WestEnd**25**

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1229-1231 25St. NW

Charles Miller – Construction Management

Consultant – Dr. Riley

Spring 2009

Final Report

Penn State Architectural Engineering

4/7/09

WestEnd25

Charles Miller ■ Architectural Engineering ■ Construction Management

Project Overview

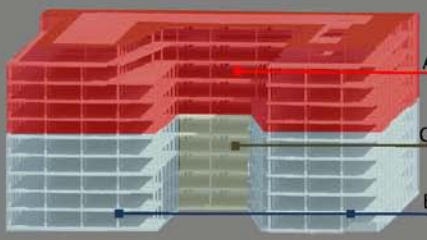
Owner: Vornado-Charles E. Smith
Location: 1229-31 25th St. NW
Washington D.C. 20037
Total Square Feet: 323,380 sq. ft.

General Contractor :
James G. Davis Construction Corp.
Project Delivery: Negotiated GMP
Project Cost : $76 million

Architecture

Architects: Shalom Baranes Associates Architects
The architectural design of WestEnd**25** developed from the two existing office buildings. The footprint of WestEnd**25** resembles a U shape facing the adjacent NW 25th Street. West End 25 stands ten stories tall and contains 283 luxury apartments. The two prime landscaping features of WestEnd**25** are the entrance courtyard and the roof top. The courtyard features an entrance colonnade and a water fountain. The roof features a pool, terraces and vegetation.

Structural



Structural Engineer: Tadjer Cohen Edelson Assoc.
WestEnd**25** is supported by spread footings. The existing superstructure of WestEnd**25** consists of conventionally reinforced concrete with a 20' by 20' column grid. The 1229 and 1231 buildings are connected by a 7" post-tensioned concrete slab. The additional floors maintain the 20' by 20' column grid and primarily have a post-tensioned concrete slab thickness of 6".

Mechanical, Electrical and Lighting

MEP Engineers : GHT Limited
The apartments of WestEnd**25** are conditioned by water cooled heat pump unit. To increase efficiency for the public conditioning system, two enthalpy wheels transfer heat between exhaust air and outdoor air. Power will enter WestEnd**25** from two locations. The high power, 3 phase 460 Volt, will enter the 1231 building and the low power, 3 phase 240 volt, will enter 1229 building. Apartment lighting utilizes track lighting for kitchens and living areas and recessed fluorescent lighting for bedrooms, bathrooms and walk-in closets.

Note: Pictures and rendering were created by Shalom Baranes Associates and have been provided for the use on Senior Thesis


WestEnd25


www.engr.psu.edu/ae/thesis/portfolios/2009/cmm5035

Executive Summary:

WestEnd**25** is a conversion of two six story office buildings to residential rental apartments. The project added four post tensioned concrete stories to the top of the existing buildings, and will fully connect the two buildings. Within this Final Report there are several analyses that look at the project schedule, site logistics, and cost implication of suggested system changes. The main theme of the construction management research analyses within this report is the reduction of productivity. Information for the analyses came from actual project documentation, 2008 R.S. Means Cost Data, meetings with industry professionals, and construction knowledge gained through course work and on the job experiences.

The Concrete Placement analysis looks at placing concrete with a pump as opposed to the original concrete placement method, crane and bucket. The primary advantage of the pump is the ability to be more productive during the placement. One drawback is that the productivity to form and rebar does not increase. This fact minimizes the shorter placement time of the concrete pump. Another drawback is the sizes of the connecting slabs are not large enough to make the pump use efficient. The analysis found that the concrete pump placement method would shorten the schedule by 10 day and save nearly $93,000. Therefore, the benefits of the more productive pump placement are not realized on this project and a more familiar but slower method is acceptable.

The Façade analysis looks at replacing the brick façade with a precast façade. The advantage of a precast façade is that it is fabricated off-site increasing quality and decreasing costs. Not only does the Façade analysis looks at the cost and schedule savings, but it also looks at the current brick installation productivity, thermal barrier differences, as well as the structural weight implications of the precast façade. Both the R-Value analysis and the structural analysis prove that a precast exterior façade is feasible. But, because of the complex issues involved with precast in an urban environment on a mid rise building there can be considerable amount of hesitation to implement, even with the cost savings of $230, 000. The risk involved is high and only a team with several years of experience would be able to determine their capabilities of maneuvering through the urban alley ways and not causing any damage. From the many issues that arose in analyzing the site plan one can determine a more practical use of precast would be on a low rise facility with large open areas around the perimeter of the building.

The spatial planning analysis attempted to create a workflow to animate the space planning process by creating masses that would allow someone with little software experience to create a 4D spatial plan. As more and more architect utilize Building Information Modeling software there will be opportunities to use the software to plan construction sequences. Research into the best practices to employ this software need to be completed to assure the most useful and productive method is used. The placing of the masses took a considerable amount of time. Much more than expected and more than any project manager or superintendent would be willing to devote.

The final analysis was based on the critical industry issue of owner involvement in LEED Certification. For this analysis a survey of industry was completed to learn how some owners are leading their projects toward certification and how other owners hinder their projects. The answers from the survey served as a basis of research to learn more about important decisions for LEED Certification. Because a new version of LEED will be unveiled research was carried into the differences between the old and new version of LEED criteria.

Table of Contents

A. Building History:

WestEnd**25** is a conversion of two six story office buildings to residential rental apartments. The project will add four post tensioned concrete stories to the top of the existing buildings, and will fully connect the two buildings. The following project history section serves as a method to familiarize readers with WestEnd**25**. Information for analysis came from actual project documentation, construction knowledge gained through course work and on the job experiences.

Project Location:

WestEnd**25** is located in Washington D.C. Washington D.C. was established in 1791 with nearly 8,000 residents. Today, Washington D.C. is a multi-cultured city with a population of about 575,000 residents. The preferred method of construction in the Washington D.C. area is concrete, specifically post tensioned concrete slab. Post tensioned concrete allows for greater floor to ceiling heights while minimizing the total height of the building. This is important because Washington, D.C. has an ordinance restricting the height of private buildings to 135 feet. The climate of Washington D.C. is one of four distinct seasons. The seasons of concern during construction are summer and winter. The summer's days are often hot, average temperature in the upper 80's, and humid which often leads to evening thunderstorms. The winter days are cold, average temperature in the low 30's.[1] Two important considerations of weather are safety and design. The climate of Washington D.C. is such that there numerous freeze/thaw cycles transitioning into and out of the winter season. These conditions create situations where dew point control and moisture barrier installation location is critical for condensation control and the prevention of mold. WestEnd**25** rests on bedrock and has a foundation system of spread footing. Because of the essence of this project is adding on to an existing structure is little excavation needed. Extra footings were installed to carry the additional loads of the building.

[1]Monthly Averages for Washington D.C. The Weather Channel Interactive, Inc. 2008 http://www.weather.com/outlook/homeandgarden/garden/wxclimatology/monthly/graph

Project Team Summary:

The following highlights the different parties involved with the development of WestEnd**25**.

Owner: Vornado - Charles E. Smith

General Contractor: James G. Davis Construction Corporation

Architects: Shalom Baranes Associates Architects

Engineers:

Structural: Tadjer Cohen Edelson Associates

MEP: GHT Limited

Civil: Bohler Engineering

Interior Designer: Forrestperkins

Landscape: Oculus

Client Information:

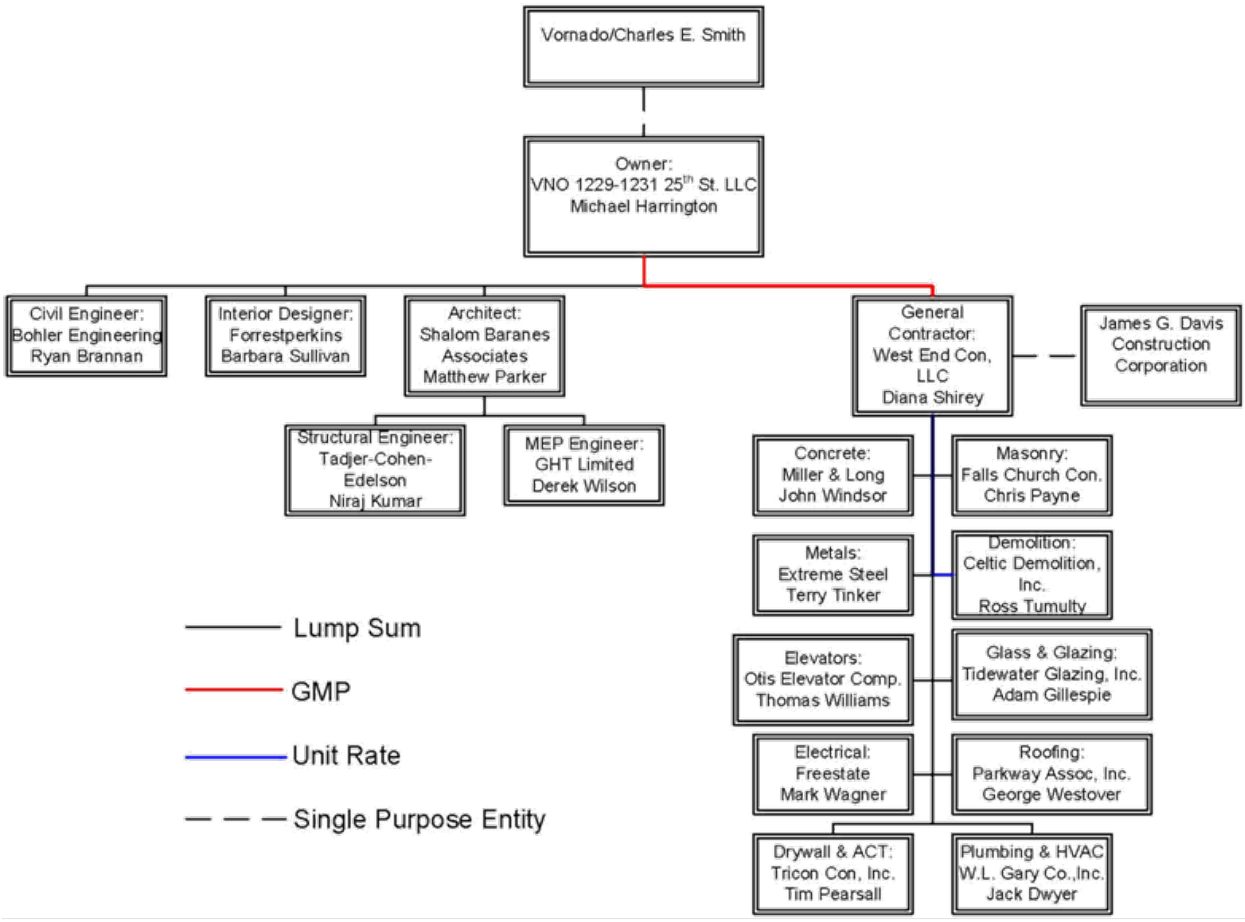
The owner of WestEnd**25** is Vornado – Charles E. Smith a division of Vornado Realty Trust and is well established in the Washington D.C. area. Vornado is an experienced and well financed realty developer. According to U.S. Securities and Exchange Commission documents the 1229 and 1231 office buildings owned by the Buena of National Affairs were purchased by Vornado for $71 million dollars.[2] To finance WestEnd**25** Vornado took out a contract loan for $ 104 million, according to Joseph Macnow of Vornado Realty Trust.[3] The purpose of WestEnd**25** is to provide apartment housing for the NW quadrant of Washington D.C. and specifically apartments for the students of George Washington University. The GMP has been negotiated between James G. Davis and Vornado to $76 million. Because of Vornado's financial plan to house students of George Washington University WestEnd**25** will be delivered in two phases, the first turned over in August 2009 and the second at the end of December 2009. This will allow for tenants to occupy WestEnd**25** for the fall 2009 semester.

Project Delivery System:

Initially, Vornado entered into contract with the design professionals to design WestEnd**25**. The general contractor was brought on board to develop preliminary budgets and to make sure the architects were designing within the owner's budget. The role of the general contractor evolved into a

[2] Exhibit 10.1 Psa for 1229-1231 25th St, 2/17/06. http://www.secinfo.com/dF1e.v5.d.htm
[3] Macnow, Joseph. Vornado Realty Trust. Reuters Business Wire. Feb28, 2008. http://www.reuters.com/article/pressRelease/idUS178195+28-Feb-2008+BW20080228

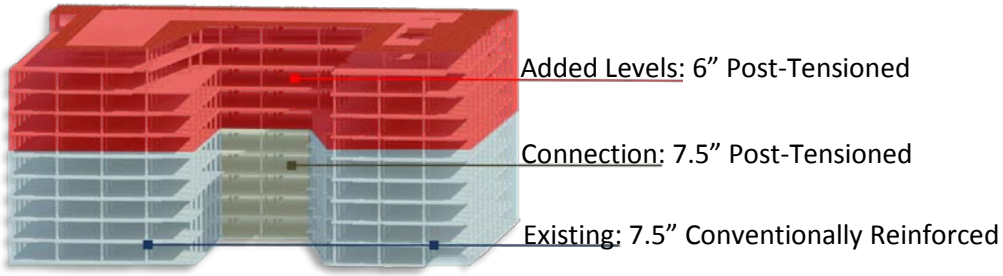
providing construction services with a negotiated GMP. The owner – general contractor agreement is an AIA A111-1997, standard form agreement with a negotiated guaranteed maximum price. Furthermore, both the owner and general contractor have entered into the agreement as a single purpose entity, LLC. The purpose of this is to protect the liability of the larger responsible firm from a lawsuit. These entities have no assets and contract employees for services. To assure the quality construction and compliance with contract price the general contractor provides a limited construction guaranty from the parent company. The general contractor is responsible for procuring worker's compensation, builder's risk insurance, commercial general liability insurance, commercial automobile liability insurance, pollution liability insurance and excess liability insurance. Furthermore, the general contractor is responsible that subcontractors obtain worker's compensation insurance, employer's liability insurance, general liability insurance, excess liability insurance, and automobile liability insurances. The owner is not requiring a bond from the general contractor but is requiring bonds from all subcontractors with contracts over $100,000 and all building envelope subcontractors. Clearly there is an established relationship between the owner and the general contractor. Because of this, in conjunction with both parties vast experience this delivery seems reasonable and appropriate for this project.



Building Systems Summary:

Cast-in-Place Concrete:

The existing structure of WestEnd**25** consists of conventionally reinforced two way concrete slabs with varies sections of waffle slabs. The typical slab thickness of the existing structure is 7.5". The project's additional four floors and six connection slabs are post-tensioned concrete. The typical slab thickness of the connection slabs is also 7.5" but the typical thickness of the additional floors is 6". The column grid of 20' by 20' is maintained throughout WestEnd**25**. Concrete will be placed via crane and bucket. The crane is located in a central position of the site, the courtyard, and concrete deliveries will come from 25th St. NW. The formwork will be traditional timber formwork and pour samples will be collected to ashore concrete reaches designed strength.



Areas of Cast-in-Place Concrete

Mechanical System:

The apartments of WestEnd**25** are conditioned by water cooled heat pump units. These units are self contained floor mounted horizontal packages with heating and cooling capabilities for each apartment. This allows for multiple independent conditioned zones. To complete the mechanical system there are four natural gas boilers to warm the condensing water during the peak heating periods and there is also a cooling tower to dissipate the heat energy from the condenser water during periods of high cooling demand. Basic considerations for this type of system are the low installation cost and the independent conditioning flexibility. Also, include as part of the public conditioning system are two enthalpy wheels that transfer heat from exhaust air and outdoor air depending on loads. Therefore, outdoor air is pre-cooled or pre-heated with exhaust air form the conditioned zones.

Electrical System:

The power for WestEnd**25** is being supplied by a main feed of 3 phase 2,500 Amp service is received from the Potomac Electric Power Company, PEPCO, from 25th street PEPCO. The main power is coming from underneath 25th street. There were two existing power vaults for each of the existing buildings. The vault at 1229 carries the 3 phase 460 voltage supply and the vault at 1231 carries the 3 phase 208 voltage supply. The switchgear rooms are located on the west side of the first level basement and distribute lines up to the first floor down the corridors to the risers on the east side of the

building. From the risers power is distributed to every apartment on each floor and each apartment is metered individually.

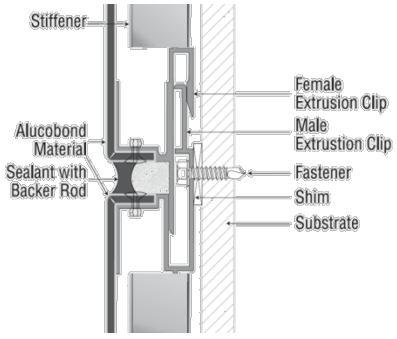
Masonry:

The façade facing the allies surrounding WestEnd**25** is called alley wrap. The ally wrap of WestEnd**25** comprises about 75% of the exterior façade. This alley wrap is a brick cavity wall with metal stud backing. A hydraulic mast climbing scaffold system will be used for the façade. The construction of the brick façade consist of face brick, concave mortar joint, airspace, masonry ties, rigid insulation, exterior gypsum board, vapor barrier and metal framing.

Hydraulic Mast Climbing Scaffold System for Masonry Installation

Curtain Wall:

The façade facing 25th St NW and the entrance courtyard is called the park wrap. The park wrap comprises about 25% of the exterior façade. The park wrap is a curtain wall is a panelized system that is installed from the interior of the building. Glazing is 1" thick insulating glass fabricated from two sheets of .25" thick low-E on #2 surface tempered glass with a .5" air space. Frames and accenting metal panels are aluminum composite material. The metal panels are fabricated with a polyethylene core and two thick aluminum skins one of with contains an anodized grey finish.



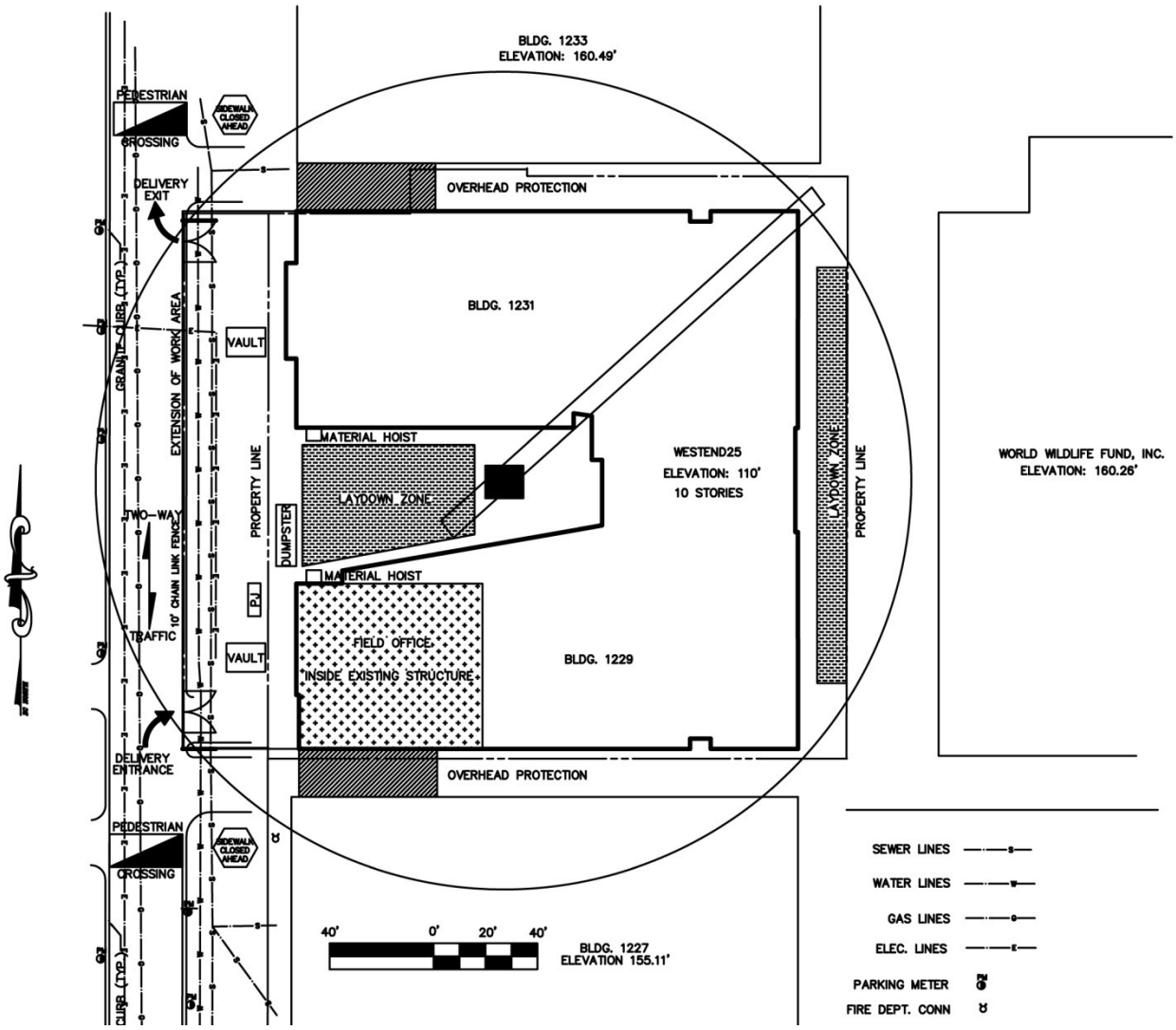
Detail of Metal Panel on Curtain Wall

Site Plan Summary:

Access to the site will be from 25th St NW. All deliveries will enter on the south end of the site and exit the north end of the site. A Peiner SK 315 tower crane with a reach of 200 feet with a max load of 8,300 lbs. will be located in the central courtyard and will primarily be used for placing concrete. The courtyard will also serve as a laydown area. Another laydown area exists on the east side of the site. The sidewalk adjacent to the site will be closed to pedestrians and the parking lane on the east side of 25th St NW will also be closed for the duration of construction. Temporary pedestrian crosswalks have been established. Furthermore, flag persons will be used to direct traffic when deliveries are expected and when there is heavy traffic during the mornings. The utilities for WestEnd**25** run from under 25th St NW and tie-in at two locations. There is one location for the north building and one location for the south building. The neighboring building to the south is also the property of the owner and will be renovated in the future, the building to the north is a residential building and the building to the east is an office building. Across 25th St NW is a public park with a softball field, soccer and lacrosse nets. This space will not be used for any storage. The footprint of WestEnd**25** extends to the alley on the north and south sides. There is overhead protection along the alleys to protect vehicles entering other building's parking garages during demolition and construction. WestEnd**25** will utilize two material hoists. The material hoists will be located on the courtyard side of both the north and south buildings and will be the primary source of vertical transportation until elevators are installed. There are two dumpsters on site which have a tipping fee of $385 per pull. The important features shown in the site plan are:

- Utilities
- Delivery Entrance/Exit
- Pedestrian Paths
- Laydown Location
- Crane Location
- Field Office Location

Site Plan:


BLDG. 1233
ELEVATION: 160.49'
PEDESTRIAN CROSSING
SIDEWALK CLOSED AHEAD
DELIVERY EXIT
OVERHEAD PROTECTION
BLDG. 1231
VAULT
GRANITE CURB (TYP.)
EXTENSION OF WORK AREA
MATERIAL HOIST
LAYDOWN ZONE
WESTEND25
ELEVATION: 110'
10 STORIES
PROPERTY LINE
DUMPSTER
TWO-WAY TRAFFIC
10' CHAIN LINK FENCE
MATERIAL HOIST
P.I.
VAULT
FIELD OFFICE
INSIDE EXISTING STRUCTURE
BLDG. 1229
LAYDOWN ZONE
PROPERTY LINE
WORLD WILDLIFE FUND, INC.
ELEVATION: 160.26'
DELIVERY ENTRANCE
OVERHEAD PROTECTION
PEDESTRIAN CROSSING
SIDEWALK CLOSED AHEAD
CURB (TYP.)
40' 0' 20' 40'
BLDG. 1227
ELEVATION 155.11'
SEWER LINES
WATER LINES
GAS LINES
ELEC. LINES
PARKING METER
FIRE DEPT. CONN

Project Schedule Summary:

WestEnd**25** is a unique project because the scope of work includes demolition of existing building systems, an early turnover of first floor and a mock up unit. The existing site contains two six story office buildings that will converted to residential rental apartments. The purpose of this schedule is to provide a summary of activities and their durations for the completion of WestEnd**25**. Work flow is created by starting at the west side of building 1231 and working in a clockwise direction. The actual summary schedule follows the section summaries. Key durations included in this schedule are:

- Demolition – 74 days
- Superstructure – 147 days
- Façade Installation – 267 days
- MEP Rough-In – 155 days
- Finishes – 186 days

Demolition:

Mobilization for WestEnd**25** began in late February, 2008. It is important to note that the existing site contains two separate office buildings and work activities are sequenced such that the north building is followed by the south building. Demolition of existing exterior façade and interior down to structural frame immediately begun and lasted until early June. This demolition also includes duration for slab cuts of existing concrete structure for slab extensions and infill.

