Michael Reese Campus:

An Urban Development Challenge

IPRO 359

SPRING 2011

Executive Summary

As the question of a finalized redevelopment master plan still remains for the former Michael Reese Campus, the opportunity of providing a turning wheel to this Chicago neighborhood's economic revolution continues to be offered to the students in EnPRO359. Based on the initial information provided to the group, our proposed plan would need to be unique, yet financially viable. In addition, the group would be required to integrate this new anchor with the original master plan that includes a highly-regarded continued care facility. Through careful consideration, EnPRO359 felt that the relocation of the Chicago's Children's Museum to this specific site would be that catalyst for Bronzeville's thriving future.

Over the past few months, the group has conducted market research, assessed financial options and consulted various professionals on this topic. Additionally, certain group members performed building design calculations for the project in accordance with Capstone requirements. During the progression of the semester, the choice of this specific building for this site became even clearer. Due to extensive research, the presumed relationship between the Children's Museum and Bronzeville is believed to become mutually beneficial. Expansion opportunities and specific venue independence guarantees larger crowds of visitors to the museum and future surrounding developments. Revitalization and potential community involvement with the Museum can produce a new image for the Bronzeville area. Ultimately, this addition can help further define the direction of future anchors to the overall master plan.

Purpose and Objectives

At one time the Michael Reese Campus was a thriving mix of famous architecture and medical centers. Recently planned to be the home of the 2016 Olympic Village, with the loss of the bid the land has been abandoned. EnPRO 356 was tasked with the challenge of designing a plan to redevelop the site. Building on previous work established by EnPRO's 359 and 356, we used the first winning anchor and master plan created for the site and developed a second anchor, the new home of the Chicago Children's Museum. This second anchor and updated master plan aims at meeting the needs of the surrounding neighborhood while bringing life back to the area.

Objectives Set by the Team

- Review and confirm work established by previous EnPRO's.
- Integrate the Chicago street grid into the site
- Improve any downfalls of the first anchor
- Gather any new information of the area surrounding the site
- Develop a idea for a second anchor that meets the needs of the neighborhood
- Determine site location of the second anchor
- Design the structure and amenities of the second anchor
- Create a business plan for the second anchor
- Skillfully present the revised master plan to city representatives and judges

Organization and Approach

There were very logical steps and tasks that the group took to complete the project. These tasks are outlined below. The group believed that this plan would best maximize the efforts of the members and other resources and would allow the best chance for completion.

- Review Previous IPRO Work
- Familiarize with the Project Scope
- Research Market Opportunities
- Assemble and Review Options for a Second Anchor
- Decide on Second Anchor
- Form Initial Site Plan
- Design: Architectural Details
- Design: Structural System
- Design: Mechanical System
- Develop Site
- Cost Estimate Second Anchor
- Create Business Plan
- Complete Pro Forma

Evaluation of progress and quality took place throughout each stage of the project. Adjustments, when needed, were made in the process through which the problem was solved.

Team Structure

The group decided not to choose a team-leader. All members were motivated enough to contribute to the discussion and were dedicated to putting in valuable work, a team leader was not needed.

The first portion of the semester primarily involved research, so each individual with the direction of each meetings' discussions, took it upon themselves to share ideas and collect information. By the second half of the semester, the team was ready to split into separate groups to carry out the design and business objectives. The team breakdown was as follows:

Architectural Engineering Team:
Fraser, Linnea V
Miller, Nathan

Architectural Design Team:
Ajose, Malik O.
Liu, Fangpeng
McNally, William T.

Structural Design Team:
Martinez, Jocsan E.
Masnaga, Masnaga
Medina, Omar J.
Steinys, Victoria J.
Strandquist, Brad

Business Team:
Nava, Fabian A.

Analysis and Findings

During our market research, the group discovered many informative points that influenced our decision. Some of the key findings showed that concerns of safety and accessibility have deterred redevelopment possibilities in recent years. Currently, break-ins at nearby apartment complexes have become an issue and as a result, the retention rates of residents in these buildings are down. To repair this problem, the group would have to redesign a well protected neighborhood to attract visitors and potential residents. Research on the Indianapolis Children's Museum also proved to be very influential in our decision. From this research we were able to show that the introduction of a well-renowned tourist attraction can impart a large financial impact on the commercial sector of the surrounding area.

For the design teams, the program layout within the building would be crucial to the interaction of the outside façade work. During our visit to the existing Chicago Children's Museum, we discovered that the exhibit layout had been somewhat predetermined due to the limitations of the pre-existing Navy Pier structure. With a more open floor plan, the visitor can be fully aware of every amenity offered to them and security issues can potentially be reduced. Having the double-skin façade was not only an aesthetically pleasing option, but the low-e coated and colored spandrel glass would minimize insulation problems common to curtain walls. Based on the guidance of PCI representatives, the choice of precast prestressed concrete would save money in the construction phase due to faster assembly and resistance to adverse climates. Also, the group discovered numerous types of precast concrete forms to choose from including those of columns and beams.

The choice to place the museum on the corner of 31st and Cottage Grove allowed easier accessibility to nearby highways and other future transit stops. Currently, the South Lakefront Transit Corridor Transit Study is seeking improvements in the connection between the downtown area and southern Chicago neighborhoods. If all goes well, the Children's Museum would not only exist as a potential stop for a future rail-line, but would become a transition point for the downtown museum campus and the Museum of Science and Industry. This would expand the downtown appeal throughout the overall span of the lakefront. The reintroduction of the street-grid would allow downtown visitors, currently the largest group of Children's Museum attendees, to instantly identify the museum due to the orientation of the main entrance to the north. In accordance with the previous EnPRO's suggestions, the green space between the continued care facility and the museum would allow visitors and residents the perfect opportunity for outside leisure activity.

The Project and Pro Forma were based on projected incomes primarily from contributions from major corporations and third party donors; the majority of which came from contributed goods and services and rental revenues which will provide more than half of our established income. Additionally our initial start up costs is based on assumed grants and donated benefits, but also has included a given debt service schedule for a 30 year lease minus our projected income for the first year. Based on the debt service schedule of the loan, we can assume to break even and that the loan including interest would be paid off in between 6-7 years. Additional income will be used for employee salaries, events, and construction repairs for possible further development of the Museum.

Conclusion and Recommendations

With certainty, the students in EnPRO359 consider the relocation of the Chicago Children's Museum as the best possible new anchor to the current master plan. The proposed design, with its colorful and lively façade, will be the perfect persuasion to draw in visitors. The chosen location off of 31st Street is ideal for traffic from outside visitors and is currently part of the focus for future Chicago transit development. Also, the location's close proximity to other types of venues such as McCormick Place, U.S. Cellular Field, and the future 31st Street Marina offers an additional revenue source from the family demographic. The paradoxical relationship between the current continued care anchor and the museum was resolved with the intention of possible involvement of residents at this facility through intergenerational activities and volunteering. Future expansion capabilities, lower costs, and less controversy give it a competitive edge over the current alternatives.

If this proposal is accepted, the future main focus should be on creating an appropriate environment to accommodate all types of visitors to the museum. This would include adding a hotel at the site's north end, a parking garage nearby, and suitable retail area that would compliment the museum. Once a safe, child-friendly atmosphere is constructed, we believe that a high demand for residential development nearby will follow. In regards to the design of the building, the incorporation of LEED requirements will reduce the costs even more and potentially gain additional popularity with prospective sponsors.

Acknowledgements

We would like to offer our appreciation to the following people for their contribution to our research:

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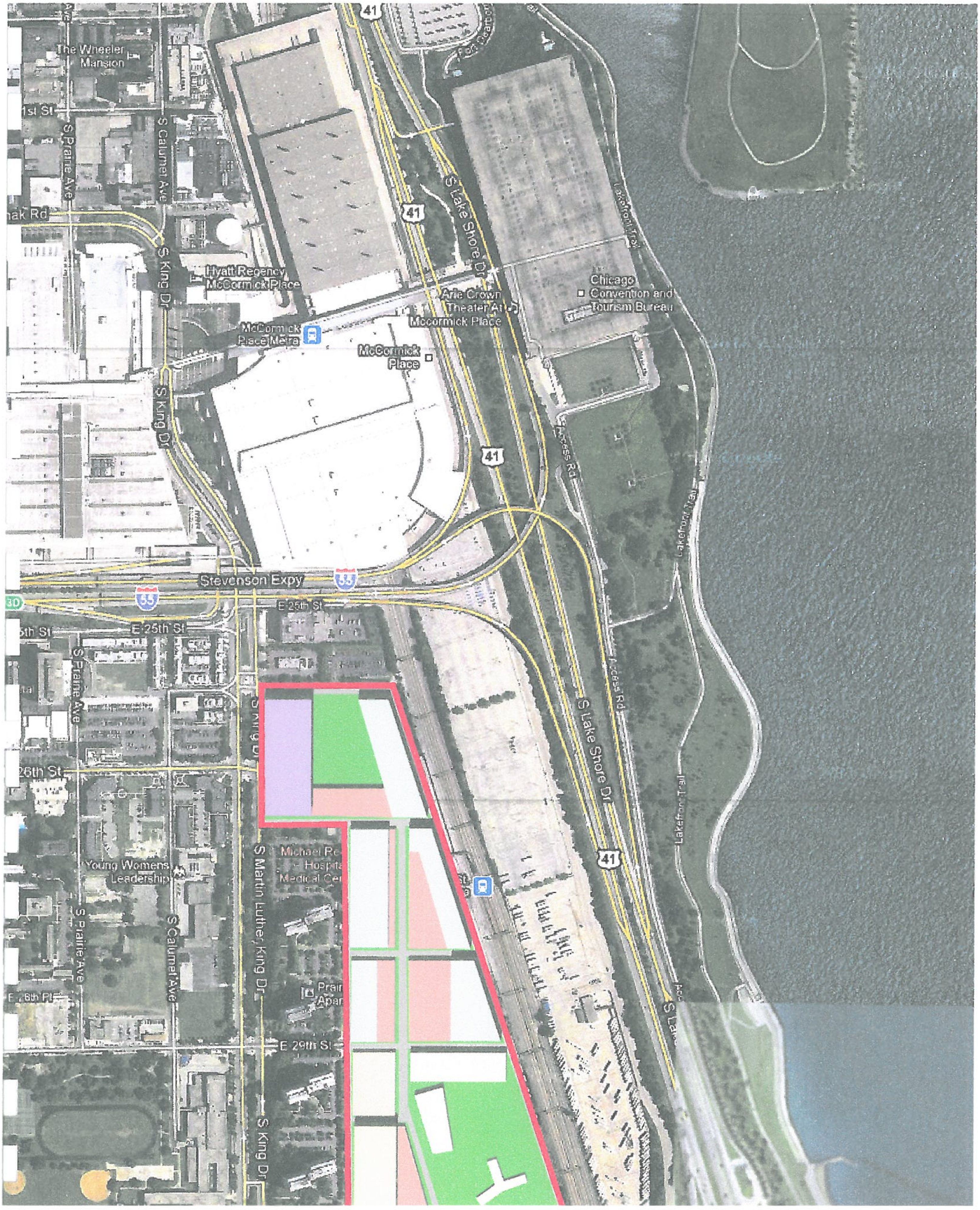
Marty McIntyre	Executive Director at PCI of Illinois and Wisconsin
Chuck Gilbert	Regional Sales Manager at Spancrete Industries
Jon Black	Consultant at The Structural Group
Brenda McGruder	Coordinating Planner for the Chicago Department of Transportation

Our advisors,
Dr. Mark Snyder, Dr. Anatol Longinow, and Steve Beck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The Wheeler Mansion
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S Prairie Ave
S Calumet Ave
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S King Dr
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McCormick Place
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Chicago Convention and Tourism Bureau
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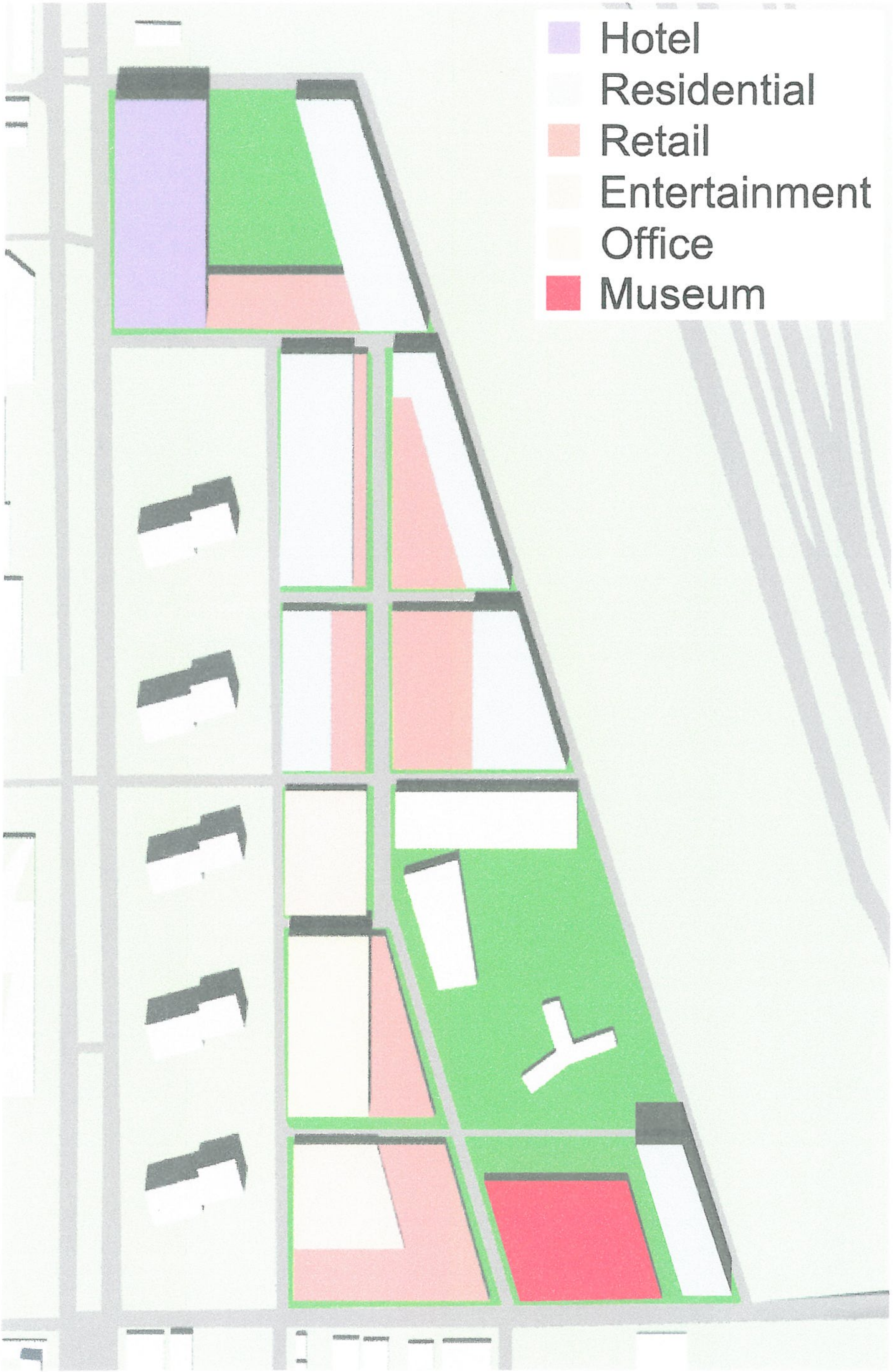
Hotel
Residential
Retail
Entertainment
Office
Museum


Suggested Detour
Existing Route
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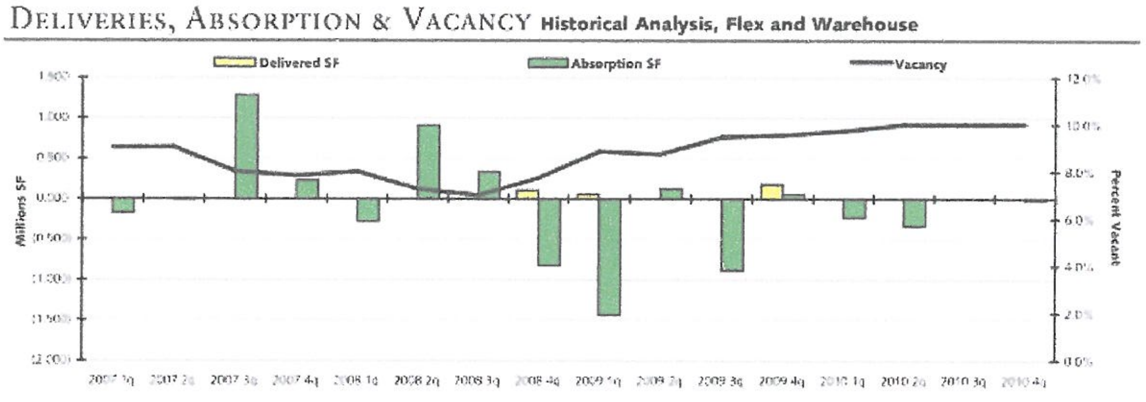
Market Research

Before the team decided to focus solely on the design of the children's museum as an anchor, other anchors were heavily considered to the point of even being included as a joint anchor with the museum. The economic impact of the museum has been made clear, but here is a summary of the real-estate research that helped our decision.

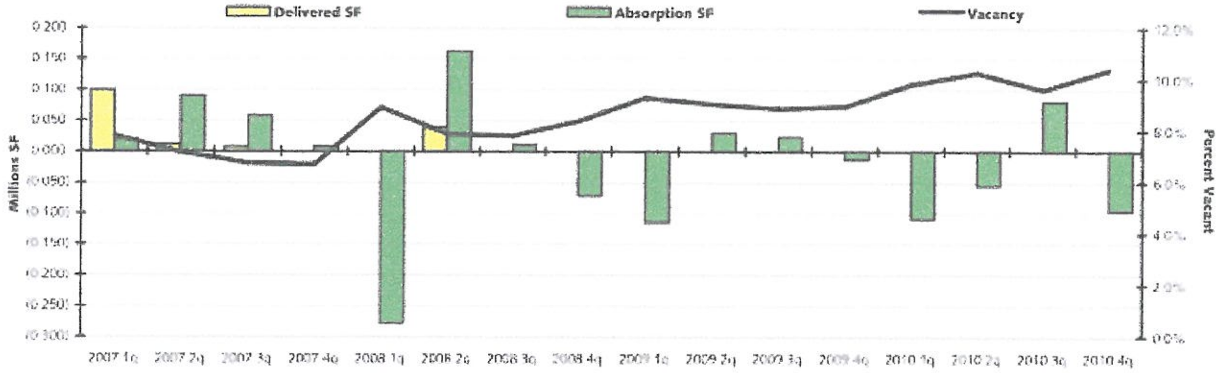
Data was first obtained showing the vacancy trends of a few types of properties in South Chicago. The vacancy rate for one type of property is the ratio of total vacant over the total space in that market. A high or rising vacancy rate can indicate a low absorption or demand and vice versa. Below is a vacancy graph of the industrial property market in South Chicago:



Source: CoStar Property®

The current vacancy rate is around 10% while absorption is near zero. This means there is a low probability of a selling an industrial property in South Chicago right now. The situation is similar for the office market:

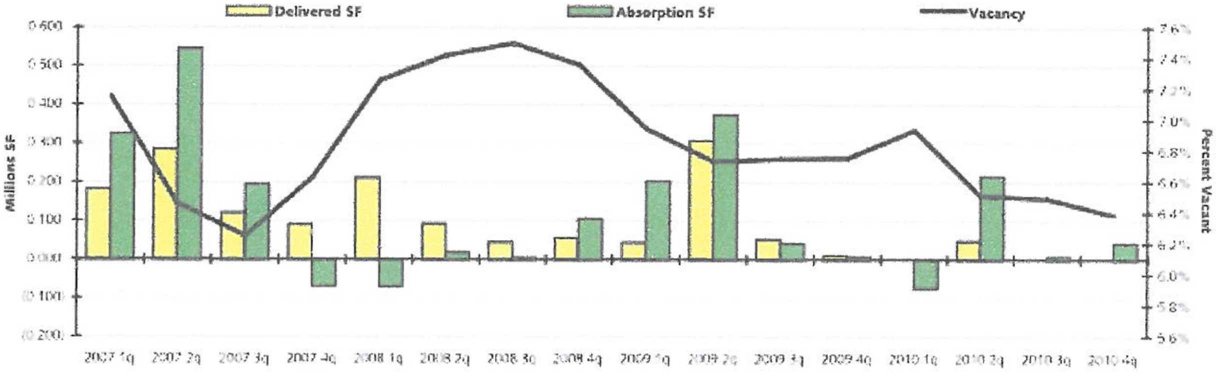
DELIVERIES, ABSORPTION & VACANCY **Historical Analysis, All Classes**



Source: CoStar Property®

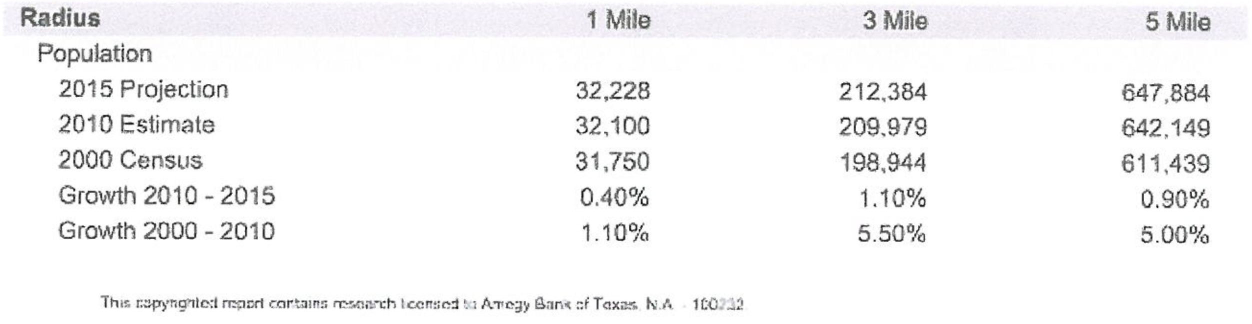
Retail properties however seem to be fairing better (Top of next page). Notice the falling vacancy and positive absorption. Out of industrial, office, and retail properties, retail has the most likelihood of being sold.

DELIVERIES, ABSORPTION & VACANCY **Historical Analysis, All Classes**



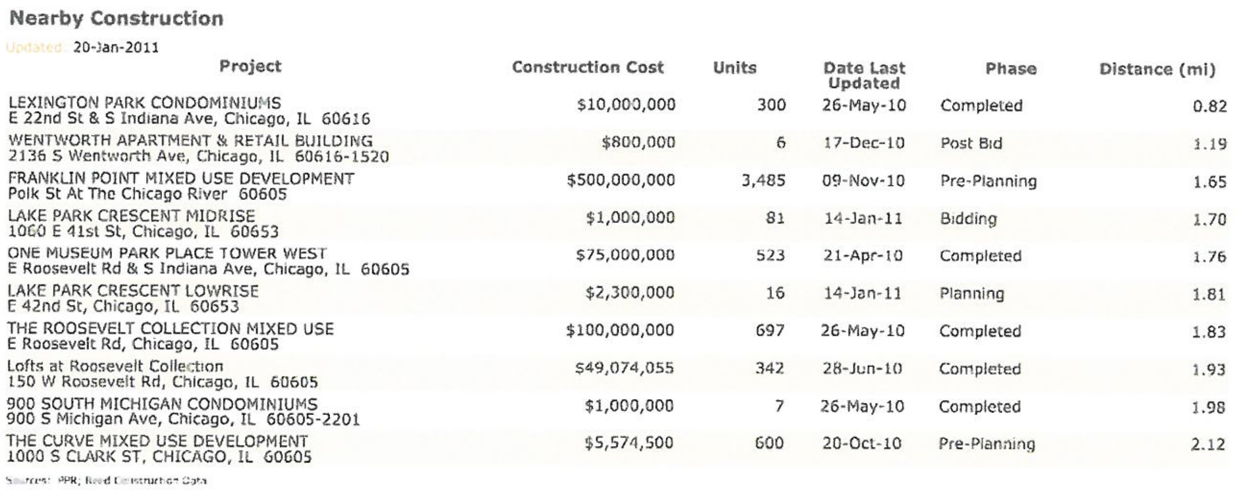
Source: CoStar Property®

I different approach was used to look at residential properties. Below is data from a consumer spending report showing population growth in the area surrounding the proposed development site:



Radius	1 Mile	3 Mile	5 Mile
Population			
2015 Projection	32,228	212,384	647,884
2010 Estimate	32,100	209,979	642,149
2000 Census	31,750	198,944	611,439
Growth 2010 - 2015	0.40%	1.10%	0.90%
Growth 2000 - 2010	1.10%	5.50%	5.00%

Within three miles of our site, the difference between the 2015 Projection and the 2010 Estimate (212,384 – 209,979) equals to 2,405 people. Within three miles of the site, there will be an estimated 2,405 more people. Next, below is list of recently finished and potential future residential developments within three miles to help gauge what will be available to shelter future residents:



Nearby Construction

Updated: 20-Jan-2011

Project	Construction Cost	Units	Date Last Updated	Phase	Distance (mi)
LEXINGTON PARK CONDOMINIUMS E 22nd St & S Indiana Ave, Chicago, IL 60616	$10,000,000	300	26-May-10	Completed	0.82
WENTWORTH APARTMENT & RETAIL BUILDING 2136 S Wentworth Ave, Chicago, IL 60616-1520	$800,000	6	17-Dec-10	Post Bid	1.19
FRANKLIN POINT MIXED USE DEVELOPMENT Polk St At The Chicago River 60605	$500,000,000	3,485	09-Nov-10	Pre-Planning	1.65
LAKE PARK CRESCENT MIDRISE 1060 E 41st St, Chicago, IL 60653	$1,000,000	81	14-Jan-11	Bidding	1.70
ONE MUSEUM PARK PLACE TOWER WEST E Roosevelt Rd & S Indiana Ave, Chicago, IL 60605	$75,000,000	523	21-Apr-10	Completed	1.76
LAKE PARK CRESCENT LOWRISE E 42nd St, Chicago, IL 60653	$2,300,000	16	14-Jan-11	Planning	1.81
THE ROOSEVELT COLLECTION MIXED USE E Roosevelt Rd, Chicago, IL 60605	$100,000,000	697	26-May-10	Completed	1.83
Lofts at Roosevelt Collection 150 W Roosevelt Rd, Chicago, IL 60605	$49,074,055	342	28-Jun-10	Completed	1.93
900 SOUTH MICHIGAN CONDOMINIUMS 900 S Michigan Ave, Chicago, IL 60605-2201	$1,000,000	7	26-May-10	Completed	1.98
THE CURVE MIXED USE DEVELOPMENT 1000 S CLARK ST, CHICAGO, IL 60605	$5,574,500	600	20-Oct-10	Pre-Planning	2.12

Sources: PPR; Reed Construction Data

Counting the units each of these properties will provide, it is apparent that there will be many more residential units available than actual people to fill them. It is likely that some of these will not ever be built, but the low population growth is coupled with vacancy rates of existing residential developments. Below is some info on nearby high rise apartments Lake Meadows and York Terrace:

York Terrace
2701 S Indiana Ave, Chicago, IL 60616

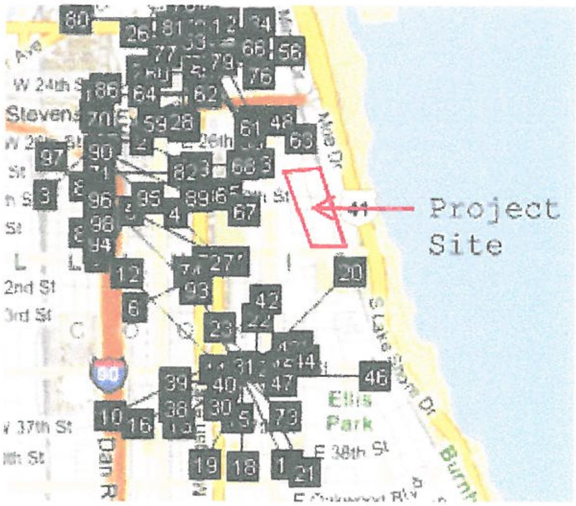
Distance	0.43 mi	**Asking Rent/Unit**	$1,057	**Status**	Stabilized
Built	1969	**Effective Rent/Unit**	$867	**Vacancy**	12.3%
Subclass	HighRise	**Floors**	21	**Concessions**	Reduced Rent
Units	331	**Effective Rent/Sqft**	$1.21		

Lake Meadows
500 E 33rd St, Chicago, IL 60616

Distance	0.56 mi	**Asking Rent/Unit**	$1,005	**Status**	Stabilized
Built	1952	**Effective Rent/Unit**	$890	**Vacancy**	8.3%
Subclass	HighRise	**Floors**	22	**Concessions**	Upfront Discount
Units	1,869	**Effective Rent/Sqft**	$1.20		

These properties are offering concessions to try and offset their vacancies. If this is in indicator of the performance of other properties in the area, it becomes clear that at least for the near future, there is an oversupply of residential units. However, the location of the proposed development may become progressively desirable in the future which may give residential development on the site an edge against other planned residential developments. As an anchor to promote development of the area however, residential, manufacturing, and industrial space would not be feasible.

A retail type property was the most economically feasible choice from a real-estate point of view and the adjacent map of nearby retail properties clearly shows the need in the area, but it was decided that a children's museum would be the better option (discussed in the children's museum impact study section of this report.)



This copyrighted report contains research licensed to Amegy Bank of Texas, N.A. - 100232
Only properties with valid lat/lon display on map

Research Summary: 31st Street Marina Impact

Once finished, the 31st Street Marina (760 slip), which is currently under construction, will bring an extraordinary amount of vibrancy and attraction to the 31st street corridor. As the marina is just a mere 2 blocks from the proposed museum site we expect this project to bring many benefits to the development of Michael Reese Campus. These benefits include:

- Increased traffic throughout Bronzeville region
- Increased tourism throughout Bronzeville region
- Allows for safe, inviting outdoor space within walking distance of the museum
- Creates another attraction for families on day trips
- Introduces the possibility of boat owners and their families to use the museum
- Introduces the possibility of alternative museum programming at the marina

Lake Meadows Master Plan

Stretching from 31st to 35th Streets, between Lake Shore Drive and Martin Luther King Drive, the Lake Meadows Master Plan will rejuvenate the south lakefront; helping to bridge the gap between development in the South Loop, Bronzeville, Kenwood and Hyde Park.

The Vision

- Provide a wide range of quality residential alternatives, including market rate, affordable, and senior housing options; rental and for-sale.
- Enhance retail and dining alternatives for the community.
- Provide employment opportunities for the community (Construction & Permanent).
- Provide well-integrated open spaces and improved connectivity to the Lakefront parks.

Maintaining A Vibrant Community

- Implement a well-designed, long-term plan (20+ years) that provides existing residents the opportunity to stay within the Lake Meadows community.
- Add new residential options before any existing buildings are removed.
- Remove existing buildings slowly, over many years, so residents are given plenty of time to choose an alternative residence.
- Build a wide range of residential properties; providing options for residents of varying financial means, including market rate, affordable & senior housing.
- Provide a priority for existing residents who choose to rent or purchase a new home within Lake Meadows.
- Provide new retail and dining options early and enhance the Town Center over time, as the community grows.

Community Impact

- New 'Town Center' will become a premier retail, dining and residential district.
- Variety of housing options, including market and affordable, rental and for-sale and senior housing will accommodate a wide-range of resident needs.
- Use of multiple architects will ensure diversity of architecture and improve aesthetic appeal.
- Master Plan manages density and promotes vibrancy.

- Master Plan will improve traffic flow by reconnecting the street grid to the broader community
- Additional households will spur retail and restaurant growth.

Parks & Amenities

- The new Lake Meadows Master Plan includes a variety of parks, strategically placed within the community. There will be eight parks in total, including the new 14-acre lakefront park.

Project Summary

- Residential: 7,845 Units
    - Rental: +/- 2,000 units
    - Home Ownership: +/- 5,845 units (Single Family, Townhomes, Condominium)
- Town Center Retail: +/- 500,000 SF
- Parks
    - 8 Parks
    - 15 acres (on-site)
    - 14 acres (Burnham Park connection)
- Job Creation
    - Construction +/- 9,200

- Permanent (Retail) +/- 1,040

South Lakefront Corridor Transit Study

Upon looking at the proposed location of the Chicago Children's Museum, the group felt the lack of adjacent transit stops to the area could be problematic. Fortunately, after some research, we were able to locate a general consensus amongst the Chicago public hoping for necessary improvements of the South Lakefront area. Searching Chicago-based websites, we came across a proposed group of professionals designated to seek prospective CTA improvements for this disconnected portion of the city. The study would consist of market analysis of the area, seeking potential building redevelopment possibilities, and pinpointing the existing transit services and land use as a reference for further transportation development. On April 13th 2011, this group organized an open house for the public to voice their opinions and provide feedback to the initial research results. The overall theme that comprised the feedback portion of the meeting appeared to be over finding a long-term solution. Considering the extent to which people became involved in this concern, there is definitely a large possibility that the plans for redevelopment will be approved by a majority of the taxpayers in the area. Most likely, we can also assume that these new improvements will be beneficial to our own site plans. If these future plans involved connecting certain south side areas of the city to the downtown area, the Michael Reese campus could exist as the transition between the downtown museum campus and the isolated Museum of Science and Industry. Overall, this transit study reinforced the prospective changes in accessibility to the area of focus that could impact visitor/customer counts.

¡imagínate! imagine!

a 31st Street Bus

¿Por qué autobuses en la Calle 31?

El transporte público
crea trabajos, ahorra dinero
y nos conecta a oportunidades
con menos polución que los carros.

Comparte tu historia de CTA en la red
Share your CTA story online
chicagopublictransit.org

- * Hasta la Playa de la Calle 31 y el Campus de Museos
- * Cada 10-15 minutos
- * 5am a 2am

Tu calle, tu derecho a transporte público

- * Route to the 31st Street Beach & Museum Campus
- * Every 10-15 minutes
- * 5am to 2am

Your street, your right to public transportation

LVEJO

Why a 31st St. bus?

Public transit helps
create jobs, save money and
connect us to opportunities
with less pollution than cars.

¿Quieres Participar?

Llama a Mike 773-762-6991
Pasar volantes • llamar a vecinos
organizar juntas • crear arte
ponerte miembro de LVEJO

Want to get involved?

Call Mike at 773-762-6991
pass out fliers • call neighbors
organize meetings • make art
become an LVEJO member

LVEJO

The Little Village Environmental Justice Organizati
2856 South Millard Ave. • Chicago, IL • 60623-45
Phone: (773) 762-6991 • Fax: (773) 762-6993
publictransit@lvejo.org • www.lvejo.org

Why The Chicago Children's Museum?

Relocating the Chicago Children's Museum (CCM) from Navy Pier to the current Michael Reese Hospital site allows for the CCM to tremendously expand its footprint. With the relocation and expansion of exhibit space, the CCM will be able to make a greater positive impact on the economy of the surrounding area and state and be a key leader in the revitalization of Bronzeville.

The table below is from the *Chicago Office of Tourism 2009 Statistical Information* report. As shown, Museums and Art Exhibits rank sixth out of eleven activities enjoyed in Chicago. This beats Concert, Play, and Dance by almost double the amount of responses.

Top Activities in Chicago	
Dining	31%
Shopping	30%
Entertainment	29%
Sightseeing	21%
Museum, Art Exhibit	17%
Night Life	14%
Watch Sports	11%
Concert, Play, Dance	9%
Visit Historic Site	4%
Festival, Craft Fair	3%

Source: D.K. Shifflet & Associates, Ltd., 2010

Statistics of the World's Children's Museums

- 30 million children and families visit children's museums annually
- Children's museums can be found in 22 countries

- ***Sixty-five percent of children's museums are located in urban areas***
- ***Thirty-five percent of children's museums are flagships in downtown revitalization projects***
- Approximately 38 children's museums existed in 1975; 80 more were created between 1976 - 1990; 125 were opened since 1990; finally, 78 children's museums are in the planning phase
- Forty-nine percent run after-school programs

The data in this section is provided by the Association of Children's Museums. www.childrensmuseums.org

The Impact

- **Economics**

A museum contributes economically to a region in various ways. It acts as a consumer of local goods and services including purchases for the daily operation of the museum (including office supplies, repairs, utilities, landscaping, food, etc.). A museum also serves as an attraction to tourists. Visitors from outside the region will spend money beyond the museum at hotels, restaurants, and local stores. A museum is also a source of new jobs for local residents. New jobs provide a direct benefit to the region, as does the added local spending from these workers. Lastly, a museum can be an incentive for new businesses and individuals searching for new locations by increasing the quality of life in the region. (Information provided from the Cincinnati Children's Museum.)

Types of economic impacts made from a children's museum are clearly explained in *The Economic Impact of Omaha Children's Museum on the City of Omaha, 2006 – 2009.* These impacts are identical for the Chicago Children's Museum. Below are the report's findings:

Direct Economic Impacts

Spending by OCM visitors has direct economic effects on their local economies by making expenditures for goods and services and by paying employee salaries. The most obvious direct expenditures are payment of wages to workers employed by OCM. In addition, expenditures by business visitors to OCM produce direct impacts on the region, affecting primarily the wholesale and retail trade industries. Direct economic impacts are color coded blue in Figure B.1.

Indirect Economic Impacts

OCM also produces indirect economic effects on the area economy. OCM generates indirect effects by increasing: (a) the number of firms drawn to a community, (b) the volume of deposits in local financial institutions and, (c) economic development. Examples of indirect economic impacts are color coded yellow on Figure B.1.

Induced Economic Impacts

Induced impacts in the region occur as the initial spending feeds back to industries in the region when workers in the area purchase additional output from local firms in a second round of spending. That is, OCM increases overall income and population, which produces another round of increased spending adding to sales, earnings and jobs for the area. Examples of induced economic impacts are color coded pink in Figure B.1.

On a national scale, museums are economic engines:

- Museums employ 400,000 Americans according to American Association Museums
- U.S. museums contribute $21 billion to the American economy each year (2008 estimate), encouraging economic growth in their communities.
- Museums rank among the top three family vacation destinations.
- Trips including cultural & heritage activities comprise one of the most popular and significant segments of the travel industry, accounting for 23% of all domestic trips.
- Visitors to historic sites and cultural attractions, including museums, stay 53% longer and spend 36% more money than other kinds of tourists.
- Quality of life issues contribute significantly to decisions businesses make in choosing to relocate, including access to cultural resources that includes a dynamic museum community.

  http://www.museum4kids.net/Economic_Impact_Statement-Children's-Museum_Utica-NY.pdf

- **Relocating the CCM to our site will significantly increase the quality of life in the neighborhood.**

  When responding to a series of statements about local museums derived from the literature review there was strong agreement that local museums:

  - develop pride in local traditions and customs
  - play an important role in tourism
  - should have exhibitions relevant to the local area
  - help people feel a sense of belonging and involvement
  - involve people in local projects

  - promote contact and cooperation across different cultures
  - develop community and social networks
  - develop contact across different age groups.

- **A new and improved CCM can increase tourism to Chicago.**

  "The Children's Museum plays a significant role in attracting visitors to Central Indiana. When out-of-town tourists visit family and friends, they may also visit The Children's Museum. That visit to the museum increases their local spending and can extend the length of their stay in the region. In addition, the museum's presence also assists in keeping local residents from going elsewhere for a trip. The retention of their spending generates real economic development for Central Indiana," said Jeffrey H. Patchen, president and CEO of The Children's Museum of Indianapolis.

Summary of A Children's Museum Impact		
	Economic	**Community Attractiveness**
Direct involvement	Wages paid to employees	Increases sense of collective identity; Builds social capital; Learning opportunities
Audience participation	Tourists spend money at local venues	Builds community pride; Personal interaction of diverse individuals
Philanthropic and government support	Brings new dollars to the community from area non-professional users of the facility	Matching funds provide a multiple of the initial gift or grant

Why the Michael Reese Site for Relocation?

In 2006, the Chicago Children's Museum began their battle to relocate to Grant Park in downtown Chicago. Once word got out, many strong opposing views surfaced. These views include many valid reasons as to why the CCM should not relocate to Grant Park.

- **Restrictions of Grant Park**

  Fourteen learning and play experiences make up the museum galleries, which are placed along a spiraling series of ramps and level floor areas.

  http://www.archdaily.com/113130/chicago-children%E2%80%99s-museum-krueck-sexton-architects/

- **Future expansion**

  "The CCM currently ranks 31 out of the top 50 children's museums in the U.S. With more space to expand their exhibits they will be able to increase their ranking."

  http://www.parents.com/fun/vacation/us-destinations/the-10-best-childrens-museums/?page=13

  The current location at Navy Pier and planned location at Grant Park both limit the amount of expansion of the CCM in future years. The location at Navy Pier is limited by establishments that directly surround it and by the actually width of the pier. At Grant Park, the proposed building is planned to be constructed underground in an existing portion of a parking garage. This leaves little room to expand considering their only option for increasing size is horizontally underground.

