Columbia Heights Community Center

Washington, DC

Christopher Glinski

Construction Management

Thesis – Spring 2006

Department of Architectural Engineering

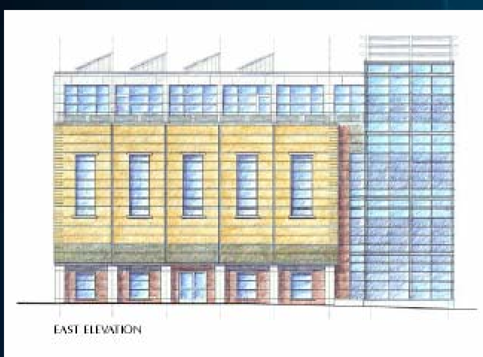
The Pennsylvania State University

Columbia Heights Community Center
Washington, DC

FORRESTER CONSTRUCTION COMPANY

Project Team

GC: Forrester Construction
CM: The Temple Group, Inc.
Architect/Engineer: Leo A. Daly
Owner: DC Department of Parks and Recreations (DPR)



Project Features

Total Cost:. $9.8 Million
Size: 47,395 Sq. Ft.
Duration: 16 Months
LEED Rating: Silver
Building Function:
Public Recreational Activity Center
Satellite offices for DPR
Facility Houses:
Classrooms, Computer Lab, Gymnasium, Stage and Dressing Rooms, Dance Studio, Weight and Aerobics Rooms, Arts / Crafts, Music Room

Mechanical, Electrical, & Lighting

Mechanical: Three rooftop Air-Handling Units totaling 31200 cfm capacity complimented by two Finned Tube Water Boilers. VAV's and Constant Volume Boxes are used at the local level.
Electrical: 2000A, 208/120 Volt, 3-phase service. 125kW Natural Gas Generator serves as backup.
Lighting: Typically 120 Volt, Fluorescent T8 Recessed Lamps and Recessed Compact Fluorescent Triple Tubes. All have a minimum CRI of 75 and color temperature rating of 3500K.

Structural

Façade: Brick and Cast Stone with Curtain Wall Assembly
Foundation: Step Footings, Strap Beams, and Tie Beams for cantilever adjacent to existing apartment
Slab on Grade: 5" Thick
Framing: Structural Steel
Decking: 3" Concrete slab on composite decking, shear bolted to steel framing
Concrete: 4000psi throughout

http://www.arche.psu.edu/thesis/eportfolio/current/portfolios/csg132/

Christopher S. Glinski
Architectural Engineering
Construction Management

Table of Contents

Acknowledgements

I would like to thank the following people for all of their help and support throughout the course of this senior thesis:

- Penn State Architectural Engineering Faculty
  - Dr. John Messner
  - Dr. David Riley
  - Professor Moses Ling
  - Professor Kevin Parfitt

- Forrester Construction Company
  - Kevin Malpass
  - Asif Virani
  - Thomas Phelps
  - Erica Poore
  - Eric Tievy

- DC Department of Parks and Recreations

- Smith Midland™ Precast Manufacturer

- All of the LEED® Rated project personnel that were contacted for my research

- Fellow AE students
  - Nathan Patrick
  - Michael Troxell
  - Christopher Shelow

- All of my friends and roommates

- Most importantly, all of my family, especially:
  - Dad, Raymond Glinski
  - Mom, Annmarie Glinski
  - Sister, Sarah Glinski
  - Cousin, Seth Glinski

Executive Summary

This senior thesis report is a result of an in-depth study of the design and construction of the Silver LEED® Rated Columbia Heights Community Center. This report is broken down into five main sections.

The beginning of this report is to provide a background of the Columbia Heights Community Center that will aid the reader in the latter analyses sections. This section of the report includes a project design overview, a project team overview, existing conditions report, and project logistics details. This bulk of this information was composed during the fall semester, prior to start of our analyses.

As mentioned above, the Columbia Heights Community Center is LEED® Silver Rated. Maintaining this level of LEED® certification throughout the project's design and construction is generally a difficult task. In the spring semester, research was conducted to identify building owners' initial goals for how and why they wanted to achieve LEED®. The intent of this study was to provide owners with a tool during the planning phase to help identify potential LEED® points in hopes that the certification level can be maintained throughout the project. The results of this study can be found in the second main section of this report.

The three remaining sections cover analyses that are geared towards minimizing material quantities in the building, ultimately supporting the goal of LEED® to minimize environmental impact. First a façade redesign (also addressing mechanical impacts) looks to minimize waste quantities by using an architectural precast system. Next, a structural redesign in the gymnasium looks to reduce the amount of steel. Finally, an evaluation on the foundation placement method will look to minimize the amount of soil to be removed.

Project Introduction

Columbia Heights Community Center, located at 1480 Girard St. NW, is just one step Washington, DC is taking towards revival of its neighborhoods. This 47,395 ft^2 facility is to replace two dilapidated apartment buildings on the site while abutting an existing apartment building that is still in use. The community center will be also following an adjacent park/playground project that was recently completed by the DC Department of Parks and Recreation.

This unique project is a mixed-use facility for learning and recreational activities as well as a satellite office for the DC Department of Parks and Recreation. The educational and recreational activities will be supported by the community center's library, classrooms, computer labs, weight / exercise rooms, and gymnasium.

Recently, the building industry has become aware of the negative impact that construction and new facilities are having on the environment. To combat this issue, the building industry has developed a rating system known as LEED® (Leadership in Energy and Environmental Design®) that building owners can opt to pursue when constructing a new facility. Constructing a LEED® rated building generally increases the initial project cost by 2%, but it has been proven to save the owner over ten times the initial investment over the life of the building[1].

The LEED® system is based on points achieved through environmentally friendly methods of construction. Methods of attaining LEED® certification include points awarded for energy efficiency, air quality, day lighting, and construction waste management with recycling. The overall rating is determined by the following criteria:

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

Columbia Heights will be pursuing a LEED® rated Silver Certification.

The community center, designed by the AE firm Leo A. Daly, will be delivered using the Traditional Delivery Method with a Program Manager (The Temple Group, Inc.) and a General Contractor (Forrester Construction Co.). The original construction schedule lasts for fourteen months, starting in July of 2005 and completing in September of 2006.

In the following project background sections, you will find more information pertaining to the design and construction of this exceptional facility.

---

[1] Hernando Miranda (Soltierra LLC), "Achieving 'Low Cost' LEED Projects", *HPAC Engineering Magazine*, April 2005.

Project Design Overview

West Elevation

Architecture:

Columbia Heights Community Center is just one step Washington DC is taking to uplift many of its neighborhoods. In an area where graffiti is a common sight, this building will provide a center for the neighborhood to gather and take part in recreational activities such as sporting events, summer camps, and learning. The facilities that will support this type of use include classrooms, a computer lab, an art room, dance studio, library, weight / exercise rooms, gymnasium, toilets/locker rooms, stage and dressing rooms, as well as administrative offices. Since the design is LEED® (Leadership in Energy and Environmental Design) Silver Rated, much emphasis is placed on natural lighting and energy efficiency. From the sky-lights in the administrative office area to the many sizeable windows throughout the rest of the building, daylight is ever present. Natural light can even be viewed from the center of the building, such as from the glass balcony that provides a magnificent view of the entire gymnasium and its full-storied windows. Along the lines of energy efficiency, much work went into the design of the mechanical systems as well as the green roof and fourth floor terrace, which overlooks the neighboring park and playground. The glass spiral staircase, which branches off of the spacious main lobby, also gives one a view of the surrounding neighborhood and park. With its clean and modern appearance, Columbia Heights Community Center will truly transform the neighborhood into a wonderful area.

Building Codes Implemented:

1996 BOCA National Building Code

1996 BOCA National Electric Code

2000 International Mechanical and Plumbing Codes

ADA Accessibility Guidelines and CABO A117.1-92

1992 DC Construction Codes Supplement

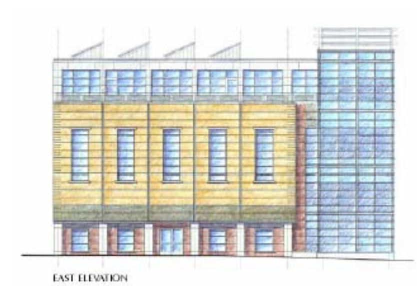
Zoning and Historical Requirements:

Washington DC R-4 with Variances: Height, Lot Size, Occupancy, Parking

Building Envelope:

North Elevation

The exterior walls of the Columbia Heights Community Center are primarily norman brick, which creates the illusion of length through its enhancement of horizontal lines. Pre-cast Concrete strips make a grid pattern throughout the brick assembly, giving the building a very rigid appearance. The windows surrounded by the brick and pre-cast are typically 1" Passive Solar Low-E Insulated-Glass Units. At the North-East corner, curtainwall glazing is used to run the entire height of the building. This is the corner where the glass stairs branch off the main lobby and run to the second floor. The remaining curtainwall is used to cover the weight / exercise room and the library. Different colored panes were used in the curtainwall to also give that horizontal appearance. The remaining East side incorporates large full-storied windows above the second floor to allow daylight into the gymnasium. The rest of the North and most of the West elevation consist of an overhang above the first floor. Pre-cast concrete is used to cover the steel columns at these locations. Along the West elevation, salvaged brick and limestone are used from the previous apartment building that was demolished to be replaced by the community center. This not only enables the community center to blend in with its neighbors, it is environmentally friendly since this material is being recycled. A metal garage door is also used on the West to allow for private entry into the staff parking lot. The South elevation is composed of solid brick with pre-cast accents. This is due to the extremely close apartment building, which is adjacent to this site.



East Elevation

At the roof level, you can observe pre-cast coping along the North-West corner and a Sun Shading Trellis above the North-East curtainwall. From the East, the skylights above the office area can be seen pointing upward from the roof. The roof system is composed of a PVC Membrane, approximately 1/8 of an inch thick, over a ½ inch cover board on tapered insulation. All of this rests on a composite metal deck system.

Construction:

Even before construction of the Columbia Heights Community Center can begin, some demolition has to be performed. The foundation slabs of the pre-demolished apartment buildings will have to be broken up in order to allow the drainage of water into the soils beneath. The existing adjacent apartment wall will have to be abated of lead (*see picture below left*). Once the abatement is complete, the tongue-and-grooved bricks from the pre-existing apartment wall will be chiseled out. After this demolition and the foundations are poured, the steel can be erected. The Columbia Heights Community Center's steel structure and composite metal decking will be erected by a truck crane. Since there are extremely tight site conditions, the crane will eventually have to work from the street, closing down one lane for a weekend. The brick and pre-cast façade, including the curtainwall, are also affected by the tight site conditions. A hydraulic scaffold will be used in lieu of traditional scaffolding since the building line abuts the sidewalk. All in all, there is approximately 8' of working space from the building face to the curb. Increased planning for material delivery and staging will also be needed. The parking garage slab on grade will not be poured until the crane is removed from within the building and onto the street. Once poured, the garage area will serve as a material staging area. Since this building sits on a corner of two One-Way streets, this delivery of materials will have to be carefully orchestrated. Construction was to begin in early May 2005, but was delayed until the beginning of July 2005 due to permit complications. The entire project will last approximately 14 months until its completion in early September of 2006.

Existing Apartment Wall

Electrical:

Power in the Columbia Heights Community Center is strictly in 208/120V. The main feeder into the building is a 2000A, 3-phase service consisting of 10-#4 conduits. Once the feeder enters the main distribution switchboard, it is split up to service the fire pump, the jockey pump, local panel boxes, and the elevators on the ground floor. Other lines rise up the building and service the local lighting and power panel boxes, as well as the three rooftop air handlers. The feeders to the local panels range from a 60A to 150A rating. Each floor has its own set of local panels. Also, 200A rated line is used to power the high demanding stage lighting, audio, and video system. The two service lines to the rooftop air handlers are rated at 300A and 500A. Lastly, a 125kW Natural Gas Generator located on the roof is used to supply emergency power to the building's elevators, fire control system, and emergency lighting.

Lighting:

Columbia Heights Community Center is mainly composed of fluorescent fixtures which all run at 120V power and have a color temperature rating of 3500K. The two most common lamp types that can be seen throughout the building include the T8 rapid-start low-mercury lamps and the compact fluorescent triple-tube lamps. The T8 lamps have a minimum Color Rendering Index (CRI) of 75 and a minimum of 2800 initial lumens per lamp. The compact fluorescent triple-tubes have a minimum CRI of 80. In the gymnasium, two other lighting systems can be found. For the basketball court, special 15" x 48" fluorescent down lights are used and come included with 4 lamps rated at 54W each. Special theater lighting is used for the stage area. Since this is an energy efficient LEED® rated building, motion sensors and timers are used to control all of the office, classroom, and multi-use spaces.

Mechanical:

The climate inside Columbia Heights Community Center is controlled by three rooftop air-handler units (RTU's). Whether during heating or cooling modes, all air from RTU-1 (22,000 average cfm) and RTU-3 (3,700 average cfm) is blown to the many Variable Air Volume (VAV) boxes throughout the building where it is then locally heated or cooled. This accounts for much of the system's energy savings. Air from RTU-2 (5,500 cfm) is blown directly into the stage and gymnasium area at constant volume. Two finned water-tube boilers and pumps are used to serve the VAV heating system during heating mode. Unit heaters are also used in certain areas for local heating. Nine exhaust fans are used in the building, mainly in the ceiling plenums around the exterior as well as on the roof.

VAV Box

Structural:

The structural system of Columbia Heights Community Center is composed of structural steel columns and beams. The floors incorporate a composite concrete slab on metal decking, which is supported by the steel structure. The typical beam size under a classroom or multiuse space is W14x22 where a typical girder is W16x31. Since the gymnasium's two-story high ceiling supports the administrative office floor above, W40x199 girders are used and are laterally braced to two parallel W24x62 girders by W14x22 pieces. The two sizes of girders both span a length of approximately 90 feet. Column sizes range from W10x39 to W14x145. The exterior columns all rest on pedestals which in turn rest on the exterior footing. On the north side of the community center, the footing must be stepped down gradually to an elevation of 10' below the datum so that the zone of influence does not affect the buried water meter vault. The interior foundation system consists of strap beams. Tie beams are used on the south-west corner as a cantilever since the community center is directly next to an existing apartment building. This is to prevent the community center's zone of influence from affecting the foundation of the apartment building. All is topped with a 5" concrete slab on grade. All concrete on this project is to achieve a compressive strength of 4000psi within 28 days.

Fire Protection:

The majority of Columbia Heights Community Center uses a wet sprinkler system. The administrative office area uses a pre-action sprinkler system. Standpipes are used in both stairwells and pressure is controlled by a fire pump, which can be fed from the emergency generator on the roof during power outages. A jockey pump and controller also exists. The alarm system is composed of smoke detectors, bells, pull stations, and strobes. All sprinklers and alarms meet the Washington DC code for fire control as well as ADA requirements.

Plumbing:

The Columbia Heights Community Center domestic water system is supplied by a duplex booster pump assembly, which includes an expansion tank. Cold water is pumped throughout the building as well as to the gas-fired domestic water heater on the roof. A pump is used to re-circulate the hot water through a make-up boiler and back to the water heater. At several locations, electronic trap primers are used to prevent floor drains on the sanitary system from becoming dry. Drains on the roof are used to direct water into the storm drainage system. The sanitary system disposes of all the domestic waste. Motion detectors are used on sinks, toilets, and urinals to limit the amount of water use and meet LEED® requirements.

Transportation:

There are three elevators inside the Columbia Heights Community Center. All elevators use hydraulic lift. There are two adjacent passenger elevators and one service elevator, all of which access every floor. The service elevator has a rated load of 4500lbs. and travels 100fpm. The passenger elevators both have a rated load of 3500lbs. and travel at 150fpm. Each elevator pit is 4 feet deep and a portable sump pump and alarm will notify and dispose of any standing water.

Special Systems:

Great emphasis is placed on Columbia Heights Community Center's Silver LEED® Design. Not only is energy efficiency an issue, but air quality and environmental impact also exist as criteria. In order to satisfy air quality guidelines, materials with low Volatile Organic Compounds (VOC's) must be used. Also, an indoor air quality management plan must be developed by the Construction Manager. Environmental impact has to be minimized in order to meet LEED® requirements. On this project, materials with recycled content, such as steel or drywall, are used and must be purchased from a location within 500 miles of the project site. Light pollution into the environment is minimized through the use of special outdoor fixtures which direct the light away from the sky and surrounding neighborhood. All of this requires increased planning from all project members.

Project Team Overview

Client Information

The owner of this project is the DC Department of Parks and Recreation (DPR). The department is constructing this community center to serve two purposes: to provide a communal facility for recreation and for the department's use as a satellite office. The Columbia Heights Community Center is to be built next to a park and playground, recently completed by DPR.

Cost is very important for the project. DPR is expanding to numerous locations and is on a strict budget so not to overextend. The owner's ability to obtain more funding is very limited and difficult since they are a governmental agency. Additional funds may be obtained, but only after a long process of lobbying and application.

It is important that this project obtain a LEED® rating and thus, a certain quality must be maintained. DC Parks and Recreations is moving towards "Greening" their facilities to conserve energy and have sustainable buildings.

Schedule is a concern for DPR, but it is not vital to meet a certain date. Construction was intended to start in the beginning of May, but was pushed back over two months to mid-June due to zoning issues. No impact to the owner was noted due to the delay in schedule other than additional general condition costs.

Upon completion of the project, DPR will move into its new office facilities and open the building to the public. At this time, the owner expects the building to be completely finished and punched-out. This also includes a successful LEED® Rating achievement.

Project Delivery System

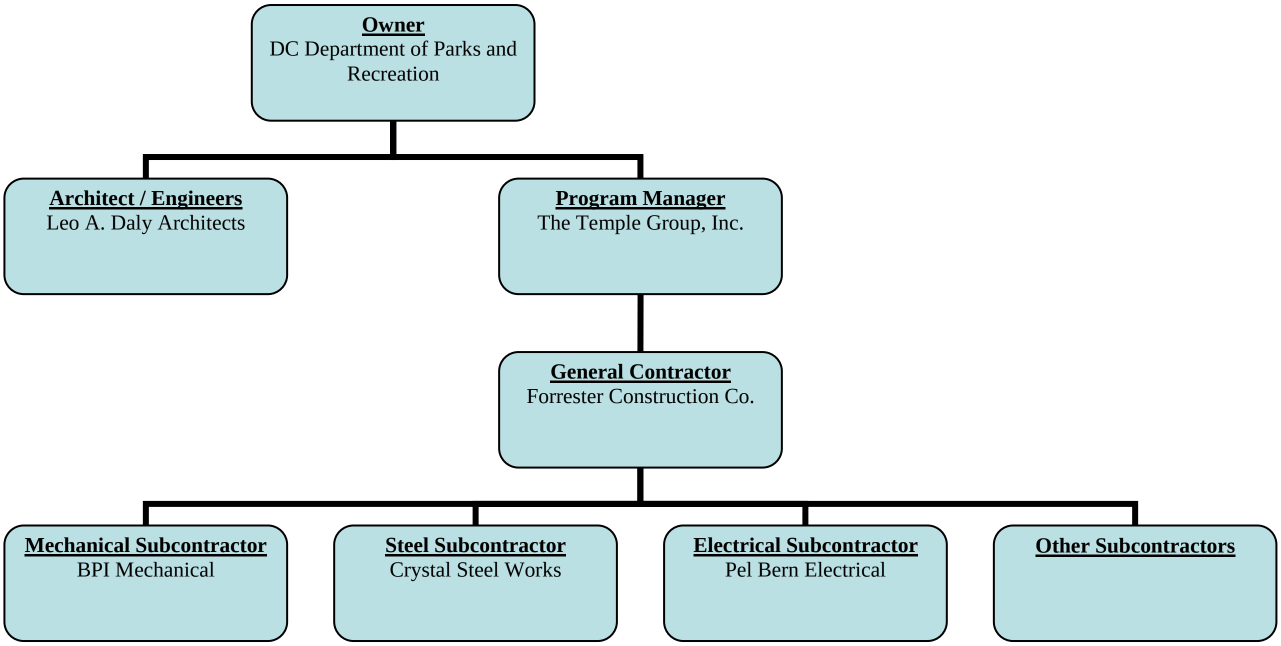
Columbia Heights Community Center is being delivered using a Traditional Delivery method with a Program Manager, who then hired a General Contractor. The Program Manager has a Lump Sum contract with the owner and the General Contractor has a Lump Sum contract with the Program Manager. The General Contractor then subcontracted the work out at a lump sum price. The Architect / Engineers hold a separate contract with the owner which is Cost plus Fee.

The Program Manager was selected by the owner because they had completed several previous projects and they had already assisted with the pre-construction planning and development for this project. From their past experience and relationships with the owner, the Program Manager has taken on many roles that are typically performed by a Construction Manager and Owner's Representative. Their role on this project is a liaison between the field (the General Contractor), the Architect/Engineer, and the Owner. The General Contractor must submit all applications for payment, change orders, progress reports, and any reports of non-compliance to the Program Manager who then submits them to the Owner. Also, all RFI's and Submittals have to be sent from the General Contractor to the Program Manager prior to the Architect's review.

The General Contractor is responsible for all construction planning and activities. Prior to the start of construction, all scheduling and estimating had to be submitted to the Program Manager for approval. The General Contractor also has to do the buyout, the execution, and the closeout. Ultimately, all correspondence must first be sent through the Program Manager. The selection of the General Contractor was based on their bid price and quality of work they provided in the past. The General Contractor must hold both insurance and bonds. All subcontractors for work packages totaling over $250,000 must also hold bonds. Subcontractors with packages between $100,000 and $250,000 are subject to review for bonding.

The Architect / Engineers are a single entity underneath the Owner. They worked alongside the Program Manager to design the structure and are working together to ensure the work-in-place meets the original specifications. They were chosen based on their design fee and prior experience and were paid to design a LEED™ Silver Rated building.

Project Delivery Chart



Staffing Plan

The General Contractor on Columbia Heights Community Center organized their staff according to function. There was an operations group, a purchasing group, and an accounting group (see "*Staff Plan*" and "*Table 1 - Team Involvement*" below).

The operations group consisted of three main levels. At the top level, the Project Executive was in charge of owner correspondence and generally overseeing the project and the rest of the operations staff. The next tier included both the Project Manager and Superintendent. The Project Manager's duties included owner correspondence, cost tracking, negotiating changes, subcontractor correspondence, and managing the schedule. The Superintendent's responsibilities were daily on-site coordination of construction activities, maintaining and updating the schedule, safety management, material tracking, and construction planning. Below the Project Manager, an Administrative Assistant was used for payroll tracking, document assembly, shipping, and other miscellaneous tasks. A Field Engineer also worked directly underneath the Project Manager. His tasks included reviewing / processing all incoming and outgoing submittals, generating / processing all RFI's, some owner correspondence, LEED point tracking, and some purchasing.

The purchasing group mainly served on the project during the beginning stages. One purchaser was assigned the task of contacting subcontractors and obtaining prices to install work. The purchaser also worked closely with the Project Manager to allow for an easy transition from purchasing into operation.

The accounting group consisted of one to two accountants. They were responsible for processing the cash flow: issuing checks, logging losses or gains, and tracking payments. The accountant also works closely with the Project Manager while tracking costs and work-in-place. This ensures that all project team members are aware of the cash flow.

Staffing Chart

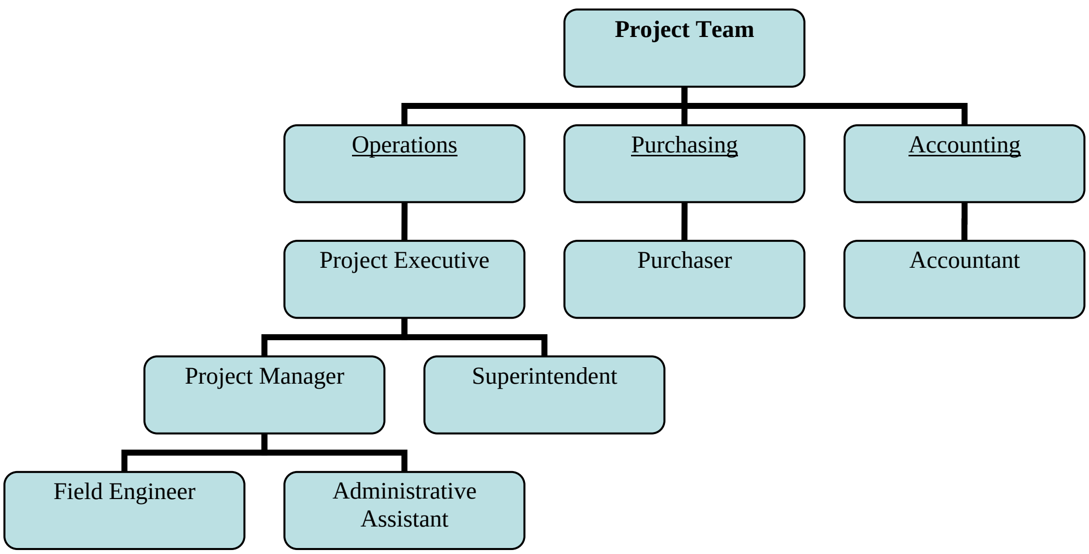


Table 1 - Team Member Involvement

Team Member	Planning	Procurement	Mobilization	Structural	Finishes	Punchout / Closeout
Project Executive	■	■				
Project Manager		■	■	■	■	■
Superintendent		■	■	■	■	■
Project Engineer		■	■	■	■	■
Administrative Assistant		■	■	■	■	■
Accountant		■	■	■	■	■
Purchaser	■	■				

■ **Member heavily involved in listed activity**

Existing Conditions Report

Local Conditions

The structure is located in North West Washington DC. Generally, the buildings of this city are constructed out of concrete to maximize floor to floor heights. For Columbia Heights Community Center, this is not the case. The owner has decided upon using a steel frame with a composite concrete slab on deck. A truck crane will be used to set the steel in three phases.

