The Research and Economic Development Center

Erie, Pa

Kristen Eash	Option: Construction Management
Advisor : D. Riley	Date: 4-3-06
Summary Book	

The Research and Economic Development Center (REDC)

Kristen Eash
http://www.arche.psu.edu/thesis/eportfolio/current/portfolios/kre124/
Construction Management
Advisor: David Riley

September 26, 2005

Building Stats

- Location: Penn State Erie Campus
  Behrend Campus
  Erie PA
- Occupancy Type: Classrooms, Labs, and Offices
- Size (Total Sq. Ft.): 161,500 Sq.Ft.
- Stories: 2.5 Floors
- Primary Project Team:
  - Owner: The Pennsylvania State University
    and Department of General Services
  - Architect: Weber Murphy Fox, Inc.
- Construction: April 28, 2004 to February 2006
- Total Cost: $30 million

Architecture

- The building has 2 wings
- Will have engineering labs, offices, classrooms, and computer labs.
- Mechanical rooms are on Basement and Second floor
- The Walls are curtain wall system that supports structural glass, brick with glass windows and metal wall panels
- The Roof is Thermoplastic Sheet Roofing over the high roof with the low roof being Architectural Metal Roofing

Structural System

- The building sits on three different types of foundations.
- The building is a steel building, with a typical column size of W14x61 and W18x35 beams
- There is no typical bay size but they run about 30'x30'.
- All floor slabs are 4" concrete slabs with 6x6 W1.4xW1.4 wire mesh.

Electrical System

- Primary service will come into the building through an underground duct bank near the loading docks.
- The first secondary feed, after coming in the building will go through a 480Y/277 volt, 1500KVA transformer and serves the majority of the building.
- The other secondary feed will enter into a 240 volt, 500 KVA transformer and will be sent out to the lab and manufacturing areas.
- The emergency power will be an indoor diesel generator rated for 150 KW at 480Y/277V.

Mechanical System

- The central cooling plant will consist of two 250 ton screw chillers and cooling towers
- The central heating plant will be two 3852 MBH cast iron hot water boilers with natural gas burners.
- There are 12 AHUs.
- Air is distributed through ceiling diffusers.
- The entire building will run off of a Direct Digital Control system.

Construction

- This project began in preliminary design stage.
- After the design had been completed a CM Agency General Contractor and Primes were hired through a bidding process.
- Construction began with the ground breaking on April 28, 2004 and is scheduled to finish on February of 2006.
- The building cost came to $21.5 million. With soft costs added in the total for the building was $30 million.

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Executive Summary

The Thesis expands on the topics for the semester long thesis research class and discusses in more depth the topics and decisions that will be presented during the Thesis Presentation. This book will go into detail of my three selected analysis topics as well as my research topic. I will discuss why each topic was chosen and describe the critical issue with each as well as provide background, research and conclusions. A general synopsis of my building will also be presented.

From the issues that were identified as a result of the PACE Roundtable, I chose to look into an issue that directly affected my project for my industry research topic; WBE/MBE solicitation. This is the process whereby all contractors who wish to bid on any DGS project need to solicit bids for subcontracted work from minority and women owned businesses. I intended to find out whether requiring this is deemed fair by prime contractors, if they increase their bids due to being forced to provide this extra work, and if there are any other issues with respect to the solicitation process. In fact, most contractors do not find this fair and just under half of them increase their bids by .5-10% with the average increase being roughly 4 %.

After a visit to my building and talking to the workers and key player for the project, several issues were brought up. Those issues were narrowed down to be used for my three technical analyses. These consisted with adjusting the cladding system for the building from a metal panel siding to either the brick or glass panels which clad the remainder of the building, structurally redesign of the skylights to remove the steel joist that runs through the center of it, and adding windmills to the roof of my building to generate electricity.

I proposed to redesign the cladding of the building to increase the construction ease and cost of the building. This will take into account the cost of fixing the system while the building is in its first fifty years of building use. A comparison with brick and glass panel walls was conducted. Research into the initial cost of construction and schedule, research into maintenance costs, a comparative analysis between the systems using cost, and schedule, and a summary are the measurable steps of this analysis. The result of this analysis was to switch the building to brick construction due to the drastic decrease in cost and the minimal increase in construction time. The structure was the same for both.

For my first breath assignment I will do a structural analysis of a skylight in an attempt to remove the steel joist from the center of it. This will make the skylight look nicer and allow more light into the area. I will perform a load analysis of the skylight and then do a structural analysis to redesign the roof system for the joist to be removed. In my summary I will show the new design of the skylight. This analysis resulted in the recordation to remove the joist and support to the system with two smaller joist in it's place. The cost increase was less than $80 and a schedule extension of merely 3 hours.

For the windmill analysis, I researched the wind patterns of Erie, PA to discover the power generating capabilities of the building. I also performed a cost analysis of the electricity savings versus the initial cost. I also performed a structural analysis of the roof to make sure that the windmill will be able to be placed on the roof. Finally, the schedule impact was looked at. It was concluded that 12 windmills should be placed on the building and these would pay themselves off within the first year. The electrical system was also redesigned to accommodate the new power supply.

Introduction

This thesis is the culmination of a year's worth of work. It began in the fall by learning the building's systems and construction techniques. It followed, by finding problems and construction issues with the building. Next, three building problems and one industry issue was selected for in-depth research and problem solving. For my project, these were a cladding system replacement, a skylight redesign, the addition of windmills to the roof of the building, and WBE/MBE Solicitation impacts. With the topics selected the remainder of the semester involved performing various analyses such as structural and cost. Finally, recommendations for each topic were made.

Throughout this book you will become acquainted with various parts of my research starting with basic building systems and moving through each research topic. You will learn what criterion was important to the owners and building users. Looking through their eyes you will be able to see why each recommendation was made.

Building Background

General:

- **Building Name:** Research and Economic Development Center (REDC) Building
- **Location:** Penn State Erie Campus
  Behrend Campus
  Erie PA
- **Building Occupants:** School of Business
  School of Engineering and Engineering Technology
  Pennsylvania State University
- **Occupancy Type:** Classrooms, Labs, and Offices
- **Size (Total Sq. Ft.):** 161,500 Sq.Ft.
- **Stories:** 2.5 Floors
- **Primary Project Team:**
  - Owner: Department of General Services
  - Using Agents: The Pennsylvania State University
  - Architect: Weber Murphy Fox, Inc.
  - Consulting Architect: NBBJ
  - Structural Engineer: Steele Structural Engineers
  - MEP Engineer: H.F. LENZ Company
  - Civil Engineer: Urban Engineers
  - Technology Consultant Group: The Sextant Group
  - Construction Manager: Turner Construction Co.
  - General Contractor: EE Austin & Son, Inc.
  - Mechanical Prime: Renick Brothers
  - Plumbing Prime: Raibe Environmental
  - Electrical Prime: Keystone/Deon – Pyramid
  - Fire Protection Prime: Simplex Grinnell

- **Dates of Construction:**
  - Start: April 28, 2004
  - Finish: February 2006

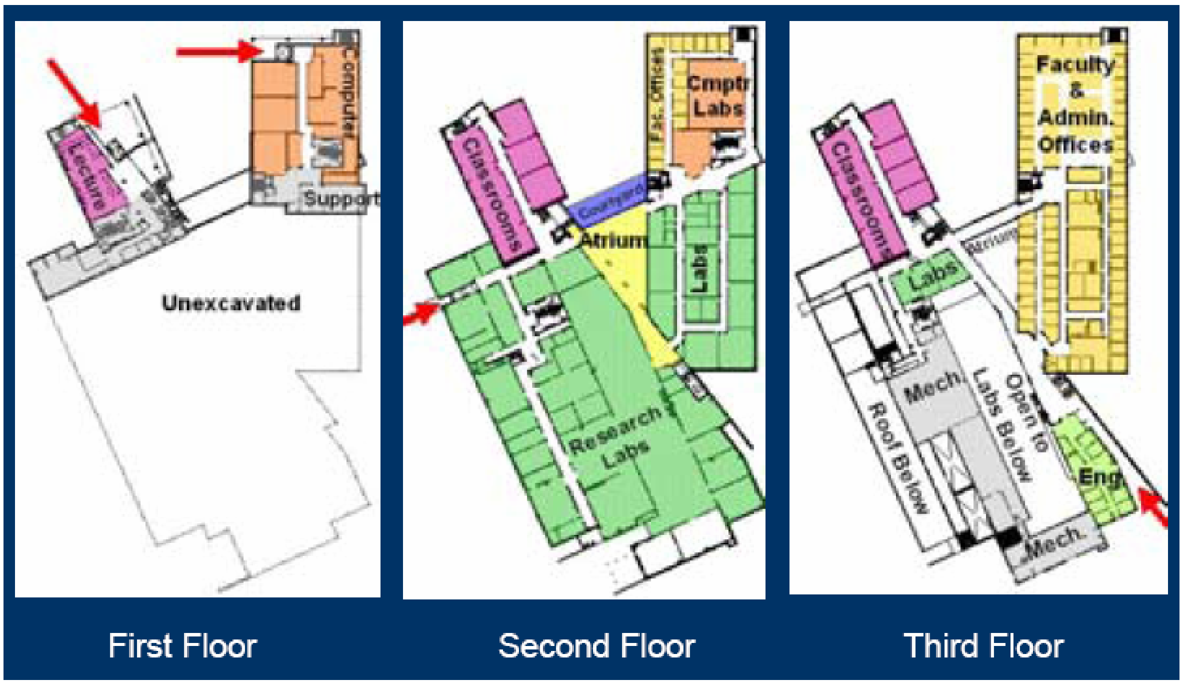
- **Cost Information:**

The overall cost of the building is $30 million or $165.76/SF. Minus soft costs the actual building cost is $21.5 million or $133.13/SF. The General costs of the building are $13,379,000 or $82.84/SF. HVAC costs were bid at $3,430,000 or $21.24/SF. The Plumbing System is $925,000 or $5.73/SF. The electrical system and telecom together cost $3,394,816 or $21.02/SF. Finally, the Fire Protection system came to $328,800 or $2.04/SF.

- **Project Delivery Method:** Design-Bid-Build

Architecture:

The building consists of a half basement and two floors with the top floor boasting an atrium bridge. The building is to link two sections of campus to promote a more unified college. It features two wings; the first faces Jordan Road and the Knowledge Park; the second faces towards the east side of campus. Wooded areas surrounding the site will be maintained along with new and existing pathways. The facility will be mainly brick as is the norm for all Penn State Buildings. The building will be home to the College of Engineering and Engineering Technology as well as the School of Business. About half of the building will be engineering labs. One fourth is proposed to be classrooms and computer classrooms. Offices will make up the remaining fourth. Mechanical rooms will be located on the Basement and Second floors.



Building Envelope:

The building has a curtain wall system that supports structural glass in the stairways, brick with glass windows in the main part of the building and metal wall panels in the dock areas. The roof is Thermoplastic Sheet Roofing over most of the roof with the low roof being Architectural Metal Roofing. Under the roofing is a six inch layer of roofing insulation over steel deck.

Construction:

This project began in preliminary design stage. An estimate was drawn up using the campus estimators and the building was found to be overpriced. By removing an auditorium the building design and estimate were completed. After the design had been completed a CM Agency was hired through a bidding process. The CM Agency then held the bidding for the General Contractor and Primes. Construction began with the ground breaking on April 28, 2004. The scheduled finish for construction is set for February of 2006. The building cost came to $21.5 million. With soft costs added in the total for the building was $30 million.

Electrical:
Electricity will come in from the medium voltage campus distribution system. Primary service will come into the building through an underground duct bank near the loading docks. This will be for future campus expansion. Two secondary feeds will also be provided. The secondary feed, after coming in the building will go through a 480Y/277 volt, 1500KVA transformer and serves the majority of the building. The other secondary feed will enter into a 240 volt, 500 KVA transformer and will be sent out to the lab and manufacturing areas. Electricity will flow from the transformer to the main breakers to the main distribution center. There will be approximately 35 - 240/120 V, 3 phase, 3-4 W panel boards; 20 – 480Y/277 V, 3 phase, 4 W panel boards; 4 – Motor Control Centers at 480 V, 3 phase, 3 W; and one natural gas generator run from the power supplied. The emergency power will be an indoor diesel generator rated for 150 KW at 480Y/277V. This will be located in a room next to the loading dock and will be able to provide 24 hours of backup.