- **Bronzeville currently needs more economic improvement than Grant Park**

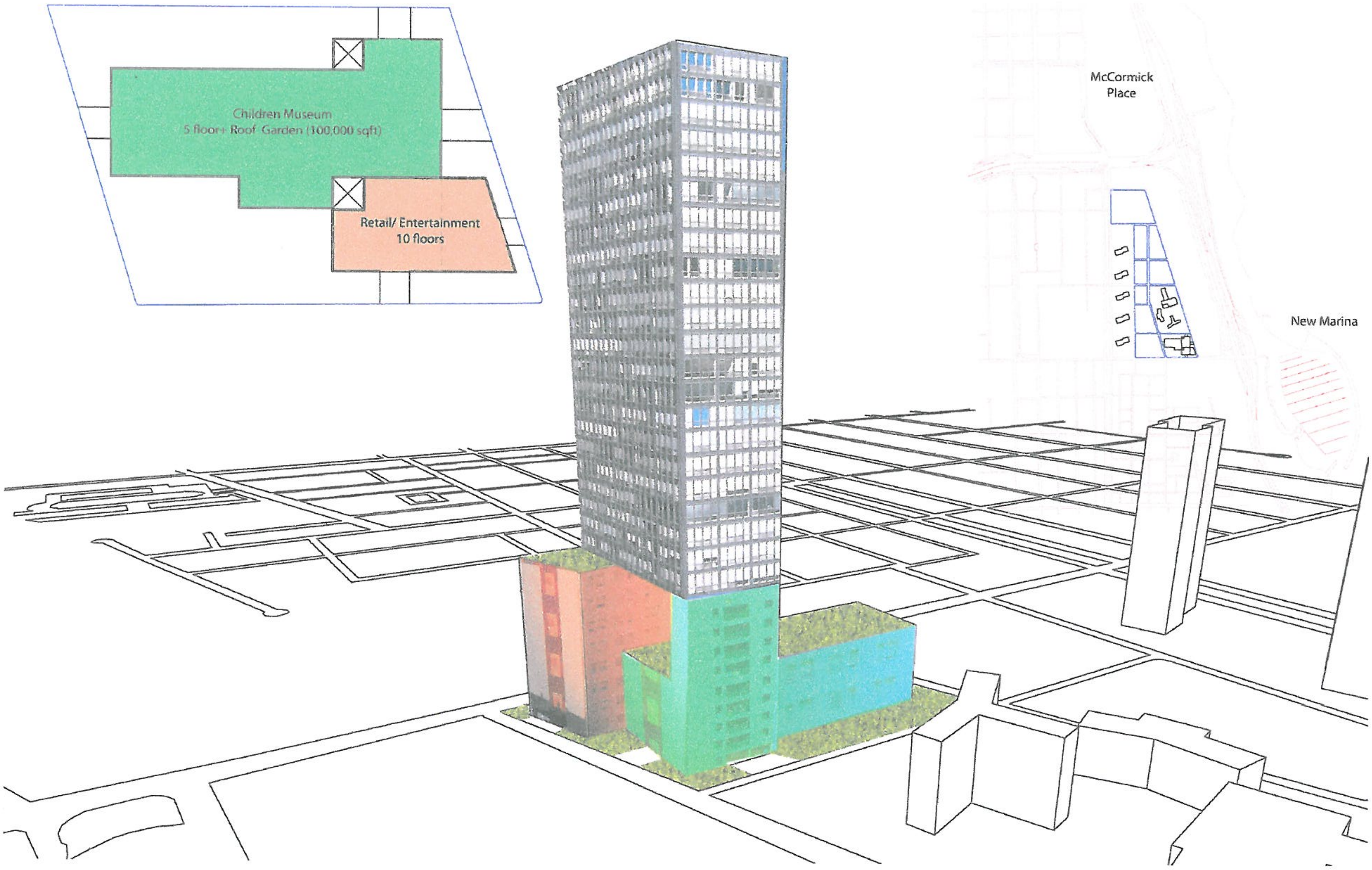
Children's Museum's mission is to create a community where play and learning connect. The museum's primary audiences are children up through fifth grade including their families, along with school and community groups that support and influence children's growth and development. In its current location at Navy Pier, the Museum lacks meaningful connections to the outdoors and is challenged with the heavily commercial environment of what has become Illinois' most popular tourist attraction. http://www.archdaily.com/113130/chicago-children%E2%80%99s-museum-krueck-sexton-architects/

- **Possible Relocation Sites:**

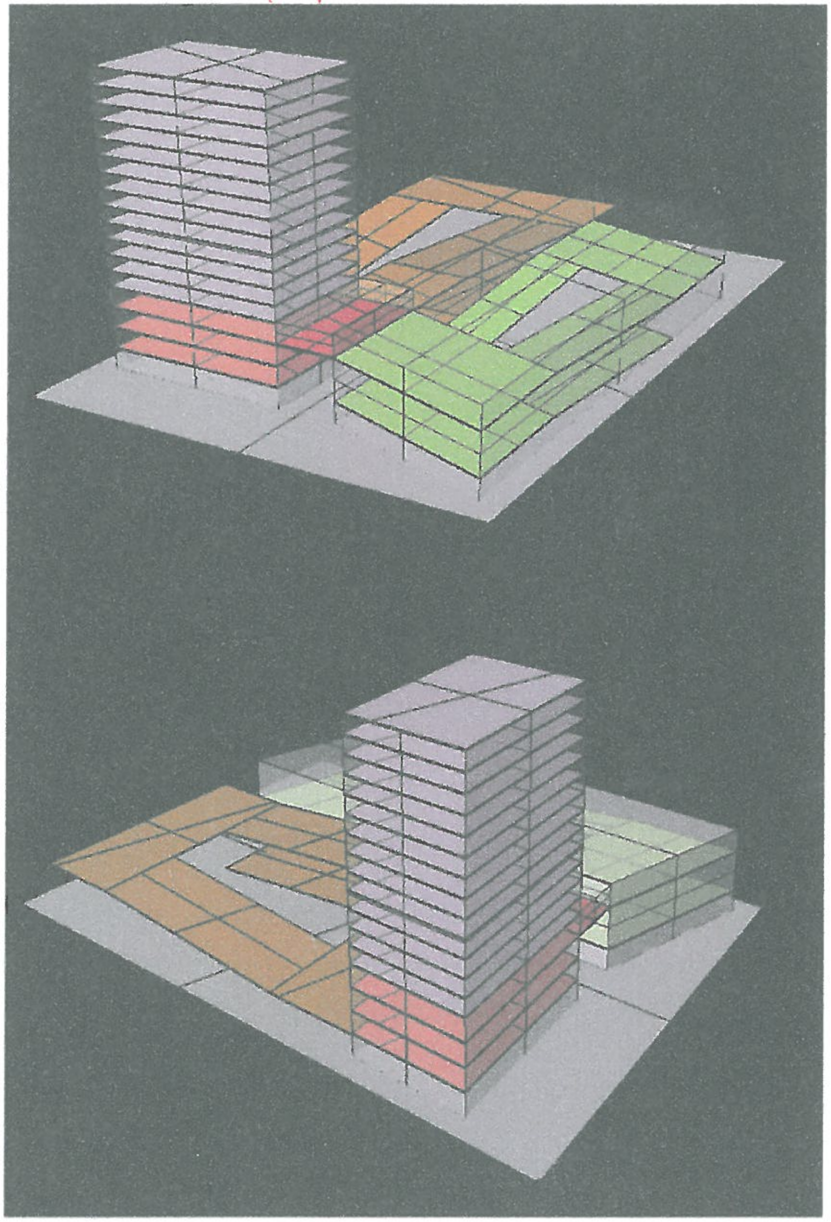
Here are the alternative sites Ald. Brendan Reilly (42nd) suggested for a new Children's Museum: http://forum.skyscraperpage.com/showthread.php?t=149735

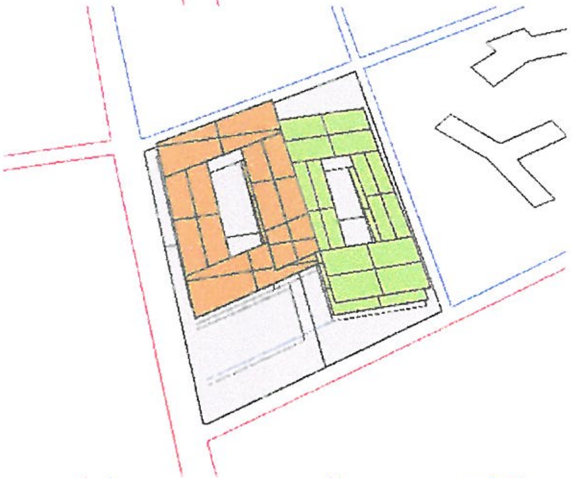
  - Northerly Island
  - Logan Square
  - Garfield Park Conservatory
  - Pritzker Park
  - **Bronzeville**
  - Calumet Park
  - State and Van Buren
  - Chicago Riverwalk (South Bank at Lake Michigan)
  - Michigan and Roosevelt (South Loop)
  - Notebaert Nature Museum (Lincoln Park)
  - Lincoln Park Zoo (adjacent to zoo)
  - Old U.S. Post Office

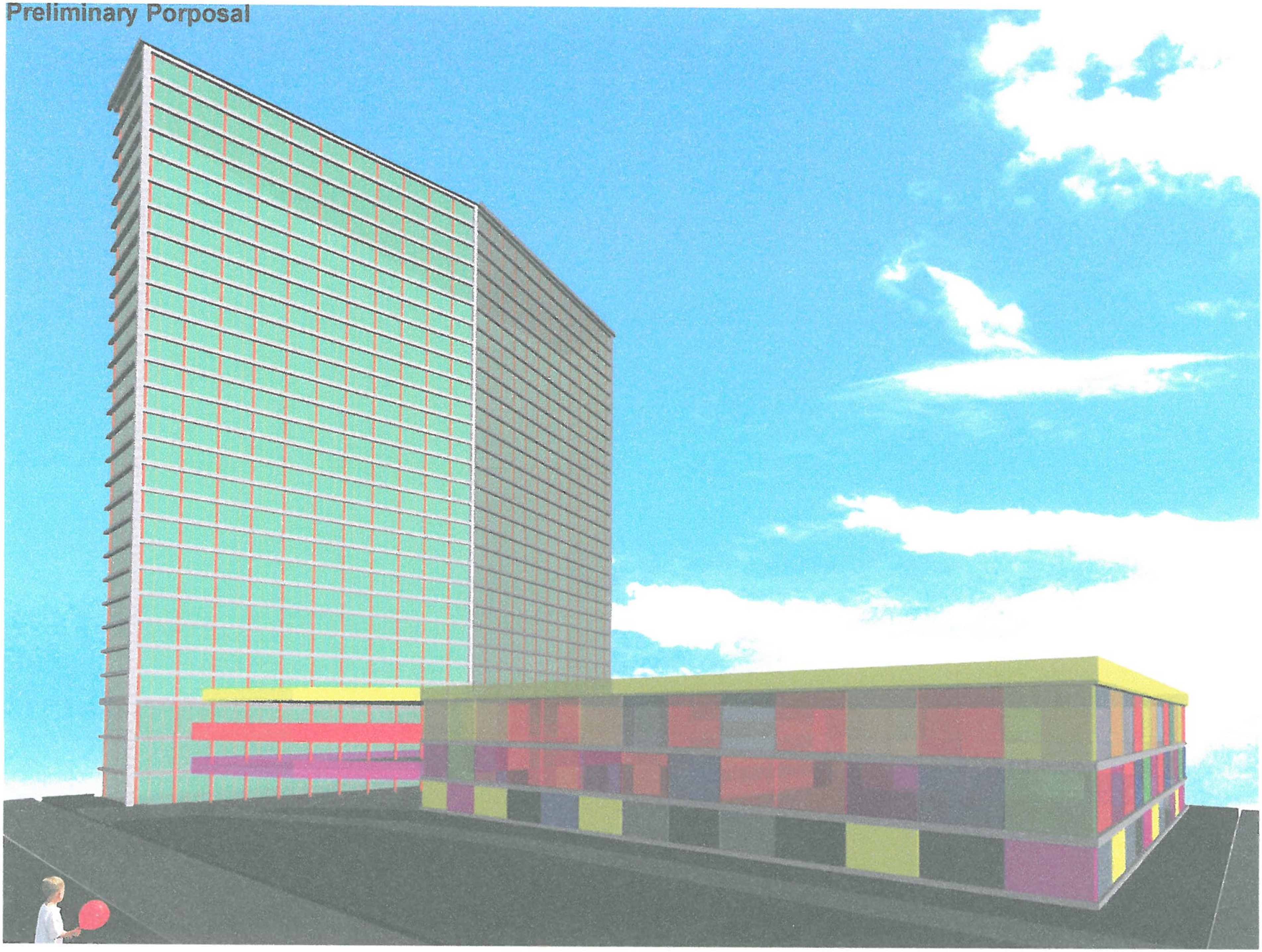
Preliminary Porposal



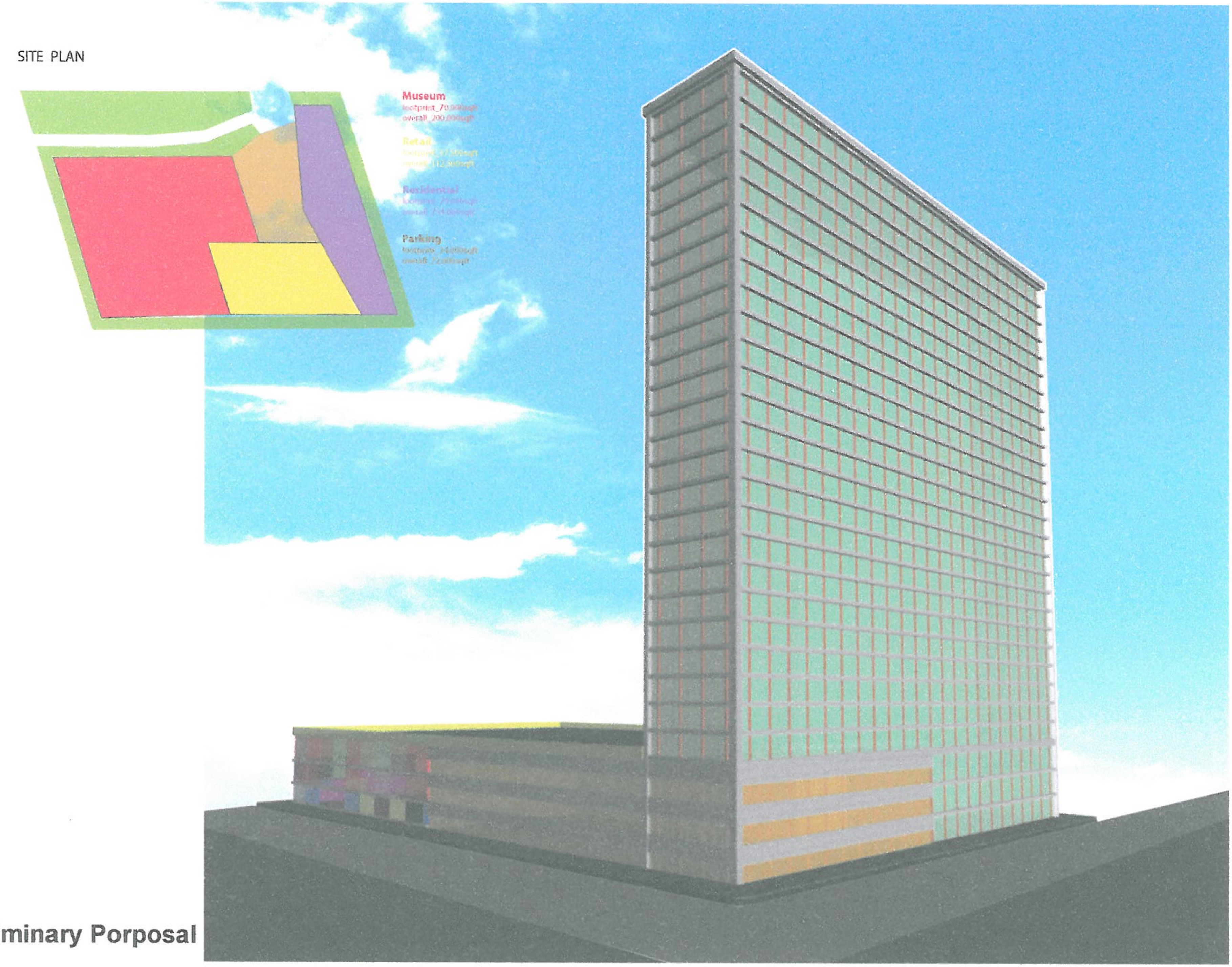
Preliminary Proposal





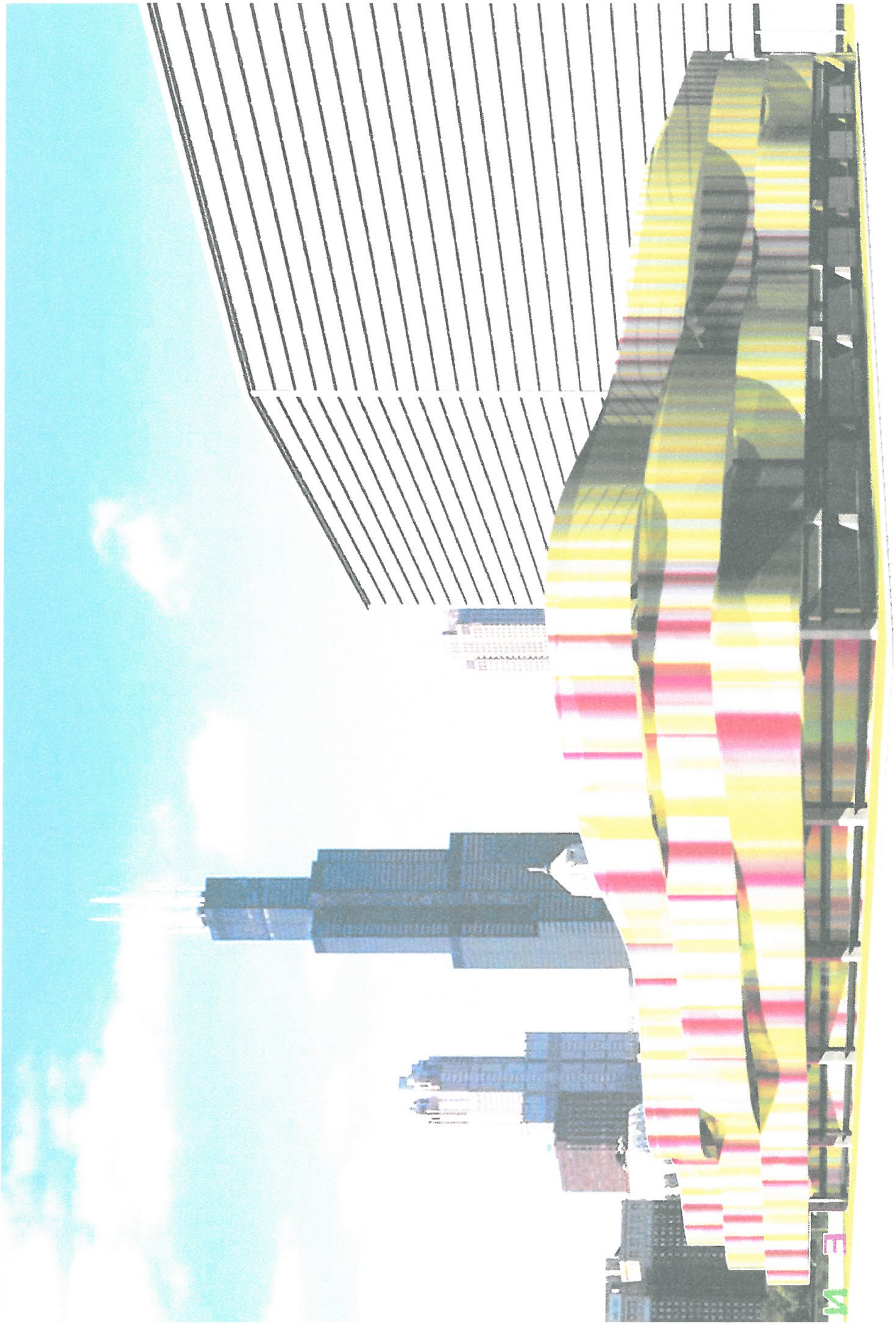

Preliminary Porposal

SITE PLAN



Preliminary Porposal


CHICAGO CHILDREN MUSEUM
CHILDREN



BUILDING FUNCTIONALITY

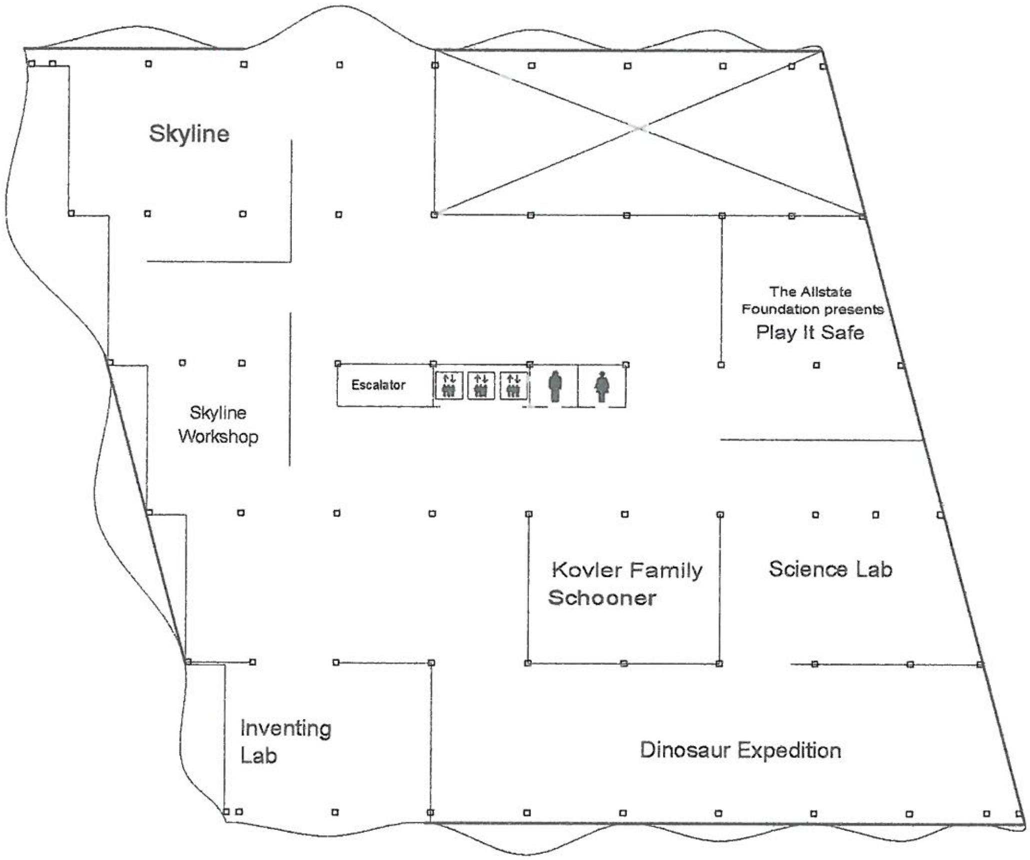
The building comprises of programs that are currently existing in the Chicago Children Museum located at Navy Pier. We have, however, increased the square footage of each program by at least thrice the current Chicago Children Museum while also adding other programs that currently doesn't exist in the current one at Navy Pier. The first floor of the museum serves as an intermediate zone between the parking lot in the basement and the second to fourth floors of the museum spaces. The front half of the museum's first floor comprises of the museum store, Kraft gallery, and a double floor height open lobby with an aquarium and a welcoming lobby. Once tickets are purchased at the ticket booth, visitors have the option to either check-in their coats or simply become immersed by the exciting activities of the museum. The second half of the first floor has a cafe/ restaurant area for the museum visitors. The cafe/ restaurant space is located on the first floor in order to have easy access to service cores, and drop off zones. Lastly, the Great Hall and performance space is also located on the first floor in order to have easy access to service core for the assemblage and disassemblage of performing equipment and stage sets. The Great Hall is scheduled to have hourly performances that cheer up children and their parents.

The second and third floor of the Children Museum consist of fun activity spaces such as the Skyline Workshop where children and their parents participate in building the tallest miniature skyscraper while learning how structural members function in unity. The Dinosaur Expedition explores the re-creation of the real Saharan expedition where Chicago paleontologist Paul Sereno discovered a NEW type of dinosaur. Children see a life-size skeleton of suchomimus (sue-co-MY-muss), dig for bones in the excavation pit, compare skulls, teeth, and claws with a T-Rex, and learn what it would be like to be part of Paul's expedition team. Some of the other fun activities in the Children Museum include the followings: Play it Safe, Kovler Family Schooner, Science Lab, Inventing Lab, Big Backyard, Rain Forest Trail, Water Ways, Early Learning Exhibits. The activities within the Children Museum were planned out in a fluid manner due to the flexibility that the core system affords in the design. The museum has a core system that consists of escalators, elevators, classroom, restrooms and mechanical and electrical service space. Hence, having all the service oriented programs in a compacted core free up spaces in the museum for the maximization of potential children activities. The core arrangement also allows selected views to the surrounding cityscape of the museum.

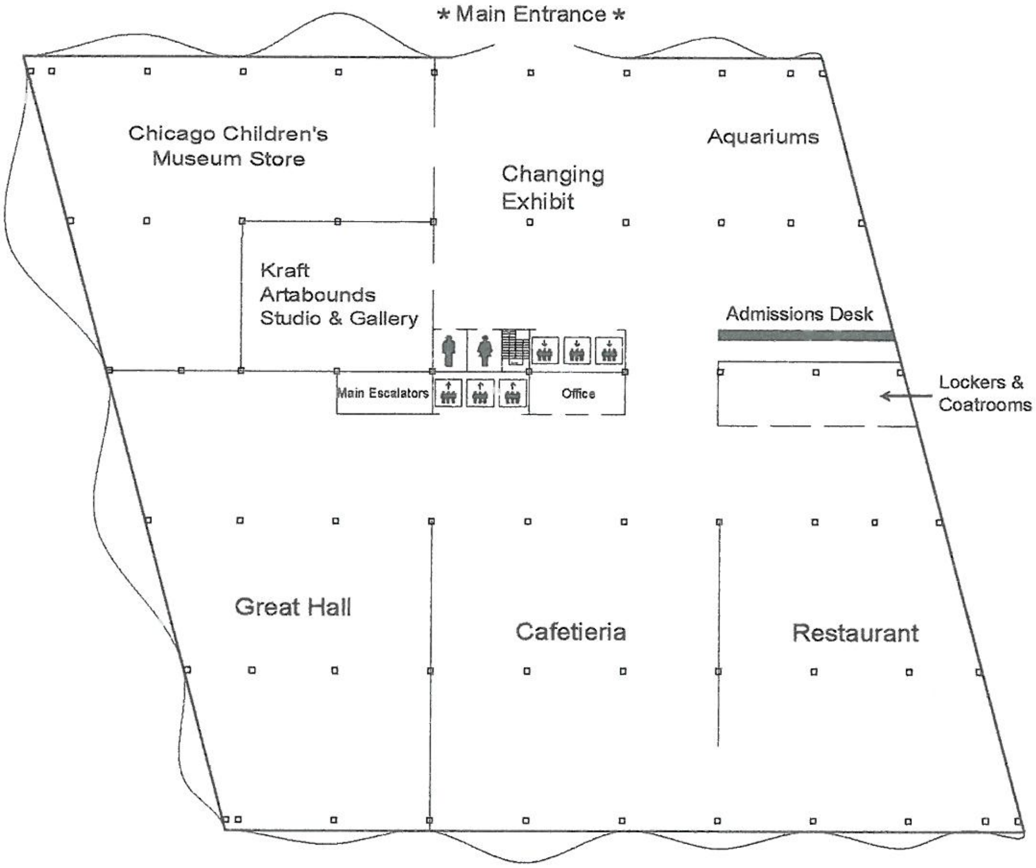
Lastly, the fourth floor consist of a general indoor playground which directly flows into the gorgeously planted roof garden. The roof garden is an attempt to connect the children with the nature that rarely exists in an urban context like the city of Chicago.

Welcome to Chicago Children's Museum!

at Michael Reese Campus



2nd Floor

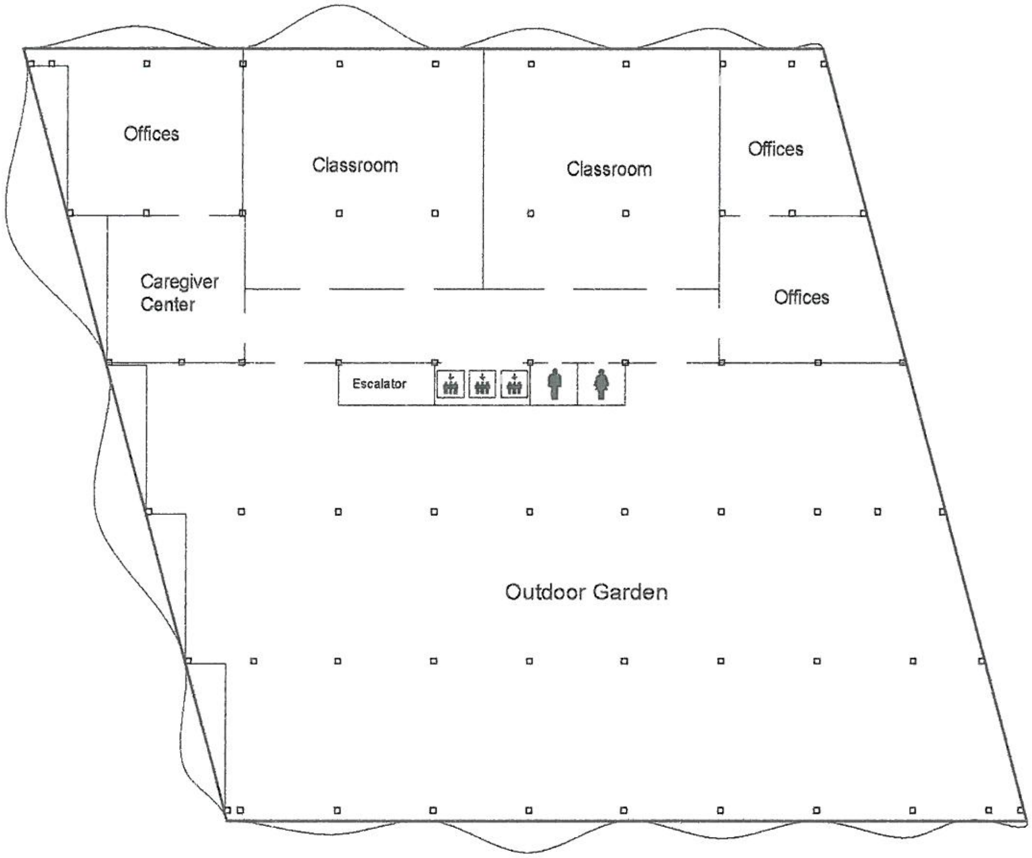


1st Floor

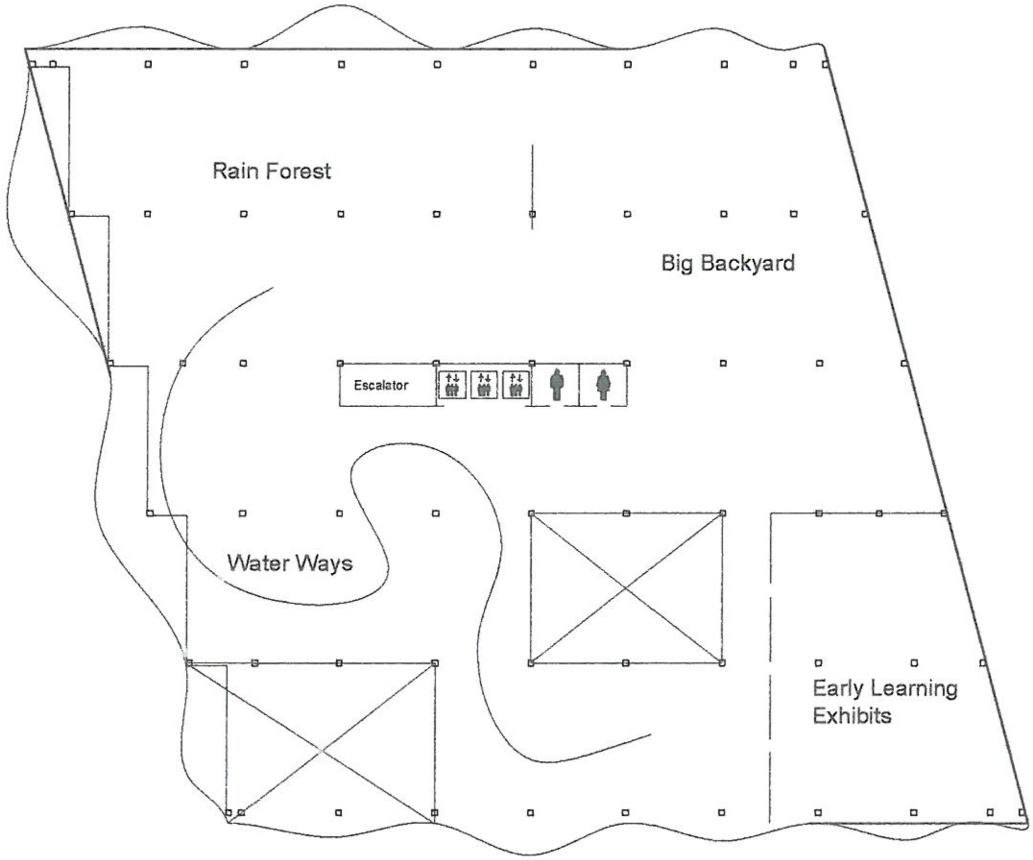
CHICAGO CHILDREN'S MUSEUM
at Michael Reese Campus

Welcome to Chicago Children's Museum!

at Michael Reese Campus



4th Floor



3rd Floor

Structural Design

Jocsan Martinez, Masnaga Masnaga, Omar Medina

Introduction

The structural group was assigned the task of developing a structural system that would be cost effective and suitable for a Children's Museum. To do so, the group first investigated the types of systems currently used in construction and chose the most appropriate system based on subject matter expert advice. Through a combination of hand-calculations and computer applications like SAP 2000 and AutoCAD, the structural group was able to create an overall structural layout that best fits this type of building.

Structural System

The system chosen was appropriated based on subject matter expert advice. Representatives from the Precast/Prestressed Concrete Institute (PCI) advised the group on the reduction in costs that come with designing a building using precast/prestressed members and its applicability to the building use. Some of the benefits with using precast/prestressed concrete are: a reduction in project time by one third as compared with regular, reinforced concrete which attributes to about 1 month of construction time saved based on the museum building size; monetary savings of about one third as compared with regular, reinforced concrete since precast/prestressed concrete can be assembled in any weather, quality control is guaranteed by the precaster, and connections are simple and fast to affix. Furthermore, the use of precast/prestressed members for the museum is superior to using steel since steel requires additional fire-proofing costs and is not cost effective for the elevated spans required by the building type. Refer to Appendix S-2 for a list of Subject Matter Experts and their contact information.

Using a precast/prestressed handbook provided by the PCI representatives, the structural group designated the member types and sizes for the museum. Additionally a space frame was made to provide a visual/conceptual view of the structural system. Refer to Appendix S-1 for space frame details and S-3 for Precast/prestressed concrete member calculations.

Shear Wall

In order to simplify the design of the space frame for the museum, it was decided that shear walls would be required to handle all lateral loads induced by the wind. The wind load on the building was based on the American Society of Civil Engineers (ASCE-7) design standards. Refer to Appendix S-5 for details of the wind load calculation. As a preliminary design, two shear walls were appropriated for the building and found adequate to handle all induced lateral loads. Refer to Appendix S-4 for a detail design of the Shear Walls.

Roof Design

Traditionally, roof design gravity loads are significantly lower than the loads applied on all building floors. However, for the purposes of the museum it was decided that the building roof would be a designated green roof and accessible to the museum patrons. Thus, the roof was designed with the same elevated gravity loads acting on all floor spaces. Refer to Appendix S-5 for details on roof design loads standards.

Footings/Retaining walls

The footings for the building were designed using regular, reinforced concrete. The use of precast/prestressed concrete is not applicable to footings since they are susceptible to corrosion caused by direct contact to soil/water. Refer to Appendix S-6 for details on the footings design calculations. Similarly the retaining walls were also designed using regular, reinforced concrete. Refer to Appendix S-7 for details on the retaining wall design calculations.

Serviceability

The serviceability requirements for the museum were deemed adequate based on calculations from the PCI and ACI Design Standards. Refer to Appendix S-8 for the American Concrete Institute (ACI) maximum deflection standards and Serviceability design calculations.

Transportation/Parking Layout

The location of the parking for the museum was decided based upon knowledge from the previous IPRO projects. Based on the master plan for the site, a need for a high density, urban feel is required. Thus the parking for the facility must not take additional land use than the appropriated square footage for the museum. In order to make certain of this, the parking was designed beneath the building. Based on the Chicago Municipal code, a required amount of parking spaces was determined and satisfied by the parking layout. For structural purposes, the column grid was designed to fit the parking layout which would enable the use of appropriate clear spans as dictated by the architectural group. Refer to Appendix S-9 for details on the parking layout design.

Facade Support

For purposes of aesthetics and interior climate control, the Architecture group developed a design for a double skin façade sorrounding the North, West, and South portions of the building. It was then the task of the structural group to develop the supports of the façade using steel composite members. Refer to appendix S-10 for details on the façade support calculations.

Conclusion and Cost Estimate

The group began designing portions of the system to develop a cost estimate through R.S. Means and with the assistance of a PCI representative. The final cost for the structural estimate came out to be $22 million. While this value is high, the estimation required some approximation due to limitations of the program. For more details and the final cost estimate spreadsheet, refer to Appendix S-11.

HVAC Design

Nathan Miller and Linnea Fraser

Introduction

The architectural engineering group was assigned the task of finding a cost effective and efficient HVAC system for the Children's Museum. Due to strict requirements by ASHRAE for this type of building, the group had to be careful not to undervalue the effect of this system on occupants overall health and well-being. Through two different resources, the group felt they would be able to provide a reasonable estimate for the largest and most energy consuming mechanical units in the proposed Children's Museum.

HVAC Load Explorer program

For some of the initial calculations, the architectural engineering group employed the help of HVAC Load Explorer offered in the Wiley Student Companion Site of McQuiston's 6th edition of *Heating, Ventilating, Air Conditioning Analysis and Design*. This program allows the user to input data for various sources and convective mediums of heat to receive a total cooling and heating load output for the overall building through the heat balance method. Once the architects and structural engineers provided the group with details on the building, the group researched the recommended values in the ASHRAE's *2009 Handbook of Fundamentals*. The values were compared the Chicago Building Code to gather the most restrictive data for this particular building.

In the program, each zone is comprised of the entire floor area for each story of the building. Typically, the floor would be broken up into various zones and rooms, but considering the current lack of details in interior spaces, we decided to only account for the shell of the building. The heat sources that were considered included the lighting, the occupants, the radiation and convective heat transfer from the exterior walls and the floors and roof. Ventilation and infiltration rates were also taken into account for the loads. Based on ASHRAE Standard 62.1-2007 values for a children's museum, we were able to provide default occupancies per floor to be 40 people/1000 sq. ft. with an expected outdoor ventilation rate of 7.5 cfm/person. While the exterior wall of the building was divided based on directional orientation, three of the four walls contained the same wall construction, a spandrel glass curtain wall with 2 in. insulation. The shear wall on the east end was comprised of a 12 in. precast concrete slab. The roof was assumed to be a concrete slab with insulation and each floor was a metal decking and raised floor. The properties of these wall constructions were found in ASHRAE's *2009 Handbook of Fundamentals* and in the 6th edition of *Principles of Heating, Ventilation, and Air Conditioning* tables found in Appendix H-2. The final loads and air supply rate were found and are provided in Appendix H-3.

RTS Calculation Spreadsheet

The heating and cooling requirements of the museum were calculated with the help of a Radiant Time Series spreadsheet included with *Principals of Heating, Ventilation, and Air Conditioning*, 6th edition, based on the *2009 ASHRAE Handbook-Fundamentals*. Each major factor of internal heat gains and building transmission is represented by separate sheets with tabs named accordingly. Since the layout of the building was constantly changing, calculations were made for the entire building with heat transmission calculations being made for the entire building shell.

Heat transmission through the floor was calculated manually and added to the final tabulation. The entire floor was assumed to have an R value of 15 which was derived from Energy Star's Recommended R-Values. The specific details on values found to use in the spreadsheet are provided in Appendix H-1. With more opportunities to provide relevant details from the building design, the architectural group felt that the RTS spreadsheet displayed a more realistic capacity for the HVAC equipment.

HVAC Equipment Design

The chiller, boiler, and air handling unit were chosen in accordance to the cooling or heating load requirements of museum. The basic calculations are provided in Appendix H-4. A table of recommended fan speeds in fpm based on air rates in cfm was used to assign the main duct fan speed. The main duct air rate was divided by the fan speed to obtain the face area of the main duct. The terminal branch duct face areas were also obtained based on recommended values. A table of average weight per length of aluminum ductwork was used to obtain the weight per length of ductwork based on the average face area of the main duct and terminal branch ducts. Looking at the plans of the museum, a rough network of ductwork was drawn with consideration for all rooms and program areas. The total length of ductwork was measured and multiplied by the previously obtained weight/length ratio of ductwork to obtain the total weight of ductwork. The weight of aluminum could then be directly counted in R. S. Means Costworks. Costworks includes the cost of fittings, joints, supports, and allowance for flexible connections with the weight of ductwork. The insulation cost was based on the surface area of the ductwork and taken from the average face area of the duct assuming a square dimension. The amount of supply and return grilles was taken from average air throw distance based on supply air rates.