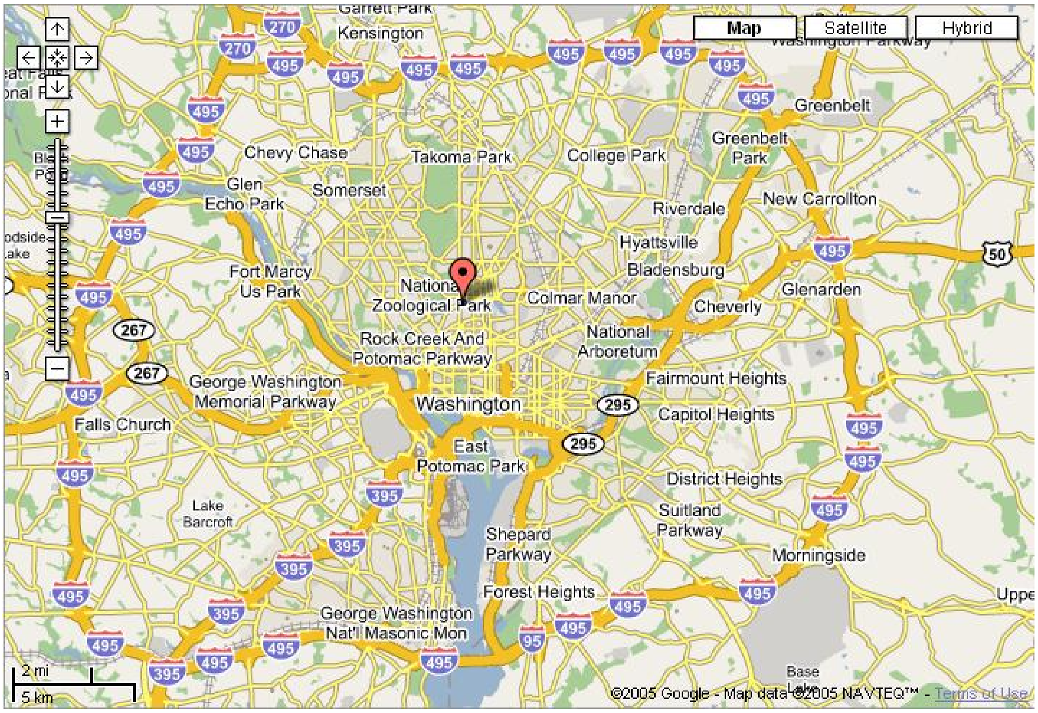
Since this project is in a downtown urban area, parking is at a premium. One lane is closed off along Girard St. (refer to site plan) which houses the trailer and temporarily houses parking only for the owner and construction management staff. Later, the parking spaces will be used as material staging. Subcontractors are responsible for their own parking, which is illustrated in their contract.

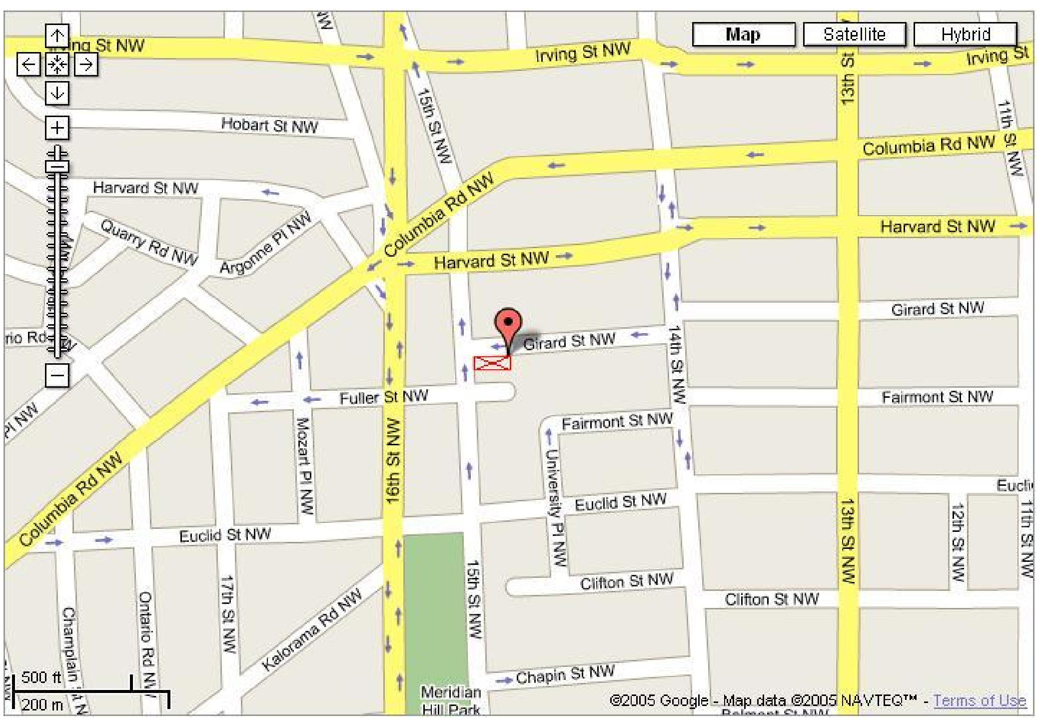
The surface soil was found to be a mix of crushed stone in some areas, and top soil in others for a depth of 3 inches. Directly below this existing fill was encountered. It consisted of medium dense silty sand and clay. Also, building material from the previously demolished apartments was mixed throughout. This layer lasted until 5 feet below the surface layer. Underneath the fill, medium loose to very dense silty to clayey gravel was discovered and ranged from 11 to 23.5 feet below the surface. Lastly, the bottom layer, which ranged from 21 to 28.5 feet, was found to contain silt, elastic silt, and silty sand. Upon removal of the site borings, the groundwater level was undetected, even at the cave-in depth.

Evaluation of these soils shows that all subsurface layers are suitable to support the shallow foundations with an allowable soil bearing capacity of 3000 psf. Only in certain areas will structural fill have to be used. The main area in question is the remaining rubble from the buried apartment building that was demolished.

Vicinity Maps

Below you will find two vicinity maps. The top one shows the location of the Columbia Heights Community Center in the Washington D.C. area, while the bottom one zooms in to show the position of the project within the community.





Site Layout Planning

The site for Columbia Heights Community Center is extremely congested. Critical phases of construction are highlighted and the site plans illustrate how work will flow during those phases. Four site plans, which include Existing Conditions, Excavation, and Steel Phases 1-3, can be found in *Appendix A*. Below is a list of three major phases and a brief description outlining a few key points:

- **Excavation**
    - There are two levels of excavation. The 10' deep section is in the area where the footing steps down to meet the water meter vault. The remainder of the site will be excavated 4' below datum to prepare for the rest of the foundation. The fleet will be balanced to minimize wait time for dump trucks before loading. All early trucks will park on the other side of 15th Street as seen on the Excavation Plan.
- **Steel Erection**
    - Steel is to be erected by bays (using multi-story columns) in three phases. Each phase is displayed on a separate drawing. The steel erection phases are as follows:
        1. Column Line (M-H)
        2. Column Line (H-E)
        3. Column Line (E-A)
            - The last piece of steel is to be erected from the street, closing a lane on 15th Street. This work will be performed on a weekend during off-peak hours so that impact to traffic is minimized.
- **Concrete Work**
    - Concrete work will follow shortly behind the steel erection. Upon completion of a steel phase, concrete will be poured in the decks of that finished area. The concrete operation will chase the steel erection until completion of the entire steel frame, and then the slab on grade will be poured.

Project Logistics Details

Detailed Project Schedule

The Columbia Heights Community Center schedule consists of 188 activities, which are broken into 13 major phases. The summary and detailed project schedule can be found in *Appendix B.*

Estimate Summary

"*Table 2 – Estimate Summary*" (below) includes all general conditions, structural, and curtainwall items. All total costs include location modifiers and the percentages are based against the reported total construction cost of $9,800,000. All data was obtained from *R.S. Means 2005*.

Table 2 - Estimate Summary

Code	Division Name	% of total Cost	Projected Cost
01000	General Requirements	6.64%	$650,994
03000	Concrete		
	Foundation	0.76%	$74,430
	Slab on Grade	0.23%	$22,200
	Decks	0.55%	$53,422
04000	Masonary		
	Face Brick	3.85%	$377,081
05000	Metals		
	Structural Steel	14.30%	$1,401,495
08000	Doors and Windows		
	Curtainwall	0.94%	$92,316
	Windows	1.25%	$122,921
	Total Building Costs	100%	$9,800,000

General Conditions Estimate

An estimate of the General Conditions (GC) for the Columbia Heights Community Center can be seen on "*Table 3 – General Conditions*" (below).

Table 3 - General Conditions

Category	Item	Quantity	Unit	Time (Months)	Unit Cost	Cost / Month ($)	Total Cost ($)
Fee							
	GC Fee	2.50%	Job	14	$245,000	$17,500	$245,000
Bonds / Insurance							
	Bonds (Performance)	0.60%	Job	14	$58,800	$4,200	$58,800
	Insurance (Builder's Risk)	0.24%	Job	14	$23,520	$1,680	$23,520
Staffing							
	Project Executive	1	Ea.	5		$10,000	$50,000
	Project Manager	1	Ea.	15	-	$7,400	$111,000
	Senior Superintendent	1	Ea.	15	-	$6,900	$103,500
	Intern / Field Engineer	1	Ea.	6	-	$3,060	$18,360
Temp Utilities							
	Temp Water (Hydrant)	1	Ea.	6	$750	-	$750
	Temp Power	1	Ea.	14	-	$250.00	$3,500
	Temp Lighting	1	Ea.	10	-	$18	$180
	Temp Heating	1	Ea.	3	-	$36	$108
	Toilets (Portable Chemical)	2	Ea.	14		$159	$4,452
Office Support							
	Trailer (10'x40')	1	Ea.	14	-	$254	$3,556
	Office Supplies	1	Ea.	14	-	$85	$1,190
	Telephone / Internet	1	Ea.	14	-	$204	$2,856
	Trailer Lights / HVAC	1	Ea.	14	-	$98	$1,372
	Copy Machine	1	Ea.	14	$250.00	-	$250.00
Other:							
	Dumpsters (Pulled Weekly)	2	Ea.	14	-	$665	$18,620
	Temporary Fencing - 8' High	520	LF	14	-	$19	$9,854
	Trash Chutes (4-12' stories)	2	Ea.	14	$7,272	-	$7,272
	Jersey Barriers	250	LF	14	$6,988	-	$6,988
					Total	**$42,528**	**$671,128**
						x DC Location Factor (.97)	
							$650,994

* All prices were taken from R.S. Means 2005

** If min and max prices listed, the average of the two was used

Analysis 1

LEED® Point Alignment Depth Study

Problem

Despite the initial goal and investment for certain level of LEED® certification, it is very difficult to maintain that level and achieve each point throughout the construction process. As the construction progressed, the Columbia Heights Community Center project team identified a few points that may not be feasible for this type of project, thus placing it into the category of the buildings mentioned above. Aligning the owner's goals with corresponding LEED® points can result in a better quality building for its intended use and a more structured approach towards maintaining and obtaining the initial LEED® certification level.

Goal

The main goal of the proposed research would be to identify LEED® points that are associated with the owner's initial goals for the construction, function, operation, and maintenance of their building. With this knowledge, an interactive tool can be produced to identify the most achievable and functional points based on the input of the owner's goals. For example, the goal of the building being accessible to the community can be linked with the set of points that cover "Alternate Transportation".

Methodology

1. Literature review to become familiar with the different LEED® points.
2. Develop a list of interview questions to determine the owner's goals.
3. Identify and interview 10 different owners on 10 different LEED® Rated projects.
4. Compare the owner's goals with the LEED® points that were achieved on that project.
5. Compile the results and generate a specific set of goals. These goals, when targeted by the owner, will produce a set of potential LEED® points.
6. Assemble an interactive program that can be used for the purpose mentioned above.

Tools

1. U.S. Green Building Council (USGBC) website (www.usgbc.org)
2. LEED® Green Building Rating System for New Construction and Major Renovations (LEED®-NC) Version 2.1
3. Microsoft Excel

Outcome

As stated before, once a list of interviewing questions was assembled (refer to *Appendix C* for the *LEED® Interview Questionnaire*), research was conducted on the USGBC website for projects that varied in location, building type, and level of LEED® certification achieved. Once contacts were made and interviews were carried out, the results were tabulated and an Excel® file was generated to help identify potential LEED® points. Upon analyzing the interview answers, several goals seemed to be common among all owners. Also, when viewing the projects' LEED® points list, there were several "popular" points that were pursued by multiple projects. These common goals and popular points aided in the assembly of the Excel® spreadsheet. For more detail on project selection, common goals, common points, and Excel® spreadsheet assembly, please see the following sections with those titles.

Project Selection

All projects were selected upon availability of information from an online database of New Construction and Major Renovations (LEED®-NC) Version 2.1 projects. See "*Table 1 – Project Directory*" on the following page for project names, locations, sizes, and primary contacts. The projects that were selected included four LEED® Certified, three LEED® Silver, two LEED® Gold, and one LEED® Platinum certification level. On this project list were government buildings, educational facilities, mixed-use buildings, a health center, and a municipal building. Of these buildings, 3 out of 10 were to be leased.

As mentioned on the previous page, some of Columbia Heights Community Center's LEED® points were identified to be difficult to achieve. A possible cause for this was that the design thus far was not able to support the points that were set for this project, such as an "Innovation in Design" credit. This project was included in the project contact list so that it could be lined up against the results from other facilities. Even if this does not immediately solve the problem of missing LEED® points, it will provide an excellent tool to show what could have been done differently, or what other points could have been pursued.

Table 1 - Project Directory

LEED® NC 2.0, 2.1

	Project	LEED® Certification Level	Size (Sq. Ft.)	Approximate Construction Cost	Project Address	Owner
1	Columbia Heights Community Center	Silver	47,395	$9.8 Million	Washington, DC	DC Department of Parks and Recreation
2	Carl T. Curtis - National Park Service	Gold	68,000	$8.5 Million	Omaha, Nebraska	National Park Service
3	Artists for Humanity EpiCenter	Platinum	23,500	$4.9 Million	Boston, MA	Artists for Humanity, Inc.
4	Baca/Dlo'ay azhi Community School	Certified	78,900	$10.4 Million	Prewitt, NM	Bureau of Indian Affairs
5	Pennsylvania Department of Environmental Protection's Cambria Office	Gold	36,000	$3.2 Million	Ebensburg, PA	Department of Environmental Protection
6	Seattle Justice Center	Silver	288,000	$91.3 Million	Seattle, WA	City of Seattle, Facilities Services Division, ESD
7	Clackamas High School	Silver	265,000	$31 Million	Clackamas, OR	Clackamas School District
8	Heimbold Visual Arts Center	Certified	60,000	$25 Million	Bronxville, New York	Sarah Lawrence College
9	Social Security Administration Child Care Center	Silver	31,900	$5.1 Million	Baltimore, MD	Social Security Administration
10	Patrick H. Dollard Health Center	Certified	28,300	$6 Million	Harris, NY	The Center For Discovery

Common Goals

By the time of the completion of the interviews, several goals were noticed to be common among most of the projects. Many of the goals depended on the occupants (and their tasks) of the building, if they owner was occupying or leasing, and what area the building was in.

Of the many existing types of building occupants, 7 out of 10 of the projects had either an office or administrative worker using their building. The main goal that was given from these owners was a healthy indoor environment for their workers. Despite that all 10 of the projects listed this as their goal, the 7 projects mentioned above made this one a top priority. In the majority of buildings, the cost of salaries far outweighs that of maintenance and construction. The productivity of the worker is important to an owner, and worker health directly impacts this. Maintaining a healthy indoor environment will prevent any negative health effects (such as "Sick Building Syndrome"), any liability, and even future maintenance. Also, research has been conducted and it was found that several million dollars are lost each year due to loss of worker productivity from a poor indoor environment[1].

Another goal that was common among the projects was lowering operation and maintenance costs. It was particularly stressed on the projects where the owner was to occupy the building. This was to be expected since the owner would be responsible for all utility and maintenance costs. The majority of the owners counted on the long term savings from these lower costs to maximize their return on investment. Even though several of the leased projects listed this as a goal, one pointed out that the utility savings would be seen from a lower rental rate.

Only 4 out of 10 owners identified themselves as being in an urban setting. This would generally mean a higher occupancy rate and a stronger need for community accessibility. Being in an urban setting greatly impacts the number of parking spaces and the methods for travel to work. Several owners expressed an interest at providing an accessible building to multiple forms of transportation.

[1] Fisk, William J. Health and Productivity Gains from Better Indoor Environments and their Relationship with Building Energy Efficiency. www.usgbc.org . March 15th, 2006.

The last goal that was popular among the owners, despite their project differences, was that of "setting an example" or "being the measuring stick" for future Green facilities. This was evident among owners who were part of an organization that had multiple projects planned for the future. This goal could be loosely tied with the fact that many organizations are now mandating that their facilities have a minimum standard of LEED® certification. Many of the projects that were contacted were either the first or second Green projects built by the organization. It was tough to align LEED® points to this goal, but one subject that was important to the owners in this category was cost. Since these owners wanted to "set an example" for their future mandated Green buildings, they wanted to make the process as economical and efficient as possible. During earlier research, a list of "Low Cost" LEED® points was found, which would benefit this type of owner. "Low Cost" LEED® points will be discussed in the next section "*Common Points*". Ultimately, the goal of a low cost LEED® building could apply for those owners who expressed these "measuring stick" goals.

The goals listed above were those that were identified most frequently by the owners. For a complete list of goals and interview responses, please see "*Table 2 – Project Comparison*" on the following page.

Table 2 - Project Comparison

LEED® NC 2.0, 2.1

	Questions	Columbia Heights Community Center	Carl T. Curtis - National Park Service	Artists for Humanity EpiCenter	Baca/Dlo'ay azhi Community School	Pennsylvania Department of Environmental Protection's Cambria Office	Seattle Justice Center	Clackamas High School	Heimbold Visual Arts Center	Social Security Administration Child Care Center	Patrick H. Dollard Health Center
		Silver	Gold	Platinum	Certified	Gold	Silver	Silver	Certified	Certified	Certified
1	Intended use of the building?	Community center, mixed recreational use, satellite officers for owner	Office use	Organization activities, afterschool / summer, art display	Elementary education	Office use - headquarters for district mines and abandoned mine wrecks	Police Dept. headquarters, Municipal courts	Educational facility, comprehensive high school	Educational use with visual arts through studios / classrooms	Child care facility for Social Security Administration, small % of community allowed	Clinic, healthcare, outpatient services, disabled, dental, occupational / physical therapy
2	Occupy or Lease?	Occupy	Lease - 20 years	Occupy	Occupy	Lease - 20 years	Intended 100% occupy, but court rooms are leased out	Occupy	Occupy	Lease	Occupy
3	Who is using the building?	D.C. Department of Parks and Recreations (owner), community members	National Park Service administration	Artist for Humanity (owner), community organizations, students	Teachers, students, councilors	Department of Environmental Protection staff (leasee)	Police administration, judges, defendants	Teachers, students, administration	Teachers, students, administration	Social Security Administration childcare staff, children	Administration, doctors / professionals
4	Types of tasks users are performing?	Sports / health related activities, theatrical, educational, administrative	Computer related activities, research, education seminars, document storage	Display gallery for rent for functions, administrative, studio design, tours	Academic, sports related activities (gymnasium), theatrical, reading (library)	Administrative, computer related, document storage	Administrative, computer related, holding cell (detainee's) awaiting trial, judicial acivities	Administrative, academic	Academic, computer related activities, sculpting, artistry	Child care, food preparation, recreation	Therapudic activities, healthcare, wheel chair access, dental work
5	What type of area is the building in? (urban, suburban, rural, residential, etc.)	Urban / Residential	Urban	Urban / industrial	Rural	Industrial park	Urban - government centers district	Suburban / residential (heavily developed)	Suburban	Suburban / mixed community	Rural
6	Is operation and maintenance cost important?	Yes	It is to the building owner so rent will be less for tenant	Yes - minimize dependence on purchased energy through heavy use of solar panels	It is required by Federal Law, but still a high priority to minimize energy costs	Yes - lower energy costs result in lower rental rates	Yes	Yes - energy management, large day light use in work spaces	Yes - need long term utility savings	Yes - SSA is given an allowance and must meet those goals	Yes
7	Was minimizing environmental impact a priority?	Yes	Yes - tenant requested it to be LEED rated	Yes - maximize renewable energy - rain water collection for irregation	Yes - building on existing school site, minimize site impact	Yes - boost local economy through local materials, redevelop brownfiel site	Yes - rebuild on existing site, minimize impact to community, reduce traffic / parking spaces	No	Yes - wanted to minimize fossil fuel consumption	Yes - build on existing lot, maintain green space	Yes - remove some existing concrete structures, irregate with rain runoff
8	Was a healthy indoor environment a priority?	Yes - high occupancy rate - children and administration will be using it - healthy place to work and play	Yes - healthy environment for workers	Yes - natural light and ventilation - better / ceaner environment for users	Yes - healthy indoor learning environment	Yes - improve worker productivity, comfortability, local sensors to monitor air quality	Yes - old building had poor air quality, local control, good filters, health of tenants	Yes - minimize HVAC runtime, use natural ventilation, induced convection, healthy air	Yes - some art supplies contain V.O.C.'s - want to maintain healthy environment by removing the pollutants	Yes - healthy environment for occupants, high visibility	Yes - occupants have compromised immune systems - health a priority
9	Is there green space on your property?	Yes - on the roof and in the park on the propoerty	Yes - use of native plants without irregation	Yes - courtyard (minimum irregation)	Yes - use of natural landscape / plants	Yes - did not remove trees, graveled parking lot for run off	Yes - green roof, plaza at street level	Yes - sports fields, use natural landscape, minimize irregation	Yes - sunk into an existing hill, greenscape on roof	Yes	No
10	When is this building used (day, night, or both)?	Day, sometimes night	Both, but mainly during standard business hours	Day, night use not common	School during day, community use at night	Day	Day, some evening	Day, some night activities (sports / theater)	Both	Day	Day
11	Are there any other reasons for obtaining LEED certification?	Improve the neighborhood while minimizing impacts to the site / community, accessibile to community	Have a positive impact on local economy (local materials), teaching tool for community to demonstrate LEED	Set an example, good marketing / advertising, helped to raise money for construction (budget), minimize impact to community through building materials reuse	Standardization of the school district, Federal order accessible to community since in rural setting	Want to be environmental leader, provide a "measuring stick" for Green failities, minimize cost / s.f.	Conserve resources (sun access), future solar collectors to be added, high visibility using daylight, provide a model for sustainability, example for community	Set an example for community, good advertising, public relations	Donation was made so that LEED could be pursued	Set example for future Silver LEED rated buildings, level of LEED a function of maintaining low square foot costs	Improve health of clients, zero combustion building (no V.O.C.'s), advertising for patients and fundraising

Common Points

A list of the LEED® points achieved, or to be achieved, by each project was found on the USGBC website. This was an extremely good aid in the process of matching up LEED® points to owners' goals. Immediately, several points were seen to be achieved on at least 90% of the projects. These included *Site Selection, Optimize Energy Performance (20% New / 10% Existing), Recycled Content (Specify 5%), Local/Regional Materials (20% Harvested Local), Low Emitting Materials (Adhesives and Sealants), Low Emitting Materials (Carpet), Innovation in Design*, and *LEED® Accredited Professional.*

As mentioned in the previous section, during preliminary research and literature reviews, a list of "low cost" LEED® points was found. This list was based off of research conducted by Hernando Miranda (Soltierra LLC) that was published under the name "Achieving Low Cost LEED® Projects" in the April 2005 issue of *HPAC Engineering Magazine*. Here, he surveyed 128 projects for which LEED® points they achieved. This research yielded 26 points that were most often earned because they were "among the least expensive and/or least difficult to obtain".

When comparing this list to the project list of LEED® points, several things were noted. First, all of the LEED® points mentioned above in this section were among the 26 points on the Low Cost list, which supports Miranda's research. Second, roughly 80% of the projects incorporated these 26 points into their certification. Surprisingly, the points that were on this list that were not as common among the projects were *Thermal Comfort (Comply with ASHRAE 55-1992), Daylight and Views (Views for 90% of Spaces),* and *Construction Waste Management.* This could be due to the extra cost associated with these points. Lastly, there were two projects that were seen to deviate from this list the most: The Patrick H. Dollard Health Center (17 out of the 26) and the Baca/Dlo'ay azhi Community School (18 out of the 26). Reasons for this were not immediately clear, but these two projects had two things in common:

1. They were not projects where the organization mandated they go Green.
2. From the interview process, they seemed to have the goal of obtaining points that were functional to their building.

Looking at these reasons, it could be said that if a project must be built Green as part of a statute or organizational mandate, the best option would be to first pursue the 26 points on the "Low Cost" list.

In all, the average amount of points achieved for the ten projects was 34.6, which would obtain a Silver rating. For a list of all the projects and their LEED® points achieved, please see "*Table 3 - LEED® Point Comparison*" on the following page.

Excel® Spreadsheet Assembly

In order to form the Excel® spreadsheet, the goals and LEED® points were matched up using the previous tables in this section, as well as knowledge obtained from reading the LEED® Green Building Rating System for New Construction and Major Renovations (LEED®-NC) Version 2.1 Handbook, which can be found on the USGBC website under publications. The final Excel® product containing the LEED® points was a result of a modification of an existing file, created by Mike Pulaski for his Ph.D. dissertation in 2005, which allows the user to weight certain factors. In this case, it is goals for LEED®.

Based on the responses from the owners, seven prime goals were identified and inserted into the Excel® file. They include:

1. Construction Cost
2. Minimize Impact to the Community
3. Operation / Maintenance Cost
4. Health of Occupants
5. Occupant Productivity
6. Accessible to the Community
7. Minimize Negative Environmental Impacts

Each of these goals is then defined on the other sheet, with the tab marked "Definitions". Along with the definitions are the corresponding LEED® points for each goal.