Lighting:
The lighting in the building is fairly simplistic and very systematic. For all of the labs, shops, and large bay areas there will be Metal Halide suspended bell lights. In the offices classrooms and smaller labs there will be fluorescent recessed lights with dimming capabilities.

Mechanical:

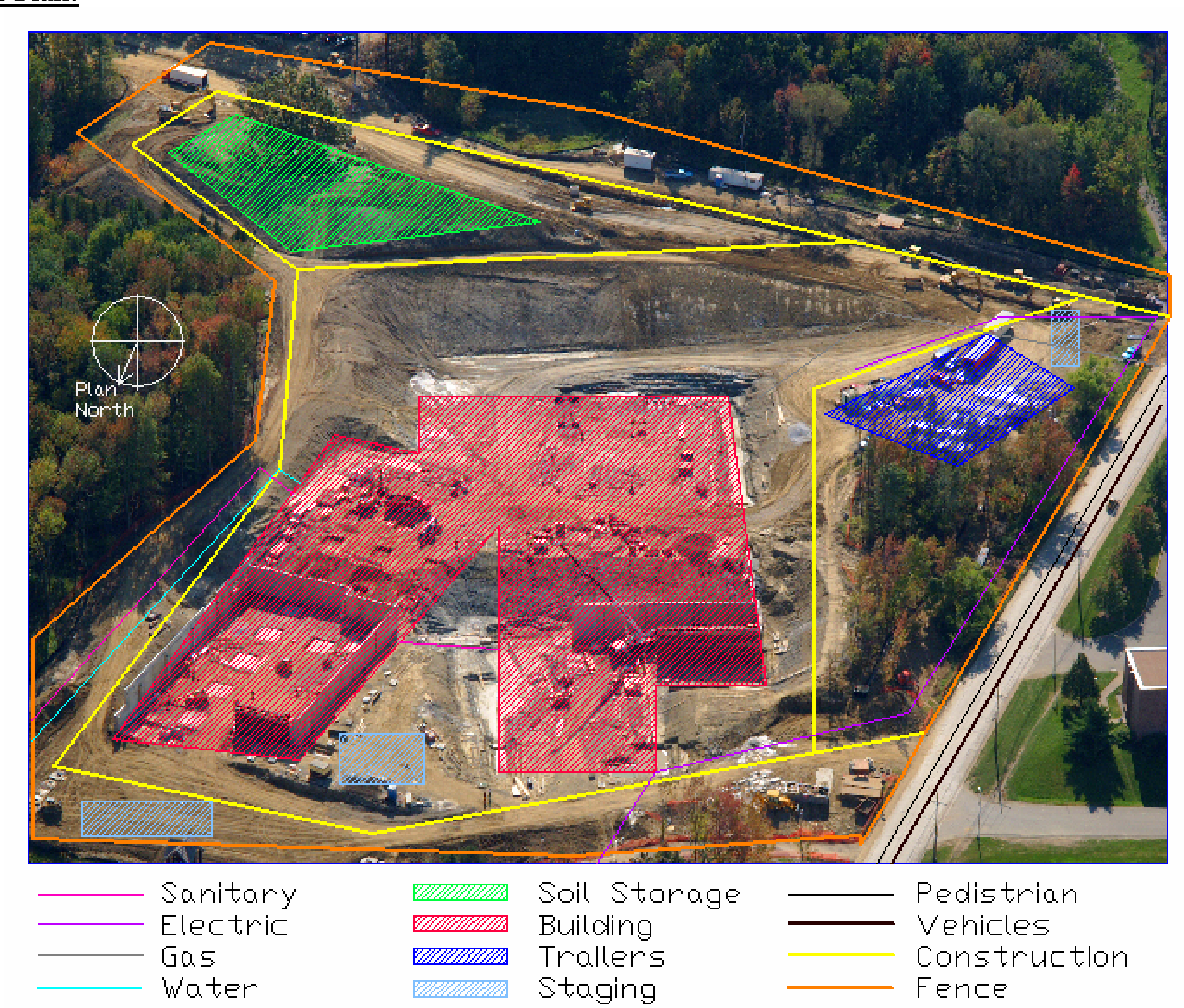
The central cooling plant will consist of two 250 ton screw chillers, cooling towers and primary/secondary pumps. The central heating plant will be two 3852 MBH cast iron hot water boilers with natural gas burners and primary/secondary zoned pumping.

The Air system will include five roof top, three basement, and four second floor air handling units. Of these ten are variable air volume and two are constant. One system has a redundant cooling for winter requirements. The building is zoned based on occupancy. Air is distributed to rooms through ceiling diffusers.

Though out the building there are 26 exhaust fans to remove air (8 rooftop, 7 basement, 2 first floor, and 9 second floor). In some areas there are cabinet unit heaters that use water to provide extra heating. The computer server rooms will have DX air conditioning units for 24 hr/ 365 day cooling capabilities. The entire building will run off of a Direct Digital Control system.

Structural:
The building sits on three different types of foundations – strip, pad, and retailing wall. Form these the steel superstructure arises. The typical column size is W14x61. Where there are CMU columns it is 8” CMU with 8” bond beam and 2 #4 bars. There is no typical bay size but they run about 30’x30’. All floor slabs are 4” concrete slabs with 6x6 W1.4xW1.4 wire mesh. The average beam size is around a W18x35 with 22KCS3 Joists. Exterior walls are all curtain walls with brick, glass, or metal. The roof is framed with 22K7 beams with joists at 3’6” on center and horizontal bridging.

Site Plan:



The picture above shows the REDC building during the excavation stage. The site is very steep with a rise of 50’ over the length of the building. It has a shale sub-grade with silt under layer. Retaining walls will be very important. The building footprint shows the location of the building and the lines around it show the traffic, site boundaries, staging and storing areas, trailers, and utilities. Near the building is the main road into campus and the campus chapel. This is the closest building to the construction and has an elevation of 1043 ft. Contractors are given parking in the University’s commuter parking lot which is located ¼ mile from the site.

Local Conditions:

The preferred method of construction is this part of Erie is steel frame construction. The contractors in this area also prefer the traditional method of project delivery, Design-Bid-Build. Construction parking is provided by the university in a nearby parking lot.

There is no practice of recycling of specific materials such as glass, paper, plastic, drywall, etc., on this project. Different accommodations, however, are made for "regular" construction waste and "heavy" construction waste. The regular materials are those already mentioned, but the heavier items consist mainly of concrete, aggregate, brick, etc. We collect the regular materials in dumpsters which usually amount too $300 to $400 per pull. The heavy construction materials are loaded into pickup, flat bed, and dump trucks and taken to local companies that turn the materials into crushed stone for use in future projects. The cost for this is usually $5 to $10 per load, and sometimes free! All in all, the project experiences about a 3 to 1 savings when recycling this way.

Client Info:

The Owner for this building is the Department of General Services. They hold the contracts for the CM Agency as well as all of the Primes. They employ a construction inspection group too. The REDC building is being built so that the user group, The Pennsylvania State University, will have a new educational facility for The School of Business and The School of Engineering and Engineering Technology. The placement of the new building was to bridge the two different sections of campus and make the entire campus more accessible by way of new walkways.

The building was estimated and expected to stay with in a budget of $30 million dollars so change orders are attempted to be kept at a minimum. Safety is to be overseen by the General Contractor and follow the department's standards. The Schedule should be adhered to as much as possible with the CM Agency, Turner, overlooking it. The only interesting thing on the schedule for the both the owner and the using group is the MUST FINISH BY DATE. This is expected to be January 31, 2006.

The key to completing this project to the owner's satisfaction is to get it done on time and on budget. The Department of General Services also needs the end users, the two colleges, to be please with the work for them to be satisfied with the construction.

Problems Identified with Building Design:

• All cable trays in the server rooms are regular cable trays but the ones through the remainder of the building are ladder trays. According to the crew running wires it is much more difficult to run wires in this type of tray.

• The mechanical room distributions are weird. Finishes in the A section can't be completed due to the fact that the mechanical rooms haven't been finished and tested. This means that this area of the building can't be completed.

• There are issues with access to Mechanical rooms. If there is a problem with an AHU there is no way to get most of them off or out of the building. There is one on the roof that is covered by an overhang that is now inaccessible. And there is a knee wall blocking the ones on the 2nd floor from being brought out how they were brought in.

• There is no site access (driving) to any of the north side of the building.

• There have been issues with the metal paneling on other buildings in this area. The panels have been having issues with buckling and not sealing at window areas. Also where the panels are joined this sealing strip has been known to deteriorate within the first five years of building operation.

• An auditorium is being added to the building now that it is +80% completed. This is going to to out to bid soon. Will it be cheaper this way or as a negotiated C.O.

• The sky lights for the building all have joists running through them.

• I would like to see if wind power could be utilized to cut down on the building power load.

• The School is worried about the loading dock location. It is located next to two main building transformers and is on a steep slope with a hard curve. This could be problematic due to the icy winters that Erie normally receives.

Industry Research Topic

WBE/MBE Solicitation

During this year's Thesis work, I examined the WBE/MBE contractor solicitation process. This is the process whereby all contractors who wish to bid on any DGS project need to solicit bids for subcontracted work from minority and women owned businesses. I intended to find out whether requiring this is deemed fair by prime contractors, if they increase their bids due to being forced to provide this extra work, and if there are any other issues with respect to the solicitation process.

I would like to this research to show The Office of Physical Plant and the Department of General Services the price of mandating WBE/MBE soliciting and forms during the prebid process.

I intended to delve into the solicitation process. A survey was sent to a selected list of general contractors, from the Office of Physical Plant's contractor database, who have bid on DGS projects in the recent past. A rough list of planned questions for this survey can be found in Appendix X. The key parts to my research will be the process review, the survey analysis, and a summary.

Background:

For State funded projects such as my thesis building and many other Penn State University building projects, the Department of General services requires contractors bidding on a project to solicit to Women and Minority Owned Businesses (MBE/WBE) for quotations for work. The goal of this program is to secure documentation that ensures that the Bidder has not discriminated against MBE and WBE subcontractors and suppliers in the Bidder's solicitation of and commitments to subcontractors and suppliers. This means that contractors must go outside their normal suppliers and subcontractors during the bidding phase to solicit work. Then documentation of all solicitations to these businesses must be submitted with bids. If this documentation is not up to DGS standards then the bid will be dismissed. A copy of the form for the solicitation process can be found on the General Service's website at http://www.dgs.state.pa.us/bcabd/site/default.asp.

The reason that this issue is so important is because this requires extra work during the prebid process. This also can result in contractors working with subcontractors and suppliers that they may have no relations with prior to this project, which could increase the risk that said contractor carries. Both of these issues may lead the contractor to mark up their bid; first due to extra work and second due to increased risk.

The last issue that could arise due to this process is one which the Office of Physical Plant encountered over the summer. All of the bidding contractors for two separate projects did not fill out the solicitation form properly. This caused all bids for both jobs to be thrown out and the project to be rebid. Now the owner is set behind schedule, the bid packages must be revised, and contractors must reinvest their time for the bidding process. This leads, not only to project delays, but also higher costs both to bidders and the owner.

Research Intent:

The intent of this research is to devise if the requirement for WBE/MBE solicitation results in higher bids. I wished to find out whether requiring this is deemed fair by prime contractors, if they increase their bids due to being forced to provide this extra work, and if there are any other issues with respect to the solicitation process.

I would like to be able to use this research to show The Office of Physical Plant and the Department of General Services the price of mandating WBE/MBE soliciting and forms during the prebid process. The key points of my research are as follows:

- Research into the existing solicitation process.
- An initial survey to test my survey on several contractors that are currently working on state funded projects.
- This survey after being refined was sent to a selected list of contractors, from the Office of Physical Plant's contractor database, who have bid on DGS projects in the recent past. (found in Appendix 1)
- After the surveys had been returned, I collated and organized the responses by type and answer.
- A summarization was made from the surveys which is presented in an upcoming section, and will be given to the Director of Design and Construction at the Office of Physical Plant.