Conclusion and Cost Estimate

Through careful consideration and project comparisons the architectural engineering group was able to calculate out some of the larger units of this mechanical system and even some of the duct work within relation to the units. The calculations were computer generated due to extensive methods that required numerous values from the ASHRAE Handbook based on this specific project design. Detailed research was conducted to generate the best possible units that would work efficiently and require little maintenance over a large period of time. The units and ductwork were added to the cost estimate in Costworks to give a final cost estimate of about $4 million. A detailed item report of the cost estimation is provided in Appendix H-5.

Square Foot Estimate

Nathan Miller and Linnea Fraser

Cost Summary

A square foot estimate was found using the data in R.S. Means Costworks by proportionally adding the different components to their respective building type. While this method is unconventional in the construction field, the limitations on building types in the program made it impractical to generalize this particular building. The unique square footage and building requirements applied to multiple building types including a restaurant, elementary school, community center, an auditorium and a retail store. A seventy-five percent increase in the median unit cost was applied to account for multiple story construction. The percentage of area per building type was determined by a schematic layout provided by the architects in addition to subjective decisions by the architectural engineering group. The overall final project cost came out to be $59,408,869.32 with the included cost of an underground enclosed parking garage square foot estimate of $8,479,500. While this value is considerable close to similar estimates of Children's Museums, the actual value will vary due to the addition of internal costs. Please see Appendix C for more details.

Structural Appendix Outline

S-1: Space Frame
S-2: Subject Matter Expert Contact Info
S-3: Prestressed/Precast Concrete Member Calculations
S-4: Shear Wall Design Calculation
S-5: Wind Load Design Calculation
S-6: Footing Design
S-7: Retaining Wall Design
S-8: ACI 318-08 (Serviceability)
S-9: Parking Layout from AutoCAD
S-10: R.S. Means cost estimate spreadsheet

HVAC Appendix Outline

H-1: ASHRAE tables
H-2: RTS Spreadsheet
H-3: HVAC Load Explorer Calculations
H-5: HVAC Equipment Calculations
H-6: R.S. Means cost estimate spreadsheet

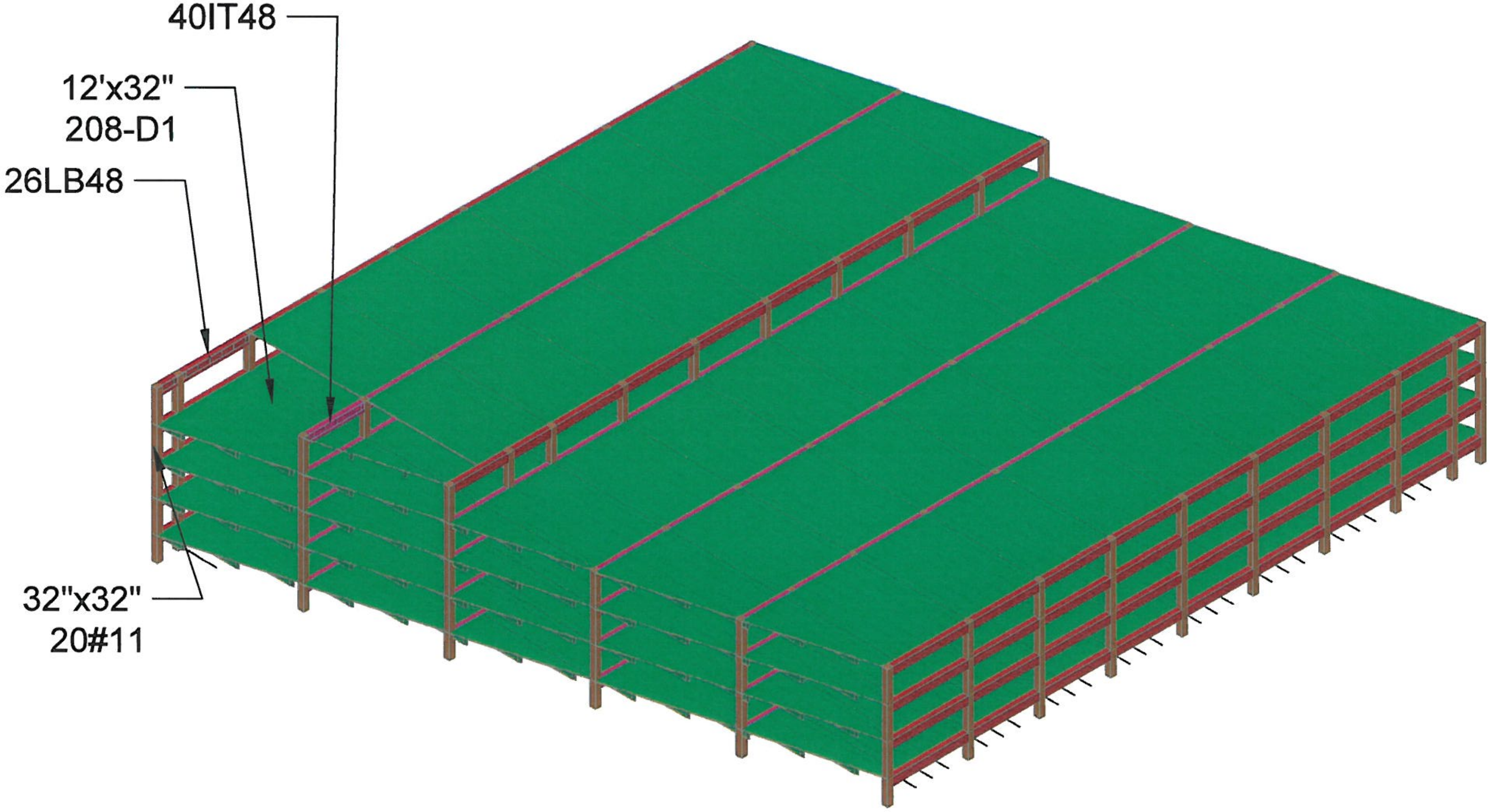
Square Foot Cost Outline

C-1: Underground Parking Garage Cost
C-2: Overall Building Cost Spreadsheet

APPENDIX: STRUCTURAL (S-1)

Space Frame

IPRO359 Spring 2011



ILLINOIS INSTITUTE OF TECHNOLOGY
CHICAGO, ILLINOIS

CHILDREN'S MUSEUM PRELIMINARY STRUCTURAL LAYOUT

Dn By: Masnaga Masnaga	IPRO 359 - MR DEVELOPMENT	
Ck By:	App By:	Sheet #:
Scale: NONE	Date: 03/29/2011	1 of: 1

APPENDIX: STRUCTURAL (S-2)

SUBJECT MATTER EXPERT CONTACT INFORMATION

Proj: SME Contact INFO **Page:** 1/ **Date:** 4/25/2011
Cals by: Jocsan Martinez **Checked by:**

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APPENDIX: STRUCTURAL (S-3)

PRESTRESSED/PRECAST CONCRETE MEMBER CALCULATIONS

IPRO359 Spring 2011

Prestressed Concrete

All members are designed based on building code requirement for structural concrete (ACI 318-08), chapter 18.

General

The code specifies strength and serviceability requirements for all concrete members, prestressed or nonprestressed. All load stages that may be critical during the life of the structure, beginning with the transfer of the prestressing force to the member.

There are several structural specific issues that must be considered in design:

ACI 318-08
18.2.3 ... stress concentration
18.13 ... requirements for post-tensioned anchorages
18.2.4 ... Compatibility of deformation with adjoining construction.
18.2.6 .. Section properties.

Design assumptions:

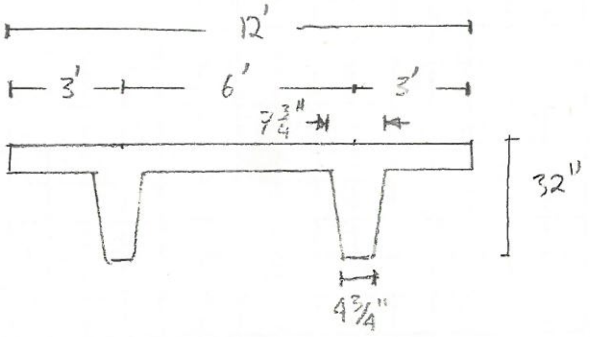
- LL = 125 psf
- DL is calculated based on the weight of structural members and partitions (assumed 25 psf)
  DL = 100 psf
- WL = 30.5 psf (ASCE 7)
- For computation of strength (18.3.1), the basic assumption given for nonprestressed members in 10.2 apply, except that 10.2.4 applies only to nonprestressed reinforcement.
- The "elastic theory" (referring to the linear variation of stress with strain) is used.
- 1/2-in-diameter regular strands (f_{pu} = 270000 psi) are used for all Members.
- f_{se} is assumed to be 170 ksi.

Preliminary design

30' X 56' span

Service load : 125 lb/ft^2

> try Double tee 12 LDT32 No topping
188-S strand pattern



$f'_c = 5000 psi$
$f_{pu} = 270000 psi$

1/2 - in - diameter regular strand
$\hookrightarrow A = 0.153 \text{ in}^2$

$A_{ps} = 18(0.153) = 2.754 \text{ in}^2$

Try $A_s = 0$ => non composite section

$d_p = 32 - Y_s = 32 - 10 = 22''$

assume $f_{se} = 170$ ksi

Since $f_{se} > 0.5 f_{pu}$, ACI 308-05 may be used

$$C\omega_{pu} = C \frac{A_{ps} f_u}{b d_p f'_c} + \frac{d}{d_p}(\omega - \omega'))$$

$$\omega = \frac{A_s f_y}{b d f'_c} = 0 \qquad \omega' = 0$$

$$C\omega_p = C \frac{A_{ps} f_{pu}}{b d_p f'_c} = 1.06 \frac{(2.754)(270)}{(144)(22)(5)} = 0.0498$$

From design aid!

$f_{ps} = 268$ ksi

$$a = \frac{A_{ps} f_{ps} + A_s f_y}{0.85 f'_c b} = \frac{2.75(268)}{0.85(5)(144)} = 1.2 \text{ in}$$

$$M_n = A_{ps} f_{ps}(d_p - a/2) + A_s f_y (d - a/2)$$

$$= (2.75)(268)(22 - 1.2/2)$$

$$= 15771.8 \text{ k.in} = 1314 \text{ k.ft}$$

$$\phi M_n = 0.9(1314) = 1183 \text{ k.ft}$$

Masnaga

Check ϕ

$c = \frac{a}{\beta_1} = \frac{1.2}{0.8} = 1.5$

$\varepsilon_t = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{30.5-1.5}{1.5}\right) = 0.058 > 0.005$ OK

tension control ($\phi = 0.9$)

Required strength

$LL = 125$ psf

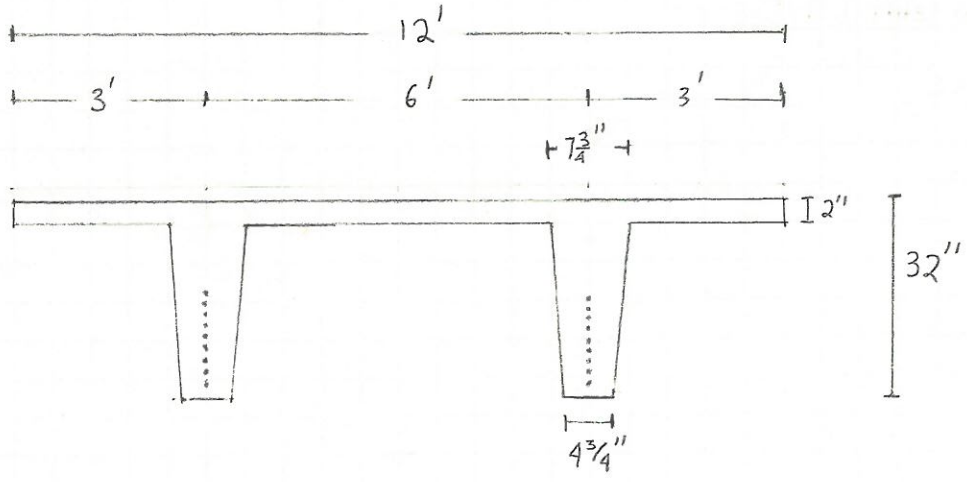
$DL = [(690/144)(56)(150\ pcf)]/(10 \times 56) = 71.88$ psf $\simeq 75$ psf

Partition = 25 psf

total DL = 100 psf

$q_u = 125(12) + 100(12) = 2700$ lb/ft

$M_u = \frac{(2700)(56)^2}{8} = 1058400$ lb.ft = 1058.4 k.ft $< \phi M_n$ OK



12 LDT 32 No topping
188 - S

But,
There is 2" thick slab that need to be added on top off the double-tee,
A bigger size double tee is needed.

Try 12' X 32"

$f'c = 5000psi$

½-in-diameter regular strand.

208-D1 No Topping +
2" slab
20 Strands

$f_{pu} = 270000psi$

Required Strength

$LL = 125 psf$
$DL = 85 \, lb/ft^2$
$Patition = 25 psf$ > 110 psf

$$q_u = 125(12) + 110(12) = 2820 \, lb/ft$$

$$M_u = \frac{2820(56)^2}{8} = 1105 \, k.ft$$

$$A_{ps} = 20(0.153) = 3.06 \, in^2$$

$A_s = 0$ → 100% prestressed steel, noncomposite section.

$$d_p = 32 - Y_s = 32 - 4.25 = 27.75''$$

Assume $f_{se} = 170ksi$

since $f_{se} > 0.5 f_{pu}$

$$C\omega_{pu} = C \frac{A_{ps} f_y}{b \, d_p \, f'c}$$

$$= 1.06 \frac{(3.06)(270)}{(144)(27.75)(5)} = 0.0438$$

From design Aid:

$$f_{ps} = 246 \, ksi$$

$$a = \frac{A_{ps} f_{ps} + A_s f_y}{0.85 f'c \, b} = \frac{3.06(246) + 0}{0.85(5)(144)} = 1.23in$$

Flexure

$$M_n = A_{ps} f_{ps} (d_p - a/2) + A_s f_y (d - a/2)$$
$$= (3.06)(246)(27.75 - 1.23/2)$$

$$= 1702 \, k.ft$$

$$\phi M_n = 1532 \, k.ft$$

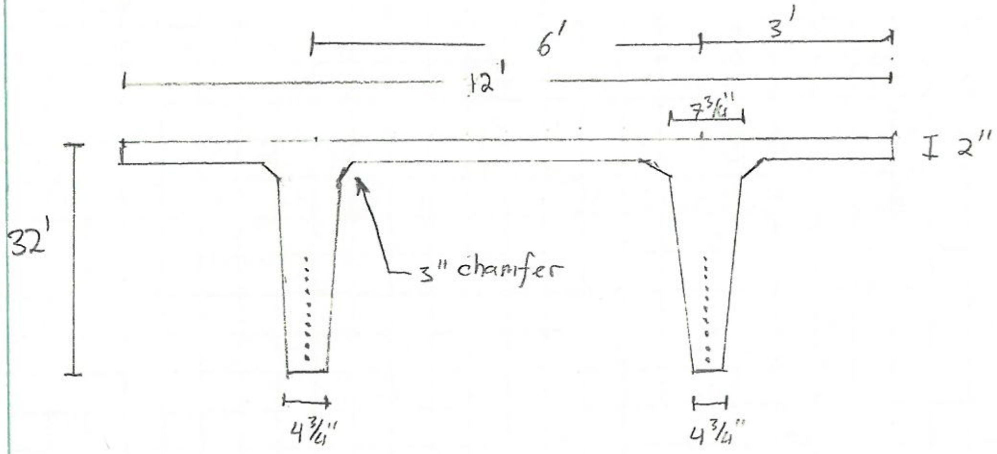
Check ϕ

$$C = \frac{a}{\beta_1} = \frac{1.23}{0.8} = 1.54$$

$\varepsilon_t = 0.003\left(\frac{d-c}{c}\right)$

$= 0.003\left(\frac{30.5-1.54}{1.54}\right) = 0.056 > 0.05 \qquad \phi = 0.9$

$\phi M_n = 0.9(1702) = 1532$ k.ft > 1105 k.ft (ok)



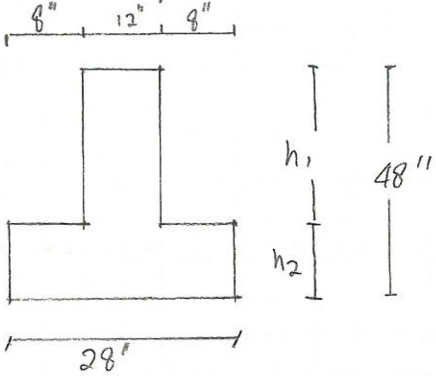
Use 12' X 32" double tee + 2" thick slab
208-D1 No topping
f'c = 5000psi
fpu = 270000psi

go to page 10 for serviceability

Prelimanary design

$LL = 56 \times 125 = 7000$ lb/ft $\rangle$ Try 28 IT 48
22 strand
$Y_s = 4.55''$

36 ft span



$f'_c = 5000$ psi
$f_{pu} = 270\,000$ psi

1/2" diameter $\rightarrow A = 0,153$ in^2

$A_{ps} = 22(0.153) = 3,366$ in^2

$h_1/h_2 = 32/16$
$A = 832$ in^2

try $A_s = 0 \rightarrow$ Non composite section

$d_p = 48'' - Y_s = 48 - 4.55 = 43.45$

assume $f_{se} = 170$ ksi

Since $f_{se} > 0.5 f_{pu} = 0.5(270000) = 135\,000$ psi

$$C_{\omega pu} = \left(\frac{A_{ps} f_u}{b\, d_p\, f'_c} + \frac{d}{d_p}(w - w')\right)$$

$$w = \frac{A_s f_y}{b\, d\, f'_c} = 0 \qquad w' = 0 \quad \text{since } A'_s = 0$$

$$C_{\omega p} = C\,\frac{A_{ps}\, f_{pu}}{b\, d_p\, f'_c} = 1.06\,\frac{(3,366)(270)}{(12)(43,45)(5)} = 0.37$$

$f_{ps} = 254$ ksi

$$a = \frac{A_{ps} f_{ps}}{0.85 f'_c b} = \frac{(3,366)(254)}{0.85(5)(12)} = 16.76''$$

$$M_n = A_{ps} f_{ps} (d_p - a/2)$$
$$= (3,366)(43.45 - 16.76/2)(254)$$
$$= 2498.6 \text{ k.ft}$$

$\phi M_n = 2249$ k.ft

Masnaga

Check ϕ

$$C = \frac{a}{\beta_1} = \frac{16.76}{0.8} = 20.95''$$

$$\varepsilon_t = 0.003\left(\frac{d-c}{c}\right) = 0.003\left(\frac{46-20.95}{20.95}\right) = 0.0036$$

$$\phi = 0.48 + 83(0.0036) = 0.78$$

$$\phi M_n = 0.78(2498.6) = 1943 \text{ k.ft}$$

Required strength

$$LL = 125\text{psf} \times 56 = 7000 \text{ lb/ft}$$

$$DL = 100\text{psf} \times 56 = 5600 \text{ lb/ft}$$

$$q_u = 1.2D + 1.6L = 1.2(5600) + 1.6(7000) = 17920 \text{ lb/ft}$$

$$= 17.92 \text{ k/ft} = 1.493 \text{ k/in}$$

$$M_u = \frac{(17.92)(34)^2}{8} = 2589 \text{ k.ft} < \phi M_n = 1943 \text{ k.ft}$$

Try to put more bars or composite section

$$M_u - \phi M_n = 2589 - 1943 = 646 \text{ k.ft}$$

$$646 = A_s f_y(d - a/2)$$

$$7752 = A_s\, 60\,(46 - 16.76/2)$$

$A_s = 3.43 \text{ in}^2 \Rightarrow$ Try 4#9 bars $= 4 \text{in}^2$

$$C\omega_{pu} = C\frac{A_{ps} f_{pu}}{b d_p f'_c} + \frac{d}{d_p}(\omega - \omega')$$

$$\omega = \frac{A_s f_y}{b d f'_c} = \frac{4(60)}{(12)(46)(5)} = 0.087 \quad , \omega' = 0$$

$$C\omega_{pu} = 1.06\frac{(5.366)(276)}{(12)(43.45)(12)} + \frac{46}{43.45}(0.087)$$

$$= 0.25$$

$$f_{ps} = 262 \text{ ksi}$$

$$a = \frac{A_{ps} f_{ps} + A_s f_y}{0.85 f'_c \, b} = \frac{(3,366)(262)+(4)(60)}{0.85 \; (5) \; (12)}$$

$$= 22''$$

$$M_n = A_{ps} f_{ps} (d_p - a/2) + A_s f_y (d - a/2)$$

$$= (3.366)(254)(43.45 - 22/2) + 4(60)(46 - 22/2)$$

$$= 2312 + 706 = 3012 \text{ k.ft}$$

Check ϕ

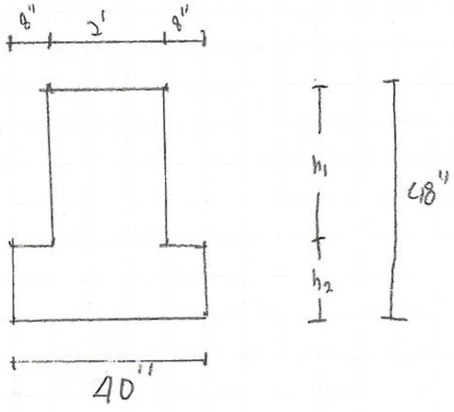
$$c = \frac{a}{\beta_1} = \frac{22}{0.8} = 27.5$$

$$\varepsilon_t = 0.003 \left(\frac{d-c}{c}\right) = 0.003\left(\frac{46-27.5}{27.5}\right) = 0.00202 < 0.005$$

$$\phi = 0.48 + 83(0.00202) = 0.65$$

$$\phi M_n = 1964 \text{ k.ft.}$$

Try 40 IT 48



$h = 48$

44 strands

$h_1/h_2 = 32/16$

$A_{ps} = 44(0.153) = 6.732 \text{ in}^2$

Try $A_s = 0 \rightarrow$ Non composite section

$d_p = 48 - 4.87 = 43.13''$

assume $f_{se} = 170$ ksi

Since $f_{se} > 0.5 f_{pu} = 135\,000$ psi

$$C_{wpu} = C \frac{A_{ps} f_u}{b \, d_p \, f'_c}$$

C = 1.06 for 5000psi concrete

$w = 0 \quad w' = 0$

$$C_{wp} = 1.06 \frac{(6.732)(270)}{(24)(43.13)(5)} = 0.351$$

$f_{ps} = 254$ ksi

$$a = \frac{(6.732)(254)}{0.85(5)(24)} = 16.76''$$

$$M_n = A_{ps} \; f_{ps} \left(d_p - a/2 \right)$$

$$= (6.732)(254)\left(43.13 - 16.76/2\right) = 4952 \text{ k.ft}$$

<u>ϕ</u>

$$c = \frac{16.76}{0.8} = 20.95''$$

$$\varepsilon_t = 0.003 \left(\frac{d-c}{c} \right) = \frac{46 - 20.95}{20.95} = 0.0036 \quad < 0.005$$

$$\phi = 0.48 + 83(0.0036) = 0.78$$

$$\phi M_n = 0.78(4952) = 3863 \text{ k.ft} > 2589 \text{ k.ft} \quad \text{ok.}$$

Mxu, Myu, and Pu are analyzed conservatively by assuming that the buiding are not skewed.' It means the columns are spaced 36' equally in x direction and 58' equally in y direction.

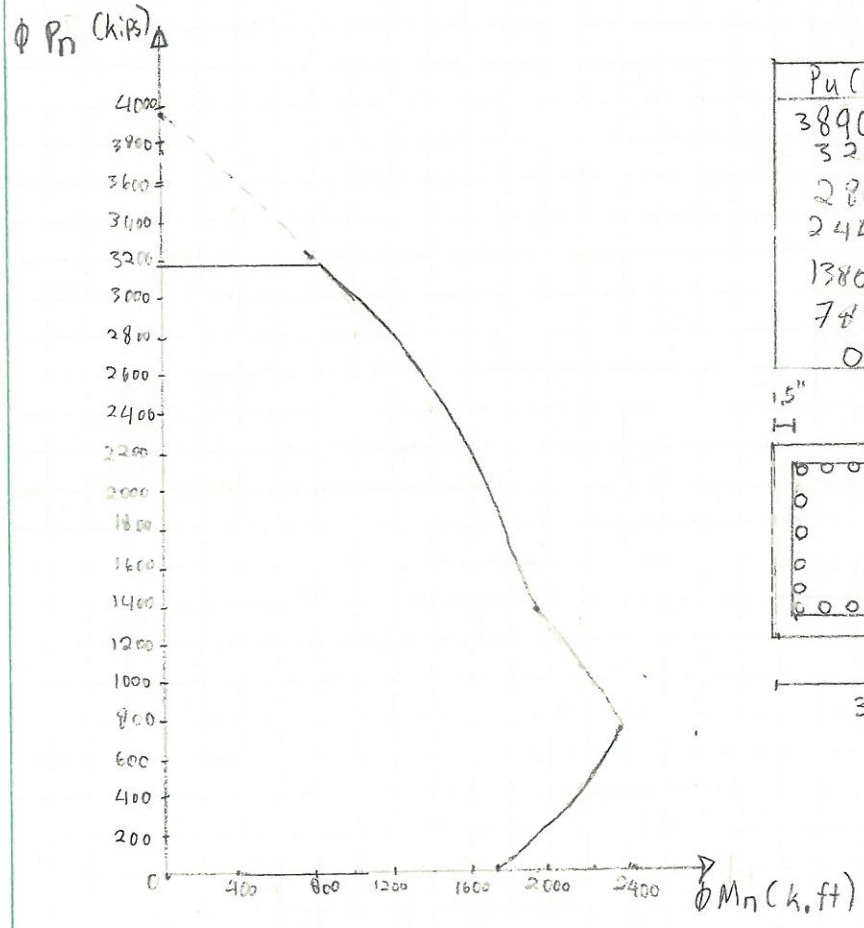
$M_{yu} = 0$
$M_{xu} = 0$
$\Big\}$ since prestressed and precast members are used.

$17.92\ ^{k}/_{ft} \times 34\ ft = 609.28$ kips

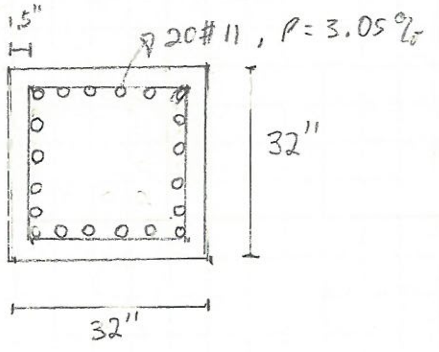
$P_u = 4 \times 609.28 = 2437$ kips

Criteria:

1. Concrete $f'c = 5000psi$, normal weight
2. Reinforcement $fy = 60000psi$
3. Curve shown for full development of reinforcement
4. Horizontal portion of curve is the maximum for tied columns $= 0.8\,\phi P_o$
5. All strands assumed 1/2" diameter, $f_{pu} = 270ksi$



Pu (k)	Mu (k.ft)	e (inches)
3890	0	0
3200	800	0.25
2800	1100	0.39
2440	1400	0.57
1380	1870	1.36
740	2370	3.04
0	1750	∞



Use 32" x 32" with 20# 11 bars for columns.

APPENDIX: STRUCTURAL (S-4)

SHEAR WALL DESIGN CALCULATIONS

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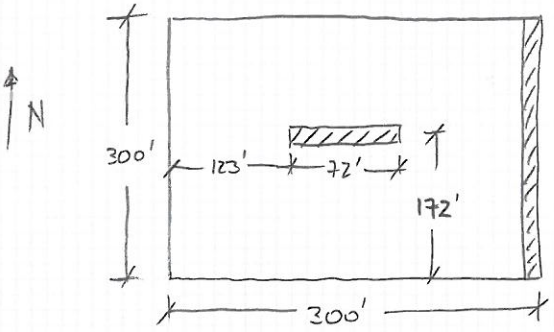
- First Need to compute the Shear @ each wall when loaded by wind load in both (North-South) & (East-west) direction

- from Wind Load Calculations => $p = 30.5\ ^{lb}/_{ft^2}$

- height of bldg = $16' \times 4 = 64$ ft

- Assumptions = - Per discussion with our structural advisor the bldg will be designed with the following shear wall locations & overall shape.
  - Shear walls will be assumed to be 12 in. thick



- Assumption with design = floors & roof behave as rigid diaphragms

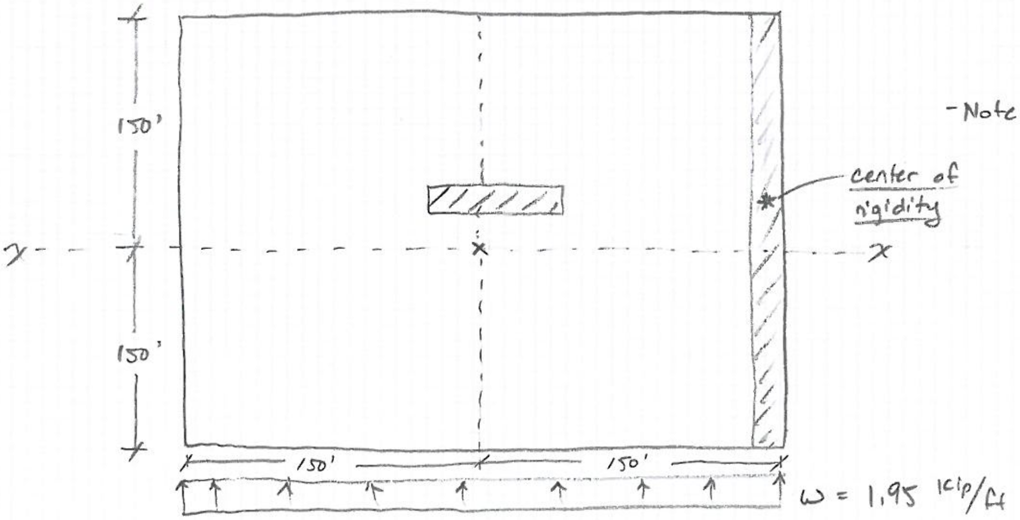
- Note: Assumptions are based on a preliminary design of bldg. further analysis of lateral resisting system will be required moving forward

Design for Lateral Load in Northward Direction

- Determination of Shear @ each Wall

$w = pH = 30.5(64)$

$w = 1.95\ ^{kip}/_{ft}$



- Note: for distribution of Direct Shear, flexural Stiffness will be neglected (conservative Approach).

Total Lateral Load = w(wall length) = $1.95(300') = 585$ kips

Proj: SHEAR WALL DESIGN **Page:** 2/ **Date:** 4/20/2011

Cals by: Jocran Martinez **Checked by:**

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Determining Center of Rigidity :

$\bar{x} = \frac{300(300)}{300} = 300$ ft. from left $\qquad \bar{y} = \frac{72'(172)}{72} = 172'$ ft. from bottom

torsional Moment = 585 (eccentricity) = 585(150') = 87750 kip·ft

Accidental Eccentricity = 0.05 (300) = 15.0 ft

$M_{t\,(\text{ACCIDENTAL})} = 15(585) = 8775$ kip·ft

$M_{t\,(\text{total})} = 87750 + 8775 = 96525$ kip·ft

Determining the polar moment of Stiffness of the Shear wall group:

$I_p = I_{xx} + I_{yy}$

where $I_{xx} = \Sigma\, l y^2$ of east-west walls

$= 72(22^2) = 34848$ ft^3

$I_{yy} = \Sigma\, l x^2$ of North-South Walls

$= 300(150-300)^2 = 6{,}750{,}000$ ft^3

$I_p = 34848 + 6750000 = 6784848$ ft^3

Shear in North-South Walls $= \frac{V_y l}{\Sigma l} + \frac{M_T x l}{I_p} = \frac{585(300)}{300} + \frac{96525(150)(300)}{6784848}$

Shear in N-S Wall : 1225.2 kips

Shear in East-West Walls $= \frac{M_T y l}{I_p} = \frac{96525(72)(22)}{6784848}$

Shear in E-W Wall : 22.5 kips

<u>Design for lateral Load in Eastward Direction</u>

- Determination of Shear @ each wall

$w = pH = 1.95$ kip/ft

Total lateral Load = 1.95(300) = 585 kips

Proj: SHEAR WALL DESIGN **Page:** 31 **Date:** 4/20/2011 ILLINOIS INSTITUTE OF TECHNOLOGY
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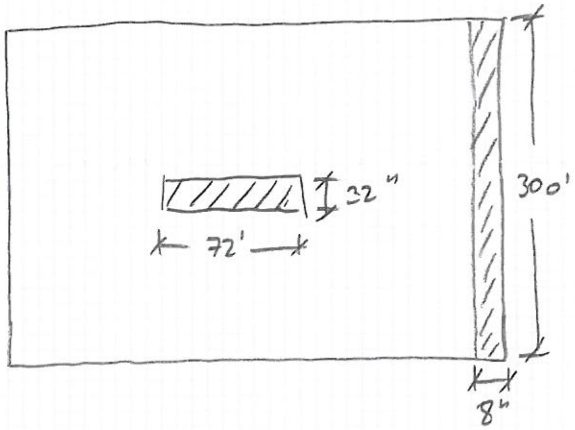
Based on the attained shears. The appropriated dimensions of the shear walls are as follows.



The heights of both shear walls extend from the foundation to the top of the fourth floor of the museum. Thus their height is 76 ft.

Having spoken with a subject matter expert regarding the applied shear on the walls & the dimensions appropriated to them he determined that the walls would suffice all lateral load requirements using reinforcement only necessary for theral expansion.

It is important to note that the shear walls are designed as nonload bearing members & such become simple in design.

Furthermore, since these walls will be constructed of precast/prestressed concrete it is necessary to divide each wall into sections which will make transportation of the walls usable by the general contractor. A standard block size was recommended @ 12 ft x 40 ft.

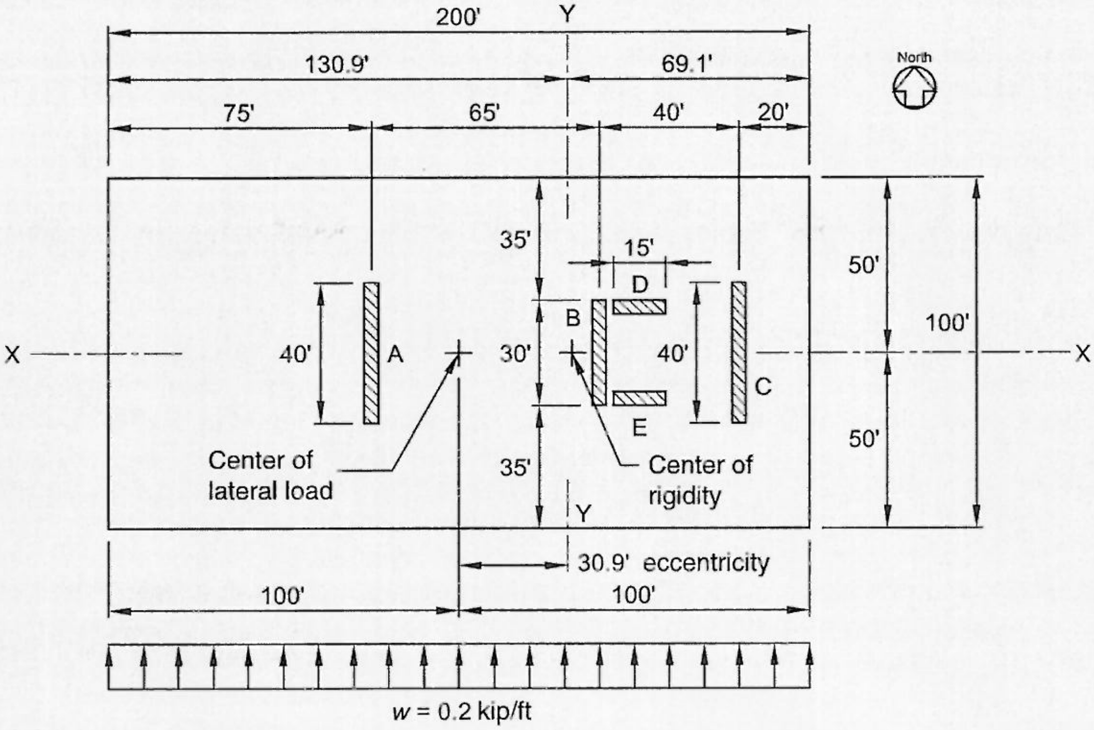
576 kips

EXAMPLE 4.5.7.1

Design of Unsymmetrical Shear Walls

Given:

The structure shown below. All walls are 8 ft high and 8 in. thick.



Problem:

For the load shown in the Y direction, determine the shear in each wall, assuming the floors and roof are rigid diaphragms. Walls D and E are not connected to wall B.

Solution:

Maximum height-to-length ratio of north-south walls = 8/30 < 0.3. Thus, for distribution of the direct wind shear, neglect flexural stiffness. Since walls are the same thickness and material, distribute in proportion to length.

Total lateral load, $V_y = 0.20 \times 200 = 40$ kip

Determine center of rigidity:

$$\overline{X} = \frac{40(75)+30(140)+40(180)}{40+30+40} = 130.9 \text{ ft from left}$$

$\overline{Y}$ = center of building, since walls D and E are placed symmetrically about the center of the building in the north-south direction.

Torsional moment, $M_T = 40(30.9) = 1236$ kip-ft

Section 12.8.4.2 of ASCE 7-05 requires that for diaphragms that are not flexible (therefore rigid), an accidental torsion be added to this. The eccentricity to be used for the accidental torsion is 5% of the building dimension perpendicular to the direction of the applied forces.

Then:

Accidental eccentricity = (0.05)(200) = 10 ft

$M_{T\,accidental} = (10)(40) = 400$ kip-ft

$M_{T\,total} = 1236 + 400 = 1636$ kip-ft

EXAMPLE 4.5.7.1

Design of Unsymmetrical Shear Walls (cont.)

Determine the polar moment of stiffness of the shear wall group about the center of rigidity:

Since the height-to-length ratios for the east-west walls are greater than 0.3, the polar moment of inertia should more correctly consider the flexural stiffness of the east-west walls. This is negligible in this example and has been omitted.

$I_p = I_{xx} + I_{yy}$

$I_{xx} = \Sigma \ell y^2$ of east-west walls $= 2(15)(15)^2 = 6750$ ft^3

$I_{yy} = \Sigma \ell x^2$ of north-south walls $= 40(130.9 - 75)^2 + 30(140 - 130.9)^2 + 40(180 - 130.9)^2 = 223{,}909$ ft^3

$I_p = 6750 + 223{,}909 = 230{,}659$ ft^3

$$\text{Shear in north-south walls} = \frac{V_y \ell}{\Sigma \ell} + \frac{M_T x \ell}{I_p}$$

$$\text{Wall A} = \frac{40(40)}{110} + \frac{1636(130.9-75)(40)}{230{,}659} = 14.5 + 15.9 = 30.4 \text{ kip}$$

$$\text{Wall B} = \frac{40(30)}{110} + \frac{1636(130.9-140)(30)}{230{,}659} = 10.9 - 1.9 = 9.0 \text{ kip}$$

$$\text{Wall C} = \frac{40(40)}{110} + \frac{1636(130.9-180)(40)}{230{,}659} = 14.5 - 13.9 = 0.6 \text{ kip}$$

$$\text{Shear in east-west walls} = \frac{M_T y \ell}{I_p} = \frac{1636(15)(15)}{230{,}659} = 1.21 \text{ kip}$$

$$F_y = \frac{V_y K_y}{\Sigma K_y} + \frac{e_x V_y (x) K_y}{\Sigma K_y (x^2) + \Sigma K_x (y^2)} \qquad \text{(Eq. 4-47)}$$

Force in the X direction is distributed to a given wall at a given level due to an applied force in the Y direction at that level:

$$F_x = \frac{e_x V_y (y) K_x}{\Sigma K_y (x^2) + \Sigma K_x (y^2)} \qquad \text{(Eq. 4-48)}$$

where:

V_y = lateral force at the level being considered

K_x, K_y = rigidity in the X and Y directions, respectively, of the wall under consideration

ΣK_x, ΣK_y = summation of rigidities of all walls at the level in the X and Y directions, respectively

x = distance of the wall from the center of stiffness in the X direction

y = distance of the wall from the center of stiffness in the Y direction

e_x = distance between the center of the load in the Y direction and the center of stiffness measured in the X direction

For most single-story buildings subjected to wind loads, a simplified, approximate analysis is commonly used to determine torsion in asymmetrically located shear walls. This type of analysis assumes a unit thickness for all shear walls, as described in Example 4.5.7.1.

4.5.8 Coupled Shear Walls

Two individual shear walls separated by large openings may be connected with structural components that can resist axial and/or flexural loads. The combined stiffness of the two coupled shear walls is greater than the sum of their uncoupled stiffnesses. Coupling shear walls can reduce the lateral deflection (drift) in a building and reduce the magnitude of the moments for which a shear wall must be designed.