Structure:

Work on the superstructure is sequenced by floors and starts with the first floor and continues to the roof/penthouse. For the first through the sixth floor the superstructure work includes installing supporting steel, F/R/P of the slab infills and slab extension for the existing structure. Interestingly, due to the slow non- repetitive nature of installing the supporting steel multiple locations compared to the F/R/P of an entire floor the durations per floor are about equivalent from existing structure to the added structure. The completion of the superstructure is scheduled for 11/24/08.

Façade:

The façade of WestEnd**25** is comprised of what is termed alley wrap and park wrap. The alley wrap is a brick veneer with metal stud backing and the park wrap is a curtain wall façade. For the durations per each floor the alley wrap is approximately 5 weeks per floor and the park wrap is approximately two weeks per floor. These durations spread across each floor leads to a milestone date of watertight building on 9/1/09.

Elevators:

The elevators begin to be installed in mid-January of 2009 and will assume the responsibility of transporting labor and material as of 5/28/09. To accomplish this elevators are being installed such that there will be one operational in the north building and one operational in the south building. The remaining duration of the elevators will be used to install the remaining elevators, but will not be used by construction personnel when completed.

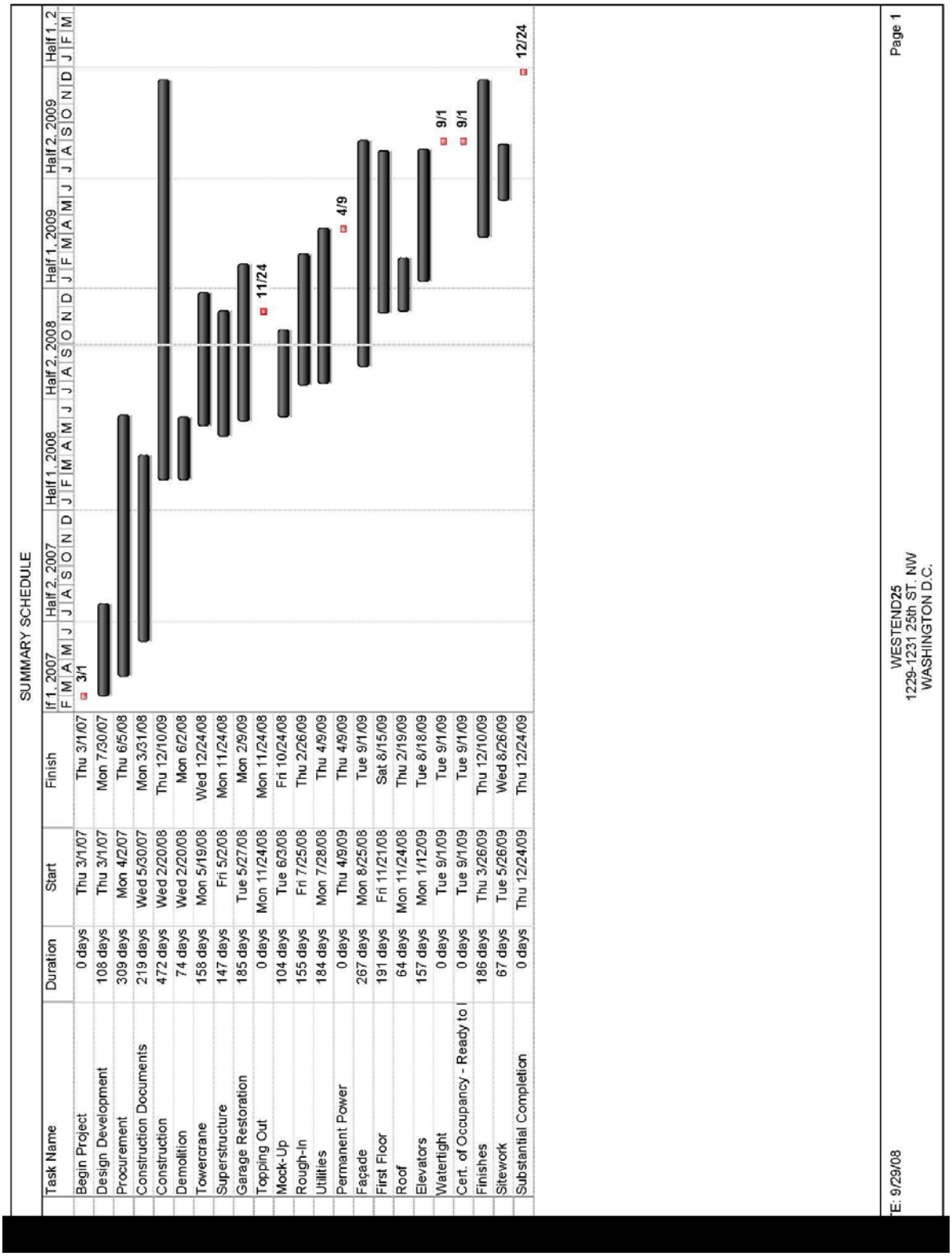
Mock Up:

An important room of WestEnd**25** is apartment 213 because that is the mock-up. Therefore, the activities of the mock-up are highlighted with their own line item. Similarly, the first floor is to be delivered and occupied earlier than the rest of the building and therefore it is also a separate line item.

Interiors:

The flow from the north building to the south building continues through MEP rough-in to finishes. The finishes of WestEnd**25** averages a duration of about 90 days per floor but can be overlapped with subsequent floors and sequenced such that trades flow up the building completing the interior finishes by 12/10/09. As previously mentioned the finishes of the first floor will be completed by 8/15/09 for turnover to owner and occupancy by 9/1/09. Substantial completion for the rest of the building will be 12/24/09.

Summary Schedule:



Project Cost Evaluation:

The project cost of WestEnd**25** is$75,881,149 at $234.65 per square foot with a construction cost of $67,241,381 at $207.93 per square foot. The table below shows the breakdown of the building systems cost.

Overall Building		
Building Construction Costs	$67,241,381	$207.93
Total:	$67,241,381	$207.93
Overall Project		
Owner's Project Cost	$75,881,149	$234.65
Total:	$75,881,149	$234.65
Building System	**Cost**	**Cost Per SF (323,380 SF)**
Structural		
Concrete	$5,622,364	$17.39
Steel	$1,982,083	$6.13
Total:	$7,604,447	$23.52
Glazing		
Glazing	$11,132,951	$34.43
Total:	$11,132,951	$34.43
Finishes		
Drywall	$5,356,540	$16.56
Ceramic Tile	$1,750,777	$5.41
Paint	$1,223,796	$3.78
Flooring	$1,046,858	$3.24
Total:	$9,377,971	$29.00
Mechanical		
HVAC/Plumbing	$12,350,000	$38.19
Sprinkler	$909,400	$2.81
Total:	$13,259,400	$41.00
Electrical		
Electrical	$7,435,850	$22.99
Total:	$7,435,850	$22.99

B. Technical Analyses:

Introduction:

The main theme of the construction management research analyses within this report is the reduction of productivity. The concrete analysis looks at using a concrete pump to improve productivity. The exterior façade analysis includes a productivity study of actual brick installation on WestEnd**25**. The third analysis looks at the implementation of a building information model as a tool to plan trade flow through a building. In theory this could lead to increased productivity by not having trades overlap and get in each other's way. Finally, the critical industry issue of owner involvement in LEED was analyzed thorough surveys of industry members including owners, architects and contractors.

Concrete Placement:

Building Structural System History:

The original 1229-1231 buildings were constructed in the late 1960's with a concrete structural systems. Four additional stories were added to increase the amount leasable apartment rental space. The four additional stories added to WestEnd**25** are also supported by a concrete structural system. The placement for the concrete was the crane and bucket method. The crane and bucket method used took 141 days to install at a package cost of $4.5 million.

Project Problems:

Placing concrete with the crane and bucket method is a slow process. This process is not continuous, it cycles with only 5 cubic yards of concrete being moved and placed at any one time. The average cycle time was about one and a half minutes. Therefore, about 70cy of concrete was placed in an hour. At this rate approximately 110cy of concrete will be placed in a day. This translates as one day for placement of the connector slabs and six days for the placement of the full size stories.

Concrete Pump Solution:

An alternative method to placing the concrete is using a concrete pump. A concrete pump offers many favorable advantages, such as increased productivity. Increase productivity is important because it means faster completion allowing the owner to receive a return on their investment sooner. Productivity data for concrete placement was taken from R.S. Means data. The productivity rate for pump placement is 160cy per day. This translates into one day to place the connector slabs and four days to place the full stories. This is a savings of two days per floor.

Pump Description:

Using a pump to place the concrete allows for a steady flow from the delivery truck to the placement locations. A concrete pump consists of a hopper, a piston system and piping. The pump works by truck mixers pouring the concrete into a hopper that funnels the concrete to hydraulic pistons

that push the concrete through the piping. To maintain a continuous flow of concrete deliveries of concrete truck will have to be coordinated such that as one truck is empty a full truck can being discharge to the hopper.

However, the tower crane will be used for other purposes than moving concrete. The crane will also be used for heavy picks such as placing the mechanical equipment for the penthouse. In order to make these picks in the future a mobile crane will need to be brought to the site. The cost of a crane that could handle the need to make daily picks, such as rebar would offset the savings. Also, a larger mobile crane would also need to be brought in to make heavier picks such as the 10,000 pound energy recovery units in the penthouse.

Schedule:

Traditional concrete placement with a crane and bucket is time consuming. An advantage of placing concrete with a pump is the speed of installation. Below is a comparison of the time of job site installation for each system. The data used for activity durations were gathered from actual productivity data from the job site and from R.S. Means. Durations for the formwork, rebar, and bucket placement were taken from actual project data. While the pump placement durations were estimated from R.S. Means data. The schedules below conclude that the pump placement system takes 10 less days when compared to the crane and bucket placement method. The concrete placement is on the project's critical path so a savings of ten days will shorten the project's overall duration, savings 10 days worth of general conditions.

ID	Task Name	Duration	Start	Finish
1	**Crane and Bucket**	**141 days**	**Fri 6/27/08**	**Fri 1/9/09**
2	Reinforce/Form/Place Columns to 2nd	1 day	Fri 6/27/08	Fri 6/27/08
3	Frame/Reinforce 2nd Flr Connector	3 days	Mon 6/30/08	Wed 7/2/08
4	Place 2nd Flr Connector	1 day	Thu 7/3/08	Thu 7/3/08
5	Reinforce/Form/Place Columns to 3rd	1 day	Tue 7/8/08	Tue 7/8/08
6	Frame/Reinforce 3rd Flr Connector	3 days	Wed 7/9/08	Fri 7/11/08
7	Place 3rd Flr Connector	1 day	Mon 7/14/08	Mon 7/14/08
8	Reinforce/Form/Place Columns to 4th	1 day	Fri 7/18/08	Fri 7/18/08
9	Frame/Reinforce 4th Flr Connector	3 days	Mon 7/21/08	Wed 7/23/08
10	Place 4th Flr Connector	1 day	Thu 7/24/08	Thu 7/24/08
11	Reinforce/Form/Place Columns to 5th	1 day	Wed 7/30/08	Wed 7/30/08
12	Frame/Reinforce 5th Flr Connector	3 days	Thu 7/31/08	Mon 8/4/08
13	Place 5th Flr Connector	1 day	Tue 8/5/08	Tue 8/5/08
14	Reinforce/Form/Place Columns to 6th	1 day	Wed 8/6/08	Wed 8/6/08
15	Frame/Reinforce 6th Flr Connector	3 days	Mon 8/11/08	Wed 8/13/08
16	Place 6th Flr Connector	1 day	Fri 8/15/08	Fri 8/15/08
17	Reinforce/Form/Place Columns to 7th	5 days	Mon 8/18/08	Fri 8/22/08
18	Frame/Reinforce 7th Flr	10 days	Mon 8/25/08	Fri 9/5/08
19	Place 7th Flr	6 days	Mon 9/8/08	Mon 9/15/08
20	Reinforce/Form/Place Columns to 8th	5 days	Tue 9/16/08	Mon 9/22/08
21	Frame/Reinforce 8th Flr	10 days	Tue 9/23/08	Mon 10/6/08
22	Place 8th Flr	6 days	Tue 10/7/08	Tue 10/14/08
23	Reinforce/Form/Place Columns to 9th	5 days	Wed 10/15/08	Tue 10/21/08
24	Frame/Reinforce 9th Flr	10 days	Wed 10/22/08	Tue 11/4/08
25	Place 9th Flr	6 days	Wed 11/5/08	Wed 11/12/08
26	Reinforce/Form/Place Columns to 10th	5 days	Thu 11/13/08	Wed 11/19/08
27	Frame/Reinforce 10th Flr	10 days	Thu 11/20/08	Wed 12/3/08
28	Place 10th Flr	6 days	Thu 12/4/08	Thu 12/11/08
29	Reinforce/Form/Place Columns to PH	5 days	Fri 12/12/08	Thu 12/18/08
30	Frame/Reinforce PH	10 days	Fri 12/19/08	Thu 1/1/09
31	Place PH	6 days	Fri 1/2/09	Fri 1/9/09
32				

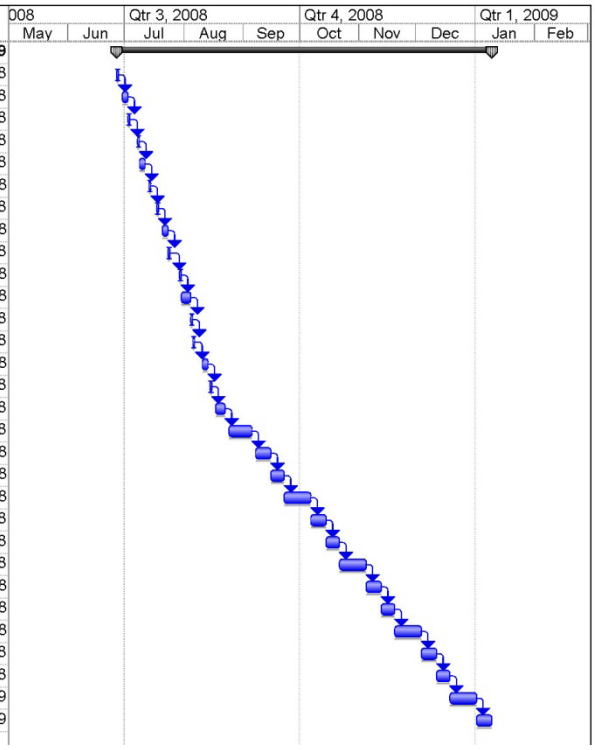


Figure CP1a: Placement Schedule Comparison

33	**Concrete Pump**	**131 days**	**Fri 6/27/08**	**Fri 12/26/08**
34	Reinforce/Form/Place Columns to 2nd	1 day	Fri 6/27/08	Fri 6/27/08
35	Frame/Reinforce 2nd Flr Connector	3 days	Mon 6/30/08	Wed 7/2/08
36	Place 2nd Flr Connector	1 day	Thu 7/3/08	Thu 7/3/08
37	Reinforce/Form/Place Columns to 3rd	1 day	Tue 7/8/08	Tue 7/8/08
38	Frame/Reinforce 3rd Flr Connector	3 days	Wed 7/9/08	Fri 7/11/08
39	Place 3rd Flr Connector	1 day	Mon 7/14/08	Mon 7/14/08
40	Reinforce/Form/Place Columns to 4th	1 day	Fri 7/18/08	Fri 7/18/08
41	Frame/Reinforce 4th Flr Connector	3 days	Mon 7/21/08	Wed 7/23/08
42	Place 4th Flr Connector	1 day	Thu 7/24/08	Thu 7/24/08
43	Reinforce/Form/Place Columns to 5th	1 day	Wed 7/30/08	Wed 7/30/08
44	Frame/Reinforce 5th Flr Connector	3 days	Thu 7/31/08	Mon 8/4/08
45	Place 5th Flr Connector	1 day	Tue 8/5/08	Tue 8/5/08
46	Reinforce/Form/Place Columns to 6th	1 day	Wed 8/6/08	Wed 8/6/08
47	Frame/Reinforce 6th Flr Connector	3 days	Mon 8/11/08	Wed 8/13/08
48	Place 6th Flr Connector	1 day	Fri 8/15/08	Fri 8/15/08
49	Reinforce/Form/Place Columns to 7th	5 days	Mon 8/18/08	Fri 8/22/08
50	Frame/Reinforce 7th Flr	10 days	Mon 8/25/08	Fri 9/5/08
51	Place 7th Flr	4 days	Mon 9/8/08	Thu 9/11/08
52	Reinforce/Form/Place Columns to 8th	5 days	Fri 9/12/08	Thu 9/18/08
53	Frame/Reinforce 8th Flr	10 days	Fri 9/19/08	Thu 10/2/08
54	Place 8th Flr	4 days	Fri 10/3/08	Wed 10/8/08
55	Reinforce/Form/Place Columns to 9th	5 days	Thu 10/9/08	Wed 10/15/08
56	Frame/Reinforce 9th Flr	10 days	Thu 10/16/08	Wed 10/29/08
57	Place 9th Flr	4 days	Thu 10/30/08	Tue 11/4/08
58	Reinforce/Form/Place Columns to 10th	5 days	Wed 11/5/08	Tue 11/11/08
59	Frame/Reinforce 10th Flr	10 days	Wed 11/12/08	Tue 11/25/08
60	Place 10th Flr	4 days	Wed 11/26/08	Mon 12/1/08
61	Reinforce/Form/Place Columns to PH	5 days	Tue 12/2/08	Mon 12/8/08
62	Frame/Reinforce PH	10 days	Tue 12/9/08	Mon 12/22/08
63	Place PH	4 days	Tue 12/23/08	Fri 12/26/08

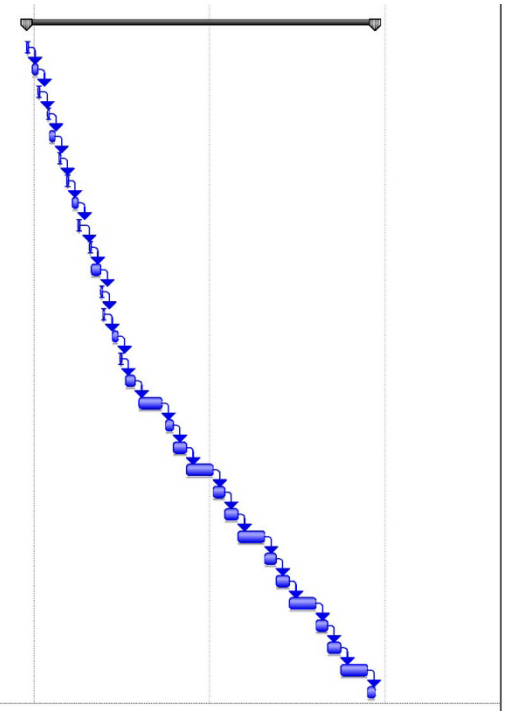


Figure CP1b: Placement Schedule Comparison

As can be seen from the schedules in Figure CP1 the formwork and rebar placement keep the two different placement methods at the relatively the same productivity. It is not until the full stories are placed that the effectiveness of the pump shortens the schedule. The full stories are 9.5 times larger than the connecting slabs. For the placement of the full slabs the pump shortens the placement time from 6 days per floor to four days per floor. The primary reason that the overall duration difference is not greater is the extensive time to place forms and rebar that need to be completed prior to the concrete placement. On WestEnd**25** the connecting slabs were not large enough to offset the pours such that the formwork and rebar could be completed in one section while a concrete placement was happening in another section. However, the full stories did allow for this to occur and therefore the pump placement was more efficient. The images in Table PC1 show how the effects of the pump change from the smaller connector slabs to the larger story slabs.