Using this program is fairly simple. On the "Weights" page, one is asked to enter a series of zeros and ones in a matrix depending on which goal they value more. Upon entering this information, the spreadsheet will calculate a weights percentage that shows which goal they ultimately hold above others. With this knowledge, they are to reference the "Definitions" page and the list of LEED® points for their goals. A detailed list of directions and an example is provided on the three pages following *Table 3*.

The main caveat with this program is that it is intended to be used as a tool for determining *potential* LEED® points for a project during the early planning phases. The *actual* LEED® points that are to be pursued should ultimately be determined by the project planning team, and not solely by this tool, as there are many more LEED® points that are not mentioned within this spreadsheet.

Table 3 - LEED® Point Comparison

	LEED-NC Version 2.1 Points	LEED™ Points Most Often Earned*	Columbia Heights Community Center	Carl T. Curtis - National Park Service	Artists for Humanity EpiCenter	Baca/Dlo'ay azhi Community School	Pennsylvania Department of Environmental Protection's Cambria Office	Seattle Justice Center	Clackamas High School	Heimbold Visual Arts Center	Social Security Administration Child Care Center	Patrick H. Dollard Health Center
		Certified	TBD	Gold	Platinum	Certified	Gold	Silver	Silver	Certified	Certified	Certified
	Sustainable Sites											
Credit 1	**Site Selection**	X	X	X	X	X		X	X	X	X	X
Credit 2	**Development Density**				X			X				
Credit 3	**Brownfield Redevelopment**			X	X							
Credit 4.1	**Alternative Transportation**, Public Transportation Access	X	X		X		X	X	X		X	
Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	X	X	X	X	X	X	X				X
Credit 4.3	**Alternative Transportation**, Alternative Fuel Vehicles					X	X	X				
Credit 4.4	**Alternative Transportation**, Parking Capacity and Carpooling	X	X	X	X	X		X		X		X
Credit 5.1	**Reduced Site Disturbance**, Protect or Restore Open Space		X			X					X	X
Credit 5.2	**Reduced Site Disturbance**, Development Footprint	X	X	X		X	X		X		X	X
Credit 6.1	**Stormwater Management**, Rate and Quantity					X	X				X	X
Credit 6.2	**Stormwater Management**, Treatment		X	X	X			X	X			
Credit 7.1	**Landscape & Exterior Design to Reduce Heat Islands**, Non-Roof	X	X	X	X	X		X	X	X		X
Credit 7.2	**Landscape & Exterior Design to Reduce Heat Islands**, Roof		X	X	X		X	X				
Credit 8	**Light Pollution Reduction**		X		X				X	X	X	
	Water Efficiency											
Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	X		X	X	X	X	X		X	X	X
Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	X		X	X	X	X	X		X	X	X
Credit 2	**Innovative Wastewater Technologies**											
Credit 3.1	**Water Use Reduction**, 20% Reduction	X		X	X	X	X		X	X		
Credit 3.2	**Water Use Reduction**, 30% Reduction			X	X	X	X					
	Energy & Atmosphere											
Credit 1	**Optimize Energy Performance** 20% New / 10% Existing (2)	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
	Optimize Energy Performance 30% New / 20% Existing (2)		X	X	XX		XX	XX	XX	XX	XX	
	Optimize Energy Performance 40% New / 30% Existing (2)				XX		XX	X	XX		X	
	Optimize Energy Performance 50% New / 40% Existing (2)				XX		XX		XX			
	Optimize Energy Performance 60% New / 50% Existing (2)				XX		XX					
Credit 2.1	**Renewable Energy**, 5%				X		X					
Credit 2.2	**Renewable Energy**, 10%				X		X					
Credit 2.3	**Renewable Energy**, 20%				X		X					
Credit 3	**Additional Commissioning**			X	X			X		X		X
Credit 4	**Ozone Depletion**		X		X							
Credit 5	**Measurement & Verification**			X	X			X	X			
Credit 6	**Green Power**			X	X	X	X		X			X
	Materials & Resources											
Credit 1.1	**Building Reuse**, Maintain 75% of Existing Shell											
Credit 1.2	**Building Reuse**, Maintain 100% of Shell											
Credit 1.3	**Building Reuse**, Maintain 100% Shell & 50% Non-Shell											
Credit 2.1	**Construction Waste Management**, Divert 50%	X		X	X			X	X	X	X	X
Credit 2.2	**Construction Waste Management**, Divert 75%				X			X	X	X	X	
Credit 3.1	**Resource Reuse**, Specify 5%						X					X
Credit 3.2	**Resource Reuse**, Specify 10%											
Credit 4.1	**Recycled Content**, Specify 5% (post-consumer + ½ post-industrial)	X	X	X	X	X	X	X	X	X	X	
Credit 4.2	**Recycled Content**, Specify 10% (post-consumer + ½ post-industrial)	X	X	X	X		X		X	X	X	
Credit 5.1	**Local/Regional Materials**, 20% Manufactured Locally	X	X	X		X	X	X	X	X	X	X
Credit 5.2	**Local/Regional Materials**, of 20% Above, 50% Harvested Locally	X	X	X					X	X	X	
Credit 6	**Rapidly Renewable Materials**						X					
Credit 7	**Certified Wood**		X	X	X					X		
	Indoor Environmental Quality											
Credit 1	**Carbon Dioxide** (CO_2) **Monitoring**		X	X			X	X				
Credit 2	**Ventilation Effectiveness**			X								X
Credit 3.1	**Construction IAQ Management Plan**, During Construction	X	X	X	X	X	X	X		X		
Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	X	X		X	X		X		X	X	
Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	X	X	X	X		X	X	X	X	X	X
Credit 4.2	**Low-Emitting Materials**, Paints	X	X	X	X		X	X		X		X
Credit 4.3	**Low-Emitting Materials**, Carpet	X	X	X	X		X	X	X	X	X	X
Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber		X		X		X			X		X
Credit 5	**Indoor Chemical & Pollutant Source Control**	X		X	X	X	X	X		X	X	
Credit 6.1	**Controllability of Systems**, Perimeter				X		X					X
Credit 6.2	**Controllability of Systems**, Non-Perimeter				X	X	X					X
Credit 7.1	**Thermal Comfort**, Comply with ASHRAE 55-1992	X		X	X		X		X		X	
Credit 7.2	**Thermal Comfort**, Permanent Monitoring System			X			X	X			X	
Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces		X	X	X		X		X			
Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	X	X	X	X		X		X		X	
	Innovation & Design Process											
Credit 1.1	**Innovation in Design**: Provide Specific Title		X	X	X	X	X	X	X	X	X	X
Credit 1.2	**Innovation in Design**: Provide Specific Title			X	X	X	X	X	X	X		X
Credit 1.3	**Innovation in Design**: Provide Specific Title			X	X	X			X			X
Credit 1.4	**Innovation in Design**: Provide Specific Title			X	X	X			X			
Credit 2	**LEED™ Accredited Professional**	X	X	X	X	X	X	X	X	X	X	X
	Total:	26	30	40	53	28	45	33	33	29	28	27

Average Points	34.6

* LEED™ Points Most Often Earned obtained from:
Hernando Miranda (Soltierra LLC), "Achieving 'Low Cost' LEED Projects", *HPAC Engineering Magazine,* April 2005.

Determining Weight Factors

Desired Performance Categories	Construction Cost	Minimize Impact to the Community	Operation / Maintenance Cost	Health of Occupants	Occupant Productivity	Accessible to the Community	Minimize Negative Environmental Impact	Sum	Weight	
Construction Cost		1	1	1	1	1	1	6	28.57%	Construction Cost
Minimize Impact to the Community	0		0	0	0	0	0	0	0.00%	Minimize Impact to the Community
Operation / Maintenance Cost	0	1		1	1	1	1	5	23.81%	Operation / Maintenance Cost
Health of Occupants	0	1	0		0	0	0	1	4.76%	Health of Occupants
Occupant Productivity	0	1	0	1		0	0	2	9.52%	Occupant Productivity
Accessible to the Community	0	1	0	1	1		0	3	14.29%	Accessible to the Community
Minimize Negative Environmental Impacts	0	1	0	1	1	1		4	19.05%	Minimize Negative Environmental Impacts
							Total	21	100.00%	

Instructions:

1. For each cell above the shaded cells, determine if the desired performance category in the left hand column is preferred vs. the category in the upper row.
2. If left hand column category is preferred enter "1"
3. If the upper row category is preferred enter "0"
DO NOT MODIFY SHADED CELLS
4. The inflection will appear on the lower half of the matrix
5. When the upper half of the matrix is complete the summation of each category will be calculated and appropriate weights assigned.
6. The total sum (J:10) should equal 21 and total weight (K:10) should equal 100.00%
7. Upon completion of this spreadsheet, notice which categories are most heavily weighted.
Refer to the page marked "Definitions" for a description of each item and a list of related points that could be pursued as a result of your preferred categories.

Note: The above example places greatest weighting on "Construction Cost" and "Operation and Maintenance Cost" which is denoted by the 1's across the board for these rows.

* *This spreadsheet was constructed to be used as a tool for determining potential LEED® points for a project during the early planning phases. The actual LEED® points that are to be pursued should ultimately be determined by the project planning team, and not solely by this tool, as there are many more LEED® points that are not mentioned within this spreadsheet.*

Goal Definitions and Related LEED® Points	
Construction Cost	This category pertains to owners who are under a strict construction budget or who want to obtain low cost LEED® Points. The following points have been determined to be among the least expensive and/or least difficult to attain from a study conducted by Hernando Miranda (Soltierra LLC). This study can bee seen in the article "Achieving 'Low Cost' LEED® Projects", HPAC Engineering Magazine, April 2005. These points were also achieved in over 90% of the projects interviewed for this research.
Related LEED® Points	
	1.) LEED® Accredited Professional
	2.) Local/Regional Materials, 20% Manufactured Locally
	3.) Low-Emitting Materials, Carpet
	4.) Recycled Content, Specify 5% (post-consumer + ½ post-industrial)
	5.) Optimize Energy Performance 20% New / 10% Existing (2)
	6.) Site Selection
	7.) Low-Emitting Materials, Adhesives & Sealants
	8.) Alternative Transportation, Bicycle Storage & Changing Rooms
Minimize Impact to the Community	This category pertains to owners who wish to minimize their building's impact to the community. This involves such measures as maintaining the original site layout, the original building appearance (through façade re-use), and reducing the disturbance to neighboring buildings.
Related LEED® Points	
	1.) Site Selection
	2.) Reduced Site Disturbance, Protect or Restore Open Space
	3.) Reduced Site Disturbance, Development Footprint
	4.) Landscape & Exterior Design to Reduce Heat Islands, Non-Roof
	5.) Landscape & Exterior Design to Reduce Heat Islands, Roof
	6.) Light Pollution Reduction
	7.) Low-Emitting Materials, Adhesives & Sealants
	8.) Building Reuse, Maintain 75% of Existing Shell
	9.) Building Reuse, Maintain 100% of Shell
	10.) Building Reuse, Maintain 100% Shell & 50% Non-Shell
Operation / Maintenance Cost	This category is important to owners who wish to minimize operation and maintenance costs throughout the life of the building. Operation and maintenance costs account for roughly 5-10% of the building's life cycle costs. Minimizing these costs involves lower energy and water consumption as well as possessing efficient HVAC systems. Typically owners who planed on occupying the building held interest in this category.
Related LEED® Points	
	1.) Water Use Reduction, 20% Reduction
	2.) Water Use Reduction, 30% Reduction
	3.) Optimize Energy Performance 20% New / 10% Existing (2)
	4.) Optimize Energy Performance 30% New / 20% Existing (2)
	5.) Optimize Energy Performance 40% New / 30% Existing (2)
	6.) Optimize Energy Performance 50% New / 40% Existing (2)
	7.) Optimize Energy Performance 60% New / 50% Existing (2)
	8.) Renewable Energy, 5%
	9.) Renewable Energy, 10%
	10.) Renewable Energy, 20%
	11.) Controllability of Systems, Perimeter
	12.) Controllability of Systems, Non-Perimeter
	13.) Thermal Comfort, Permanent Monitoring System
	14.) Landscape & Exterior Design to Reduce Heat Islands, Roof
Health of Occupants	This category applies to owners who are concerned about the health of the occupants of the building. Typically, this involves minimizing indoor pollutants and maintaining a clean indoor air environment. Owners whose occupants included children, the elderly, and the sick would have this initial goal of a healthy indoor environment.
Related LEED® Points	
	1.) Additional Commissioning
	2.) Carbon Dioxide (CO_2) **Monitoring**
	3.) Ventilation Effectiveness

	4.) Construction IAQ Management Plan, During Construction
	5.) Construction IAQ Management Plan, Before Occupancy
	6.) Low-Emitting Materials, Adhesives & Sealants
	7.) Low-Emitting Materials, Paints
	8.) Low-Emitting Materials, Carpet
	9.) Low-Emitting Materials, Composite Wood & Agrifiber
	10.) Indoor Chemical & Pollutant Source Control
	11.) Controllability of Systems, Perimeter
	12.) Controllability of Systems, Non-Perimeter
	13.) Thermal Comfort, Comply with ASHRAE 55-1992
	14.) Thermal Comfort, Permanent Monitoring System
Occupant Productivity	This category pertains to owners who are conscience about their personnel costs and productivity throughout the life of the building. According to a study conducted by the National Institute of Standards and Technology (NIST), personnel costs account for roughly 92% of the building's total life cycle costs. Improving occupant productivity through a comfortable indoor environment has been proven to reduce these costs. Typically owners who occupy an office or operate a business are interested in this category.
Related LEED® Points	
	1.) Indoor Chemical & Pollutant Source Control
	2.) Controllability of Systems, Perimeter
	3.) Controllability of Systems, Non-Perimeter
	4.) Thermal Comfort, Comply with ASHRAE 55-1992
	5.) Thermal Comfort, Permanent Monitoring System
	6.) Daylight & Views, Daylight 75% of Spaces
	7.) Daylight & Views, Views for 90% of Spaces
Accessible to the Community	This category is of interest to owners who wish to have their building easily accessible from the surrounding community. Owners who expressed interest in this category built projects such as community centers, office buildings, schools, and public buildings.
Related LEED® Points	
	1.) Development Density
	2.) Alternative Transportation, Public Transportation Access
	3.) Alternative Transportation, Bicycle Storage & Changing Rooms
	4.) Alternative Transportation, Alternative Fuel Vehicles
	5.) Alternative Transportation, Parking Capacity and Carpooling
Minimize Negative Environmental Impacts	This category involves minimizing negative environmental impacts throughout the construction of a project via reduction of waste, pollution, and disturbances to the building's surroundings. Owners who frequently had this goal for their project included government buildings, park services, and environmental agencies.
Related LEED® Points	
	1.) Site Selection
	2.) Brownfield Redevelopment
	3.) Reduced Site Disturbance, Protect or Restore Open Space
	4.) Reduced Site Disturbance, Development Footprint
	5.) Landscape & Exterior Design to Reduce Heat Islands, Non-Roof
	6.) Landscape & Exterior Design to Reduce Heat Islands, Roof
	7.) Light Pollution Reduction
	8.) Green Power
	9.) Construction Waste Management, Divert 50%
	10.) Construction Waste Management, Divert 75%
	11.) Recycled Content, Specify 5% (post-consumer + ½ post-industrial)
	12.) Recycled Content, Specify 10% (post-consumer + ½ post-industrial)
	13.) Rapidly Renewable Materials

Conclusions

LEED® (Leadership in Energy and Environmental Design®) is a rating system that building owners can opt to pursue when constructing a new facility. Constructing a LEED® rated building not only minimizes the environmental impact, it has also been proven to save the owner roughly ten times the initial investment over the life of the building[2].

As mentioned before, despite the initial goal and investment for a certain level of LEED® Certification, the Columbia Heights Community Center is finding it very difficult to maintain that level and achieve each point throughout the construction process. This situation is not uncommon in the building industry. The purpose for this analysis was to combat this issue by providing a tool that could be used during the project planning phase to help identify potential LEED® points. Using this tool upfront will invoke thought and discussion, increasing the amount of planning. This tool was assembled by comparing owners' goals with the LEED® points that they achieved on their project. A total of ten projects were interviewed and analyzed. Their points were also compared to the "Most Achievable" LEED® points to see how many did and did not match. It was found that two projects deviated significantly more than the rest, which could be contributed to the facts that they were not required to go Green, and that they looked to obtain points that would serve a more functional purpose for their projects.

Overall, this was an interesting topic to research. It is a timely issue within the construction industry. It is certain that the information obtained form this analysis can help future LEED® rated projects. Unfortunately, since this tool was just built, it has not yet been tested in a real setting. In order to determine its effectiveness, it would have to be applied to several projects and then upon their completion, its success would have to be analyzed. This study would have to be carried out over a number of years. However, a study like this could ultimately improve this tool, increasing its chance for success and helping projects maintain their level of LEED®.

[2] Hernando Miranda (Soltierra LLC), "Achieving 'Low Cost' LEED Projects", *HPAC Engineering Magazine*, April 2005.

Analysis 2

Precast Architectural Brick façade in lieu of Norman Bricks on South Wall

Problem

The south wall of the Columbia Heights Community Center runs parallel to the adjacent apartment complex at a distance of roughly 10'-0" away (see Site Plan in Existing Conditions Report). Approximately 1/4 of the south wall lies directly alongside the complex. The close proximity of the apartment restricts any deliveries of material to this wall from the south, and the east is restricted by the existing park. Space is very limited for material staging and most of it will be located within the building footprint. In this configuration, bricks will have to be fed to the masons from the inside, decreasing production.

Goal

The goal of this analysis is to see if replacing the bricks with Architectural Precast Brick Panels can reduce the construction time, labor costs, and the amount of wasted material. The analysis will focus on impacts to cost, schedule, and quality. Also, since the panels are prefabricated in a factory, material waste is generally less. This analysis will look at this issue as well.

Methodology

1. Determine the quantity of brick to be replaced by the panels.
2. Select an Architectural Precast Brick Panel to replace the brick.
3. Contact the panel manufacturer to determine costs and typical erection times.
4. Compare cost and duration to those in estimating tools (R.S. Means).
5. Analyze the impact on the structural system.
6. Compare costs, durations, and material amounts between the existing brick façade and the proposed panel system.
7. Analyze the impact on mechanical loads through a heat-loss analysis.
8. Assemble the data.

Tools

1. The Blue Book of Construction (http://www.thebluebook.com/)
2. R.S. Means 2006 Edition
3. Penn State Architectural Engineering faculty
4. Smith-Midland™ Precast Manufacturer
5. 1997 ASHRAE Handbook of Fundamentals

Outcome

After research into solid precast panels, it was decided that ordinary architectural brick panels would cost and weigh significantly more than the existing brick. Further research led to the discovery of the Slenderwall® System (see *image* below) by the manufacturer Smith-Midland™. The Slenderwall® System is comprised of architectural precast concrete (reinforced with hot-dipped galvanized welded wire), insulated Nelson® anchors (THERMAGUARD™), and heavy gauge galvanized or stainless steel framing backup. It is much lighter and less expensive than the traditional solid precast panels.

After a full analysis that addressed the impacts to cost, schedule, structural loads, and mechanical loads, the Slenderwall® is viewed to be better than the original brick face in all categories except cost. The sections on the following pages will give a detailed view of each analysis and their outcomes.

Cost Impacts

Precast assemblies have a higher initial cost, which is associated with the manufacturing of the panels offsite. This higher cost is somewhat offset by the erection speeds and the reduction in the schedule. In this case, the Slenderwall® initially costs roughly 41% more than the original brick façade. Please see *"Table 1 – Cost Comparison"* below for the quantities and costs of each system. Any assumptions are italicized below each chart.

Table 1 - Cost Comparison

Item	Dimension	Quantity (SF)	Unit Material Cost ($/SF)	Total Material Cost	Unit Labor Cost ($/SF)	Total Labor Cost	Total Unit Cost ($/SF)	Total Cost
Norman Brick (to be removed)	110'x52'	5720	$5.25	$30,030.00	$8.55	$48,906.00	$13.80	**$78,936.00**
						x D.C. Location Factor (.97)		
						+ 5% Waste Factor		
						+ 5% Productivity Factor		
						Total Cost:		**$84,416.13**

** Prices taken from R.S. Means 2006 Assembly Estimate*

*** Price includes brick, bonding materials, backer rods, control joints, sealers, shelf angles, and flashing*

**** Assume 5% Waste Factor*

***** Assume 5% Productivity Factor due to brick placement methods - see the "Problem" section of Analysis 2*

****** Assume no Time Modification Factor since construction is in currently in progress*

Panel Takeoff		
Item	**Dimension**	**Quantity**
First Floor	12'-8" height	110 LF
Second / Third Floor	27'-0" height	110 LF
Fourth Floor / Roof	12'-4" height	110 LF

** Precast Slenderwall® Paneling (6" Thick)*

Panel Size (b x h)	Panel Type	Quantity	Square Feet	Cost / SF	Total Cost
10'-0" x 39'-8"	A	11	4363.33	$25.00	$109,083.34
10'-0" x 12'-4"	B	11	1356.66	$25.00	$33,916.58
					$142,999.92

** Panel A to be from Grade to top elevation of 4th Floor Deck*

*** Panel B to be from top elevation of 4th Floor Deck to Roof coping elevation*

**** Price per SF - direct quote from manufacturer to be from $22/sf - $33/sf. Price here was used due to simple façade*

Price Difference:	**40.97%** ↑

Schedule

As stated previously, precast assemblies are quicker to install than traditional face-brick. After consulting R.S. Means 2006 and Smith-Midland™, unit rates for the assembly of each system was determined. When entered into the equation, it was found that the Slenderwall® System was almost 14 days less than the brick on the south wall. That is over two weeks saved in the construction schedule, which is a significant gain. This would account for a General Conditions savings of roughly $21,000 (see *Tech Report 2* for General Conditions costs). A trade off for this advantage would be the amount of lead time. Talks with the manufacturer revealed that the typical lead time for the Slenderwall® System is 6 weeks for shop drawings and 6-8 weeks for fabrication. Therefore, increased planning upfront will be needed to coordinate the fabrication and delivery of this system. The erection of the Slenderwall® Panels is expected to be done concurrently with the steel framing in that area, so as not to extend the crane's reach any more than was planned. Erecting the panels during this time will give the construction team over four months to coordinate the delivery of the paneling, which is more than required. Please see *"Table 2 – Schedule Comparison"* below for the full results and assumptions.

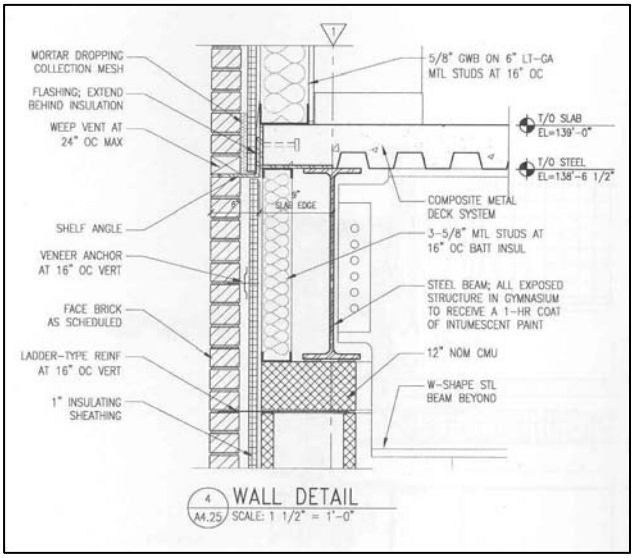
Table 2 - Schedule Comparison

Item	Quantity	Man Hours / Quantity	Total Hours	Total Days
Brick	5720 SF	0.125	715	15.0
Slenderwall® Panels	22 Panels	0.5	11	1.4
			Difference:	**13.6 ↓**

** As per Slenderwall® manufacturer, productivity is 15-20 panels per day.*
*** Assume 16 panels per day since structural connection is simple*
**** Assume 8 hour work days*
***** Brick productivity rate taken from R.S. Means 2006*
****** Existing brick crew is 6 Masons - total time will be divided by 6*

Structural Impacts

The original 5,720 square foot brick system was designed to be supported by a shelf angle which was welded to another steel angle that served as the pour stop for the slab on metal deck (see *Wall Detail* - left). The entire brick system weighed roughly 228,800 lbs. The Slenderwall® System is supported by a connection plate that is welded to the steel angle pour stop and braced by a connection plate welded to the bottom of a steel beam (see *Typical Spandrel* detail – below right). These connection plates are to be bolted to the stainless steel framing, which is spaced at 16" O.C.



This bolted assembly allows the building frame to move independently of the exterior skin, isolating it from loads associated with expansion and contraction. The Slenderwall® System was found to weigh 30% less than the brick at approximately 160,160 lbs. Despite the fact that the brick is supported along a continuous shelf angle, the many point loads from the 16" O.C. Slenderwall® connection plates could be treated as a distributed load. Taking this approach, the Slenderwall® has no negative impact on the structural system. When considering wind loads, the Slenderwall® is designed to handle loads outlined in the LRFD Manual, and it is still attached to the steel frame at the same location as the brick. Therefore, no impacts to wind loading is seen. Please see *"Table 3 – Structural Impacts"* on the following page for a summary of the structural data. The table *"Table 4 – Crane Impact"* is also included on the following page to show that there are no impacts to the crane size.

