	57	0.05	10	SW	Rain	
Monday	05/19/08	62	70	53	0.00	10	WNW		
Tuesday	05/20/08	58	63	52	0.58	6	NNW	Rain	
Wednesday	05/21/08	62	72	51	0.01	7	WSW	Rain	Trace=0.01
Thursday	05/22/08	61	71	51	0.00	12	WNW		
Friday	05/23/08	62	72	52	0.00	8	NW		
Saturday	05/24/08	65	75	54	0.00	8	NNW		
Sunday	05/25/08	67	78	56	0.00	7	ENE		
Monday	05/26/08	72	85	59	0.00	12	S		
Tuesday	05/27/08	76	83	69	0.01	8	SSW	Rain	Trace=0.01
Wednesday	05/28/08	65	73	57	0.01	11	NNE	Rain	Trace=0.01
Thursday	05/29/08	65	77	53	0.00	8	S		
Friday	05/30/08	71	82	59	0.00	9	S		
Saturday	05/31/08	78	87	69	1.45	10	S	Fog, Rain, Thunderstorm	
Sunday	06/01/08	76	86	66	0.00	9	SW		
Monday	06/02/08	71	80	62	0.00	8	NW		
Tuesday	06/03/08	72	81	62	0.79	11	S	Rain, Thunderstorm	
Wednesday	06/04/08	77	84	69	1.49	8	SSW	Rain, Thunderstorm	
Thursday	06/05/08	77	87	67	0.00	7	SSE		
Friday	06/06/08	77	84	69	0.00	6	SSE		
Saturday	06/07/08	86	98	74	0.15	6	SSE	Fog, Rain, Thunderstorm	
Sunday	06/08/08	85	96	74	0.00	7	SSW		
Monday	06/09/08	87	96	77	0.00	7	WSW		
Tuesday	06/10/08	85	96	74	0.33	6	SW	Rain, Hail, Thunderstorm	
Wednesday	06/11/08	80	88	72	0.00	8	NNW		
Thursday	06/12/08	81	91	70	0.00	12	SSE	Rain	
Friday	06/13/08	80	87	72	0.00	9	S		
Saturday	06/14/08	81	89	73	0.13	7	SW	Rain, Thunderstorm	
Sunday	06/15/08	79	86	71	0.00	9	WNW		
Monday	06/16/08	77	87	66	0.88	7	WSW	Fog, Rain, Thunderstorm	
Tuesday	06/17/08	72	79	64	0.00	10	WNW	Thunderstorm	
Wednesday	06/18/08	70	81	58	0.01	9	W	Rain, Thunderstorm	Trace=0.01
Thursday	06/19/08	69	77	60	0.01	6	WNW	Rain	Trace=0.01
Friday	06/20/08	72	83	61	0.00	7	SSW		
Saturday	06/21/08	76	85	67	0.08	7	S	Rain, Thunderstorm	
Sunday	06/22/08	77	85	69	0.06	8	S	Rain, Thunderstorm	
Monday	06/23/08	77	86	67	0.14	6	WSW	Rain, Thunderstorm	
Tuesday	06/24/08	73	84	62	0.00	9	NW		
Wednesday	06/25/08	77	87	66	0.00	6	SSW		
Thursday	06/26/08	83	94	72	0.00	7	SW		
Friday	06/27/08	85	94	75	0.09	6	S	Rain, Thunderstorm	
Saturday	06/28/08	83	92	74	0.50	6	SSW	Rain, Thunderstorm	
Sunday	06/29/08	82	89	74	0.00	10	SSW		

Day	Date	Average	High	Low	Perc.	Wind Speed (mph)	Wind Direction	Event	Assumptions
Monday	06/30/08	77	85	68	0.16	5	W	Rain, Thunderstorm	
Tuesday	07/01/08	74	82	65	0.00	7	WNW		
Wednesday	07/02/08	77	86	68	0.00	8	WSW		
Thursday	07/03/08	81	93	68	0.00	9	SSW		
Friday	07/04/08	80	88	72	0.05	6	N	Rain, Thunderstorm	