Crane and Bucket vs. Concrete Pump Placement	
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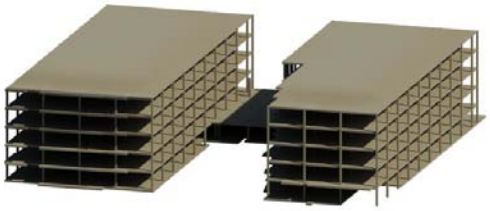
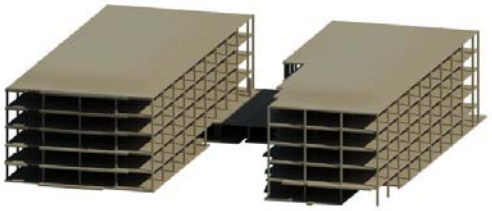
Crane and Bucket 	Pump 
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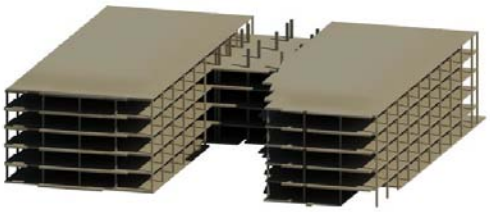
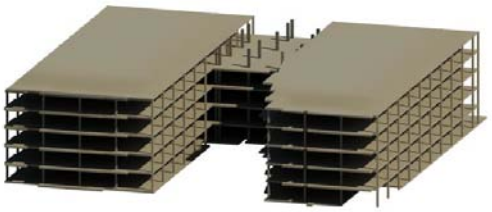
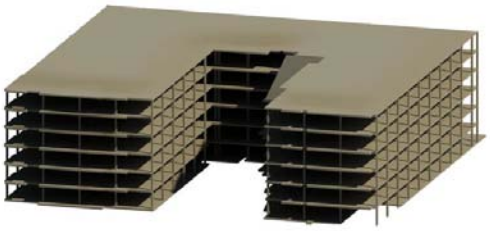
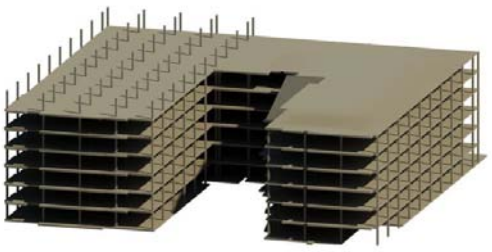
Crane and Bucket 	Pump 
Date: 9/15/08	
Crane and Bucket 	Pump 

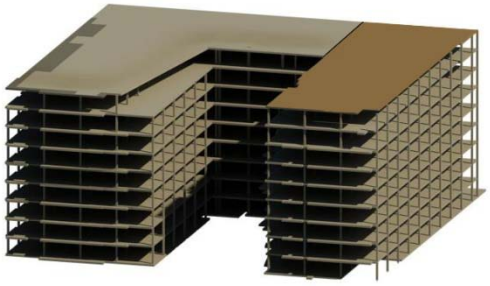
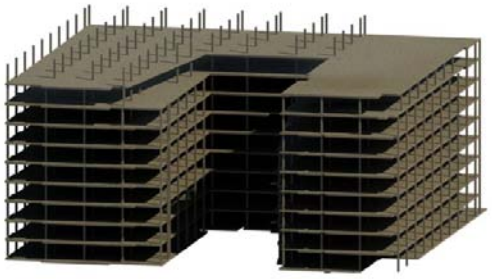
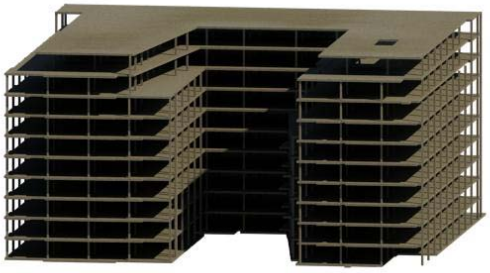
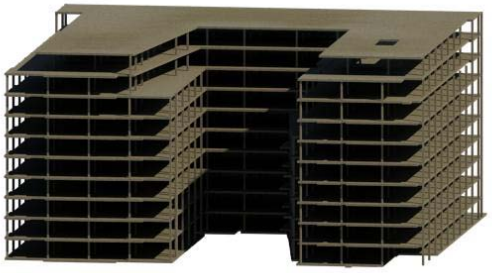
Date: 11/8/09	
Crane and Bucket 	Pump 
Finish	
Crane and Bucket **1/9/09** 	Pump **12/26/09** 

Table PC1: Visualization of Comparison

Cost:

The cost difference is a vital number in determining the feasibility of pump placement. Costs of the crane and bucket placement have been gathered from actual project data. Pump placement costs have been estimated using supplier information and R.S. Means. A location factor .93 was applied to the data from R.S. Means to account for the Washington D.C. location. In Table PC2 below a breakdown of associated costs is shown.

Item	Quantity	Cost Basis	Total Cost
Crane and Bucket Placement	4,106 CY	Equipment = $7,000/week Labor = $13/ CY	$193,375
Pump Placement	4,106 CY	$18.20/ CY	$74,750
		Cost Difference	$118,625
Supplemental Crane: *Assumed 18 Ton; quote from Capitol Building Supply, Inc.		$650/day For 131 days	($85,150)
		Net Savings:	$33,475
General Conditions Savings		$5,925/day For 10 days	$59,250
		Total Savings:	$92,725

Table PC2: Placement Cost Breakdown

The result of the cost analysis is quite profound. With the utilization of the pump placement system there would only be a savings of $33,475. However, the effect of a decreasing the duration of installing the structure is a shorter project duration which results in a further savings of $59,250, resulting in a total savings of $92,725.

Placement Conclusions:

From the 33%increase in productivity between the connecting slabs and full stories it can be concluded that the effectiveness of the pump concrete placement method increases as the pour size increases. In other words, the smaller the pour the less effective the pump will be at saving overall project time. WestEnd**25** has too many small pours to reap the benefits from the pump. Nevertheless, the pump placement seems to be a considerable savings in cost. However, $92,725 is only 2% of the package cost and 0.12% of the total project cost. Therefore, the benefits of the more productive pump placement are not realized on this project and a more familiar but slower method is acceptable.

Exterior Façade:

Building Façade History:

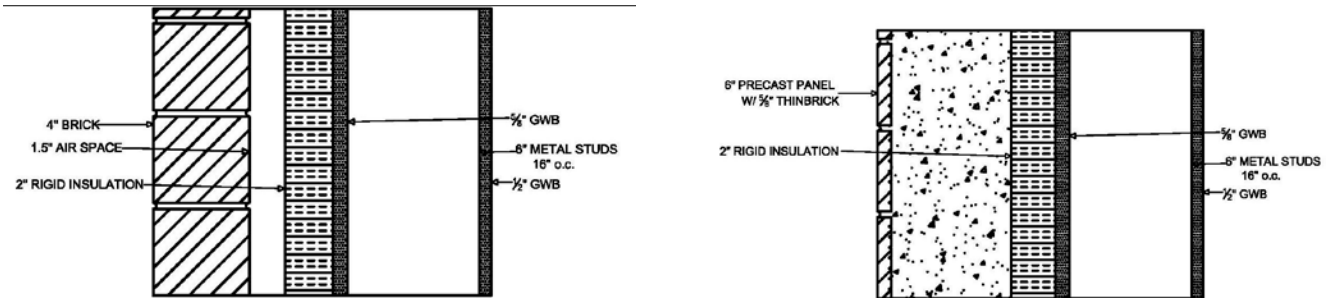
The original 1229-1231 buildings were constructed in the late 1960's with a precast façade wrapping the entire buildings. For 40 years these buildings have served as offices for the Bureau of National Affairs. In 2007 the properties were purchased by Vornado/Charles E. Smith to be redeveloped into residential apartments. The current façade design consists of removing the old precast façade and replacing it with a combination of curtain wall on the street side of the building and a traditional brick façade for the remaining façade. The design of the brick cavity wall consists of 3-5/8" brick, 2" airspace, 2" of rigid insulation and an air/vapor barrier.

Project Problems:

The demolition work has revealed that the slab edges at varies parts of the building's perimeter do not run in straight lines. This did not cause problems with the original precast façade, because the panels had installation tolerances that enabled to them to be adjusted to look flush. A traditional brick masonry wall lacks this benefit. Instead the slab edges must be grinded back to make the perimeter run flush. The extra work has delayed the installation of the façade and increased the demolition cost, forcing the mason to use extra crews and work overtime to get back on schedule.

Precast Solution:

Given that the original façade was precast, then a new façade design that also used precast would have negated the need for extra demolition. Discussion with Mark Taylor of Nitterhouse Concrete Products verified this fact. According to Mr. Taylor precast panels have a 1"-2" clearance between the back of the panel and the supporting structure. The purpose of this tolerance is to allow for variance, like the aforementioned, and assure the outside faces of the panels align and are visually appealing. Therefore, the proposed façade design is an architectural precast brick veneer panel system. The panels consist of 5/8" thin set brick cast in and 5-3/8" concrete. The material differences can be seen in Figure PC1 below.



Existing Façade Proposed Facade

Figure PC1: Wall Sections

Panel Description:

These panels are produced in a factory environment. First, the panel is formed and then the thin set bricks are arranged within a plastic set grid. Then concrete is placed, vibrated and leveled. Because of the factory environment the curing temperature is regulated resulting in higher concrete strengths. After the concrete is cured the set grid is removed revealing the joints of the brick. The joints are made to look like the panel would have been hand crafted. During installation brick tiles may chip and may require replacing.

On WestEnd**25** the precast will run vertically up the building. The widths of the panels will vary because of the façade design. Figure PC2 below highlights the outlines of the precast panels.

Figure PC2: Precast Panel Typical Layout

Schedule:

Traditional brick facades are hand crafted by talented labor. Therefore, the installation is meticulous and time consuming. An advantage of precast panels over masonry brick is the speed of installation. In Figure PC3 a comparison of the time for job site installation for each system is shown.

ID	Task Name	Duration	Start	Finish
1	**Install Brick Alley Wrap**	**70 days**	**Mon 2/2/09**	**Fri 5/8/09**
2	Install Alley Wrap - 1st Floor	7 days	Mon 2/2/09	Tue 2/10/09
3	Install Alley Wrap - 2nd Floor	7 days	Wed 2/11/09	Thu 2/19/09
4	Install Alley Wrap - 3rd Floor	7 days	Fri 2/20/09	Mon 3/2/09
5	Install Alley Wrap - 4th Floor	7 days	Tue 3/3/09	Wed 3/11/09
6	Install Alley Wrap - 5th Floor	7 days	Thu 3/12/09	Fri 3/20/09
7	Install Alley Wrap - 6th Floor	7 days	Mon 3/23/09	Tue 3/31/09
8	Install Alley Wrap - 7th Floor	7 days	Wed 4/1/09	Thu 4/9/09
9	Install Alley Wrap - 8th Floor	7 days	Fri 4/10/09	Mon 4/20/09
10	Install Alley Wrap - 9th Floor	7 days	Tue 4/21/09	Wed 4/29/09
11	Install Alley Wrap - 10th Floor	7 days	Thu 4/30/09	Fri 5/8/09
12				
13				
14	**Install Precast Alley Wrap**	**19 days**	**Mon 2/2/09**	**Thu 2/26/09**
15	Install Alley Wrap - North Façade	6 days	Mon 2/2/09	Mon 2/9/09
16	Install Alley Wrap - East Façade	8 days	Tue 2/10/09	Thu 2/19/09
17	Install Alley Wrap - South Façade	5 days	Fri 2/20/09	Thu 2/26/09

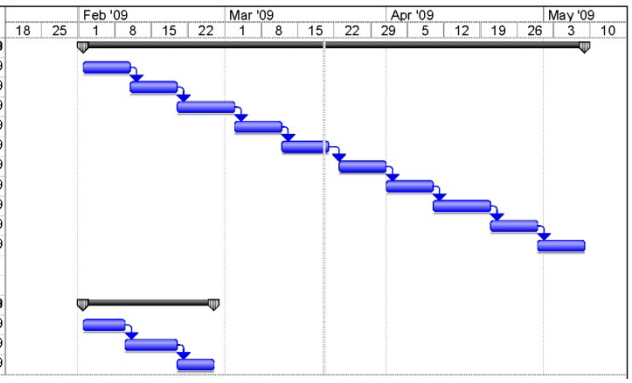


Figure PC3: Schedule Comparison

As can be seen in the above schedules the precast system takes 51 less days to install. The data for the brick alley wrap installation is from the project contract schedule. The difference between the sequencing of activates is that the traditional brick will proceed by installing brick around the perimeter of the building one floor at a time moving up the building. The precast installation will complete entire facades a while moving around the building.

Cost:

The cost difference is a vital in determining the feasibility of a precast façade. The cost of the traditional brick façade includes the cost of materials, labor and hydraulic scaffolding around the building. The cost of the architectural precast panel façade is listed as a square-footage cost, which includes fabrication, delivery and installation. The cost of the precast façade also includes the benefits of a shorter schedule, discussed above, by calculating the savings in general conditions. The cost breakdown is shown in Table PC1.

Item	Quantity	Cost Basis	Total Cost
Brick Façade	23,030 sq. ft.	Budget Estimate: Labor = $48,900 Material Estimate = $416,000 Equipment = $131,250	$1,036,250
Precast Facade	23,030 sq. ft.	$35/sq.ft.	$806,050
		Difference:	$230,200
		Demolition Extra Work:	$77,000
		Total Savings:	$307,200

Table PC1: Cost Comparison

The results of the cost analysis show that there is a $230,200 cost difference in favor of the precast façade. The difference can be accounted for by the cost in equipment. The brick façade uses hydraulic scaffolding around the entire alley wrap for a long duration. The precast façade uses a crane but for a much shorter duration. The cost basis of $35/sq.ft. was gathered from Mark Taylor of Nitterhouse Precast. This cost basis is higher than the $25 square footage costs of R.S. Means, which includes material and labor. The $35/sq.ft. cost is still reasonable because it includes fabrication and delivery on top of material and labor. This cost analysis does not take general conditions into consideration because the alley wrap is not on the critical path and therefore would not shorten the schedule.

Productivity Analysis (MAE Element) :

A productivity analysis has been completed in order to implement graduate level work into this report. A similar analysis was completed for CE 533 – Construction Productivity Analysis and Performance Evaluation on the Lewis Katz building at University Park, PA. The curtain wall façade was analyzed for productivity. Weekly site visits and meetings with the subcontractor were held to build a relationship and successfully gather data. For WestEnd**25** the brick façade has been analyzed for productivity. It was unfeasible to make weekly site visits due to the location of the project. However, there is a preexisting relationship with the project team and weekly meetings were completed via phone to obtain daily installation numbers and manpower.

The flowchart in Figure PC4 shows the process used to complete this analysis. The first level of the flowchart requires that the activity of interest should be in progress while collecting data. This is important to assure accurate numbers. The next step is to obtain daily installed quantities and workhours. The best method to do this is by being on-site and physically recording the quantities and workhours in person. This was not possible for this analysis due to project location. Instead information

was provided from the project team. Next, the productivity can be calculated with daily quantities and workhours. The final step of the flow chart is to evaluate the results. The evaluation should look at the baseline productivity and how much variances there is between the daily productivities vary from the baseline. Baseline productivity is calculated by taking 10% of the data dates with the highest output. A total of 5 data dates were used because 10% of the collected data dates would be too small. The baseline productivity is calculated by dividing the summed baseline workhours by the summed baseline quantity. The baseline productivity is considered the best productivity that can be expected for the construction method and design complexity. Also, during evaluation factors such as weather impact, material, and managerial impacts should be considered for peaks of poor productivity.

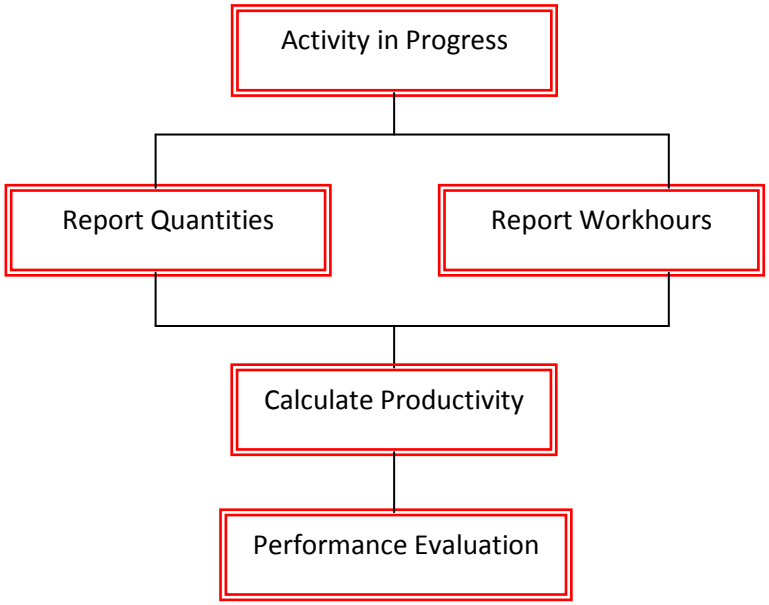
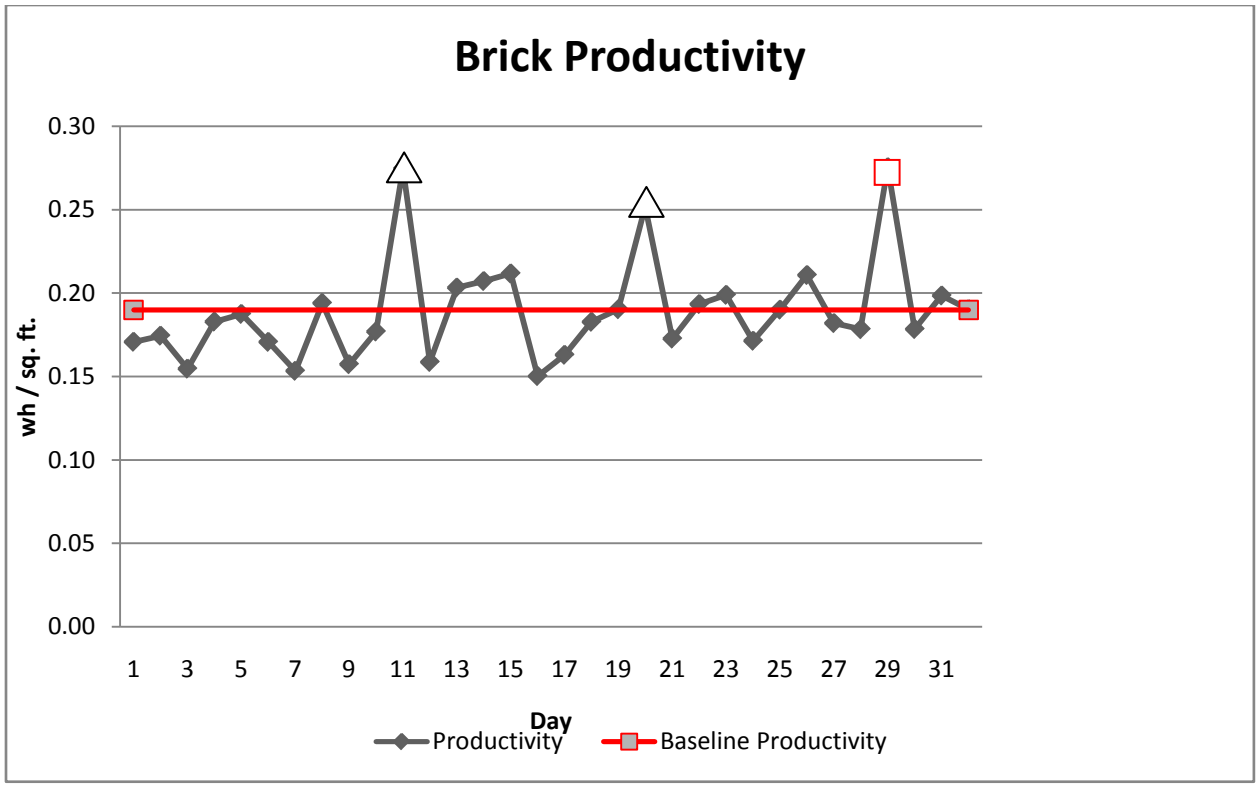


Figure PC4: Productivity Performance Workflow

For this analysis the brick installation is the activity of interest. It is ongoing and only the first 32 days of installation data were gathered. The daily quantities and workhours used in this analysis can be found in the appendices. The graph in Figure PC5 below shows the productivity during brick installation. There are three noticeable peaks which indicate a decrease in productivity. Two of these peaks were the result of weather not allowing the installation of brick. The third peak was caused by preceding trade work not being completed. Many of the remaining data points are below the baseline productivity indicating better than expected productivity.