I expected that contractors that fall under the WBE/MBE classification will be happy with the process. I also believed that the other contractors would think that the process is fair but would still increase their bids by a marginal percentage due to the extra work.

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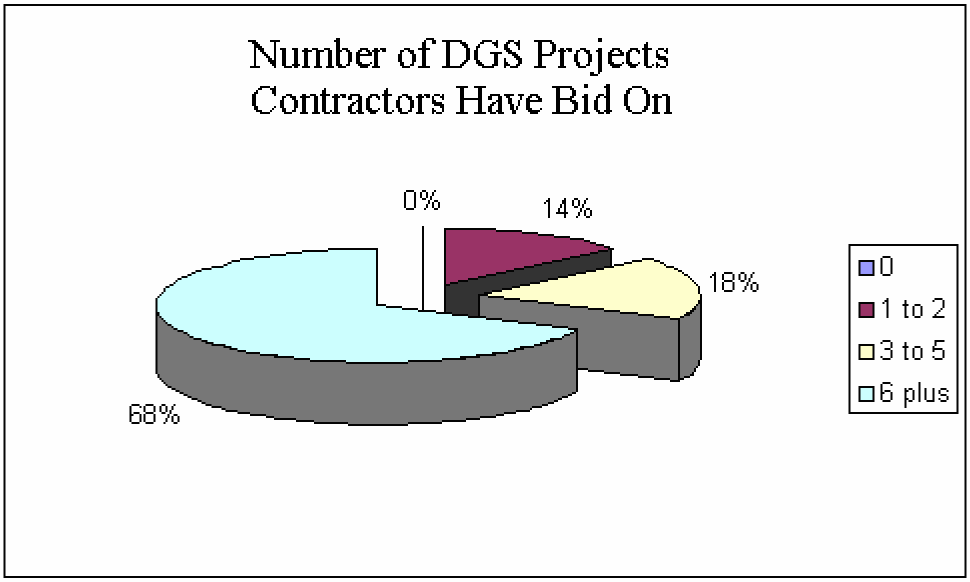
Survey Results:
Below are the results for each contractor that responded to my survey.

Survey #	WBE/MBE Contractor?	Bid on DGS Project?	How Many Projects?	Paperwork increase pre-bid time?	Increase bid due to this?	Increase %?	Fair Requisite?	Hired subs?	Good Contract?	Requisite Working?
1	N	Y	3 or 5	Y	Y	15000 to 45,000	both	Y	N	N
2	N	Y	6+	Y	N	-	N	Y	N	N
3	N	Y	6+	Y	Y	3-10%	both	Y	N	Y
4	N	Y	6+	Y	N	-	Y	N	-	N
5	N	Y	6+	Y	N	-	N	Y	Y	Y
6	N	Y	1 or 2	Y	N		N	N	-	N
7	N	Y	6+	Y	N	-	Y	Y	Y	Y
8	N	Y	0	Y	N	-	N	Y	Y	N
9	N	Y	3 or 5	Y	N		N	Y	N	N
10	N	Y	6+	Y	Y	1% plus	N	Y	Y	N
11	N	Y	1or2	Y	N		N	Y	Y	N
12	N	Y	6 +	Y	N		N	Y	Y	N
13	N	Y	6 +	Y	Y	.5 - 1%	N	Y	Y	N
14	N	Y	3 or 5	Y	Y	5 - 7%	N	Y	Y	N
15	N	Y	6 +	Y	Y	5%	N	Y	N	N
16	N	Y	6 +	Y	Y	proportional to work size	Y	Y	N	N
17	N	Y	6 +	Y	Y	1-3%	Y	Y	Y	N
18	N	Y	6 +	Y	N		N	Y	Y	Y
19	N	Y	6 +	Y	Y	varies by project	Y	Y	N	N
20	N	Y	3 or 5	Y	Y	depends on size	N	Y	N	N
21	N	Y	6 +	Y	N		N	Y		N
22	N	Y	6 +	Y	Y		N	Y	Y	N

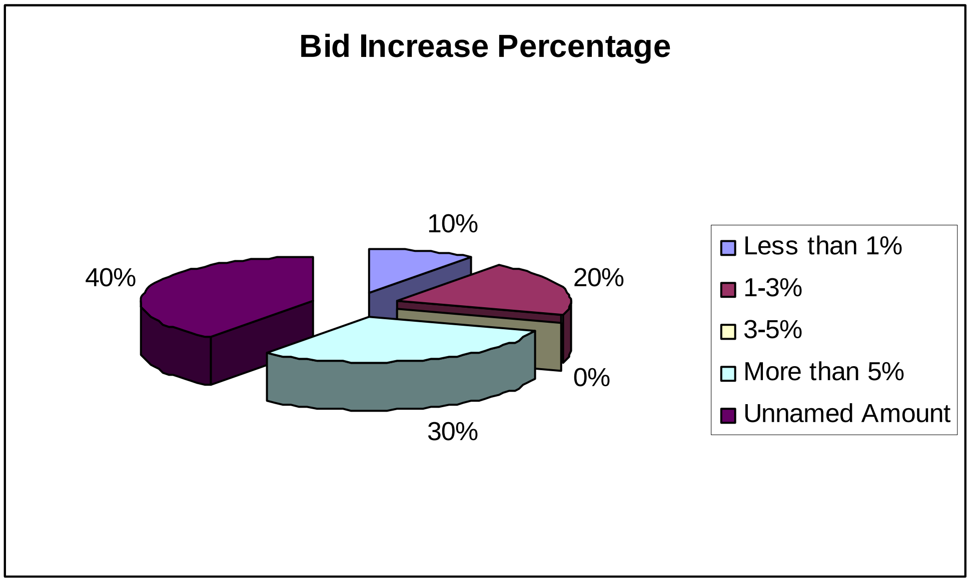
There are a number of interesting things that resulted from this survey. It is very important to note though that there were no WBE/MBE Contractors that responded to this survey although I did get 23 companies to respond.

- All respondents have bid on at least one project



As shown, 68% of the contractors that responded have bid on at least 6 projects.

- All of the Contractors admit that WBE/MBE Contractor Solicitation increases the time that is required in the pre-bid processes.
- Of those 46% increase their bids



- 71% of the contractors this that WBE/MBE Contractor Solicitation is an unfair bidding requirement.
- 91% said that they have used subs that they normally would not have due to the solicitation results.
    - If these only 58% of those contracts were considered successful by the Contractors.
- 83% of the respondents replied that WBE/MBE Contractor Solicitation is not working as DGS intended for the following reasons:
    - The WBE/MBE Subcontractors are not properly qualified.
    - The WBE/MBE Subcontractors do not respond to solicitation attempts enough.
    - The resulting bids that the WBE/MBE Subcontractors offer are typically not viable bids.
    - Many Contractors feel that this program does not help truly disadvantaged businesses and is therefore corrupt.
    - Other contractors feel that there should be no difference between “disadvantaged businesses” and other companies.

Conclusion:

The responses to my survey were almost all that I hoped for. I was looking for at least 20 respondents with at least 3 of these being WBE/MBE contractors. Although I got no responses from the women and minority businesses (which is interesting because that is the same problem that most of the other contractors had difficulties with), I still got very conclusive responses from the contractors that do not fall into this category.

I had originally thought that most of the contractors would say that the process was fair, although in my opinion it is not. It came as somewhat of a shock to learn that 71% of them said it was not. Not only that, 81% said that the process itself is not working. Most complained of the unqualified abilities of the WBE/MBE subcontractors as well as them not responding to bid requests. One respondent wrote, “It is hart to use the subcontractors if only 5% of them respond and only 5% of those that respond have a viable bid quote.”

The most important thing that I learned, and the most relevant to my “client audience” (Office Of Physical Plant), it that 45% of contractors that are required to bid on projects requiring WBE/MBE Solicitation increase their bid. On average the bids will be roughly 4% higher than regular. This means that in general you will be paying 1.8% more on DGS project that require WBE/MBE solicitation.

Technical Analysis

Cladding System

There is a problem with metal panel siding in Erie due to the weather swings and construction practices so I proposed to redesign the cladding of the building to increase the construction ease and cost of the building. This will take into account the cost of fixing the system while the building is in its first fifty years of building use. A comparison with brick and glass panel walls was conducted. Research into the initial cost of construction and schedule, research into maintenance costs, a comparative analysis between the systems using cost, and schedule, and a summary are the measurable steps of this analysis.

Background:

At the Pennsylvania State University, Erie, The Behrend Campus, there are now three buildings with metal panel systems. The two previous buildings have both needed work on the metal panel within five years due to leaking at windows, doors, and panel connections. This leaking has been attributed to the climate changes throughout the year causing major expansion and contraction of the panels. Although this expansion was expected, the results on the sealant were not. The weather is harsh on the sealant which gets harder than it would normally. This and the movement with the panels cause cracking in the caulk. These cracks have been causing water damage in the buildings. It is expected that this issue will arise with the metal panel system on the new Research and Economic Development Center as well. There are approximately 3900 square feet of metal siding on the building which will see this damage.

Research Intent:
The intent for this analysis is changing the cladding system to either the glass panels or the brick that the remainder of the building is built with. A comparison between these replacement systems and the existing systems consists of schedule comparisons, cost comparisons and cost of maintenance comparisons. Also it was important to check that the structural system will remain the same or of a similar cost.

I would like to be able to use this research to show the architect and owners of the building which system would be the best to use. The key points of my research are as follows:

- Research into the cost of maintaining the metal panel systems and the length of time between the need for maintenance.
- Cost of systems analysis using RS Means cost data
- Duration of construction of system analysis using RS Means construction duration estimates
- Research into maintaining the proposed systems and the length of time between needs for maintenance.
- A weight of system comparison.
- Structural redesign of curtain wall down to the first floor columns. The structural system at this point and lower should not need to be redesigned due to factors of safety used and because the wall system load should not differ that greatly.
- A chart of the pros and cons of each system was used to identify which system is the best to use. This chart is listed in the conclusion of this section.

I expect that the brick system will end up being the system selected. The metal panel will be the cheapest and shorter to construct but have a high maintenance cost and problems with the construction. The glass system is predicted to be the highest cost second longest construction. It will also have high maintenance cost and issues during construction. Because brick is very traditional, it will have lower cost than glass have less maintenance issues and ease of construction. It will also probably have the longest construction time.

Material Cost:

Name	Cost/ SF
Glass and aluminum supports	$45
Brick	$28.75
Metal Siding and aluminum supports	$9.79

If you were to just look at the total system costs then you could come up with

Name	Cost
Glass	$175,500
Brick	$112,125
Metal Siding	$35,244

But the metal siding will require approximately $85,000 worth of repair work due to caulking issues. This repair work will come every seven years. With the building life being estimated at 49 years this could add significant cost to the metal siding. A present value for this will need to be calculated. I will be calculating the highest interest rate that will be required to choose the higher priced material. The table will show the present value of the maintenance at various interest rates the total column. This number must be higher than the difference in systems or else the original metal siding system will be cheaper.

The equation is $P=i(1+i)^{-n}$ or using interest tables it is P=A(P/F, i, n) for each year payment is made.

i= the interest percentage in decimal
n = the number of years

	Year 7	Year 14	Year 21	Year 28	Year 35	Year 42	Year 49	Total
1%	$79,280	$73,950	$68,969	$64,328	$60,002	$55,964	$52,199	$454,692
2%	$74,001	$64,558	$56,083	$48,824	$42,500	$37,001	$32,215	$355,181
4%	$64,592	$49,088	$37,298	$28,348	$21,539	$16,371	$12,436	$229,670
6.75%	$52,930	$32,963	$20,528	$12,784	$7,965	$5,304	$3,086	$135,558
11.25%	$40,299	$19,108	$9,061	$4,293	$2,040	$969	$459	$76,228

Because the difference between the metal siding and the brick is $76,881 it is cheaper to use the brick so long as the interest rate is lower than 11.75%. It is cheaper to use the glass only if the interest is less than 6.75 % due to the price difference between the two being $140,256. (Although this chart only shows some numbers I solved for many to find the rate that yielded a material choice difference.)

This also assumes that the other systems will not need repaired in this time. Brick is used quite often at this campus and typically need very little work on it. The glass system is untested so although there may indeed be maintenance issues there can be no cost comparison using the maintenance data. Thus it will be assumed that with proper construction practices there will be no need for maintenance on this system.