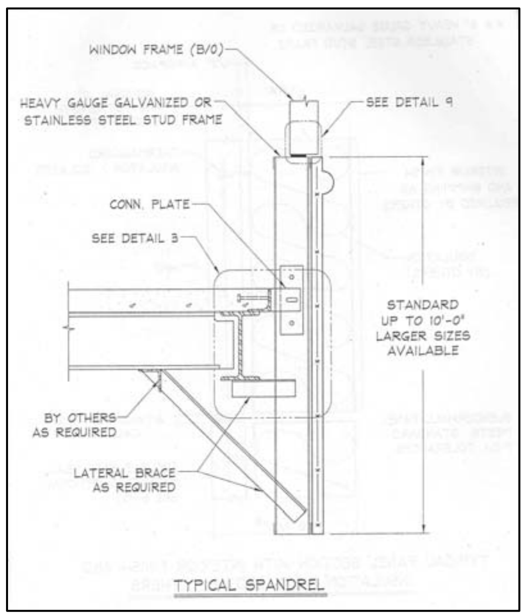


Table 3 - Structural Impact

Item	Quantity (SF)	Weight / SF (lbs./sf)	Total Weight (lbs.)
Brick	5720	40	228,800.00
Slenderwall® Panels	5720	28	160,160.00
		% Difference:	**30% ↓**

** Assume Brick weight 120 lbs./cf → 40 lbs./sf since brick is 4" thick*

*** Panel weight taken from manufacturer's specifications*

Table 4 - Crane Impact

Item	Square Feet	Weight / SF (lbs./sf)	Total Weight (tons)
10'-0" x 39'-8" Panel	396.67	28	5.55

** Panel weight taken from manufacturer's specifications*

*** Panel above is the largest and heaviest panel*

**** Maximum crane load is 80 tons*
***** Crane Manufacturer specifications show a 5.5 ton lift with 115'-0" boom and 90'-0" radius (Grove® TMS900E Crane)*

Mechanical Impacts

Impacts to the mechanical loads were analyzed by viewing the impacts to the insulation values of each wall system. In this analysis, the R-Values were compared from the exterior face of each system to the interior face of the CMU blocks. Each system would still include the interior 12" CMU's. The original brick assembly included a 4" thick face brick, 1" air space, and 1" thick extruded polystyrene rigid insulation. The Slenderwall® System includes a 2" thick architectural concrete layer, ½" air space, and 6" steel frame supports filled with fiberglass batt insulation. Obtaining typical material R-Values from the *1997 ASHRAE Handbook of Fundamentals,* it is seen that the Slenderwall® will reduce heat loss and gain. Impacts to the mechanical system itself will be mainly visible in the gymnasium, since this area is heated by a constant air volume supply, and will be seen as a reduction in the demand for heating and cooling. This could result in lower energy costs, adding to the LEED® aspect of Columbia Heights. "*Table 5 – System R-Values*" (below) outlines each system's insulation values.

TABLE 5 – SYSTEM R-VALUES

System	Item	Thickness (in.)	R-Value	Total R-Value	
Brick Assembly					
	Outside Air Film	∞	0.17 / unit	0.17	
	Norman Brick	4.0	0.8 / thickness	0.8	
	Air space	1.0	1.0 / unit	1	
	Rigid Insulation Sheathing*	1.0	5.0 / inch	5	
	CMU 12" Nom	12.0	1.28 / thickness	1.23	
	Inside Air Film	∞	0.68 / unit	0.68	
			Total R-Value	**8.71**	hr-sf-F/BTU
			U-Value	**0.115**	BTU/hr-sf-F
Slenderwall®					
	Outside Air Film	∞	0.17 / unit	0.17	
	Concrete Face	2.0	0.8 / inch	1.6	
	Air space	0.5	1.0 / unit	1	
	Fiberglass Batt Insulation	6.0	13.0 / thickness	13	
	CMU 12" Nom	12.0	1.28 / thickness	1.23	
	Inside Air Film	∞	0.68 / unit	0.68	
			Total R-Value	**17.51**	hr-sf-F/BTU
			U-Value	**0.057**	BTU/hr-sf-F

** Rigid insulation to be Extruded Polystyrene Board*

*** R-Values taken from 1997 ASHRAE Handbook Fundamentals*

Mechanical Impacts (continued)

After obtaining the R-Values for each wall system, an analysis was performed to see the exact impacts to the building's mechanical loadings. As mentioned above, the area that will mainly be affected by this change is the gymnasium, since it is located on the south side of the building. Ultimately, this mechanical analysis will determine if the existing constant-air-volume AHU, that serves the gymnasium, can be downsized due to the increase in insulation value. Please see "*Table 6 – Mechanical Analysis*" on the following page for the calculations that were performed for this analysis.

Table 6 - Mechanical Analysis

Areas:		
Gymnasium Wall:	110'-0" x 27'-0"	2970 SF

Winter Temperature	
To	15 F
Ti	70 F
Δ T	55 F

Summer Temperature	
To	95 F
Ti	70 F
Δ T	25 F

** Temperatures taken from 1997 ASHRAE Handbook Fundamentals*

Heat-loss Winter				
Item	**U-Value**	**Area (sf)**	**Δ T (F)**	**Heat-loss (BTU/hr)**
Brick Assembly	0.144	2970	55	23522.40
Slenderwall®	0.057	2970	55	9310.95
			Difference:	**14211.45**
			Existing AHU	**218700**
		% Difference of Total AHU Load:		**6.50%**

Heat-gain Summer					
Item	**U-Value**	**Area (sf)**	**Delta T (F)**	**Heat-gain (BTU/hr)**	**Heat-gain (tons)**
Brick Assembly	0.144	2970	25	10692.00	0.89
Slenderwall®	0.057	2970	25	4232.25	0.35
			Difference:	**6459.75**	**0.54**
			Existing AHU		**20.04**
		% Difference of Total AHU Load:			**2.69%**

Mechanical Impacts (continued)

Despite that the Slenderwall® system increases the insulation value of the wall by more than 50%, it only reduces heat-loss in the winter by about 6.5% of the total AHU's heating volume. It also reduces heat-gain in the summer by a value that only makes up 2.69% of the air handler's cooling tonnage. These results show that even though the Slenderwall® has a positive affect, it still is not enough to reduce the size of the air handler unit.

Conclusion

When viewing all the results, the Slenderwall® System out-performs the original brick system in all categories except cost. The Slenderwall® System saves roughly 14 days on the schedule, it is lighter and does not impact the structural system or crane, and it reduces mechanical loads in the gymnasium. Since Slenderwall® is manufactured in a more controlled environment, it *does* reduce waste quantities, but the exact amount is hard to determine. This system also solves the initial problem of the congestion along the south wall: it does not require material staging areas and scaffolding.

When looking at the immediate cost impact, it may be hard to propose the switch from brick to the Slenderwall® System. The Slenderwall® panels cost roughly $58,500 more than the brick, which is roughly a 41% increase. But, if one looks at the entire project cost, the Slenderwall® accounts for an increase of only 0.65%. Also, this increase will be moderately offset by the savings in General Conditions costs.

Ultimately, using the Slenderwall® System to replace the Norman Brick along the south wall of the Columbia Heights Community Center would be very beneficial and should be pursued.

Analysis 3

Alternate structural systems to replace the large steel I-beams in the gymnasium

Problem

Structural steel members in the Columbia Heights Community Center gymnasium are extremely large. They span a distance of 60'-0" and receive loading from the open-plan office above as well as roof loads through transfer columns. The gymnasium is a two-story space and the average steel beam in this area is a W40x215x60'. These large members are very costly in terms of material and also require a larger crane to set them in place.

Goal

The goal of this analysis is to see if this system can be replaced with an alternate system that can save costs through use of less material. The current system will be modeled in RAM Steel v 10.0 to determine if it can be reduced or even changed to an open-web steel joist system.

Methodology

1. Determine the building loads that the current steel members support.
2. Design alternate systems using these loads in RAM Steel v10.0 modeling software.
3. Analyze the systems' impacts to cost and schedule.
4. Perform comparison between the proposed systems.
5. Select best viable solution.

Tools

1. RAM Steel v10.0 modeling software
2. R.S. Means 2006 Edition
3. AISC - LRFD Manual of Steel Construction 3rd Edition
4. ASCE7 2005 Minimum Design Loads for Buildings
5. Canam Steel Corporation Joist Catalog
6. Penn State Architectural Engineering faculty

Outcome

Upon completion of the analysis and a tabulation of the results generated from the Ram Steel modeling software, it was determined that an open-web steel joist system will be less in price and save material (tonnage). In terms of erection speeds, the open-web joist system barely impacts the schedule, saving only a few minutes. Please see the following pages for the complete analysis including tables, loading diagrams, and layouts.

Building Load Determination

In order to enter the steel structure into the RAM modeling software, the buildings existing loading must be determined. Using a combination of the structural specifications for Columbia Heights Community Center and the ASCE7 2005 Minimum Design Loads for Buildings manual, the worst case scenario loadings were determined. On a few occasions, the structural specifications called for higher loads than the ASCE7 manual. When this occurred, the heavier load was used. Please see "*Table 1 – Building Loads*" on the following page for all the loads that were considered when redesigning the steel structure in the gymnasium.

Table 1 - Building Loads

Snow

(roof slope 1/4" / 12")

	C_e	C_t	I	p_g (psf)	p_f (psf)
0.7	0.9	1.0	1.1	25.0	**17.33**
	**Fully Exposed*		**Category III*		
	***Category B*				

**Quantities and calculation method taken from ASCE7-05(Ch.7)*

*** Use 30psf per drawing S 1.00*

Dead Loads

Component	***Load (psf)***
Roof	
PVC Roofing Membrane (single ply)	0.7
Polyisocyanurate Board Insulation (glass-fiber)	1.1
Skylight Metal Frame	8.0
Steel Deck (20 gage)	2.5
Concrete slab on deck (lightweight 3" thick)	50.0
Green Roof*	50.0
Miscellaneous	0.7
Ceiling System (4th Floor)	
Acoustical Fiberboard	1.0
Mechanical Allowance	4.0
Total:	**118.0**
Floor System (4th Floor)	
Carpet Tile	2.0
Steel Deck (18 gage)	3.0
Concrete slab on deck (lightweight 3" thick)	50.0
Ceiling System (Gymnasium)	
Mechanical Allowance	4.0
Total:	**57.0**

** Per drawing S 1.00*

**Quantities and calculation method taken from ASCE7-05(Ch.3)*

Live Loads

Component	***Load (psf)***
Fourth Floor	
Open Office / corridor	**80.0**

**Quantities and calculation method taken from ASCE7-05(Ch.4)*

System Design

Once these building loads were identified, they were then entered into the RAM Steel v10.0 Modeling Software. Only the gymnasium ceiling (4th floor system) and the roof system were entered into the modeling software, along with their loadings, since these are the only systems that will affect the area of redesign. Initially, the existing members at their spacing of 6'-6" were looked at. Surprisingly, the RAM modeling software yielded results that show the existing large members, W40x215x60', reduced to W30x90x60'. This was unexpected considering the loadings determined in the previous section encompassed all known loads, both in the structural specifications and in the ASCE7 manual. Ultimately, the RAM software produced a system that was almost 50% lighter and would save around $86,000.

After this analysis, a test was then run to determine if open-web steel joists could be used. In order for this type of system to work, the typical spacing had to be adjusted from the original 6'-6" to 4'-0" on center. Having done this, the RAM software was able to design a system with a standard joist of 44LH09 and a special joist of 44LH15 to handle the transfer columns. All joists are to have diagonal bridging, with a minimum angle size of 1-1/4, r=.25" (per *Table 2.5.2 Maximum Joist Spacing for Diagonal Bridging* in the *Canam Steel Corporation Joist Catalog*). This resulting open-web joist system was found to weigh approximately 10% less than the original system and cost about $35,000 less.

On the following page, you will see "*Table 2 – System Comparison Sheet*", which gives a complete breakdown of each system and a summary comparison. On the pages following this table, you will find a floor plan for the original system, reduced steel system, and the open-web joist system. Also, you will find all calculations and loading models used to design the open-web joist system.

Table 2 - System Comparison Sheet

Original Steel System

Item	Number	Total Length (ft.)	Tons	Material $ / Ton	Total Material $	Labor $ / Ton	Total Labor $	Equipment $ / Ton	Total Equipment $	Total Cost	Daily Output (L.F. / day)	Total Work Days
Beams			**Tons**									
W 12x30	5	60.00	0.90	2550.00	$2,295	360.00	$324	169.00	$152	$2,771	810	0.074
W 14x22	20	144.00	1.58	2550.00	$4,039	360.00	$570	169.00	$268	$4,877	990	0.145
W 24x55	3	30.00	0.83	2550.00	$2,104	360.00	$297	169.00	$139	$2,540	1100	0.027
W 24x62	19	760.00	23.56	2550.00	$60,078	360.00	$8,482	169.00	$3,982	$72,541	1100	0.691
W 36x182	1	60.00	5.46	2550.00	$13,923	360.00	$1,966	169.00	$923	$16,811	1125	0.053
W 40x183	1	60.00	5.49	2550.00	$14,000	360.00	$1,976	169.00	$928	$16,904	1025	0.059
W 40x199	2	120.00	11.94	2550.00	$30,447	360.00	$4,298	169.00	$2,018	$36,763	1025	0.117
W 40x215	2	120.00	12.90	2550.00	$32,895	360.00	$4,644	169.00	$2,180	$39,719	1025	0.117
Total	**53**	**1354.00**	**62.66**		**$159,780**		**$22,557**		**$10,589**	**$192,927**		**1.284**

Reduced Steel System

Item	Number	Total Length (ft.)	Tons	Material $ / Ton	Total Material $	Labor $ / Ton	Total Labor $	Equipment $ / Ton	Total Equipment $	Total Cost	Daily Output (L.F. / day)	Total Work Days
Beams			**Tons**									
W 8x10	25	184.00	0.92	2550.00	$2,346	360.00	$331	169.00	$155	$2,833	810	0.227
W 10x12	2	20.00	0.12	2550.00	$306	360.00	$43	169.00	$20	$369	810	0.025
W 12x16	1	10.00	0.08	2550.00	$204	360.00	$29	169.00	$14	$246	810	0.012
W 16x26	4	80.00	1.04	2550.00	$2,652	360.00	$374	169.00	$176	$3,202	810	0.099
W 16x31	1	20.00	0.31	2550.00	$791	360.00	$112	169.00	$52	$954	810	0.025
W 18x35	3	60.00	1.05	2550.00	$2,678	360.00	$378	169.00	$177	$3,233	990	0.061
W 21x44	2	80.00	1.76	2550.00	$4,488	360.00	$634	169.00	$297	$5,419	990	0.081
W 21x50	1	60.00	1.50	2550.00	$3,825	360.00	$540	169.00	$254	$4,619	990	0.061
W 24x55	8	480.00	13.20	2550.00	$33,660	360.00	$4,752	169.00	$2,231	$40,643	1100	0.436
W 27x84	4	240.00	10.08	2550.00	$25,704	360.00	$3,629	169.00	$1,704	$31,036	1125	0.213
W 30x90	2	120.00	5.40	2550.00	$13,770	360.00	$1,944	169.00	$913	$16,627	1025	0.117
Total	**53**	**1354.00**	**34.54**		**$88,077**		**$12,434**		**$5,837**	**$106,349**		**1.129**

Proposed Steel Joist System

Item	Number	Total Length (ft.)	Tons	Material $ / L.F.	Total Material $	Labor $ / L.F.	Total Labor $	Equipment $ / L.F.	Total Equipment $	Total Cost	Daily Output	Total Work Days
Steel Joists												
44LH15	6	358.50	6.45	28.50	$10,217.25	1.36	$487.56	0.68	$243.78	$10,948.59	2200	0.163
44LH09	18	1075.50	10.22	14.85	$15,971.18	1.36	$1,462.68	0.68	$731.34	$18,165.20	2200	0.489
Beams				**Material $ / Ton**		**Labor $ / Ton**						
W 8x10	10	100.00	3.80	2550.00	$9,690	360.00	$1,368	169.00	$642	$11,700	600	0.167
W 12x19	4	80.00	0.61	2550.00	$1,556	360.00	$220	169.00	$103	$1,878	880	0.091
W 14x22	1	20.00	16.61	2550.00	$42,356	360.00	$5,980	169.00	$2,807	$51,142	990	0.020
W 16x26	3	60.00	2.50	2550.00	$6,375	360.00	$900	169.00	$423	$7,698	1000	0.060
W 16x31	1	20.00	1.43	2550.00	$3,647	360.00	$515	169.00	$242	$4,403	900	0.022
W 18x35	1	60.00	17.15	2550.00	$43,733	360.00	$6,174	169.00	$2,898	$52,805	960	0.063
Total	**44**	**1774.00**	**58.77**		**$133,543.43**		**$17,106.24**		**$8,090.02**	**$158,739.69**		**1.074**

System Comparison Summary

Item	Number	Total Length (ft.)	Tons	Total Material $	Total Labor $	Total Equipment $	Total Cost	Total Work Days
Original Steel System	53	1354.00	62.66	$159,780.45	$22,557.24	$10,589.37	$192,927.06	1.284
Reduced Steel System	53	1354.00	34.54	$88,077.00	$12,434.40	$5,837.26	$106,348.66	1.129
Proposed Steel Joist System	44	1774.00	58.77	$133,543.43	$17,106.24	$8,090.02	$158,739.69	1.074

** Costs and daily output taken from R.S. Means 2006*

*** Systems only include the area of redesign, the gymnasium ceiling structure, Columns 1-4 and E.5 - M.*

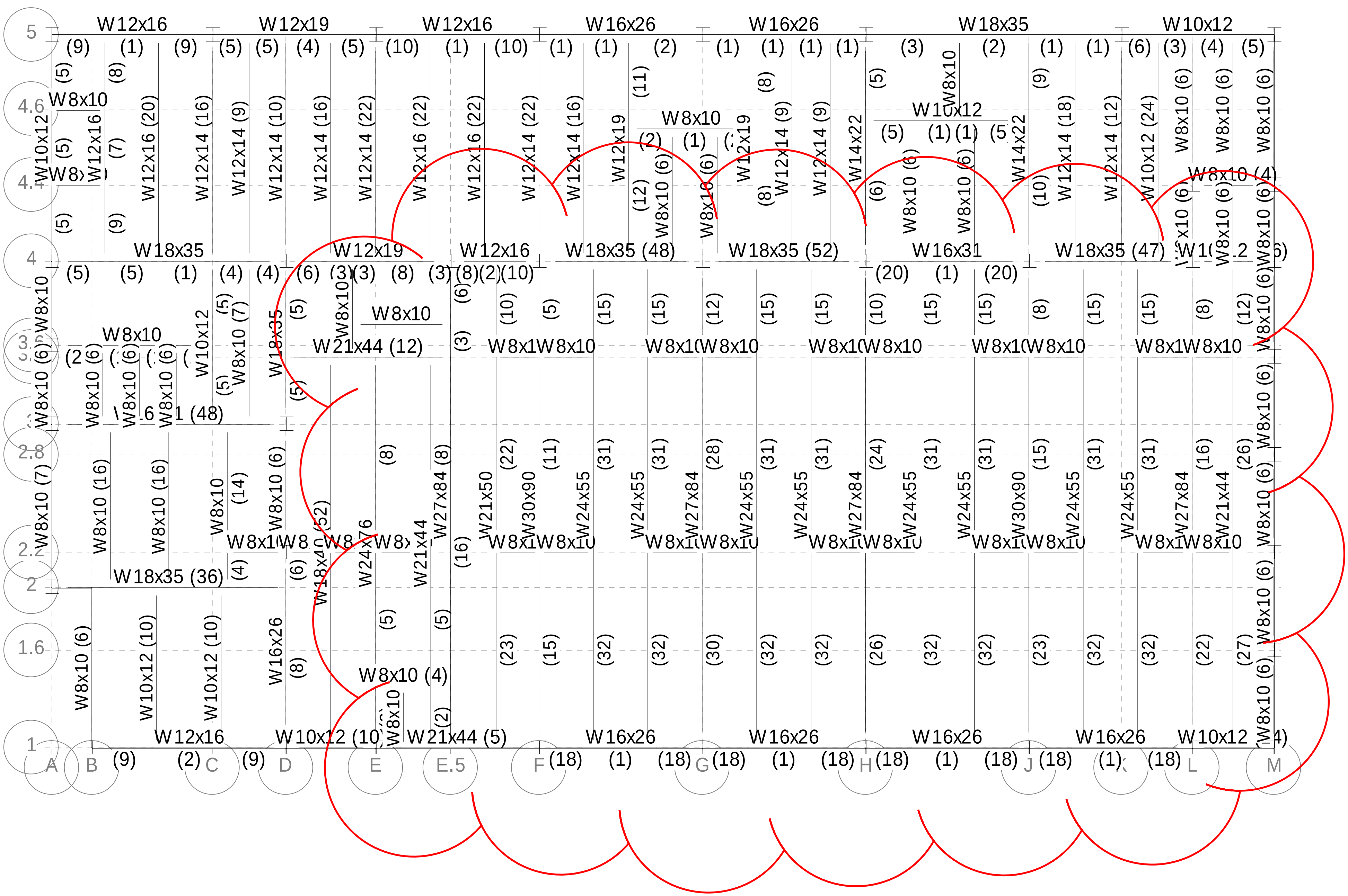
1 S1.04 FOURTH FLOOR FRAMING PLAN
SCALE: 1/8"=1'-0"

Reduced Steel Floor Map

RAM Steel v10.0
DataBase: glinski thesis existing
Building Code: IBC

03/22/06 21:27:43
Steel Code: ASD 9th Ed.

Floor Type: FOURTH

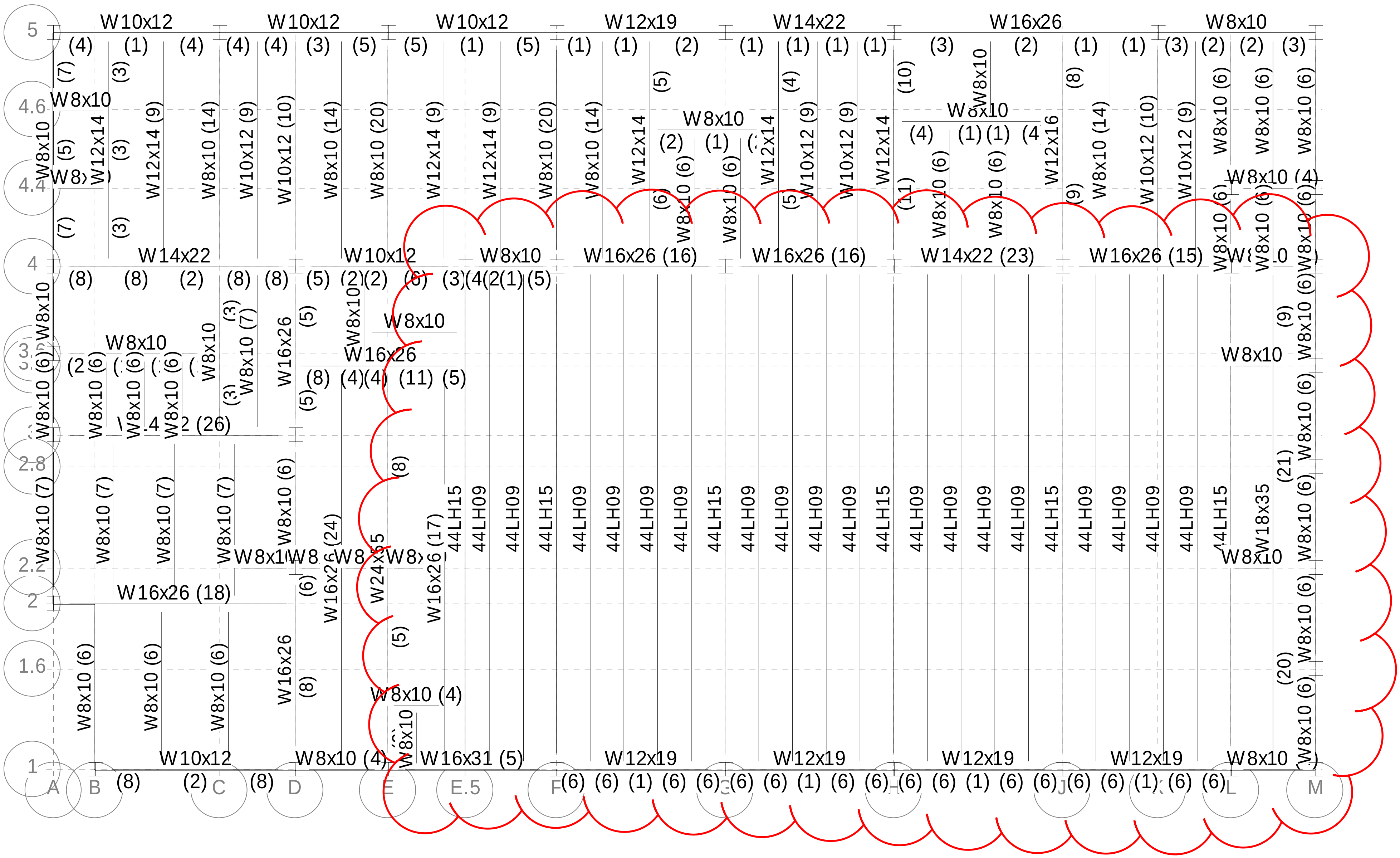


Open-web Joist Floor Map

RAM Steel v10.0
DataBase: glinski thesis proposed
Building Code: IBC

03/22/06 21:25:40
Steel Code: ASD 9th Ed.

Floor Type: FOURTH



Gravity Beam Design Takeoff

RAM Steel v10.0
DataBase: glinski thesis proposed 03/22/06 21:25:40
Building Code: IBC Steel Code: ASD 9th Ed.