△ = Weather Delays

□ = Other Trade Delay

Figure PC5: Brick Productivity

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In Figure PC6 a theoretical productivity plot of the precast installation based on planned panel installation per day is shown. The planned panel installation quantities and workhours can be found in the appendices. The initial peak in the graph is caused by extra time need to maneuver equipment for installation, discussed in the preceding site logistics section. The remaining data points are mostly above the baseline but do not vary much. This indicates an expected consistent installation of panels from day to day. Weather delays are less likely during precast installation. However, precast installation is still very susceptible to delays from other trades or deliveries.

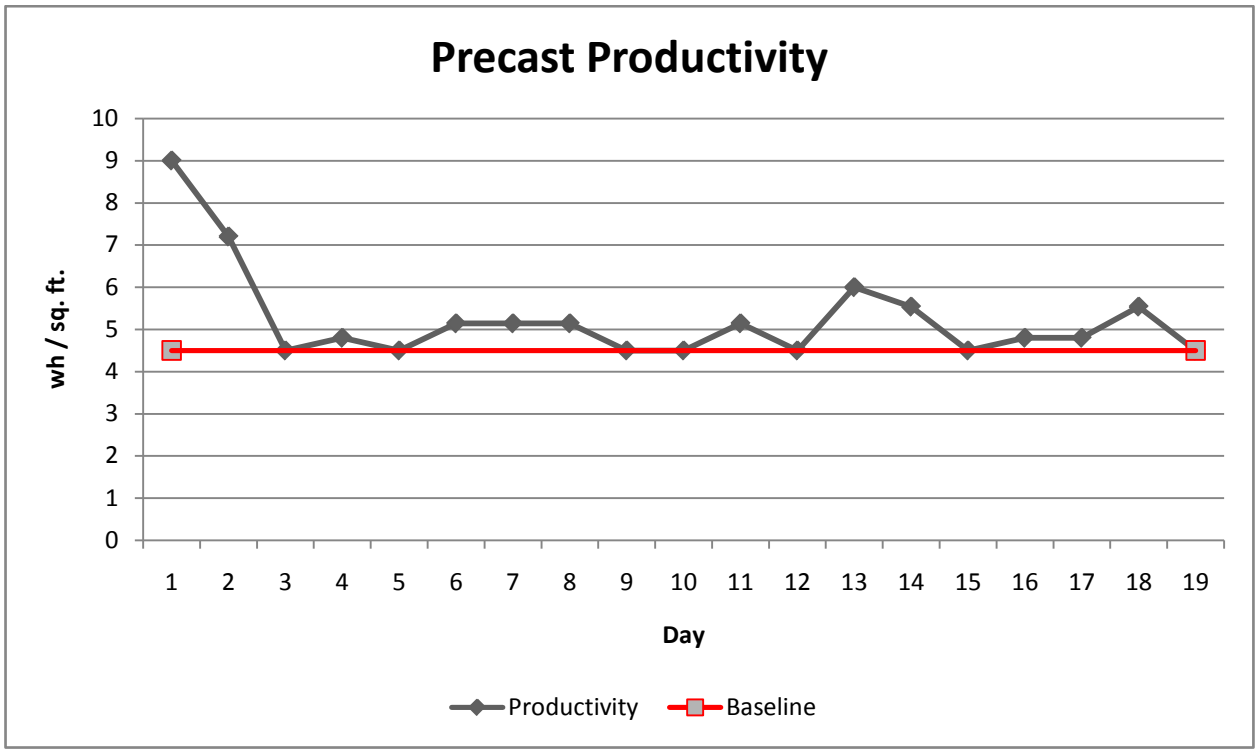


Figure PC6: Precast Productivity

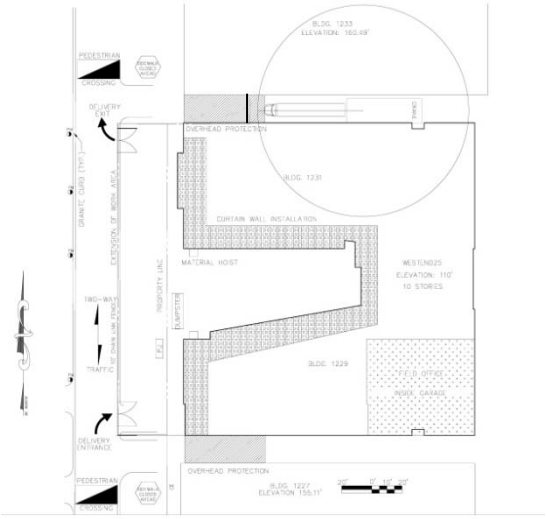
Productivity Conclusion:

The brick installation was effected two of the 32 days of installation by weather. To make up this lost productivity extra hours will need to be worked. Delays such as this are costly on projects. With the precast productivity analysis no effects of weather were considered because precast installation is less effected by weather. The largest potential for delay comes from delivery delays from the precast fabricator. If the panels do not show on site when they are schedule the crew will have nothing to do and productivity will be greatly impacted.

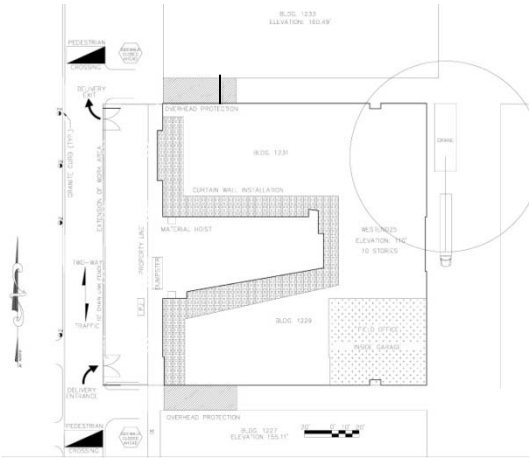
Site Logistics:

Site Logistics are an important consideration to the feasibility of a precast brick façade. The precast façade panels will need to be installed with a mobile crane. The crane must be able to lift the panels the entire height of the building. It must also be able to fit and maneuver in the surrounding alley. The specifications of a Terex T790-90 ton capacity crane met the required lifting capacities for installing the precast panels with max pick weight of 19,600 pounds at a height of 110+ ft. Therefore the specifications have been used for this analysis. To best make the crane fit in the alley one set of outriggers should be set on the ground floor and the other side set in the alley. Another complication to

the site logistics is a wall in the north alley near the start of the brick alley wrap. Because of this obstacle a delivery truck will need to go down the alley first followed by the crane to place the first set of panels. Then the crane will need to back out of the alley to let the truck back out of the alley and let another truck in. This process is very time consuming, but would only need to be done four times over the duration of two days. The number of panels per delivery was estimated based on the legal transportation limits. The legal weight limit is 80,000 pounds; 30,000 pounds of which are the truck allowing a maximum load of 50,000. In consultation with construction industry professional Jim Faust and professional truck driver Ronald Kreider the weight range for loads is between 44,000 pounds and 48,000 pounds. Afterwards the crane can go down the alley and essentially trail the trucks around the building. Site plans depicting this operation are below. Figure PC6 below shows the necessary crane movement during installation.



This site plan depicts the need to have the delivery truck enter the north alley. For the second delivery, both the crane and truck will need to exit to allow another delivery truck to enter.



After the first four sets of panels are installed the crane can follow the truck around the perimeter of the building.

Figure PC6: Site Logistics During Precast Installation

U Value Analysis (Breadth 1):

U-Value:

The U Value is a coefficient of heat transfer that indicates the amount of heat that will move through a material. The lower the U-Value number means a greater the ability to resist heat movement. U-Values are expressed in Btu/(hr*ft^2*^{o}F). This analysis will calculate both the existing brick cavity façade U-Value and the proposed precast façade U-Value.

Calculation Method:

The parallel material calculation method was used to calculate the U-Value. This method requires the gathering of R-Values for the materials that comprise the wall section. These R-Values come from ASHRAE standards and from manufacturer's data, based on independent test results. All the material's R-Values are summed to get a total R-Value. The reciprocal of this number is taken and is equal to the U-Value. The values can be seen in the tables below. WestEnd**25** is in Zone 4A as determined by ASHRAE Standard 90.1. As such, the wall assembly must have a U-Value under 0.064 Btu/(hr*ft^2*^{o}F) and a continuous insulation R-Value of at least 7.5 (hr*ft^2*^{o}F)/Btu , with an R-Value greater than 13 (hr*ft^2*^{o}F)/Btu for the remaining wall elements. As can be seen in the calculations below, both wall sections meet this requirement. The existing brick cavity wall has a lower U-Value and therefore better performance.

To obtain the R-Values ASHRAE Standard 90.1 was primarily used. The tables below list the location the R-Value was found. The ASHRAE Handbook – Fundamentals was used to determine the R-Value for the brick and concrete. The density of the brick façade is 113 lbs/ft^3, to calculate the R-Value a more conservative density of 110 lbs/ft^3 was used from Table 25.4 to obtain a value of 0.8 (hr*ft^2*^{o}F)/Btu. To calculate the R-Value of concrete the density of 150 lbs/ft^3 was used from Table 25.4 to obtain a value of 0.6 (hr*ft^2*^{o}F)/Btu. Part of the wall assembly is also a vapor barrier and air barrier. These were left out of the analysis because according ASHRAE Handbook – Fundamentals their thermal barrier effectiveness is negligible. This is not to say their importance in the wall assembly is negligible. The air and vapor barriers play a vital role in the prevention of moisture infiltration to the dry zone of a wall assembly.

Hand Calculations:

Traditional Brick Façade:

Layer	R – Value ((hr*ft^2*^{o}F)/Btu)	Source
Exterior Air Film	0.17	Standard 90.1 – 2004 A9.4.1
4 in. Face Brick	0.80	2005 ASHRAE Handbook Table 25.4
1.5” Air Space	0.93	Standard 90.1 -2004 TableA9.4A
2” Rigid Insulation	10.00	Manufacturer’s Data
5/8” Gypsum Board	0.56	Standard 90.1 – 2004 Table A9.2D
Framing Cavity	9.0	Standard 90.1 – 2004 Table A9.2B
1/2” Gypsum Board	0.45	Standard 90.1 – 2004 Table A9.2D
Interior Air Film	0.68	Standard 90.1 – 2004 A9.4.1
Total	22.59	
U-Value	0.044	

Table U1: Brick Façade U-Value

Precast Façade:

Layer	R - Value ((hr*ft^2*^{o}F)/Btu)	Source
Exterior Air Film	0.17	Standard 90.1 – 2004 A9.4.1
6” Concrete	0.60	2005 ASHRAE Handbook Table 25.4
2” Rigid Insulation	10.00	Manufacturer’s Data
5/8” Gypsum Board	0.56	Standard 90.1 – 2004 Table A9.2D
Framing Cavity	9.0	Standard 90.1 – 2004 Table A9.2B
1/2" Gypsum Board	0.45	Standard 90.1 – 2004 Table A9.2D
Interior Air Film	0.68	Standard 90.1 – 2004 A9.4.1
Total	21.46	
U-Value	0.047	

Table U2: Precast Façade U-Value

H. A. M. Analysis:

The Heat, Air, and Moisture Building Science Toolbox is a computer program that facilitates design analysis of an exterior wall system. There are several analyses that can be completed on an exterior wall. This program was used in AE 542 - Building Enclosure Science and Design to determine wall systems' R-Value. This analysis looks at the program's R-Value calculation features. The first step of this program is selecting the location of the project. The following step requires the user to build the wall section from materials in the program's database that match the materials that make up the wall system. The H.A.M. program contains stored data for the weather conditions that the wall system will be subjected to, as well as material properties for the components of the wall. The results of the analysis are shown below.

Traditional Brick Façade:

	Generic Material	Manufacturer	Model No.	Thick (in.)	RVal (R)	W.Temp. (°F)	S.Temp. (°F)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.75	0.17	15.6	94.9
2	brick (TTW), 4 in.	No Recor...	Generic...	4.00	0.64	16.7	94.5
3	cavity, 2 in.	No Recor...	Generic...	2.00	0.98	18.5	93.8
4	rigid ins.,(extru.), 2 in.	No Recor...	Generic...	2.00	10.27	37.0	87.1
5	gypsum bd., 5/8 in., (#1)	No Recor...	Generic...	0.63	0.46	37.8	86.8
6	batt ins., 5-1/2 in.	No Recor...	Generic...	5.50	16.76	68.0	75.7
7	gypsum bd., 1/2 in., (#2)	No Recor...	Generic...	0.50	0.46	68.9	75.4
8	air film (int), 3/4 in.	No Recor...	Generic...	0.75	0.64	70.0	75.0

Table U3: H.A.M. R-Value Calculation for Brick Façade

Precast Façade:

	Generic Material	Manufacturer	Model No.	Thick (in.)	RVal (R)	W.Temp. (°F)	S.Temp. (°F)
1	air film (ext), 3/4 in.	No Recor...	Generic...	0.75	0.17	15.6	94.9
2	concrete wall, 6 in.	No Recor...	Generic...	6.02	0.87	17.2	94.3
3	rigid ins.,(extru.), 2 in.	No Recor...	Generic...	2.00	10.27	36.2	87.4
4	gypsum bd., 5/8 in., (#1)	No Recor...	Generic...	0.63	0.46	37.0	87.1
5	batt ins., 5-1/2 in.	No Recor...	Generic...	5.50	16.76	68.0	75.7
6	gypsum bd., 1/2 in., (#2)	No Recor...	Generic...	0.50	0.46	68.8	75.4
7	air film (int), 3/4 in.	No Recor...	Generic...	0.75	0.64	70.0	75.0

Table U4: H.A.M R-Value Calculation for Precast Façade

The H.A.M. analysis resulted in a much higher wall assembly R-Value. This difference can be attributed to the program's inability to take into consideration the thermal breaks of the metal studs in the interior cavity. In the H.A.M. analysis the R-Value of the cavity is the value of the batt insulation, 16.67 (hr*ft^2*^{o}F)/Btu. In comparison the effective R-Value taking into consideration the metal framing and the batt insulation, per ASHRAE standards, is 9.0 (hr*ft^2*^{o}F)/Btu, a difference of 7.67 (hr*ft^2*^{o}F)/Btu. If this difference would be taken into account then difference between the analysis would only be 0.13 (hr*ft^2*^{o}F)/Btu, a more reasonable difference.

U-Value Conclusion:

Both the precast and the brick facades meet the required U-Value requirements. Their closeness stems from their similarities of materials and their properties. The concrete and the brick do not provide a significant thermal barrier. The thermal strength of the wall comes from the rigid insulation. The higher precast U-Value implies that there will be a greater rate of heat flow across the wall assembly, requiring more energy to be consumed conditioning the interior spaces. Nevertheless, the precast system is a feasible option.

Structural Analysis (Breadth 2):

Structural Implications:

The use of precast panels will approximately add an additional 40 lbs/ft^3. to the structural system of WestEnd**25**. It is important to assure that the existing structure will be able to support this added load without significant extra reinforcing. The following analysis uses a computer program to determine if the carrying capacity of the existing structure is high enough to support the added precast loads.

pcaColumn:

A computer program called pcaColumn was used to determine the ability of the existing structure to carry the added loads to the building from the weight of the precast panels. pcaColumn is software designed for investigation of reinforced concrete column strengths. The program takes the load values and the existing structure column properties, both entered by the user, to run through calculations and determine the capabilities of the structure with the given loads. The load values that were entered can be found in Table ST1.

Load	Calculation	Total
Panel	150lbs/ft^3(.5ft)(1ft)(10.6ft)=795lbs/ftwidth 795lbs/ftwidth(12ftwidth)	9,540 lbs
Concrete	(0.625ft)(150lb/ft^3)=93.75lbs/ft^2 93.57lb/ft^2(200ft^2)+(22.5ft^3)(150lbs/ft^3)	22,089 lbs
Wind	43psf(1ft)(10.6)=455.8lbs/ftwidth 455.8lbs/ftwidth(12ftwidth)	5,469.6 lbs
Floor	40psf + 20psf =60psf 60psf(200 ft^2)	12,000lbs

Table ST1: Calculations for Entered Load Values

In order to run this analysis there were several assumptions made to simplify the data set. The loads used in this calculation were run assuming no windows and that the loads acted across the entire tributary area of the column. This is a conservative assumption because in fact windows break the tributary area and would lessen the dead loads applied to the column. This analysis was completed looking at a one story column located on the ground floor. This was done to simplify calculations. Loads were magnified by a factor of ten to factor all stories of the building.

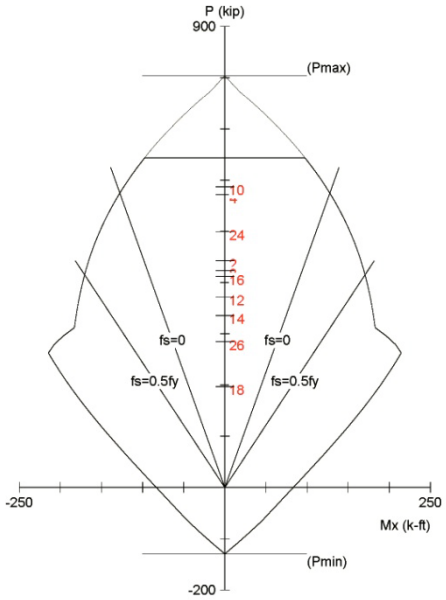


Figure ST1: Moment Interaction Diagram

Figure ST1, is a moment interaction diagram that is typically used to illustrate a columns ability to support axial and eccentric loads. This analysis was completed with the assumption of no lateral forces and no eccentric loads. The diagram indicates that all loads are within the compressive carrying capacity of the existing structure and below the critical load 640 kips and therefore the column is adequate for precast panels.

Structural Conclusion:

The precast panels add an additional weight to the building's structure. By using a computer software program it has been determined that the structure will be adequate enough to support the added loads. Therefore, from a structural standpoint the precast panels are feasible.

Façade Conclusion:

Both the R-Value analysis and the structural analysis prove that a precast exterior façade is feasible. But, because of the complex issues involved with precast in an urban environment on a mid rise building there can be considerable amount of hesitation to implement, even with the cost savings of $307,200. The risk involved is high and only a team with several years of experience would be able to determine their capabilities of maneuvering through the urban alley ways and not causing any damage. From the many issues that arose in analyzing the site plan one can determine a more practical use of precast would be on a low rise facility with large open areas around the perimeter of the building.

Spatial Planning:

The purpose of this research is to analyze the usefulness of animating the space planning process by creating generic masses that would allow someone with little software experience to create a 4D spatial plan. On WestEnd**25** the typical spatial trade conflicts were expected and merely tolerated. This paper's process goal will be to allow a general contractor to have an easy medium that spatial planning can be completed and trade interference can be avoided. The idea behind this analysis is that designers will be more likely to use designing software based on parametric data which can quickly produce three dimensional representations of their designs. According to a poll by the American Institute of Architects shows that 10% of architectural firms that have purchased Building Information Modeling, BIM, and software are using it for billable work[4]. It is expected that the amount of architecture firm will only increase. With the use of such software becoming common place, contractors will be faced with an ability to use a tool to help with project planning. Designers who use such software will be able to share versions with different parties of the project team with a copy of the building. One potential use of this software for a contractor will be for spatial planning. This analysis looks at using Revit Architecture (Revit), a database modeling program, and NavisWorks, a multipurpose planning program in order to plan the flow of trades through a building floor plan. The main criteria that will be used to determine the success will be ease of the process and the time to complete.

Workflow:

The workflow shown in Figure SP2, starts with the assumption of a complete architectural model and project schedule. The architectural model can be copied as a contractor version so that a contractor may edit the model data in terms of inserting blocks, as discussed above. To insert the block the contractor needs to go to the desired floor plan in the model and load the block library into the project. From this stage the contractor can begin inserting the specific trade blocks in their desired location. NavisWorks lists the blocks in the sequential order in which they were entered into Revit. This is important because the step of linking the blocks to the schedule can be facilitated by logically placing the block in the order that they will be tied to schedule activities. Figure SP1 shows a potential layout of the imported schedule and model object.

[4] Goldberg, H. Edward, AIA. How Are Architects Using Digital Design Tools? *Cadalyst*. June 1, 2007.