Schedule Changes:

The production for each system component is as follows:

Name	Daily Output
Metal Siding	775 SF/Day
Glass Panels	98 SF/Day
Metal Support	1020 SF/Day
Brick Face Cavity Wall	230 SF/Day

I will be assuming that the Metal Support will begin one day before the glass panels or the metal siding that it would support and then the work would continue concurrently. This means that the schedule for each of these items will have one day added to it for an entire system length.

The system construction length assuming the work area is 3,900 SF is as follows:

Name	Construction Length
Metal Siding	6 days
Glass Panels	41 days
Brick Face Cavity Wall	17 days

The changing from Metal Siding to Glass Panels will result in a 35 Day, or 7 weeks, schedule addition. Like wise changing from the metal siding to the Brick wall will only change the schedule by 11 days, or just over 2 weeks. This will not affect the building enclosure so interior work will be able to proceed. Also since on the CPM schedule the exterior work does finish well before the building does a delay in the schedule will not be a huge problem even though work will end up continuing through early winter.

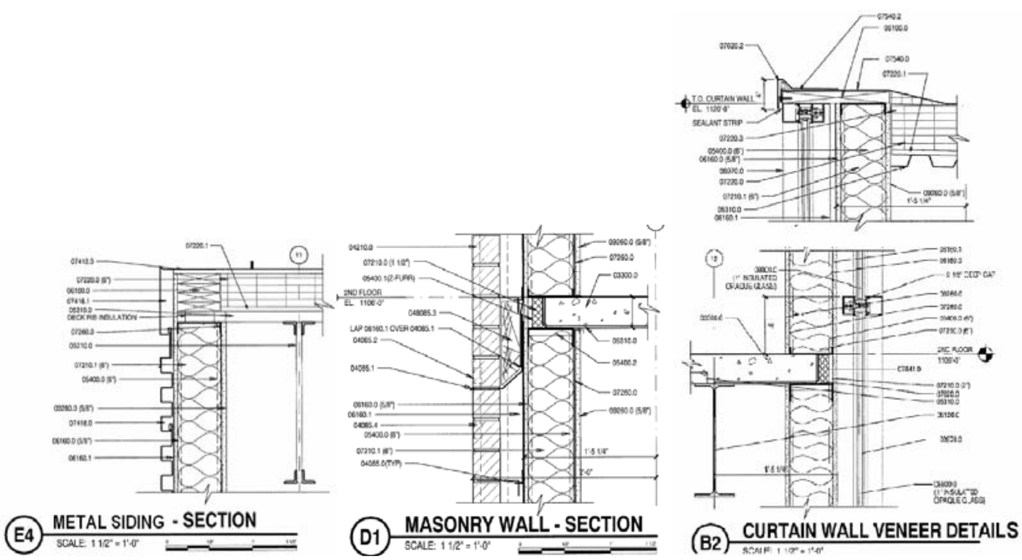
Constructuability:

In Erie, brick is a very common construction material. It also makes up the majority of the building. This will result in a better construction and higher learning curve. The glass is a less common material. In this area the typical use for this material is for strictly window use not cladding. However it is also the second most prevalent material on the building. Because of these factors glass will have a slower learning curve than brick and the construction may be less easy. The metal siding has been used before on buildings in this area but it has had construction issues in the past. It also is the least used material on the building yielding the slowest learning curve.

Structural System:

It was important to find out if the structural system that supports the wall panels would change due to switching the cladding. To do this I found the weight of each wall section. The metal panel weights the least at 12 psf. The glass came next at 30 psf. Coming in at the heaviest was the brick at 55 psf. Next example section of the wall systems that are currently in the building are shown below and will be compared.

By looking at the wall sections it was found that the support system for each wall is the same. This means that the same curtain wall system was used, 6"metal stud wall with bat insulation. Because the same wall supports each system it can be concluded that there will not be a need to change the structural system. This is important to note because there will now be no additional charges due to beefing up the structure.



Conclusion:
Each system must be compared to determine which should be used. Using a chart and ranking the research points, the best system will be chosen.

Research	Metal Panel	Glass	Brick
Lifetime Cost (@ 4%)	$229,670	$175,500	$112,125
Maintenance	$85,000 every 7 years	$0	$0
System	$35,244	$175,500	$112,125
Schedule	6 days	41 day	17 days
Structure	All same	All same	All same
Constructability	Worst	Middle	Best

The ranking of research points are, cost being the most important issue to the University, (especially since the maintenance is paid for by the university while construction is paid by DGS); schedule being second ranked; structure next; finally will be constructability.

Following the criteria importance, brick would be the best system. This is because it is the cheapest and easiest to construct. It may be slower to build than metal panel cladding but due to the construction schedule, the schedule ends up not being important.

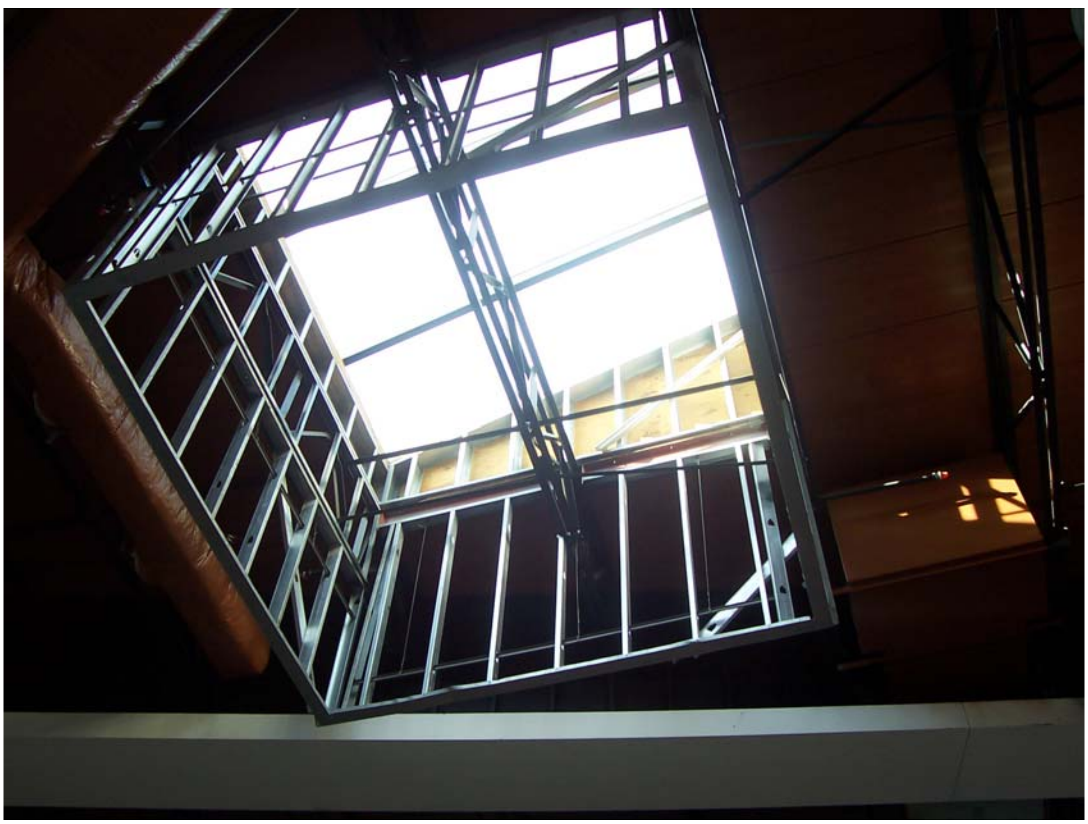
Breath Topic 1

Skylight Redesign

For my first breath assignment I will do a structural analysis of a skylight in an attempt to remove the steel joist from the center of it. This will make the skylight look nicer and allow more light into the area. I will perform a load analysis of the skylight and then do a structural analysis to redesign the roof system for the joist to be removed. In my summary I will show the new design of the skylight.

Background:

In the entrance of the building, there is a skylight. The roof of the building has an exposed joist system. The joist system goes right through the center of the skylight. According to the architect, the truss was designed to be exposed as an architectural feature. The Project Manager and the users of the building however, all agree that it is silly. They would like it removed. The joist and skylight is shown below.



Research Intent:

The intent for this analysis is to check the possibility of removing the joist from the center of the skylight. Cost and load impacts were taken into effect. The roof truss system was then redesigned.

I would like to be able to use this research to show the owners of the building how to remove the joist and provide a price to fix it. The key points of my research are as follows:

- A load analysis of the current skylight system.
- Structural design program was used to see how the system could be redesigned to remove the joist from the center of it
- The final plan for new design of the roof will be drawn and a total cost of the redesign performed and submitted in my thesis presentation as well as my final thesis submission.
- Cost comparison of the original design versus my solution.

I expect that the joist will be able to be removed. I also expect that the cost will not be too much to detriment the owner form wanting to remove the joist from the skylight.

The Structural Analysis:

Due to the spacing, each joist is figured to carry 155PLF LL and 125 PLF DL as shown below (figure 1). This means that when the joist is cut half of the length of the joist will be multiplied by the 1.6LL+1.2DL to yield a point load on the beam that will support it. This load will be evenly distributed to each joist that supports the beam. The beam also supports the skylights weight which is divided evenly between each beam (figure 2). A plan view of the steel can be found below in figure 3.