STEEL BEAM DESIGN TAKEOFF:

Floor Type: ROOF
Story Level 2
Steel Grade: 50

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W8X10	144	2526.26	25445
W10X12	7	143.91	1734
W12X14	4	88.00	1246
W12X16	4	103.00	1651
W8X18	1	24.00	430
W12X19	1	31.33	594
W14X22	4	110.25	2435
	-----		-------------
	165		**33533**

Total Number of Studs = **897**

Floor Type: FOURTH
Story Level 1
Steel Grade: 50

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W8X10	59	870.09	8764
W10X12	11	270.16	3254
W12X14	7	194.25	2750
W12X16	1	27.75	445
W12X19	5	100.00	1895
W14X22	4	97.50	2153
W16X26	10	280.24	7324
W16X31	1	20.00	621
W18X35	1	59.75	2094
W24X55	1	48.00	2662
	-----		-------------
	100		**31962**

Total Number of Studs = **1010**

TOTAL STRUCTURE GRAVITY BEAM TAKEOFF

Steel Grade: 50

Gravity Beam Design Takeoff

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
W8X10	203	3396.35	34209
W10X12	18	414.07	4988
W12X14	11	282.25	3995
W12X16	5	130.75	2096
W8X18	1	24.00	430
W12X19	6	131.33	2489
W14X22	8	207.75	4588
W16X26	10	280.24	7324
W16X31	1	20.00	621
W18X35	1	59.75	2094
W24X55	1	48.00	2662
	-----		-------------
	265		**65496**

Total Number of Studs = **1907**

Gravity Beam Design Takeoff

JOIST SELECTION TAKEOFF:

Floor Type: FOURTH
Story Level 1

Standard Joists:

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
44LH09	18	1075.50	20435
	-----		-------------
	18		**20435**

Special Joists:

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
44LH15	6	358.50	12906

	6		

TOTAL STRUCTURE JOIST SELECTION TAKEOFF

Standard Joists:

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
44LH09	18	1075.50	20435
	-----		-------------
	18		**20435**

Special Joists:

SIZE	#	LENGTH (ft)	WEIGHT (lbs)
44LH15	6	359	12906

	6		

Special Joist Selection

RAM Steel v10.0
DataBase: glinski thesis proposed 03/22/06 21:25:40
Building Code: IBC

Floor Type: FOURTH **Beam Number = 39**

SPAN INFORMATION (ft): I-End (59.75,0.00) J-End (59.75,59.75)

Joist Size (User Selected) = 44LH15
Total Beam Length (ft) = 59.75

POINT LOADS (kips):

Dist	DL	RedLL	Red%	NonRLL	StorLL	Red%	RoofLL	Red%
24.000	14.24							
48.000	14.61							

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.140	0.200	6.4%	Red
	59.750	0.140	0.200		
2	0.000	0.000	0.000	---	NonR
	59.750	0.000	0.000		

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	413.8	24.0

REACTIONS (kips):

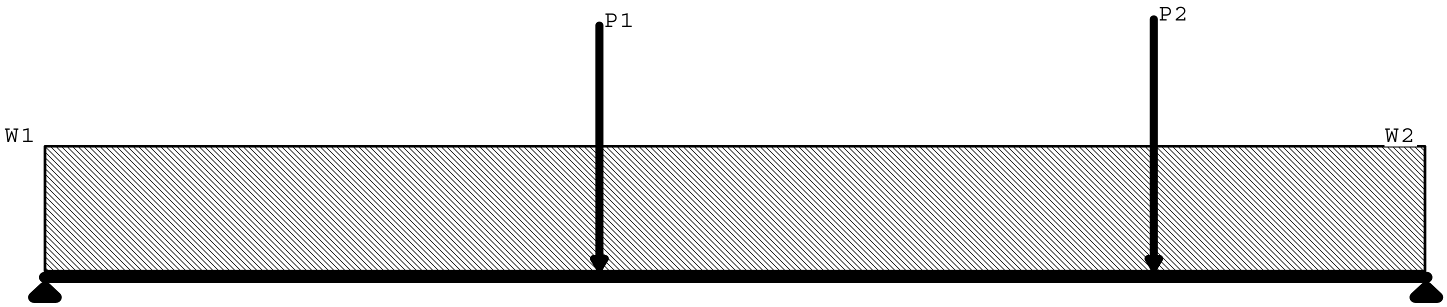
	Left	**Right**
DL reaction	15.57	21.64
Max +LL reaction	5.59	5.59
Max +total reaction	21.17	27.23

Load Diagram

RAM Steel v10.0
DataBase: glinski thesis proposed
Building Code: IBC

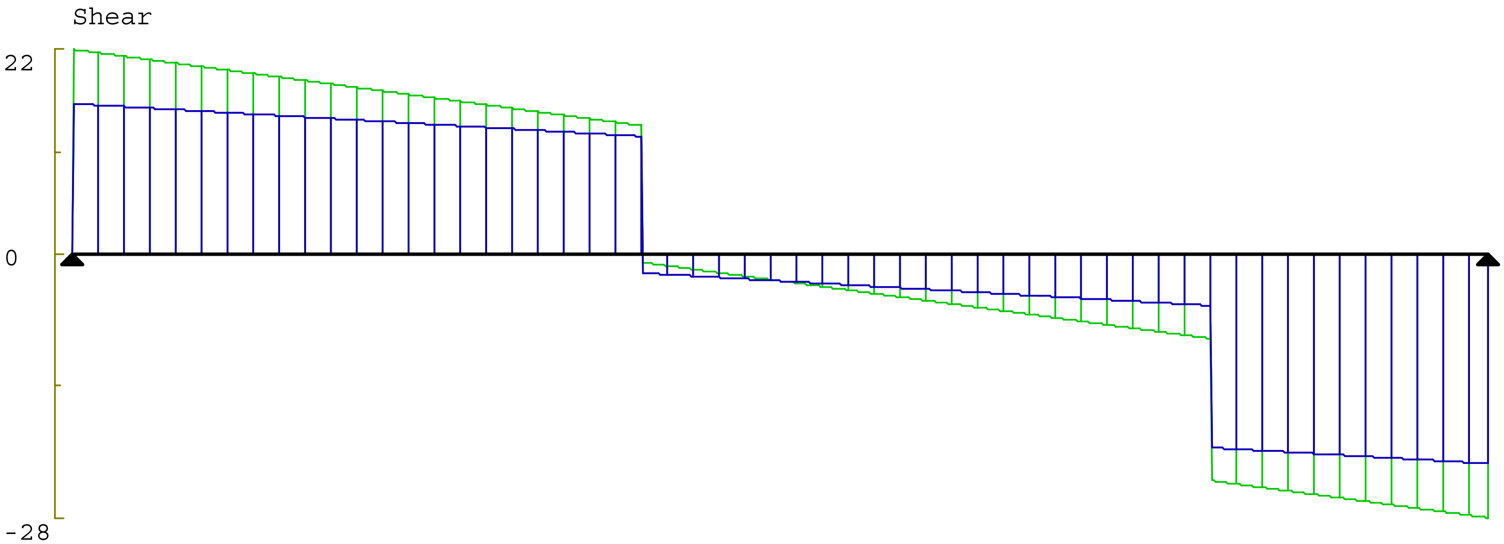
03/22/06 21:25:40

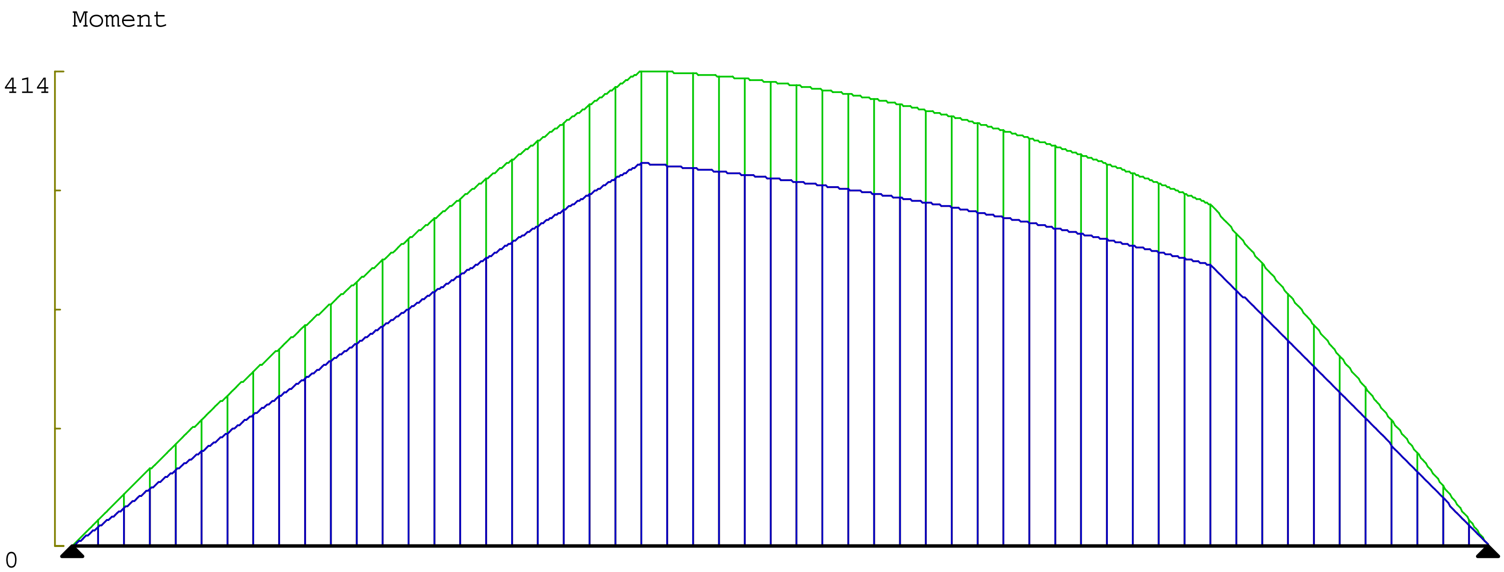
Floor Type: FOURTH **Beam Number = 39**
Span information (ft): I-End (59.75,0.00) J-End (59.75,59.75)



Load	Dist	DL	LL+	LL-	Max Tot
	ft	kips	kips	kips	kips
P1	24.000	14.240	0.000	0.000	14.240
P2	48.000	14.607	0.000	0.000	14.607
	ft	k/ft	k/ft	k/ft	k/ft
W1	0.000	0.140	0.187	0.000	0.327
W2	59.750	0.140	0.187	0.000	0.327

Ram Steel v10.0 Shear, Moment, and Deflection Diagrams
DataBase: glinski thesis proposed   03/22/06 21:25:40
Building Code: IBC
Floor Type: FOURTH   Beam Number = 39
Span information (ft):   I-End (59.75,0.00)   J-End (59.75,59.75)





Max DL Shear = 21.64 kips
Max Shear = 27.23 kips

Max Pos Moment = 413.79 kip-ft   at 24.000 ft

Standard Joist Selection

RAM Steel v10.0
DataBase: glinski thesis proposed
Building Code: IBC

03/22/06 21:25:40

Floor Type: FOURTH **Beam Number = 172**

SPAN INFORMATION (ft): I-End (63.75,0.00) J-End (63.75,59.75)

Joist Size (User Selected) = 44LH09
Total Beam Length (ft) = 59.75

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type
1	0.000	0.140	0.200	6.4%	Red
	59.750	0.140	0.200		
2	0.000	0.000	0.000	---	NonR
	59.750	0.000	0.000		

Maximum Total Unif. Load at any location (lbs/ft) : 327.2

Allowable Stress Ratio: 1.00

	Design Loads	Allowable Loads (lbs/ft)
Dead:	140.0	
Live:	187.2	240.4
Total:	327.2	334.6

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	146.0	29.9

REACTIONS (kips):

	Left	**Right**
DL reaction	4.18	4.18
Max +LL reaction	5.59	5.59
Max +total reaction	9.78	9.78

DEFLECTIONS:

Dead load (in)	=	1.160	L/D	=	618
Live load (in)	=	1.551	L/D	=	462
Total load (in)	=	2.711	L/D	=	264

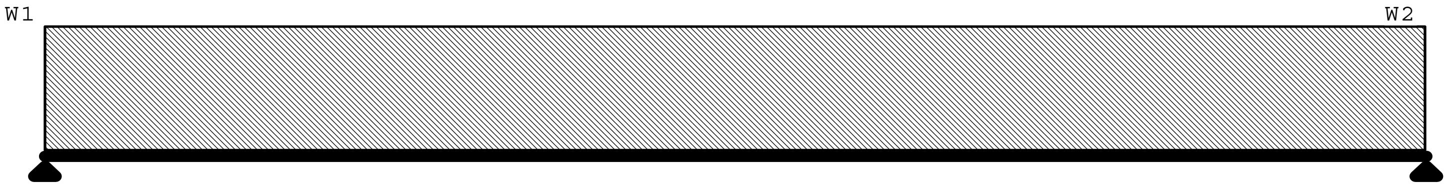
Load Diagram

RAM Steel v10.0
DataBase: glinski thesis proposed
Building Code: IBC

03/22/06 21:25:40

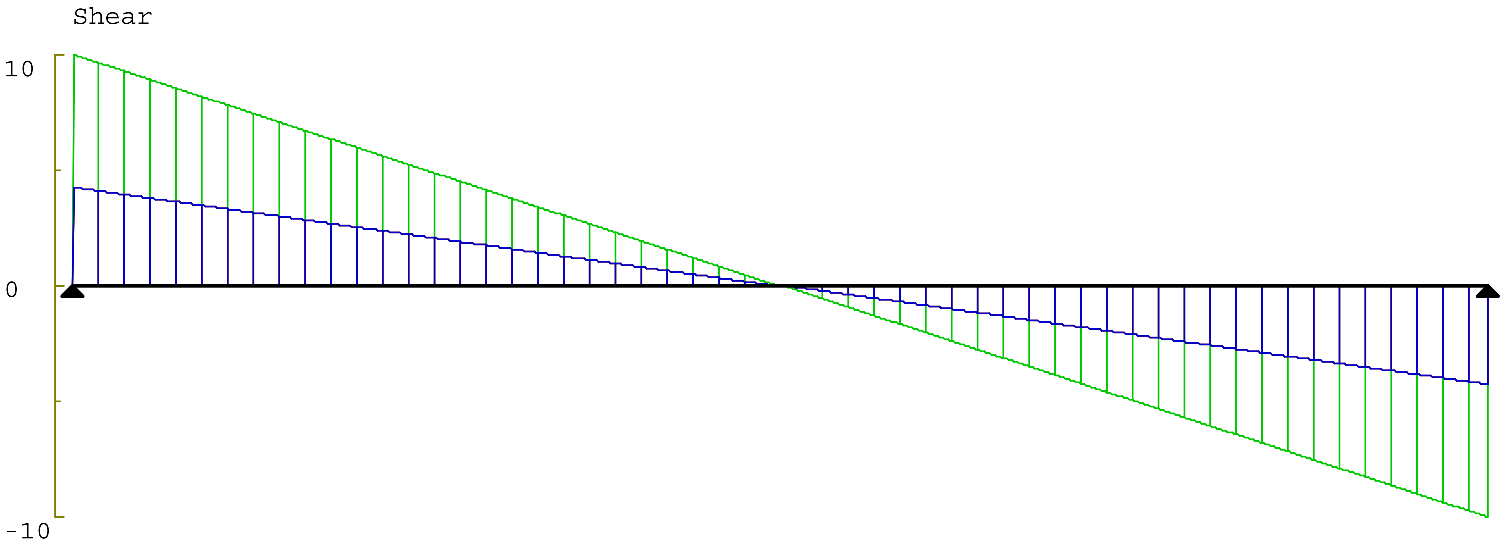
Floor Type: FOURTH **Beam Number = 172**

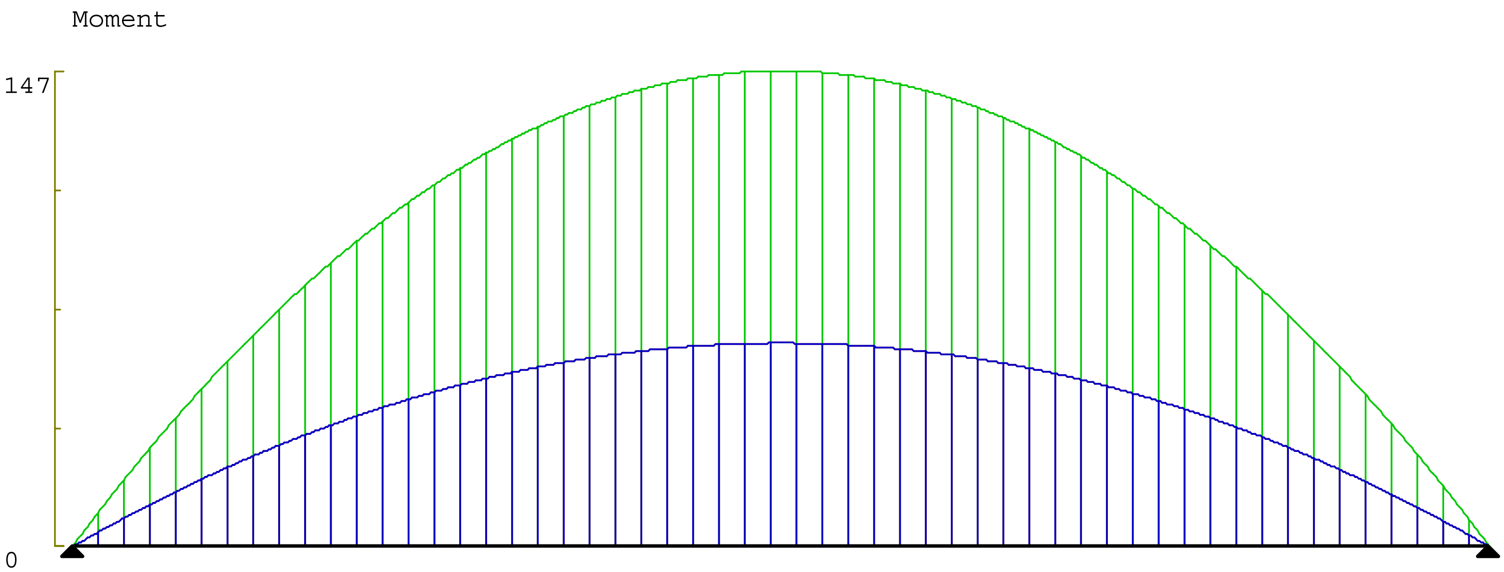
Span information (ft): I-End (63.75,0.00) J-End (63.75,59.75)



Load	Dist	DL	LL+	LL-	Max Tot
	ft	k/ft	k/ft	k/ft	k/ft
W1	0.000	0.140	0.187	0.000	0.327
W2	59.750	0.140	0.187	0.000	0.327

Ram Steel v10.0 Shear, Moment, and Deflection Diagrams
DataBase: glinski thesis proposed 03/22/06 21:25:40
Building Code: IBC
Floor Type: FOURTH Beam Number = 172
Span information (ft): I-End (63.75,0.00) J-End (63.75,59.75)





Max DL Shear = 4.18 kips
Max Shear = 9.78 kips

Max Pos Moment = 146.02 kip-ft at 29.875 ft

Conclusion

Overall, the RAM Steel software was extremely helpful for redesigning the steel system in the gymnasium. After determining all the building loadings and entering that information into the RAM model, it was determined that the steel system could be reduced (still incorporating steel I-beams), or it could be changed to open-web steel joists. Each system would reduce the amount of steel material in Columbia Heights Community Center, which would yet again support the building's LEED® aspect. Along with the savings of material, costs would also be reduced. The reduced system would save approximately $85,000 while the open-web joists would save roughly $35,000. Each option would only affect the schedule by a few minutes, and thus, this should be considered negligible.

Ultimately, the option of open-web joists should be pursued. Despite the fact that it does not reduce costs and material tonnage as much as the reduced steel system, it is a more solid system that is known to handle the loads. The results from the RAM model that produced the reduced steel system were unexpected. The structural engineer must have included some extra loading in order to obtain the large sized members. Using the open-web steel joists will maximize the ceiling space in the gymnasium since the ducts could pass between the open-webs. It would also be a safer choice that would still reduce costs and material amounts.

Analysis 4

Alternate method for placement of the building foundation

Problem

Originally, the general contractor proposed that the entire footprint be excavated to the bottom elevation of the foundation system and then forming will be used for the pour. After the concrete pour, the footings will be stripped and then the area will be backfilled with structural fill and stone. This method (bulk excavation) not only involves more soil to be removed, it also requires more fill.

Goal

The goal of this analysis is to see if pouring the foundation system into excavated pits can reduce labor costs, schedule, and the amount of material used. This method of placement (trench excavation) eliminates the need for forming and reduces the amount of material removed and the amount of fill.

Methodology

1. Determine the quantities of soil to be removed for each placement method (trench vs. bulk).
2. Estimate the forming costs and labor productivity.
3. Assess the change in demand for the excavator.
4. Compare the material costs, labor costs, and activity durations.

Tools

1. R.S. Means 2006 Edition
2. Penn State Architectural Engineering faculty
3. Forrester Construction Company – General Contractor

Outcome

After performing a detailed cost and schedule analysis, it has been determined that the trench excavation method for placing the foundation system is more efficient. The trench excavation method costs less and is faster than the bulk excavation method because it does not require as much material to be removed. This reduction of material can further support the LEED® aspect of Columbia Heights. The following pages will give a detailed view of each analysis and their results.

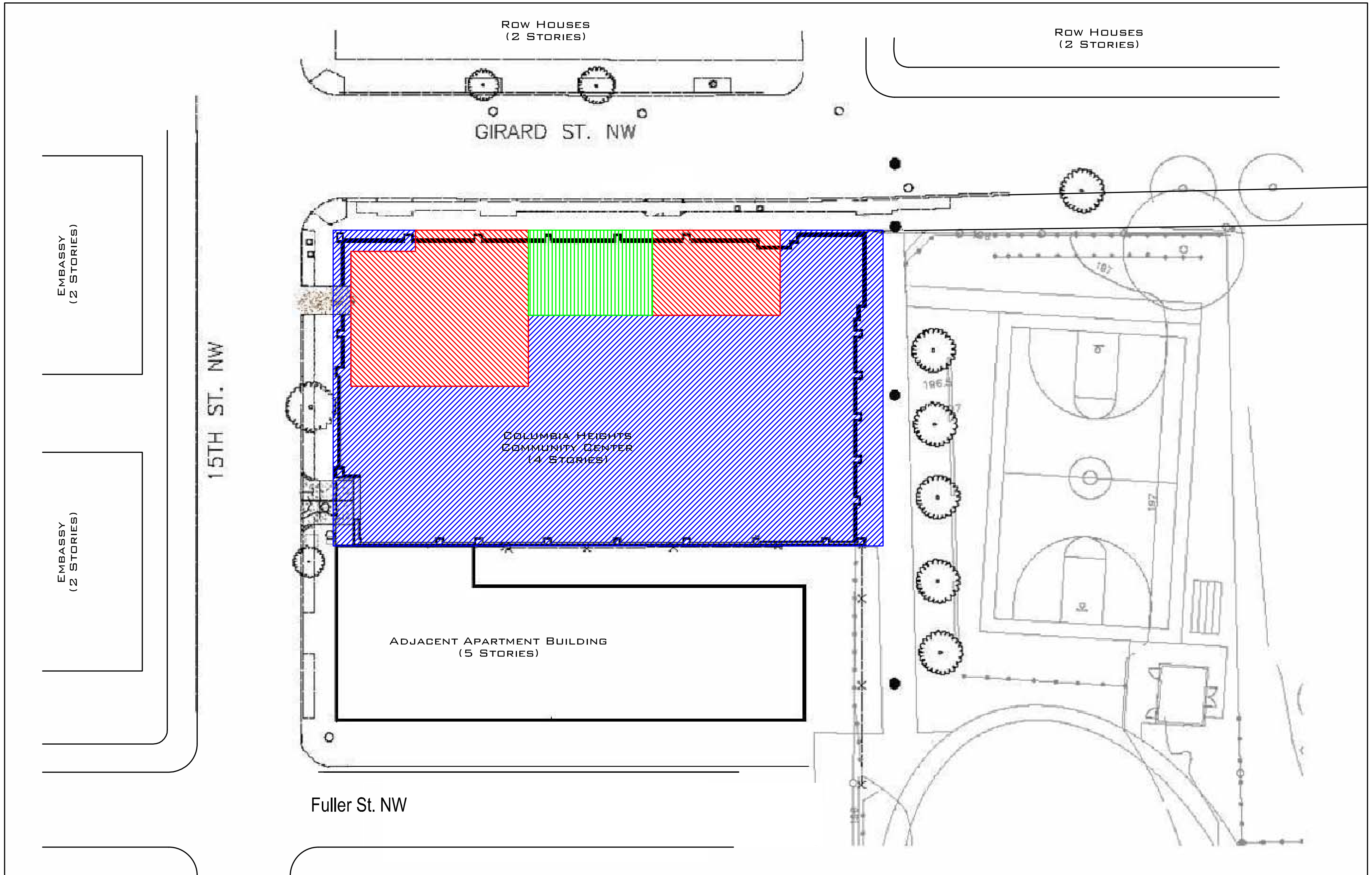
Cost Impacts

In order to perform this analysis, quantities of soils to be removed were taken from the structural foundation plans. For both the trench and bulk method, it was assumed that the excavation would be performed until the bottom elevation of the footing. The difference between this elevation and the grade elevation of 100'-0" would provide the depth of excavation needed. Using this depth, the trench excavation method used the width of each foundation to produce the total quantity of soil. The bulk excavation quantity was determined by using the average depth of three different areas, which can be viewed on the following page (*Excavation Depth Plan*). Please see *"Table 1 – Cost Difference Summary"* below for an overview of the results.

Table 1 – Cost Difference Summary

Item	Trench Excavation	Bulk Excavation	Difference
Material (BCY)	967.09	2620.93	**1653.84**
Material (LCY)	1063.80	2883.02	**1819.22**
Total Costs	$27,893.91	$120,317.59	**$92,423.68**

As it can be seen, the difference in material to be removed is significant. The bulk excavation method quantity is nearly triple that of the trench method. This is what accounts for the large difference in cost. The costs seen above include all excavation, removal, and forming costs. Concrete placement costs were not analyzed because they will not change between the trench and bulk methods, concrete will still be pumped to the location of the footing. By using the trench placement method, it will have a savings of roughly 77%. The exact quantities of soil to be removed, costs, and the assumptions for each method can be found in "*Table2 –Excavation Estimate*" on the page following the "*Excavation Depth Plan*".