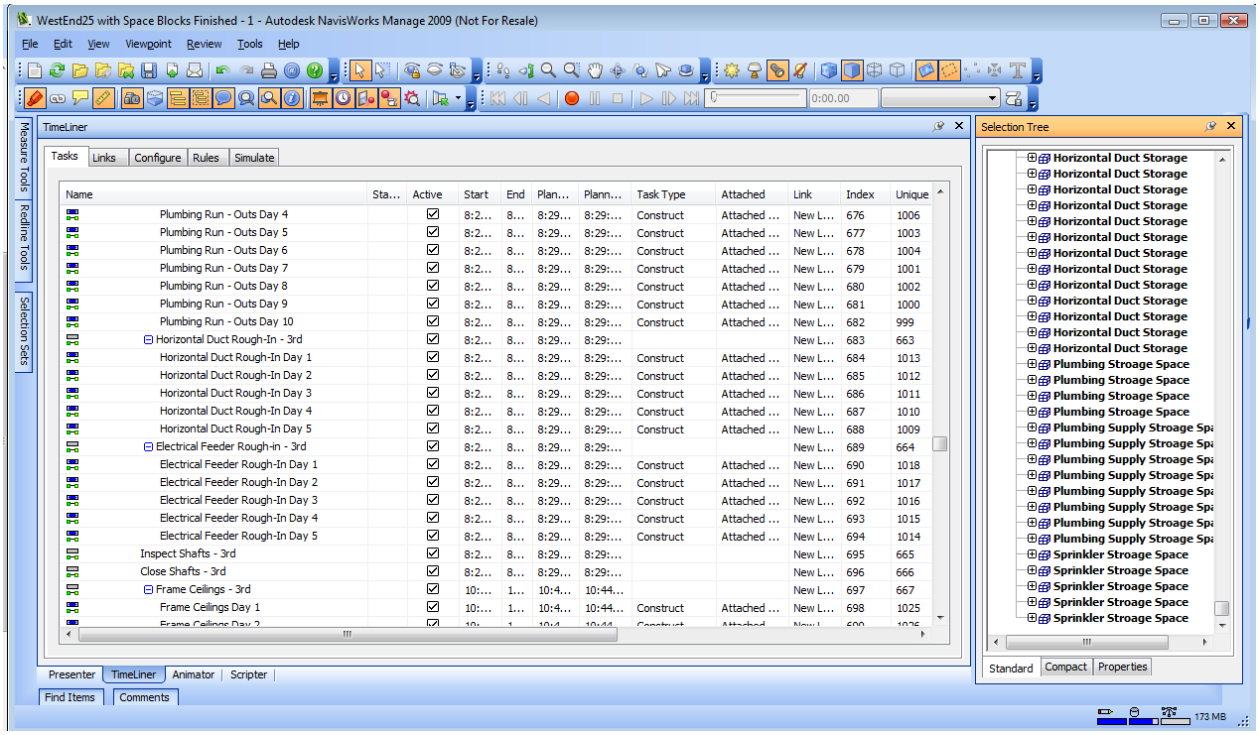


Figure SP1: NavisWorks Schedule – Object Interface

The project schedule should show the specific activities and durations of the work space that are being modeled in Revit. Once all the blocks are inserted the floor plan can be exported to NavisWorks. In NavisWorks the project schedule can be imported. Linking the activities in the schedule to the objects creates a 4D representation of the trade flow on a floor. This flow should be evaluated for major clashes or out of sequenced work.

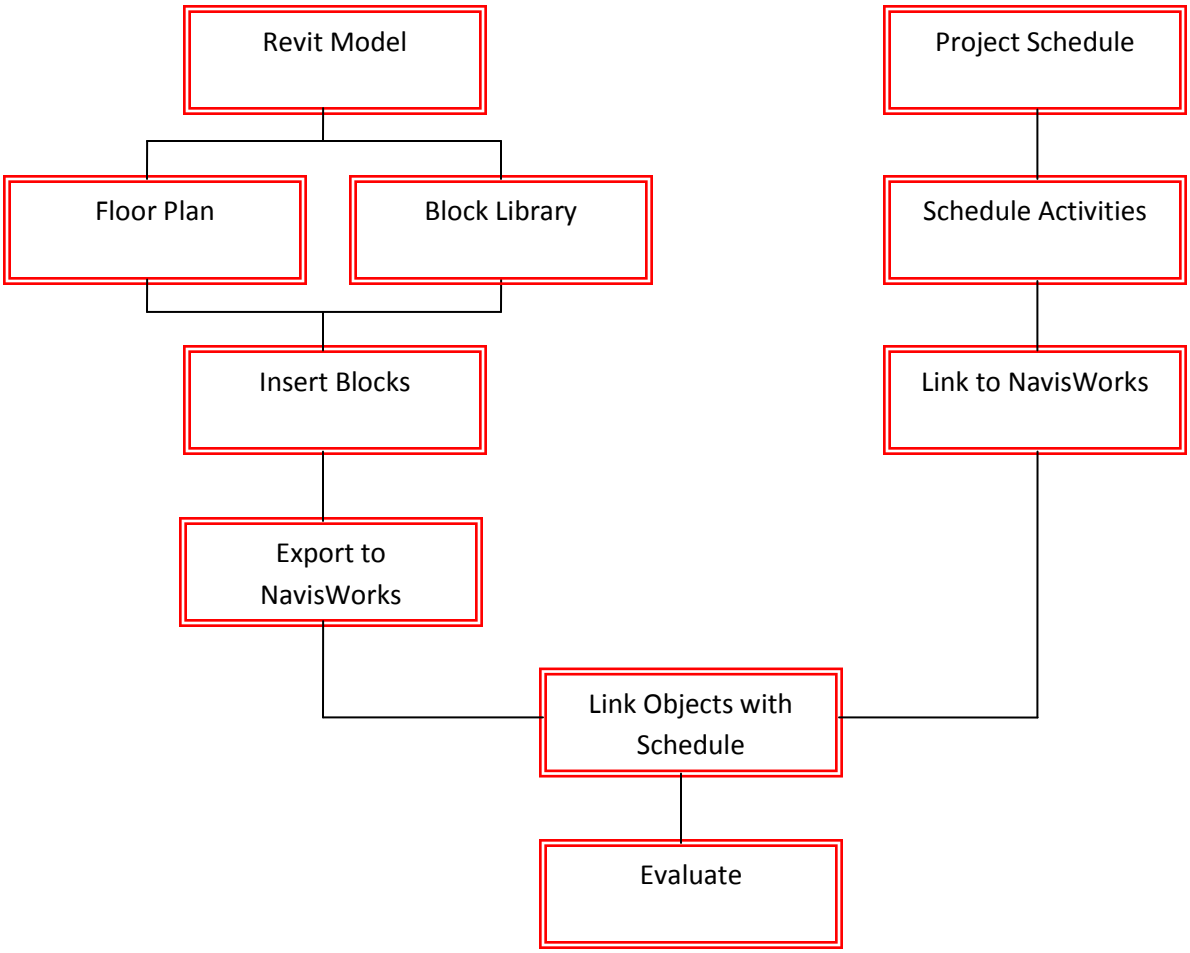


Figure SP2: Animated Spatial Planning Workflow

Blocks:

The creation of space blocks is an important step in the planning process. The time taken to determine the size and create the shapes of the space blocks have not been considered as part of the planning process. This is because once they are created they can be reused for multiple projects. In the workflow above this is called a Block Library to highlight the preexisting choices of blocks that can be picked from. The size of these block are based on typical medium sized floor planes. Blocks were created for work space, storage space, and equipment space for each building system. An advantage of the multiple blocks is that they only need to be created once and then can be inserted into any project numerous times.

Specific vs. Generic:

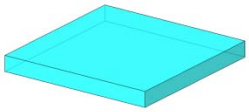
The blocks that have been created for the Block Library are considered specific blocks. They have been created with a particular trade in mind. Specific blocks allow easier assigning of schedule activities in the planning program. The downside to this is that similar proportioned blocks must be

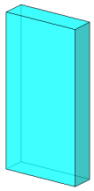
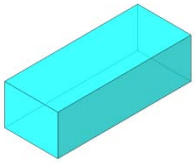
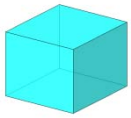
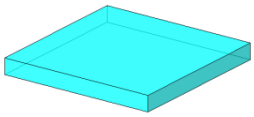
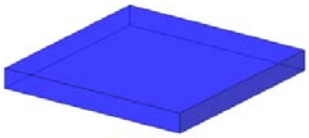
inserted at relatively same locations on the floor plan and Revit does not accept overlapping blocks well. The benefit of generic blocks is that they only need to inserted once into Revit and then can be tied to a specific trade in the schedule with relative ease in NavisWorks. This concept works well for wall spaces that will have multiple trades working at different times. Therefore, instead of inserting the same space five times for five different trades, it only needs to be inserted once and multiple trades can be associated to that space at different times in the planning program. Furthermore, it is important to note that the blocks should be inserted into Revit as the spaces would be used in real life. NavisWorks maintains the knowledge of the order the blocks were inserted and lists the blocks in that order. Therefore, an organized insertion method makes tying blocks to the schedule much easier. Table SP1 below highlights important aspects of generic and specific block types.

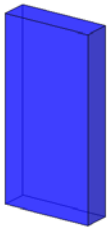
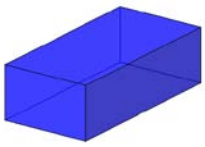
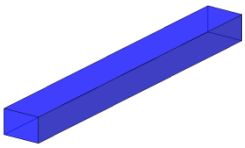
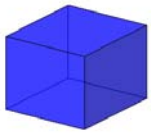
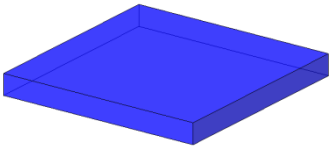
Blocks	Software	User
Generic	Allows multiple selection of same space for multiple trades	Best to put in order to be tied to schedule
Specific	Color characteristics are lost in the export to NavisWorks	Cannot put more than one block in one location in Revit

Table SP1: Block Type Shortcomings

The summary of the Block Library can be found in the Table SP2 below:

Trade Activity	Properties
Mechanical	
Mechanical Ceiling: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 2’ Depth: 20’

Mechanical Wall: 	Description of Properties: <u>Size-</u> Width: 2’, 3’, 5’, 10’ Height: 10’ Depth: 1’ 6”
Mechanical Duct Storage Space: 	Description of Properties: <u>Size-</u> Width: 4’ Height: 3’6” Depth: 10’
Mechanical Finishes Storage Space: 	Description of Properties: <u>Size-</u> Width: 4’6” Height: Depth: <u>Number per Story-</u>
Mechanical Finishes Work Space: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 2’ Depth: 20’
Plumbing	
Plumbing Ceiling: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 2’ Depth: 20’

Plumbing Wall: 	Description of Properties: <u>Size-</u> Width: 2’, 3’, 5’, 10’ Height: 10’ Depth: 1’ 6”
Plumbing Storage Space: 	Description of Properties: <u>Size-</u> Width: 4’6” Height: 3’ Depth: 10’
Plumbing Work Space: 	Description of Properties: <u>Size-</u> Width: 3’ Height: 2’ Depth: 25’
Plumbing Finishes Storage Space: 	Description of Properties: <u>Size-</u> Width: 4’6” Height: 3’ 8” Depth: 5’
Plumbing Finishes Work Space: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 2’ Depth: 20’ <u>Number per Story-</u>

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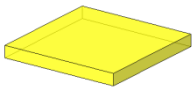
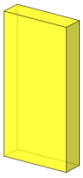
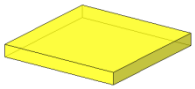
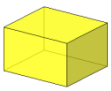
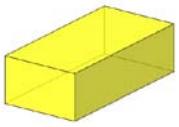
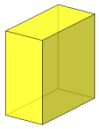
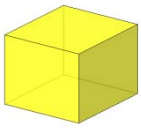
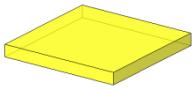
Electrical Ceiling Work Space: 	Description of Properties: Size- Width: 20’ Height: 2’ Depth: 20’
Electrical Wall Work Space: 	Description of Properties: Size- Width: 2’, 3’, 5’, 10’ Height: 10’ Depth: 1’ 6”
Electrical Roughin Room Space: 	Description of Properties: Size- Width: 20’ Height: 2’ Depth: 20’
Electrical Roughin Skid Storage: 	Description of Properties: Size- Width: 5’ Height: 3’ Depth: 4’ 6”
Electrical Roughin Storage Space: 	Description of Properties: Size- Width: 5’ Height: 3’ Depth: 10’

Electrical Work Space: 	Description of Properties: <u>Size-</u> Width: 5’ Height: 10’ Depth: 10’
Electrical Finishes Storage Space: 	Description of Properties: <u>Size-</u> Width: 4’6” Height: 3’ 8” Depth: 5’
Electrical Finishes Work Space: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 2’ Depth: 20’
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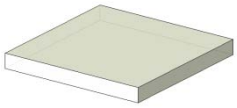
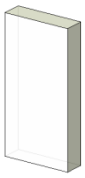
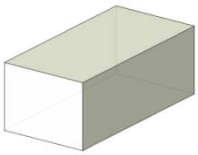
Drywall Ceiling Work Space: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 2’ Depth: 20’
Drywall Wall Work Space: 	Description of Properties: <u>Size-</u> Width: 2’, 3’, 5’, 10’ Height: 10’ Depth: 1’ 6”

Drywall Storage Space: 	Description of Properties: <u>Size-</u> Width: 4’ Height: 3’ Depth: 8’
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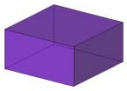
Finish Floor Work Space: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 10’ Depth: 20’
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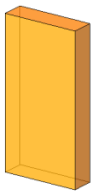
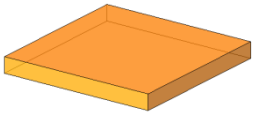
Paint Wall Work Space: 	Description of Properties: <u>Size-</u> Width: 2’, 3’, 5’, 10’ Height: 10’ Depth: 1’ 6”
Paint Ceiling Work Space: 	Description of Properties: <u>Size-</u> Width: 20’ Height: 2 Depth: 20’
Paint Storage: 	Description of Properties: <u>Size-</u> Width: 5’ Height: 3’ Depth: 4’ 6”

Partitions	
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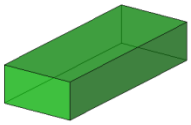
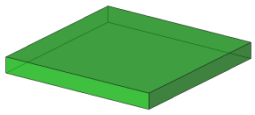
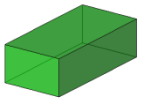
Frame Corridor Ceiling Work Space: 	Description of Properties: Size- Width: 4’ Height: 2’ Depth: 10’
Frame Room Ceiling Work Space: 	Description of Properties: Size- Width: 20’ Height: 2’ Depth: 20’
Frame Storage: 	Description of Properties: Size- Width: 5’ Height: 3’ Depth: 10’

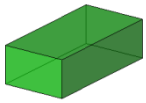
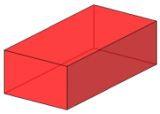
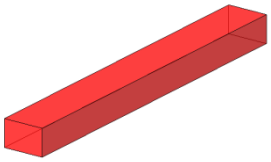
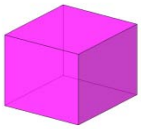
Interior Partitions Storage: 	Description of Properties: Size- Width: 5’ Height: 3’ Depth: 10’
Sprinkler	
Sprinkler Storage Space: 	Description of Properties: Size- Width: 5’ Height: 3’ Depth: 10’
Sprinkler Work Space: 	Description of Properties: Size- Width: 3’ Height: 2’ Depth: 25’
Equipment	
Standard Equipment Space: 	Description of Properties: Size- Width: 4’ 6” Height: 3’ 8” Depth: 5’

Table SP2: Block Types and Descriptions

Results:

It was intended with a general knowledge of how the trades will move through the floor a superintendent or project manager could spend relatively little time, at most two hours, to insert the pre-made blocks and tie them to a schedule. The contractor would not need to create their own blocks because once generic space blocks are made they can be used from on project to another. However, the inserting of blocks took more time than what was expected, approximately six and a half hours.

Furthermore, in the export to NavisWorks the visual properties, which were intended to show the different trades work, were lost and every block was the same color as shown in Figure SP3. This made the selection of the blocks tedious and the simulation meaningless. The tying of schedule activities to blocks took four hours.

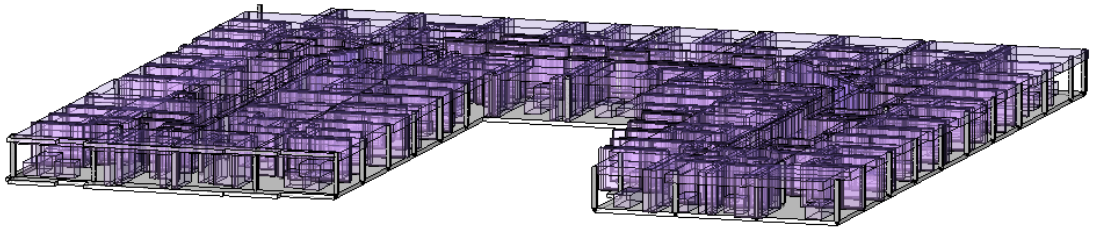


Figure SP 3: Conjested blocks in NavisWorks

Lesson Learned:

By working through the process described above several issues were found that made this planning method not worth the time investment. From these problems lessons have been learned and potential different methods have been theorized. There were problems with the sizes associated with the blocks. The large ceiling spaces were created to cover the size of the typical rooms. But this either caused an overlap of similar blocks or voids in the planning. Contrastingly, the wall blocks were created with the foresight that there needs to be a way to adjust for non-uniform wall lengths. Therefore, wall lengths of ten, five, three and two feet were created. However, the main factor that inserting blocks took so much more time than expected was from inserting the detailed wall blocks. To accurately model the wall work spaces several different sized block had to be used. Also, because this is a residential building there are multiple partitions all of which were modeled. If this was a core and shell building it can be expected that this would be less of a problem.

A better method can be theorized from these results. If it is possible to alter the wall structure to include workspace then entire walls can be selected in NavisWorks and the inserting of wall work spaces in Revit does not need to be completed. The downside to this is this method is that walls may need to be separated to create reasonable workable lengths. Also, this may not be a feasible option if the Revit model will also be used for material estimates. Also, a better method for ceiling and floor work spaces can be to use room walls as boundaries and extrude masses to create work spaces. This requires more experience with Revit but can be quickly learned.

Spatial Planning Conclusion:

With the ever increasing use of BIM software to design buildings there will be opportunities for contractors to also implement the software to handle their responsibilities. This analysis looked at the use of BIM software to complete a 4D spatial plan of trades. This process should not take a long period of time to complete and should be a simple workflow, in order for those with little computer experience but a lot of industry experience to complete. The suggested workflow took too long for the planning and therefore should not be implemented. Further problems include a loss of trade color differentiation. Research into the best practices and methods is extremely important to find for when BIM software is part of standard industry practice.

LEED:

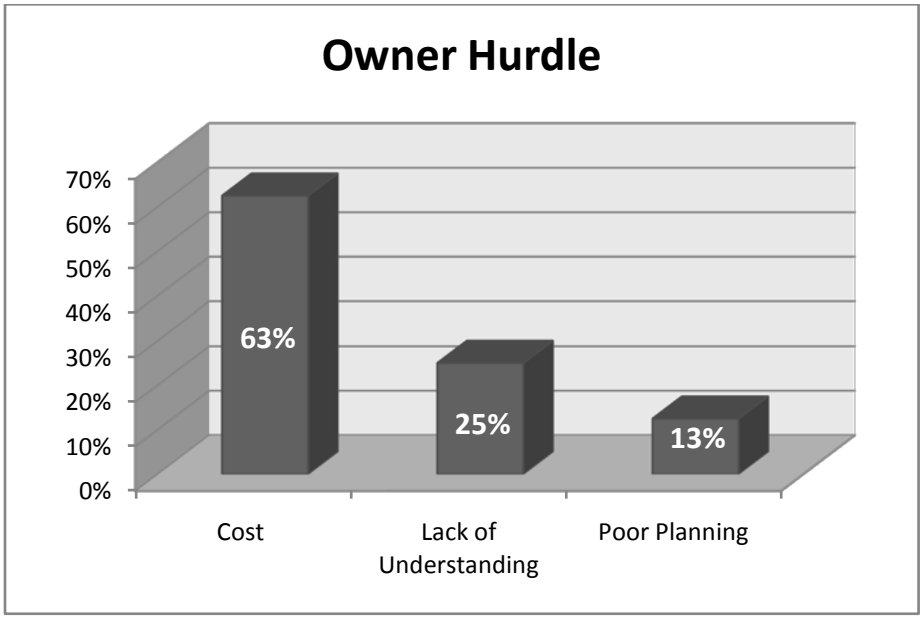
Leadership in Energy and Environmental Design or LEED is a rating system based on criteria to quantify green building design measures. LEED criteria focus on five important areas of building design and its effects on human and environmental wellbeing. These areas include site characteristics, water consumption, energy use, material selection, and interior environment. Certification levels are based on points and increase with a range of points from Certified, to Silver, to Gold, and to Platinum. Platinum is the highest rating that can be obtained. The purpose of this analysis is to understand the thoughts of industry members about owner involvement in LEED to determine where owners fall short and where they are being successful. To obtain the view of industry professional a questionnaire was sent asking for responses based on their professional experiences working on actual projects. Respondents included owners, contractors, LEED consultants, and designers.

LEED Research:

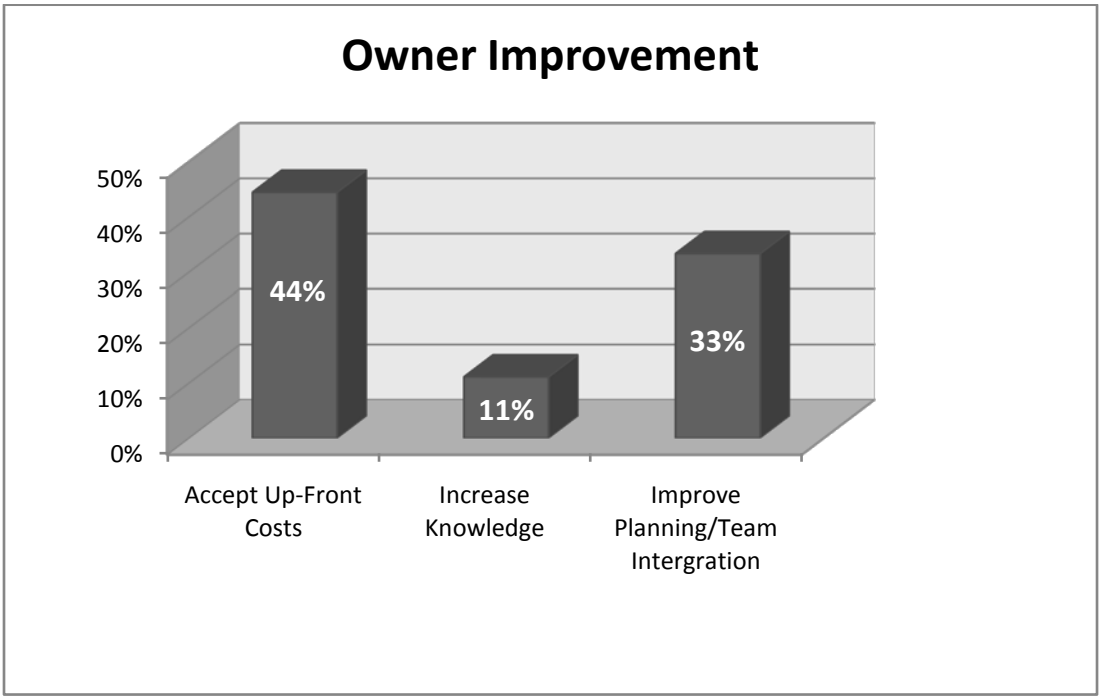
The goal of this research is to provide a useful tool to educate owners on practices that are key to sustainability success. In discussion with industry professionals at the *2008 PACE Roundtable Breakout Session: LEED Evolution* there was a consensus that owners were either too late in deciding to go LEED or not willing to commit to obtain certification. The best way to attain owner involvement on projects is to educate them and assure their understanding of what commitments will need to be made. The following report includes analysis of the LEED credit system highlighting important aspects for owners while tying in research gathered from industry professionals including owners, architects and contractors. The participants brought forth valuable information that owners wanting to develop a sustainable building should know. This research acknowledges that all owners should desire being sustainable, but that certification is not necessary to be sustainable. Nevertheless, the focus of this research has been on the LEED Criteria point system.