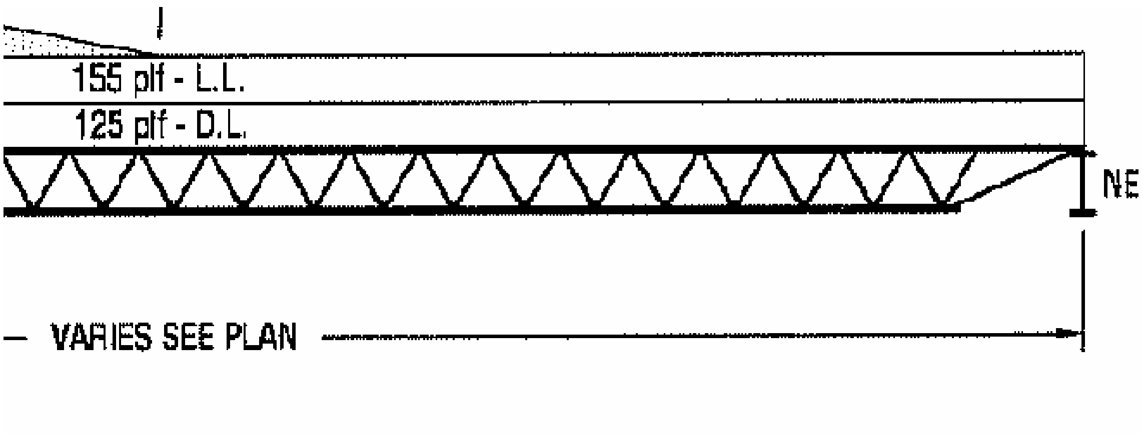


Figure 1: Roof Joist with distributed roof live and dead loads

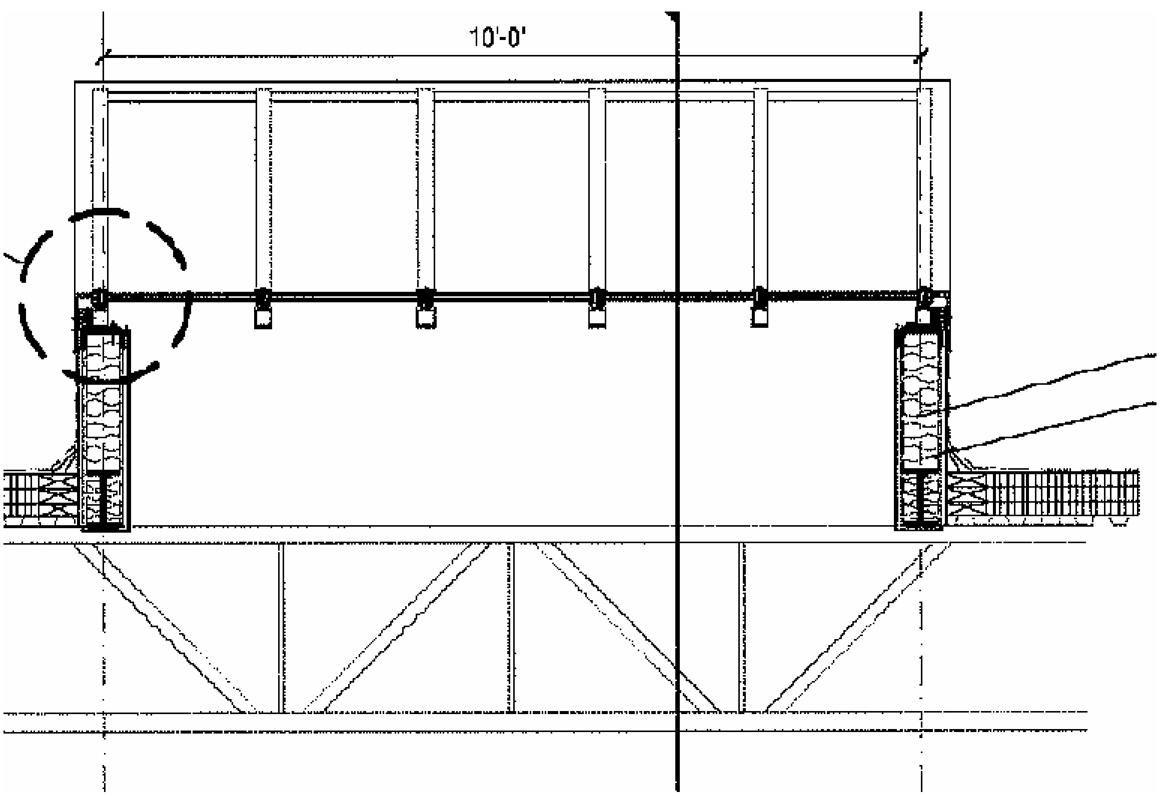


Figure 2: Section of the skylight showing how load is carried by beams

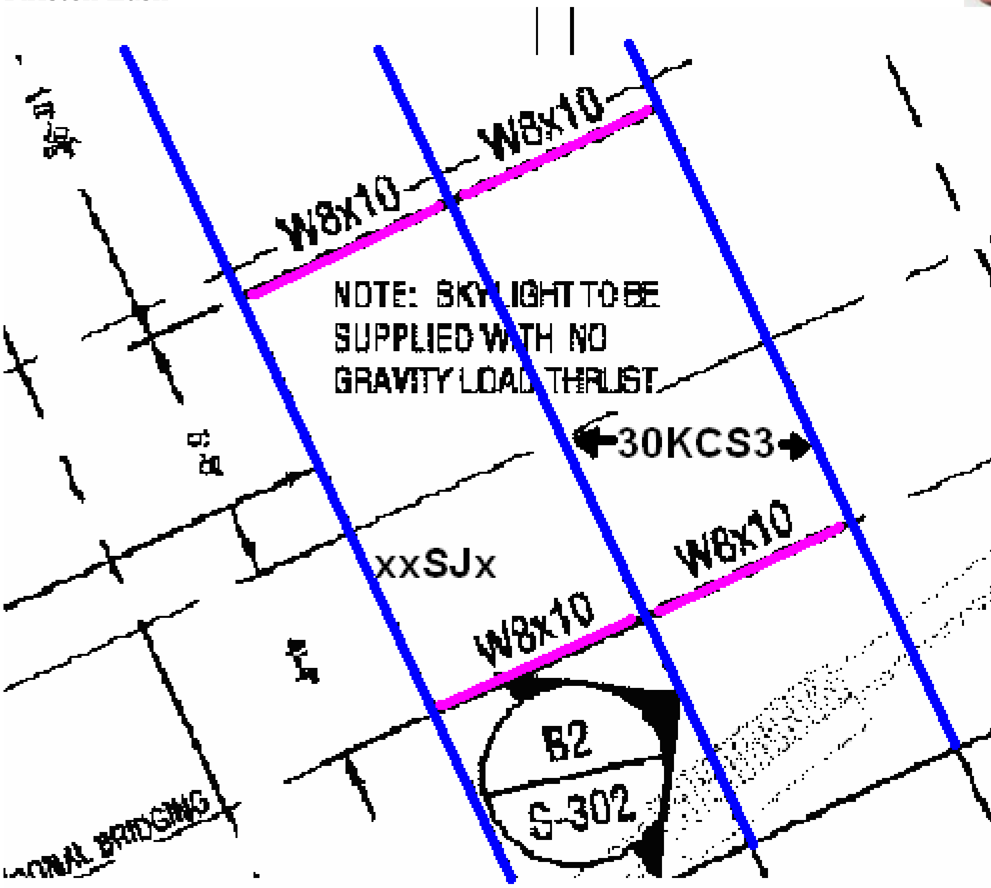


Figure 3: Plan view of steel for skylight area

The total point load that the joist yields on the beam is 398 plf times 15 and 8 feet yielding in a load of 5970 lbs on the out northwest side and 3184 on the southeastern side. This point load can be supported by the W8x10 that is specified. This will also allow the beam to carry the load of the skylight which is estimated with an even distribution to weigh 160 psf. This means that with the 3000 or 6000 lbs point load the beam will also carry an 800 plf distributed load. This loading is ok on the W10x15.

Next to check are the joists. Because of the loading that was figured out above it is determined that there will be a 7000 and 5600 lb point load on each joist. The joists are 30KCS3 which can carry 8000 lbs shear and a nominal joist which can carry approximately 6000 lbs. This means that the joists will be sufficient. A structural program was then used to check my calculations. The loads are shown in figure 4 and the resultant joist design is shown in figure 5

The last thing to look at is the how the joist will connect to the beam. It was suggested to hang the joists from the beam using welded steel plates. This surrounds the end of the joist and is to be suspended from the beam. A diagram of this can be found in figure 6

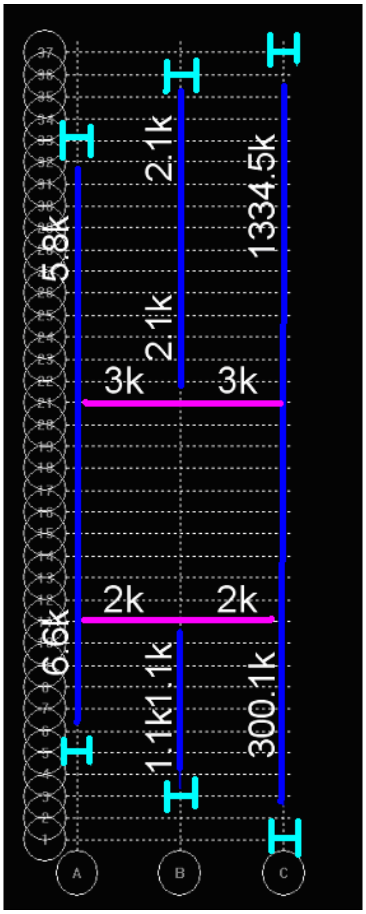


Figure 4: beam and joist loads

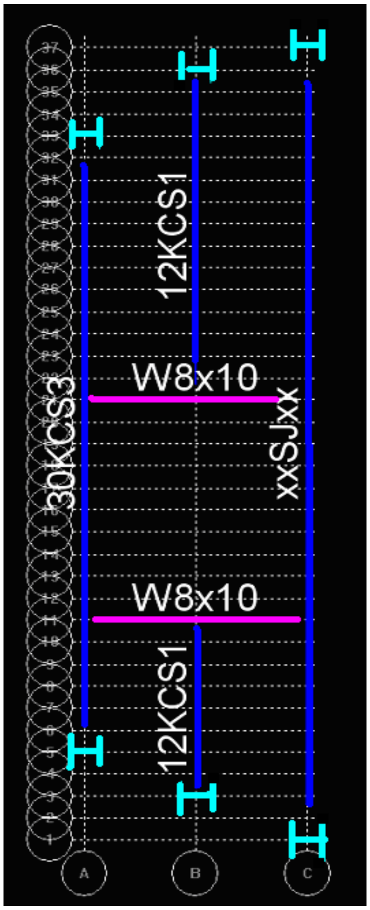


Figure 5: beam and joist design

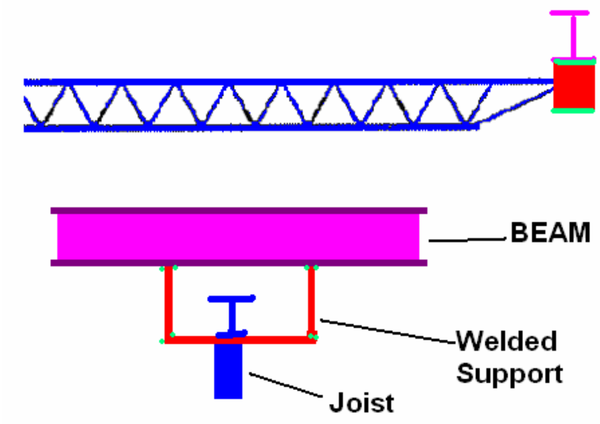


Figure 6: Welded plates that support joist from beam.

The Cost Effects:

Name	Unit	Original Amount	New Amount
30KCS3	13.13 per LF	69 LF ($905.97)	36 LF ($472.68)
12KCS1	9.57 per LF	0	23 LF ($220.11)
Welding	51.60 per LF	0	4 LF ($206.40)
1" Steel Plate	39 per SF	0	2 SF ($78.00)
Everything Else Same			
	Total	$905.97	$977.19

This yields a total difference of $71.22 more to remove the beam.

The Schedule Effects:

Name	Unit	Original Amount	New Amount
Welding	12 per Day	0	4 LF (+2hr 40 min)
Connect Joist	10 per hour	6	8 (+12 min)

Because everything else takes the same amount of time there is an increase in erecting time of 2 hours and 52 minutes due to the welding of the plates.

Results:

The Joist can be removed and replaced for an additional $72 and 3 hours of work. To do so, the center beam (30KCS3) may be replaced with two 12KCS1 while every thing else remains the same.

Conclusion:
It is my recommendation that the Joist be removed and replaced from the center of the skylight. With the changes needed to remove the adjust the system, it would only result in a additional 3 hours of work time and a total of $71.22. The additional time is not enough that it will delay the project and the cost is negligible. This must, however, be caught before construction and steel procurement/fabrication has been started. A picture of how the skylight would look without the joist is shown below.

Breath Topic 2

Windmill Analysis

For the windmill analysis, I researched the wind patterns of Erie, PA to discover the power generating capabilities of the building. I also performed a cost analysis of the electricity savings versus the initial cost. I also performed a structural analysis of the roof to make sure that the windmill will be able to be placed on the roof. Finally, the schedule impact was looked at. This Breath Assignment deals with electrical power use reduction and circuit redesign as well as a structural strength check. Research of windmills and wind availability, the structural analysis, the electrical load reduction, the cost analysis, schedule impact, and a summary are the key issues to this topic.

Background:

Because clean power has become a more prevalent theme in construction, I have decided to look into one of these systems. Since the building sits less than 8 miles from Lake Erie, there is an abundance of lake effect wind on the building. From the roof of the building, you can actually see the lake and the wind is very noticeable. The idea to generate clean power naturally fell to wind power. Wind power has many pros and cons. It can generate power whenever there is wind but is considered by many to be unsightly and noisy. These windmills will be attached into the power system and will be supplied with a backup battery system so that no power will be wasted. Because the building will be used for engineering and engineering technology purposes, the windmills could then be used as an interactive learning tool. A kiosk will be placed into the main lobby that will allow students and visitors to see the power production and other education information.

Research and Economic Development Center
Erie, Pa
Kristen Eash

Research Intent:

The intent for this analysis is to analyze the pros and cons of placing one or more windmills on the roof of the Research and Economic Development building. Wind patterns and intensity were used to estimate power generated. A specific windmill system was selected and designed for. Cost, schedule impacts, and load impacts were taken into effect. I also looked into vibration and sound proofing the system with respect to the rest of the building.

I would like to be able to use this research to show the owners of the building that this would be a viable alternative to traditional power and that it is cost effective to do so. The key points of my research are as follows:

- Windmill system selection
- Wind analysis of building
- Generating and estimate of power production and building load reduction
- Look into vibration and noise protection
- Calculate the schedule impact
- Check that the building can structurally carry a windmill on the roof and possible ways to beef up the roof if it can't
- Design the electrical system that will connect the windmill to the main power supply.