Saturday	07/05/08	82	91	72	0.07	4	E	Rain	
Sunday	07/06/08	78	84	72	0.01	4	SSE	Rain, Thunderstorm	
Monday	07/07/08	79	86	72	0.00	8	SSW		
Tuesday	07/08/08	81	91	71	0.00	11	S		
Wednesday	07/09/08	81	88	73	0.01	11	SSW	Rain	
Thursday	07/10/08	82	89	74	0.00	8	NW		
Friday	07/11/08	81	90	71	0.00	5	S		
Saturday	07/12/08	83	91	74	0.00	9	S		
Sunday	07/13/08	83	92	73	0.58	11	SSW	Rain, Thunderstorm	
Monday	07/14/08	79	87	71	0.53	4	NW	Rain	
Tuesday	07/15/08	79	89	69	0.00	4	ESE		
Wednesday	07/16/08	82	93	70	0.00	5	NNE		
Thursday	07/17/08	84	94	73	0.26	5	SSE	Rain, Thunderstorm	
Friday	07/18/08	85	94	75	0.00	8	S		
Saturday	07/19/08	84	94	74	0.00	9	S		
Sunday	07/20/08	86	95	77	0.00	9	S	Thunderstorm	
Monday	07/21/08	86	96	75	0.01	8	NW	Rain	Trace=0.01
Tuesday	07/22/08	84	92	76	0.04	6	WSW	Rain, Thunderstorm	
Wednesday	07/23/08	78	87	68	1.09	8	WSW	Rain, Thunderstorm	
Thursday	07/24/08	76	85	67	0.01	5	W	Rain	Trace=0.01
Friday	07/25/08	78	88	68	0.00	7	SSE		
Saturday	07/26/08	81	89	73	0.00	11	S		
Sunday	07/27/08	81	89	73	0.95	6	SSW	Fog, Rain, Thunderstorm	
Monday	07/28/08	78	87	69	0.01	5	WSW		Trace=0.01
Tuesday	07/29/08	83	91	74	0.01	5	SSE	Rain	
Wednesday	07/30/08	85	92	78	0.00	4	SW		
Thursday	07/31/08	83	88	78	0.01	5	W	Rain	Trace=0.01
Friday	08/01/08	84	93	75	0.00	7	NNW		
Saturday	08/02/08	82	90	74	0.23	5	W	Rain, Thunderstorm	
Sunday	08/03/08	79	87	70	0.00	9	NW		
Monday	08/04/08	80	89	70	0.00	7	NNW		
Tuesday	08/05/08	81	86	75	0.01	5	SSW		
Wednesday	08/06/08	85	94	76	0.00	10	NW		
Thursday	08/07/08	80	87	72	0.13	6	NE	Rain, Thunderstorm	
Friday	08/08/08	78	86	69	0.01	11	NW	Rain	Trace=0.01
Saturday	08/09/08	74	84	64	0.00	7	NW		
Sunday	08/10/08	77	88	66	0.01	5	SSW	Rain	Trace=0.01
Monday	08/11/08	74	81	66	0.00	11	NW		
Tuesday	08/12/08	75	86	64	0.00	8	NW		
Wednesday	08/13/08	78	87	68	0.00	6	S		
Thursday	08/14/08	77	87	67	0.20	6	SSW	Rain, Thunderstorm	
Friday	08/15/08	75	83	67	0.01	5	NW	Rain	Trace=0.01
Saturday	08/16/08	76	86	66	0.00	7	NW		
Sunday	08/17/08	78	89	66	0.00	6	W		
Monday	08/18/08	81	93	69	0.00	7	S		
Tuesday	08/19/08	82	94	70	0.00	9	WNW		
Wednesday	08/20/08	75	83	67	0.00	7	ENE		
Thursday	08/21/08	77	86	67	0.00	5	SE		
Friday	08/22/08	77	86	67	0.00	7	ESE		
Saturday	08/23/08	77	86	68	0.00	6	ESE		

Day	Date	Average	High	Low	Perc.	Wind Speed (mph)	Wind Direction	Event	Assumptions