Figure 4.5.4 shows two examples of coupled shear walls. The effect of coupling is to increase the stiffness by transfer of shear and moment through the coupling beam. The wall curvatures are altered from that of a cantilever because of the frame action that is developed. Figure 4.5.5 shows how the deflected shapes differ in response to lateral loads.

Several approaches may be used to analyze the response of coupled shear walls. A simple approach is to ignore the coupling effect by considering the walls as independent cantilevers. This method results in a conservative wall design.

APPENDIX: STRUCTURAL (S-5)

WIND LOAD DESIGN CALCULATION

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Proj: WIND LOAD CALCULATION **Page:** 1 **Date:** 4/20/2011 ILLINOIS INSTITUTE OF TECHNOLOGY Transforming Lives. Inventing the Future. www.iit.edu

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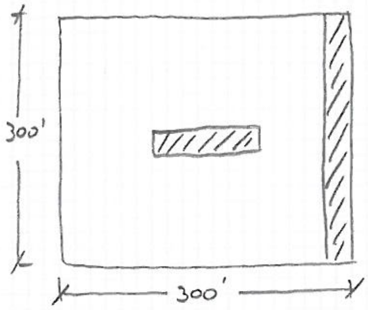
Reference: ASCE STANDARD 7

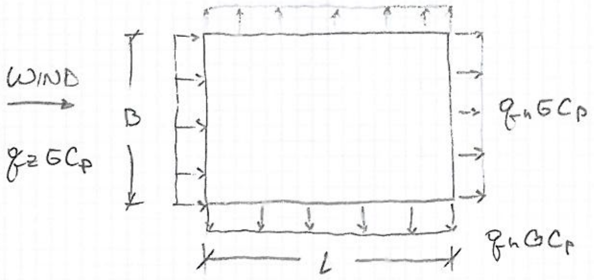
- Wind Load Calculations: must be @ least $10\ lb/ft^2$
- Design wind Loading = $p = qGC_p - q_hGC_{pi}$

Assumptions



- ▨ = Shear Walls
- Bldg. Height = 16' × 4 = 64 ft
- with 12' high parking space below grade

- By ASCE Bldg. will experience pressure as follows:



Velocity Pressure: $q_z = 0.00256\, K_z K_{zt} V^2 I$ (lb/ft^2)

I = Importance factor ⇒ By table 1-1 in ASCE bldg. classification = III

thus $\underline{\underline{I = 1.15}}$

K_z is based on table 6-3 & exposure category of bldg.

- Will assume exposure category to be "B" by the following reasons:
  - conservative approach for an urban location
  - acknowledges that future bldgs surrounding ours will be of equal or greater height

thus, by linear interpolation for 64 ft. height @ category B ⇒ $K_z = 0.87$

K_{zt} ⇒ assumed to be 1.0 since we aren't concerned with hill induced winds

Proj: Wind Load Calculation **Page:** 2/ **Date:** 4/20/11

Cals by: Joran Martinez **Checked by:**

Basic Wind Speed ⇒ V is determined by ASCE figure 6-1

for CHICAGO region V = 90 mph based on 3 second gust speeds

thus: $q_z = 0.00256(0.87)(1.0)(90^2)(1.15) \Rightarrow q_z = 20.75 \; (\text{lb}/\text{ft}^2)$

Gust Effect Factor G per exposure area "B" is designated as ⇒ G = 0.8

$$\left.\begin{array}{ll} \text{for windward wall} & \Rightarrow C_p = 0.8 \\ \text{Leeward wall} & \Rightarrow C_p = -0.5 \\ \text{Side walls} & \Rightarrow C_p = -0.7 \end{array}\right\} \Rightarrow \text{By table 6-3 in ASCE}$$

from table 6-4 ⇒ for partially enclosed bldg. $GC_{pi} = -0.30$

thus: $p = q_z GC_p - q_h GC_{pi} - q_h GC_{plw} - q_h GC_{psw}$

$= 20.75(.8)(.8) - 20.75(.8)(-.3) - 20.75(.8)(-.5) - 20.75(.8)(0.7)$

$p = 38.18 \; \text{lb}/\text{ft}^2$

Now appropriating factor for roof uplift force: By ASCE figure 6-3

for Surface Area of Roof = 300′ × 300′ = 90,000 S.Q. ⇒ reduction factor = 0.8

thus $p = 38.18(.8) \Rightarrow$ "$\underline{p = 30.5 \; \text{lb}/\text{ft}^2 \quad \text{Wind load}}$"

APPENDIX: STRUCTURAL (S-6)

FOOTING DESIGN

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Proj: FOOTING DESIGN **Page:** 1 **Date:** 4/20/2011

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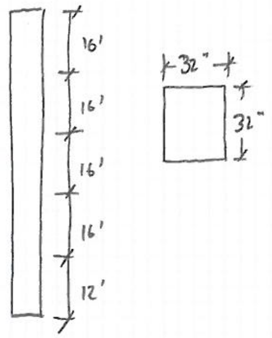
- First Need to calculate Point loads occurring on footing by load transfer of columns.

- Will be designing a continuous footing with unsymmetrical loading.

LOADINGS ⇒ from Column Self weight : "Assumed as ordinary concrete"

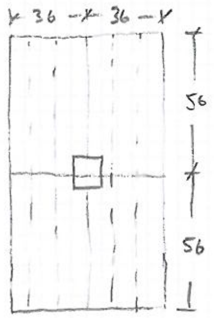


$\gamma_c = 150\ \text{lb}/\text{ft}^3$

$W_{column} = \gamma_c A H = 15\left(\frac{32}{12}\right)\left(\frac{32}{12}\right)(76')$

$= 8107\ \text{lbs}$

⇒ from Double Tee Dead Load : "Assumed from ACI Code"



Tributary Area = 56' × 36' = 2016 ft²

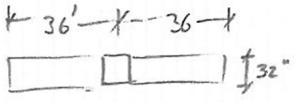
DL of Double Tee : 85 lb/ft^2

DL W_{DT} : A(DL) = 2016(85)

DL W_{DT} = 171360 lbs

⇒ from Inverted Tee Dead Load : "Assumed from ACI Code"

Tributary Area = 36' × (32/12)' = 96 ft²



DL of Inverted tee : 1467 lb/ft

Thus : DL of Inverted Tee = 1467(36)

DL W_{IT} = 52812 lbs

⇒ from Live Load on tributary area :

W_L = 125 psf   Tributary Area = Same as Double Tee = 2016 ft²

P_{LL} = 125(2016) = 252,000 lbs

Calculation of P_u on footing by typical column:

$P_u = P_{DL}(1.2) + P_{LL}(1.6)$

$P_{DL} = \sum W_{DL} = 8107 + 171360 + 52812 = 232279$ lbs

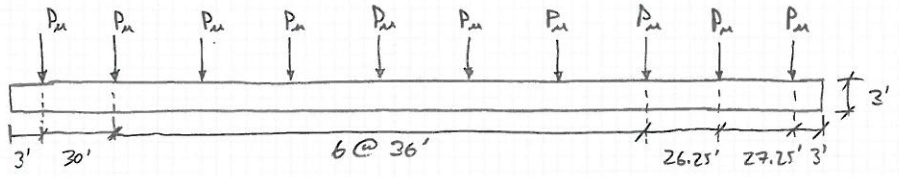
$P_{LL} = 252{,}000$ lbs

$P_u = 1.2(232279) + 1.6(252{,}000)$

$P_u = 682$ kips

By Continuous footing method: Assumptions: No moments acting at column
base since column does not
take lateral loads
(refer to Shear Wall Design)

Diagram of footing:

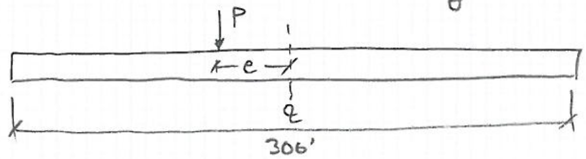


total length of footing = 306'

Assumptions: Bearing Capacity of Soil = 3000 psf
Soil Pressure: @ 5' since footing is assumed to be 5' embedded
@ $\gamma_s = 90\ \text{lb/ft}^3$

Need to attribute all P_u's as a single point load acting @ an eccentricity value from the center line of the footing

(i.e.)



thus: $e = \sum M / \sum P$

ΣP = sum of all Vertical forces : $P_u(10) = 6820$ kips

ΣM = sum of all moments about ℄ of footing $(\circlearrowright +)$

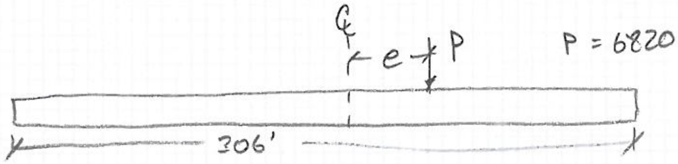
$= 682(150) + 682(120) + 682(84) + 682(48) + 682(12)$

$- 682(24) - 628(60) - 682(96) - 682(122.25) - 682(150)$

$= 26087$ lb·ft $\circlearrowright$

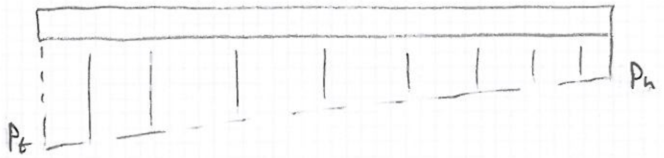
$e = \Sigma M / \Sigma P = 26087/6820 = 3.825$ ft (to the right of ℄)

$\frac{\Delta}{6} = \frac{306'}{6} = 51' > e$ OK (No uplift)



$P = 6820$ kips $e = 3.825'$

Checking Bearing Pressure:



Note: Need to use nominal Values for ΣP & ΣM

$\Sigma P = 10(8.107 + 171.36 + 52.812 + 252) = 4843$ kips

$P_t = \frac{\Sigma P}{L \cdot B}\left(1 + \frac{6e}{L}\right) + \gamma_s h_s + \gamma_c h$

$= \frac{4843000}{306(10)}\left(1 + \frac{6(3.825)}{306}\right) + 90(5') + 150(3)$

$P_t = 2602$ psf < 3000 psf OK

$P_h = \frac{\Sigma P}{LB}\left(1 - \frac{6e}{L}\right) + 90(5) + 150(3)$

$P_h = 2364$ psf < 3000 psf OK

Note: B = 10 ft Since Footings will be continuous with 10 ft. width

Proj: FOOTING DESIGN **Page:** 4/ **Date:** 4/20/2011

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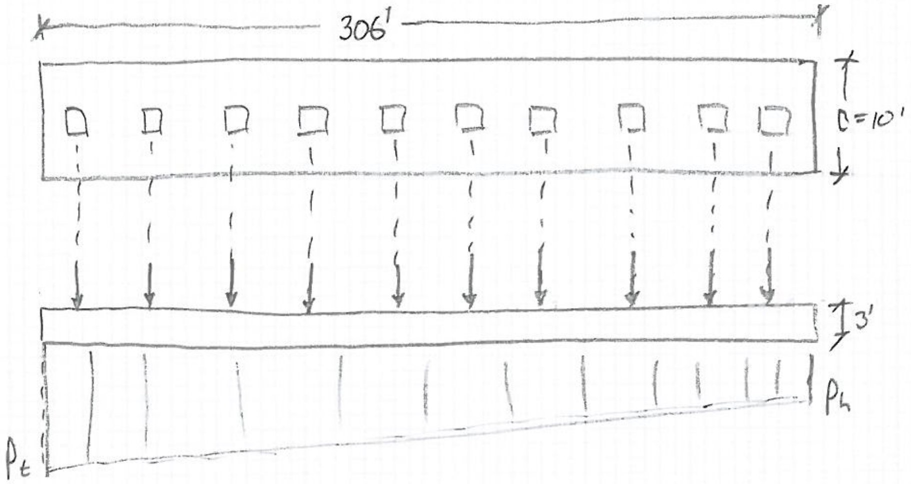
DIAGRAM



APPENDIX: STRUCTURAL (S-7)

RETAINING WALL DESIGN

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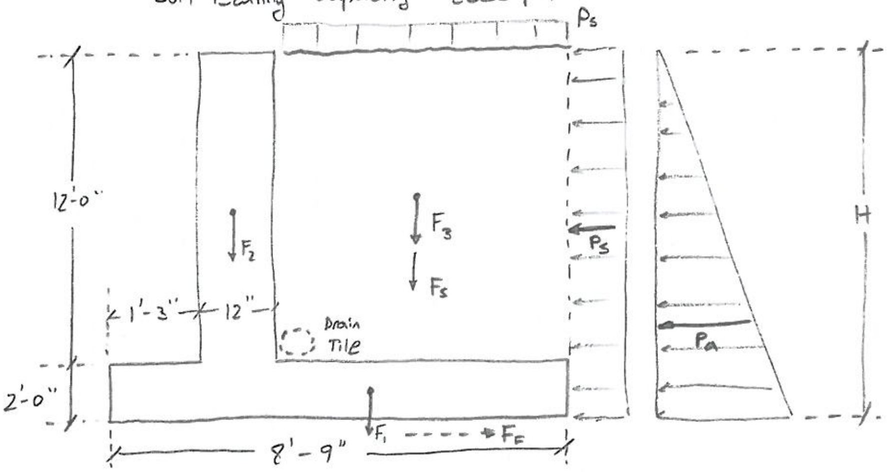
Design of Cantilever retaining wall

- By North face of bldg. wall will experience greatest surcharge value due to elevated pedestrian/vehicle volume
- will design all wall faces based on worst estimated surcharge

Assumptions :
- By providing adequate drainage, hydraulic pressure will not be considered in design process
- $\gamma_s = 90$ lb/ft³ $K_a = 0.3$ (typical)
- Surcharge : $p_s = 125$ lb/ft²
- $f'_c = 4000$ psi $f_y = 60{,}000$ psi
- friction coeff. = 0.60 (Assuming proper contact btwn. footing & underlayn Soil)
- Soil Bearing Capacity = 3000 psf



- All dimensions are assumed based on preliminary assumptions

In above figure: p_s = surcharge (psf) F_i = Various Weights
P_s = surcharge effect F_F = Friction Force
P_a = Soil Active force $F_F = \mu \Sigma F_i$

DESIGN AGAINST SLIDING & OVERTURNING

Factor of Safety = 1.5 or higher

$$F.S._{SLIDING} = \frac{\mu \Sigma F_i}{P_a + P_s}$$

- To be conservative : passive forces induced by soil will be ignored in design process

- $\gamma_c = 150$ lb/ft³

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FORCE	VALUE (lb/ft)	DIST. FROM TOE	[lb·ft/ft] MOMENT (w.r.t. toe)
P_a	$\frac{1}{2} K_a \gamma_s H^2$ $\frac{1}{2}(0.3)(90)(14^2)$ 2646 lb/ft	$\frac{1}{3} H$ $\frac{1}{3}(14)$ 4.667 ft	12350 lb·ft/ft ↻
P_s	$K_a p_s H$ $0.3(125)(14)$ 525 lb/ft	$\frac{1}{2} H$ $\frac{1}{2}(14)$ 7.0 ft	3675 lb·ft/ft ↻
F_s	(cantilever dirt.) p_s $[8'\text{-}9'' - (1' + 1'\text{-}3'')]125$ 812.5 lb/ft	$\frac{6.5'}{2} + 1' + 1'\text{-}3''$ 5.5 ft	4468.75 lb·ft/ft ↷
F_3	$6.5\, \gamma_s (12')$ $6.5(90)(12')$ 7020 lb/ft	5.5 ft	38610 lb·ft/ft ↷
F_2	$(1'\text{-}3'' + 1')\, \gamma_c (12')$ 4050 lb/ft	$1'\text{-}3'' + 1/2$ 1.75 ft	7087.5 lb·ft/ft ↷
F_1	$(8'\text{-}9'')\, \gamma_c (2')$ 2625 lb/ft	$8'\text{-}9''/2$ 4.375 ft	11484.0 lb·ft/ft ↷

ΣF_i = sum of vertical forces $= F_1 + F_2 + F_3 + F_s = 14508$ lb/ft

ΣM_i = sum of all moments [↻+] $= -45626$ lb·ft/ft

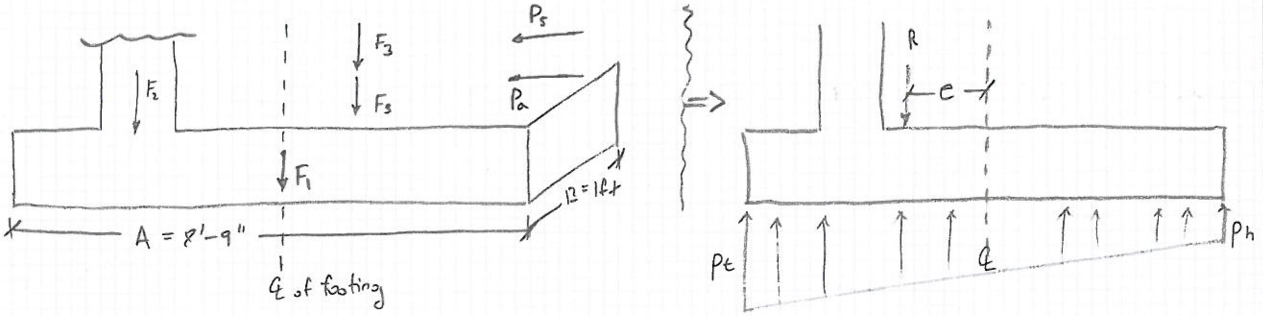
$$F.S._{\text{SLIDING}} = \frac{\mu \Sigma F_i}{P_a + P_s} = \frac{0.6(14508)}{2646 + 525} = 2.745 > 1.5 \quad \underline{\underline{\text{OK}}}$$

$$F.S._{\text{OVERTURNING @ toe}}: \frac{\Sigma F_i a_i}{M_a + M_p} = \frac{4469 + 38610 + 7087 + 11484}{12350 + 3675} = 3.85 > 1.5$$

<u>OK</u>

CHECK FOR SOIL PRESSURE UNDER FOOTING:

- Need to convert all forces acting on footing into a resultant force acting at some eccentricity from centerline of footing



FORCE	VALUE (lb/ft)	Dist. from ℄ Footing (ft)	MOMENT (w.r.t ℄ footing)	
P_a	2646 (lb/ft)	4.667 (ft)	12350 lb·ft/ft	↺
P_s	525 (lb/ft)	7.0 (ft)	3675 lb·ft/ft	↺
F_s	813 (lb/ft)	$5.5-\left(\frac{8.75}{2}\right)$		
		1.125 (ft)	915 lb·ft/ft	↻
F_3	7020 (lb/ft)	1.125 (ft)	7898 lb·ft/ft	↻
F_2	4050 (lb/ft)	$\frac{8.75}{2}-1.75$		
		2.63 (ft)	10650 lb·ft/ft	↺
F_1	2625 (lb/ft)	0 (ft)	0 lb·ft/ft	↔

ΣM of all forces w.r.t. ℄ of footing [↺+] = 17862 lb·ft/ft

$R = \Sigma F_i$ = sum of all Vertical Forces = 14508 lb/ft

$e = \Sigma M / \Sigma F_i = \frac{17862}{14508} = 1.23'$ (to the left of ℄)

checking uplift: $\frac{A}{6} = \frac{8.75'}{6} = 1.46' > e$ OK for uplift

$$p_t = \frac{R}{A \cdot B}\left(1 + \frac{6e}{A}\right) = \frac{14508}{8.75(1)}\left(1 + \frac{6(1.23)}{8.75}\right)$$

$$p_t = 3056.51 \text{ psf}$$

$$p_h = \frac{R}{A \cdot B}\left(1 - \frac{6e}{A}\right)$$

$$p_h = 259.6 \text{ psf}$$

$p_h <$ bearing capacity (3000 psf) $\underline{\underline{\text{OK}}}$

$p_t >$ bearing capacity

$\hookrightarrow \left(\frac{3056.51 - 3000}{3000}\right)100 = 1.88\% < \underline{\underline{5\%}}$ $\underline{\underline{\text{OK}}}$ for design

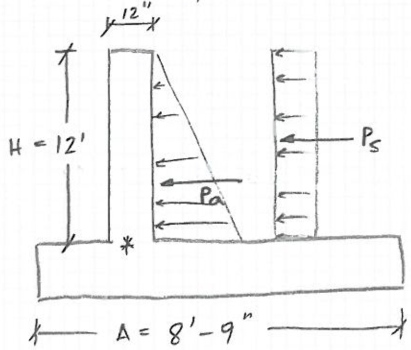
"THUS : Footing Dimensions OK for Stability concerns."

Design for Bending & Shear [reinforcement]

Note: per Stability design considerations : bldg. would require 35400 ft^3 of concrete for footing

Reinforcement Design for Wall

- Wall is designed as a cantilever for 12' height



$$P_a = \tfrac{1}{2} K_a \gamma_s H^2 = \tfrac{1}{2}(0.3)(90)(12^2)$$

$$P_a = 1944 \text{ lb/ft}$$

$$P_s = K_a p_s H = 0.3(125)(12)$$

$$P_s = 450 \text{ lb/ft}$$

$$M_u = 1.6\left[P_a\left(\tfrac{H}{3}\right) + P_s\left(\tfrac{H}{2}\right)\right]$$

$$= 1.6\left(1944\left(\tfrac{12}{3}\right) + 450\left(\tfrac{12}{2}\right)\right]$$

$$M_u = 16761.6 \text{ lb·ft/ft} \quad \text{(required)}$$

using #6 bars $\Rightarrow d = 12 - (3 + \tfrac{1}{2} d_b) = 12 - [3 + \tfrac{1}{2}(.75)]$

$$d = 8.63''$$

Assuming $\phi = 0.9$ (will verify later)

$$R = \frac{M_N}{bd^2} = \frac{16761.6(12)/0.9}{12(8.63)^2} = 250.06 \text{ psi}$$

$$m = f_y/.85f'_c = 60000/.85(4000) = 17.65$$

$$\rho = \frac{1}{m}\left[1 - \sqrt{1 - \frac{2mR}{f_y}}\right] = \frac{1}{17.65}\cdot\left[1 - \sqrt{1 - \frac{2(17.65)(250.06)}{60000}}\right]$$

$$\rho = 0.00433$$

$$A_s = \rho bd = 0.00433(12)(8.63) = 0.448 \text{ in}^2/\text{ft}$$

$$\text{Spacing} = \left(A_{s(BAR)}/A_s\right) \times 12 \text{ in} = \frac{.44}{.448}(12) = 11.8 \text{ in}$$

"Thus use #6 @ $11\frac{3}{4}$ in. O.C."

Verify $\phi \Rightarrow a = \frac{A_s f_y}{.85 f'_c b} = \frac{.448(60000)}{.85(4000)(12)} = 0.658 \qquad x = \frac{a}{\beta_1} = \frac{.658}{.85} = .775$

$$\varepsilon_t = 0.003\left(\frac{d-x}{x}\right) = 0.003\left(\frac{8.63 - .775}{.775}\right) = 0.03 > 0.005 \longrightarrow \phi = 0.9 \ \underline{OK}$$

for $f_y = 60000$ psi & #6 bars : minimum reinforcement $= \begin{cases} 0.0015 b h_w & \text{(vertical)} \\ 0.0025 b h_w & \text{(horizontal)} \end{cases}$

$$A_{s(min)\,vert.} = 0.0015(12)(12) = 0.216 \text{ in}^2/\text{ft}$$

using #3 bar $\Rightarrow$ Spacing $= \frac{.11}{.216}(12) = 6.11$ in "thus use #3 @ 6 in O.C."

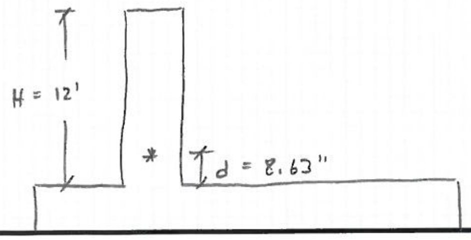
$$A_{s(min)\,Horizontal} = 0.0025(12)(12) = 0.36 \text{ in}^2/\text{ft}$$

using #3 bar $\Rightarrow$ spacing $= \frac{.11}{.36}(12) = 3.67$ in

using #4 bar $\Rightarrow$ spacing $= \frac{.2}{.36}(12) = 6.667$ in "thus use #4 @ $6\frac{1}{2}$ in O.C."

Shear Design for wall

V_u is computed @ "d" distance away from bottom of wall.



$$V_u = 1.6\left[K_a \gamma_s \left(H - \frac{d}{12}\right)^2/2 + K_a p_s\left(H - \frac{d}{12}\right)\right]$$

$$V_u = 1.6\left[.3(90)\left(12 - \frac{8.63}{12}\right)^2/2 + .3(125)\left(12 - \frac{8.63}{12}\right)\right]$$

$$V_u = 3425.61 \text{ lb/ft}$$

$$\phi V_c = 0.75(2)\sqrt{f'_c}\ bd = 0.75(2)\sqrt{4000}\,(12)(8.63)$$

$$\phi V_c = 9824.6\ \text{lb/ft} > V_u \quad \underline{\underline{\text{OK}}}$$

Footing Reinforcement

- Need to apply factored values for reinforcement design of footing by refering to table taking momentr about the ℄ of footing

FORCE	Value (lb/ft)	Dist from ℄ (ft)	Moment (lb·ft/ft)	ACI Load Factor	Factored Force	Factored Moment
P_a	2646	4.667	12350 ↻	1.6	4234	19760 ↻
P_s	525	7.0	3675 ↻	1.6	840	5880 ↻
F_s	813	1.125	915 ↺	1.6	1301	1464 ↺
F_3	7020	1.125	7898 ↺	1.2	8424	9478 ↺
F_2	4050	2.63	10650 ↺	1.2	4860	12780 ↺
F_1	2625	0	0	1.2	3150	0

ΣM_u = sum of all Factored Moments $\Rightarrow \Sigma M_u = 1918\ \text{lb·ft/ft}$ ↻

ΣP_u = Sum of Vertical Forces $\Rightarrow \Sigma P_u = 17735\ \text{lb/ft}$

$$e' = \frac{\Sigma M_u}{\Sigma P_u} = \frac{1918}{17735} = 0.108\ \text{ft}$$

$$\frac{A}{6} = \frac{8.75'}{6} = 1.46' \qquad \text{Since } e' < \frac{A}{6} \text{ then No Uplift} \quad \underline{\underline{\text{OK}}}$$

$$(p_t)_u = \frac{\Sigma P_u}{A}\left(1 + \frac{6e'}{A}\right) = \frac{17735}{8.75}\left(1 + \frac{6(.108)}{8.75}\right) = 2177\ \text{psf}$$

$$(p_h)_u = \frac{\Sigma P_u}{A}\left(1 - \frac{6e'}{A}\right) = \frac{17735}{8.75}\left(1 - \frac{6(.108)}{8.75}\right) = 1876.75\ \text{psf}$$

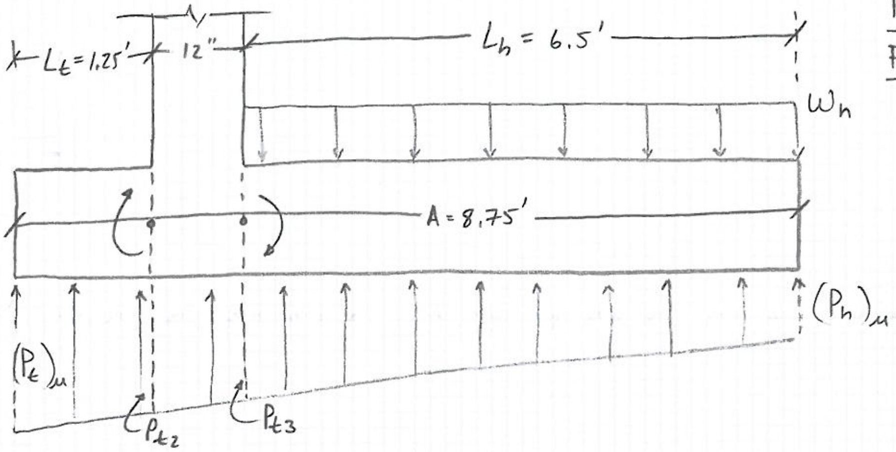
w_h = factored vertical load from soil, overburden, & weight of footing on heel span

$$w_h = 1.6\,p_s + 1.2\,\gamma_s h_s + 1.2\,\gamma_c h_f = 1.6(125) + 1.2(90)(12) + 1.2(150)(2)$$

$$w_h = 1856\ \text{psf}$$

w_t = factored vertical load from footing on toe span = 0 psf (neglected)

DIAGRAM OF LOADS ON FOOTING



$$P_{t3} = (P_h)_u + \frac{(P_t)_u - (P_{hu})}{A}(L_h) = 1876.75 + \frac{2177 - 1876.75}{8.75}(6.5) = 2100 \text{ psf}$$

$$P_{t2} = (P_h)_u + \frac{(P_t)_u - (P_{hu})}{A}(A - L_t) = 1876.75 + \frac{2177 - 1876.75}{8.75}(7.5) = 2134 \text{ psf}$$

$(M_u)_h$ = moment for L_h cantilever

$$= \frac{w_h L_h^2}{2} - \left[(P_h)_u\left(\frac{L_h}{2}\right)\left(\frac{2}{3}L_h\right) + P_{t3}\left(\frac{L_h}{2}\right)\left(\frac{1}{3}L_h\right)\right]$$

$$= \frac{1856(6.5^2)}{2} - \left[1877\left(\frac{6.5}{2}\right)\left(\frac{2}{3}6.5\right) + 2100\left(\frac{6.5}{2}\right)\left(\frac{1}{3}6.5\right)\right]$$

$$= 2014 \text{ lb}\cdot\text{ft/ft} \circlearrowright$$

Note: by the attained $(M_u)_h$ main reinforcement would be minimal @ bottom

- following discussion with Professor Mohamadi ⇒ worst case scenario for the moment of footing corner by way of nominal P_t & P_h values. Following procedure above $(M_u)_h$ becomes:

$$P_{t3} = 259.6 + \left(\frac{3056.5 - 259.6}{8.75}\right)6.5 = 2337.3 \text{ psf}$$

$$(M_u)_h = \frac{1856(6.5^2)}{2} - \left[260\left(\frac{6.5}{2}\right)\left(\frac{2}{3}\right)6.5 + 2337.3\left(\frac{6.5}{2}\right)\left(\frac{1}{3}\right)(6.5)\right]$$

$$(M_u)_h = 19088 \text{ lb}\cdot\text{ft/ft} \circlearrowright$$ main reinforcement @ top

using $\phi = 0.9 \Rightarrow$ required $M_n = \frac{19088}{0.9} = \left(21209 \text{ lb}\cdot\text{ft/ft}\right)12 = 254{,}505 \frac{\text{lb}\cdot\text{in}}{\text{ft}}$

Using #5 bars, $d = 2'(12) - \left[3 + \frac{1}{2}\left(\frac{5}{8}\right)\right] = 20.69 \text{ in}$

$$R = \frac{M_n}{bd^2} = \frac{254505}{12(20.69)^2} = 49.56 \text{ psi}$$

$$\rho = \frac{1}{m}\left[1-\sqrt{1-\frac{2mR}{f_y}}\right] = \frac{1}{17.65}\left[1-\sqrt{1-\frac{2(17.65)(49.56)}{60000}}\right]$$

$\rho = 0.000832$

Since ρ is very small $A_{s(min)}$ will be used to compute A_s

$A_{s(min)} = \frac{4}{3}\rho bd = \frac{4}{3}(.000832)(12)(20.69) = 0.275 \ in^2/ft$

Spacing $= \frac{0.31}{0.275}(12) = 13.53$ in $> 12''$ "thus use #5 @ 12 in o.c."

$(M_u)_t$ = moment for L_t cantilever

$= \left(\frac{(p_{t4}L_t}{2}\left(\frac{2}{3}\right)L_t + p_{t2}\left(\frac{L_t}{2}\right)\left(\frac{1}{3}\right)L_t\right]$

$= \frac{2177(1.25)}{2}\left(\frac{2}{3}\right)(1.25) + 2134\left(\frac{1.25}{2}\right)\left(\frac{1}{3}\right)(1.25) = 1689.6 \ lb{\cdot}ft/ft$

checking M based on nominal values

$p_{t2} = 259.6 + \left(\frac{3056.5 - 259.6}{8.75}\right)(7.5) = 2656.9$ psf

$M_u = \frac{3056.5(1.25)}{2}\left(\frac{2}{3}\right)1.25 + 2656.9\left(\frac{1.25}{2}\right)\left(\frac{1}{3}\right)(1.25) = 2284 \ lb{\cdot}ft/ft$

[GOVERNS]

using #5 bars => d = 20.69 in

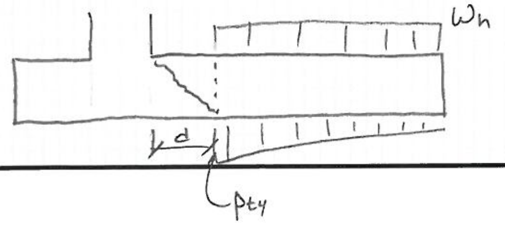
$$R = \frac{M_N}{bd^2} = \frac{\frac{2284(12)}{.9}}{12(20.69)^2} = 5.93$$

$$\rho = \frac{1}{m}\left[1-\sqrt{1-\frac{2mR}{f_y}}\right] = \frac{1}{17.65}\left[1-\sqrt{1-\frac{2(17.65)(5.93)}{60000}}\right] = .000099$$

using $A_{s(min)} = \frac{4}{3}(.000099)(12)(20.69) = 0.0327$

Spacing $= \frac{0.31}{.0327}(12) = 113.6 > 12''$ "thus use #5 bars @ 12" o.c."

Checking Shear for footing



$p_{t4} = 260 + \left(\frac{3056.5 - 260}{8.75}\right)\left(6.5 - \frac{20.69}{12}\right)$

$p_{t4} = 1786.36$ psf

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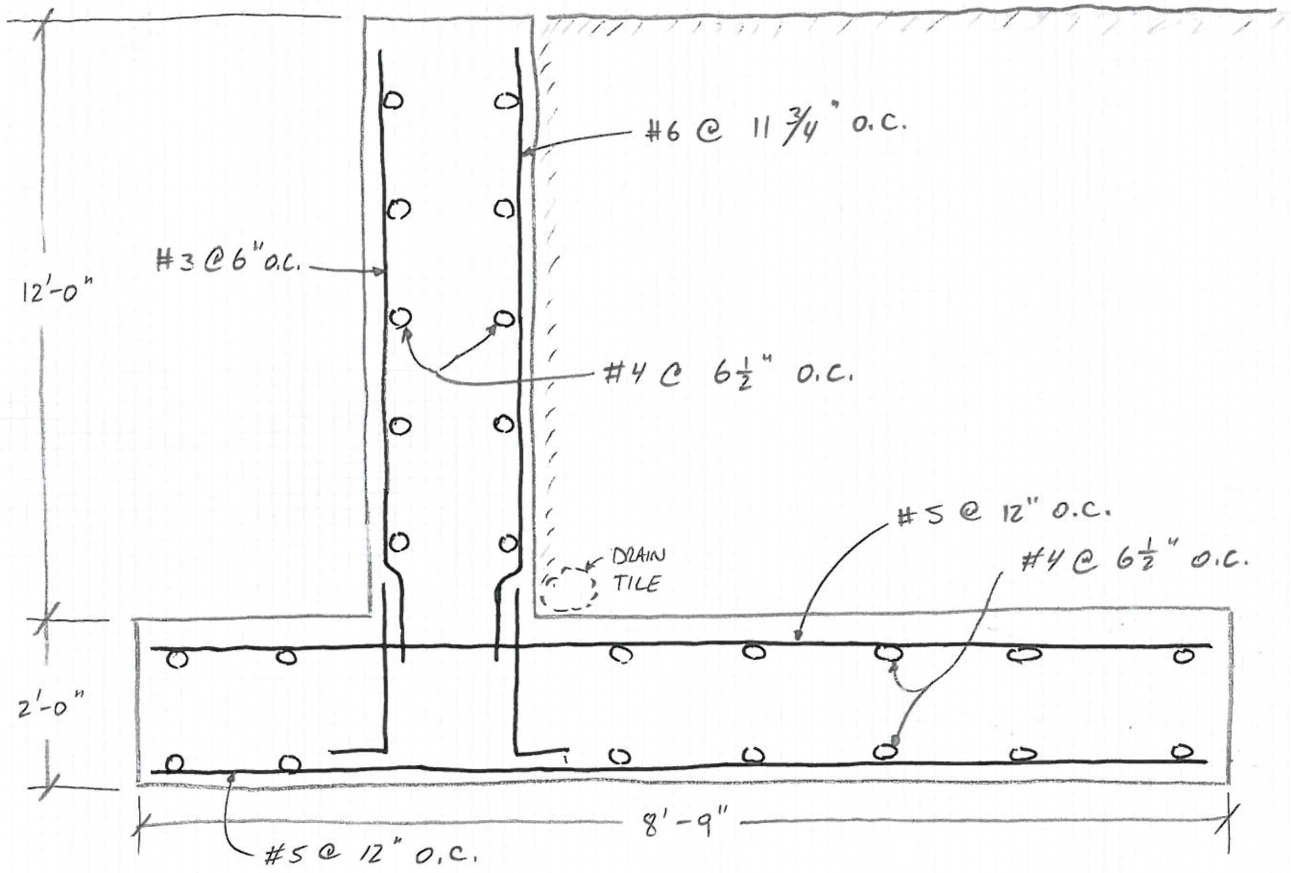
$$V_u = -\left(\frac{260 + 1786.36}{2}\right)(4.78') + 1856(4.78) = 3980.9 \ \text{lbs/ft}$$

$$\phi V_c = 0.75(2)\sqrt{4000}\,(12)(20.69) = 23{,}554 \ \text{lb/ft} > V_u \quad \underline{\underline{\text{OK}}}$$

Footing Detail



APPENDIX: STRUCTURAL (S-8)

ACI 318-08 (SERVICEABILITY)

Serviceability

ACI 318-08

table 9.5(b) - Maximum permissible computed deflection

$\ell/480 = 56(12)/480 = 1.41''$

$12' \times 32''$ → $A = 690 in^2$ $\quad y_t = 6.23$ in

208-D1 No topping $\quad S_b = 2840 in^3$

$f'_c = 5000 psi$

$W_d = 110(12) = 1320 lb/ft = 1.32 k/ft$

$W_L = 125(12) = 1500 lb/ft = 1.5 k/ft$

$M_d = W_d \ell^2/8 = \frac{1.32(56)^2(12)}{8} = 6397 k.in$

$M_L = w_L \ell^2/8 = \frac{1.5(56)^2(12)}{8} = 7056 k.in$

$M_{ext} = M_d + M_L = 13453 k.in$

Prestress force:

$A_{ps} = 20(0.153) = 3.06 in^2$

$f_{pu} = 270 ksi$

initial prestress lvl = 0.75 fpu

Estimated loss = 20%

$f_{se} = 270(0.75)(1-0.2) = 162 ksi$

$P_e = 3.06(162) = 495.72 kip$

$e = 27.75 - 6.23 = 21.52$

$$f_b = \frac{P_e}{A} + \frac{P_e e}{S_b} - \frac{M_{ex}}{S_b}$$

$$= \frac{(495.72)(1000)}{690} + \frac{(495.72)(21.52)(1000)}{2840} - \frac{13453(1000)}{2048}$$

$$= 718 + 3756 - 6569 = 2095 psi$$

f_b = stress at bottom fiber

$f_r = 7.5\sqrt{5000} = 530 psi < 2095 psi$

Tension caused by live load $= \frac{M_L}{S_b} = \frac{7056}{2840} \times 1000 = 2485 psi$

Portion of live load will result in cracking (530psi)

$2095 - 530 = 1565 psi$

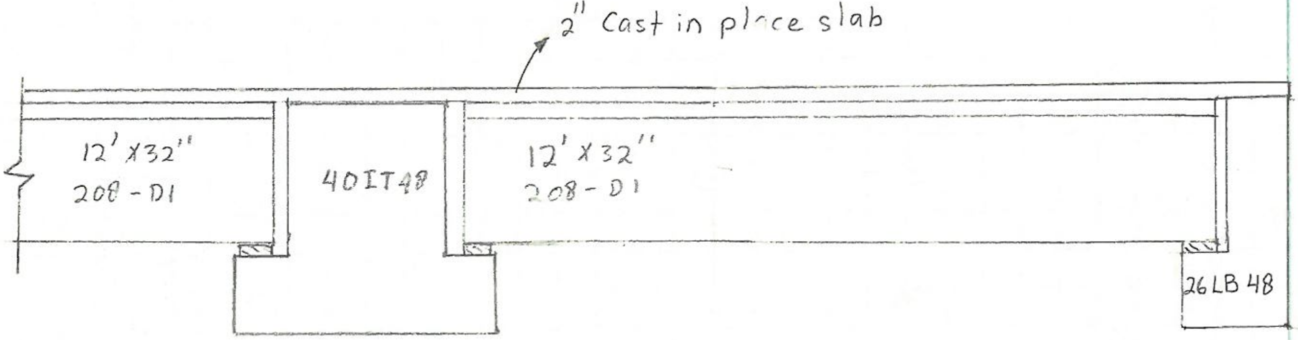
$$\frac{2485-1565}{2485}(1,5) = 0,56\ ^{k}/_{ft}$$

$$\Delta_g = \frac{5 w l^4}{384 E_c I_g} = \frac{5\left(\frac{0,56}{12}\right)\left[(56)(12)\right]^4}{384(4031)(64620)} = 0,47\ in < 1,4''$$

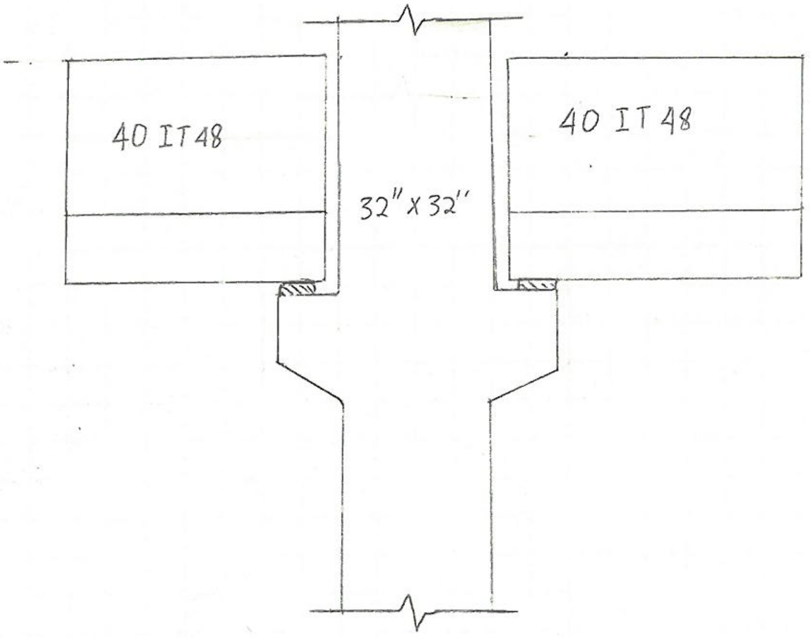
(OK)

$$E_c = 57000\sqrt{f'c} = 4031\ ksi$$

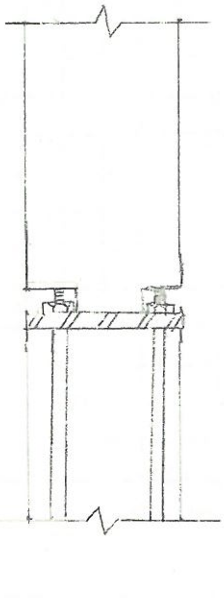
Double - Tee, inverted-Tee and L-Beam connection

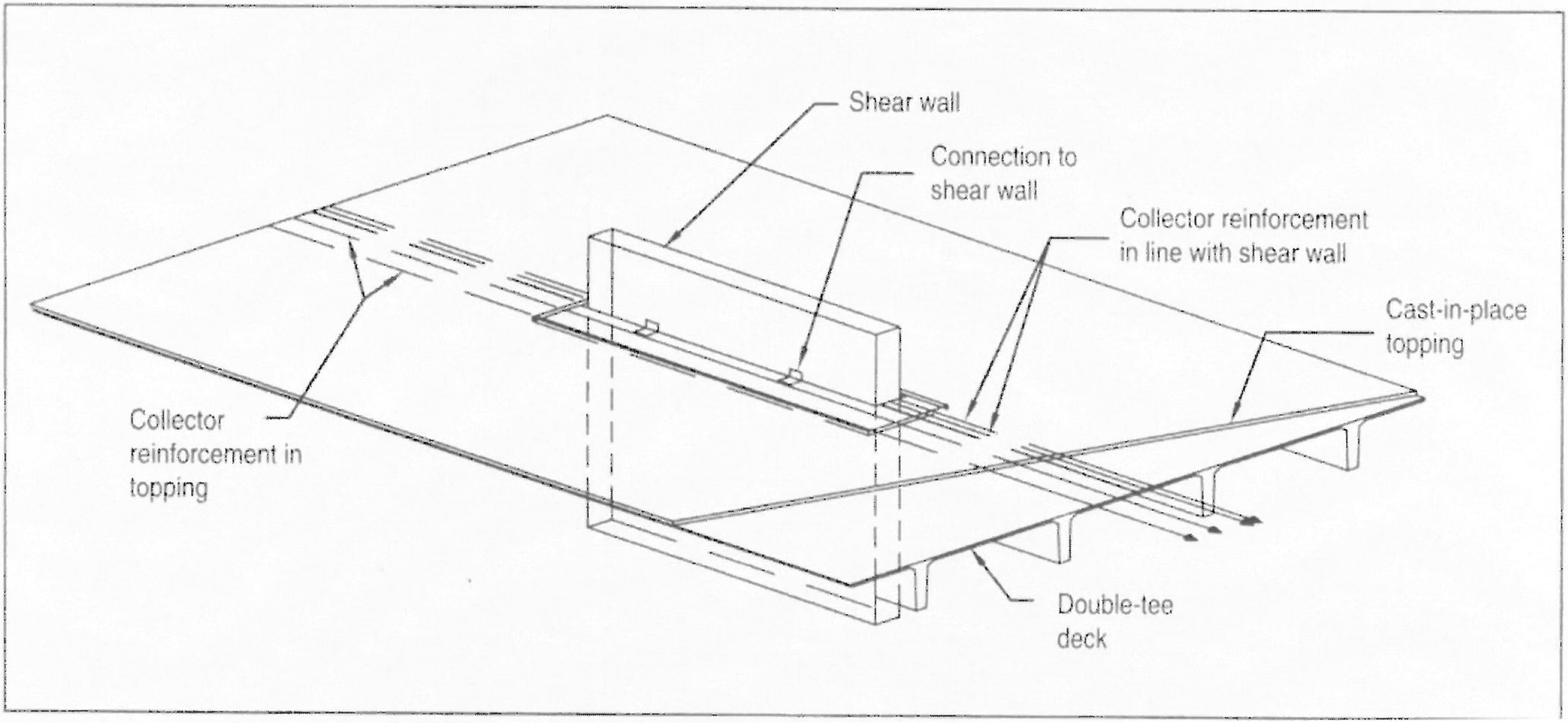


Column and inverted - tee connection.