The following graphs are breakdowns of participants' responses that had profound influence on the following document. It is important to note that the questions asked were open-ended and the participants did not have a bank of answers to choose from. The similarities of the answers are significant of similar thoughts across the industry. Although an attempt was made to include all regions of America most of the participants work in the Washington D.C. region. The graph will follow the corresponding question. A complete report of the questions and answers can be found in the appendix.

What problems do owners typically run into when trying to get their project LEED Certified?

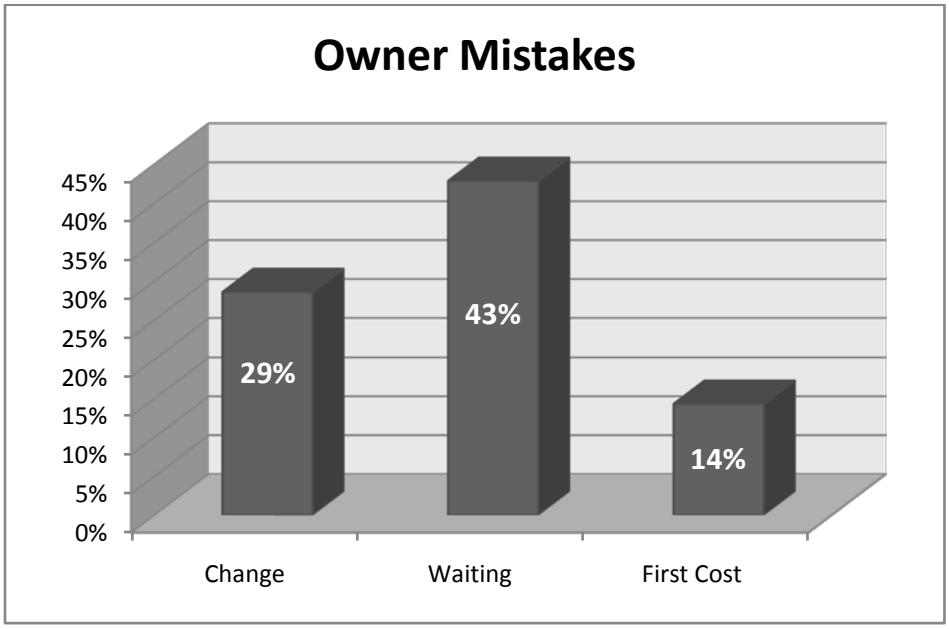


What do owners need to do differently?

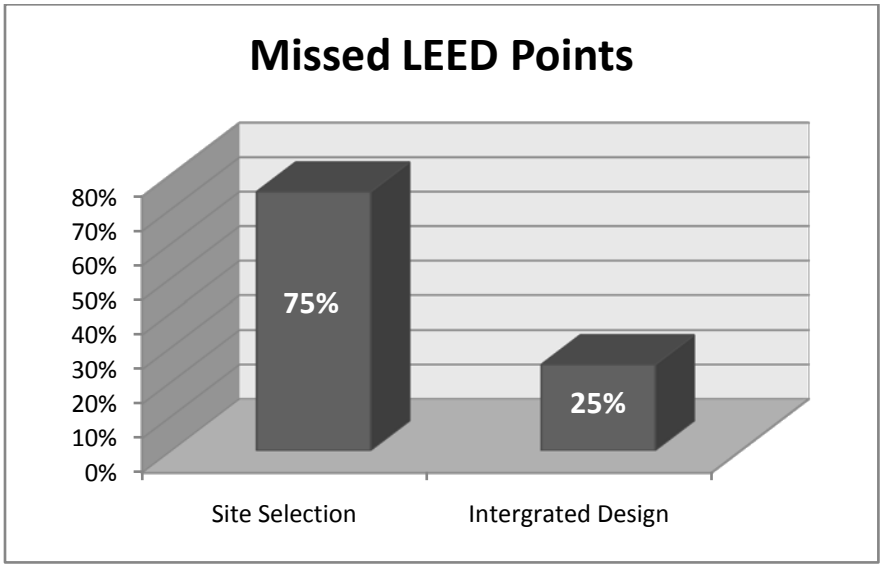


What do owners do that is successful and helps the overall project?

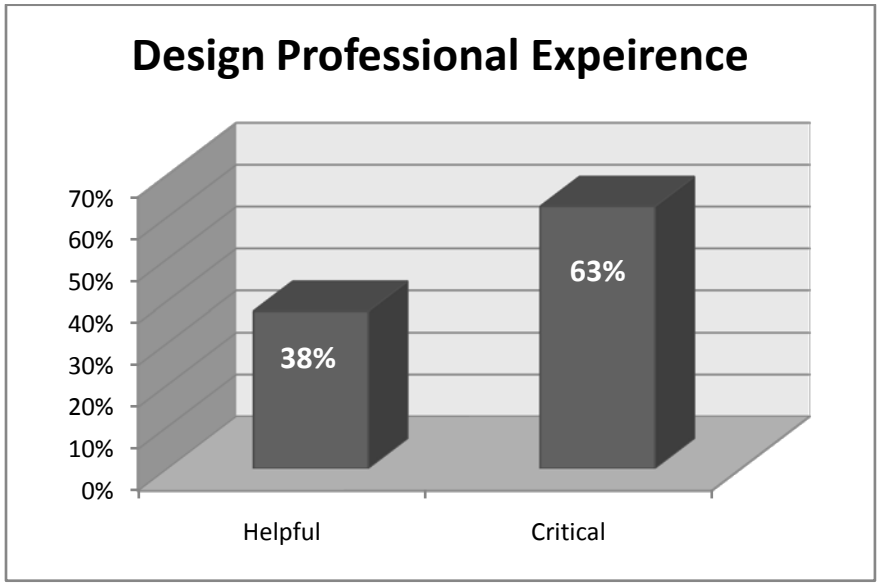
What mistakes do owners typically make that cause problems for the design/construction profssionals for a project attempt ing a LEED Certification?



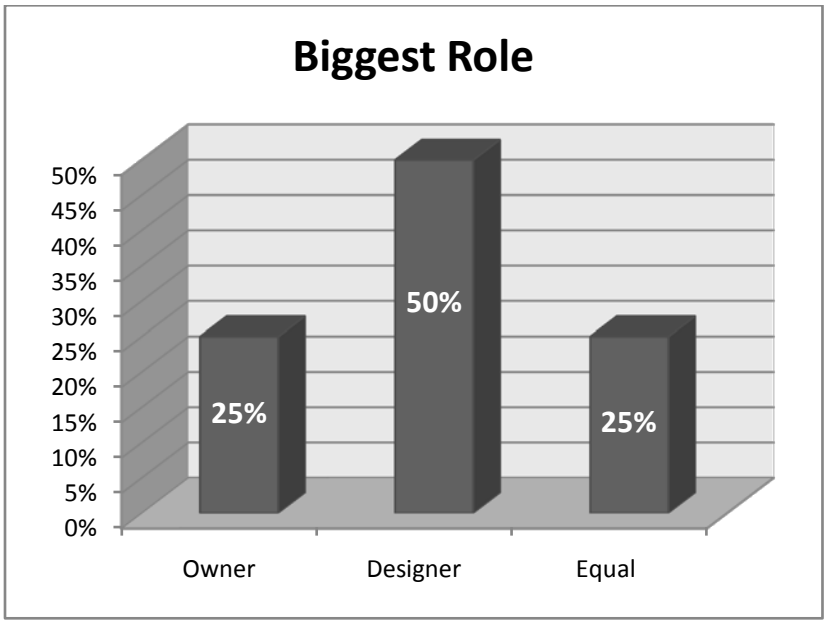
What design decisions are typically passed over without early owner commitment to LEED?



How important is the selection of a design professional that has experience and expertise with sustainable design?



Who plays the biggest role in a successful LEED Certified project?



Green Planning:

The following information provides insight to the key components in the success of designing and constructing a sustainable building. More and more owners are beginning to realize the benefits of sustainable design in terms of reduced operation costs and increased worker productivity increasing company profits. Following the guidance below will be imperative for an owner who has little experience but wants a green building. LEED is a widely accepted benchmarking tool to determine the level of sustainability. The concepts below reference LEED, but by no means is a LEED certification necessary to be sustainable.

Sustainability Goals:

Setting sustainability goals allow for the project team to measure their performance against the goals. Goals should assure that there is proper communication to provide an integration of building systems. Participants of this analysis indicated that an owner who knows their sustainability goals and are able to handle associated up-front costs are more successful than those who take a long time to make decisions or make decisions too late. Sustainability goals should be clear and concise but provide the criteria to be used to determine whether or not the design team has succeeded in meeting the goal. The best method in setting sustainability goals and communicating a commitment to the sustainability success of a project is by establishing a sustainability policy. A sustainability policy highlights the main sustainability concerns to the team. The very first part of a quality sustainability policy is announcing the owner's commitment to the environment. Sustainability goals with considerations for success should follow. The participants in this analysis also stated that integrated teams are vital to the success of sustainable buildings. Therefore, a statement stressing the importance of team members working together should be included in the policy. If there is an intention of using the LEED rating system than there should be an overview of mandatory credits that the project team must meet. Further statements on LEED can be found in the following sections. The more an owner knows what they want to achieve in terms of sustainability, the more likely that those goals will be accomplished. Furthermore, as materials and technologies change having a written policy will provide guidance for maintaining an owner's initiative of sustainability for future projects.

Design professionals:

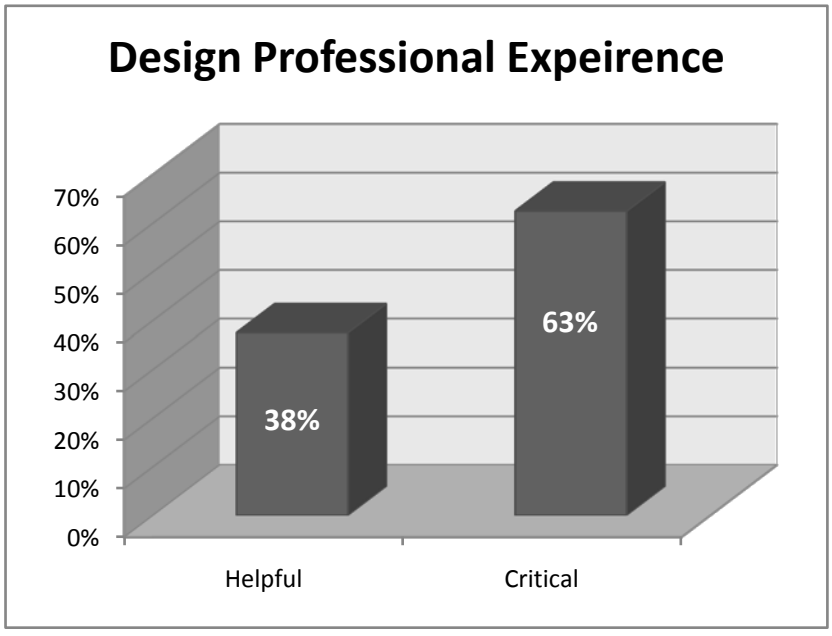
Participants in this analysis indicated that designer selection is an extremely important decision for sustainable success. The hard cost of sustainability come from the selection of materials that contain a premium for their sustainability but often pay for themselves in reduce life cycle cost. Premiums are also decreasing due to more manufactures producing material to meet demands. Nevertheless, the

survey of industry professionals indicated that 63% of participant felt that the cost factor is a major hurdle for the owner to get over. In general owners are still discouraged by the notion of increased expenses for sustainable projects. The important cost factor is the soft cost called brainpower of the design professional. Design professionals with more sustainable experience can charge less of a design fee because they have less of a burden. Therefore, as sustainable design becomes more commonplace design fees for sustainable projects will also start to decline. Professionals should demonstrate their commitment to maximizing building performance.

To appropriately select designers, look for team that:

- Are enthusiastic about sustainable design
- Are committed to maximizing building performance
- Are capable of meeting energy targets
- Contain energy/sustainability expert
- Are familiar with new materials
- Are familiar with new energy technology and analysis tools
- Proficient with sustainable rating criteria, such as LEED
- Understand code requirements
- Cite completed successful projects

The level of importance that a design professional has sustainable experience according to industry professionals is indicated by the graph L1 below.



Graph L1

An important design professional for a sustainable design is the mechanical engineer. The role of a mechanical engineer is to size the mechanical system, determine the best mechanical system strategies, and maintain an energy analysis during the development of the design. Energy modeling is an important aspect of the LEED rating criteria. As part of an option of Energy & Atmosphere prerequisite a 10% improvement must be shown with an energy model. Energy modeling can be accomplished with varies software applications but all simulate the buildings energy performance. Energy modeling promotes a better understanding of the energy use and cost implications of system's design in a building. The factors that go into a useful model include building envelope, HVAC system, daylighting, lighting efficiencies and renewable energy supplies. As the design progresses, modifications must be maintained in the model. Meetings are necessary to communicated changes in energy results to the design team due to their design changes.

The cost associated with energy modeling greatly depends on the size and complexity of the project. Cost estimates range from $0.15/SF to $0.30/SF but generally greater than $5,000. Performance based fees reword the effort for minimizing the project's life cycle cost and reward the designer for not over-sizing equipment. The implications involved with setting performance based fees are establishing clear goals along with how performance of those goals is to be measured, providing a fee schedule showing how the fee relates to success in meeting the goal, and a protocol for resolving disputes without expensive litigation. An owner should demonstrate their cooperation in sustainable design by establishing a minimum fee, to reduce the engineer's risk.

LEED Criteria Rating System:

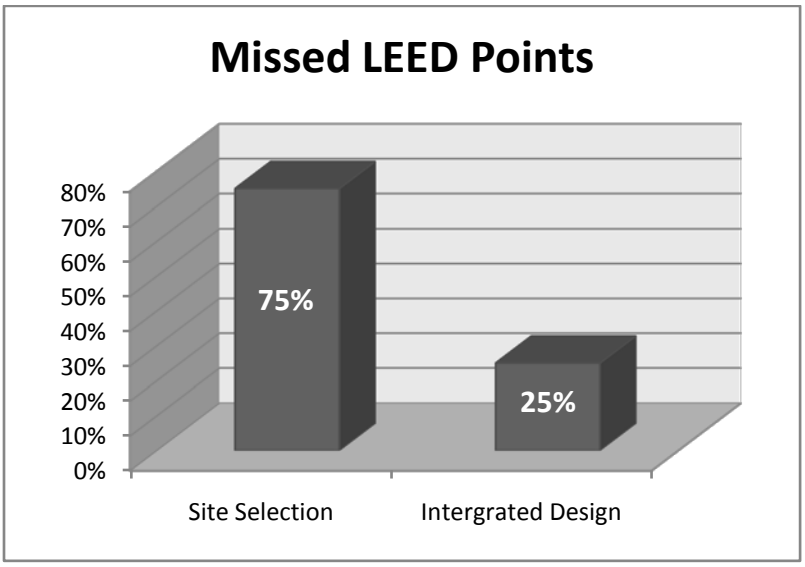
On April 27th, 2009 the U.S. Green Building Council, the creator of LEED, will be implementing a new version of LEED called LEED v.3.0 or 2009. The exact name of this new version seems to change from document to document. This report uses the term v.3.0 to easily differentiate between LEED v.2.2. However, the restructuring and alignment of LEED provides an easier way to make multiple changes for updates similar to building codes. Therefore, it is believed that the actual name will be LEED 2009 so that the latest and most recent version will be highlighted. The changes to LEED include a restructuring of points such that more points can be awarded to more credits that provide a greater positive impact on the environment. The following analysis highlights the different credits.

Site Selection:

The category of site selection rewards points for developing in a location that will minimize the effects on the local ecosystem. The prerequisite to obtain points for site selection includes reducing pollution form construction activities by controlling soil erosion, waterway sedimentation and airborne dust generation. This is a rather simple and straight forward prerequisite to meet. The criteria for points of site selection includes not developing on environmentally sensitive areas, developing in urban areas, rehabilitation of damaged sites, reduction of pollution from automobile use, protecting natural habitats, reducing development effects on natural water flows, reduce the heat island effect, and reduce nighttime light pollution.

The following highlights the changes form LEED v2.2 to LEED v.3.0. In the LEED v.2.2the development density and community connectivity credits, which recognizes development in urban areas, was only worth one point. In the version 3.0, meeting this credit is worth five points. In the v2.2 alternative transportation: public transportation access was worth one point and in the new v.3.0 this credit is worth 6 points. Also, the credit for alternative transportation: low emitting & fuel efficient vehicles was worth one point under v2.2 and now is worth 3 points under v3.0.

The choice of where to locate a new building can have a major effect on its long term environmental impact. Participants in this analysis indicated that site selection is often overlooked, shown in graph L2 below.



Graph L2

This generally is because an owner is developing a preexisting land asset or LEED is considered after the fact. Furthermore, the overall efficiency of the building can be completely minimized if the building's site is causing harm to the environment, by interfering with natural water flows, displacing wetlands, or damaging local biodiversity. There are three best options for site development, these are

building renovation, brownfield and infill development. Renovating existing buildings reduces construction cost while salvaging existing materials. Brownfield sites are abandoned industrial areas that need certain level of remediation before new construction. Infill sites are vacant sites within an established urban area. These options are beneficial because they tend to have lower infrastructure costs because sewage, electric, gas are already in place. Also these sites are generally near other commodities such as schools, businesses, retail which enhances the convenience of occupants.

Water Efficiency:

The purpose of water efficiency is to reduce the amount of water supply required for a building and to reduce the amount of water entering storm and sewer lines. Prerequisite to obtain points for water efficiency is a water use reduction of 20%, which use to be worth a point in LEED v.2.2. Criteria to obtain points for water efficiency include reducing the amount of potable water for irrigation, reducing the amount of wastewater, and increasing the building efficiency to reduce the needed water supply and generated wastewater. Water efficiency is based on a point scale directly relating to the amount of efficiency. The new range rewards points for 30%, 35%, and 40% reduction in water use. A simple method to obtain these credits is to use low-flow water fixtures. A great resource to find a manufacture and product of these fixtures is the Water Sense program by the U.S. Environmental Protection Agency.

Energy and Atmosphere:

The purpose of Energy and Atmosphere criteria is to optimize building energy performance. Prerequisites for energy and atmosphere include basic commissioning on energy related systems, establishing a minimum level of energy efficiency, and refrigerant management. Criteria to obtain points for energy and atmosphere includes reducing the required building energy, generating on-site renewable energy, enhanced commissioning, enhanced refrigerant management, measurement and verification plan, and obtaining energy from renewable energy providers. LEED v. 3.0 places a greater emphasis on energy efficiency by making more points available, compared to LEED v.2.2. In LEED v3.0 32% of the points available come from energy and atmosphere criteria compared to 24% of LEED v.2.2.

Energy Optimization:

In LEED v 3.0 points for optimized energy performance have 19 points available based on amount of increased performance. This is a section of high importance to the U.S. Green Building Council. Performance is based on a baseline performance set by ASHRAE Standard 90.1-2007 building project simulation. The number of points acquired is determined by the level of energy performance.

Renewable Energy:

On-Site renewable energy can obtain up to 7 points based on the percentage of energy produced. This is a change over LEED v.2.2 which only offered a maximum of three points. Using photovoltaics and wind turbines are common methods of creating renewable energy.

Measurement and Verification Plan:

The points obtainable for an ongoing measurement and verification plan have increased from one to three points to increase the incentive to assure building system performance. Rapidly rising energy costs provide a direct incentive to assure building systems are functionally properly.

Energy Programs:

LEED offers the opportunity to buy power from a utility company that generates renewable energy. Green-e Energy is a certification program that assures funds go to the development of new energy generating project.

Materials and Resources:

Materials and Resources credits are awarded for reduction in waste from the selection and use of sustainable materials. Prerequisite for materials and resources include recycling of paper, corrugated cardboard, glass, plastics and metals. Criteria to obtain material and resources points include reuse of existing building structure, recycling of construction waste, reuse building materials, use of recycled material, use of locally manufactured materials, and use of rapidly renewable materials.

Materials and Resource section has not received too many changes in the need v3.0 version. The main point change came from an increase points awarded to higher percentages of building reuse. The selection of material and where to obtain them have an important impact to the sustainability of a new building. Buildings that use renewable resources or recycled resources are more sustainable than those that do not. Materials should also be manufactured locally and should not include harmful toxins. Greenguard Environmental Institute operates a certification program of building products with low toxins. The selection of the right materials can be easy points. The design professionals should have the experience and knowledge to determine the best sustainable materials for the building. There are several programs that aid in the material selection. These programs include the global ecolabling network, green seal, and green spec listed. During construction extra attention may be needed to assure contractors are complying with waste recycling. Compliance is most effective by the owner, superintendent and other upper management stressing the issue.