Sunday	08/24/08	80	89	71	0.00	9	S		
Monday	08/25/08	83	92	73	0.00	7	WSW		
Tuesday	08/26/08	76	82	69	0.00	9	NE		
Wednesday	08/27/08	74	79	68	0.01	7	E	Rain	Trace=0.01
Thursday	08/28/08	72	75	69	0.48	9	ENE	Rain	
Friday	08/29/08	74	78	69	0.19	7	NNE		
Saturday	08/30/08	81	90	71	0.00	5	NNW		
Sunday	08/31/08	79	89	69	0.00	6	NNE		
Monday	09/01/08	77	89	65	0.00	5	N		
Tuesday	09/02/08	79	92	65	0.00	5	NNW		
Wednesday	09/03/08	82	95	69	0.00	4	NW		
Thursday	09/04/08	85	95	74	0.00	7	SSE		
Friday	09/05/08	82	90	73	0.40	8	SE	Rain	
Saturday	09/06/08	76	78	73	3.50	12	NNE	Rain	
Sunday	09/07/08	76	85	66	0.00	6	W		
Monday	09/08/08	78	87	69	0.00	5	SE		
Tuesday	09/09/08	77	81	72	0.18	8	SSW	Rain	
Wednesday	09/10/08	74	79	68	0.01	9	NE	Rain	Trace=0.01
Thursday	09/11/08	74	80	68	0.00	7	ESE		
Friday	09/12/08	76	81	70	0.03	9	S	Rain	
Saturday	09/13/08	84	93	74	0.00	5	WSW		
Sunday	09/14/08	84	92	75	0.00	11	SSW		
Monday	09/15/08	80	86	73	0.00	12	NW		
Tuesday	09/16/08	71	76	65	0.00	9	N		
Wednesday	09/17/08	70	79	61	0.00	4	NNW		
Thursday	09/18/08	72	83	61	0.00	9	N		
Friday	09/19/08	68	74	61	0.00	10	ENE		
Saturday	09/20/08	66	75	56	0.00	4	NE		
Sunday	09/21/08	69	82	56	0.00	3	SE		
Monday	09/22/08	73	83	62	0.00	7	NE		
Tuesday	09/23/08	69	76	62	0.00	10	NE		
Wednesday	09/24/08	66	74	57	0.00	11	NE		
Thursday	09/25/08	63	66	59	0.22	17	NNE	Rain	
Friday	09/26/08	68	73	62	0.72	12	NNE	Rain	
Saturday	09/27/08	75	80	70	0.27	5	ENE	Rain, Thunderstorm	
Sunday	09/28/08	75	80	69	0.65	4	W	Rain	
Monday	09/29/08	71	78	64	0.00	7	NNW		
Tuesday	09/30/08	68	75	61	0.44	5	ESE	Rain, Thunderstorm	
Wednesday	10/01/08	65	74	56	0.04	6	W	Rain	
Thursday	10/02/08	60	68	52	0.00	9	W		
Friday	10/03/08	63	75	51	0.00	7	SW		
Saturday	10/04/08	66	74	58	0.00	4	NE		
Sunday	10/05/08	67	76	58	0.00	5	NNW		
Monday	10/06/08	64	71	56	0.00	8	NNE		
Tuesday	10/07/08	59	67	50	0.00	5	ENE		
Wednesday	10/08/08	61	70	52	0.01	8	S	Rain	Trace=0.01
Thursday	10/09/08	72	79	65	0.00	7	S		
Friday	10/10/08	70	79	60	0.00	5	NNE		
Saturday	10/11/08	66	77	54	0.00	5	NNE		
Sunday	10/12/08	66	78	54	0.00	3	E		
Monday	10/13/08	69	82	55	0.00	4	SSW		
Tuesday	10/14/08	70	81	58	0.00	4	S		
Wednesday	10/15/08	75	82	67	0.00	5	SSW		
Thursday	10/16/08	73	82	63	0.01	10	WSW	Rain	Trace=0.01
Friday	10/17/08	58	63	52	0.00	11	N		
Saturday	10/18/08	55	61	48	0.00	14	N		
Sunday	10/19/08	51	59	43	0.00	10	N		