I expect that the windmills will be possible so long as the structural system does not need to be a lot larger. I believe that with the wind that I experienced while visiting my building, there will be an adequate amount of wind to make this system a cost savings. I will also expect that since has the ability to become an educational area even if it does end up being slightly more expensive to install windmills, they could still be installed.

Research and Economic Development Center
Erie, Pa
Kristen Eash

Wind Study Done 11-2-05

SOLOMAT 510e

PRINT STORED READINGS
TIME INTERVAL 1 HOUR
SITE 1- ERIE, PA (REDC)

RDG	SITE	MEASURE	UNITS
Max	1	12.65	m/s
Min	1	0.00	m/s
Avg	1	2.55	m/s

DATE 11-2-05

The idea behind this study was to get an idea of the wind speeds for Erie, Pa. This was done by taking wind measurements from the top of the building facing towards the lake.

System Secection:

The windmill is an Air 403 industrial wind generator. It will be placed on a 27 foot Air Tower to keep the view of the building clean. For the lobby's kiosk, a Slabb M touch screen kiosk was chosen. The specification for each of these system can be found in Appendix 2 (windmill), 3 (Tower) and 4(kiosk) with a quick recap of the systems listed below.

Air 403 Industrial Wind Generator

- Weight: 14 lbs
- Start Speed: 2.7 m/s
- Output: 400 watts at 12.5 m/s
- Price: $995.00

Tower Kit

- Height: 27 foot
- Price: $140.00
- Anchors: $55.00

Kiosk

- Price: $2,600.00

Power Capacity:

Wind Turbine Power: **(**http://www.awea.org/faq/windpower.html**)**

P = 0.5 x rho x A x Cp x V^3 x Ng x Nb

where:

P = power in watts (746 watts = 1 hp) (1,000 watts = 1 kilowatt)
rho = air density (about 1.225 kg/m^3 at sea level, less higher up)
A = rotor swept area, exposed to the wind (m^2)
Cp = Coefficient of performance (.59 {Betz limit} is the maximum thoretically possible, .35 for a good design)
V = wind speed in meters/sec (20 mph = 9 m/s)
Ng = generator efficiency (50% for car alternator, 80% or possibly more for a permanent magnet generator or grid-connected induction generator)
Nb = gearbox/bearings efficiency (depends, could be as high as 95% if good)

If there is any single equation that the beginning wind enthusiast should memorize, this is it.

The average wind speed to the building is 11.1 mph (5 m/s) according to the National Weather Service.

Because the windmill produces 400 watts at 28 mph with a rotor radius of 0.57 m, these numbers can be entered into the wind turbine power equation to yield the windmill efficiency and performance (a combination of Cp, Ng, and Nb)

A=.51 m^2

$400=0.5*1.225*0.51*(12.6)^3*$ efficiency
Efficiency=0.64

This means that the power produced using the average wind speed will be:
$P=.5*1.225*0.51*0.64*(5)^3$
P=25 watts

Assuming that the windmill is kept running 24 hours a day (and rounded down to represent the time that the windmill will not be in use due to low wind speeds), a total of 200,000 kWh per year will be produced. This power will be integrated directly into the buildings power supply. Since the building uses power 24 hours a day as well due to the computer usage and lights, this power will be able to be used completely.

Shown on the next page are the 12 locations that the windmills will be placed.

Roof Plan Showing Windmill Locations:

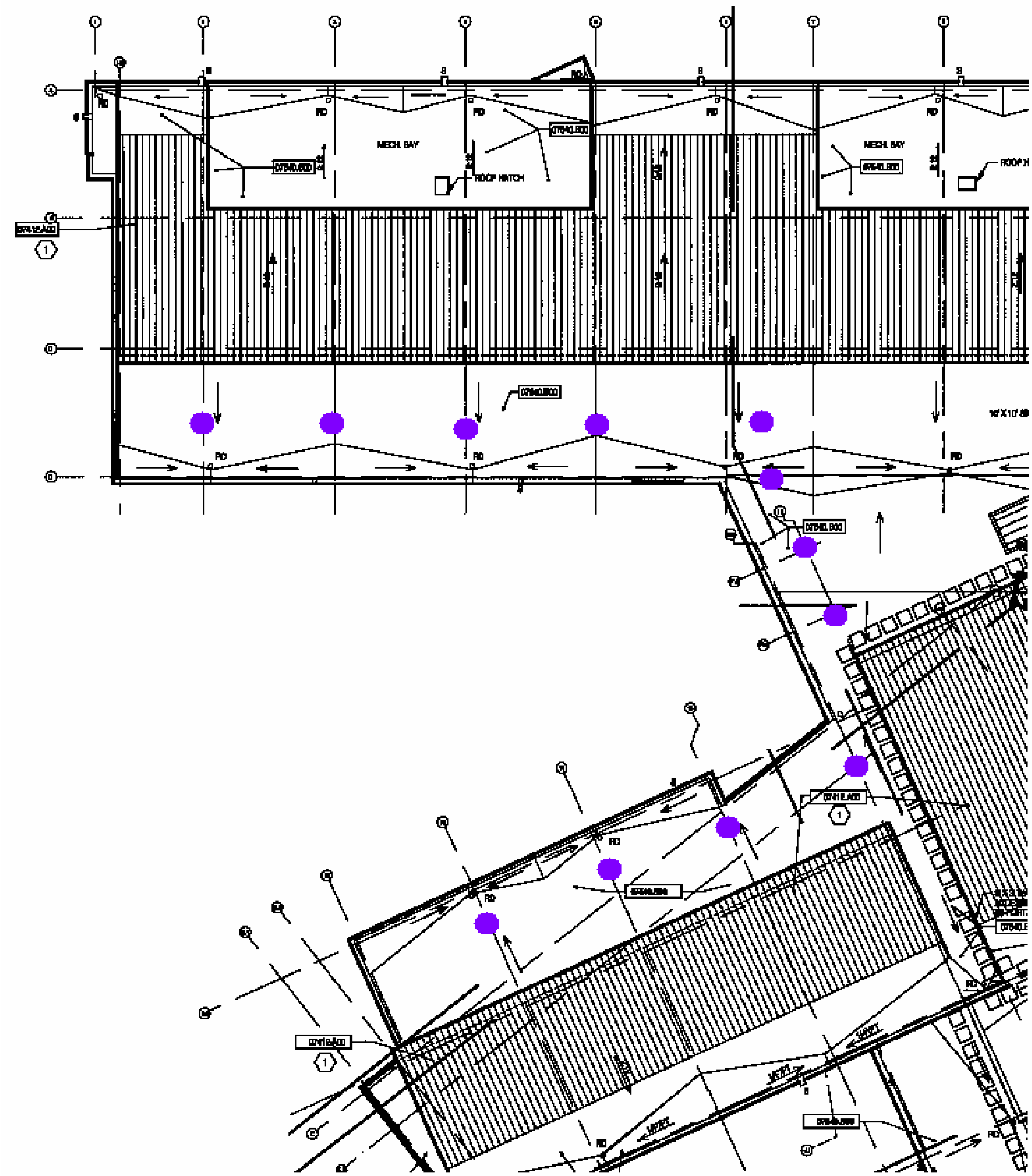


figure 1: windmill locations

Electrical Hookup:

The following information for the electrical system tie-in is sited from the Owner and Operations Manual for the Air 403 by Southwest Windpower.

Grounding/Lightning Protection

The windturbine must be properly grounded to protect the electronics if it is to last for long-term usage. This is especially true in lighting areas. The green lead wire provides grounding for the body of the turbine. This wire must be connected to the building's earth ground wire or a ground rod near the base of the tower. For extra protection another wire should connect the tower to the building's ground wire or the grounding rod. The negative wire for the system should also be connected to the building's ground wire by a wire from the negative battery terminal to the building's ground.

Fusing

Because the AIR-403 is capable of producing high amperages, the properly sized fuses and circuit breakers are very important to the protection of the turbines. These fuses should be placed between the stop switch and the positive terminal of the battery (as shown in figure 2 the stop switch wiring).

Recommended Size for Circuit Breakers or Slow-Blow Fuses

• 12-volt model: 50 amps D.C.
• 24-volt model: 30 amps D.C.

Stop Switch

This switch disconnects the battery and then shorts the turbine wires causing the turbine to stop spinning (in high winds the blades will spin slowly). Shorting the turbine will not cause any damage or additional wear to the wind generator.

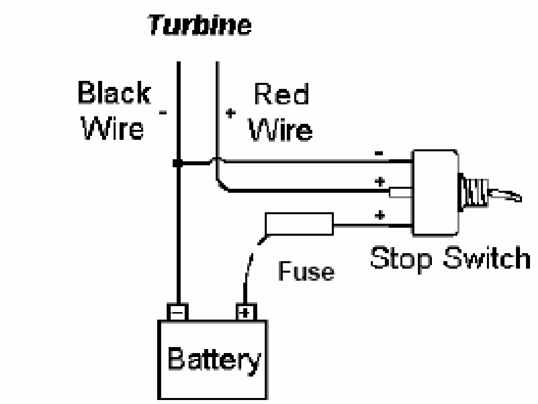


Figure 2 Stop Switch Wiring(http://windenergy.com/AIR_X_Land_Owners_Manual.pdf)

Multiple AIR Installation

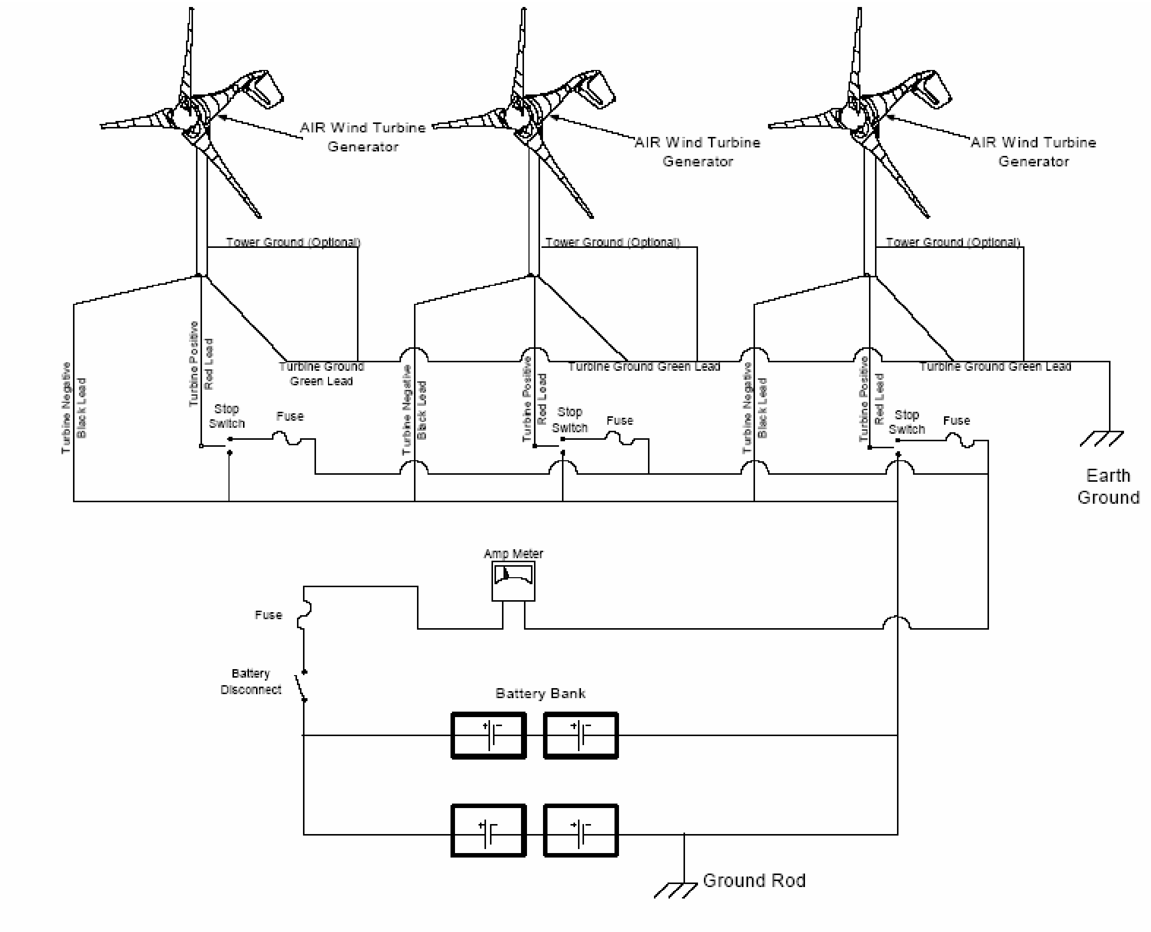


figure 3: windmill wiring diagram (from the http://windenergy.com/AIR_X_Land_Owners_Manual.pdf)

Each Turbine Wired To A Bus Bar

Because for this installation more than two turbines are being wired, they must be connected to a "bus", and then one set of wires will run from the bus to the battery. This way each turbine's internal regulator can be used or it is possible to install an external regulator. For the external regulator use a diversion style regulator that turns excess power into heat for heating a room, water etc. When wiring multiple turbines, it is possible to reduce your wiring costs by using a bus bar system This is shown above in figure 3

To connect the batteries to the main system the power goes through a DC Circuit breaker and then a controller. After this it passes through an inverter which switches it to AC Current. This inverter is estimated to cost roughly $2000. The AC power then goes through an AC Circuit Breaker where it attaches to the main power for the building. This means that when the building pulls power the draw will be from the windmill first and the main power second. It will also mean that when the building's main power supply goes down there will be no backflow from the wind turbine power into the utility lines. It also means that when working on the building it will be necessary to turn off the power from both the turbine and the utility.