Indoor Environmental Quality:

The purpose indoor environmental quality credits are to maximize occupant health and comfort. Prerequisites for obtaining indoor environmental quality credits include establishing a minimum indoor air quality performance which meets ASHRAE 62.1-2007 Ventilation for Acceptable Indoor Air Quality and reducing tobacco smoke to the interior of the building. Criteria for obtaining indoor environmental quality credits include monitoring ventilation system, increasing ventilation, reducing construction contamination, use nontoxic materials, minimize exterior hazards from entering building, zonal control of lighting, zonal control of air temperature, thermal comfort, and daylighting interior spaces. ASHRAE 62.1-2007 is an important standard regarding the design of the ventilation system. It is referenced often

as minimum design standard needed to be reached to obtain points. Another important standard is ASHRAE Standard 55-2004 which sets the requirements for thermal comfort. Air quality should be protected by ensuring adequate ventilation and locating air intakes away from exhaust vents and loading docks. Carbon dioxide monitors should be installed to ensure adequate ventilation. Heat recovery ventilators can capture heat from the exhausted air. During construction it is important to ventilate finishes and building materials to improve indoor air quality. Indoor environment has the largest impact on the occupants. Points are given for the increased capacity of an individual to determine what their own zonal conditions, including thermal comfort and lighting comfort. Daylighting is a cost effective lighting solution to reduce the need of artificial light resulting in energy and cost savings. Daylighting has an additional benefit in that occupants of daylit space are more productive and have a greater satisfaction in their work.

Innovation & Design:

These credits are assigned to stimulate new ideas and uses of new materials and products to design better and better buildings. The purpose of these credits is to seek improvement instead of replicating what worked last time.

Regional Priorities:

Regional priority credits are new in LEED v3.0. They have been created to address geographic specific environmental priorities. U.S. Green Building Council regional committees are working to establish a database of priorities. Rod Letonja of Envision Design and committee member of The Metropolitan Washington Council of Governments Intergovernmental Green Building Group, identified six priorities for the Washington D.C. area. These priorities are listed below:

- Watershed protection and stormwater management
- Energy efficiency and renewable energies
- Public transportation, density, and sprawl
- Heat island effect
- Waste management (construction and long term)
- Indoor air quality

LEED Point Change Summary

The table below has been created to better highlight the changes mentioned above.

Credit	LEED v2.2	LEED v3.0
SSc2 Development Density & Community Connectivity	1 point	5 points
SSc4.1 Alternative Transportation, Public Transportation Access	1 point	6 points
SSc4.3 Alternative Transportation, Low-Emitting and Fuel-Efficient Vehicles	1 point	3 points
SSc4.4 Alternative Transportation, Parking Capacity	1 point	2 points
WEp1 Water Use Reduction, 20%	1 point	New Prerequisite
WEc1.1 Water Efficient Landscaping, Reduce by 50%	1 point	2 points
WEc1.2 Water Efficient Landscaping, No Potable Use or No Irrigation	1 point	2 points
WEc2 Innovative Wastewater Technologies	1 point	2 points
WEc3 Water Use Reduction, 30%	1 point	2 points
WE c3 Water Use Reduction, 35%	N/A	3 points
WE c3 Water Use Reduction, 40%	N/A	4 points
EAc1 Optimize Energy Performance	1 – 10 points	1 – 19 points
EAc2 Onsite Renewable Energy	1 – 3 points	1 – 7 points
EAc3 Enhanced Commissioning	1 point	2 points
EAc4 Enhanced Refrigerant Management	1 point	2 points
EAc5 Measurement & Verification	1 point	3 points
EAc6 Green Power	1 point	2 points
MRc1.1 Building Reuse, Maintain 55% of Existing Walls, Floors & Roof	N/A	1 point

MRc1.1 Building Reuse, Maintain 75% of Existing Walls, Floors & Roof	1 point	2 points
MRc1.1 Building Reuse, Maintain 95% of Existing Walls, Floors & Roof	2 points	3 points
IEQc4.3 Low-Emitting Materials, Carpet Systems		Low-Emitting Systems, **Flooring** Systems 1 point
Regional Priority Credits	N/A	1 – 4 points

Table L1

To provide a convenient and easily accessible way to view the information presented in the above sections a pamphlet has been created. This pamphlet encourages owner involvement through basic education of LEED points and useful resources. This pamphlet contains information to guide owners with sustainability goals pertaining to buildings. It also steps through the different LEED criteria highlighting the basic requirements.

LEED Conclusion:

This analysis shows the areas of improvements for owners. Owners need to understand the cost factors associated with sustainable systems. First costs are generally higher; however the life cycle costs are lower. Also, sustainable choices will lead to happier occupants. This can translate to higher rental revenue or increased worker productivity, depending on building type. The choice of design professionals is also extremely important. Professionals who know the bust sustainable products and systems that can be implemented and know how their decisions may affect others will bring invaluable experience to the project. This analysis shows that industry professionals feel that the design professional plays the largest role in a successful project. Finally, this analysis shows that owners can improve the likelihood of success for a project by clearly stating their sustainability goals and being committed to sustainable products and systems in their building.

C. Acknowledgements:

The successfulness of this project would not have been possible without the help of others. I would like to thank the following people for their support throughout the duration of this Senior Thesis.

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Michael Sgriccia

Mike Grobaski

Jeremy Sibert

Daniel Flickinger

Wendy Body

Jim Faust

Rich Gill

Ken Hamilton

Janice Salyer

Dale Murphy

Cynthia Cogil

John Bechtel

Jumanne Smith

I would also like to thank my family and friends for their continuous support.

D. Resources:

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E. Appendices:

Concrete Pump Productivity Data:

	Total CY	Pump Productivity (Day)
Floor 2		
Center	78.24	0.49
1229	15.81	0.10
1229	2.51	0.02
1231	3.48	0.02
	100.04	0.63
Floor 3		
Center	78.24	0.49
1229	15.81	0.10
1229	2.51	0.02
1231	3.48	0.02
	100.04	0.63
Floor 4		
Center	78.24	0.49
1229	15.81	0.10
1229	2.51	0.02
1231	3.48	0.02
	100.04	0.63
Floor 5		
Center	78.24	0.49
1229	15.81	0.10
1229	2.51	0.02
1231	3.48	0.02
	100.04	0.63
Floor 6		
Center	78.24	0.49
1229	15.81	0.10
1229	2.51	0.02
1231	3.48	0.02
	100.04	0.63

Floor 7		
	601.11	3.8
		0
Floor 8		
0	601.11	3.8
Floor 9		
	648.15	4.05
Floor 10		
	631.51	3.95
Floor 11		
	602.31	3.76
Floor 12		
	178.77	1.12

Brick Productivity Data:

Workday	Date	Total sq. ft.	Workhours	Productivity
1	2/16/2009	486	83	0.17
2	2/17/2009	493	86	0.17
3	2/18/2009	472	73	0.15
4	2/19/2009	503	92	0.18
5	2/20/2009	512	96	0.19
6	2/23/2009	492	84	0.17
7	2/24/2009	476	73	0.15
8	2/25/2009	505	98	0.19
9	2/26/2009	483	76	0.16
10	2/27/2009	503	89	0.18
11	3/2/2009	342	94	0.27
12	3/3/2009	958	152	0.16
13	3/4/2009	964	196	0.20
14	3/5/2009	953	197.5	0.21
15	3/6/2009	982	208	0.21
16	3/7/2009	486	73	0.15
17	3/9/2009	945	154	0.16
18	3/10/2009	963	176	0.18
19	3/11/2009	972	185	0.19
20	3/12/2009	492	124	0.25
21	3/13/2009	886	153	0.17
22	3/14/2009	336	65	0.19
23	3/16/2009	965	192	0.20
24	3/17/2009	951	163	0.17
25	3/18/2009	968	184	0.19
26	3/19/2009	958	202	0.21
27	3/20/2009	967	176	0.18
28	3/23/2009	942	168	0.18
29	3/24/2009	450	124	0.28
30	3/25/2009	936	167	0.18
31	3/26/2009	967	192	0.20
32	3/27/2009	972	185	0.19

Baseline productivity is calculated by taking 10% of the data dates with the highest output. A total of 5 data dates were used because 10% of the collected data dates would be too small. The 5 highest outputs have been highlighted in red in the table above. The baseline productivity is calculated by dividing the summed baseline workhours by the summed baseline quantity. The baseline productivity is considered the best productivity that can be expected for the construction method and design complexity.

Baseline	Total sq. ft.	Workhours
Day 15	982	208
Day 19	972	185
Day 25	968	184
Day 27	967	176
Day 31	967	176
Day 32	972	185
	5828	1114
Baseline Productivity:		0.19

Precast Productivity:

Workday	Pieces	Workhours *	Productivity
1	8	72	9
2	10	72	7.2
3	16	72	4.5
4	15	72	4.8
5	16	72	4.5
6	14	72	5.142857
7	14	72	5.142857
8	14	72	5.142857
9	16	72	4.5
10	16	72	4.5
11	14	72	5.142857
12	16	72	4.5
13	12	72	6
14	13	72	5.538462
15	16	72	4.5
16	15	72	4.8
17	15	72	4.8
18	13	72	5.538462
19	16	72	4.5

* Assumed 1 Foreman, 7 Workers

Uniquely all the baseline data sets contain the same productivity. The baseline quantity data sets have been highlighted in red in the table above. This is because of the assumed standard labor hours. Actual hours would vary from day to day. Nevertheless, this still represents the best productivity that can be expected for precast installation.

Baseline	Pieces	Workhours
Day 3	16	72
Day 5	16	72
Day 9	16	72
Day 10	16	72
Day 12	16	72
Day 15	16	72
Day 19	16	72
	112	504
Baseline Productivity:		4.5

LEED Questionnaire Responses:

Questions were asked to find similarities across the industry and then draw conclusions that will be the basis of successful owner involvement on LEED projects.

The following are the responses of John Bechtel from Penn State's OPP.

How did you communicate your commitment to sustainability and your desire of LEED Certification to the design/construction teams? How were the end goals communicated to the design/construction team?
Penn State has a LEED policy that outlines the LEED credits and the level of their importance.
What did you know in advance about what you wanted implemented on your project? What were the design/construction teams able to bring to the table to further your mission and goals of the project?
The OPP provides design and construction standard available to contractors via the web.
What sort of involvement did you take on this project to assure its LEED Certification?
The OPP has in house design professionals that attend schematic design meetings with project leaders to assure building use and sustainability goals are being met.
How were decisions on system types made?
Team approach with in house professionals.
What considerations were made to determine if a system should be made more efficient?
Level of certification and levels of energy efficiency.
How important is the selection of a design professional that has experience and expertise with sustainable design?
Extremely critical because they have more lessons learned.
Were there checkpoints or a system of benchmarking to make sure that the sustainability goals were being met? If so, how did it work?
Responsibility of A/E to monitor LEED credits and submissions.

The questions and answers below are from Ken Hamiltion from the National Audubon Society who served as a project manager during the interior renovation of their new New York Headquarters.

How did you communicate your commitment to sustainability and your desire of LEED Certification to the design/construction teams? How were the end goals communicated to the design/construction team?
As an environmental organization, and as the owner of the first "green" building in New York City (700 Broadway), we had a firm commitment to a green home office - the highest possible level of certification within our budget was part of the selection process for the architect, for the site, etc. - it was made clear from the beginning and as the owner, Audubon was the driver for this....
What did you know in advance about what you wanted implemented on your project? What were the design/construction teams able to bring to the table to further your mission and goals of the project?
We had very specific ideas about the materials and design; as well as the overall goal of "walking the walk" in relation to our mission. As an owner and, personally having managed a green building for the past 15 years, we worked closely and on much the same page as the design team throughout D&D and construction. The team brought innovative suggestions and were a great help in doing the legwork for our choices - an example was finding a "used" (read 'recycled') source for the raised flooring used in our office - increasing the amount of recycled material we utilized and saving about 55K in the process...
How important were your missions and goals to the design and construction teams?
Obviously integral -"walking the walk" - and being consistent with our new construction projects throughout the country (we have the first Platinum-NC building in CA, other platinum rated centers and mane at varying levels...)
What sort of involvement did you take on this project to assure its LEED Certification?
As the project manager/owner, I was the "driver" - watching budget expenses as well as ensuring we made the smartest 'green' choices we could along the way.
How did your understanding of the LEED points and LEED certification process help during the design and construction phases of the project?
Very much - and I came to this with a fairly detailed understanding of the process and the "scorecard"...

How were decisions on system types made?
By the design team suggesting several alternatives, and balancing cost with point achievement as well as working with the landlord.....complex matrix but, in all, enthusiasm for the goal and attention to the process on all sides.
What considerations were made to determine if a system should be made more efficient?
Cost, life-cycle analysis (we have a 20 year lease), efficiency and points gained - as well as impact on the working environment we were providing for our staff.
How important is the selection of a design professional that has experience and expertise with sustainable design?
We looked at design professionals with and without LEED experience - in the end we decided that a LEED-experienced professional would be better able to give us better "bang for the buck" - and contribute to achieving more with less -
How much did you know about the 'green' systems you wanted? What was left up to the design professionals to decide based on desired outcome?
We did know a lot - we had preferred some more efficient systems that proved impossible because of cost or lease/space restrictions - designers steered us to FF&E, lighting controls, etc. - but we had many of these systems in place on a primitive scale in our previous offices....
Were there checkpoints or a system of benchmarking to make sure that the sustainability goals were being met? If so, how did it work?
Working with a LEED consultant - like an 'official scorekeeper" - we reviewed our standing for LEED as the project progressed and various decision points were reached....

The following section contains questions and answers from contractor within the industry that have had experience working with owners on LEED projects. For the purpose of privacy the names and companies will not be indicated.

Respondent 3:

What problems do owners typically run into when trying to get their project LEED Certified?
Not understanding the process, starting the process late in the evolution of the project.
What do owners need to do differently?
Make the decision to go LEED at the initiation of the project when the cost to implement is minimized.
If you have had positive experiences with owners seeking a LEED Certification what did they do that was successful and helped the overall project?
Set clear objectives and goals for the project.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
LEED recommends the Owner be responsible to develop and document the project "Owner's Project Requirements" this is best relayed to the design team through a series of design meetings. LEED Cert. as part of the goals requires numerous design approaches that are intricate to the design and should be recognized in the initial design phase to minimize cost.
How do projects differ in terms of ease of successfully reaching a desired certification limit when sustainability goals are clearly defined during the conceptual and schematic phases of the project compared to when such goals are wanted later in a projects life?
Cost and schedule are the major variables. Throw enough time and money at a problem and you can resolve it. LEED cert. is no different. Clearly defined goals minimizes time and cost!
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
Changing their minds.
What design decisions are typically passed over without early owner commitment to LEED?
Site issues. Owners typically already own a property so site selection as well as most of the

Sustainable Site credits are out of reach.
What experiences have you had where the owner knew what they wanted (in terms of LEED) and was proactive in receiving a certification rating? What did they do different from other owners?
No experience.
How important is the selection of a design professional that has experience and expertise with sustainable design?
Helpful but this is all a new process for all disciplines. LEED is really just a variation of Code requirements that design professionals design to. Give them standards to follow as well as follow good architectural practices and LEED cert. will be achieved.
How often do owners have a very specific idea about the materials and design to reach their LEED Certification goals?
Typical owner starts with, "I want solar panels" that is a typical statement from an owner who wants to go green but does not understand LEED.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
Very little, LEED specs. are typically a tighter and trades to date are still learning the credits. Manufacturers are starting to drive alternates but to date very little.
How much does a subcontractor understanding of LEED credits and LEED Certification help during the design and construction phases of the project?
In our area the trades are just getting involved in their first LEED project so they are just along for the ride so far.
How are decisions made to determine if a system should be made more efficient?
Efficiency of systems is locked down during design modeling. Once work starts on site it is typically too late.
Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors...)
Owner, but LEED is best achieved with an integrated team working together.
How important is it to work with a designer that had experience with sustainable design?

Same as anything else if you have been there before it is much faster and more efficient.
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
LEED credits are typically submitted at the completion of the design phase and again at the completion of the construction phase. During construction the submittal process is the key to assuring materials are as specified. Waste handling is typically tracked and documented, etc. LEED projects are not that different from other projects during implementation, follow the Specification requirements.

Respondent 4:

What problems do owners typically run into when trying to get their project LEED Certified?
Justifying the cost.
What do owners need to do differently?
Accept the financial responsibility.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
Through discussions at monthly meetings.
How do projects differ in terms of ease of successfully reaching a desired certification limit when sustainability goals are clearly defined during the conceptual and schematic phases of the project compared to when such goals are wanted later in a projects life?
The earlier the goals are developed and incorporated into the design, the better the project fairs.
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
Waffling. Meaning "considering" pursuing a certain LEED credits too long, and not committing to the investment.
Is there extra responsibility put on certain contractors on LEED projects, if so, how can owner involvement spread the responsibilities?

The Owner has to take the lead and provide vision/direction to the Architect/CM during the earliest stages of design.
How important is the selection of a design professional that has experience and expertise with sustainable design?
*Supremely important. A designer that has no "real" LEED experience drags the process down. LEED must be clearly incorporated into the documents for success.
How often do owners have a very specific idea about the materials and design to reach their LEED Certification goals?
Seldom.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
Trades have even less LEED experience than Owners. Aside from providing LEED materials that vendors suggest, trades are relatively uninitiated with regard to LEED.
How much does a subcontractor understanding of LEED credits and LEED Certification help during the design and construction phases of the project?
Mechanical involvement would help, but most other material information should and does come from vendors and/or suppliers.
How are decisions made to determine if a system should be made more efficient?
Typically, the final decision falls to the Owner, but lacking information, he/she would defer to the Architect. The CM guides the process.
Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors…) How important is it to work with a designer that had experience with sustainable design?
Designer, followed shortly by Owner. See above * regarding Designer experience.
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
Monthly meetings and on-board design reviews work.

Respondent 5:

What problems do owners typically run into when trying to get their project LEED Certified?
Front end costs. We've run into issues about the cost of more energy saving equipment for both mechanical and electrical equipment. Landscaping, usually the first cost to get cut, contributes to about 6 LEED credits. Other materials may cost more, here the cheapest steel came from Arkansas, well beyond our 500 mile limit for regional.
What do owners need to do differently?
Look at the long-term $$$ savings, the SROI (sustainable return on investment; and pay attention to surveys about Evidenced Based Design. EBD has show that office workers with access to daylight and views are more productive and take less sick days. Patients with a view to the outdoors leave the hospital 40% faster than those without a view. Children in schools constructed with increased ventilation, a more rigorous filtration system, no VOCs, access to daylight and views have less health problems (asthma) that those in other older schools. I questioned the daylight part and was told it's a Vitamin D issue.
If you have had positive experiences with owners seeking a LEED Certification what did they do that was successful and helped the overall project?
All new construction over $7.5M must achieve LEED silver, either through certification or proof positive that the project has assessed the correct number of points to qualify. Other municipalities also have the same rules, as does the Federal Government. Arlington County requires that ALL new construction reach Silver, including private development. Then again, North Carolina has none.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
I wasn't here from the very beginning but this is a design-build project. The architect, HDR, came in with a clear vision of what they wanted to do. This project was envisioned in 2001, designed in terms of 2001 dollars but repeatedly delayed. Much has changed since 2001. HDR has done a tremendous amount of hospital work, and a lot of other LEED projects.
How do projects differ in terms of ease of successfully reaching a desired certification limit when sustainability goals are clearly defined during the conceptual and schematic phases of the project compared to when such goals are wanted later in a projects life?
MUCH! The early design decisions, using an already developed site or remediating a brownfield, access to public transportation, connectivity to community services to encourage pedestrians,

building on an east-west access, fenestration, open space….all these are decisions that take place early in the project.
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
Changes, budget. Not understanding what a “sustainable” design is….”green” is a concept. One of the worst questions on the LEED test is “If your Owner decides not to build the smoking pavilion, what credits are affected?” Better question is which ones are not. My brain automatically goes to cost impact, schedule impact. Here the green roof was reduced in a value engineering exercise to about 30% from 75%. This cost us 100% potable water reduction for irrigation. Because this used to be a golf course, it did not affect Open Space.
Is there extra responsibility put on certain contractors on LEED projects, if so, how can owner involvement spread the responsibilities?
Purchasing and documentation. Many products we’ve used before we can’t use now, VOCs in particular. PUT IT IN THE SPECS. I worked with the spec writer here to ensure that there was a submittal requirement for regional/recycled/VOC/etc in the specs so I can tie that to the Schedule of Values. No ticket, no laundry. The Owner needs to be clear about his intentions, be open-minded. Sometimes a little knowledge is a bad thing, the owner needs to be willing to honestly consider the AE’s suggestions. Contraction waste recycling is a huge issue, it’s all about educating the workforce. This is the bane of my existence. I have become the Garbage Czar. This needs to trickle down from the top, the supers and foremen need to be vigilant. More on this later.
What design decisions are typically passed over without early owner commitment to LEED?
Site ones. Daylight/Views. Depending on how far into the project the energy ones, the water efficiency ones, some of the IEQ ones. Once you start building the building, it’s hard to get points and stay within budget.
What experiences have you had where the owner knew what they wanted (in terms of LEED) and was proactive in receiving a certification rating? What did they do different from other owners?
I’m fortunate that the Contracting Officer is on board and understands that LEED cannot take a back seat to budget. The VE decisions we make have to consider the LEED impact. The AE is committed to making this a LEED Silver project. The Owner understands early on what must be incorporated into the design. Usually, what the Owner wants, the Owner gets.
How important is the selection of a design professional that has experience and expertise with

sustainable design?
HUGE. This is the person who guides the design to include specific equipment and materials. This is the person who stands up in meetings and says, No, you can't cut that and here's why.
How often do owners have a very specific idea about the materials and design to reach their LEED Certification goals?
This is the first Army hospital to go for LEED. Most of the hospital personnel have very specific ideas about what goes where and how it works, and aren't open to much change. Our Owner understands that this will be a "world class facility" and the standard to which all future Army hospitals will be held to. We replace Walter Reed.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
Specs. Everyone tries for regional. The ones who can, try for recycled. So far, the only thing I've found that contains NO recycled material is sealants. Some specs list the requirement to the % of recycled material. Specs say no VOCs, no urea-formaldehyde in the composite wood, all wood must be FSC. We bid out per specs and plans. Purchasing is responsible for ensuring we use local labor, local labor means they know the local market. Regional is cheaper for them, too.
How much does a subcontractor understanding of LEED credits and LEED Certification help during the design and construction phases of the project?
From what I've seen, not much. They will build what's on the contract documents. The electrician doesn't really care about anything but performing his specific scope of work. But there needs to be someone in the office who understands the documentation requirements, what needs to be added to the submittal package besides the usual product data, installation instructions and MSDS.
How are decisions made to determine if a system should be made more efficient?
Here we really tried to be more energy efficient and reduce water use. We're hampered because it's a hospital, 24/7 with infection control issues. We have more toilets, showers, sinks, washing machines than the typical office building and we can't just turn the lights off at 5 and have them come back on at 7.
Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors…) How important is it to work with a designer that had experience with sustainable design?
The designer is huge, that's the point of most impact. It's the designer who makes the

decisions, who provides the contract documents that building will be built from. An owner that understands what he wants and that the AE can get him there. The LEED team meets every other Thursday.
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
We have a bunch. There's the Checklist and the Matrix. The Checklist is what we are working towards, some the designer is responsible for, some the contractor. Since there is a 2-part review, the design team can get a good idea of what in the design works, what doesn't and how to tweak it. The contractor does the things the contractor has control over, which for us is 11 of the 34 credits we believe we'll achieve; and I think we'll get some of the "maybe" ones, like FSC wood and VOC agrifiber/composite wood.