Monday	10/20/08	50	62	38	0.00	5	WNW		
Tuesday	10/21/08	55	65	44	0.00	12	W		
Wednesday	10/22/08	81	57	44	0.00	14	NNW		
Thursday	10/23/08	49	58	39	0.00	7	NE		
Friday	10/24/08	51	57	44	0.01	5	ESE	Rain	Trace=0.01
Saturday	10/25/08	59	68	50	0.84	10	S	Fog, Rain	
Sunday	10/26/08	54	63	45	0.00	6	S		

Day	Date	Average	High	Low	Perc.	Wind Speed (mph)	Wind Direction	Event	Assumptions
Monday	10/27/08	47	53	40	0.18	10	NNW	Rain	
Tuesday	10/28/08	47	51	42	0.07	17	WNW	Rain	
Wednesday	10/29/08	46	52	39	0.00	13	W		
Thursday	10/30/08	46	54	37	0.00	8	WNW		
Friday	10/31/08	49	62	36	0.00	6	S		
Saturday	11/01/08	58	74	41	0.00	6	SSW		
Sunday	11/02/08	54	57	50	0.00	9	ENE		
Monday	11/03/08	54	58	49	0.01	3	NE		Trace=0.01
Tuesday	11/04/08	55	59	51	0.07	8	NNE	Rain	
Wednesday	11/05/08	62	68	55	0.02	13	N	Rain	
Thursday	11/06/08	63	67	58	0.01	14	N	Rain	
Friday	11/07/08	62	70	54	0.00	4	SSE		
Saturday	11/08/08	61	67	55	0.01	6	NW	Rain	Trace=0.01
Sunday	11/09/08	53	60	46	0.00	6	NW		
Monday	11/10/08	45	52	37	0.00	10	NW		
Tuesday	11/11/08	43	50	35	0.00	7	NW		
Wednesday	11/12/08	47	50	44	0.01	5	SSE	Rain	Trace=0.01
Thursday	11/13/08	49	52	45	0.76	4	N	Rain	
Friday	11/14/08	54	57	51	0.01	3	S	Fog, Rain	
Saturday	11/15/08	63	74	52	0.74	11	SSW	Rain, Thunderstorm	
Sunday	11/16/08	45	52	38	0.00	13	WNW		
Monday	11/17/08	41	47	35	0.01	8	W	Rain	Trace=0.01
Tuesday	11/18/08	36	40	31	0.01	15	NW	Snow	Trace=0.01
Wednesday	11/19/08	34	40	27	0.00	11	NW		
Thursday	11/20/08	41	47	35	0.00	10	WSW		
Friday	11/21/08	34	40	28	0.01	14	WNW	Snow	Trace=0.01
Saturday	11/22/08	32	37	26	0.00	11	WNW		
Sunday	11/23/08	35	42	27	0.00	7	SW		
Monday	11/24/08	42	53	30	0.08	9	S	Rain	
Tuesday	11/25/08	43	48	37	0.00	11	WSW		
Wednesday	11/26/08	39	45	32	0.00	8	WSW		
Thursday	11/27/08	39	49	29	0.00	4	S		
Friday	11/28/08	42	48	35	0.00	3	SW		
Saturday	11/29/08	40	49	31	0.01	4	NE		Trace=0.01
Sunday	11/30/08	41	45	37	0.74	7	NNE	Fog, Rain	
Monday	12/01/08	45	50	39	0.00	14	SSW		
Tuesday	12/02/08	40	46	33	0.00	6	W		
Wednesday	12/03/08	37	46	28	0.00	7	S		
Thursday	12/04/08	46	53	39	0.04	9	SW	Rain	
Friday	12/05/08	34	41	27	0.00	9	NNW		
Saturday	12/06/08	30	36	24	0.01	8	SSW	Snow	Trace=0.01
Sunday	12/07/08	30	35	24	0.00	14	WNW		
Monday	12/08/08	28	33	22	0.00	6	S		
Tuesday	12/09/08	41	49	33	0.02	7.00	S	Rain	
Wednesday	12/10/08	57	66	48	0.07	9	SSW	Fog, Rain	