The reading from the ammeter will then be collected and the output will be able to be read from the Kiosk. The Kiosk will also read the rotor speed from the monitoring wire of the windmill

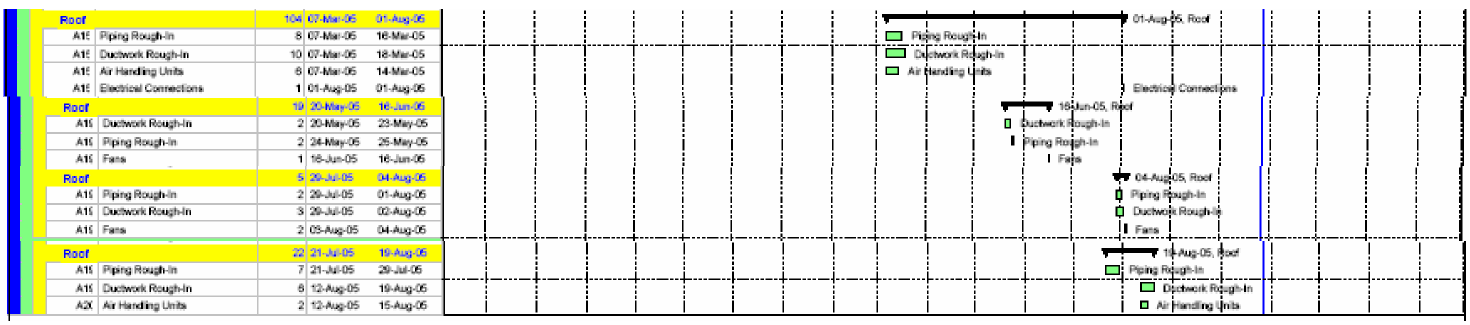
Cost:

With the cost of power in Erie being around 9.6 ¢/kWh a total of $18,800 is saved per windmill. This is amazing due to the fact that on average the windmill will cost around $1,500 including the installation per windmill. This will yield a total of $225,600 per year saving in electrical costs

There will also be other costs for this system to work. The kiosk will cost $2,600 including the stand, touch screen monitor, hard drive, shipping and tax. The new electrical system for the building will cost roughly $6,000 for the wiring and new controls. The battery backup will also run roughly $3,000 for a mid sized backup system. This ran the initial cost of the system up to just under $30,000. This however will be earned back by the end of the first year's power production.

Schedule:

Because the windmills will go on the roof and the roof gets done very early. There will be no schedule change. The length of time for the installation of the windmills does not affect the overall CPM schedule. This also includes the time for running the wires, since there are only two wires run from the windmill. One is the power output wire that gets connected to the building's power system. The other is the monitoring wire that will go to the kiosk and records the RPM of the windmill and computes the windmill power output. Both of these wires sets will run through an existing conduit. You can see how the roof schedule is very open by looking at excerpts of the schedule below



Roof		104	07-Mar-05	01-Aug-05
A1!	Piping Rough-In	8	07-Mar-05	16-Mar-05
A1!	Ductwork Rough-In	10	07-Mar-05	18-Mar-05
A1!	Air Handling Units	6	07-Mar-05	14-Mar-05
A1!	Electrical Connections	1	01-Aug-05	01-Aug-05
Roof		19	20-May-05	16-Jun-05
A1!	Ductwork Rough-In	2	20-May-05	23-May-05
A1!	Piping Rough-In	2	24-May-05	25-May-05
A1!	Fans	1	16-Jun-05	16-Jun-05
Roof		5	29-Jul-05	04-Aug-05
A1!	Piping Rough-In	2	29-Jul-05	01-Aug-05
A1!	Ductwork Rough-In	3	29-Jul-05	02-Aug-05
A1!	Fans	2	03-Aug-05	04-Aug-05
Roof		22	21-Jul-05	19-Aug-05
A1!	Piping Rough-In	7	21-Jul-05	29-Jul-05
A1!	Ductwork Rough-In	6	12-Aug-05	19-Aug-05
A2(	Air Handling Units	2	12-Aug-05	15-Aug-05

Noise:

Many wind turbines relied on their aero-elastic blade design for protection in high winds, causing loud flutter noise in winds above 35 mph (16 m/s). AIR-430's circuit monitors the wind speed and electronically slows the blades as it reaches its rated output preventing it from going into flutter. This results in a much quieter wind turbine. The tower will also sit on isolators so that no vibrations will travel through the structure of the building causing noise inside the building.

Structural:

All of the Windmills will sit directly on a joist or a column. With the weight of the windmill being only 15lbs and the tower structure weighing roughly 30lbs, the total load due to each windmill will be only 45 lbs dead. There is also a torsion load and moment due to the movement of the windmill due to the wind. This will also be very minimal. Each joist or column will hold only one windmill. As shown in the skylight analysis, the roof truss system can support far greater loads than is on it due to it's large over design for safety factors. This means that the small load that the windmill causes will not affect the structural system. A picture of showing where the windmills will sit on the structural system is shown below.

figure 4: windmill location on roof structural plan showing support.

Conclusion:

I recommend that the windmills get installed onto the roof of the REDC building. Although there is a high initial cost, the building should be able to save enough in energy that the windmills will pay for themselves by the end of the first year with extra monies saved. The schedule changes also are unimportant because of where the system sits and the schedule for roof construction. There should be no concern for structural issues or vibrations.

The other important thing to remember about this, is that the windmill is expected to be used for educational purposes. That alone would have justified the added cost and schedule demands associated with installing this system.

Conclusion

I hope that you have enjoyed your trip through my building and my research. Hopefully you have learned a great deal about the various building systems. By recommending the changes that I have, the building will run smoother and be more useful for the building's occupants. This research is also not completed. For every topic one must pick a logical place to stop but more can always be done and each topic could be expanded. The next section recommends ways to continue on with this research.

Continuing Research

If one were to desire to continue any of the research that has begun during this thesis, here are some suggestions of where to go.

WBE/MBE Solicitation

- Continue on with the survey and attempt to get a broader range of respondents.
- Interview DGS and find out why they have this program.
- Do a more in-depth research of what state have a similar program and find out what if any problems they have encountered. Also find out if any states have banned the program and why.
- Talk to owners for DGS projects and explain what the impact of the solicitation is.

Cladding Analysis

- Find out why the specified cladding is having difficulties and what it would take to fix it.
- Look for other materials to redesign the building with.

Skylight Analysis

- What would a different skylight do?
- Could there be an artistic way to leave it in and not have it be noticeable?
- What happens if the building is built as specified and they want to change it later?

Windmill Analysis

- Go more in-depth with the electrical analysis.
- Would other types of windmills make a difference? Different Heights?
- Find out what it would take to make a wind farm on PSU Erie Campus to power the campus.
- See about having the power go directly to the hot water or some other full time power load.

Citations/Sources

DGS - http://www.dgs.state.pa.us/bcabd/site/default.asp. All information regarding WBE/MBE policies

RS Means – Square Foot Estimate, All schedule and cost related information.

Research and Economic Development Center Bid Documents by Weber Murphy and Fox- All building and building system information.

http://www.bitterrootsolar.com/wind.htm - All windmill and tower prices and specifications.

http://windenergy.com/AIR_X_Land_Owners_Manual.pdf - All information related to the electrical installation of the windmill and figures 2 and 3 from the windmill analysis.

Engineering Economic Analysis by Michael R. Lindeburg, 2001. – All interest tables and current value analysis information

PA Clean Energy Expo Vendors – Information on how to hook a battery bank into the main power supply system.

http://www.awea.org/faq/windpower.html - Wind turbine power equation.

Appendices

Appendix 1 - Survey

Appendix 2 – Existing Cladding System

Appendix 3 – Windmill Spec Sheet

Appendix 4- Tower Kit Specification

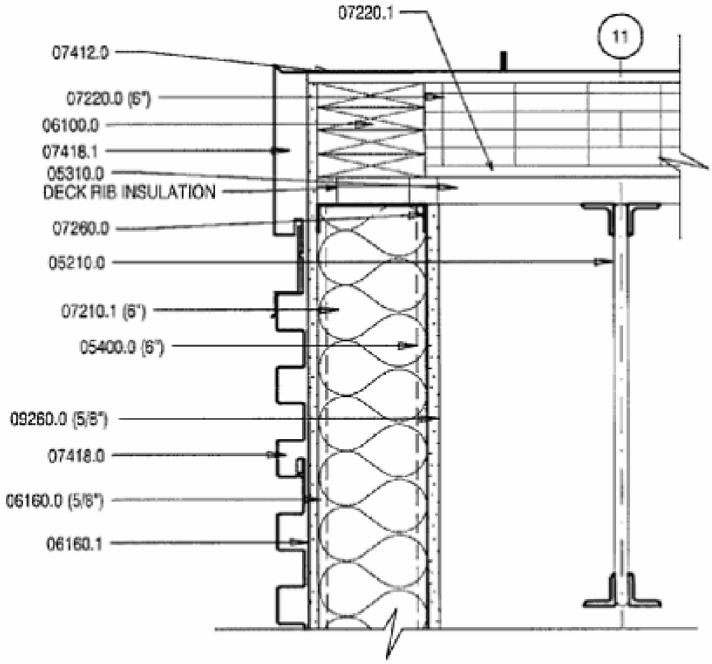
Appendix 5 - Kiosk Cut Sheet

Appendix 1 - Survey

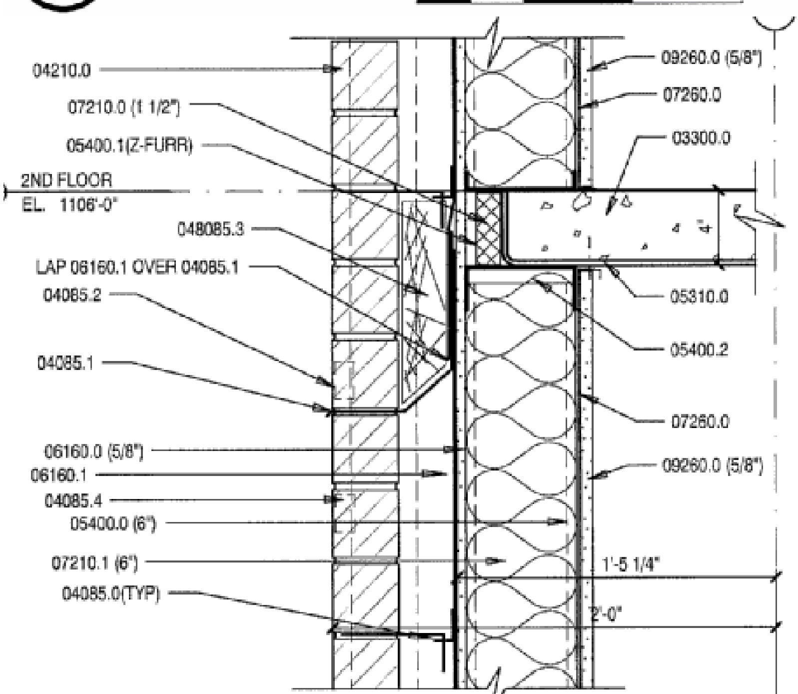
MBE/WBE Solicitation Survey
For General Service's Projects