Column to Column connection

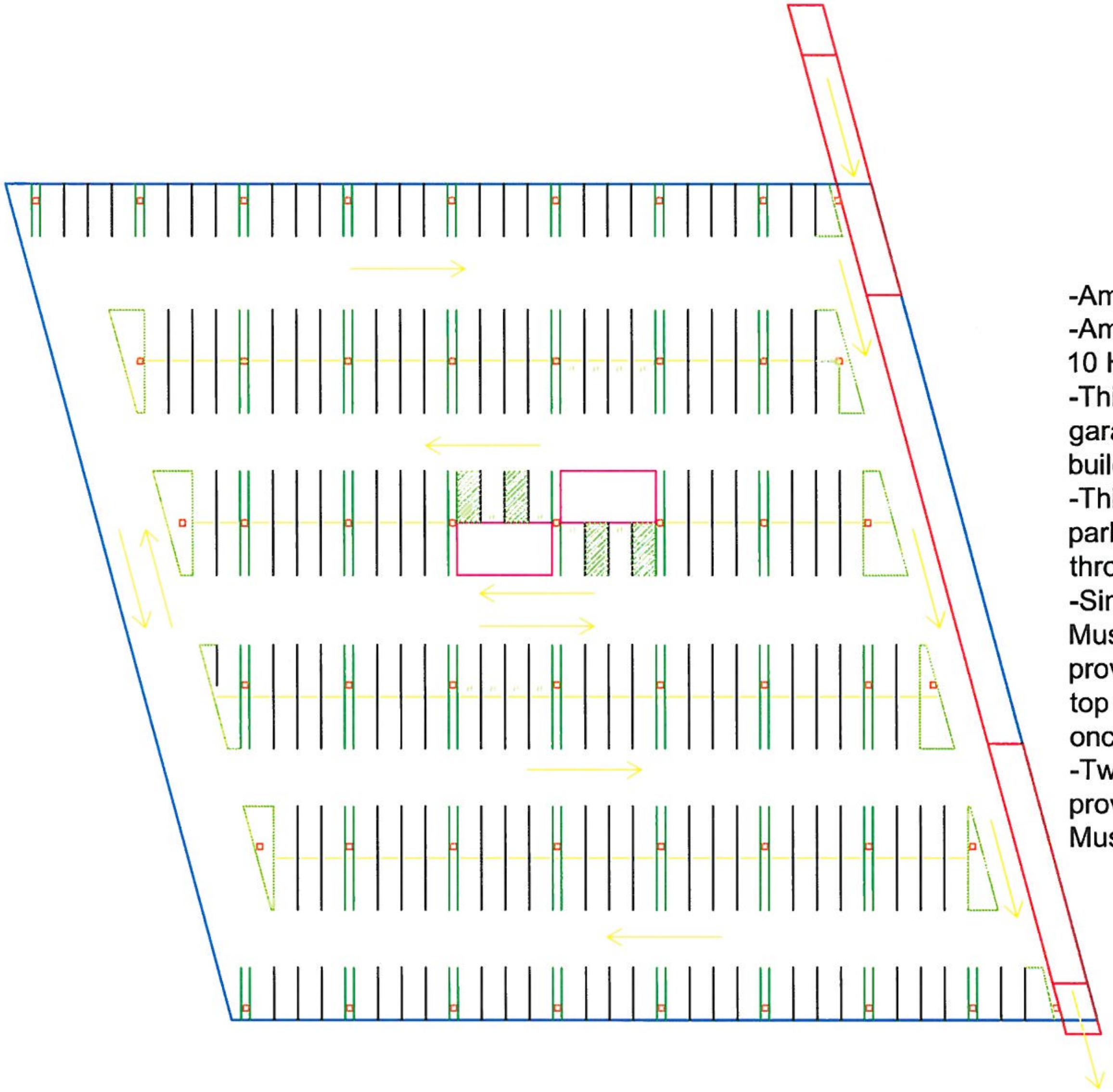



Shear wall
Connection to shear wall
Collector reinforcement in line with shear wall
Cast-in-place topping
Collector reinforcement in topping
Double-tee deck

APPENDIX: STRUCTURAL (S-9)

PARKING LAYOUT FROM CAD FILE

IPRO359 Spring 2011



-Amount of Parking Spots Required - 240
-Amount of Parking Spots Provided - 258 (Including 10 Handicap Spots)
-This design was chosen in order to fit the parking garage into the given structural constraints of the building.
-This layout provides the maximum number of parking spots while still allowing for cars to navigate through the aisles with ease.
-Since the parking garage is underneath the Museum, an entry and exit ramp have been provided. Both include a flat transition landing at the top to make it easier for cars to merge safely into oncoming traffic.
-Two separate elevators and stairwells have been provided which both lead to the ground floor of the Museum

ILLINOIS INSTITUTE OF TECHNOLOGY
CHICAGO, ILLINOIS

CHILDREN'S MUSEUM PRELIMINARY PARKING LAYOUT

Dn By: OMAR MEDINA	IPRO 359 - MR DEVELOPMENT	
Ck By:	App By:	Sheet #: 1 of: 1
Scale: NONE	Date: 03/29/2011	

APPENDIX: STRUCTURAL (S-10)

FAÇADE SUPPORT CALCULATIONS

IPRO359 Spring 2011

Proj: FACADE SUPPORT **Page:** 1 **Date:** 04/19

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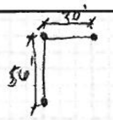
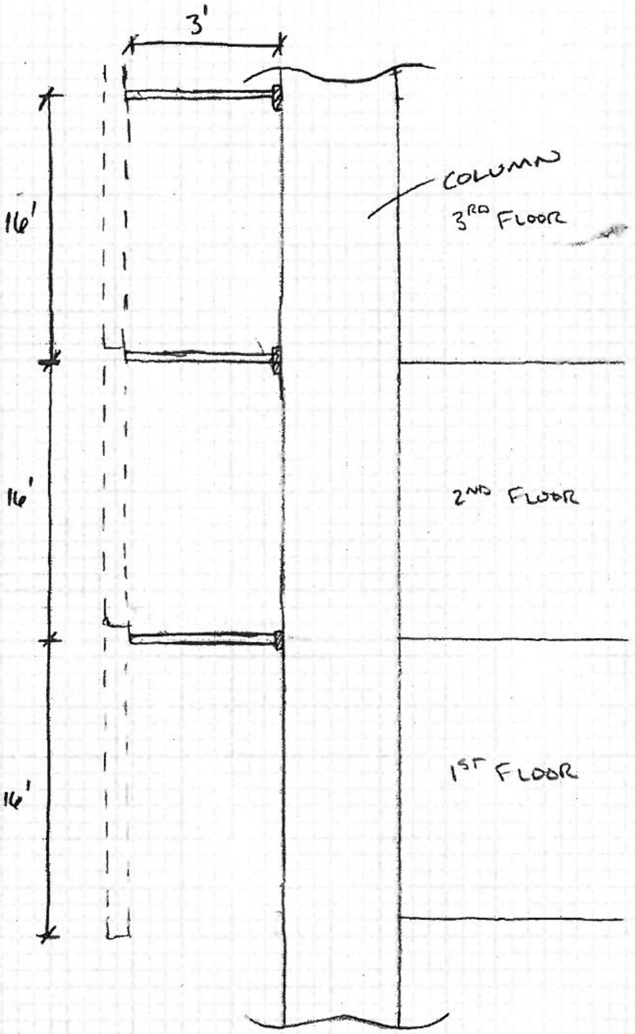




DL = GLASS WEIGHT = 27 LB/FT² (2" THICK GLASS)

LL = 25 LB/FT² MAINTENANCE

LATERAL LOADS

WL = 30.5 LB/FT² — CALCULATED BY TEAM MEMBER

RL = 25 LB/FT² } CHICAGO MUNICIPAL CODE

L = SPAN LENGTH = 3'

DESIGN (N-S WALLS)

TRIBUTARY WIDTH = 30'

DL = (27 LB/FT²)(30 FT) = 810 LB/FT

LL = (25 LB/FT²)(30 FT) = 750 LB/FT

RL = (25 LB/FT²)(30 FT) = 750 LB/FT

WL = (30.5 LB/FT²)(30 FT) = 915 LB/FT

$w_D = .810$ K/FT

$w_L = .750$ K/FT

$w_R = .750$ K/FT

$w_W = .915$ K/FT

FACTORED LOADS:

$w_u = 1.2 w_D + 1.6 w_W + 0.5 w_L + 0.5 w_R$

$= (1.2)(.810) + (1.6)(.915) + (.5)(.750) + (.5)(.750)$

$w_u = 3.186$ KIPS/FT

$M_u = \frac{1}{8} w_u L^2 = \left(\frac{1}{8}\right)(3.186 \text{ K/FT})(30 \text{ FT})^2 = \underline{358.43 \text{ K}\cdot\text{FT}}$

TRY W10 x 77

$\phi M_n = 366$ K-FT > 358.43 K-FT ✓OK

CHECK BEAM WEIGHT: (77 LB/FT)

$M_u = 358.43 + (\frac{1}{8})(1.2)(.077)(30)^2 = 368.83$ (N.G.)

→ TRY W18 x 50

$\phi M_n = 379$ K-FT > 358.43 K-FT ✓OK

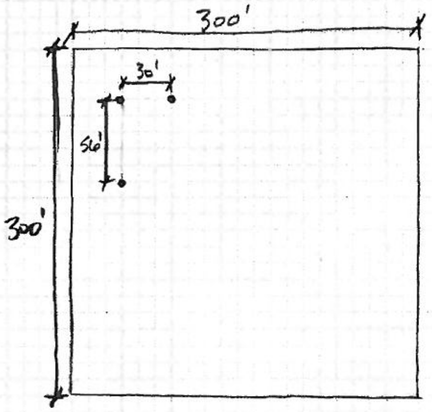
CHECK BEAM WEIGHT: (50 LB/FT)

$M_u = 358.43 + (\frac{1}{8})(1.2)(.050)(30)^2 = 365.18$ K-FT ✓OK

MAX SHEAR:

$V_u = \frac{w_u L}{2} = \frac{(3.186)(30)}{2} = 47.79$ KIPS

$\phi V_n = 192$ KIPS > 47.79 KIPS ✓OK



CONT'D.

MAX PERMISSIBLE DEFLECTION: (SERVICEABILITY)

$$\frac{L}{360} = \frac{(30\text{ FT})(12\text{ IN/FT})}{360} = 1.0''$$

$$\Delta_L = \frac{5}{384}\frac{w_L L^4}{EI} = \left(\frac{5}{384}\right)\left[\frac{(.750\text{ K/FT})\left(\frac{1\text{ FT}}{12\text{ IN}}\right)(30\text{ FT}\cdot 12\text{ IN/FT})^4}{(29{,}000)(800\text{ IN}^4)}\right] = .589'' < 1.0''\ \checkmark\text{OK}$$

CHECK FLEXURAL STRENGTH

$$\frac{b_f}{2t_f} = \frac{(7.50)}{(2)(.57)} = 6.58 \quad \text{(FROM AISC MANUAL)}$$

$$0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{29000}{50}} = 9.15 > 6.58 \quad \therefore \text{THE FLANGE IS COMPACT}$$

$$M_n = M_p = F_y Z_x = (50)(101) = 5050\text{ K-IN} = 420.83\text{ K-FT}$$

$$M_u = 358.43\text{ K-FT}$$

$$\phi M_n = (0.9)(420.83) = 378.75\text{ K-FT} > 358.43\text{ K-FT}\ \checkmark\text{OK}$$

→ $\boxed{\text{USE W18}\times\text{50 @ 30' (N-S WALLS)}}$ 22 PER FLOOR

DESIGN (WEST WALL)

TRIBUTARY WIDTH = 56'

$DL = (27\text{ LB/FT}^2)(56\text{ FT}) = 1512\text{ LB/FT} \rightarrow w_D = 1.512\text{ K/FT}$

$LL = (25\text{ LB/FT}^2)(56\text{ FT}) = 1400\text{ LB/FT} \rightarrow w_L = 1.400\text{ K/FT}$

$RL = (25\text{ LB/FT}^2)(56\text{ FT}) = 1400\text{ LB/FT} \rightarrow w_R = 1.400\text{ K/FT}$

$WL = (30.5\text{ LB/FT}^2)(56\text{ FT}) = 1708\text{ LB/FT} \rightarrow w_W = 1.708\text{ K/FT}$

$w_u = 1.2w_D + 1.6w_W + 0.5w_L + 0.5w_R = (1.2)(1.512) + (1.6)(1.708) + (.5)(1.4) + (.5)(1.4) = 5.95\text{ K/FT}$

$M_u = \frac{1}{8}w_u L^2 = \left(\frac{1}{8}\right)(5.95\text{ K/FT})(56\text{ FT})^2 = 2332.40\text{ K-FT}$

TRY W36 X 160

$\phi M_n = 2340\text{ K-FT} > 2332.40\text{ K-FT}\ \checkmark\text{OK}$

CHECK BEAM WEIGHT! (160 LB/FT)

$M_u = 2332.40 + \left(\frac{1}{8}\right)(1.2)(.160)(56)^2 = 2407.66\text{ K-FT}$ (N.G.)

TRY W36 X 170

$\phi M_n = 2510\text{ K-FT} > 2332.40\text{ K-FT}\ \checkmark\text{OK}$

CHECK BEAM WEIGHT! (170 LB/FT)

$M_u = 2332.40 + \left(\frac{1}{8}\right)(1.2)(.170)(56)^2 = 2412.37\text{ K-FT}\ \checkmark\text{OK}$

CHECK MAX SHEAR!

$$V_u = \frac{w_u L}{2} = \frac{(5.95)(56)}{2} = 166.6\text{ KIPS}$$

$\phi V_n = 738\text{ KIPS} > 166.6\text{ KIPS}\ \checkmark\text{OK}$

Proj: FACADE SUPPORT **Page:** 3/ **Date:** 04/19
Cals by: OMAR MEDINA **Checked by:**

CONT'D.

MAX PERMISSIBLE SHEAR: (SERVICEABILITY)

$$\frac{L}{360} = \frac{(56\ \text{FT})(12\ \frac{\text{IN}}{\text{FT}})}{360} = 1.87''$$

$$\Delta_L = \frac{5}{384}\ \frac{w_L L^4}{EI} = \left(\frac{5}{384}\right)\left[\frac{(1.4\ \text{K/FT})(\frac{1\ \text{FT}}{12\ \text{IN}})(56\ \text{FT}\cdot\frac{12\ \text{IN}}{1\ \text{FT}})^4}{(29000)(10{,}500\ \text{IN}^4)}\right] = \underline{1.02'' < 1.87''}\ \checkmark\text{OK}$$

CHECK FLEXURAL STRENGTH

$$\frac{b_f}{2t_f} = \frac{12}{2(1.10)} = 5.45$$ (FROM AISC MANUAL)

$$0.38\sqrt{\frac{E}{F_y}} = 0.38\sqrt{\frac{29000}{50}} = \underline{9.15 > 5.45}$$ ∴ THE FLANGE IS COMPACT

$$M_n = M_p = F_y Z_x = (50\ \text{K/IN}^2)(83.8\ \text{IN}^3) = 4190\ \text{K-FT}$$

$$M_u = 2412.37\ \text{K-FT}$$

$$\phi M_n = (0.9)(4190) = \underline{3771 > 2412.37}\ \checkmark\text{OK}$$

→ $\boxed{\text{USE W36 X170 @ 56' (WEST WALL)}}$ 6 PER FLOOR

APPENDIX: STRUCTURAL (S-11)

R.S. MEANS COST ESTIMATE SPREADSHEET

IPRO359 Spring 2011

IPRO359-Structural estimate

City of Chicago

2929 South Ellis Avenue

Chicago **IL** **60616**

Data Release : Year 2011

Unit Cost Estimate

Quantity	LineNumber	Source	SubC	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total
608	034133601500			Precast tees, double, floor, 60' span, 32" x 10' wide, prestressed	C11	14	5.143	Ea.	$ 5,675.00	$ 245.00	$ 136.00	$ 6,056.00
1	034133601500	A		Precast beam, inverted tee, large, add to above, includes material only				Ea.	$ 1,135.00	$ -	$ -	$ 1,135.00
90	034105100500			Precast beam, L shaped, 24" x 52", includes material only	C11	12	6	Ea.	$12,000.00	$ 286.00	$ 159.00	$ 12,445.00
391500	033053403250			Structural concrete, in place, elevated slab (4000 psi), floor fill, 2-1/2" thick, includes finishing, excl forms, reinforcing	C8	2685	0.021	S.F.	$ 0.85	$ 0.79	$ 0.28	$ 1.92
4125	034105150350			Precast column, large, square, to 24' high, 3000 psi, includes material only	C11	144	0.5	L.F.	$ 184.00	$ 24.00	$ 13.25	$ 221.25
19	034123500750			Precast stairs, front entrance, 5 risers, 7' wide, 48" platform	C12	10	4.8	Flight	$ 1,075.00	$ 204.00	$ 65.50	$ 1,344.50
1	999999999999	U		Factor for double tees		0	0		$ -	$ -	$ -	$ -
1200	323213103100			Cast-in place retaining walls, reinforced concrete cantilever, 33 degree slope embankment, 10' high, includes excavation, backfill & reinforcing	C17C	20	4.15	L.F.	$ 99.00	$ 186.00	$ 32.00	$ 317.00
54778	312316425610			Excavating, bulk bank measure,sandy clay/loam, open site, 1/2 C.Y. capacity = 44 C.Y./hour, backhoe, hydraulic, wheel mounted, excluding truck loading	B12E	352	0.045	B.C.Y.	$ -	$ 1.84	$ 1.04	$ 2.88
89376	034513500700			Precast wall panel, smooth, gray, uninsulated, high rise, 16' x 8' x 4" thick, 3000 psi	C11	768	0.094	S.F.	$ 21.00	$ 4.47	$ 2.48	$ 27.95
2040	033053403850			Structural concrete, in place, spread footing (3000 psi), over 5 C.Y., includes forms, reinforcing steel, concrete, placing and finishing	C14C	75	1.493	C.Y.	$ 171.00	$ 61.50	$ 0.31	$ 232.81
222	051223753700			Structural steel member, 100-ton project, 1 to 2 story building, W18x50, A992 steel, shop fabricated, incl shop primer, bolted connections	E5	912	0.088	L.F.	$ 62.00	$ 4.20	$ 1.90	$ 68.10
63	051223757600			Structural steel member, 100-ton project, 1 to 2 story building, W36x170, A992 steel, shop fabricated, incl shop primer, bolted connections	E5	1150	0.07	L.F.	$ 210.00	$ 3.33	$ 1.51	$ 214.84

Total

Ext. Mat.	Ext. Labor	Ext. Equip.	Ext. Total	Mat. O&P	Labor O&P	Equip. O&P	Total O&P	Ext. Mat. O&P	Ext. Labor O&P
$ 3,450,400.00	$ 148,960.00	$ 82,688.00	$ 3,682,048.00	$ 6,225.00	$ 420.00	$ 150.00	$ 6,795.00	$ 3,784,800.00	$ 255,360.00
$ 690,080.00	$ -	$ -	$ 690,080.00	$ 1,245.00	$ -	$ -	$ 1,245.00	$ 756,960.00	$ -
$ 1,080,000.00	$ 25,740.00	$ 14,310.00	$ 1,120,050.00	$ 13,100.00	$ 490.00	$ 175.00	$ 13,765.00	$ 1,179,000.00	$ 44,100.00
$ 332,775.00	$ 309,285.00	$ 109,620.00	$ 751,680.00	$ 0.93	$ 1.19	$ 0.30	$ 2.42	$ 364,095.00	$ 465,885.00
$ 759,000.00	$ 99,000.00	$ 54,656.25	$ 912,656.25	$ 202.00	$ 41.00	$ 14.55	$ 257.55	$ 833,250.00	$ 169,125.00
$ 20,425.00	$ 3,876.00	$ 1,244.50	$ 25,545.50	$ 1,200.00	$ 310.00	$ 72.00	$ 1,582.00	$ 22,800.00	$ 5,890.00
$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 441,846.00	$ -	$ -
$ 118,800.00	$ 223,200.00	$ 38,400.00	$ 380,400.00	$ 109.00	$ 285.00	$ 35.00	$ 429.00	$ 130,800.00	$ 342,000.00
$ -	$ 100,791.52	$ 56,969.12	$ 157,760.64	$ -	$ 2.78	$ 1.14	$ 3.92	$ -	$ 152,282.84
$ 1,876,896.00	$ 399,510.72	$ 221,652.48	$ 2,498,059.20	$ 23.00	$ 7.65	$ 2.73	$ 33.38	$ 2,055,648.00	$ 683,726.40
$ 348,840.00	$ 125,460.00	$ 632.40	$ 474,932.40	$ 188.00	$ 95.00	$ 0.34	$ 283.34	$ 383,520.00	$ 193,800.00
$ 13,764.00	$ 932.40	$ 421.80	$ 15,118.20	$ 68.00	$ 7.20	$ 2.09	$ 77.29	$ 15,096.00	$ 1,598.40
$ 13,230.00	$ 209.79	$ 95.13	$ 13,534.92	$ 231.00	$ 5.70	$ 1.66	$ 238.36	$ 14,553.00	$ 359.10
$8704210.00	$1436965.43	$580689.68	$10721865.11					$9540522.00	$2314126.74

Ext. Equip. O&P	Ext. Total O&P	Labor Type	Data Release	Zip Code	Notes
$ 91,200.00	##########	STD	Year 2011		
$ -	$756,960.00	STD	Year 2011		[Adjusted by 034105101050]
$ 15,750.00	##########	STD	Year 2011		
$ 117,450.00	$947,430.00	STD	Year 2011		
$ 60,018.75	##########	STD	Year 2011		
$ 1,368.00	$ 30,058.00	STD	Year 2011		
$ -	$441,846.00	USER	Year 2011		
$ 42,000.00	$514,800.00	STD	Year 2011		
$ 62,446.92	$214,729.76	STD	Year 2011		
$ 243,996.48	##########	STD	Year 2011		
$ 693.60	$578,013.60	STD	Year 2011		
$ 463.98	$ 17,158.38	STD	Year 2011		
$ 104.58	$ 15,016.68	STD	Year 2011		
$635492.31	**$12931987.05**				

APPENDIX: HVAC (H-1)

ASHRAE TABLES

IPRO359 Spring 2011

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Type And Number Of Chillers Ashare 90.1

Table G3.1.3.7 of ASHRAE 90.1-2004 says that for a building with conditioned area equal to more than 240,000 square feet, "2 centrifugal chillers minimum with chillers added so that no chiller is larger than 800 tons, all sized equally" should be the size and number of chillers.

1) ASHRAE 90.1-2004, Appendix G, G3.1.2.2: Equipment Capacities, Page 178:

G3.1.3.7 Type and Number of Chillers (Systems 7 and 8). Electric chillers shall be used in the baseline building design regardless of the cooling energy source, e.g., direct fired absorption, absorption from purchased steam, or purchased chilled water. The baseline building design's chiller plant shall be modeled with chillers having the number and type as indicated in Table G3.1.3.7 as a function of building conditioned floor area.

Table G3.1.3.7 Type and number of chillers

Building Conditioned floor area	Number and type of chillers
<= 120,000 sq ft	1 screw chiller
> 120,000 sq ft, <240,000 sq ft	2 screw chillers sized equally
>=240,000 sq ft	2 centrifugal chillers minimum with chillers added so that no chiller is larger than 800 tons, all sized equally.

2) ASHRAE 90.1-2004 User Manual Appendix G ,Type and Number of Chillers (§ G3.1.3.7), G-30:

For baseline building systems 7 and 8, which have chilled water plants, electric chillers shall be used for the baseline building no matter what the cooling energy source in the proposed building. Even though the proposed building may have gas engine driven chillers or absorption chillers, the baseline building shall be modeled with electric chillers.
The type of chillers that are placed in the baseline building depends on the conditioned floor area of the baseline building, which is the same as the proposed building. If the building has an area of 120,000 ft² or less, then a single screw chiller is modeled. For floor areas greater than 120,000 ft² but less than 240,000 ft², then two equally sized screw chillers are modeled in the baseline building. For buildings that are 240,000 ft² or larger, the baseline building is modeled with two or more centrifugal chillers. In this case at least two equally sized centrifugal chillers are always modeled, but additional equally sized chillers are added as necessary so that all chillers are 800 tons are smaller.

Explanation

Understanding/Interpreting/Calculating the number of chillers and chiller size:

In the table above, when the conditioned area of the building is more than or equal to 240,000 sq ft, it is specified that "2 centrifugal chillers minimum with chillers added so that no chiller is larger than 800 tons, all equally sized", in this specification the standard is not clear in specifying the minimum size of chiller which is to be used.
It specifies the minimum number as two and maximum tonnage as 800 tons, which may lead to a confusion as in the following example:

> Suppose a non residential building more than 6 floors with a conditioned area greater than 3, 00,000 sq ft, following ASHRAE 90.1 Appendix G. ASHRAE 90.1-2004 Table G3.1.3.7 (Type and number of chillers) says that it should be "2 centrifugal chillers minimum with chiller added so that no chiller is larger than 800 tons, all sized equally."
>
> After a sizing run of the model, the tonnage came out to be approximately 1000 tons. **I can divide this into 2 x 500 tons chiller or into 4 x 250 tons chillers.** In each case the COP of the chiller is different as per Table 6.8.1C.

This is to be understood such that, depending on the total tonnage there are a minimum of two (but not less than two) chillers equally sized with a maximum of 800 tons each and over that **for the remaining tonnage the chillers are further added** which are not greater than 800 tons in size, such that all the chiller tonnages are adjusted to be equally sized.
This specifies that the number of chiller is the base case should be as low as possible but not less than two and none of it more than 800tons, all equally sized.
There is a building with total tonnage T. The number of chiller is first known by dividing the total tonnage by maximum tonnage allowable, which is T/800 (say X). Round off this X on to its higher side which is Y. This tells that there are Y numbers of chillers which are equally sized. Size of each chiller S, now is total tonnage T divided by Y, (S=T/Y).
If Total tonnage T: 2700 tons, than

First step;
X= T/800= 3.75 (round it on higher side)
Y= 4
Number of Chillers= 4
Size of each Chiller S = T/4

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Table 1 Representative Rates at Which Heat and Moisture Are Given Off by Human Beings in Different States of Activity

		Total Heat, Btu/h		Sensible Heat, Btu/h	Latent Heat, Btu/h	% Sensible Heat that is Radiant[b]	
Degree of Activity	Location	Adult Male	Adjusted, M/F[a]			Low V	High V
Seated at theater	Theater, matinee	390	330	225	105		
Seated at theater, night	Theater, night	390	350	245	105	60	27
Seated, very light work	Offices, hotels, apartments	450	400	245	155		
Moderately active office work	Offices, hotels, apartments	475	450	250	200		
Standing, light work; walking	Department store, retail store	550	450	250	200	58	38
Walking, standing	Drug store, bank	550	500	250	250		
Sedentary work	Restaurant[c]	490	550	275	275		
Light bench work	Factory	800	750	275	475		
Moderate dancing	Dance hall	900	850	305	545	49	35
Walking 3 mph, light machine work	Factory	1000	1000	375	625		
Bowling[d]	Bowling alley	1500	1450	580	870		
Heavy work	Factory	1500	1450	580	870	54	19
Heavy machine work, lifting	Factory	1600	1600	635	965		
Athletics	Gymnasium	2000	1800	710	1090		

Notes:

1. Tabulated values are based on 75°F room dry-bulb temperature. For 80°F room dry bulb, total heat remains the same, but sensible heat values should be decreased by approximately 20%, and latent heat values increased accordingly.
2. Also see Table 4, Chapter 9, for additional rates of metabolic heat generation.
3. All values are rounded to nearest 5 Btu/h.

[a] Adjusted heat gain is based on normal percentage of men, women, and children for the application listed, and assumes that gain from an adult female is 85% of that for an adult male, and gain from a child is 75% of that for an adult male.

[b] Values approximated from data in Table 6, Chapter 9, where V is air velocity with limits shown in that table.

[c] Adjusted heat gain includes 60 Btu/h for food per individual (30 Btu/h sensible and 30 Btu/h latent).

[d] Figure one person per alley actually bowling, and all others as sitting (400 Btu/h) or standing or walking slowly (550 Btu/h).

Table 15 Solar Absorptance Values of Various Surfaces

Surface	Absorptance
Brick, red (Purdue)[a]	0.63
Paint	
Red[b]	0.63
Black, matte[b]	0.94
Sandstone[b]	0.50
White acrylic[a]	0.26
Sheet metal, galvanized	
New[a]	0.65
Weathered[a]	0.80
Shingles	0.82
Gray[b]	
Brown[b]	0.91
Black[b]	0.97
White[b]	0.75
Concrete[a,c]	0.60 to 0.83

[a] Incropera and DeWitt (1990).

[b] Parker et al. (2000).

[c] Miller (1971).

Table 5 Ground Reflectance of Foreground Surfaces

Foreground Surface	Reflectance
Water (large angle of incidences)	0.07
Coniferous forest (winter)	0.07
Bituminous and gravel roof	0.13
Dry bare ground	0.2
Weathered concrete	0.22
Green grass	0.26
Dry grassland	0.2 to 0.3
Desert sand	0.4
Light building surfaces	0.6
Snow-covered surfaces:	
Typical city centre	0.2
Typical urban site	0.4
Typical rural site	0.5
Isolated rural site	0.7

Source: Adapted from Thevenard and Haddad (2006).

Table 5 Emissivities and Absorptivities of Some Surfaces

Surface	Total Hemispherical Emissivity	Solar Absorptivity*
Aluminum		
Foil, bright dipped	0.03	0.10
Alloy: 6061	0.04	0.37
Roofing	0.24	
Asphalt	0.88	
Brass		
Oxidized	0.60	
Polished	0.04	
Brick	0.90	
Concrete, rough	0.91	0.60
Copper		
Electroplated	0.03	0.47
Black oxidized in Ebanol C	0.16	0.91
Plate, oxidized	0.76	
Glass		
Polished	0.87 to 0.92	
Pyrex	0.80	
Smooth	0.91	
Granite	0.44	
Gravel	0.30	
Ice	0.96 to 0.97	
Limestone	0.92	
Marble		
Polished or white	0.89 to 0.92	
Smooth	0.56	
Mortar, lime	0.90	
Nickel		
Electroplated	0.03	0.22
Solar absorber, electro-oxidized on copper	0.05 to 0.11	0.85
Paints		
Black		
Parsons optical, silicone high heat, epoxy	0.87 to 0.92	0.94 to 0.97
Gloss	0.90	
Enamel, heated 1000 h at 710°F	0.80	
Silver chromatone	0.24	0.20
White		
Acrylic resin	0.90	0.26
Gloss	0.85	
Epoxy	0.85	0.25
Paper, roofing or white	0.88 to 0.86	
Plaster, rough	0.89	
Refractory	0.90 to 0.94	
Sand	0.75	
Sandstone, red	0.59	
Silver, polished	0.02	
Snow, fresh	0.82	0.13
Soil	0.94	
Water	0.90	0.98
White potassium zirconium silicate	0.87	0.13

Source: Mills (1999)

*Values are for extraterrestrial conditions, except for concrete, snow, and water.

Table 1 Surface Conductances and Resistances for Air

Position of Surface	Direction of Heat Flow	Surface Emittance, ε					
		Nonreflective		Reflective			
		ε = 0.90		ε = 0.20		ε = 0.05	
		h_i	R	h_i	R	h_i	R
Still Air							
Horizontal	Upward	1.63	0.61	0.91	1.10	0.76	1.32
Sloping at 45°	Upward	1.60	0.62	0.88	1.14	0.73	1.37
Vertical	Horizontal	1.46	0.68	0.74	1.35	0.59	1.70
Sloping at 45°	Downward	1.32	0.76	0.60	1.67	0.45	2.22
Horizontal	Downward	1.08	0.92	0.37	2.70	0.22	4.55
Moving Air (any position)		h_o	R				
15 mph wind (for winter)	Any	6.00	0.17	—	—	—	—
7.5 mph wind (for summer)	Any	4.00	0.25	—	—	—	—

Notes:

1. Surface conductance h_i and h_o measured in Btu/h·ft²·°F; resistance R in h·ft²·°F/Btu.
2. No surface has both an air space resistance value and a surface resistance value.
3. Conductances are for surfaces of the stated emittance facing virtual black-body surroundings at same temperature as ambient air. Values based on surface/air temperature difference of 10°F and surface temperatures of 70°F.
4. See Chapter 4 for more detailed information.
5. Condensate can have significant effect on surface emittance (see Table 2).