Legend:

Grade at El. 100'-0"

Area 1 (Bottom El. 96'-0")

Area 2 (Bottom El. 93'-0")

Area 3 (Bottom El. 88'-0")

EXCAVATION DEPTH PLAN		
Scale: 1/32" = 1'-0"	Approved By:	Revised:
Date: 02/27/2006		
For: Columbia Heights Community Center		
Drawn By: Christopher Glinski		Drawing Number: C-1

Table 2 - Excavation Estimate

Excavation of Footings Only (Trench)

Item	Length (ft.)	Quantity	Depth to bottom ftg. elev. (ft.)	Volume Soil (BCY)	Volume Soil (LCY)	Material Removal ($ / LCY)	Total Material Removal ($)	Labor ($ / BCY)	Total Labor ($)	Equipment ($ / BCY)	Total Equipment ($)	Total Cost ($)
Column Footings/ Grade Beams												
6' W x 2' Thick (98'-0")	355	1.00	4.00	315.56	347.11	$23.73	$8,236.95	$1.31	$413.38	$1.40	$441.78	$9,092.10
6' W x 2' Thick (97'-0")	18	1.00	5.00	20.00	22.00	$23.73	$522.06	$1.31	$26.20	$1.40	$28.00	$576.26
6' W x 2' Thick (95'-0")	33	1.00	7.00	51.33	56.47	$23.73	$1,339.95	$1.31	$67.25	$1.40	$71.87	$1,479.07
6' W x 2' Thick (94'-0")	8	1.00	8.00	14.22	15.64	$23.73	$371.24	$1.31	$18.63	$1.40	$19.91	$409.78
6' W x 2' Thick (92'-0")	17	1.00	10.00	37.78	41.56	$23.73	$986.11	$1.46	$55.16	$1.56	$58.93	$1,100.20
6' W x 2' Thick (90'-0")	21	1.00	12.00	56.00	61.60	$23.73	$1,461.77	$1.46	$81.76	$1.56	$87.36	$1,630.89
10' x 10' x 2' Thick (98'-0")	--	3.00	4.00	44.44	48.89	$23.73	$1,160.13	$1.31	$58.22	$1.40	$62.22	$1,280.58
10' x 10' x 2' Thick (95'-0")	--	2.00	7.00	51.85	57.04	$23.73	$1,353.49	$1.31	$67.93	$1.40	$72.59	$1,494.01
9' x 9' x 2.5' Thick (98'-0")	--	1.00	4.50	13.50	14.85	$23.73	$352.39	$1.31	$17.69	$1.40	$18.90	$388.98
9' x 9' x 1.5' Thick (98'-0")	--	1.00	3.50	10.50	11.55	$23.73	$274.08	$1.31	$13.76	$1.40	$14.70	$302.54
5' x 5' x 2.5' Thick (98'-0")	--	3.00	4.50	12.50	13.75	$23.73	$326.29	$1.31	$16.38	$1.40	$17.50	$360.16
11' x 11' x 2' Thick (98'-0")	--	2.00	4.00	35.85	39.44	$23.73	$935.84	$1.31	$46.97	$1.40	$50.19	$1,033.00
6' x 6' x 1.5' Thick (98'-0")	--	5.00	3.50	23.33	25.67	$23.73	$609.07	$1.31	$30.57	$1.40	$32.67	$672.30
10' x 10' x 1.5' Thick (98'-0")	--	1.00	3.50	12.96	14.26	$23.73	$338.37	$1.31	$16.98	$1.40	$18.15	$373.50
Strap Beams												
4' W x 1.5' Thick (98'-0")	252	1.00	3.50	130.67	143.73	$23.73	$3,410.79	$1.31	$171.17	$1.40	$182.93	$3,764.90
4' W x 1.5' Thick (96'-0")	31	1.00	5.50	25.26	27.79	$23.73	$659.34	$1.31	$33.09	$1.40	$35.36	$727.80
4' W x 1.5' Thick (94'-0")	54	1.00	7.50	60.00	66.00	$23.73	$1,566.18	$1.31	$78.60	$1.40	$84.00	$1,728.78
Tie Beams												
4' W x 2.5' Thick (98'-0")	77	1.00	4.50	51.33	56.47	$23.73	$1,339.95	$1.31	$67.25	$1.40	$71.87	$1,479.07
			Total:	**967.09**	**1063.80**		**$25,244.02**		**$1,280.96**		**$1,368.93**	**$27,893.91**

**Grade is at elevation 100'-0"*
***Assume average swell factor to be 10%*
****Assume C.Y. of soil to be quantity excavated to bottom of footing elevation*
***** Assume equipment is 1.0 C.Y. Backhoe*
****** Unit Rates for trench (footing) excavation taken from R.S. Means 2006. Price increased as depth increases.*
******* Material Removal cost is based on total hauling costs and fleet size determined below - (3) 6 C.Y. Dump Truck with 4 mile round trip (1.8 loads / hour)*

Excavation of Entire Site (Bulk)

Item	Area (sf)	Area Elevation	Depth (ft.)	Volume Soil (BCY)	Volume Soil (LCY)	Material ($ / Unit)	Total Material ($)	Labor ($ / Unit)	Total Labor ($)	Equipment ($ / Unit)	Total Equipment ($)	Total Cost ($)
Area 1	10000	96'-0"	4.00	1481.48	1629.63	$31.64	$51,561.48	$1.31	$1,940.74	$1.40	$2,074.07	$55,576.30
Area 2	2955	93'-0"	7.00	766.11	842.72	$31.64	$26,663.73	$1.31	$1,003.61	$1.40	$1,072.56	$28,739.89
Area 3	840	88'-0"	12.00	373.33	410.67	$31.64	$12,993.49	$1.46	$545.07	$1.56	$582.40	$14,120.96
			Total:	**2620.93**	**2883.02**		**$91,218.71**		**$3,489.41**		**$3,729.03**	**$98,437.15**

**Depth is based on Grade at elevation 100'-0"*
***Assume average swell factor to be 10%*
****Assume CY of soil to be quantity excavated to bottom of footing elevation*
***** Material Removal cost is based on total hauling costs and fleet size determined below - (4) 6 C.Y. Dump Truck with 4 mile round trip (1.8 loads / hour)*

Forming Costs

Item	Depth (ft.)	Contact Area (SF)	Material $ / Unit		Total Material $	Labor $ / Unit	Total Labor $	Total Cost
Column Footings / Grade Beams	Varies	3004.00	2.31		$6,939	2.76	$8,291	$15,230
Strap Beams	1.5'	1092.00	1.56		$1,704	3.02	$3,298	$5,001
Tie Beams	Varies	360.00	1.56		$562	3.02	$1,087	$1,649
							Total:	**$21,880**

**Grade is at elevation 100'-0"*
***Assume average swell factor to be 10%*
****Assume CY of soil to be quantity excavated to bottom of footing elevation*

Fleet Size per 6 C.Y. Load

Item	Equipment	Labor (hrs/BCY)	BCY/ Hr	LCY / hr	Dump Truck LCY/hr	Dump Trucks Needed
Trench Excavation	1 C.Y. Hydraulic Backhoe	0.040	25.00	27.50	10.8	3
Bulk Excavation	1 C.Y. Hydraulic Backhoe	0.027	37.04	40.74	10.8	4

** Based on 6 C.Y. Dump Truck with 4 mile round trip (1.8 loads / hour)*

Schedule and Excavator Demand Impact

The impact to schedule and excavator demand in this analysis are equal. On the Columbia Heights Community Center project, only one excavator was used for removal. After determining the difference in the quantities of soils removed for both excavation methods, it was seen that the trench excavation method was shorter, which contradicts the expected outcome that was noted in the proposal (see "Analysis 4 – Expected Outcome" in *Final Thesis Proposal*). It was expected that the trenching activity would take longer due to the intricate system of foundation members throughout the site. Even though the productivity rate for the trench method was less than that of the bulk method, the large difference in soil quantity was the main factor in the schedule difference. As seen below in *"Table 3 – Schedule / Excavator Demand Impact"*, the bulk method takes nearly twice as long as the trench method.

TABLE 3 - SCHEDULE / EXCAVATOR DEMAND IMPACT

Item	Equipment	Labor (hrs/BCY)	Total BCY	Total hrs	Total Days
Trench Excavation	1 C.Y. Hydraulic Backhoe	0.040	967.09	38.68	4.8
Bulk Excavation	1 C.Y. Hydraulic Backhoe	0.027	2620.93	70.77	8.8
			Difference:	**32.08**	**4**

**Assume 8 hour work day*

*** Productivity rates taken from R.S. Means 2006*

Conclusion

When viewing these results, it can be seen that the trench excavation foundation placement method is more efficient than the original proposed method of bulk excavation placement. It cuts costs associated with soil removal by roughly 77%.

Even though the trench placement method will take more planning and layout during the excavation phase, it is offset by the planning and layout needed during the forming activity in the bulk excavation placement method. Using the trench method decreases the activity duration and excavator demand by roughly 50%.

With all of these factors in mind, it is strongly recommended that the trench excavation foundation placement method be used in lieu of the original plan of bulk excavation. Not only does it cut costs and durations, it also reduces the amount of waste material, thus supporting Columbia Heights Community Center's LEED® aspect.

Summary and Conclusions

Greening buildings through the LEED® Point rating system is increasingly becoming popular in the construction industry. The Columbia Heights Community Center is a prime example as it is striving to achieve a Silver certification. The analyses found in this report all touch upon this "green", environmentally friendly trend.

The first analysis was geared towards determining common goals for achieving LEED®, and points that can be associated with them. Research was conducted to identify building owners' initial goals for how and why they wanted to achieve LEED®. A tool was then generated in Microsoft Excel® that allows owners to input weights to common goals and lists LEED® points that correspond to these goals. Also, this research confirmed several popular points that many projects achieved.

The second analysis looked to reduce waste quantities through a redesign of the brick façade. The exact quantity of waste saved was unable to be determined, but it is known that the selected system, Slenderwall® Architectural Precast Paneling, does reduce waste since it is assembled in a factory setting. Also determined in this analysis was that there was no impacts to the structural system and mechanical system (despite increasing the insulation value of the wall).

The third analysis was intended to determine whether the amount of steel could be reduced in the gymnasium. A common steel beam in this area is a W40x215x60'. A structural redesign, using the RAM Steel v10.0 modeling software, looked to reduce the member sizes. It was found that the system could be reduced (still incorporating I-beams) or it could be changed to open-web joists. Open-web joists were determined to be the best option because not only did they reduce the amount of steel, they also saved costs.

Finally, the fourth analysis included an evaluation of the foundation placement method, geared towards minimizing the amount of soil to be removed. The original plan was to perform a bulk excavation of the entire site to below the footing elevation and then use forms for placing the concrete. This analysis checked if it was feasible to just dig trenches and pour concrete directly into the trench, without the use of forms. It was determined that the trench method would not only save money and time, it would significantly reduce the amount of soil to be removed.

Appendix A

Site Plans

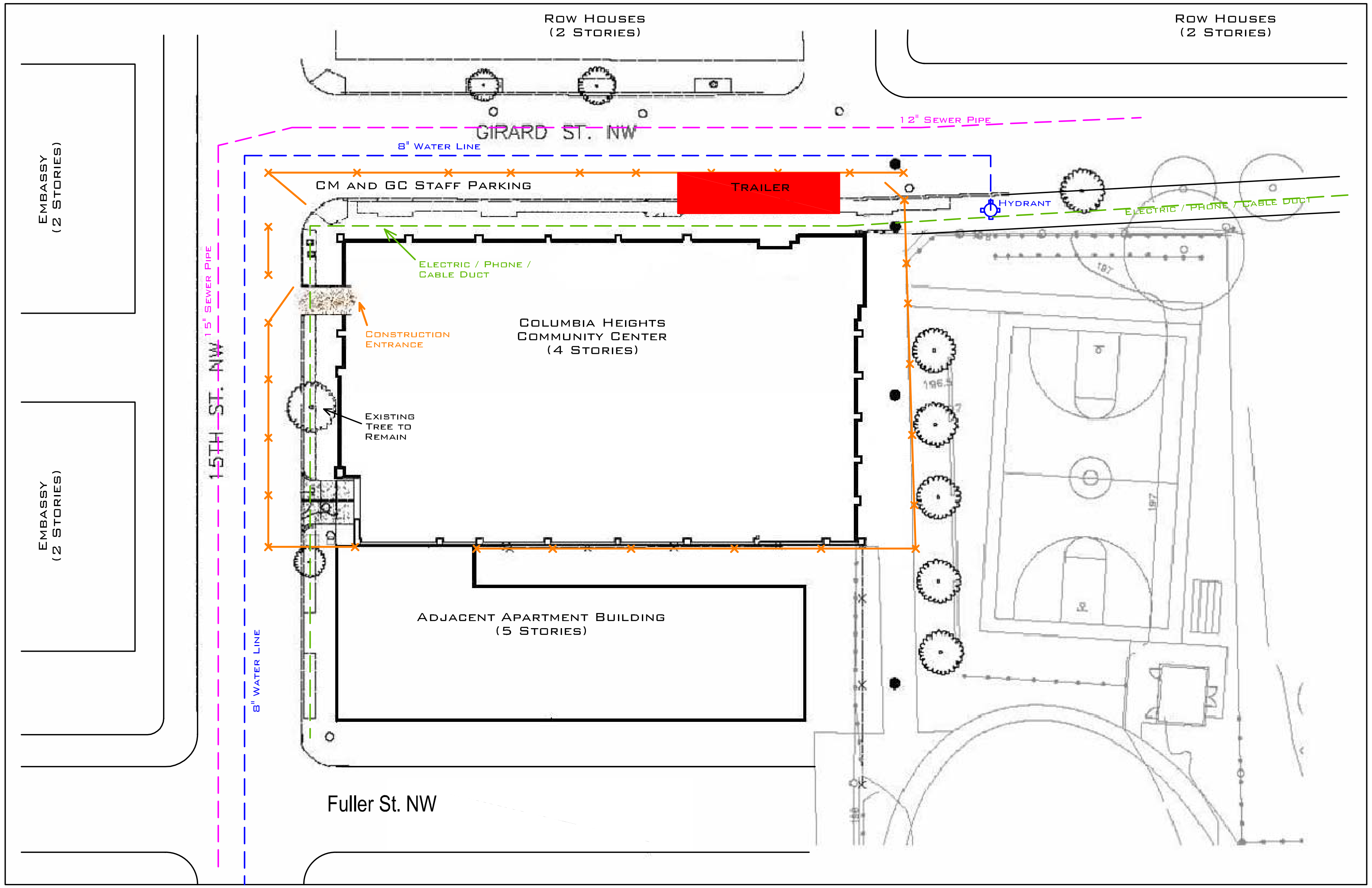
Existing Conditions Plan

Excavation Plan

Steel Phase 1 Plan

Steel Phase 2 Plan

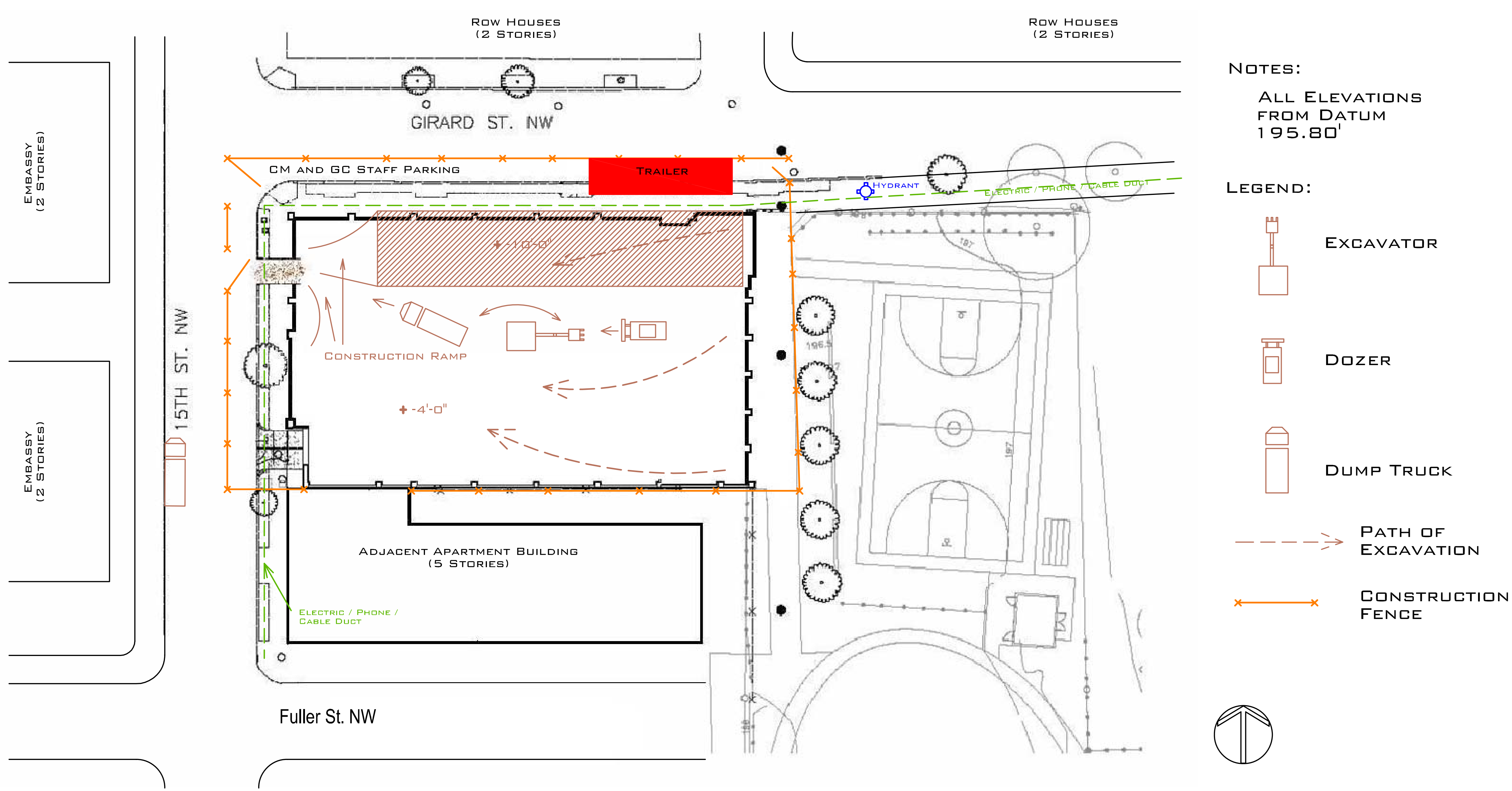
Steel Phase 3 Plan



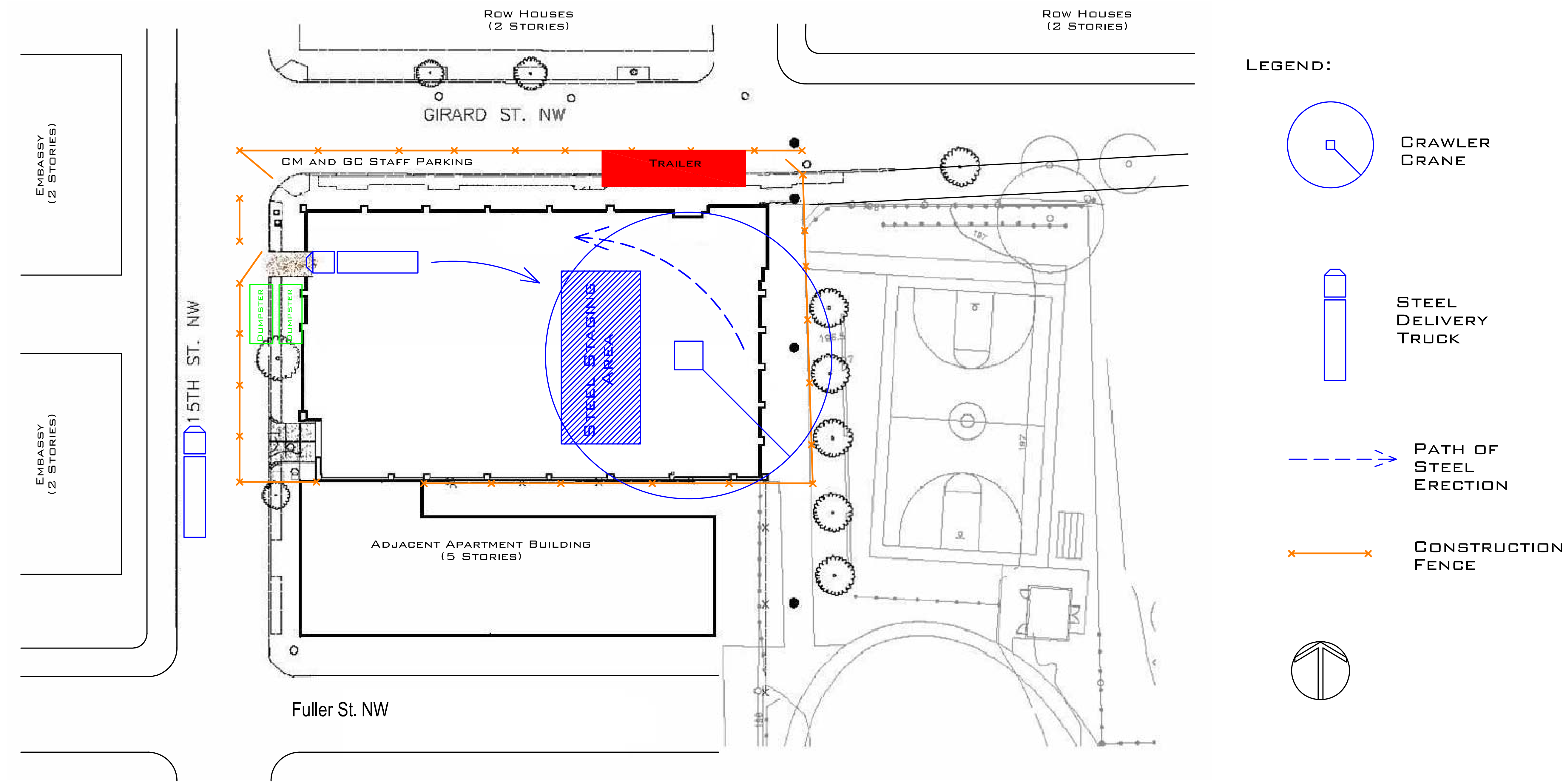
Legend:

Construction Fencing

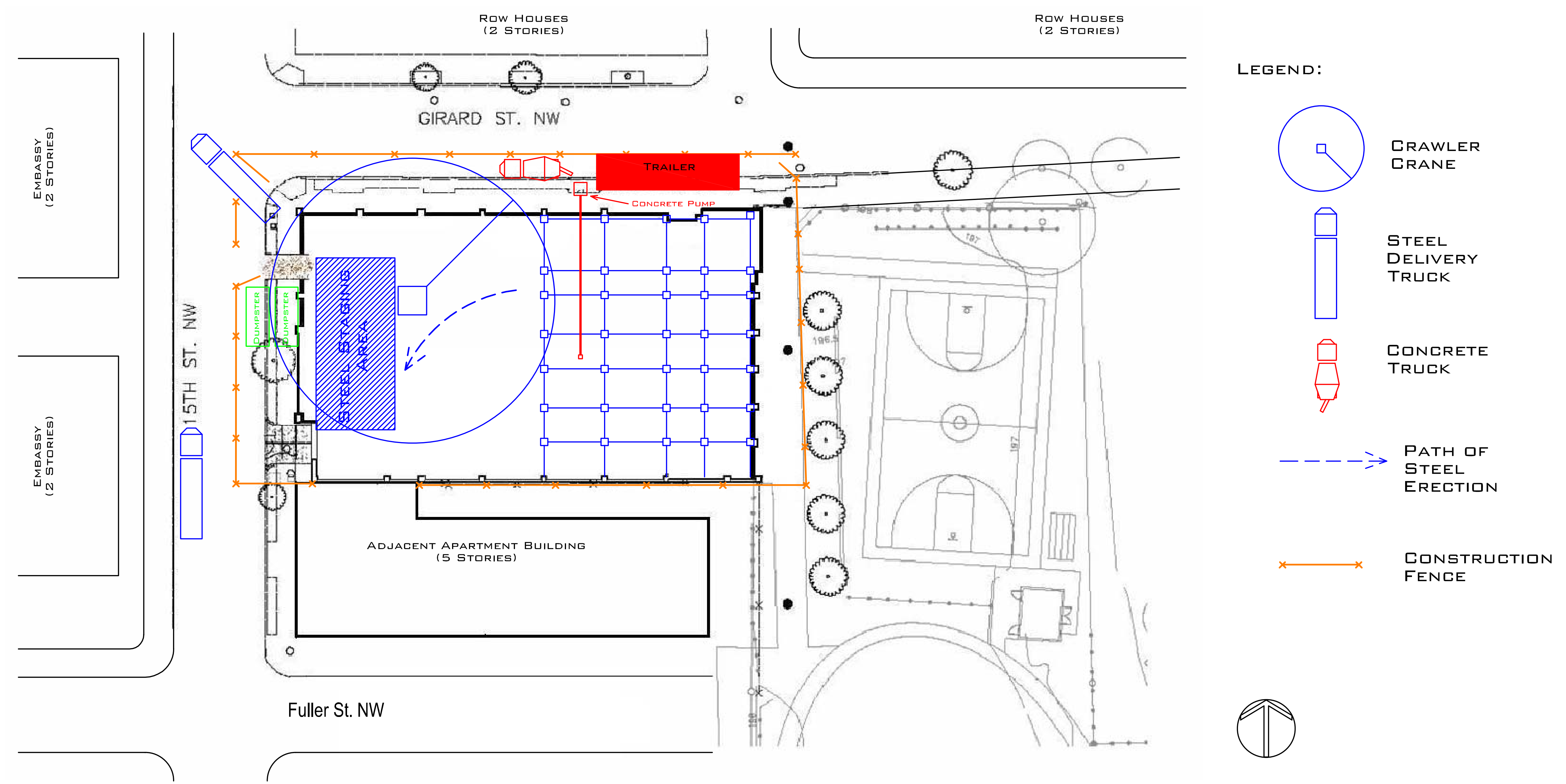
EXISTING CONDITIONS SITE PLAN		
Scale: 1/32" = 1'-0"	Approved By:	Revised:
Date: 10/25/2005		
For: Columbia Heights Community Center		
Drawn By: Christopher Glinski		Drawing Number: C-1