Thursday	12/11/08	48	56	39	1.66	12	NNE	Rain	
Friday	12/12/08	38	44	32	0.05	14	NW	Rain	
Saturday	12/13/08	34	38	29	0.00	7	NW		
Sunday	12/14/08	39	48	30	0.00	10	S		
Monday	12/15/08	55	67	42	0.07	10	SSW	Rain	
Tuesday	12/16/08	45	55	34	0.47	11	NE	Rain	
Wednesday	12/17/08	41	47	34	0.12	5	SSW	Rain	
Thursday	12/18/08	41	47	38	0.00	3	ENE		
Friday	12/19/08	44	47	40	0.33	6	ESE	Rain	
Saturday	12/20/08	36	41	31	0.00	9	NE		
Sunday	12/21/08	36	44	27	0.10	10	NNE	Rain	
Monday	12/22/08	22	28	16	0.00	15	WNW		
Tuesday	12/23/08	26	35	17	0.00	7	SSW		
Wednesday	12/24/08	46	57	34	0.01	12	SSW	Rain	Trace=0.01
Thursday	12/25/08	45	58	32	0.00	11	NNW		
Friday	12/26/08	35	41	29	0.04	4	S	Rain	
Saturday	12/27/08	49	59	36	0.01	8	S		Trace=0.01
Sunday	12/28/08	60	70	50	0.01	13	SW	Rain	Trace=0.01
Monday	12/29/08	45	51	38	0.00	8	WNW		
Tuesday	12/30/08	47	54	39	0.00	9	NW		

Day	Date	Average	High	Low	Perc.	Wind Speed (mph)	Wind Direction	Event	Assumptions
Wednesday	12/31/08	36	47	25	0.01	16	NW	Rain, Snow	Trace=0.01
Thursday	01/01/09	29	34	23	0.00	10	WNW		
Friday	01/02/09	37	43	30	0.00	11	SSW		
Saturday	01/03/09	39	47	31	0.00	7	N		
Sunday	01/04/09	36	45	27	0.00	4	S		
Monday	01/05/09	44	51	37	0.01	7	NNW	Rain	Trace=0.01
Tuesday	01/06/09	37	41	32	0.52	8	NE	Rain	
Wednesday	01/07/09	38	42	33	1.26	4	SSW	Rain	
Thursday	01/08/09	36	42	30	0.01	12	W		Trace=0.01
Friday	01/09/09	33	39	27	0.00	8	NW		
Saturday	01/10/09	36	40	32	0.14	6	ENE	Rain	
Sunday	01/11/09	34	40	28	0.10	10	NNW	Rain	
Monday	01/12/09	34	40	27	0.00	7	N		
Tuesday	01/13/09	34	39	29	0.00	6	S		
Wednesday	01/14/09	29	35	22	0.00	10	NNW		
Thursday	01/15/09	23	29	17	0.01	13	NNW	Snow	Trace=0.01
Friday	01/16/09	15	18	11	0.00	13	NW		
Saturday	01/17/09	18	27	8	0.00	8	SSE		
Sunday	01/18/09	32	37	26	0.00	8	S		
Monday	01/19/09	30	36	24	0.01	6	NNE	Snow	Trace=0.01
Tuesday	01/20/09	25	30	19	0.00	13	NNW		
Wednesday	01/21/09	26	34	18	0.00	9	NW		
Thursday	01/22/09	30	41	19	0.00	6	S		
Friday	01/23/09	38	51	24	0.00	5	S		
Saturday	01/24/09	37	50	24	0.00	14	NW		
Sunday	01/25/09	27	34	20	0.00	5	ESE		
Monday	01/26/09	28	31	25	0.01	5	ENE	Snow	Trace=0.01
Tuesday	01/27/09	29	30	27	2.29	5	ENE	Rain, Snow	
Wednesday	01/28/09	37	43	30	0.27	7	SSW	Rain	
Thursday	01/29/09	33	38	27	0.00	7	NNW		
Friday	01/30/09	34	43	25	0.00	7	WNW		
Saturday	01/31/09	29	36	22	0.00	8	NW		