TABLE 505.5.2
INTERIOR LIGHTING POWER ALLOWANCES

LIGHTING POWER DENSITY	
Building Area Type [a]	**(W/ft2)**
Automotive Facility	0.9
Convention Center	1.2
Court House	1.2
Dining: Bar Lounge/Leisure	1.3
Dining: Cafeteria/Fast Food	1.4
Dining: Family	1.6
Dormitory	1.0
Exercise Center	1.0
Gymnasium	1.1
Healthcare-Clinic	1.0
Hospital	1.2
Hotel	1.0
Library	1.3
Manufacturing Facility	1.3
Motel	1.0
Motion Picture Theater	1.2
Multi-Family	0.7
Museum	1.1
Office	1.0
Parking Garage	0.3
Penitentiary	1.0
Performing Arts Theater	1.6
Police/Fire Station	1.0
Post Office	1.1
Religious Building	1.3

Table 4 U-Factors for Various Fenestration Products in Btu/h · ft^2 · °F

	Product Type	Glass Only		Vertical Installation									
				Operable (including sliding and swinging glass doors)					Fixed				
	Frame Type			Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Insulated Fiberglass/ Vinyl
ID	Glazing Type	Center of Glass	Edge of Glass										
	Single Glazing												
1	1/8 in. glass	*1.04*	*1.04*	1.23	1.07	0.93	0.91	0.85	1.12	1.07	0.98	0.98	1.04
2	1/4 in. acrylic/polycarbonate	*0.88*	*0.88*	1.10	0.94	0.81	0.80	0.74	0.98	0.92	0.84	0.84	0.88
3	1/8 in. acrylic/polycarbonate	*0.96*	*0.96*	1.17	1.01	0.87	0.86	0.79	1.05	0.99	0.91	0.91	0.96
	Double Glazing												
4	1/4 in. air space	*0.55*	*0.64*	0.81	0.64	0.57	0.55	0.50	0.68	0.62	0.56	0.56	0.55
5	1/2 in. air space	*0.48*	*0.59*	0.76	0.58	0.52	0.50	0.45	0.62	0.56	0.50	0.50	0.48
6	1/4 in. argon space	*0.51*	*0.61*	0.78	0.61	0.54	0.52	0.47	0.65	0.59	0.53	0.52	0.51
7	1/2 in. argon space	*0.45*	*0.57*	0.73	0.56	0.50	0.48	0.43	0.60	0.53	0.48	0.47	0.45
	Double Glazing, $e = 0.60$ on surface 2 or 3												
8	1/4 in. air space	*0.52*	*0.62*	0.79	0.61	0.55	0.53	0.48	0.66	0.59	0.54	0.53	0.52
9	1/2 in. air space	*0.44*	*0.56*	0.72	0.55	0.49	0.48	0.43	0.59	0.53	0.47	0.47	0.44
10	1/4 in. argon space	*0.47*	*0.58*	0.75	0.57	0.51	0.50	0.45	0.61	0.55	0.49	0.49	0.47
11	1/2 in. argon space	*0.41*	*0.54*	0.70	0.53	0.47	0.45	0.41	0.56	0.50	0.44	0.44	0.41
	Double Glazing, $e = 0.40$ on surface 2 or 3												
12	1/4 in. air space	*0.49*	*0.60*	0.76	0.59	0.53	0.51	0.46	0.63	0.57	0.51	0.51	0.49
13	1/2 in. air space	*0.40*	*0.54*	0.69	0.52	0.47	0.45	0.40	0.55	0.49	0.44	0.43	0.40
14	1/4 in. argon space	*0.43*	*0.56*	0.72	0.54	0.49	0.47	0.42	0.58	0.52	0.46	0.46	0.43
15	1/2 in. argon space	*0.36*	*0.51*	0.66	0.49	0.44	0.42	0.37	0.52	0.46	0.40	0.40	0.36
	Double Glazing, $e = 0.20$ on surface 2 or 3												
16	1/4 in. air space	*0.45*	*0.57*	0.73	0.56	0.50	0.48	0.43	0.60	0.53	0.48	0.47	0.45
17	1/2 in. air space	*0.35*	*0.50*	0.65	0.48	0.43	0.41	0.37	0.51	0.45	0.39	0.39	0.35
18	1/4 in. argon space	*0.38*	*0.52*	0.68	0.51	0.45	0.43	0.39	0.54	0.47	0.42	0.42	0.38
19	1/2 in. argon space	*0.30*	*0.46*	0.61	0.45	0.39	0.38	0.33	0.47	0.41	0.35	0.35	0.30
	Double Glazing, $e = 0.10$ on surface 2 or 3												
20	1/4 in. air space	*0.42*	*0.55*	0.71	0.54	0.48	0.46	0.41	0.57	0.51	0.45	0.45	0.42
21	1/2 in. air space	*0.32*	*0.48*	0.63	0.46	0.41	0.39	0.34	0.49	0.42	0.37	0.37	0.32
22	1/4 in. argon space	*0.35*	*0.50*	0.65	0.48	0.43	0.41	0.37	0.51	0.45	0.39	0.39	0.35
23	1/2 in. argon space	*0.27*	*0.44*	0.59	0.42	0.37	0.36	0.31	0.44	0.38	0.33	0.32	0.27
	Double Glazing, $e = 0.05$ on surface 2 or 3												
24	1/4 in. air space	*0.41*	*0.54*	0.70	0.53	0.47	0.45	0.41	0.56	0.50	0.44	0.44	0.41

Table 4 U-Factors for Various Fenestration Products in Btu/h · ft^2 · °F (*Concluded*)

Vertical Installation					Sloped Installation									
Garden Windows		Curtain Wall			Glass Only (Skylights)		Manufactured Skylight				Site-Assembled Sloped/Overhead Glazing			
Aluminum Without Thermal Break	Wood/ Vinyl	Aluminum Without Thermal Break	Aluminum With Thermal Break	Structural Glazing	Center of Glass	Edge of Glass	Aluminum Without Thermal Break	Aluminum With Thermal Break	Reinforced Vinyl/ Aluminum Clad Wood	Wood/ Vinyl	Aluminum Without Thermal Break	Aluminum With Thermal Break	Structural Glazing	ID
2.50	2.10	1.21	1.10	1.10	*1.19*	*1.19*	1.77	1.70	1.61	1.42	1.35	1.34	1.25	1
2.24	1.84	1.06	0.96	0.96	*1.03*	*1.03*	1.60	1.54	1.45	1.31	1.20	1.20	1.10	2
2.37	1.97	1.13	1.03	1.03	*1.11*	*1.11*	1.68	1.62	1.53	1.39	1.27	1.27	1.18	3
1.72	1.32	0.77	0.67	0.63	*0.58*	*0.66*	1.10	0.96	0.92	0.84	0.80	0.83	0.66	4
1.62	1.22	0.71	0.61	0.57	*0.57*	*0.65*	1.09	0.95	0.91	0.84	0.79	0.82	0.65	5
1.66	1.26	0.74	0.63	0.59	*0.53*	*0.63*	1.05	0.91	0.87	0.80	0.76	0.80	0.62	6
1.57	1.17	0.68	0.58	0.54	*0.53*	*0.63*	1.05	0.91	0.87	0.80	0.76	0.80	0.62	7
1.68	1.28	0.74	0.64	0.60	*0.54*	*0.63*	1.06	0.92	0.88	0.81	0.77	0.80	0.63	8
1.56	1.16	0.68	0.57	0.53	*0.53*	*0.63*	1.05	0.91	0.87	0.80	0.76	0.80	0.62	9
1.60	1.20	0.70	0.60	0.56	*0.49*	*0.60*	1.01	0.87	0.83	0.76	0.72	0.77	0.58	10
1.51	1.11	0.65	0.55	0.51	*0.49*	*0.60*	1.01	0.87	0.83	0.76	0.72	0.77	0.58	11
1.63	1.23	0.72	0.62	0.58	*0.51*	*0.61*	1.03	0.89	0.85	0.78	0.74	0.78	0.60	12
1.50	1.10	0.64	0.54	0.50	*0.50*	*0.61*	1.02	0.88	0.84	0.77	0.73	0.78	0.59	13
1.54	1.14	0.67	0.56	0.52	*0.44*	*0.56*	0.96	0.83	0.78	0.72	0.68	0.74	0.54	14
1.44	1.04	0.61	0.50	0.46	*0.46*	*0.58*	0.98	0.85	0.80	0.74	0.70	0.75	0.56	15
1.57	1.17	0.68	0.58	0.54	*0.46*	*0.58*	0.98	0.85	0.80	0.74	0.70	0.75	0.56	16
1.43	1.03	0.60	0.50	0.45	*0.46*	*0.58*	0.98	0.85	0.80	0.74	0.70	0.75	0.56	17
1.47	1.07	0.62	0.52	0.48	*0.39*	*0.53*	0.91	0.78	0.74	0.68	0.64	0.70	0.50	18
1.35	0.95	0.55	0.45	0.41	*0.40*	*0.54*	0.92	0.79	0.75	0.68	0.64	0.71	0.51	19
1.53	1.13	0.66	0.56	0.51	*0.44*	*0.56*	0.96	0.83	0.78	0.72	0.68	0.74	0.54	20
1.38	0.98	0.57	0.47	0.43	*0.44*	*0.56*	0.96	0.83	0.78	0.72	0.68	0.74	0.54	21
1.43	1.03	0.60	0.50	0.45	*0.36*	*0.51*	0.88	0.75	0.71	0.65	0.61	0.68	0.47	22
1.30	0.90	0.53	0.43	0.38	*0.38*	*0.52*	0.90	0.77	0.73	0.67	0.63	0.69	0.49	23

APPENDIX: HVAC (H-2)

RTS SPREADSHEET

IPRO359 Spring 2011

RTS Method Spreadsheet

Cooling	**Btu/h**	
July, 3pm	**Sensible**	**Latent**
Internal Heat Gain		
People	1,750,000	1,554,000
Lighting	670,870	
Transmission		
South Wall	243,983	
West Wall	233,634	
North Wall	201,085	
East Wall	24,098	
Roof	100,329	
Green Roof	51,837	
Floor	177,000	
Roof Window	273,957	
Total	**3,726,793**	**1,554,000**

Heating	**Btu/h**	
January, 7pm	**Sensible**	**Latent**
Transmission		
South Wall	-169,675	
West Wall	-150,309	
North Wall	-168,544	
East Wall	-16,221	
Roof	-67,435	
Green Roof	-49,022	
Floor	-408,000	
Roof Window	-44,630	
Total	**-1,073,836**	

Total Cooling cfm	**114,847**
Total Heating cfm	**67,793**

COOLING LOAD COMPONENTS

DESIGN WEATHER PROFILES

#REF!

#REF!

24-Apr-11

OUTSIDE AIR PROFILES - PEAK DRY BULB AND MEAN COINCIDENT WET BULB

USA - IL - CHICAGO MIDWAY AP - 0.4%

USA - IL - CHICAGO MIDWAY AP - 0.4%

	Latitude	Longitude	Elevation,ft	Hours +/- UTC	Time Zone	Standard Meridian
Index = 1389	41.79	-87.75	617	-6	Central	-90

Inside Heating Design Temperature, F = 70

Outside Heating Design Temp, F (99.6%) = -1.6

Outside Heating Design Temp, F (99%) = 4.3

Design OA heating:

78.76 Btuh/cfm

72.27 Btuh/cfm

Inside Cooling Design Conditions:

DB, F	**RH**	DBR	PWS	PW	W
68	50%	527.67	0.3392147	0.1696073	0.007262

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Monthly Design DB =	55.6	60.6	74.6	84.2	88.7	93.4	97.5	94.6	90.6	82.5	70	62.9
Mean Coincident WB =	51.1	51.3	61.1	65.3	70.6	74.7	78.4	77.1	72	66.3	58.1	59.3
Daily Range, DB =	15.9	18.4	23.4	24.9	22.6	20.5	19.1	18.3	19.8	22.2	18.4	16.6
Daily Range, WB =	13.5	14.1	15.7	14.6	11.9	9.5	8.6	8.3	9.4	12.7	14.6	14.3
SOLAR TAU-B	0.305	0.349	0.397	0.42	0.446	0.464	0.457	0.457	0.416	0.368	0.339	0.311
SOLAR TAU-D	2.344	2.123	2.004	1.986	1.97	1.982	2.043	2.03	2.13	2.248	2.29	2.363
WBR =	510.77	510.97	520.77	524.97	530.27	534.37	538.07	536.77	531.67	525.97	517.77	518.97
PWS =	0.185531	0.186910	0.266564	0.308949	0.370781	0.425784	0.481405	0.461180	0.388819	0.319870	0.239501	0.250022
WST =	0.007953	0.008013	0.011490	0.013356	0.016099	0.018558	0.021065	0.020151	0.016903	0.013839	0.010304	0.010765
W =	0.006925	0.005893	0.008383	0.008992	0.011886	0.014178	0.016563	0.016033	0.012565	0.010089	0.007574	0.009935
Peak Design OA cooling load,												
sensible, Btuh/cfm =	-13.64	-8.14	7.26	17.82	22.77	27.94	32.45	29.26	24.86	15.95	2.20	-5.61
latent, Btuh/cfm =	-1.63	-6.63	5.43	8.37	22.38	33.47	45.01	42.45	25.67	13.68	1.51	12.94
Total, Btuh/cfm =	-15.27	-14.77	12.69	26.19	45.15	61.41	77.46	71.71	50.53	29.63	3.71	7.33

COOLING LOAD COMPONENTS

PEOPLE

#REF! #REF!

24-Apr-11

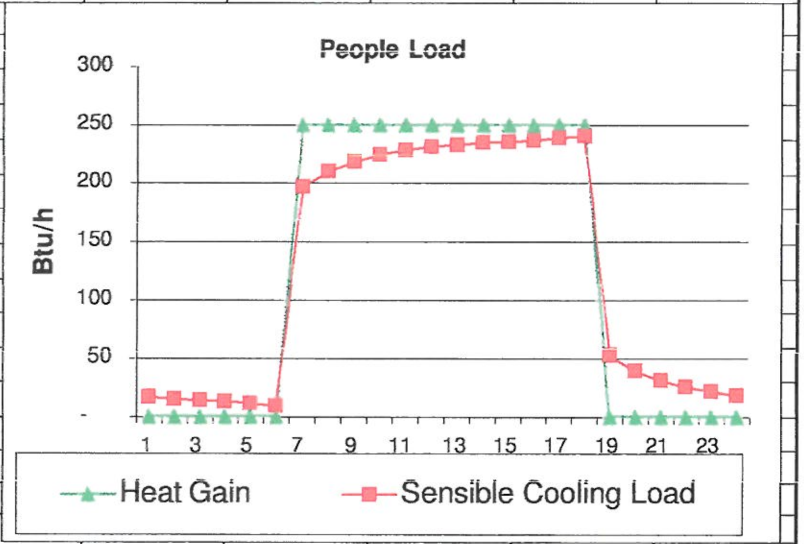
COOLING LOAD - PER PERSON

INPUT DATA:

250	Btuh/person sensible
62%	% Convective
38%	% Radiant
250	Btuh/person latent

MW no Carpet 90% glass

12	RTS Zone Type
MW no Carpet 90% glass	



Hour	Input Usage Profile	Heat Gain Btuh/person	Heat Gain Convective % 62%	Radiant % 38%	Non-Solar RTS Zone Type 12	Radiant Cooling Load	**Total Sensible Cooling Load Btuh/pers**	**Latent Cooling Load Btuh/person**
1	**0%**	-	-	-	35%	17	**17**	**-**
2	**0%**	-	-	-	15%	15	**15**	**-**
3	**0%**	-	-	-	10%	14	**14**	**-**
4	**0%**	-	-	-	7%	13	**13**	**-**
5	**0%**	-	-	-	5%	11	**11**	**-**
6	**0%**	-	-	-	4%	10	**10**	**-**
7	**100%**	250	155	95	3%	42	**197**	**250**
8	**100%**	250	155	95	3%	55	**210**	**250**
9	**100%**	250	155	95	2%	64	**219**	**250**
10	**100%**	250	155	95	2%	69	**224**	**250**
11	**100%**	250	155	95	2%	73	**228**	**250**
12	**100%**	250	155	95	2%	76	**231**	**250**
13	**100%**	250	155	95	1%	78	**233**	**250**
14	**100%**	250	155	95	1%	80	**235**	**250**
15	**100%**	250	155	95	1%	81	**236**	**250**
16	**100%**	250	155	95	1%	82	**237**	**250**
17	**100%**	250	155	95	1%	84	**239**	**250**
18	**100%**	250	155	95	1%	86	**241**	**250**
19	**0%**	-	-	-	1%	53	**53**	**-**
20	**0%**	-	-	-	1%	40	**40**	**-**
21	**0%**	-	-	-	1%	31	**31**	**-**
22	**0%**	-	-	-	1%	26	**26**	**-**
23	**0%**	-	-	-	0%	22	**22**	**-**
24	**0%**	-	-	-	0%	19	**19**	**-**
		3,000	1,860	1,140	100%	1,140	3,000	

COOLING LOAD COMPONENTS

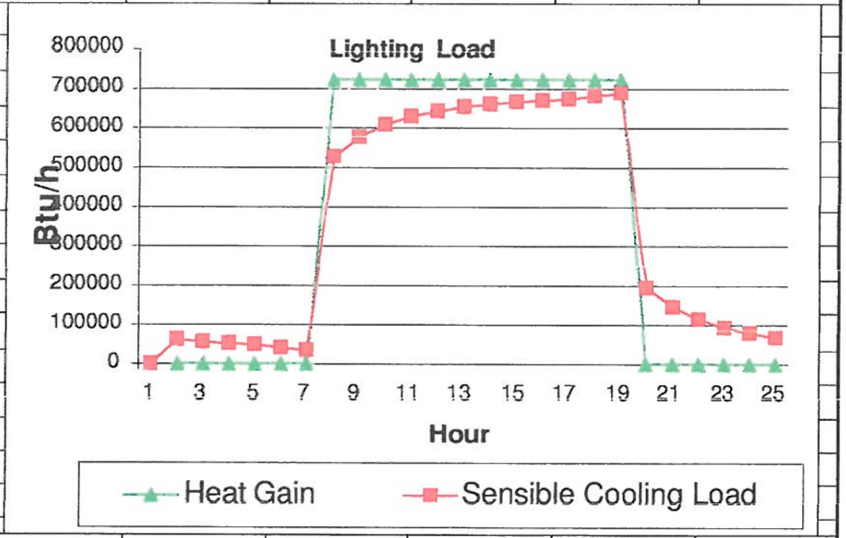
LIGHTING

#REF! **#REF!**

24-Apr-11

COOLING LOAD - LIGHTING

INPUT DATA:	
212000	watt peak lighting
722,920	btu/h sensible peak gain
52%	% Convective
48%	% Radiant
MW no Carpet 90% glass	
12	RTS Zone Type
MW no Carpet 90% glass	



	Input		Heat Gain		Non-Solar	Radiant	**Total**
	Usage		Convective %	Radiant %	RTS Zone Type	Cooling	**Sensible Cooling**
Hour	Profile	Heat Gain	52%	48%	12	Load	**Load**
							Btuh/lighting watt
1	**0%**	-	-	-	35%	62,460	**62,460**
2	**0%**	-	-	-	15%	55,520	**55,520**
3	**0%**	-	-	-	10%	52,050	**52,050**
4	**0%**	-	-	-	7%	48,580	**48,580**
5	**0%**	-	-	-	5%	41,640	**41,640**
6	**0%**	-	-	-	4%	34,700	**34,700**
7	**100%**	722,920	375,918	347,002	3%	152,681	**528,599**
8	**100%**	722,920	375,918	347,002	3%	201,261	**577,179**
9	**100%**	722,920	375,918	347,002	2%	232,491	**608,409**
10	**100%**	722,920	375,918	347,002	2%	253,311	**629,230**
11	**100%**	722,920	375,918	347,002	2%	267,191	**643,110**
12	**100%**	722,920	375,918	347,002	2%	277,601	**653,520**
13	**100%**	722,920	375,918	347,002	1%	284,541	**660,460**
14	**100%**	722,920	375,918	347,002	1%	291,481	**667,400**
15	**100%**	722,920	375,918	347,002	1%	294,951	**670,870**
16	**100%**	722,920	375,918	347,002	1%	298,421	**674,340**
17	**100%**	722,920	375,918	347,002	1%	305,361	**681,280**
18	**100%**	722,920	375,918	347,002	1%	312,301	**688,220**
19	**0%**	-	-	-	1%	194,321	**194,321**
20	**0%**	-	-	-	1%	145,741	**145,741**
21	**0%**	-	-	-	1%	114,511	**114,511**
22	**0%**	-	-	-	1%	93,690	**93,690**
23	**0%**	-	-	-	0%	79,810	**79,810**
24	**0%**	-	-	-	0%	69,400	**69,400**
		8,675,040	########	########	1	########	########

COOLING LOAD COMPONENTS

South Wall

#REF! #REF!

24-Apr-11

WALL - COOLING LOAD PER SQUARE FOOT

Azimuth = 0
Tilt = 90

Location and design weather %:
USA - IL - CHICAGO MIDWAY AP - 0.4%
Latitude = 41.79
Longitude = 84.43
Time Zone = -6
Central
Local Standard Meridian = 75

Ground Reflectivity = 20%

Room Temperature = 68

WALL DESCRIPTION: Spandrel Glass Wall
Area, square feet = 14400
Input U = 0.45 Btu/hr/sf F
CTS TYPE: Spandrel Glass, R-10 Bd, Gyp Bd

CTS Wall ID: 1
CTS Desc: Spandrel Glass, R-10 Insulation Board, Gyp Board
Outside Surface Absorptance 0.45
Outside Surface h = 5
Outside Surface Emittance 0.91
Outside surface delta R 0
RTS ZONE TYPE: MW no Carpet 90% glass

RTS Zone ID: 12
RTS Desc: MW no Carpet 90% glass
% Convective 54%
% Radiant: 46%

WALL UNIT COOLING LOADS - Btuh/sf of wall

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Hour = 1	-10.28	-8.84	-4.21	-0.46	2.24	5.02	7.33	6.36	4.14	-0.28	-4.69	-7.28
2	-10.74	-9.35	-4.84	-1.12	1.64	4.48	6.82	5.86	3.60	-0.87	-5.19	-7.74
3	-11.10	-9.76	-5.34	-1.66	1.16	4.03	6.41	5.47	3.17	-1.35	-5.59	-8.12
4	-11.39	-10.10	-5.75	-2.09	0.77	3.67	6.09	5.14	2.82	-1.75	-5.92	-8.42
5	-11.64	-10.37	-6.10	-2.46	0.48	3.42	5.83	4.87	2.52	-2.08	-6.18	-8.67
6	-11.79	-10.56	-6.34	-2.64	0.43	3.41	5.78	4.74	2.35	-2.30	-6.36	-8.83
7	-11.78	-10.46	-6.11	-2.26	0.79	3.75	6.09	5.06	2.71	-2.02	-6.28	-8.81
8	-11.07	-9.43	-4.67	-1.02	1.73	4.56	6.90	6.06	4.21	-0.31	-5.22	-8.07
9	-8.51	-6.74	-1.97	1.44	3.68	6.14	8.54	8.11	6.72	2.71	-2.24	-5.47
10	-5.12	-3.48	1.25	4.43	6.23	8.41	10.81	10.61	9.62	6.03	1.16	-2.02
11	-2.01	-0.42	4.33	7.31	8.75	10.72	13.10	13.04	12.31	9.02	4.15	1.08
12	0.38	2.05	6.87	9.70	10.85	12.68	15.05	15.04	14.44	11.34	6.39	3.42
13	1.90	3.66	8.58	11.31	12.26	13.99	16.35	16.36	15.80	12.76	7.70	4.82
14	2.51	4.40	9.40	12.09	12.95	14.64	17.00	16.96	16.34	13.28	8.08	5.28
15	2.15	4.18	9.31	12.02	12.87	14.60	16.94	16.81	16.05	12.85	7.45	4.71
16	0.69	2.97	8.24	11.07	12.02	13.83	16.16	15.89	14.91	11.43	5.68	2.92
17	-1.84	0.81	6.34	9.39	10.64	12.63	14.88	14.36	13.07	9.16	3.11	0.23
18	-4.44	-1.75	4.07	7.53	9.35	11.54	13.63	12.67	11.05	6.84	1.22	-1.74
19	-5.89	-3.65	2.03	5.91	8.06	10.39	12.44	11.30	9.38	5.36	0.03	-2.93
20	-6.95	-4.98	0.48	4.38	6.66	9.11	11.20	10.05	8.11	4.07	-1.02	-3.92
21	-7.79	-5.98	-0.72	3.15	5.51	8.01	10.16	9.09	7.09	3.00	-1.93	-4.75
22	-8.52	-6.82	-1.73	2.10	4.56	7.13	9.32	8.30	6.24	2.06	-2.72	-5.48
23	-9.18	-7.57	-2.65	1.15	3.68	6.34	8.58	7.58	5.45	1.19	-3.45	-6.15
24	-9.78	-8.25	-3.49	0.29	2.90	5.62	7.91	6.92	4.75	0.40	-4.12	-6.76

COOLING LOAD COMPONENTS

West Wall

#REF!

#REF!

24-Apr-11

WALL - COOLING LOAD PER SQUARE FOOT

Azimuth = **70**
Tilt = **90**

Location and design weather %:
USA - IL - CHICAGO MIDWAY AP - 0.4%
Latitude = 41.79
Longitude = 84.43
Time Zone = -6
Central
Local Standard Meridian = 75

Ground Reflectivity = **20%**

Room Temperature = **68**

WALL DESCRIPTION: **Spandrel Glass Wall**
Area, square feet = 12600
Input U = **0.45** Btu/hr/sf F
CTS TYPE: Spandrel Glass, R-10 Bd, Gyp Bd
CTS Wall ID: 1
CTS Desc: Spandrel Glass, R-10 Insulation Board, Gyp Board
Outside Surface Absorptance **0.45**
Outside Surface h = **5**
Outside Surface Emittance **0.91**
Outside surface delta R **0**
RTS ZONE TYPE: MW no Carpet 90% glass
RTS Zone ID: 12
RTS Desc: MW no Carpet 90% glass
% Convective **54%**
% Radiant: 46%

WALL UNIT COOLING LOADS - Btuh/sf of wall

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Hour = 1	-10.45	-8.95	-4.21	-0.30	2.49	5.30	7.59	6.51	4.15	-0.38	-4.84	-7.45
2	-10.89	-9.45	-4.85	-0.99	1.85	4.72	7.04	5.99	3.60	-0.97	-5.33	-7.90
3	-11.24	-9.86	-5.36	-1.55	1.34	4.24	6.60	5.57	3.16	-1.46	-5.73	-8.27
4	-11.54	-10.21	-5.79	-2.01	0.92	3.85	6.25	5.22	2.79	-1.86	-6.06	-8.58
5	-11.80	-10.49	-6.16	-2.41	0.60	3.56	5.96	4.92	2.47	-2.21	-6.33	-8.83
6	-11.95	-10.69	-6.41	-2.61	0.52	3.52	5.87	4.77	2.28	-2.43	-6.51	-8.98
7	-11.93	-10.63	-6.30	-2.32	0.85	3.83	6.16	5.03	2.45	-2.34	-6.46	-8.95
8	-11.56	-10.11	-5.52	-1.47	1.63	4.56	6.86	5.71	3.13	-1.67	-5.98	-8.57
9	-10.63	-8.99	-4.09	0.03	3.00	5.81	8.05	6.88	4.34	-0.37	-4.91	-7.62
10	-9.43	-7.60	-2.39	1.80	4.62	7.30	9.45	8.24	5.80	1.21	-3.58	-6.41
11	-8.15	-6.21	-0.70	3.57	6.22	8.78	10.83	9.59	7.30	2.96	-2.04	-5.02
12	-6.49	-4.57	1.19	5.51	7.96	10.33	12.29	11.11	9.15	5.29	0.14	-3.09
13	-4.13	-2.09	3.87	8.14	10.27	12.34	14.24	13.28	11.71	8.03	2.62	-0.73
14	-1.77	0.50	6.64	10.90	12.77	14.66	16.54	15.69	14.25	10.55	4.83	1.46
15	-0.04	2.52	8.85	13.11	14.83	16.64	18.54	17.69	16.18	12.24	6.14	2.82
16	0.32	3.37	9.92	14.25	15.95	17.78	19.74	18.77	16.96	12.46	5.70	2.49
17	-1.46	2.30	9.31	13.94	15.82	17.80	19.82	18.60	16.08	10.50	3.27	0.14
18	-4.53	-0.71	6.69	11.96	14.37	16.64	18.69	16.94	13.41	7.20	1.05	-2.02
19	-6.18	-3.43	2.99	8.54	11.56	14.23	16.24	13.97	10.25	5.31	-0.25	-3.27
20	-7.27	-5.07	0.76	5.47	8.25	11.11	13.07	11.16	8.38	3.92	-1.31	-4.25
21	-8.08	-6.13	-0.64	3.66	6.27	8.97	11.05	9.60	7.19	2.84	-2.19	-5.05
22	-8.78	-6.97	-1.70	2.42	5.04	7.70	9.84	8.60	6.28	1.91	-2.96	-5.75
23	-9.41	-7.71	-2.65	1.38	4.05	6.75	8.96	7.80	5.46	1.05	-3.65	-6.38
24	-9.97	-8.38	-3.49	0.47	3.20	5.96	8.21	7.10	4.76	0.28	-4.29	-6.95

COOLING LOAD COMPONENTS

North Wall

#REF!

#REF!

24-Apr-11

WALL - COOLING LOAD PER SQUARE FOOT

Azimuth = **180**
Tilt = **90**

Location and design weather %:
USA - IL - CHICAGO MIDWAY AP - 0.4%
Latitude = 41.79
Longitude = 84.43
Time Zone = -6
Central
Local Standard Meridian = 75

Ground Reflectivity = **20%**

Room Temperature = **68**

WALL DESCRIPTION: **Spandrel Glass Wall**
Area, square feet = 14400
Input U = **0.45** Btu/hr/sf F
CTS TYPE: Spandrel Glass, R-10 Bd, Gyp Bd

CTS Wall ID: 1
CTS Desc: Spandrel Glass, R-10 Insulation Board, Gyp Board
Outside Surface Absorptance **0.45**
Outside Surface h = **5**
Outside Surface Emittance **0.91**
Outside surface delta R **0**
RTS ZONE TYPE: MW no Carpet 90% glass

RTS Zone ID: 12
RTS Desc: MW no Carpet 90% glass
% Convective **54%**
% Radiant: 46%

WALL UNIT COOLING LOADS - Btuh/sf of wall

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Hour = 1	-10.73	-9.28	-4.59	-0.71	2.12	4.96	7.22	6.12	3.79	-0.68	-5.08	-7.68
2	-11.13	-9.74	-5.18	-1.34	1.54	4.43	6.73	5.65	3.29	-1.23	-5.54	-8.10
3	-11.45	-10.11	-5.65	-1.86	1.06	3.98	6.33	5.28	2.88	-1.68	-5.91	-8.45
4	-11.72	-10.42	-6.03	-2.28	0.68	3.63	6.01	4.97	2.55	-2.05	-6.21	-8.72
5	-11.95	-10.68	-6.37	-2.64	0.48	3.50	5.81	4.70	2.27	-2.37	-6.47	-8.96
6	-12.10	-10.86	-6.60	-2.74	0.82	4.02	6.09	4.65	2.10	-2.58	-6.64	-9.11
7	-12.07	-10.79	-6.48	-2.25	1.49	4.77	6.81	5.09	2.28	-2.50	-6.59	-9.08
8	-11.70	-10.27	-5.69	-1.49	2.08	5.32	7.39	5.69	2.96	-1.83	-6.11	-8.69
9	-10.78	-9.15	-4.27	-0.08	3.14	6.12	8.23	6.78	4.17	-0.53	-5.04	-7.75
10	-9.57	-7.76	-2.57	1.65	4.61	7.39	9.46	8.10	5.62	1.05	-3.72	-6.53
11	-8.39	-6.40	-0.89	3.39	6.13	8.76	10.76	9.43	7.05	2.60	-2.41	-5.33
12	-7.36	-5.19	0.60	4.94	7.52	10.01	11.95	10.61	8.29	3.97	-1.25	-4.27
13	-6.57	-4.27	1.75	6.14	8.60	10.98	12.87	11.51	9.25	5.01	-0.38	-3.47
14	-5.99	-3.59	2.59	7.03	9.40	11.71	13.55	12.17	9.95	5.78	0.25	-2.88
15	-5.67	-3.21	3.09	7.56	9.87	12.16	13.96	12.55	10.34	6.22	0.60	-2.56
16	-5.68	-3.21	3.13	7.61	9.94	12.24	14.02	12.56	10.34	6.23	0.57	-2.58
17	-6.06	-3.63	2.67	7.18	9.66	12.05	13.79	12.19	9.92	5.77	0.17	-2.95
18	-6.62	-4.31	1.85	6.44	9.34	11.90	13.54	11.59	9.20	5.04	-0.39	-3.45
19	-7.22	-5.12	0.75	5.38	8.42	11.16	12.84	10.79	8.28	4.21	-1.04	-4.05
20	-7.94	-6.01	-0.41	3.91	6.70	9.54	11.36	9.61	7.31	3.20	-1.87	-4.79
21	-8.60	-6.80	-1.42	2.72	5.38	8.09	10.10	8.69	6.46	2.28	-2.63	-5.48
22	-9.20	-7.50	-2.31	1.73	4.40	7.09	9.19	7.94	5.70	1.45	-3.32	-6.10
23	-9.77	-8.16	-3.15	0.83	3.54	6.28	8.44	7.27	4.99	0.66	-3.97	-6.69
24	-10.29	-8.76	-3.92	0.00	2.77	5.56	7.79	6.65	4.35	-0.06	-4.56	-7.22

COOLING LOAD COMPONENTS

East Wall

#REF! **#REF!** 24-Apr-11

WALL - COOLING LOAD PER SQUARE FOOT

Azimuth = -70
Tilt = 90

Location and design weather %:
USA - IL - CHICAGO MIDWAY AP - 0.4%
Latitude = 41.79
Longitude = 84.43
Time Zone = -6
Central
Local Standard Meridian = 75

Ground Reflectivity = 20%

Room Temperature = 68

WALL DESCRIPTION: Concrete Wall
Area, square feet = 12600
Input U = 0.068 Btu/hr/sf F
CTS TYPE: 8" LW Concrete. R-11 Batt, Gyp Bd

CTS Wall ID: 31
CTS Desc: 8" LW Concrete. R-11 Batt Insulation, Gyp Board
Outside Surface Absorptance 0.6
Outside Surface h = 5
Outside Surface Emittance 0.91
Outside surface delta R 0
RTS ZONE TYPE: MW no Carpet 90% glass

RTS Zone ID: 12
RTS Desc: MW no Carpet 90% glass
% Convective 54%
% Radiant: 46%

WALL UNIT COOLING LOADS - Btuh/sf of wall

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Hour = 1	-1.00	-0.67	0.19	0.83	1.21	1.58	1.90	1.71	1.35	0.67	-0.12	-0.56
2	-1.05	-0.73	0.12	0.76	1.14	1.52	1.84	1.65	1.29	0.61	-0.17	-0.61
3	-1.10	-0.79	0.05	0.69	1.07	1.46	1.77	1.59	1.23	0.55	-0.23	-0.66
4	-1.15	-0.85	-0.03	0.61	1.00	1.39	1.71	1.52	1.16	0.49	-0.28	-0.71
5	-1.20	-0.91	-0.09	0.54	0.93	1.32	1.65	1.47	1.11	0.42	-0.33	-0.76
6	-1.25	-0.96	-0.16	0.47	0.86	1.26	1.59	1.41	1.05	0.37	-0.38	-0.80
7	-1.29	-1.01	-0.22	0.40	0.80	1.21	1.53	1.35	0.99	0.31	-0.43	-0.84
8	-1.33	-1.06	-0.28	0.34	0.76	1.17	1.50	1.31	0.94	0.25	-0.47	-0.89
9	-1.37	-1.10	-0.33	0.32	0.75	1.17	1.49	1.30	0.92	0.21	-0.51	-0.93
10	-1.39	-1.11	-0.32	0.34	0.78	1.20	1.52	1.32	0.93	0.21	-0.53	-0.94
11	-1.36	-1.08	-0.28	0.40	0.85	1.26	1.58	1.38	0.99	0.26	-0.50	-0.93
12	-1.30	-1.00	-0.19	0.50	0.94	1.34	1.67	1.47	1.07	0.34	-0.44	-0.87
13	-1.22	-0.90	-0.08	0.60	1.03	1.43	1.76	1.57	1.17	0.43	-0.35	-0.79
14	-1.12	-0.80	0.03	0.70	1.12	1.51	1.84	1.66	1.27	0.53	-0.26	-0.70
15	-1.04	-0.71	0.12	0.79	1.19	1.58	1.91	1.73	1.34	0.61	-0.19	-0.62
16	-0.97	-0.64	0.20	0.86	1.26	1.64	1.97	1.79	1.40	0.68	-0.13	-0.56
17	-0.93	-0.59	0.26	0.92	1.31	1.69	2.01	1.83	1.45	0.73	-0.08	-0.52
18	-0.89	-0.55	0.31	0.97	1.35	1.72	2.05	1.86	1.49	0.77	-0.04	-0.48
19	-0.88	-0.53	0.34	1.00	1.38	1.75	2.07	1.88	1.51	0.80	-0.02	-0.46
20	-0.87	-0.52	0.36	1.02	1.39	1.76	2.08	1.89	1.52	0.82	-0.01	-0.45
21	-0.87	-0.52	0.35	1.01	1.39	1.76	2.07	1.88	1.51	0.81	-0.01	-0.45
22	-0.89	-0.54	0.33	0.99	1.36	1.73	2.05	1.85	1.49	0.80	-0.02	-0.47
23	-0.92	-0.58	0.29	0.95	1.32	1.70	2.01	1.81	1.45	0.76	-0.05	-0.49
24	-0.96	-0.62	0.25	0.90	1.27	1.64	1.96	1.77	1.40	0.72	-0.08	-0.52

#REF!

#REF!