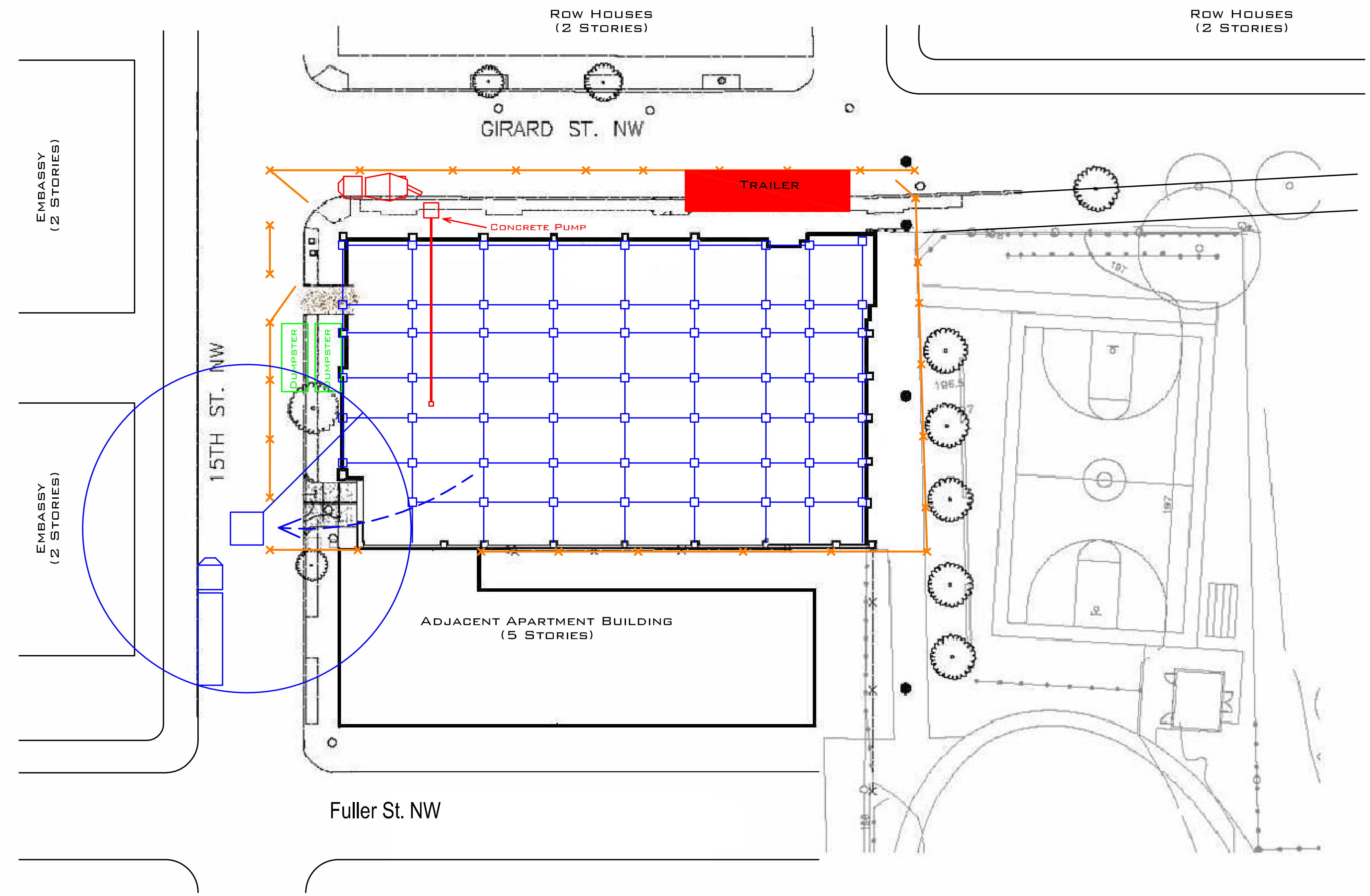
EXCAVATION PLAN		
Scale: 1/32" = 1'-0"	Approved By:	Revised:
Date: 10/31/2005		
For: Columbia Heights Community Center		
Drawn By: Christopher Glinski		Drawing Number: C-3



STEEL ERECTION PHASE 1		
Scale: 1/32" = 1'-0"	Approved By:	Revised:
Date: 10/31/2005		
For: Columbia Heights Community Center		
Drawn By: Christopher Glinski		Drawing Number: C-4



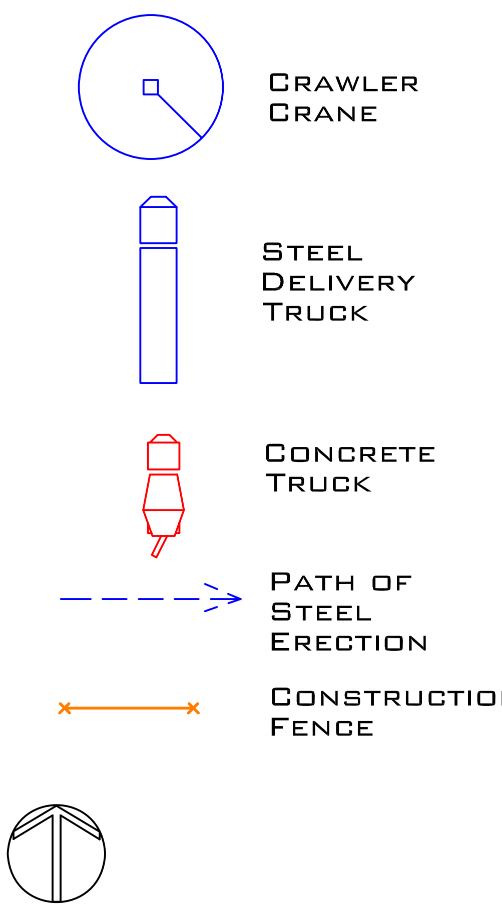
STEEL ERECTION PHASE 2		
Scale: 1/32" = 1'-0"	Approved By:	Revised:
Date: 10/31/2005		
For: Columbia Heights Community Center		
Drawn By: Christopher Glinski		Drawing Number: C-5



NOTE:

ONE LANE OF 15TH ST. NW TO BE TEMPORARILY CLOSED WHILE LAST PIECE ERECTED

LEGEND:



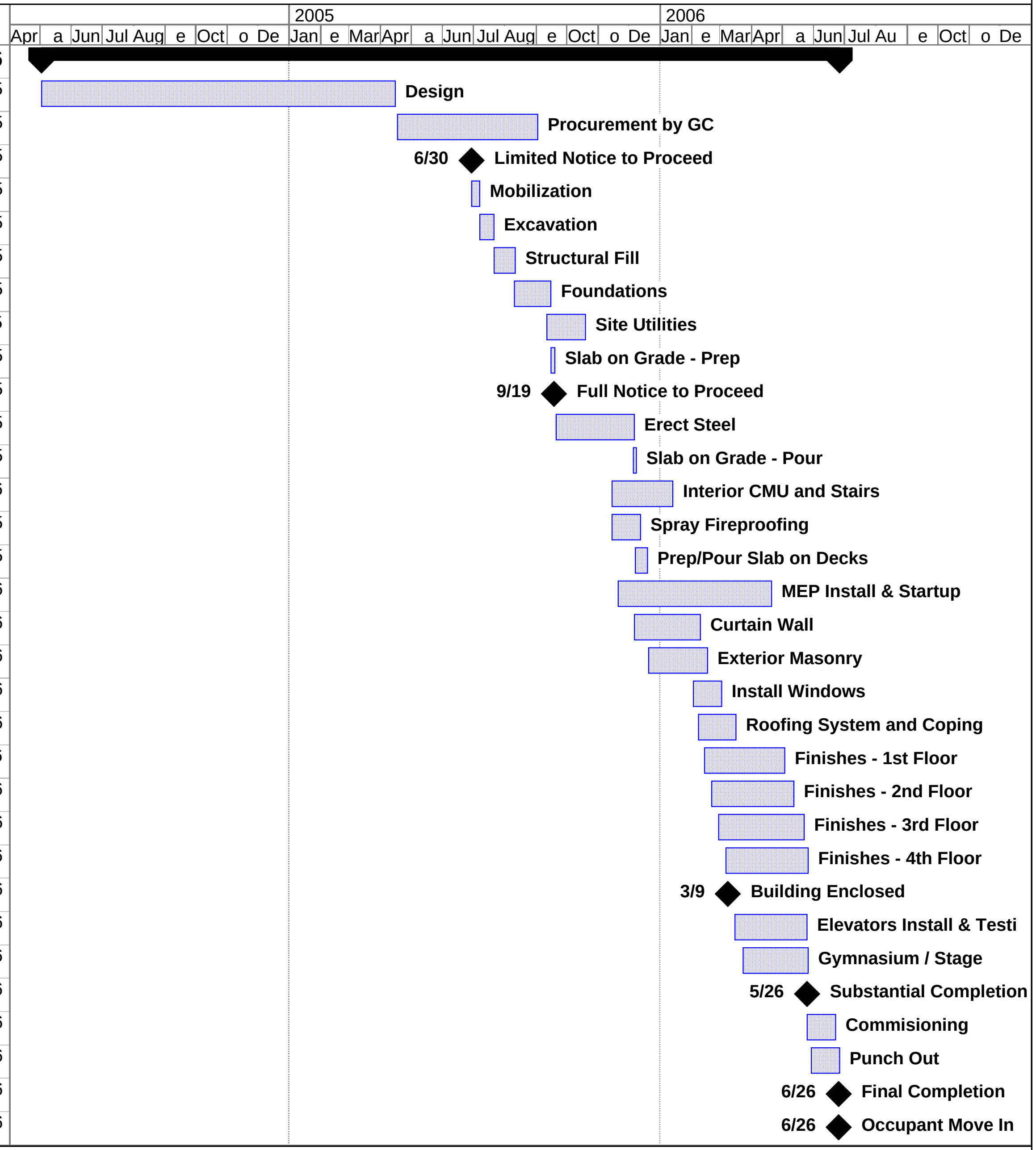
STEEL ERECTION PHASE 3		
Scale: 1/32" = 1'-0"	Approved By:	Revised:
Date: 10/31/2005		
For: Columbia Heights Community Center		
Drawn By: Christopher Glinski		Drawing Number: C-6

Appendix B

Project Summary /Detailed Schedule

Columbia Heights Community Center
Summary Schedule

ID		Task Name	Duration	Start	Finish
1		**Total Project**	**546 days**	**Mon 5/3/04**	**Mon 6/26/06**
29		Design	243 days	Mon 5/3/04	Fri 4/15/05
30		Procurement by GC	98 days	Mon 4/18/05	Fri 9/2/05
31		Limited Notice to Proceed	0 days	Thu 6/30/05	Thu 6/30/05
2		Mobilization	5 days	Thu 6/30/05	Thu 7/7/05
3		Excavation	10 days	Fri 7/8/05	Thu 7/21/05
4		Structural Fill	15 days	Fri 7/22/05	Thu 8/11/05
5		Foundations	25 days	Thu 8/11/05	Thu 9/15/05
9		Site Utilities	28 days	Mon 9/12/05	Wed 10/19/05
6		Slab on Grade - Prep	2 days	Fri 9/16/05	Mon 9/19/05
32		Full Notice to Proceed	0 days	Mon 9/19/05	Mon 9/19/05
7		Erect Steel	53 days	Wed 9/21/05	Tue 12/6/05
8		Slab on Grade - Pour	3 days	Tue 12/6/05	Thu 12/8/05
11		Interior CMU and Stairs	40 days	Tue 11/15/05	Fri 1/13/06
12		Spray Fireproofing	18 days	Tue 11/15/05	Mon 12/12/05
10		Prep/Pour Slab on Decks	8 days	Thu 12/8/05	Mon 12/19/05
25		MEP Install & Startup	105 days	Mon 11/21/05	Thu 4/20/06
13		Curtain Wall	45 days	Wed 12/7/05	Thu 2/9/06
14		Exterior Masonry	40 days	Wed 12/21/05	Thu 2/16/06
15		Install Windows	20 days	Fri 2/3/06	Thu 3/2/06
16		Roofing System and Coping	27 days	Wed 2/8/06	Thu 3/16/06
18		Finishes - 1st Floor	57 days	Tue 2/14/06	Wed 5/3/06
19		Finishes - 2nd Floor	59 days	Tue 2/21/06	Fri 5/12/06
20		Finishes - 3rd Floor	60 days	Tue 2/28/06	Mon 5/22/06
21		Finishes - 4th Floor	59 days	Tue 3/7/06	Fri 5/26/06
17		Building Enclosed	0 days	Thu 3/9/06	Thu 3/9/06
24		Elevators Install & Testing	51 days	Thu 3/16/06	Thu 5/25/06
22		Gymnasium / Stage	46 days	Fri 3/24/06	Fri 5/26/06
23		Substantial Completion	0 days	Fri 5/26/06	Fri 5/26/06
27		Commisioning	19 days	Fri 5/26/06	Thu 6/22/06
26		Punch Out	20 days	Tue 5/30/06	Mon 6/26/06
28		Final Completion	0 days	Mon 6/26/06	Mon 6/26/06
33		Occupant Move In	0 days	Mon 6/26/06	Mon 6/26/06



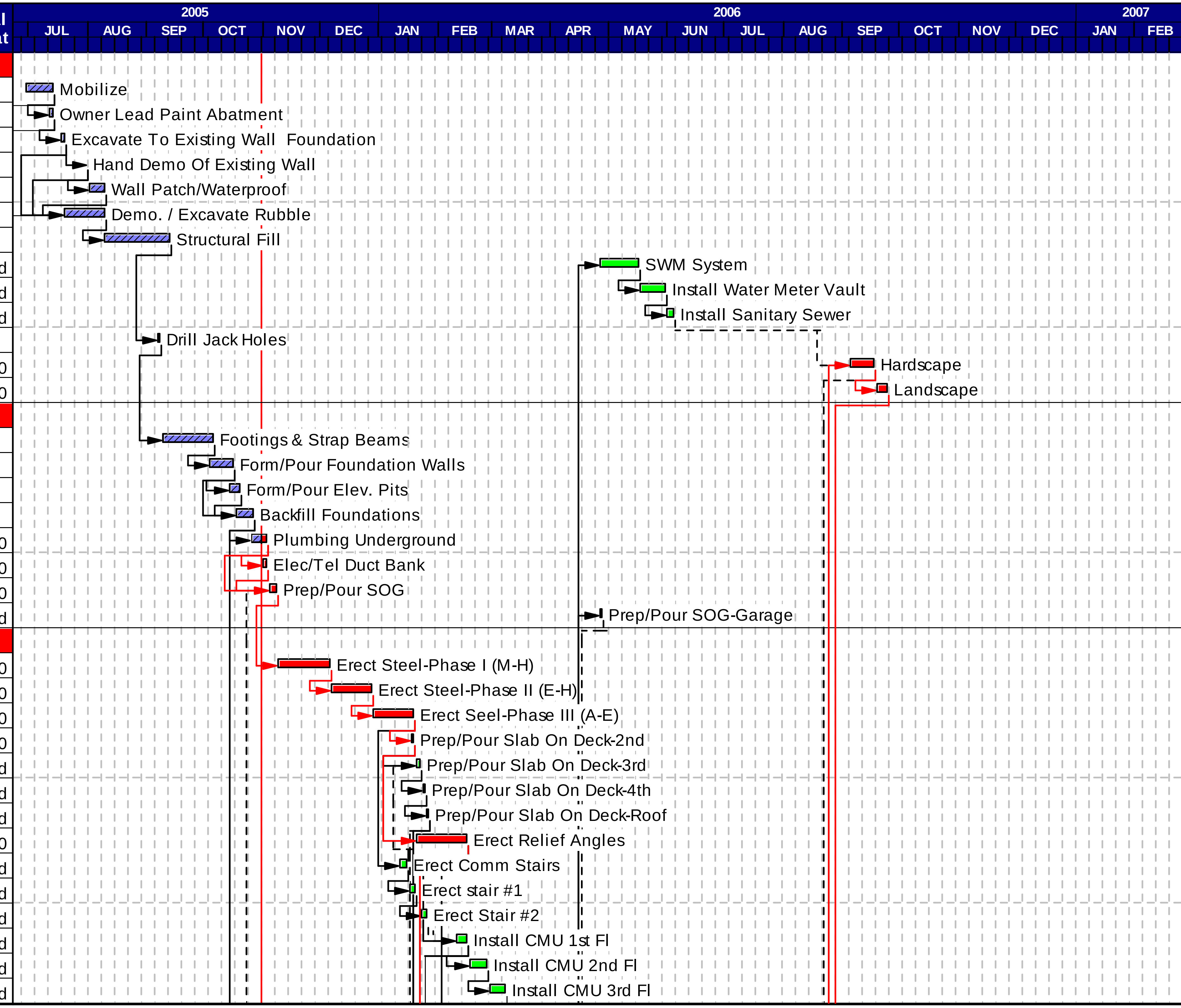
Project: Columbia Heights Community
Date: Tue 10/25/05

Task	Milestone	External Tasks
Split	Summary	External Milestone
Progress	Project Summary	Deadline

Christopher Glinski
Construction Management

Detailed Project Schedule

Phase	Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
Sitework							
SITE	1000	Mobilize	10d	0	30JUN05 A	14JUL05 A	
SITE	1001	Owner Lead Paint	5d	0	12JUL05 A	14JUL05 A	
SITE	1002	Excavate To Existing Wall	2d	0	18JUL05 A	20JUL05 A	
SITE	1003	Hand Demo Of Existing	5d	0	01AUG05	01AUG05	
SITE	1004	Wall Patch/Waterproof	14d	0	02AUG05	10AUG05	
SITE	1010	Demo. / Excavate Rubble	10d	0	20JUL05 A	10AUG05	
SITE	1020	Structural Fill	10d	0 *	10AUG05	13SEP05	
SITE	1030	SWM System	15d	15d	27APR06	17MAY06	64d
SITE	1040	Install Water Meter Vault	10d	10d	18MAY06	31MAY06	64d
SITE	1050	Install Sanitary Sewer	3d	3d	01JUN06	05JUN06	64d
SITE	1060	Drill Jack Holes	3d	0	07SEP05	08SEP05	
SITE	1065	Hardscape	10d	10d	05SEP06	18SEP06	0
SITE	1067	Landscape	5d	5d	19SEP06	25SEP06	0
Foundations							
FDN	1070	Footings & Strap Beams	20d	0	09SEP05	06OCT05	
FDN	1080	Form/Pour Foundation	10d	0	04OCT05	17OCT05	
FDN	1090	Form/Pour Elev. Pits	5d	0	14OCT05	20OCT05	
FDN	1100	Backfill Foundations	8d	0	18OCT05	27OCT05	
FDN	1110	Plumbing Underground	7d	4d	26OCT05	03NOV05	0
FDN	1120	Elec/Tel Duct Bank	3d	3d	01NOV05	03NOV05	0
FDN	1130	Prep/Pour SOG	3d	3d	04NOV05	08NOV05	0
FDN	1135	Prep/Pour SOG-Garage	2d	2d	27APR06	28APR06	20d
Structure							
STR	1140	Erect Steel-Phase I (M-H)	18d	18d	09NOV05	06DEC05	0
STR	1150	Erect Steel-Phase II (E-H)	15d	15d	07DEC05	28DEC05	0
STR	1160	Erect Seel-Phase III (A-E)	15d	15d	29DEC05	19JAN06	0
STR	1170	Prep/Pour Slab On	2d	2d	18JAN06	19JAN06	0
STR	1180	Prep/Pour Slab On	2d	2d	20JAN06	23JAN06	4d
STR	1190	Prep/Pour Slab On	2d	2d	24JAN06	25JAN06	4d
STR	1200	Prep/Pour Slab On	2d	2d	26JAN06	27JAN06	4d
STR	1210	Erect Relief Angles	20d	20d	20JAN06	16FEB06	0
STR	1220	Erect Comm Stairs	3d	3d	12JAN06	16JAN06	7d
STR	1230	Erect stair #1	4d	4d	17JAN06	20JAN06	30d
STR	1240	Erect Stair #2	4d	4d	23JAN06	26JAN06	30d
STR	1250	Install CMU 1st Fl	5d	5d	10FEB06	16FEB06	20d
STR	1260	Install CMU 2nd Fl	7d	7d	17FEB06	27FEB06	20d
STR	1270	Install CMU 3rd Fl	7d	7d	28FEB06	08MAR06	20d



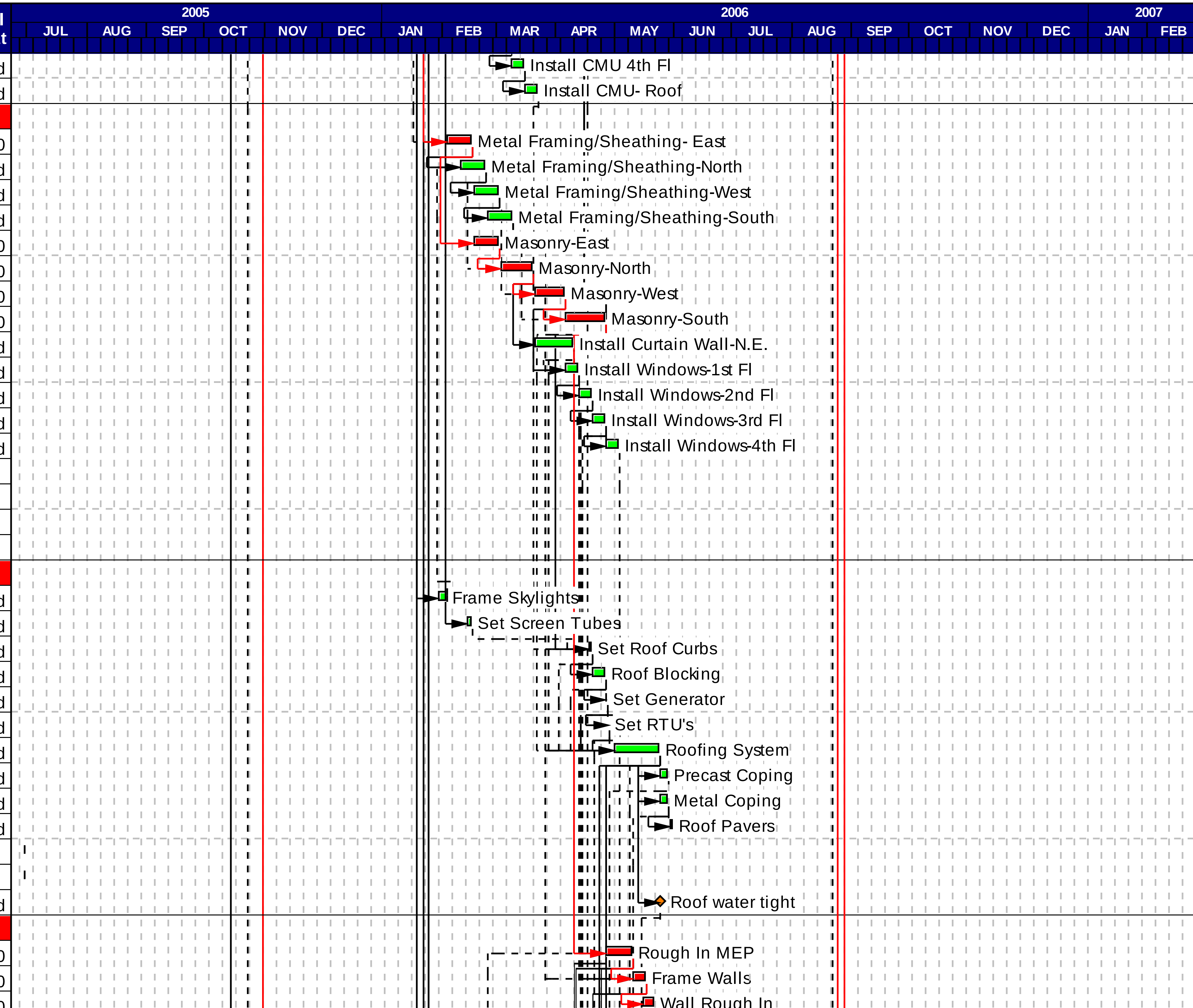
Start date	30JUN05
Finish date	16OCT06
Data date	31OCT05
Run date	31OCT05
Page number	1A

Columbia Heights Community Center

Early bar
Progress bar
Critical bar
Summary bar
Start milestone poin
Finish milestone poi