Respondent 6:

What problems do owners typically run into when trying to get their project LEED Certified?
Lack of understanding of the LEED scoring system prior to writing it into their contracts. Results in unrealistic expectations.
What do owners need to do differently?
Become more knowledgeable in sustainable design/construction so that they can make better decisions during the concept and design phases.
If you have had positive experiences with owners seeking a LEED Certification what did they do that was successful and helped the overall project?
My clients thus far have been Federal. The single biggest positive is their commitment to sustainability. As said above, now they just need to understand it better.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
Regarding lump sum design-bid-build, it is communicated via the contract. Little to no input is received from the contractor and can result in conflict at the job level for contractors that don't fully understand what they are expected to deliver. Regarding negotiated design-build, it tends to be communicated in a performance document. This is acceptable as problems only occur when the owner wishes to do more than the RFP indicated and decisions are made late in design. It becomes challenging to demonstrate to the owner why a particular feature may increase contract costs and not simply be absorbed into the design-build process.
How do projects differ in terms of ease of successfully reaching a desired certification limit when

sustainability goals are clearly defined during the conceptual and schematic phases of the project compared to when such goals are wanted later in a projects life?
As with so many design changes, early decision making is critical. Many of the sustainable features necessary to attain a LEED certification are not surface deep. In other words, they impact site selection, installed materials, MEP systems, etc.
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
Simply said, not taking the evaluation process needed for sustainable construction seriously. Putting it on the back burner as an add-in that can be selected at anytime along the design-construct continuum.
Is there extra responsibility put on certain contractors on LEED projects, if so, how can owner involvement spread the responsibilities?
Many of the subcontractors burden the responsibilities on a LEED project. This is and should be controlled by the GC, not the owner.
What experiences have you had where the owner knew what they wanted (in terms of LEED) and was proactive in receiving a certification rating? What did they do different from other owners?
In general, Just knowing what they want is a huge plus.
How important is the selection of a design professional that has experience and expertise with sustainable design?
Critical. Many of the points lie fully in decisions made by the designer. If the project is not designed with LEED in mind, it can become nearly impossible to make it up with construction controlled points.
How often do owners have a very specific idea about the materials and design to reach their LEED Certification goals?
I have not experience this yet. Federal contracts are limited in how specific they can be so as not to sole source.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
For the projects I have been on to date, we have taken on the responsibility to guide this process. We have found the majority of our subcontractors to have very limited working knowledge of LEED. Hence, they don't have the expertise to take the on these responsibilities without our leadership.
How much does a subcontractor understanding of LEED credits and LEED Certification help

during the design and construction phases of the project?
Again, very limited.
How are decisions made to determine if a system should be made more efficient?
This is one of the first things we review with our designers on design-build projects.
Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors…) How important is it to work with a designer that had experience with sustainable design?
It depends… on a design-bid-build job, the designer needs to sit in the driver's seat and drive the process. On a design-build project, the contractor needs to take the leadership role while supporting and listening to the designer
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
This is still be proven by our company. The LEED score card is a good base. Outside of that, we are simply folding the LEED score system into our standard business practices so that it just becomes a normal part of business allowing us to impart the same control techniques on our subcontractors as we do for all aspects of the construction process.

Respondent 7:

What problems do owners typically run into when trying to get their project LEED Certified?
I think that owner still tend to run into the cost obstacle. LEED certification starts off as a great idea and has a great "feeling" associated with it. However, I think that certain credits still come at a first-cost premium, that some owner struggle to want to pay. This, in turn, may cause them to shy away from certain points that my help them achieve the certification that they are pursuing, simply due to cost.
What do owners need to do differently?
Related to my response above, owners should try to separate their sustainable construction goals from their financial goals. It has been our experience that LEED certification still comes at a premium. This includes added cost of construction and added administration cost associated with the certification process. If owners accept this, up front, and separate their expectations for LEED certification from expectations for minimizing cost, I believe they may have a more pleasant experience in getting their project certified. The construction industry has embraced sustainable construction, and in doing so, I believe that many of the materials and methods that are currently used in LEED projects, at a premium, will soon be equal to or less costly that

standard materials and methods. When this happens, it should make the cost premium much less an issue.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
In the cm business, we always preach "getting the whole team involved early." With sustainability and LEED as part of the project goals, this is even more critical. I don't think you can have a successful LEED project without the full-team cooperation very early in the project.
What design decisions are typically passed over without early owner commitment to LEED?
I think that many of the site selection criteria are decided prior to pursuing a LEED design. Most owners have their site selected prior to designing their project, not the other way around.

Respondent 8:

What problems do owners typically run into when trying to get their project LEED Certified?
There usually is a perceived cost to certifying a project. For example, the project must be registered with the USGBC and an outside commissioning agent needs to be hired.
What do owners need to do differently?
Make the LEED effort more of a team effort. If the points are distributed amongst the team, the perceived burden is a lot less. Owner who participate and show by example their commitment to the sustainable approach have the most successful projects.
If you have had positive experiences with owners seeking a LEED Certification what did they do that was successful and helped the overall project?
Owner who attended LEED meetings and celebrated LEED milestones (e.g. Design submittal) were most successful.
Typically, how are the owner’s mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
Usually the BOD communicates the owner’s goals for the project. Having LEED part of the BOD really helps the team understand the commitment of the owner.
How do projects differ in terms of ease of successfully reaching a desired certification limit when

sustainability goals are clearly defined during the conceptual and schematic phases of the project compared to when such goals are wanted later in a projects life?
If the goals are identified early, the owner can take advantage of integrated design and possibly save money on the project.
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
The look at first costs instead of the life cycle of the building.
What design decisions are typically passed over without early owner commitment to LEED?
Integrated design decisions that will allow for example, a smaller HVAC system because the skin of the building has been designed at a much higher R value.
What experiences have you had where the owner knew what they wanted (in terms of LEED) and was proactive in receiving a certification rating? What did they do different from other owners?
They instructed the Design Team early to do the “right” thing and not worry about first costs.
How important is the selection of a design professional that has experience and expertise with sustainable design?
I actually think that a good design professional already incorporates a lot of the sustainable features into a project. I think a balance between doing LEED and not LEED projects is essential. I have worked with Designers that only do LEED projects and I think they are sometimes guilty of “greenwashing”.
How often do owners have a very specific idea about the materials and design to reach their LEED Certification goals?
I think most owners rely on the Design Professionals to make decisions about material selection.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
The heaviest burden falls about the MEP contractors because there are specific guidelines for the prefunctional, functional and commissioning. I am not sure material selection creates a burden because most manufacturers are becoming more sustainable to survive.
How much does a subcontractor understanding of LEED credits and LEED Certification help during the design and construction phases of the project?
Contractors who have had experience with the process are much less likely to put extra money

into the project for the LEED burden.
How are decisions made to determine if a system should be made more efficient?
I think if you are talking about HVAC design, I think energy modeling is employed.
Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors…)
I actually think all three play an equal role. Without enforcement from the top (the owner) the team loses momentum. If the Designer does not do their homework, the credits are difficult obtain. If the contractor does not buy into the design, the documentation for the credits will be difficult.
How important is it to work with a designer that had experience with sustainable design?
As I mentioned before, I think experience is very helpful but I also think designers who only do LEED projects are not sensitive to market conditions.
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
The easy benchmark is LEED points. Projects that are sustainable but not LEED certified can use building occupant satisfaction and reduced operating costs as benchmarks.

Respondent 9:

What problems do owners typically run into when trying to get their project LEED Certified?
They either decide to pursue a certification too late and scramble to find the available points without proper planning and advice or hire a consultant to advise them and that consultant does not take the proper time to evaluate existing conditions, design, etc or relies on what they achieved in the past.
What do owners need to do differently?
Proactive involvement in the planning for success in achieving the goals and the impacts of pursuing each achievable rating point.
If you have had positive experiences with owners seeking a LEED Certification what did they do that was successful and helped the overall project?
Define the points early, define responsibilities for achieving each point, incorporating the items to achieve the points into the Contract Documents.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?

The design team and CM should be part of the planning for defining and documenting the planned points. When defined and documented the design team must plan for appropriate execution, budgeting and who to assign those efforts to. For example defining when air systems must be run for removing VOC's or building you loading dock for recycling dumpsters.
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
Deciding to apply for certificating too late and not buying enough administration time for the LEED professional to monitor and document LEED rating points.
What experiences have you had where the owner knew what they wanted (in terms of LEED) and was proactive in receiving a certification rating? What did they do different from other owners?
Hire appropriate consultants to document required points and gather documentation during the construction process.
How important is the selection of a design professional that has experience and expertise with sustainable design?
I feel that each discipline hold have an awareness in LEED processes in order to understand what is required of each member of the team.
How often do owners have a very specific idea about the materials and design to reach their LEED Certification goals?
Usually they have an awareness but use consultants, the design team and the CM for specific applications.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
A consultant defines the plan with each team member buying into the goals and doing their part to define and document the process. Usually, the trade contractors only need to be told what is required and what is defined in the Contract Documents so they can fairly price the necessary labor, time and materials.
How much does a subcontractor understanding of LEED credits and LEED Certification help during the design and construction phases of the project?
Awareness is key but when key elements are defined, the CM must incorporate the means and methods into the budget and the logistics plans and schedules.

Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors…)
The client plays the largest role since they set the vision and tone for the project.
What issues of constructability are important in LEED Certification?
This usually will impact the start up and commissioning processes.
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
Define the points to achieve and responsibility for each point. Monthly meeting should be held to monitor the documentation and planning efforts of the design team and the CM. During purchasing of the trades a review should be held prior to award so that the appropriate sub knows what is expected and what impacts they will have during the project. Quarterly meetings should be held during the construction phase to document progress and verify necessary documentation is being gathered and formatted.

Respondent 10:

What problems do owners typically run into when trying to get their project LEED Certified?
One issue is expectation for various levels and cost and deciding the return on investment and what they want to spend. i.e. what is worth it to them to go for silver, gold etc.
What do owners need to do differently?
When it is possible they should get contractors involved during the design phase to help give material selection and cost input.
If you have had positive experiences with owners seeking a LEED Certification what did they do that was successful and helped the overall project?
On projects where it is possible to get contractor input early owners benefit as does the project but the typical job these days does not allow for this so in lieu of that the owners getting the architect/design team to be the LEED managing agent helps coordinate the process.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
Typically it is communicated in the documents and emphasized to the team during construction in project meetings and the submittal process. The affect on the project is an additional administrative burden and depending on the credits that are being pursued burden in the field

to maintain and plan for certain material delivery and treatment requirements. So in the end it requires additional resources on the construction team's end to facilitate.
What mistakes do owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
My experience is the owners seem to be fairly hands off once they decide to go for it and leave t the managing up to the design and construction team. They need to get more educate in the process.
How important is the selection of a design professional that has experience and expertise with sustainable design?
This is crucial they have to be knowledgeable or the process is hindered from the start and their ability to know what is needed during the construction process is very valuable in terms of helping to monitor the process.
How often do owners have a very specific idea about the materials and design to reach their LEED Certification goals?
I have not seen owners being very aware they seem to typically depend on the design team for this knowledge.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
The specifications formulated by the design team dictate what the trades provide. Yes the trades will typically try and VE if there is room to do so in the documents. But the LEED requirements tend to make this a lot more limited than it has been in the past.
How much does a subcontractor understanding of LEED credits and LEED Certification help during the design and construction phases of the project?
Typically the trades don't get much input in the design phase but if allowed the input would be very helpful and head off problems that are encountered when material are spec but not available because the design team is not intimately aware of material availability.
Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors…)
Design team and establishing realistic expectations and goals.
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
Design credit check is done, material tracking is done over the course of the project and during

the submittal process, regular documentation of material handling, commissioning check list.

Respondent 11:

If you have had positive experiences with owners seeking a LEED Certification what did they do that was successful and helped the overall project?
The owner employed both a design and construction team that was knowledgeable and committed to the LEED process and concepts. The owner had a clear vision as to the project goals and was committed form the onset to achieving those goals.
Typically, how are the owner's mission and goals communicated to the design and construction team and how does having sustainability and LEED Certification part of those goals affect the project?
The goals are typically communicated at the proposal or bidding phase. Having those goals at the onset of the project is critical in the success of the LEED process. It allows for the design team to properly incorporate the concepts into the initial design and allows the contractors to base their initial pricing on the materials and equipment that is necessary to achieve those goals.
How do projects differ in terms of ease of successfully reaching a desired certification limit when sustainability goals are clearly defined during the conceptual and schematic phases of the project compared to when such goals are wanted later in a projects life?
It is much easier to achieve the desired goals when they are clearly established at the beginning of the project. If an owner decides to pursue LEED certification later in the project life, it is more difficult to make the design adjustments necessary and can add significant additional cost that was not originally incorporated into the project.
How important is the selection of a design professional that has experience and expertise with sustainable design?
Extremely important. The ability to achieve a LEED certification is very dependent on the incorporation of those design concepts early on in the process. An experienced LEED design profession will have an understanding of what design elements are critical in achieving the owner's project goals, as well as provide valuable advice throughout the construction process.
For a LEED project how is the responsibility for obtaining LEED Credits distributed amongst the trades? Do trades try to value engineer for the most sustainable materials?
It is the trades' responsibility to meet the intent of the project design. The work of some trades effect of the overall LEED outcome more than others. Many of the common construction materials today meet the minimum requirements LEED asks for.

If a specified sustainable material adds a great deal of cost to the project, the construction team will evaluate the benefit of using a certain sustainable material over using a traditional material.
How much does a subcontractor understanding of LEED credits and LEED Certification help during the design and construction phases of the project?
It is very helpful, both in terms of knowing the materials and processes required and the documentation necessary.
How are decisions made to determine if a system should be made more efficient?
Typically by an evaluation by the design and construction teams along with the owner.
Who plays the biggest role in a successful LEED Certified project? (Owner, Designers, Contractors…)
It has to be a total team effort. Each party plays a significant role in meeting the requirements.
Typically what is the system of checkpoints of benchmarks used to make sure sustainability goals are being met?
An initial LEED checklist is developed at the beginning of the project to identify the LEED credit goals. This checklist is continuously evaluated throughout the project to make sure all parties are aware of the credit goals.

The following are answers from SmithGroup who were the architects of the Chesapeake Bay Foundation's Philip Merrill Environmental Center.

What worked well compared to other owners on other projects? Where do other owners on other projects fall short?
LEED Certification has moved from what was a voluntary action to a mandated one in many jurisdictions. CBF still remains one of the best examples of an Owner who's Organizational Mission and thus, their project goals for their new headquarters, aligned quite well with the initiatives embedded within the LEED Rating System. They were doing "right" for all the right reasons. Organizational Mission: in short, to Save the Bay! Project Goals: ▪ Create the best workplace for staff while supporting on-site education and volunteer training; ▪ Develop the most environmentally sensitive building possible;

- Establish an example for others to create equally “green” buildings;
- Be the best neighbor possible; and,
- Shape a workplace and environment from which to monitor and investigate the state of the Bay

When an Owner is pursuing LEED because of external forces or because they “have to”, it often leads to what we term in the industry as “point chasing”. Point chasing can still yield the LEED Certification Level necessary, but oftentimes has the following negative outcomes:

1. Tasks are done out of sequence and are done to validate or confirm rather than inform decision making processes;
2. Synergies are not properly explored that may have led to greater overall performance and economy;
3. Limited or potentially no (may be applicable to projects registered before June 26, 2007) improvement in energy performance.

How was the owner's mission and goals communicated to the design and construction team?

The Owner’s mission was well known and documented. During predesign, the U.S. Green Building Council's LEED Rating System was used in setting goals for the project before the design commenced. Benchmarking tours of other green projects and CBF's educational centers were also influential.

How were decisions on system types made? What considerations were made to determine if a system should be made more efficient?

A peer review of the concept design was organized by the Sustainable Building Industries Council (funded by the Department of Energy) and included reviewers from the Maryland Energy Administration, Maryland Department of Natural Resources, World Wildlife Fund and National Renewable Energy Laboratory. The peer review tested the design from various angles and recommendations were further studied and some incorporated. An integrated approach to design was used, and in-house engineers worked closely with architects.

The litmus test as to whether something was incorporated or “pushed” to higher levels of efficiency or performance was often the answer to this question - does it meet the goals of the project?

How were the end goals communicated to the design/construction team?

The goals for the project were developed in concert between the design team and the Owner and were based on their Organization Mission, the purpose for constructing a new HQ building,

the context of the site, benchmarking studies of green projects, etc. They were documented for all to know.
What did the owner know about the 'green' systems they wanted? What was left up to the design professionals to decide based on desired outcome?
Perhaps one of the most important considerations for the building and site was water. Given their mission and proximity to the Bay, it was obvious from the start that water conservation and control of quantity and quality of storm water runoff was paramount. For example, CBF had experience using composting toilets at various sites for 20 years. It took some education on behalf of the design team to embrace and design for this strategy in a commercial building. On the other hand, the design team was faced with an inadequate supply of well water in the event of a fire. Rather than extend municipal water service to the site, we integrated a rainwater catchment system with a fire suppression holding tank to serve multiple purposes. In one case, the design team advised the Owner against PV because of its poor life-cycle cost, but the Owner wished to have it simply to demonstrate the technology to others, particularly visitors. In general, much of the process was iterative. There were a few sacred cows so to speak, but the final outcome was born out of the process.
What design decisions would typically be passed over without early owner commitment to LEED? e.g. would the architectural site placement have been considered if the owner did not understand the effects of a solar gain on a south facing façade and the owner never voiced a desire for LEED Certification?
In short, optimization. Oftentimes, we use minimum standards to guide us along with good industry practice. An Owner who is committed to sustainable design and/or who has clear goals for the project is often more willing to pay for additional simulation and analysis to optimize the design (e.g., orientation, fenestration, shading, daylighting, envelope performance, HVAC system selection, etc.). They are interested in long-term benefits rather than first cost alone.
What did the CBF do right that other owners need to do differently? Where there checkpoints or benchmarking strategies?
1. Set goals early and never strayed; 2. Supported an integrated design process; 3. Organized a peer review team to further inform the design; 4. Reiterated and prioritized goals in the face of value engineering efforts;

What could other owners learn from the CBF's involvement on the project?
Truly become a member of the team. CBF was as much a part of the design team as were the design professionals. They often had as many good ideas to contribute as anyone in the architecture and/or engineering disciplines. No one knows the Owner's needs, dreams, and culture better than the Owner himself.
What mistakes do other owners typically make that cause problems for the design/construction professionals for a project attempting a LEED Certification?
1. Believing the hype that you can do a LEED Building and it won't cost you any more than doing a conventional building. 2. There are a lot of tradeoffs when designing/constructing a green building; the Owner needs to identify a decision maker on their end who will not only help the design team make important decisions, but assist their own various constituents in aligning goals and prioritization.
How important is the selection of a design professional that has experience and expertise with sustainable design?
I believe that a LEED-experienced design professional can benefit the project in the following ways: 1. They understand the LEED Certification and design process and can ensure that certain milestones are met and that decisions are made at the right time; 2. They are able to provide lessons learned and share information on previous projects with current clients; While experience with LEED is important, it doesn't necessarily guarantee an innovative and integrated solution that meets all the client's goals. Similarly, experience with sustainable design (process and technologies) is also quite helpful, but if the end result doesn't meet the client's needs, it too cannot be relied upon for the key to success. It really requires a combination of skills.
How well did CBF understand the LEED points and the LEED certification process? How much did this help? How much would this hurt if the owner did not?
CBF was part of the LEED NC V1.0 Pilot Program so no one was familiar with LEED prior to this project. Furthermore, under the Pilot Program, the requirements for Credit submission and acceptance were not well defined as they are today. Generally speaking, there was a level of subjectivism that was used both on the part of the A/E and USBGC in interpreting whether the documentation adequately supported the intent of the credit.