24-Apr-11

ROOF- COOLING LOAD PER SQUARE FOOT

Azimuth = 0
Tilt = 0

Location and design weather %:
USA - IL - CHICAGO MIDWAY AP - 0.4%
Latitude = 41.79
Longitude = -87.75
Time Zone = -6
Central
Local Standard Meridian = -90

Ground Reflectivity = 20%

Room Temperature = 68

ROOF DESCRIPTION: Metal Deck
Area, square feet = 45000
Input U = 0.05 Btu/hr/sf F
CTS TYPE: Metal Roof, R-19 Batt Insulation

CTS Roof ID: 3
CTS Desc: Metal Roof, R-19 Batt Insulation
Outside Surface Absorptance = 0.45
Outside Surface h = 5
Outside Surface Emittance = 0.87
Outside surface delta R = 20
RTS ZONE TYPE: MW no Carpet 90% glass

RTS Zone ID: 12
RTS Desc: MW no Carpet 90% glass
% Convective: 54%
% Radiant: 46%

ROOF UNIT COOLING LOADS - Btuh/sf of roof

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Hour = 1	-1.36	-1.19	-0.66	-0.22	0.10	0.42	0.67	0.54	0.27	-0.24	-0.73	-1.02
2	-1.40	-1.24	-0.73	-0.29	0.03	0.35	0.61	0.49	0.21	-0.30	-0.79	-1.07
3	-1.44	-1.28	-0.78	-0.35	-0.02	0.30	0.56	0.44	0.17	-0.35	-0.83	-1.11
4	-1.47	-1.32	-0.82	-0.40	-0.07	0.26	0.53	0.41	0.13	-0.39	-0.86	-1.14
5	-1.49	-1.35	-0.86	-0.44	-0.09	0.24	0.50	0.38	0.10	-0.43	-0.89	-1.16
6	-1.51	-1.36	-0.88	-0.43	-0.04	0.30	0.54	0.38	0.09	-0.45	-0.90	-1.18
7	-1.50	-1.34	-0.83	-0.30	0.12	0.46	0.69	0.50	0.16	-0.41	-0.89	-1.17
8	-1.43	-1.23	-0.63	-0.04	0.39	0.72	0.93	0.73	0.36	-0.25	-0.79	-1.10
9	-1.24	-0.98	-0.30	0.32	0.73	1.04	1.24	1.03	0.66	0.04	-0.57	-0.92
10	-0.98	-0.67	0.06	0.69	1.07	1.36	1.56	1.35	0.98	0.36	-0.30	-0.67
11	-0.74	-0.39	0.38	1.01	1.37	1.65	1.84	1.63	1.26	0.64	-0.06	-0.44
12	-0.54	-0.16	0.64	1.27	1.61	1.87	2.06	1.84	1.47	0.85	0.13	-0.26
13	-0.42	-0.02	0.80	1.43	1.75	2.01	2.20	1.97	1.60	0.98	0.24	-0.15
14	-0.38	0.03	0.87	1.50	1.81	2.07	2.26	2.02	1.64	1.02	0.26	-0.12
15	-0.42	0.00	0.84	1.47	1.78	2.04	2.23	1.99	1.59	0.97	0.21	-0.16
16	-0.54	-0.13	0.71	1.33	1.65	1.92	2.11	1.86	1.45	0.83	0.08	-0.28
17	-0.71	-0.33	0.48	1.10	1.43	1.72	1.91	1.65	1.24	0.63	-0.07	-0.42
18	-0.85	-0.54	0.23	0.82	1.16	1.46	1.66	1.40	1.01	0.46	-0.17	-0.52
19	-0.94	-0.68	0.00	0.55	0.88	1.19	1.39	1.16	0.83	0.34	-0.26	-0.60
20	-1.03	-0.80	-0.16	0.34	0.64	0.94	1.16	0.97	0.70	0.21	-0.37	-0.69
21	-1.11	-0.90	-0.28	0.19	0.49	0.78	1.01	0.86	0.59	0.10	-0.45	-0.77
22	-1.18	-0.98	-0.39	0.07	0.37	0.67	0.91	0.76	0.50	0.00	-0.53	-0.84
23	-1.25	-1.06	-0.49	-0.04	0.27	0.57	0.82	0.68	0.41	-0.09	-0.61	-0.91
24	-1.31	-1.13	-0.58	-0.14	0.18	0.49	0.74	0.61	0.34	-0.17	-0.68	-0.97

#REF! #REF! 24-Apr-11

ROOF- COOLING LOAD PER SQUARE FOOT

Azimuth = 0
Tilt = 0

Location and design weather %:
USA - IL - CHICAGO MIDWAY AP - 0.4%
Latitude = 41.79
Longitude = -87.75
Time Zone = -6
Central
Local Standard Meridian = -90

Ground Reflectivity = 20%

Room Temperature = 68

ROOF DESCRIPTION: Metal Deck
Area, square feet = 45000
Input U = 0.05 Btu/hr/sf F
CTS TYPE: Memb, R-15 Bd, 8" LW Conc
CTS Roof ID: 16
CTS Desc: Membrane, Sheathing, R-15 Insulation Board, 8" LW Concre
Outside Surface Absorptance = 0.45
Outside Surface h = 5
Outside Surface Emittance = 0.91
Outside surface delta R = 20
RTS ZONE TYPE: MW no Carpet 90% glass
RTS Zone ID: 12
RTS Desc: MW no Carpet 90% glass
% Convective: 54%
% Radiant: 46%

ROOF UNIT COOLING LOADS - Btuh/sf of roof

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Hour = 1	-0.97	-0.69	-0.01	0.54	0.88	1.17	1.39	1.19	0.85	0.29	-0.32	-0.66
2	-0.99	-0.71	-0.03	0.51	0.85	1.14	1.36	1.16	0.83	0.27	-0.34	-0.67
3	-1.00	-0.73	-0.06	0.48	0.81	1.11	1.32	1.13	0.80	0.25	-0.36	-0.69
4	-1.02	-0.76	-0.10	0.44	0.77	1.07	1.29	1.10	0.77	0.22	-0.38	-0.71
5	-1.04	-0.79	-0.13	0.40	0.73	1.03	1.25	1.06	0.74	0.19	-0.40	-0.73
6	-1.07	-0.81	-0.17	0.35	0.68	0.99	1.21	1.03	0.71	0.16	-0.42	-0.75
7	-1.09	-0.84	-0.21	0.31	0.64	0.94	1.17	0.99	0.67	0.13	-0.45	-0.77
8	-1.11	-0.87	-0.25	0.26	0.60	0.90	1.13	0.95	0.64	0.10	-0.47	-0.79
9	-1.14	-0.90	-0.28	0.22	0.56	0.87	1.09	0.92	0.61	0.06	-0.50	-0.82
10	-1.16	-0.93	-0.32	0.19	0.53	0.84	1.07	0.89	0.58	0.04	-0.52	-0.84
11	-1.17	-0.95	-0.34	0.18	0.52	0.83	1.06	0.88	0.57	0.02	-0.54	-0.85
12	-1.18	-0.95	-0.34	0.18	0.52	0.83	1.06	0.88	0.57	0.01	-0.54	-0.86
13	-1.18	-0.94	-0.33	0.19	0.54	0.85	1.08	0.90	0.58	0.03	-0.54	-0.85
14	-1.16	-0.92	-0.30	0.23	0.58	0.88	1.11	0.93	0.61	0.05	-0.52	-0.84
15	-1.13	-0.89	-0.26	0.27	0.62	0.93	1.15	0.97	0.65	0.08	-0.49	-0.81
16	-1.10	-0.85	-0.21	0.33	0.68	0.98	1.20	1.02	0.69	0.13	-0.46	-0.78
17	-1.07	-0.80	-0.15	0.39	0.74	1.04	1.26	1.07	0.74	0.17	-0.42	-0.75
18	-1.03	-0.76	-0.10	0.45	0.80	1.10	1.31	1.12	0.79	0.22	-0.39	-0.72
19	-1.00	-0.73	-0.05	0.50	0.85	1.15	1.36	1.17	0.83	0.25	-0.36	-0.69
20	-0.98	-0.70	-0.02	0.54	0.89	1.18	1.40	1.20	0.86	0.28	-0.34	-0.67
21	-0.97	-0.68	0.01	0.57	0.91	1.21	1.42	1.22	0.87	0.30	-0.32	-0.66
22	-0.96	-0.67	0.02	0.58	0.92	1.22	1.43	1.22	0.88	0.31	-0.31	-0.65
23	-0.96	-0.67	0.02	0.57	0.91	1.21	1.42	1.22	0.88	0.31	-0.31	-0.65
24	-0.96	-0.68	0.01	0.56	0.90	1.20	1.41	1.21	0.87	0.30	-0.31	-0.65

#REF! #REF! 24-Apr-11

ROOF- COOLING LOAD PER SQUARE FOOT

Azimuth = 0
Tilt = 0

Location and design weather %:
USA - IL - CHICAGO MIDWAY AP - 0.4%
Latitude = 41.79
Longitude = -87.75
Time Zone = -6
Central
Local Standard Meridian = -90

Ground Reflectivity = 20%

Room Temperature = 68

ROOF DESCRIPTION: Metal Deck
Area, square feet = 45000
Input U = 0.05 Btu/hr/sf F
CTS TYPE: Memb, R-15 Bd, 8" LW Conc
CTS Roof ID: 16
CTS Desc: Membrane, Sheathing, R-15 Insulation Board, 8" LW Concre
Outside Surface Absorptance = 0.45
Outside Surface h = 5
Outside Surface Emittance = 0.91
Outside surface delta R = 20
RTS ZONE TYPE: MW no Carpet 90% glass
RTS Zone ID: 12
RTS Desc: MW no Carpet 90% glass
% Convective: 54%
% Radiant: 46%

ROOF UNIT COOLING LOADS - Btuh/sf of roof

Month =	1	2	3	4	5	6	7	8	9	10	11	12
Hour = 1	-0.97	-0.69	-0.01	0.54	0.88	1.17	1.39	1.19	0.85	0.29	-0.32	-0.66
2	-0.99	-0.71	-0.03	0.51	0.85	1.14	1.36	1.16	0.83	0.27	-0.34	-0.67
3	-1.00	-0.73	-0.06	0.48	0.81	1.11	1.32	1.13	0.80	0.25	-0.36	-0.69
4	-1.02	-0.76	-0.10	0.44	0.77	1.07	1.29	1.10	0.77	0.22	-0.38	-0.71
5	-1.04	-0.79	-0.13	0.40	0.73	1.03	1.25	1.06	0.74	0.19	-0.40	-0.73
6	-1.07	-0.81	-0.17	0.35	0.68	0.99	1.21	1.03	0.71	0.16	-0.42	-0.75
7	-1.09	-0.84	-0.21	0.31	0.64	0.94	1.17	0.99	0.67	0.13	-0.45	-0.77
8	-1.11	-0.87	-0.25	0.26	0.60	0.90	1.13	0.95	0.64	0.10	-0.47	-0.79
9	-1.14	-0.90	-0.28	0.22	0.56	0.87	1.09	0.92	0.61	0.06	-0.50	-0.82
10	-1.16	-0.93	-0.32	0.19	0.53	0.84	1.07	0.89	0.58	0.04	-0.52	-0.84
11	-1.17	-0.95	-0.34	0.18	0.52	0.83	1.06	0.88	0.57	0.02	-0.54	-0.85
12	-1.18	-0.95	-0.34	0.18	0.52	0.83	1.06	0.88	0.57	0.01	-0.54	-0.86
13	-1.18	-0.94	-0.33	0.19	0.54	0.85	1.08	0.90	0.58	0.03	-0.54	-0.85
14	-1.16	-0.92	-0.30	0.23	0.58	0.88	1.11	0.93	0.61	0.05	-0.52	-0.84
15	-1.13	-0.89	-0.26	0.27	0.62	0.93	1.15	0.97	0.65	0.08	-0.49	-0.81
16	-1.10	-0.85	-0.21	0.33	0.68	0.98	1.20	1.02	0.69	0.13	-0.46	-0.78
17	-1.07	-0.80	-0.15	0.39	0.74	1.04	1.26	1.07	0.74	0.17	-0.42	-0.75
18	-1.03	-0.76	-0.10	0.45	0.80	1.10	1.31	1.12	0.79	0.22	-0.39	-0.72
19	-1.00	-0.73	-0.05	0.50	0.85	1.15	1.36	1.17	0.83	0.25	-0.36	-0.69
20	-0.98	-0.70	-0.02	0.54	0.89	1.18	1.40	1.20	0.86	0.28	-0.34	-0.67
21	-0.97	-0.68	0.01	0.57	0.91	1.21	1.42	1.22	0.87	0.30	-0.32	-0.66
22	-0.96	-0.67	0.02	0.58	0.92	1.22	1.43	1.22	0.88	0.31	-0.31	-0.65
23	-0.96	-0.67	0.02	0.57	0.91	1.21	1.42	1.22	0.88	0.31	-0.31	-0.65
24	-0.96	-0.68	0.01	0.56	0.90	1.20	1.41	1.21	0.87	0.30	-0.31	-0.65

APPENDIX: HVAC (H-3)

HVAC LOAD EXPLORER CALCULATIONS

IPRO359 Spring 2011

```
Summary Report(Peak Loads)
Name Of Building:   Chicago Children's Museum
Building Location Details
Building City: Chicago Ohare International Airport
Building State: Illinois
Latitude: 42.0

BUILDING SUMMER CONDITIONS
  Dry Bulb Temperature: 88.0 F
  Daily Range: 19.6 F
  Wet Bulb Temperature: 73.0 F
  Clearness: 1.0000
  Ground Reflectivity: 0.2
  Atm. Pressure: 14.6 PSI
  Wind Direction: 270.0 degrees clockwise from North
  Wind Speed: 17.6 mph



BUILDING WINTER CONDITIONS
  Dry Bulb Temperature: -1.0 F
  Daily Range: 32.0
  Wet Bulb Temperature: -6.0 F
  Clearness: 0.0000
  Ground Reflectivity: 0.2
  Atm. Pressure: 14.6 PSI
  Wind Direction: 270.0 degrees clockwise from North
  Wind Speed: 14.6 mph


##Cooling Load Calculations##
Coil Loads
----------
|         Load        |Hour  |   Total CLg  |Sensible CLg  |  Latent CLg  |  Air Flow

|                     |      |   Coil Load  |   Coil Load  |   Coil Load  |
|                     |      |    (BTU/Hr)  |    (BTU/Hr)  |    (BTU/Hr)  |     (CFM)


-------------------------------------------------------------------------------------
          First Floor   17     3054866.3      2027135.4      1027730.9     195841.9
         Second Floor   16     2715114.0      1687469.4      1027644.6     161176.6
          Third Floor   16     2715114.0      1687469.4      1027644.6     161176.6
         Fourth Floor   17     1160321.6       784946.3       375375.3      75647.6
                  Sum          9645415.9      6187020.5      3458395.4     593842.8
```

```
Summary Report(Peak Loads)
Name Of Building:   Chicago Children's Museum
Building Location Details
Building City: Chicago Ohare International Airport
Building State: Illinois
Latitude: 42.0

BUILDING SUMMER CONDITIONS
  Dry Bulb Temperature: 88.0 F
  Daily Range: 19.6 F
  Wet Bulb Temperature: 73.0 F
  Clearness: 1.0000
  Ground Reflectivity: 0.2
  Atm. Pressure: 14.6 PSI
  Wind Direction: 270.0 degrees clockwise from North
  Wind Speed: 12.0 mph



BUILDING WINTER CONDITIONS
  Dry Bulb Temperature: -1.0 F
  Daily Range: 0.0
  Wet Bulb Temperature: -6.0 F
  Clearness: 0.0000
  Ground Reflectivity: 0.2
  Atm. Pressure: 14.6 PSI
  Wind Direction: 270.0 degrees clockwise from North
  Wind Speed: 10.0 mph


##Heating Load Calculations##
Coil Loads
----------
|         Load         |Hour  |   Total Htg  |Sensible Htg  |  Latent Htg  |  Air Flow

|                      |      |   Coil Load  |  Coil Load   |  Coil Load   |
|                      |      |    (BTU/Hr)  |   (BTU/Hr)   |   (BTU/Hr)   |     (CFM)


__________________________________________________________________________________
         First Floor     1       486503.4      310528.2       175975.2       4747.0
        Second Floor     1       486503.4      310528.2       175975.2       4747.0
         Third Floor     1       486503.4      310528.2       175975.2       4747.0
        Fourth Floor     1       199684.1      127455.5        72228.6       1948.4
                 Sum            1659194.4     1059040.0       600154.1      16189.4
```

APPENDIX: HVAC (H-4)

HVAC EQUIPMENT CALCULATIONS

IPRO359 Spring 2011

HVAC Equipment Sizing

Based on our final cooling loads, heating loads, and air flow supply rates from HVAC Load explorer, we were able to size the larger HVAC units for the building.

For our chiller, the capacity was based on our total cooling load for the building:

(Total Cooling Load) 5,238,673.01Btu/h x 1 ton/12,000 Btu/h = 436 ton

We used one 450 ton centrifugal chiller for the museum.

For our cooling tower, the capacity was also based on our total cooling load, but at a 80% efficiency:

(Total Cooling Load) 5,238,673.01Btu/h x 1 ton/15,000 Btu/h = 349 ton

We used one

For our boiler, the capacity was based on our total heating load for the building:

(Total Heating Load) 1,126,987Btu/h x 1 MBH/1000 Btu/h = 1127 MBH

We used a 1000 MBH gas-fired boiler.

For our air handling unit, the supply flow rate was based on the largest flow rate of the building:

(Total air supply flow rate) = 113,549 CFM

We divided this flow rate into a 15,000 CFM air handlers to supply the fourth floor, one 20,000 CFM unit on the second and third floors, and two 30,000 CFM air handler on the first floor.

U.S. Department of Energy - Energy Efficiency and Renewable Energy
Federal Energy Management Program

Energy Cost Calculator for Water-Cooled Electric Chillers

Vary equipment size, energy cost, hours of operation, and /or efficiency level.

INPUT SECTION

Input the following data (if any parameter is missing, calculator will set it to the default value).			Defaults
Chiller Project Type	New Installation		*New*
Existing Efficiency * Full Load		kW/ton	—
Existing Capacity *		tons	—
New Chiller Type (by compressor type)	Centrifugal		*Centrifugal*
New Capacity	800	tons	*500 tons*
New Efficiency Full Load	0.56	kW/ton	*0.56 kW/ton*
Energy Cost	$ .15	per kWh	*$0.06 per kWh*
Quantity of Chillers to be Purchased	2	unit(s)	*1 unit*
Annual Hours of Operation**	1900	hours	*2000 hours*

* Existing values should only be entered when Project Type is a replacement.
** Value entered should be equivalent full load hours (e.g., 1000 hours @ 50% load equals 500 hours.)

Calculate Reset

OUTPUT SECTION

Water-Cooled Chiller Performance	**Your New Chiller**	**Existing Chiller**	**Base Model**	**FEMP Recommended Level**	**Best Available**
Efficiency	0.56 kW/ton		0.68	0.56	0.47
Annual Energy Use	851200 kWh		1033600	851200	714400
Annual Energy Cost	$ 127680	$	$ 155040	$ 127680	$ 107160
Lifetime Energy Cost	$ 2019898	$	$ 2452733	$ 2019898	$ 1695271
Lifetime Energy Cost Savings	$ 432835	$	$ 0	$ 432835	$ 757462
Lifetime Energy Cost Savings for 2 **Chiller(s)**	$ 865670	$	$ 0	$ 865670	$ 1514924

Your selection of a 800 ton centrifugal chiller unit will have a $ 432835 energy cost savings per chiller (over its estimated 23 year life expectancy compared to the base model).

Assumptions

- "Base model" has an efficiency that just meets ASHRAE Standard 90.1.
- Calculator assumes user is entering efficiency ratings based on ARI's 1998 Standard 550/590.
- Lifetime energy cost is the sum of the discounted value of the annual energy cost based on assumed chiller life of 23 years.
- Future electricity price trends and a discount rate of 3.2% are based on Federal guidelines.
- $0.06 for electricity is the Federal average price in the U.S.

Disclaimer

This cost calculator is a screening tool that estimates a product's lifetime energy cost savings at various efficiency levels. Maintenance and installation costs do not vary significantly among the same product having different efficiencies; so, these costs are not included in this calculator tool. For a detailed life-cycle cost analysis, FEMP has developed a tool called Building Life-Cycle Cost (BLCC). This downloadable tool allows the user to vary interest rates, installation costs, maintenance costs, salvage values, and life expectancy for a product or an entire energy project.

U.S. Department of Energy - Energy Efficiency and Renewable Energy
Federal Energy Management Program

Energy Cost Calculator for Commercial Boilers (Closed Loop, Space Heating Applications Only)

Vary equipment size, energy cost, hours of operation, and /or efficiency level.

INPUT SECTION

Input the following data (if any parameter is missing, calculator will set to default value).			*Defaults*
Project Type	New Installation		*New Installation*
Deliverable Fluid	Water		*Water*
Fuel Used	Gas		*Gas*
Existing Capacity *		MBtu/h	—
Existing Thermal Efficiency *		% Et	—
New Capacity	1875 MBtu/h**		*5000 MBtu/h*
New Thermal Efficiency	80	% Et	*80% Et*
Energy Cost	$ 0.86 therms	per	*$0.60 per therm*
Quantity of Boilers to be Purchased	1	unit(s)	*1 unit*
Annual Hours of Operation***	1800	hours	*1500 hours*

* Existing values should only be entered when Project Type is a replacement.
** 1 MBtu/h = 1000 Btu/h; 1 Therm = 100,000 Btu; 1.4 Therms = 140,000 Btu
*** Value entered should be equivalent full load hours (e.g., 1000 hours @ 50% load equals 500 hours).

Calculate Reset

OUTPUT SECTION

Performance per Boiler	**Your Choice**	**Existing Boiler**	**Base Model**	**FEMP Recommended Level**	**Best Available**
Thermal Efficiency	80 Et		75	80	86.7
Annual Energy Use therms	42187		45000	42187	38927
Annual Energy Costs	$ 36280	$	$ 38700	$ 36280	$ 33477
Lifetime Energy Costs	$ 625104	$	$ 666801	$ 625104	$ 576808
Lifetime Energy Cost Savings	$ 41697	$	$ 0	$ 41697	$ 89993
Lifetime Energy Cost Savings for 1 **Boiler(s)**	$ 41697	$	$ 0	$ 41697	$ 89993

Your selection of a 1875 MBtu/h water boiler will have an energy cost savings of $ 41697 over an estimated life of 25 years as compared to the base model.

Assumptions

- $0.06/kWh is the Federal average electricity price in the U.S.
- $0.60/therm is the Federal average gas price in the U.S.
- $0.66/gallon is the Federal average fuel oil price in the U.S.
- Future electricity price trends and a discount rate of 3.2% are based on Federal guidelines.
- Lifetime energy cost is the sum of the discounted value of annual energy costs based on assumed boiler life of 25 years.
- The average heating value for No. 2 oil is 140,000 Btu/gallon.

Disclaimer

This cost calculator is a screening tool that estimates a product's lifetime energy cost savings at various efficiency levels. Maintenance and installation costs do not vary significantly among the same product having different efficiencies; so, these costs are not included in this calculator tool. For a detailed life-cycle cost analysis, FEMP has developed a tool called Building Life-Cycle Cost (BLCC). This downloadable tool allows the user to vary interest rates, installation costs, maintenance costs, salvage values, and life expectancy for a product or an entire energy project.

Extended-Size Vision™ Indoor Air Handlers

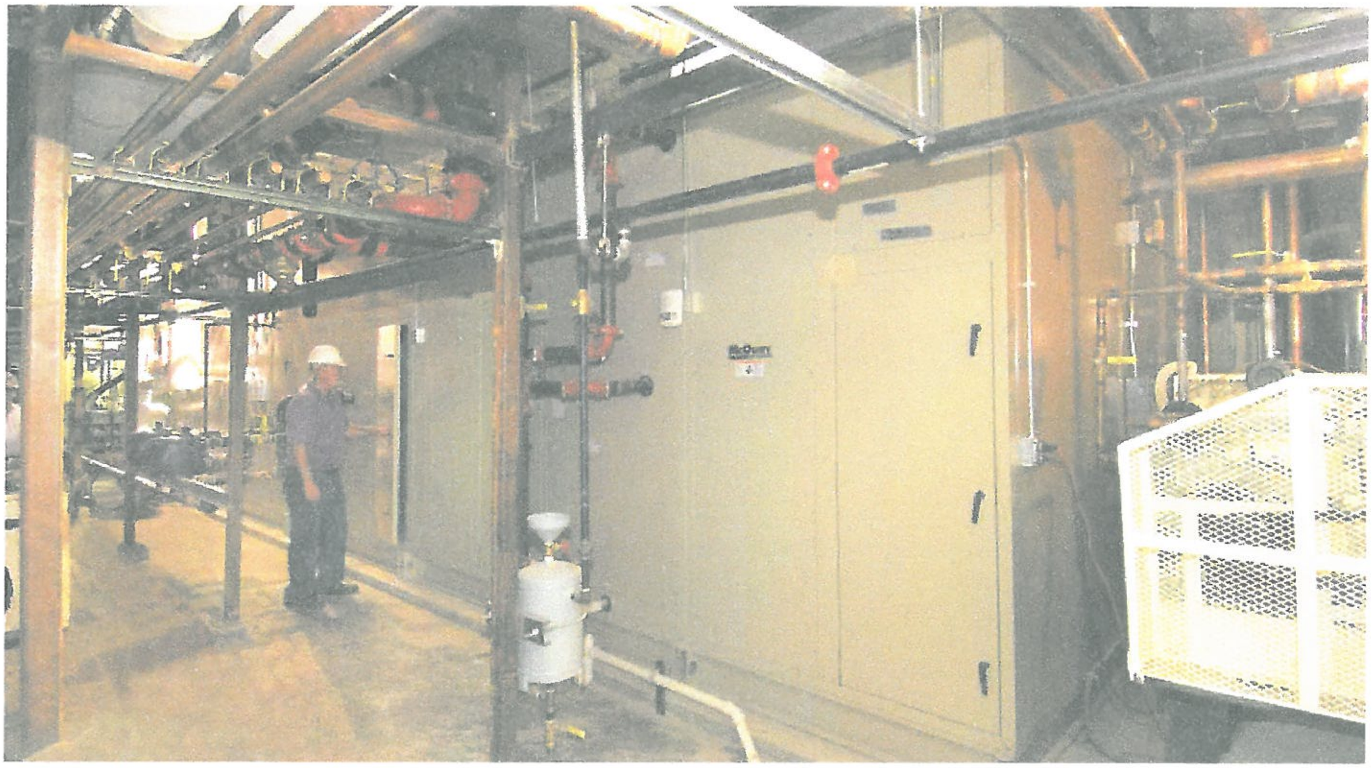
Up to 160 sq.ft. coil face area and 100,000 cfm

What alternative do I have to specifying multiple air handlers or purchasing an expensive custom unit when the air handling requirements surpass the maximum sizes available from most manufacturers?

McQuay now offers Vision indoor air handlers in capacities up to 100,000 cfm with coil face areas up to 160 square feet. These are not only the largest indoor air handling units available in a standard platform, but also the largest units that are AHRI certified. Best of all, they offer the same features, benefits, options and accessories that have made Vision such a popular air handler platform.

Features

- Standard units in sizes up to 100,000 cfm and 160 square feet of coil face area. AHRI certification provides added assurance that these units will perform as designed.
- Custom-size units of up to 122 inches in height and 228 inches in width. Our Variable Dimensioning™ feature allows cabinet sizing in increments of 4 inches in width and 2 inches in height up to these maximums. A short-and-wide unit can be configured that is ideal for low-height ceilings and high-air-volume projects.
- Heavy-duty, patent-pending base rail to handle heavier component loads.
- Retractable lifting lugs provide a balanced, even load for easy rigging. Together with our patented splice collars, they make installation and assembly of unit sections fast and easy.
- DWDI fans up to 49 inches in diameter, Class III.
- Plenum fans up to 66 inches in diameter, Class III .



McQuay®
Air Conditioning

- 100, 125 and 150 horsepower motors.
- Center-split coils option to minimize fluid pressure drop and coil pull length.

Benefits

- An economical alternative to installing multiple air handlers or a custom system for high-cfm applications.
- A patented product platform that gives you the flexibility to build the exact air handling system to meet your project's demands for operating efficiency, indoor air quality, quiet operation and low cost installation and maintenance.
- The Vision air handler's unique, custom-modular platform and Variable Dimensioning™ feature provide tremendous component and sizing flexibility, allowing you to configure the optimal air handling system for your client's environment.
- Choose from a wide variety of unit sizes, fan assemblies and motors, plus many options to custom-build the best Vision air handler for your application. See our Vision Customized Indoor Air Handlers brochure for details on all of the options available.
- User-friendly McQuay SelectTools™ selection software makes it easy to design your customized unit, and it generates drawings and specifications in minutes.

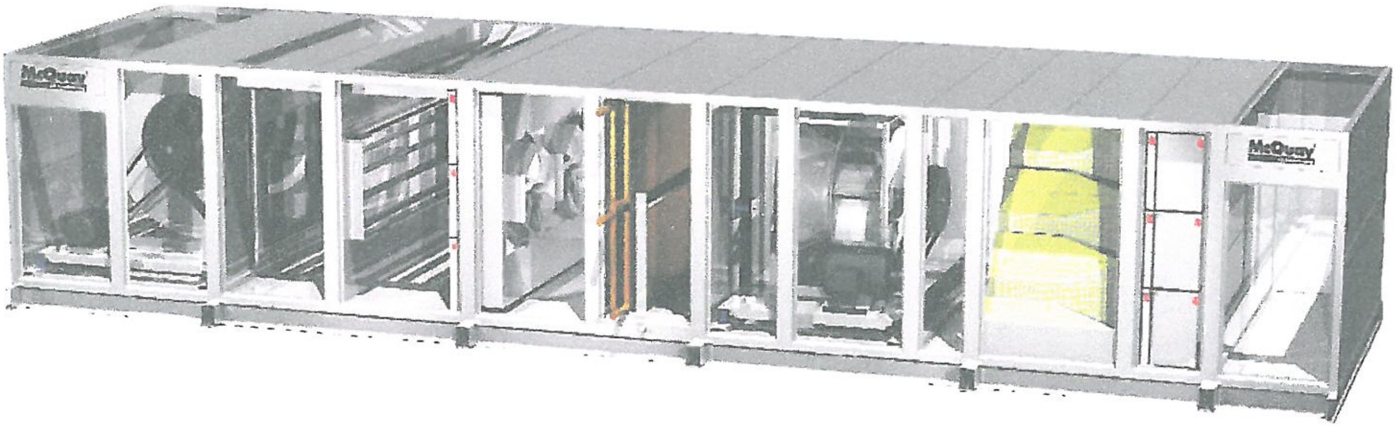
For more information

For more information on Vision Extended Size air handlers for your next project, contact your local McQuay representative. To locate your representative, visit www.mcquay.com or call (800) 432-1342.

Technical Specifications

Description	Unit Size				
	107	124	141	160	169
Airflow range, cfm	29,000 -77,500	33,600 -89, 500	40,300 -107,400	45,600 - 121,800	48,400 - 129,000
cfm @ 500 ft/min through large face area coil	48,400	55,900	67,100	76,200	80,600
Height × width (in)*	108 x 168	108 x 192	122 x 192	122 x 216	122 x 228
Cooling coil face area, sq ft, large	109.79	126.79	134.25	152.25	161.25
Cooling coil face area, sq ft, medium	77.5	89.5	96.;96	109.96	116.46

* Note: Vision air handler units are available in 2-inch increments of height and 4-inch increments of width to fit the exact space requirements..



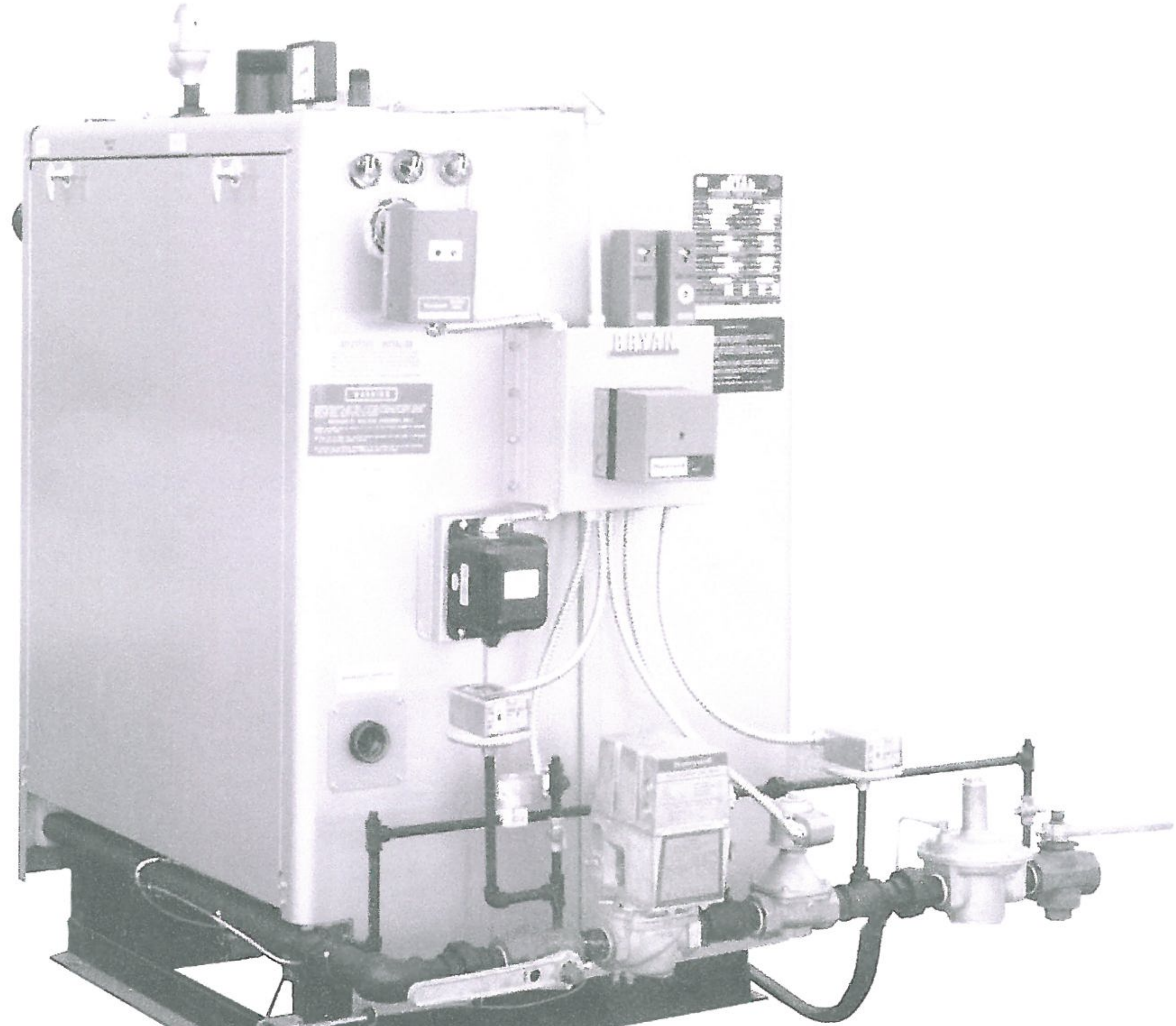
McQuay
International
a member of DAIKIN group

Form No. 1900-2
(Rev. 3/01)

Bryan "Flexible Water Tube"

CL Series Water Boilers

900,000 to 3,000,000 BTUH
Atmospheric gas fired



BRYAN BOILERS

Originators of the "Flexible Water Tube" design

High efficiency hot water heat for commercial industrial applications

In a range of sizes from 900,000 to 3,000,000 BTUH input, Bryan CL series flexible tube hot water boilers are ideal for many commercial, institutional and industrial applications. These include healthcare facilities; schools; apartments; churches; office buildings; correctional facilities; airports; sewage treatment plants; golf, tennis and fitness clubs.

All Bryan boilers are built in accordance with the requirements of the ASME Boiler and Pressure Vessel Code.

Efficient "Flexible Water Tube" design

The Bryan bent water tube provides rapid internal circulation — for maximum heat transfer and operating efficiency.

Easily replaceable tubes

Tubes are easily removable and replaceable without welding or rolling. Requires little service space.

No "Thermal Shock"

The flexibility of the bent water tube design eliminates all possible damage from "Thermal Shock" and from stresses caused by poor or unequal internal circulation. This is particularly important with forced hot water heating systems designed for higher temperatures and greater temperature drops.

Featuring Bryan's exclusive "Flexible Water Tube" design

Natural internal circulation

The water tube design and the large downcomer legs provide adequate internal circulation without concern over exterior pumping conditions. Low pressure drop through boiler.

Compact — minimum floor space

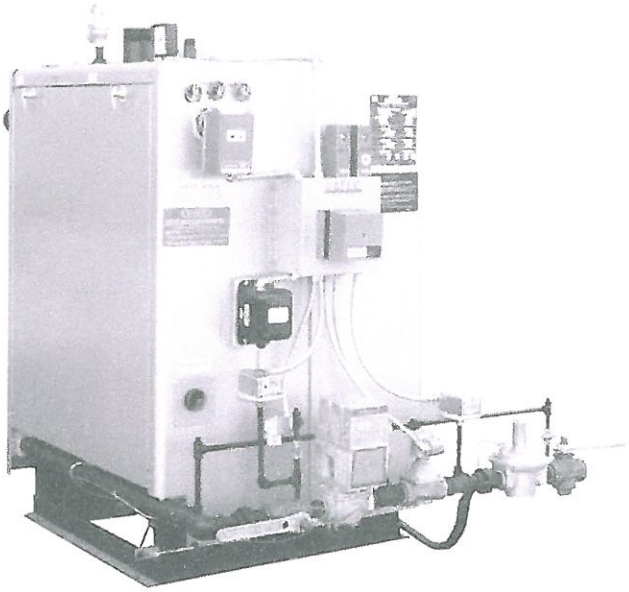
Requires less floor space than most boilers—minimum boiler room size.

Shipped completely assembled and wired. Units can also be shipped "Knocked Down" for on-site assembly.

Tubes are easily removable and replaceable, requiring little service space.

Bryan CL Series Water Boiler Specifications

Boiler Model Number	Input	Nominal Output		Net Load Recom. (EDR)		Approx. Shipping Weight
	MBH	MBH	Boiler H.P.	MBH	Hot Water Radiation Sq. Ft.	
CL-90	900	720	21	626	4,180	1,425
CL-120	1,200	960	29	835	5,560	1,550
CL-150	1,500	1,200	36	1,042	6,870	1,875
CL-180	1,800	1,440	43	1,250	8,350	2,075
CL-210	2,100	1,680	50	1,460	9,750	2,475
CL-240	2,400	1,920	57	1,670	11,120	2,800
CL-270	2,700	2,160	64	1,880	12,500	3,000
CL-300	3,000	2,400	72	2,087	13,920	3,825



Bryan Boilers are designed and built to the requirements of the appropriate A.S.M.E. Boiler code. *Not approved for installation on combustible floor.*

Look at these unique features of the Bryan CL Series

A. Heavy steel boiler frame, built and stamped in accordance with the ASME Boiler Code. Constructed as standard for hot water operating pressures to 60 psi. Also available for higher pressures.

B. Water leg downcomers to insure rapid internal circulation and temperature equalization.

C. Bryan flexible water tubes, easily replaceable, requiring no welding or rolling.

D. Access panels, interior of boiler easily accessible for service and inspection. Entire burner assembly completely accessible.

E. Boiler tube access panel bolted tightly and sealed to boiler frame. Constructed of high temperature insulation in steel framework. Tubes installed from one side.

F. Boiler frame insulated with 1½" thick insulating refractory.

G. Boiler jacket, heavy gauge, zinc-coated, rust resistant with attractive enamel and fiberglas insulation.

H. Draft diverter.

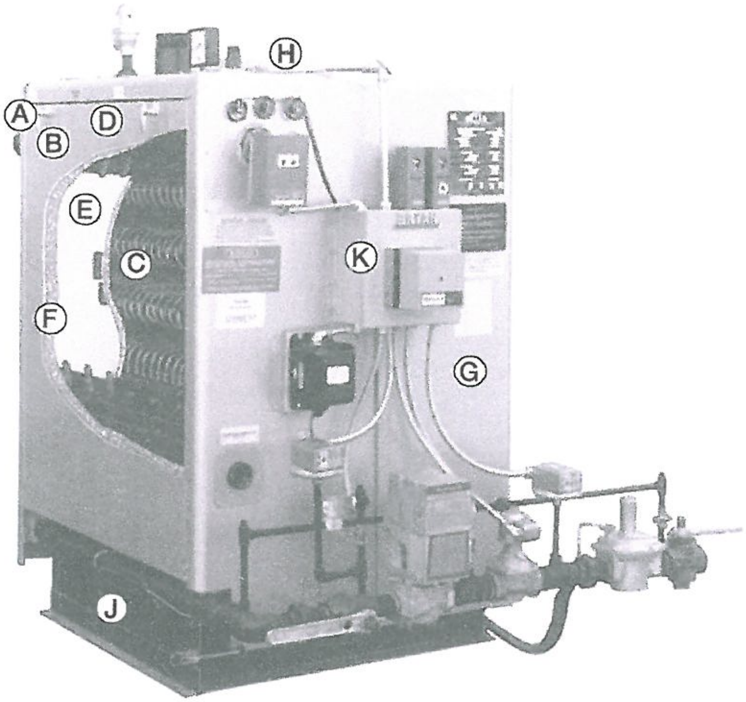
J. Gas burner—atmospheric. Quiet electric ignition and operation. No moving parts or complicated adjustments.

K. All controls installed and wired.

Extra Value

20 year warranty

Because of the proven effectiveness of the flexible water tube design in eliminating thermal shock damage, every Bryan Flexible Watertube Boiler is warranted for 20 years, *non-prorated*, against pressure vessel damage due to thermal shock.



Compact design requires minimum floor space

Due to the flexible water tube design, floor space requirements are minimized, while heating surface area per boiler HP is exceptionally high. The CL Series requires only 24" clearance for servicing the water tubes, only on one side of the boiler. Dramatically reduced space requirements in a boiler room mean considerable savings in building costs.

Bryan CL Series Boilers Standard and Optional Equipment

STANDARD EQUIPMENT FURNISHED

Combination thermometer and altitude gauge, ASME Code rated boiler relief valve, water temperature control (240°F Max. Std.), high limit control, probe LWCO, electronic combustion safety control, automatic operating gas valve, safety gas valve, pilot solenoid valve, electric ignition assembly, main manual gas shut-off valve, pilot cock, pilot and main gas pressure regulators, draft diverter, all controls mounted and wired.

OPTIONAL EQUIPMENT, EXTRA COST

[1] Manual reset high limit control, installed
[2] Manual reset low water cutoff
[3] Auxiliary low water cutoff
[4] Combination low water cutoff and feeder
[5] Barometric damper
[6] Alarm bells or horns
[7] UL, FM, IRI, CSD-1 or other insurance approved control systems
[8] Indicating lights, as desired
[9] Low fire start, Hi-Lo or modulation fire control
[10] Heat exchanger coils for domestic water
[11] Lead-lag systems for two or more boilers with or without outdoor reset control

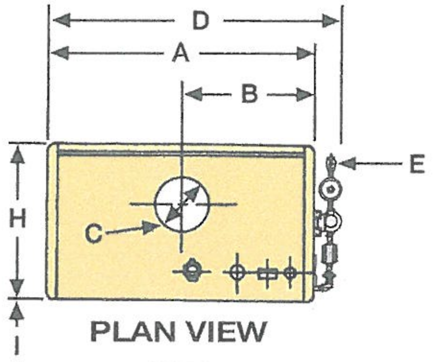
OPTIONAL CONSTRUCTION, HIGH TEMPERATURE HOT WATER

Optional construction to ASME Power Boiler Code requirements for temperatures exceeding 250°F and/or pressure exceeding 150 psi to maximum of 300°F and 250 psi, high temperature gauge and operating controls included.

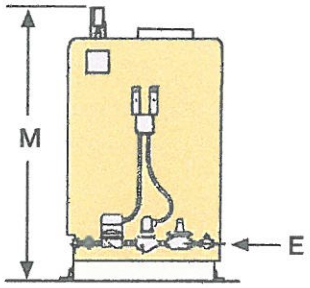
When ordering, please specify:

[1] Boiler size
[2] Supply and return temperatures required
[3] Boiler relief valve setting
[4] Type of fuel: natural, LP or other gas
[5] Gas type, BTU content, specific gravity and pressure available
[6] Electric power voltage, phase and frequency
[7] Optional extra equipment or construction
[8] Special approvals required (FM, IRI or other)

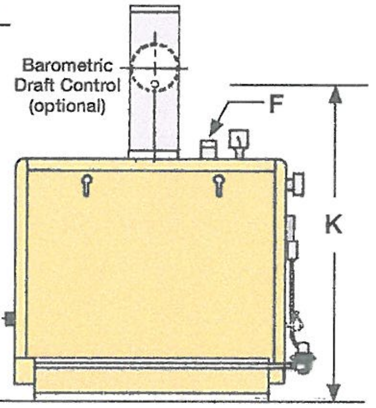
Bryan CL Series Atmospheric Gas Fired Water Tube Boilers



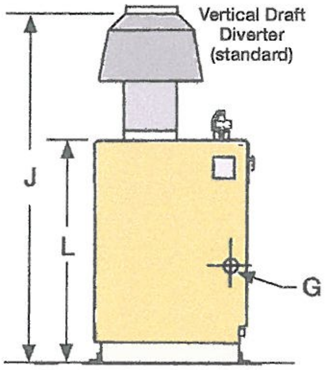
PLAN VIEW



RIGHT END VIEW



FRONT VIEW



LEFT END VIEW

DIMENSIONS—inches (cm)													
	A	B	C	D	E	F	G	H	I	J	K	L	M
Boiler Model Number	Length of Jacket	Flue Location	Flue Size	Overall Length	Gas Train Conn.	Supply Nozzle	Return Nozzle	Width Outside Jacket	Min. Tube Removal Clearance	Height Over Diverter	Height To Barometric	Height Over Jacket	Floor to Flow Nozzle
CL-90-W	41½ (105.41)	20¾ (52.71)	14 (35.56)	55½ (140.9)	1¼ (3.18)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	91⅜ (231.99)	65½ (166.37)	55½ (140.97)	59½ (151.1)
CL-120-W	50¾ (128.91)	25⅜ (64.45)	16 (40.64)	64¾ (164.5)	1¼ (3.18)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	94¼ (239.60)	67 (170.18)	55½ (140.97)	59½ (151.1)
CL-150-W	59¾ (151.77)	29⅞ (75.88)	18 (45.72)	73¾ (187.3)	1½ (3.81)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	96¼ (244.48)	67½ (171.45)	55½ (140.97)	59½ (151.1)
CL-180-W	69 (175.26)	34½ (87.63)	20 (50.80)	83 (210.82)	2 (5.08)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	98¼ (249.56)	68 (172.72)	55½ (140.97)	59½ (151.1)
CL-210-W	78¼ (198.76)	39⅛ (99.38)	20 (50.80)	92¼ (234.3)	2 (5.08)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	98¼ (249.56)	68½ (173.99)	55½ (140.97)	59½ (151.1)
CL-240-W	87½ (222.25)	43¾ (111.13)	22 (55.88)	101½ (257.8)	2 (5.08)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	101¼ (257.18)	69 (175.26)	55½ (140.97)	59½ (151.1)
CL-270-W	96¾ (245.75)	48⅜ (122.87)	22 (55.88)	110¾ (281.3)	2 (5.08)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	101¼ (257.18)	69½ (176.53)	55½ (140.97)	59½ (151.1)
CL-300-W	106 (269.24)	53 (134.62)	22 (55.88)	120 (304.80)	2½ (6.35)	3" NPT (7.62)	3" NPT (7.62)	34½ (87.63)	24 (60.96)	101¼ (257.18)	70 (177.80)	55½ (140.97)	59½ (151.1)

Dimensions and specifications are subject to change without notice. Consult factory for certified dimensions.