Detailed Project Schedule

Phase	Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
STR	1280	Install CMU 4th Fl	5d	5d	09MAR06	15MAR06	20d
STR	1290	Install CMU- Roof	5d	5d	16MAR06	22MAR06	20d
skin							
SKIN	1300	Metal Framing/Sheathing-	10d	10d	03FEB06	16FEB06	0
SKIN	1310	Metal	10d	10d	10FEB06	23FEB06	5d
SKIN	1320	Metal	10d	10d	17FEB06	02MAR06	12d
SKIN	1330	Metal	10d	10d	24FEB06	09MAR06	19d
SKIN	1340	Masonry-East	10d	10d	17FEB06	02MAR06	0
SKIN	1350	Masonry-North	12d	12d	03MAR06	20MAR06	0
SKIN	1360	Masonry-West	12d	12d	21MAR06	05APR06	0
SKIN	1370	Masonry-South	15d	15d	06APR06	26APR06	0
SKIN	1380	Install Curtain Wall-N.E.	15d	15d	21MAR06	10APR06	16d
SKIN	1390	Install Windows-1st Fl	5d	5d	06APR06	12APR06	20d
SKIN	1400	Install Windows-2nd Fl	5d	5d	13APR06	19APR06	25d
SKIN	1410	Install Windows-3rd Fl	5d	5d	20APR06	26APR06	25d
SKIN	1420	Install Windows-4th Fl	5d	5d	27APR06	03MAY06	25d
SKIN	1430		0	0	30JUN05 A	29JUN05 A	
SKIN	1440		0	0	30JUN05 A	29JUN05 A	
SKIN	1450		0	0	30JUN05 A	29JUN05 A	
SKIN	1460		0	0	30JUN05 A	29JUN05 A	
roof							
ROOF	1470	Frame Skylights	5d	5d	30JAN06	03FEB06	9d
ROOF	1480	Set Screen Tubes	3d	3d	14FEB06	16FEB06	44d
ROOF	1490	Set Roof Curbs	2d	2d	18APR06	19APR06	2d
ROOF	1500	Roof Blocking	5d	5d	20APR06	26APR06	2d
ROOF	1510	Set Generator	1d	1d	27APR06	27APR06	2d
ROOF	1520	Set RTU's	1d	1d	28APR06	28APR06	2d
ROOF	1530	Roofing System	18d	18d	01MAY06	24MAY06	2d
ROOF	1540	Precast Coping	3d	3d	25MAY06	29MAY06	24d
ROOF	1550	Metal Coping	3d	3d	25MAY06	29MAY06	24d
ROOF	1560	Roof Pavers	2d	2d	30MAY06	31MAY06	97d
ROOF	1570		1d	0	30JUN05 A	30JUN05 A	
ROOF	1580		1d	0	30JUN05 A	30JUN05 A	
ROOF	2580	Roof water tight	0	0		24MAY06	5d
1st Floor Finishes							
1ST	1590	Rough In MEP	10d	10d	27APR06	10MAY06	0
1ST	1600	Frame Walls	5d	5d	11MAY06	17MAY06	0
1ST	1610	Wall Rough In	5d	5d	16MAY06	22MAY06	0



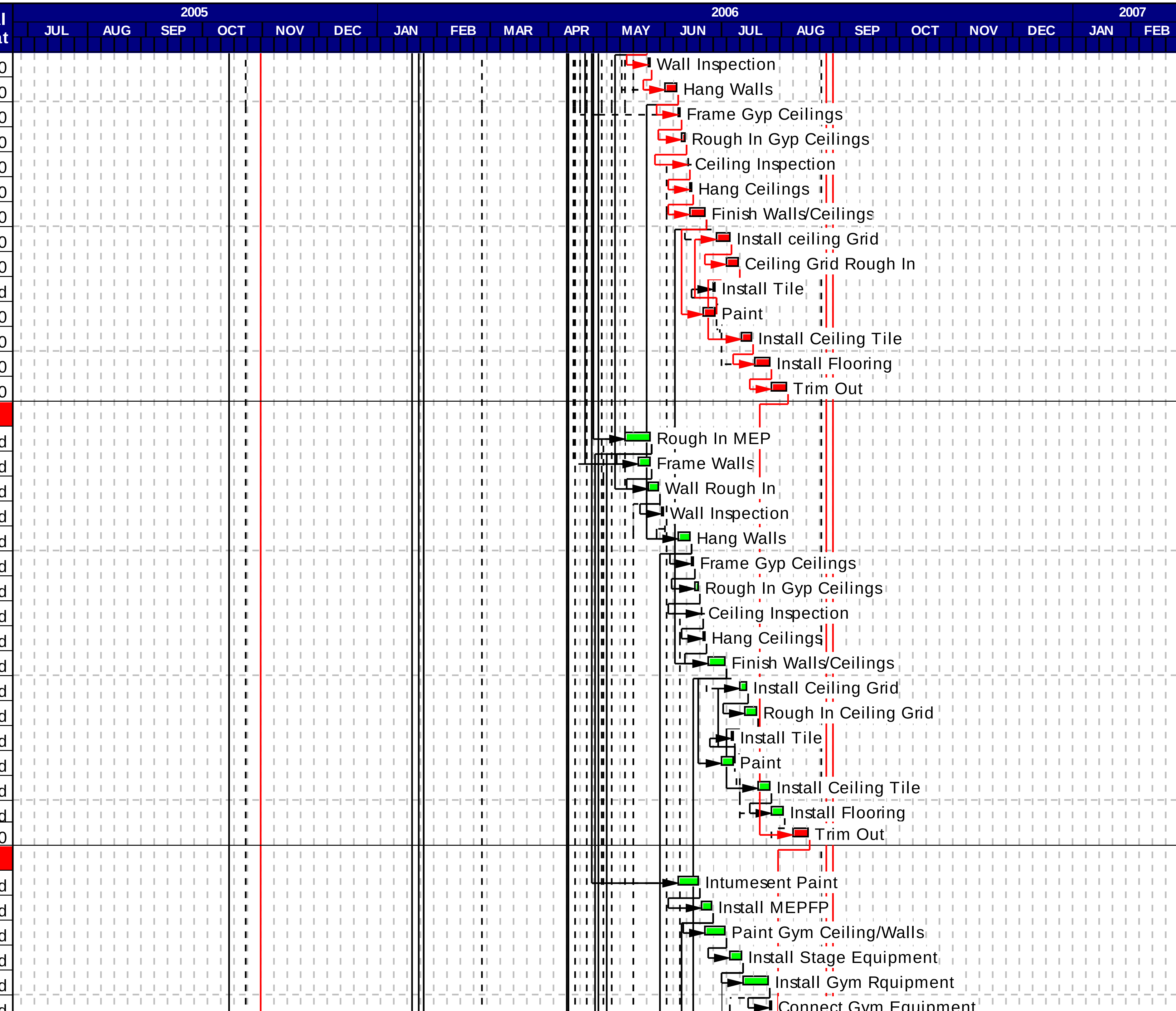
Start date	30JUN05
Finish date	16OCT06
Data date	31OCT05
Run date	31OCT05
Page number	2A

Columbia Heights Community Center

- Early bar
- Progress bar
- Critical bar
- Summary bar
- Start milestone poin
- Finish milestone poi

Detailed Project Schedule

Phase	Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
1ST	1620	Wall Inspection	2d	2d	23MAY06	24MAY06	0
1ST	1630	Hang Walls	5d	5d	01JUN06	07JUN06	0
1ST	1640	Frame Gyp Ceilings	2d	2d	08JUN06	09JUN06	0
1ST	1650	Rough In Gyp Ceilings	2d	2d	09JUN06	12JUN06	0
1ST	1660	Ceiling Inspection	1d	1d	13JUN06	13JUN06	0
1ST	1670	Hang Ceilings	2d	2d	14JUN06	15JUN06	0
1ST	1680	Finish Walls/Ceilings	7d	7d	14JUN06	22JUN06	0
1ST	1681	Install ceiling Grid	5d	5d	28JUN06	05JUL06	0
1ST	1682	Ceiling Grid Rough In	5d	5d	03JUL06	10JUL06	0
1ST	1690	Install Tile	2d	2d	26JUN06	27JUN06	13d
1ST	1700	Paint	5d	5d	21JUN06	27JUN06	0
1ST	1710	Install Ceiling Tile	5d	5d	11JUL06	17JUL06	0
1ST	1720	Install Flooring	7d	7d	18JUL06	26JUL06	0
1ST	1730	Trim Out	7d	7d	27JUL06	04AUG06	0
2nd Floor Finishes							
2ND	1740	Rough In MEP	10d	10d	11MAY06	24MAY06	5d
2ND	1750	Frame Walls	5d	5d	18MAY06	24MAY06	7d
2ND	1760	Wall Rough In	5d	5d	23MAY06	29MAY06	7d
2ND	1770	Wall Inspection	2d	2d	30MAY06	31MAY06	7d
2ND	1780	Hang Walls	5d	5d	08JUN06	14JUN06	2d
2ND	1790	Frame Gyp Ceilings	2d	2d	15JUN06	16JUN06	2d
2ND	1800	Rough In Gyp Ceilings	2d	2d	16JUN06	19JUN06	2d
2ND	1810	Ceiling Inspection	1d	1d	20JUN06	20JUN06	2d
2ND	1820	Hang Ceilings	2d	2d	21JUN06	22JUN06	2d
2ND	1830	Finish Walls/Ceilings	7d	7d	23JUN06	03JUL06	2d
2ND	1831	Install Ceiling Grid	5d	5d	10JUL06	14JUL06	2d
2ND	1832	Rough In Ceiling Grid	5d	5d	13JUL06	19JUL06	2d
2ND	1840	Install Tile	2d	2d	06JUL06	07JUL06	15d
2ND	1850	Paint	5d	5d	30JUN06	07JUL06	2d
2ND	1860	Install Ceiling Tile	5d	5d	20JUL06	26JUL06	2d
2ND	1870	Install Flooring	5d	5d	27JUL06	02AUG06	2d
2ND	1875	Trim Out	7d	7d	07AUG06	15AUG06	0
Gymnasium							
GYM	2160	Intumesent Paint	8d	8d	08JUN06	19JUN06	17d
GYM	2170	Install MEPFP	5d	5d	20JUN06	26JUN06	17d
GYM	2180	Paint Gym Ceiling/Walls	8d	8d	22JUN06	03JUL06	17d
GYM	2190	Install Stage Equipment	5d	5d	05JUL06	11JUL06	17d
GYM	2200	Install Gym Rquipment	10d	10d	12JUL06	25JUL06	17d
GYM	2210	Connect Gym Equipment	2d	2d	26JUL06	27JUL06	17d



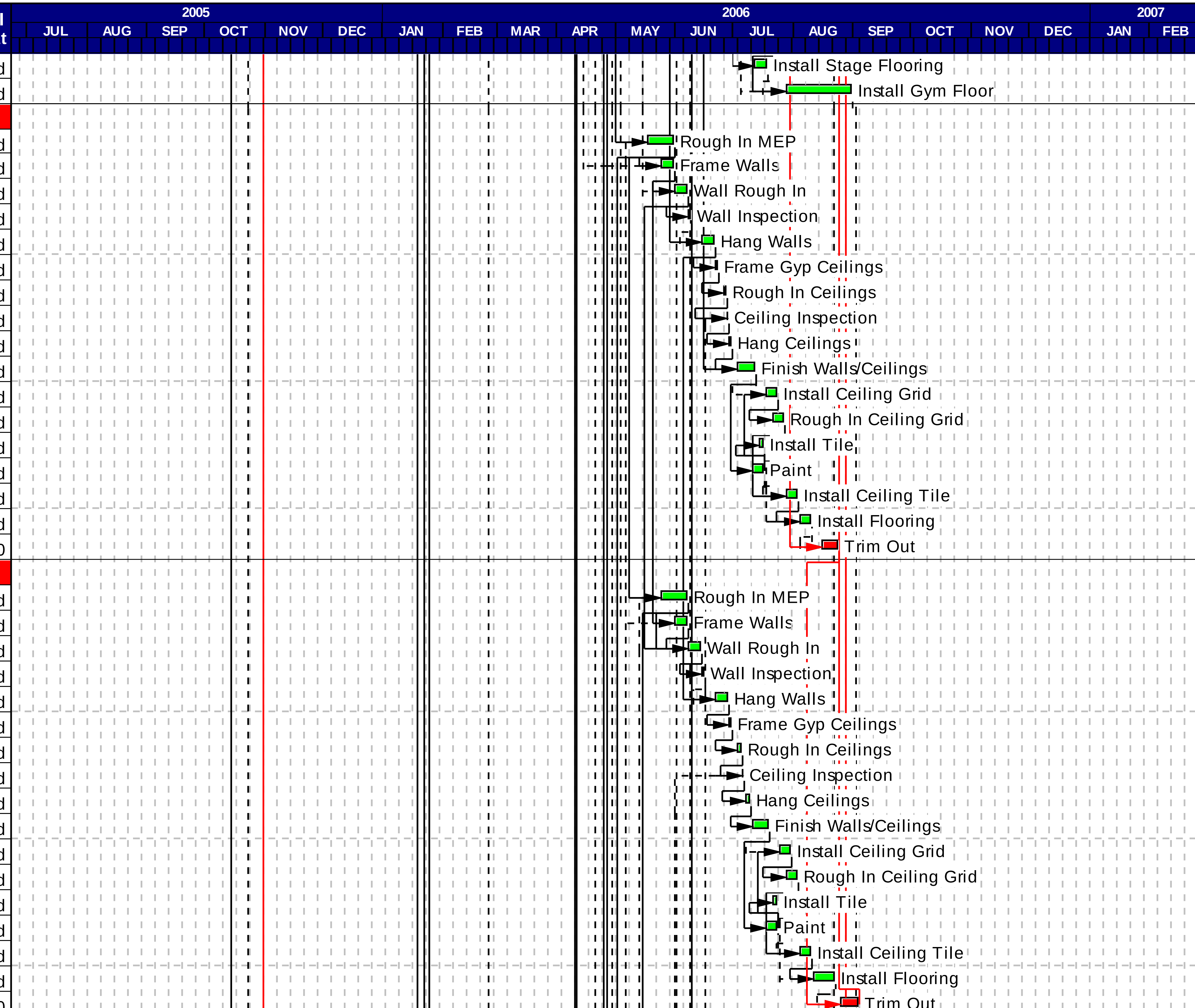
Start date	30JUN05
Finish date	16OCT06
Data date	31OCT05
Run date	31OCT05
Page number	3A

Columbia Heights Community Center

Early bar
Progress bar
Critical bar
Summary bar
Start milestone poin
Finish milestone poi

Detailed Project Schedule

Phase	Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
GYM	2220	Install Stage Flooring	5d	5d	12JUL06	18JUL06	24d
GYM	2230	Install Gym Floor	25d	25d	28JUL06	31AUG06	17d
3rd Floor Finishes							
3RD	1880	Rough In MEP	10d	10d	18MAY06	31MAY06	5d
3RD	1890	Frame Walls	5d	5d	25MAY06	31MAY06	5d
3RD	1900	Wall Rough In	5d	5d	01JUN06	07JUN06	5d
3RD	1910	Wall Inspection	2d	2d	08JUN06	09JUN06	5d
3RD	1920	Hang Walls	5d	5d	15JUN06	21JUN06	2d
3RD	1930	Frame Gyp Ceilings	2d	2d	22JUN06	23JUN06	3d
3RD	1940	Rough In Ceilings	2d	2d	26JUN06	27JUN06	3d
3RD	1950	Ceiling Inspection	1d	1d	28JUN06	28JUN06	3d
3RD	1960	Hang Ceilings	2d	2d	29JUN06	30JUN06	3d
3RD	1970	Finish Walls/Ceilings	7d	7d	03JUL06	12JUL06	3d
3RD	1971	Install Ceiling Grid	5d	5d	18JUL06	24JUL06	3d
3RD	1972	Rough In Ceiling Grid	5d	5d	21JUL06	27JUL06	3d
3RD	1980	Install Tile	2d	2d	14JUL06	17JUL06	16d
3RD	1990	Paint	5d	5d	11JUL06	17JUL06	3d
3RD	2000	Install Ceiling Tile	5d	5d	28JUL06	03AUG06	3d
3RD	2010	Install Flooring	5d	5d	04AUG06	10AUG06	3d
3RD	2015	Trim Out	7d	7d	16AUG06	24AUG06	0
4th Floor Finishes							
4TH	2020	Rough In MEP	10d	10d	25MAY06	07JUN06	5d
4TH	2030	Frame Walls	5d	5d	01JUN06	07JUN06	5d
4TH	2040	Wall Rough In	5d	5d	08JUN06	14JUN06	5d
4TH	2050	Wall Inspection	2d	2d	15JUN06	16JUN06	5d
4TH	2060	Hang Walls	5d	5d	22JUN06	28JUN06	2d
4TH	2070	Frame Gyp Ceilings	2d	2d	29JUN06	30JUN06	2d
4TH	2080	Rough In Ceilings	2d	2d	03JUL06	05JUL06	2d
4TH	2090	Ceiling Inspection	1d	1d	06JUL06	06JUL06	2d
4TH	2100	Hang Ceilings	2d	2d	07JUL06	10JUL06	2d
4TH	2110	Finish Walls/Ceilings	7d	7d	11JUL06	19JUL06	2d
4TH	2111	Install Ceiling Grid	5d	5d	25JUL06	31JUL06	2d
4TH	2112	Rough In Ceiling Grid	5d	5d	28JUL06	03AUG06	2d
4TH	2120	Install Tile	2d	2d	21JUL06	24JUL06	15d
4TH	2130	Paint	5d	5d	18JUL06	24JUL06	2d
4TH	2140	Install Ceiling Tile	5d	5d	04AUG06	10AUG06	2d
4TH	2150	Install Flooring	8d	8d	11AUG06	22AUG06	2d
4TH	2240	Trim Out	7d	7d	25AUG06	04SEP06	0



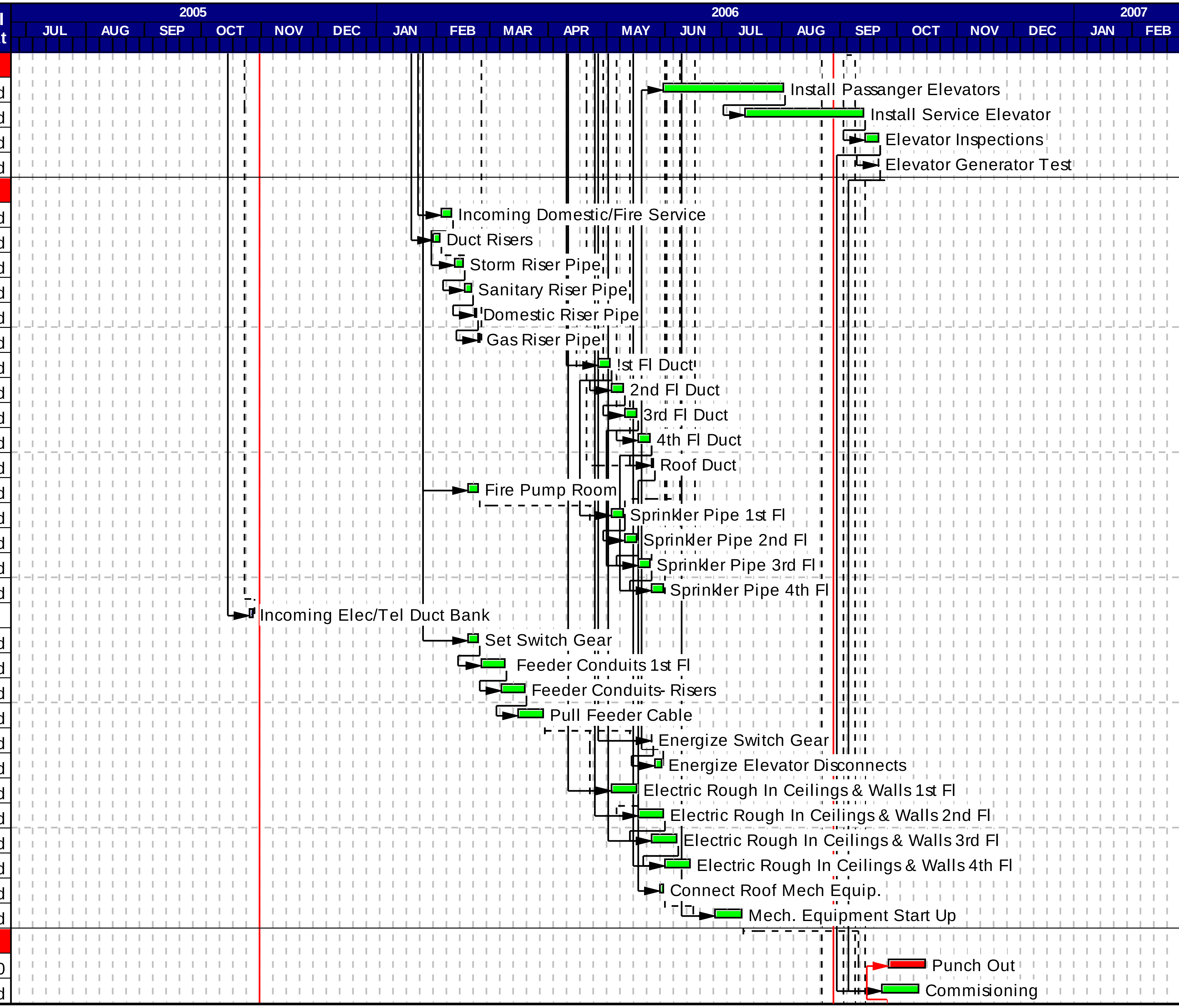
Start date	30JUN05
Finish date	16OCT06
Data date	31OCT05
Run date	31OCT05
Page number	4A

Columbia Heights Community Center

- Early bar
- Progress bar
- Critical bar
- Summary bar
- Start milestone poin
- Finish milestone poi

Detailed Project Schedule

Phase	Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
Elevators							
ELEV	2250	Install Passanger Elevators	45d	45d	31MAY06	02AUG06	2d
ELEV	2260	Install Service Elevator	45d	45d	13JUL06	13SEP06	2d
ELEV	2270	Elevator Inspections	6d	6d	14SEP06	21SEP06	2d
ELEV	2280	Elevator Generator Test	1d	1d	21SEP06	21SEP06	2d
MEP							
MEP	2300	Incoming Domestic/Fire	5d	5d	03FEB06	09FEB06	43d
MEP	2310	Duct Risers	5d	5d	30JAN06	03FEB06	68d
MEP	2320	Storm Riser Pipe	4d	4d	10FEB06	15FEB06	43d
MEP	2330	Sanitary Riser Pipe	3d	3d	16FEB06	20FEB06	43d
MEP	2340	Domestic Riser Pipe	2d	2d	21FEB06	22FEB06	43d
MEP	2350	Gas Riser Pipe	2d	2d	23FEB06	24FEB06	43d
MEP	2360	!st Fl Duct	5d	5d	27APR06	03MAY06	10d
MEP	2370	2nd Fl Duct	5d	5d	04MAY06	10MAY06	10d
MEP	2380	3rd Fl Duct	5d	5d	11MAY06	17MAY06	10d
MEP	2390	4th Fl Duct	5d	5d	18MAY06	24MAY06	10d
MEP	2400	Roof Duct	2d	2d	25MAY06	26MAY06	72d
MEP	2410	Fire Pump Room	5d	5d	17FEB06	23FEB06	72d
MEP	2420	Sprinkler Pipe 1st Fl	5d	5d	04MAY06	10MAY06	23d
MEP	2430	Sprinkler Pipe 2nd Fl	5d	5d	11MAY06	17MAY06	25d
MEP	2440	Sprinkler Pipe 3rd Fl	5d	5d	18MAY06	24MAY06	26d
MEP	2450	Sprinkler Pipe 4th Fl	5d	5d	25MAY06	31MAY06	26d
MEP	2460	Incoming Elec/Tel Duct	3d	0	26OCT05	28OCT05	
MEP	2470	Set Switch Gear	5d	5d	17FEB06	23FEB06	42d
MEP	2480	Feeder Conduits 1st Fl	10d	10d	24FEB06	09MAR06	42d
MEP	2490	Feeder Conduits- Risers	10d	10d	07MAR06	20MAR06	42d
MEP	2500	Pull Feeder Cable	10d	10d	16MAR06	29MAR06	42d
MEP	2510	Energize Switch Gear	1d	1d	25MAY06	25MAY06	2d
MEP	2520	Energize Elevator	3d	3d	26MAY06	30MAY06	2d
MEP	2530	Electric Rough In Ceilings	10d	10d	04MAY06	17MAY06	92d
MEP	2540	Electric Rough In Ceilings	10d	10d	18MAY06	31MAY06	87d
MEP	2550	Electric Rough In Ceilings	10d	10d	25MAY06	07JUN06	87d
MEP	2560	Electric Rough In Ceilings	10d	10d	01JUN06	14JUN06	87d
MEP	2570	Connect Roof Mech Equip.	3d	3d	29MAY06	31MAY06	72d
MEP	25800	Mech. Equipment Start Up	10d	10d	27JUN06	11JUL06	54d
Punchlist / Commisioning							
PNCH	2590	Punch Out	15d	15d	26SEP06	16OCT06	0
PNCH	2600	Commisioning	15d	15d	22SEP06	12OCT06	2d



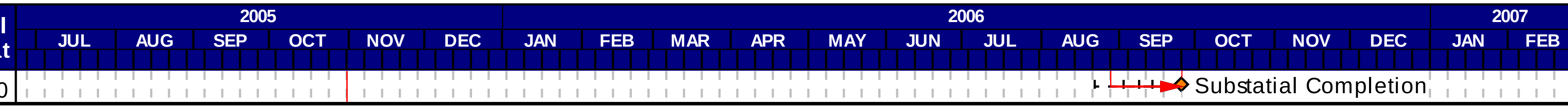
Start date	30JUN05
Finish date	16OCT06
Data date	31OCT05
Run date	31OCT05
Page number	5A

Columbia Heights Community Center

Early bar
Progress bar
Critical bar
Summary bar
Start milestone poin
Finish milestone poi

Detailed Project Schedule

	Phase	Act ID	Description	Orig Dur	Rem Dur	Early Start	Early Finish	Total Float
	PNCH	2610	Substatial Completion	0	0		25SEP06	0



Start date	30JUN05
Finish date	16OCT06
Data date	31OCT05
Run date	31OCT05
Page number	6A

Columbia Heights Community Center

Early bar
Progress bar
Critical bar
Summary bar
Start milestone poin
Finish milestone poi

Appendix C

LEED® Interview Questionnaire

Name of Person, Company

LEED® Rating (Certified, Silver, Gold, Platinum)

Name of Project

1. What is the intended use of your building?

2. Did you plan to occupy or lease the building?

3. Who is using the building?

4. What type of tasks are the users performing?

5. What type of area is your building in?
   (Urban, suburban, rural, residential, commercial, industrial, etc.)

6. Is operation and maintenance cost important to you?

7. Was minimizing environmental impact a priority when planning this project?

8. Was a healthy indoor environment a priority when planning this project?

9. Is there green space on your property?

10. When is this building used? (day, night, or both)

11. Are there any other reasons for obtaining LEED® certification?