1. Are you a WBE/MBE Contractor?
2. Have you bid on a DGS project which has required WBE/MBE Contractor Solicitation?
3. How many projects reqiring WBE/MBE Contractor Solicitation have you worked on?
4. Does the paper work needed for WBE/MBE Contractor Solicitation increase the time that is required in the pre-bid processes?
5. Does your company increase its bid to cover extra work and risk involved with WBE/MBE Solicitation?
6. How much does your company increase the bid by? (percentage or dollar amount)
7. Do you think that WBE/MBE Contractor Solicitation is a fair requirement for all DGS projects?
8. Have you hired a subcontractor that you wouldn't have normally used, due to the solicitation requirements?
9. If yes, has it resulted in a successful contract?
10. Do you feel that this requirement is accomplishing its intended purpose of increasing the usage of disadvantaged businesses in state projects?
11. Additional Comments

Appendix 2 – Existing Cladding System



E4 **METAL SIDING - SECTION**
SCALE: 1 1/2" = 1'-0"



D1 **MASONRY WALL - SECTION**
SCALE: 1 1/2" = 1'-0"

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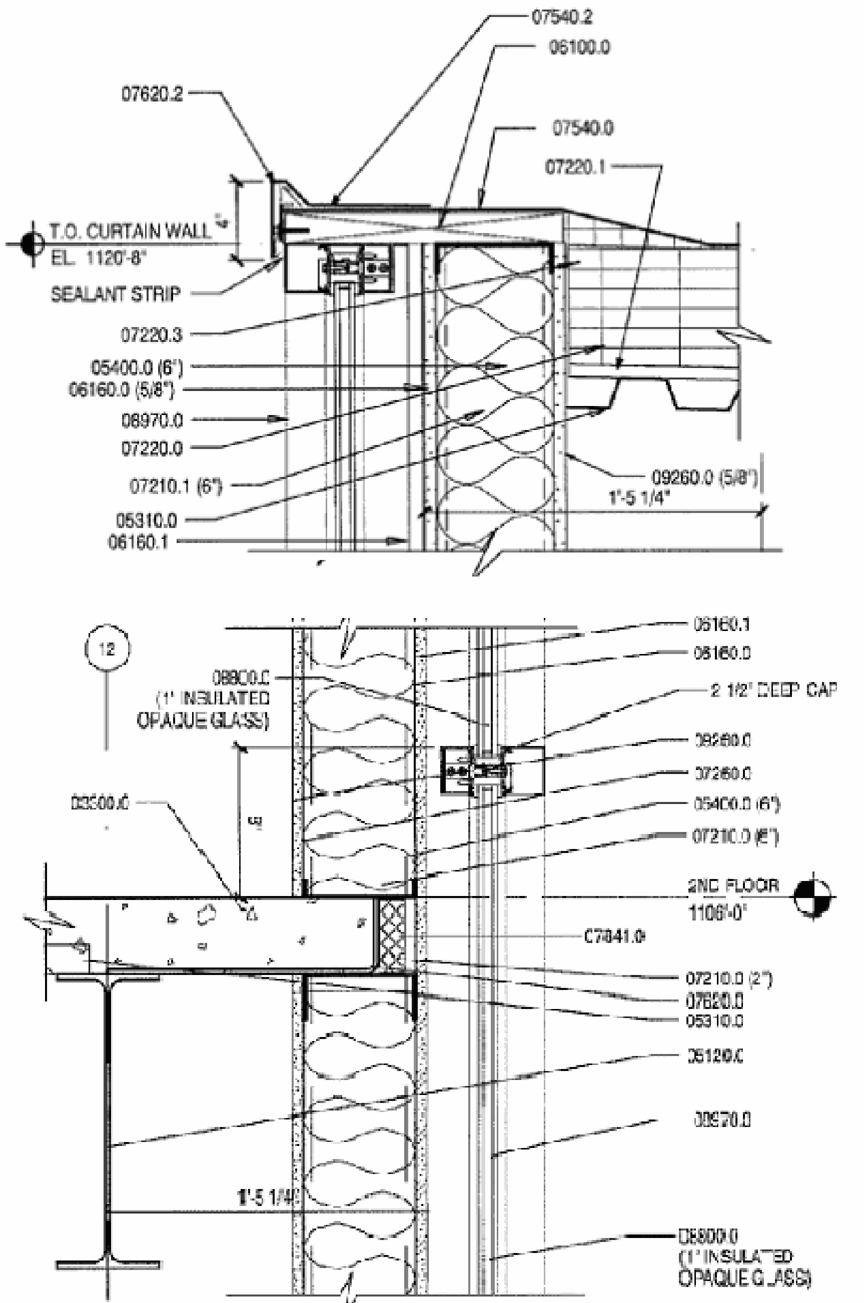


B2 **CURTAIN WALL VENEER DETAILS**
SCALE: 1 1/2" = 1'-0"

Appendix 3 – Windmill Spec Sheet

Air 403 Industrial Wind Generator

Same quality features as the AIR 403 and the AIR Marine, but designed for heavy duty use in continuous high wind conditions. Operates in hurricane winds.

Specifications for AIR 403 Industrial Wind Module

Rotor Diameter:	**45" (1.14 meters)**
Weight:	**14 lbs (6.2 kg)**
Start up wind speed:	**6 knots/7 mph (2.7 m/s)**
Voltage:	**12, 24, 48 volts**
Output:	**400 watts at 24 knots (12.5 m/s)**

3 YEAR WARRANTY

BLADES: The **AIR**'s blades are made of carbon fiber reinforced composite that twists as the turbine reaches its rated output. This twisting effect changes the shape of the blade, causing it to go into stall mode. This limits the RPM of the alternator, preventing damage in high winds.

ALTERNATOR: The **AIR**'s alternator is optimized to match as close as possible the energy available in the wind. It is constructed with Neodymium Iron Boron permanent magnets and is brushless for superior performance and maintenance-free operation.

REGULATION & CONTROL ELECTRONICS: The electronics performs several functions to assure maximum output and safety for the user. The control electronics maintains a load on the alternator at all times to make sure that the turbine never over speeds, regardless of the condition of the battery. As the battery is charged, the sophisticated regulator periodically checks the line, correcting for voltage loss and monitoring charge rate. Once the battery has reached its optimum charge level the regulator shuts the current off, preventing the battery from being overcharged while maintaining a load on the alternator at all times to prevent over speeding.

List Price $995.00 **SALE PRICE $879.00**

Stop switch	50 amp, DC, single pole double throw switch	$20
Ammeter	0-30 amp, DC, analog metter	$21
Circuit breaker	100 amp DC breaker	$49

Appendix 4- Tower Kit Specification

Wind Generator Tower Kits from Southwest Windpower

The Tower Kit

27 foot kit: $139.00

45 foot kit: $199.00

(kits do not include poles or anchors)

Anchors

36" (for 27 foot kit) set of 4 $55.00

48" (for 45 foot kit) set of 4 $70.00

Available in 27 and 45 foot kits

Installs in a few hours No Cement

No Gin Pole (27' only)

No Winching

No Sweat!

Includes everything except pipe and anchors

45' Tower Kit includes gin pole hardware

No Room for a tower...

Simple roof top tower mount offers easy installation for your AIR wind module

Design includes vibration isolation mounts that reduce mechanically transmitted noise by 80%

Installs on the side of a building or through the roof

Includes everything except pole and mounting bolts

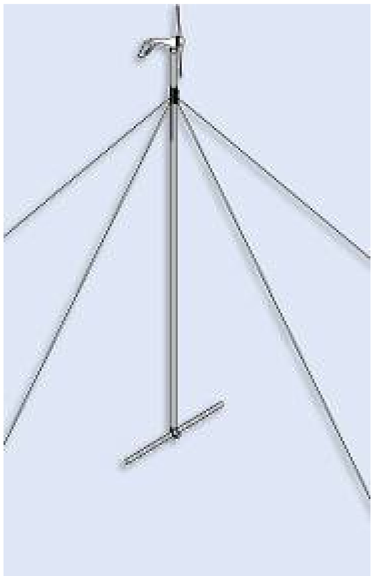
How easy is it to install?

Technical Information

27' Guyed Tower Kit

Technical Information

A Revolution in Tower Design



Kits include:	**27 ft (8 m)**
Base Connector	**1**
Lower Wire Set (160 ft. pre-cut)	**1**
Base Staples	**2**
3/8" x 1 ½" Bolt	**2**
3/8" Locknut	**2**
Cable Thimbles	**4**
Cable Clamps	**8**

Pipe Pieces Needed:

(available at fence suppliers)

- **24 foot (7.2 meter) length for tower**
- **3 foot (.9 meter) length for tower**
- **6 foot (1.8 meter) length for tower base**

Pipe Requirements

Tower Kits use 1-7/8 inch (47.5 mm) Steel Tubing

Maximum Wind Speed

Maximum Wind Speed	Recommended Wall Thickness	Pipe Schedule
90 mph	.065 inch (1.65 mm)	n/a
100 mph	.090 inch (2.3 mm)	Schedule 20
120 mph	.140 inch (3.6 mm)	Schedule 40

http://www.bitterrootsolar.com/wind.htm

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Appendix 5 - Kiosk Cut Sheet

GENERAL

The Slabb M kiosk was the first kiosk released in the new X series line. Its super modern design and amazingly low price allow more clients to utilize high-end kiosk technology without the high price tag. It is a smart blend of stainless steel, simplicity, elegance, function and aesthetics.

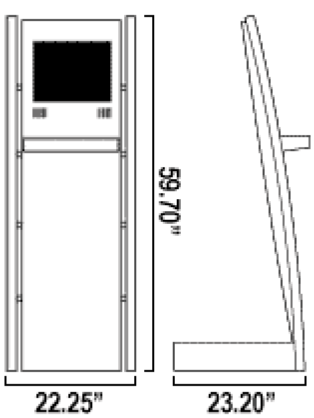
The display is a 17" LCD monitor which allows a large space to advertise content to people within close proximity of the kiosk. Options include a stainless steel keyboard/trackball, custom color finishes, SAW Glass Touchscreen, and Book Sized PC.

The Slabb M kiosk ships in a flat box which lowers shipping costs. Light assembly is required by the end-user, but setup time does not exceed 10 minutes per kiosk.

This kiosk was designed to accommodate a small form factor PC. We recommend that you use a Dell Optiplex GX520 PC which can be supplied from us.

Standard colors include silver/gray, white or black.

Lead Time: 1-2 weeks (some basic models ship in 48-72 hours).



SPECIFICATIONS

16 Gauge Mild and Stainless Steel Enclosure
17" LCD Monitor (1280 X 1024 Max Resolution)
Vandal Resistant Powder coat Finish
Brushed Stainless Steel Poles with spacers
Cooling Fan in base
Steel Power Strip
Large Access Doors with Tubular Locks/Keys
Protective Glass (if no touchscreen used)
ADA Compliant Design

Dimensions:
With Keyboard: 59.70" Tall x 22.25" Wide x 24.375" Deep
Without Keyboard: 59.75" Tall x 22.25" Wide x 23.2" Deep
Packed Dimensions: 30" Deep X 18.5" Tall X 68" Wide

Weight:
Kiosk Weight: 85 lbs
Packed Weight: 120 lbs
Add 7 pounds for keyboard/trackball
Add 12 pounds for book sized PC

Base Unit ::	1-9
Slabb M Floor Standing Kiosk with 17" LCD	$1695

http://www.slabb.com/productDetails.jsp?product=1

Acknowledgments

Bruce Rohrbach – Thank you for the help with the building systems and getting me drawings and specs.

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