BRYAN BOILERS™
Bryan Steam LLC — Leaders Since 1916
783 N. Chili Ave., Peru, Indiana 46970 U.S.A.
Phone: 765-473-6651 • Internet: www.bryanboilers.com
Fax: 765-473-3074 • E-mail: bryanboilers@iquest.net

Form No. 1900-2

Printed in USA
31-3343

APPENDIX: HVAC (H-5)

R.S. MEANS COST ESTIMATE SPREADSHEET

IPRO359 Spring 2011

Ext. Mat. O&P	Ext. Labor O&P	Ext. Equip. O&P	Ext. Total O&P	Labor Type	Data Release	Zip Code	Notes
$ 2,450.00	$ 281.00	$ -	#######	STD	Year 2011		
$ 5,325.00	$ 2,625.00	$ -	#######	STD	Year 2011		
$ 798.75	$ 393.75	$ -	#######	STD	Year 2011		[Adjusted by 23091310 0020]
$ 9,240.00	$ 125,160.00	$ -	#######	STD	Year 2011		
$ 4,700.00	$ 3,000.00	$ -	#######	STD	Year 2011		
$ 28,000.00	$ 970.00	$ -	#######	STD	Year 2011		
$ 232,000.00	$ 1,205,000.00	$ -	#######	STD	Year 2011		
$ -	$ 132,550.00	$ -	#######	STD	Year 2011		[Adjusted by 23311313 1220]
$ -	$ 482,000.00	$ -	#######	STD	Year 2011		[Adjusted by 23311313 1200]
$ -	$ 72,300.00	$ -	#######	STD	Year 2011		[Adjusted by 23311313 0052]
$ 630.00	$ 416.00	$ -	#######	STD	Year 2011		
$ 102,000.00	$ 8,400.00	$ -	#######	STD	Year 2011		
$ 45,900.00	$ 10,650.00	$ -	#######	STD	Year 2011		
$ 39,200.00	$ 2,250.00	$ -	#######	STD	Year 2011		
$ 24,500.00	$ 9,775.00	$ -	#######	STD	Year 2011		
$ 18,500.00	$ 14,250.00	$ -	#######	STD	Year 2011		
$ 7,450.00	$ 625.00	$ -	#######	STD	Year 2011		
$ 209,500.00	$ 22,400.00	$ -	#######	STD	Year 2011		
$ 16,600.00	$ 7,250.00	$ -	#######	STD	Year 2011		
$ 142,000.00	$ 12,500.00	$ -	#######	STD	Year 2011		
$ 195,000.00	$ 18,100.00	$ -	#######	STD	Year 2011		
$ 54,500.00	$ 4,525.00	$ -	#######	STD	Year 2011		
$ 43,200.00	$ 5,225.00	$ -	#######	STD	Year 2011		
$1181493.76	$2140795.76	$.00	322289.60				

IPRO359-
Mechanical
estimate
City of Chicago
2929 South Ellis
Avenue
Chicago IL 60616

Data Release Year
2011

Unit Cost Estimate

Quantity	LineNumber	Source	SubC	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Equipment	Total	Ext Mat	Ext Labor	Ext Equip	Ext Total	Mat O&P	Labor O&P	Equip O&P	Total O&P
1	233516108032			Exhaust system, blower, for tailpipe exhaust system, belt drive, 1400 CFM, 1 H P	Q9	4	4	Ea	$ 2,225.00	$ 186.00	$ -	$ 2,411.00	$ 2,225.00	$ 186.00	$ -	$ 2,411.00	$ 2,450.00	$ 281.00	$ -	$ 2,731.00
1	230943100620			Pneumatic Control Systems, heating & ventilating, split system, cooling tower, fan cycle, damper control, control system, including water readout in/out at panel	Q19	0.67	35.821	Ea	$ 4,850.00	$ 1,775.00	$ -	$ 6,625.00	$ 4,850.00	$ 1,775.00	$ -	$ 6,625.00	$ 5,325.00	$ 2,625.00	$ -	$ 7,950.00
1	230943100620	A		Electronic control systems, for electronic costs, add to Section 23 09 43 10 (13336-200)				Ea	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 798.75	$ 393.75	$ -	$ 1,192.50
42000	230713103160			Insulation, ductwork, blanket type, fiberglass, flexible, FSK vapor barrier wrap, .75 lb. density, 1" thick	Q14	350	0.046	S F	$ 0.20	$ 1.93	$ -	$ 2.13	$ 8,400.00	$ 81,060.00	$ -	$ 89,460.00	$ 0.22	$ 2.98	$ -	$ 3.20
1	230943100260			Pneumatic Control Systems, heating & ventilating, split system, mixed air control, economizer cycle, panel readout, tubing, over 20 tons, including nominal 50' of tubing, add control panelboard if required	Q19	0.58	41.096	Ea	$ 4,275.00	$ 2,025.00	$ -	$ 6,300.00	$ 4,275.00	$ 2,025.00	$ -	$ 6,300.00	$ 4,700.00	$ 3,000.00	$ -	$ 7,700.00
2	2321204[illegible]160			Expansion tanks, steel, liquid expansion, rubber diaphragm, size is acceptable capacity, 528 gallon capacity, ASME	Q5	2.4	6.667	Ea	$ 12,800.00	$ 325.00	$ -	$ 13,125.00	$ 25,600.00	$ 650.00	$ -	$ 26,250.00	$ 14,000.00	$ 485.00	$ -	$ 14,485.00
100000	233113130160			Metal Ductwork, fabricated rectangular, over 5000 lb., aluminum alloy 3003-H14, includes fittings, joints, supports and allowance for a flexible connection, excludes insulation	Q10	145	0.110	Lb	$ 2.11	$ 8.00	$ -	$ 10.11	$ 211,000.00	$ 800,000.00	$ -	$ 1,011,000.00	$ 2.32	$ 12.05	$ -	$ 14.37
1	233113130160	A		Metal Ductwork, fabricated rectangular, for 30% fittings, add				Lb	$ -	$ 0.88	$ -	$ 0.88	$ -	$ 88,000.00	$ -	$ 88,000.00	$ -	$ 1.33	$ -	$ 1.33
1	233113130160	A		Metal Ductwork, fabricated rectangular, for high pressure ductwork, add				Lb	$ -	$ 3.20	$ -	$ 3.20	$ -	$ 320,000.00	$ -	$ 320,000.00	$ -	$ 4.82	$ -	$ 4.82
1	233113130160	A		Metal Ductwork, fabricated rectangular, 10' to 15' high, includes fittings, joints, supports and allowance for a flexible connection, excludes insulation, add to labor for elevated installation of fabricated ductwork					$ -	$ 0.48	$ -	$ 0.48	$ -	$ 48,000.00	$ -	$ 48,000.00	$ -	$ 0.72	$ -	$ 0.72
2	233313136200			Duct accessories, multi-blade dampers, opposed blade, 56" x 36"	Q9	5.4	2.963	Ea	$ 287.00	$ 138.00	$ -	$ 425.00	$ 574.00	$ 276.00	$ -	$ 850.00	$ 315.00	$ 208.00	$ -	$ 523.00
20	233413100050			Fans, air conditioning and process air handling, axial flow, compact, low sound, 2.5" S P , 3800 CFM, 5 H P	Q20	3.4	5.882	Ea	$ 4,625.00	$ 278.00	$ -	$ 4,903.00	$ 92,500.00	$ 5,560.00	$ -	$ 98,060.00	$ 5,100.00	$ 420.00	$ -	$ 5,520.00
3	233413100160			Fans, air conditioning and process air handling, axial flow, compact, low sound, 2.5" S P , 28,000 CFM, 20 H P	Q20	0.4	50	Ea	$ 13,900.00	$ 2,350.00	$ -	$ 16,250.00	$ 41,700.00	$ 7,050.00	$ -	$ 48,750.00	$ 15,300.00	$ 3,550.00	$ -	$ 18,850.00
2	233416104280			Fans, centrifugal, airfoil, double width wheel, belt drive, capacities at 2000 fpm, 2.5" S P for motor size indicated, 60,920 CFM, 40 H P , excludes motor	Q9	1	16	Ea	$ 17,900.00	$ 745.00	$ -	$ 18,645.00	$ 35,800.00	$ 1,490.00	$ -	$ 37,290.00	$ 19,600.00	$ 1,125.00	$ -	$ 20,725.00
500	233713100120			Diffuser, aluminum, ceiling, also for sidewall, 2" wide, includes opposed blade damper	1 Shee	32	0.25	L F	$ 44.50	$ 12.90	$ -	$ 57.40	$ 22,250.00	$ 6,450.00	$ -	$ 28,700.00	$ 49.00	$ 19.55	$ -	$ 68.55
500	233713300220			Grille, aluminum, air supply, adjustable, single deflection, 12" x 12"	1 Shee	22	0.364	Ea	$ 33.50	$ 18.80	$ -	$ 52.30	$ 16,750.00	$ 9,400.00	$ -	$ 26,150.00	$ 37.00	$ 28.50	$ -	$ 65.50
1	237213201120			Heat reclaim unit, heat pipe exchanger, combined supply/exhaust air volume, 2.5 to 6 MCFM	Q10	2.8	8.571	MCFM	$ 6,775.00	$ 415.00	$ -	$ 7,190.00	$ 6,775.00	$ 415.00	$ -	$ 7,190.00	$ 7,450.00	$ 625.00	$ -	$ 8,075.00
1	236416100282			Water chiller, centrifugal liquid chiller, packaged unit, water cooled, 450 ton, includes standard controls, excludes water tower	Q7	0.11	290	Ea	$190,500.00	$15,000.00	$ -	$ 205,500.00	$ 190,500.00	$ 15,000.00	$ -	$ 205,500.00	$ 209,500.00	$ 22,400.00	$ -	$ 231,900.00
1	235223202280			Boiler, gas fired, natural or propane, cast iron, steam, gross output, 1275 MBH, includes standard controls and insulated jacket, packaged	Q7	0.34	94.118	Ea	$ 15,100.00	$ 4,850.00	$ -	$ 19,950.00	$ 15,100.00	$ 4,850.00	$ -	$ 19,950.00	$ 16,600.00	$ 7,250.00	$ -	$ 23,850.00
2	237313202170			Central station air handling unit, packaged indoor, variable air volume, 20,000 CFM, cooling coils may be chilled water or DX, heating coils may be hot water, steam or electric	Q6	0.29	82.759	Ea	$ 64,500.00	$ 4,175.00	$ -	$ 68,675.00	$ 129,000.00	$ 8,350.00	$ -	$ 137,350.00	$ 71,000.00	$ 6,250.00	$ -	$ 77,250.00
2	237313202150			Central station air handling unit, packaged indoor, variable air volume, 30,000 CFM, cooling coils may be chilled water or DX, heating coils may be hot water, steam or electric	Q6	0.2	120	Ea	$ 88,500.00	$ 6,050.00	$ -	$ 94,550.00	$ 177,000.00	$ 12,100.00	$ -	$ 189,100.00	$ 97,500.00	$ 9,050.00	$ -	$ 106,550.00
1	237313202130			Central station air handling unit, packaged indoor, variable air volume, 15,000 CFM, cooling coils may be chilled water or DX, heating coils may be hot water, steam or electric	Q6	0.4	60	Ea	$ 49,500.00	$ 3,025.00	$ -	$ 52,525.00	$ 49,500.00	$ 3,025.00	$ -	$ 52,525.00	$ 54,500.00	$ 4,525.00	$ -	$ 59,025.00
1	236513102544			Cooling tower, packaged unit, galvanized steel, blow through, centrifugal type, 350 ton, includes standard controls, excludes pumps and piping	Q7	0.47	68.085	Ea.	$ 39,200.00	$ 3,500.00	$ -	$ 42,700.00	$ 39,200.00	$ 3,500.00	$ -	$ 42,700.00	$ 43,200.00	$ 5,225.00	$ -	$ 48,425.00
Total													$1072999.00	$1419162.00	$.00	$2492161.00				

	Adjustable Inputs	**Non-Adjustable Inputs**
Development Inputs		
Development/ Renovation Costs	**$30,000,000**	
Loan/Debt Inputs		
Loan to Value	**70.00%**	
Developer Contribution %		**30.00%**
Debt Rate	**7.50%**	
Length of Loan (up to 30 years)	**30**	
Revenue/Expense Inputs		
Venue Annual Rent (Assuming a 30 yr lease)	**$2,000,000**	
Revenue Inflation	**3.00%**	
Expense Inflation	**3.00%**	
Developer Return Requirements		
Developer Annual Return Requirement (IRR)	**18.00%**	
Cap Rate Used for Disposition After 30 yrs		
Reversion Cap Rate on Developer Sale	**10.00%**	

KEY MODEL INPUTS		**Parking per Space**
Component:	**1 Children's Museum**	**2 Parking**
Estimated Stabilized Occupancy Rate	65%	75%
Assumed Annual Lease Expiration	5.00%	N/A
Revenues:		
Lease Rate	**$20.00**	**$900.00**
Unit/Duration	Per RSF/Yr	Per Space/Yr
Revenue Assumptions		
Concessions	N/A	N/A
Other Income	N/A	N/A
Vacancy/Credit Loss (% of Rental Revenue)	3.00%	3.00%
Expenses:		
Stabilized Operating Expenses	$3.00	$300.00
	N/A	N/A
Stabilized Real Estate Taxes	$0.00	$0.00
structural improvements	$0.00	N/A
Capital Reserve	$0.00	$0.00
Development Costs:		
Development/ Renovation Costs		
Hard Costs		
Base Building (per Gross Square Foot)	$212.00	$5,000.00
Escalation Contingency (% of Base Bldg Cost)	3.00%	3.00%
Construction Contingency (% of Base Bldg + Escalation Conting)	5.00%	5.00%
($/RSF)	$20.00	N/A
Site Work	$15.00	$500.00
Owner/Design Contingency (% of Total Hard Costs above)	3.00%	3.00%
Soft Costs ($/sf)	$25.00	$1,000.00
Development Fee % of Total Project Costs)	0.00%	0.00%
Square Feet developed/Parking Spaces	**278,045**	**243**

Specifications	**Adjustable Inputs**	**non**
Debt Rate	**7.50%**	
Length of Loan (years)	**30**	
Revenue Inflation	**3.00%**	
Expense Inflation	**3.00%**	
Financing Fees (% of Total Development Loan)	**1.00%**	
Loan to Value	**70.00%**	
Private Developer Contribution % (where applic.)		**30%**
Reversion Cap Rate on Developer Sale	**10.00%**	
Discount Rate (the rate of return that could be earned on an investment in the financial markets with similar risk)	**18.00%**	

Portfolio-Projections

	Total SF or spaces	Total Project Costs	Construction Year **Developer Capital Contribution**	Operational Year 1		
				Yr 1	*Yr 2*	*Yr 3*
Total Development Financial Impact			*2012*	*2013*	*2014*	*2015*
Children's Museum Capital Costs	278,045	$51,347,569	($15,404,271)			
Children's Museum Cash Flow				$4,515,254	$2,211,221	$2,397,618
Children's Museum Property Sale Yr 31						
Parking Capital Costs	243	$8,479,500	($520,092)			
Parking Cash Flow				$473,127	$477,353	$481,706
Parking Property Sale Yr 31						
Total Development Costs		$59,827,069				
Cumulative Financial Impact			**($15,924,363)**	**$4,988,380**	**$2,688,574**	**$2,879,324**
Total Annual Cash Flow			$0	$4,988,380	$2,688,574	$2,879,324
Terminal Value (Yr 31)						

Portfolio-Projections

	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11
	2016	2017	2018	2019	2020	2021	2022	2023
Total Development Financial Impact								
Children's Museum Capital Costs								
Children's Museum Cash Flow	$2,589,606	$2,787,354	$2,991,034	$3,200,825	$3,416,910	$3,639,477	$3,868,721	$4,104,842
Children's Museum Property Sale Yr 31								
Parking Capital Costs								
Parking Cash Flow	$486,190	$490,808	$495,565	$500,465	$505,511	$510,709	$516,063	$521,577
Parking Property Sale Yr 31								
Total Development Costs								
Cumulative Financial Impact	**$3,075,796**	**$3,278,162**	**$3,486,599**	**$3,701,290**	**$3,922,421**	**$4,150,186**	**$4,384,784**	**$4,626,420**
Total Annual Cash Flow	$3,075,796	$3,278,162	$3,486,599	$3,701,290	$3,922,421	$4,150,186	$4,384,784	$4,626,420
Terminal Value (Yr 31)								

Portfolio-Projections

	Yr 12	*Yr 13*	*Yr 14*	*Yr 15*	*Yr 16*	*Yr 17*	*Yr 18*
	2024	*2025*	*2026*	*2027*	*2028*	*2029*	*2030*
Total Development Financial Impact							
Children's Museum Capital Costs							
Children's Museum Cash Flow	$4,348,047	$4,598,549	$4,856,565	$5,122,322	$9,564,681	$9,846,622	$10,137,022
Children's Museum Property Sale Yr 31							
Parking Capital Costs							
Parking Cash Flow	$527,257	$533,108	$539,133	$545,340	$551,733	$558,317	$565,099
Parking Property Sale Yr 31							
Total Development Costs							
Cumulative Financial Impact	**$4,875,305**	**$5,131,656**	**$5,395,698**	**$5,667,662**	**$10,116,414**	**$10,404,940**	**$10,702,121**
Total Annual Cash Flow	$4,875,305	$5,131,656	$5,395,698	$5,667,662	$10,116,414	$9,846,622	$10,137,022
Terminal Value (Yr 31)							

Portfolio-Projections

	Yr 19	*Yr 20*	*Yr 21*	*Yr 22*	*Yr 23*	*Yr 24*
	2031	*2032*	*2033*	*2034*	*2035*	*2036*
Total Development Financial Impact						
Children's Museum Capital Costs						
Children's Museum Cash Flow	$10,436,134	$10,744,219	$11,061,546	$11,388,393	$11,725,046	$12,071,798
Children's Museum Property Sale Yr 31						
Parking Capital Costs						
Parking Cash Flow	$572,085	$579,280	$586,691	$594,324	$602,187	$610,285
Parking Property Sale Yr 31						
Total Development Costs						
Cumulative Financial Impact	**$11,008,219**	**$11,323,499**	**$11,648,237**	**$11,982,718**	**$12,327,233**	**$12,682,083**
Total Annual Cash Flow	$11,008,219	$11,323,499	$11,648,237	$11,982,718	$12,327,233	$12,682,083
Terminal Value (Yr 31)						

Children's Museum
Operating Pro Forma

	Construction Year	Operational Year 1											
Foundations		$250,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
Corporations		$1,500,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000
Governemt Grants		$75,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000
Benefit Events		$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000
Admissions		$2,265,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
Museum store		$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000
Investment Income		$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000
Membership Dues		$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000
Rental Revenues		$3,614,585	$3,723,023	$3,834,713	$3,949,755	$4,068,247	$4,190,295	$4,316,004	$4,445,484	$4,578,848	$4,716,214	$4,857,700	$5,003,431
Contributed Goods and Services		$3,251,797	$3,349,351	$3,449,832	$3,553,327	$3,659,926	$3,769,724	$3,882,816	$3,999,300	$4,119,279	$4,242,858	$4,370,144	$4,501,248
revenues		$12,561,382	$10,282,374	$10,494,545	$10,713,081	$10,938,174	$11,170,019	$11,408,819	$11,654,784	$11,908,128	$12,169,071	$12,437,844	$12,714,679
Venue Annual Rent		$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000
Employee Salaries		$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000
Marketing/Communications		$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550
Fundraising		$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480
Program Services		$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600
Operating Expenses		$834,135	$859,159	$884,934	$911,482	$938,826	$966,991	$996,001	$1,025,881	$1,056,657	$1,088,357	$1,121,008	$1,154,638
Stabilized Real Estate Taxes		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Expenses		$5,002,765	$5,027,789	$5,053,564	$5,080,112	$5,107,456	$5,135,621	$5,164,631	$5,194,511	$5,225,287	$5,256,987	$5,289,638	$5,323,268
NOI		**$7,558,617**	**$5,254,585**	**$5,440,981**	**$5,632,969**	**$5,830,717**	**$6,034,398**	**$6,244,189**	**$6,460,273**	**$6,682,840**	**$6,912,084**	**$7,148,206**	**$7,391,411**
Capital Reserve		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
structural Improvements		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cash Flow - Pre Debt Service		$7,558,617	$5,254,585	$5,440,981	$5,632,969	$5,830,717	$6,034,398	$6,244,189	$6,460,273	$6,682,840	$6,912,084	$7,148,206	$7,391,411
Development Costs													
Hard Costs		$44,039,510											
Soft Costs		$6,951,125											
Construction Financing Costs		$356,934											
Developer Fee		$0											
Total Development Costs		**$51,347,569**											
Development Equity Required		($15,404,271)											
Annual Debt Service		($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364
Ending Cash Balance (Cash Flow)	($15,404,271)	**$4,515,254**	**$2,211,221**	**$2,397,618**	**$2,589,606**	**$2,787,354**	**$2,991,034**	**$3,200,825**	**$3,416,910**	**$3,639,477**	**$3,868,721**	**$4,104,842**	**$4,348,047**
Cumulative Cash Flow		$4,515,254	$6,726,475	$9,124,092	$11,713,698	$14,501,052	$17,492,087	$20,692,912	$24,109,822	$27,749,298	$31,618,019	$35,722,862	$40,070,909
DSCR		2.484	1.727	1.788	1.851	1.916	1.983	2.052	2.123	2.196	2.271	2.349	2.429
NPV of Projected Future Cash Flows (Present Value of Land)		**$12,653,892.68**											
Sale in year 31:		**$178,518,474**											
Loan Payoff		**$0**											
Cash Flows:	($15,404,271)	**$4,515,254**	**$2,211,221**	**$2,397,618**	**$2,589,606**	**$2,787,354**	**$2,991,034**	**$3,200,825**	**$3,416,910**	**$3,639,477**	**$3,868,721**	**$4,104,842**	**$4,348,047**
Developer Annual Return on Investment:		**23.43%**											
Sale in year 11:		**$71,482,059**											
Loan Payoff		($31,025,543)											
Cash Flows:	($15,404,271)	**$4,515,254**	**$2,211,221**	**$2,397,618**	**$2,589,606**	**$2,787,354**	**$2,991,034**	**$3,200,825**	**$3,416,910**	**$3,639,477**	**$44,325,237**		
Developer Annual Return on Investment:		**25.15%**											

$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000	$200,000
$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,000	$1,200,00
$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000	$55,000
$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,000	$1,100,00
$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000
$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000	$175,000
$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000	$145,000
$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000	$185,000
$5,800,348	$5,974,358	$6,153,589	$6,338,197	$6,528,343	$6,724,193	$6,925,919	$7,133,696	$7,347,707	$7,568,138	$7,795,182	$8,029,038	$8,269,909	$8,518,00
$5,218,180	$5,374,725	$5,535,967	$5,702,046	$5,873,108	$6,049,301	$6,230,780	$6,417,703	$6,610,234	$6,808,541	$7,012,798	$7,223,181	$7,439,877	$7,663,07
$14,228,528	**$14,559,084**	**$14,899,556**	**$15,250,243**	**$15,611,450**	**$15,983,494**	**$16,366,698**	**$16,761,399**	**$17,167,941**	**$17,586,680**	**$18,017,980**	**$18,462,219**	**$18,919,786**	**$19,391,08**
$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,000	$2,000,00
$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,000	$1,750,00
$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550	$67,550
$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480	$875,480
$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,600	$1,475,60
$1,338,542	$1,378,698	$1,420,059	$1,462,661	$1,506,541	$1,551,737	$1,598,289	$1,646,238	$1,695,625	$1,746,493	$1,798,888	$1,852,855	$1,908,441	$1,965,69
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$1,338,542	**$1,378,698**	**$1,420,059**	**$1,462,661**	**$1,506,541**	**$1,551,737**	**$1,598,289**	**$1,646,238**	**$1,695,625**	**$1,746,493**	**$1,798,888**	**$1,852,855**	**$1,908,441**	**$1,965,69**
$12,889,986	**$13,180,386**	**$13,479,497**	**$13,787,582**	**$14,104,910**	**$14,431,757**	**$14,768,410**	**$15,115,162**	**$15,472,317**	**$15,840,186**	**$16,219,092**	**$16,609,364**	**$17,011,345**	**$17,425,38**
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$12,889,986	$13,180,386	$13,479,497	$13,787,582	$14,104,910	$14,431,757	$14,768,410	$15,115,162	$15,472,317	$15,840,186	$16,219,092	$16,609,364	$17,011,345	$17,425,38
($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,364)	($3,043,36
$9,846,622	**$10,137,022**	**$10,436,134**	**$10,744,219**	**$11,061,546**	**$11,388,393**	**$11,725,046**	**$12,071,798**	**$12,428,953**	**$12,796,823**	**$13,175,728**	**$13,566,001**	**$13,967,982**	**$14,382,02**
$74,059,648	$84,196,670	$94,632,804	$105,377,022	$116,438,568	$127,826,962	$139,552,008	$151,623,806	$164,052,759	$176,849,582	$190,025,310	$203,591,311	$217,559,293	$231,941,31
4.235	4.331	4.429	4.530	4.635	4.742	4.853	4.967	5.084	5.205	5.329	5.458	5.590	5.726
$9,846,622	**$10,137,022**	**$10,436,134**	**$10,744,219**	**$11,061,546**	**$11,388,393**	**$11,725,046**	**$12,071,798**	**$12,428,953**	**$12,796,823**	**$13,175,728**	**$13,566,001**	**$13,967,982**	**$192,900,49**

Parking
Operating Pro Forma

	Construction Year	Operational Year 1										
Parking Revenue		$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000
Rental Revenues		$164,025	$168,946	$174,014	$179,235	$184,612	$190,150	$195,854	$201,730	$207,782	$214,015	$220,436
Expense Recoveries		$54,675	$56,315	$58,005	$59,745	$61,537	$63,383	$65,285	$67,243	$69,261	$71,338	$73,479
Vacancy/Credit Loss		($4,921)	($5,068)	($5,220)	($5,377)	($5,538)	($5,704)	($5,876)	($6,052)	($6,233)	($6,420)	($6,613)
Total Revenues		**$648,779**	**$655,193**	**$661,798**	**$668,602**	**$675,610**	**$682,829**	**$690,264**	**$697,922**	**$705,809**	**$713,933**	**$722,301**
Operating Expenses		$72,900	$75,087	$77,340	$79,660	$82,050	$84,511	$87,046	$89,658	$92,348	$95,118	$97,972
Stabilized Real Estate Taxes		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Expenses		**$72,900**	**$75,087**	**$77,340**	**$79,660**	**$82,050**	**$84,511**	**$87,046**	**$89,658**	**$92,348**	**$95,118**	**$97,972**
NOI		**$575,879**	**$580,106**	**$584,459**	**$588,943**	**$593,561**	**$598,318**	**$603,217**	**$608,264**	**$613,462**	**$618,815**	**$624,330**
Capital Reserve		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cash Flow - Pre Debt Service		$575,879	$580,106	$584,459	$588,943	$593,561	$598,318	$603,217	$608,264	$613,462	$618,815	$624,330
Development Costs												
Hard Costs		$1,478,588										
Soft Costs		$243,000										
Construction Financing Costs		$12,051										
Developer Fee		$0										
Total Development Costs		**$1,733,639**										
Development Equity Required		($520,092)										
Annual Debt Service		($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753
Ending Cash Balance (Cash Flow)	($520,092)	**$473,127**	**$477,353**	**$481,706**	**$486,190**	**$490,808**	**$495,565**	**$500,465**	**$505,511**	**$510,709**	**$516,063**	**$521,577**
Cumulative Cash Flow		$473,127	$950,480	$1,432,186	$1,918,376	$2,409,184	$2,904,749	$3,405,214	$3,910,725	$4,421,434	$4,937,497	$5,459,07
DSCR		5.605	5.646	5.688	5.732	5.777	5.823	5.871	5.920	5.970	6.022	6.076

$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,000	$435,
$248,103	$255,546	$263,212	$271,108	$279,242	$287,619	$296,247	$305,135	$314,289	$323,718	$333,429	$343,432	$353,735	$364,347	$375,
$82,701	$85,182	$87,737	$90,369	$93,081	$95,873	$98,749	$101,712	$104,763	$107,906	$111,143	$114,477	$117,912	$121,449	$125,
($7,443)	($7,666)	($7,396)	($8,133)	($8,377)	($8,629)	($8,387)	($9,154)	($9,429)	($9,712)	($10,003)	($10,303)	($10,612)	($10,930)	($11,
$758,360	**$768,061**	**$778,053**	**$788,345**	**$798,945**	**$809,863**	**$821,109**	**$832,692**	**$844,623**	**$856,912**	**$869,569**	**$882,606**	**$896,034**	**$909,865**	**$924,**
$110,268	$113,576	$116,983	$120,493	$124,107	$127,831	$131,666	$135,615	$139,684	$143,874	$148,191	$152,636	$157,216	$161,932	$166,
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$110,268	**$113,576**	**$116,983**	**$120,493**	**$124,107**	**$127,831**	**$131,666**	**$135,615**	**$139,684**	**$143,874**	**$148,191**	**$152,636**	**$157,216**	**$161,932**	**$166,**
$648,093	**$654,485**	**$661,070**	**$667,852**	**$674,837**	**$682,033**	**$689,444**	**$697,077**	**$704,939**	**$713,037**	**$721,379**	**$729,970**	**$738,819**	**$747,934**	**$757,**
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$648,093	$654,485	$661,070	$667,852	$674,837	$682,033	$689,444	$697,077	$704,939	$713,037	$721,379	$729,970	$738,819	$747,934	$757,
($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,753)	($102,
$545,340	**$551,733**	**$558,317**	**$565,099**	**$572,085**	**$579,280**	**$586,691**	**$594,324**	**$602,187**	**$610,285**	**$618,626**	**$627,217**	**$636,066**	**$645,181**	**$654,**
$7,603,913	$8,155,645	$8,713,963	$9,279,062	$9,851,147	$10,430,427	$11,017,118	$11,611,442	$12,213,629	$12,823,914	$13,442,540	$14,069,757	$14,705,823	$15,351,004	$16,005
6.307	6.370	6.434	6.500	6.568	6.638	6.710	6.784	6.861	6.939	7.021	7.104	7.190	7.279	7.37

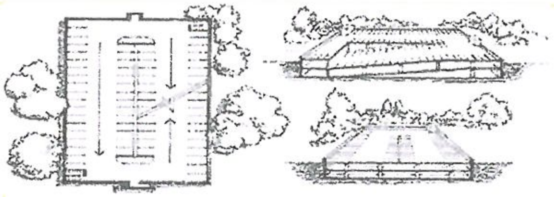
APPENDIX: SQUARE FOOT COST (C-1)

UNDERGROUND PARKING GARAGE COST

IPRO359 Spring 2011

Square Foot Cost Estimate Report

Estimate Name:	**IPRO 359 Parking Garage** S Cottage Grove Ave & E 31st St , Chicago , Illinois , 60616
Building Type:	**Garage, Underground Parking with Reinforced Concrete / R/Conc. Frame**
Location:	**CHICAGO, IL**
Story Count:	**1**
Story Height (L.F.):	**10**
Floor Area (S.F.):	**86933**
Labor Type:	**Union**
Basement Included:	**No**
Data Release:	**Year 2011**
Cost Per Square Foot:	**$97.54**
Building Cost:	**$8,479,500**



Costs are derived from a building model with basic components.

Scope differences and market conditions can cause costs to vary significantly

		% of Total	Cost Per S.F.	Cost
A Substructure		**22.60%**	**$16.36**	**$1,422,000**
A1010	**Standard Foundations** Strip footing, concrete, reinforced, load 11.1 KLF, soil bearing capacity 6 KSF, 12" deep x 24" wide Spread footings, 3000 PSI concrete, load 200K, soil bearing capacity 3 KSF, 8' -6" square x 20" deep Spread footings, 3000 PSI concrete, load 300K, soil bearing capacity 3 KSF, 10' - 6" square x 25" deep Foundation dampproofing, asphalt with fibers, 1/8" thick, 8' high		**$6.19**	**$538,500**
A1030	**Slab on Grade** Slab on grade, 5" thick, light industrial, reinforced		**$4.07**	**$354,000**
A2010	**Basement Excavation** earth, off site storage		**$6.09**	**$529,500**
B Shell		**55.10%**	**$39.84**	**$3,463,000**
B1010	**Floor Construction** Cast-in-place concrete column, 28", square, tied, minimum reinforcing, 1000K load, 10'-14' story height, 740 lbs/LF, 4000PSI Cast-in-place concrete beam and slab, 9" slab, one way, 26" column, 35'x35' bay, 200 PSF superimposed load, 355 PSF total load Floor, metal deck, 18 ga, 2" deep, concrete slab, 10' span, 4" deep, 125 PSF superimposed load, 165 PSF total load		**$16.17**	**$1,405,500**
B1020	**Roof Construction** Floor, concrete, beam and slab, 35'x35' bay, 40 PSF superimposed load, 26" deep beam, 9" slab, 209 PSF total load		**$14.89**	**$1,294,500**
B2010	**Exterior Walls** Concrete wall, reinforced, 8' high, 8" thick, plain finish, 4000 PSI		**$5.89**	**$512,000**

B2030	**Exterior Doors**		**$0.19**	**$16,500**
	Door, aluminum & glass, with transom, black finish, double door, hardware, 6'-0" x 10'-0" opening			
	Door, steel 18 gauge, hollow metal, 1 door with frame, no label, 3'-0" x 7'-0" opening			
B3010	**Roof Coverings**		**$2.70**	**$234,500**
	Vinyl and neoprene membrane traffic deck			
C Interiors		2.60%	$1.86	$162,000
C1010	**Partitions**		**$1.20**	**$104,000**
	Concrere block (CMU) partition, light weight, hollow, 8" thick, no finish			
	8" concrete block partition			
C1020	**Interior Doors**		**$0.11**	**$9,500**
	Door, single leaf, kd steel frame, hollow metal, commercial quality, flush, 3'-0" x 7'-0" x 1-3/8"			
C2010	**Stair Construction**		**$0.41**	**$35,500**
	Stairs, CIP concrete, w/landing, 16 risers, with nosing			
C3010	**Wall Finishes**		**$0.15**	**$13,000**
	Painting, masonry or concrete, latex, brushwork, primer & 2 coats			
D Services		19.10%	$13.80	$1,199,500
D1010	**Elevators and Lifts**		**$3.10**	**$269,500**
	2 - Hydraulic, passenger elevator, 1500 lb, 2 floors, 100 FPM			
	Hydraulic passenger elevator, 2500 lb., 2 floor, 125 FPM			
D2010	**Plumbing Fixtures**		**$0.06**	**$5,500**
	Water closet, vitreous china, bowl only with flush valve, floor mount			
	Lavatory w/trim, wall hung, PE on CI, 19" x 17"			
D2020	**Domestic Water Distribution**		**$0.10**	**$8,500**
	Electric water heater, commercial, 100< F rise, 50 gallon tank, 9 KW 37 GPH			
D2040	**Rain Water Drainage**		**$1.46**	**$127,000**
	Roof drain, steel galv sch 40 threaded, 3" diam piping, 10' high			
	Roof drain, steel galv sch 40 threaded, 3" diam piping, for each additional foot add			
D3050	**Terminal & Package Units**		**$0.16**	**$14,000**
	16000 CFM, 5 HP vane axial fan			
D4010	**Sprinklers**		**$4.51**	**$392,000**
	Dry pipe sprinkler systems, steel, ordinary hazard, 1 floor, 50,000 SF			
	Dry pipe sprinkler systems, steel, ordinary hazard, each additional floor, 50,000 SF			
D4020	**Standpipes**		**$0.16**	**$14,000**
	Dry standpipe risers, class III, steel, black, sch 40, 4" diam pipe, 1 floor			
	Dry standpipe risers, class III, steel, black, sch 40, 4" diam pipe, additional floors			

D5010	**Electrical Service/Distribution**		$0.14	$12,500
	Service installation, includes breakers, metering, 20' conduit & wire, 3 phase, 4 wire, 120/208 V, 200 A			
	Feeder installation 600 V, including RGS conduit and XHHW wire, 200 A			
	Switchgear installation, incl switchboard, panels & circuit breaker, 400 A			
D5020	**Lighting and Branch Wiring**		$3.85	$334,500
	Receptacles incl plate, box, conduit, wire, 2.5 per 1000 SF, .3 watts per SF			
	Miscellaneous power, to .5 watts			
	Fluorescent fixtures recess mounted in ceiling, 0.8 watt per SF, 20 FC, 5 fixtures @32 watt per 1000 SF			
D5030	**Communications and Security**		$0.19	$16,500
	Communication and alarm systems, fire detection, addressable, 12 detectors, includes outlets, boxes, conduit and wire			
	Fire alarm command center, addressable without voice, excl. wire & conduit			
D5090	**Other Electrical Systems**		$0.06	$5,500
	Generator sets, w/battery, charger, muffler and transfer switch, gas/gasoline operated, 3 phase, 4 wire, 277/480 V, 11.5 kW			
E Equipment & Furnishings		0.60%	$0.40	$34,500
E1030	**Vehicular Equipment**		$0.40	$34,500
	Architectural equipment, parking equipment, automatic gates, 8 FT arm, 1 way			
	Architectural equipment, parking equipment, booth for attendant, economy			
	Architectural equipment, parking equipment, ticket printer/dispenser, rate computing			
E1090	**Other Equipment**		$0.00	$0
F Special Construction		0.00%	$0.00	$0
G Building Sitework		0.00%	$0.00	$0

SubTotal	100%	$72.25	$6,281,000
Contractor Fees (General Conditions,Overhead,Profit)	25.00%	$18.07	$1,570,500
Architectural Fees	8.00%	$7.22	$628,000
User Fees	0.00%	$0.00	$0
Total Building Cost		$97.54	$8,479,500

APPENDIX: SQUARE FOOT COST (C-2)

OVERALL BUILDING COST SPREADSHEET

IPRO359 Spring 2011

Spaces	% of Building	Proposed Size (sq ft)	¾ Unit Cost ($)		Typical Size Gross Sq Ft	Size Factor	Cost Multiplier	Location Factor	Square Foot Estimate ($)
Restaurant	0.04	11856.52	221	26202.9092	4400	2.694663636	0.91	1.16	$ 2,765,979.10
Elementary School	0.43	127457.59	152	193735.537	41000	3.108721707	0.903	1.16	$ 20,293,410.01
Office	0.142857143	42344.71429	154	65210.86	20000	2.117235714	0.932	1.16	$ 7,050,076.50
Community Center	0.1	29641.3	132	39126.516	9400	3.153329787	0.9	1.16	$ 4,084,808.27
Retail Store	0.05	14820.65	110	16302.715	7200	2.058423611	0.94	1.16	$ 1,777,648.04
Gymnasium	0.15	44461.95	172	76474.554	19200	2.315726563	0.92	1.16	$ 8,161,364.40
Auditorium	0.09	26677.17	202	53887.8834	25000	1.0670868	0.99	1.16	$ 6,188,484.53
								Σ Square Foot Estimate (sq ft)	$ 50,321,770.85
	Additives								
Elevators, Hydraulic Passenger, 2 stops	1500# Capacity	$60,900.00	Additional Stops	Add 8,500.00	Escalators 48" wide, 10' story height	$148,200.00			
Total	4	$243,600.00	4	34000	6	$889,200.00			
Final Square Foot Cost	**$51,488,570.85**								

Community Center

	% of Total	Specific Costs
Equipment	3.01	$1,549,805.98
Plumbing	7	$3,604,199.96
Heating, ventilating, air conditioning	10.35	$5,329,067.08
Electrical	9	$4,633,971.38
Total: Mechanical & Electrical	25	$12,872,142.71
Building Shell	37.7	$19,411,191.21
Substructure	5.1	$2,625,917.11
Interiors	23.5	$12,099,814.15
Total Square Foot Cost Estimate	**$59,968,070.85**	

Light Energy Cost Estimate			**Source**
Lighting Area	sf	270,000	
Watts/area	W/sf	1.1	2009 IECC Lighting Provisions
Total Watts	W	297000	
Useage	h/day	12	
Daily Watts	W	3564000	
	kWh	3564	
Chicago Rate	$/kWh	$0.15	U.S. Bureau of Labor Statistics
Cost/day		**$531.04**	
Cost/month		**$16,462.12**	
Cost/year		**$197,545.39**	