Coppin State University

Health and Human Services Building

Baltimore, Maryland

Final Senior Thesis Report

Corinne Ambler
Construction Management

Spring 2007

COPPIN STATE UNIVERSITY

HEALTH & HUMAN SERVICES BUILDING
BALTIMORE, MARYLAND

PROJECT TEAM

Owner - University of Maryland, Baltimore

Client - Coppin State University

CM- Barton Malow Company

Architect - Design Collective, Inc.

Structural Engineer - Hope Furrer Associates

MEP Engineer - RMF Engineering

Civil Engineer - Site Resources, Inc.

STRUCTURAL

Framing - ASTM A992 Structural Steel

Facade - Glazed Aluminum Curtain Wall, Storefront. Face-Brick Veneer in Masonry Cavity, Cast Stone Panels, & Insulated Metal Panels

Foundation - 4000psi Concrete Caissons and Grade Beams

Decking - Composite Metal Deck with 3" 3500 psi Reinforced Lightweight Concrete Slab

Roofing - Metal Screen, EPDM Single Ply Membrane & Hot- Fluid Applied Roofing

MECHANICAL & ELECTRICAL

Mechanical - (2) 1200 GPM 400 ton Cooling Towers
(7) Air Handling Units ranging 1200 - 28000 CFM
(1) 1500 CFM Make-Up Air Handling Unit
(2) 6700 MBH Natural Gas Boilers
(2) 400 ton Chillers
VAV Boxes with Reheat Coils and Baseboard Heating

Electrical - 3000A, 480/277 Volt, 3-Phase 4-wire Service with 400kW Emergency Back-Up Generator

*Overhead Connector Bridge for Pedestrians connects the Future South Campus HUB for Telecommunications and Water Service with the Existing Coppin State Campus

PROJECT FEATURES

Function - Academic

Size - 150,000 sq. ft.

Estimated Cost - $48.6 million

Dates of Construction - January 2006 - June 2008

Delivery Method - CM at Risk - Soft GMP

Project Houses - Child-Care Demonstration Suite One story section on the south end Lecture Halls, Meeting Rooms, Offices,Outpatient Health Clinic, Research Labs, Moot Courtroom, Forensic Lab & Overhead Connection Bridge

*First Building on South Campus

CORINNE AMBLER • ARCHITECTURAL ENGINEERING • CONSTRUCTION MANAGEMENT

SPONSORED BY BARTON MALOW COMPANY & DESIGN COLLECTIVE, INC.

HTTP://WWW.ARCHE.PSU.EDU/THESIS/EPORTFOLIO/2007/PORTFOLIOS/CRA140/

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ACKNOWLEDGEMENTS

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Barton Malow Company

Bob Grottenthaler	Vice President
Katie Lynahan	Project Manager
Jason McFadden	Project Engineer
Ben Morgan	Project Director
Allen Turnbaugh	General Superintendent
Todd Vorchinsky	Chief Estimator

Coppin State University & University of Maryland, Baltimore

Design Collective, Inc.

Matt Herbert	Associate
Eric Wohnsigl	Principal

Fellow Architectural Engineering Students

Alexis Kreft	Lighting/Electrical
Joe Mugford	Structural
Angela Nudy	Lighting Electrical

Industry Members who participated in Research Interviews

RMF Engineering

Merton Harris	Mechanical Engineer

The Pennsylvania University

Dr. Michael Horman	Associate Professor -Construction
Dr. Moses Ling	Associate Professor - Mechanical
Dr. John Messner	Associate Professor – Construction
Dr. David Riley	Emeritus Professor - Construction

I would also like to thank my friends and family for supporting me throughout my time at Penn State.

EXECUTIVE SUMMARY

This senior thesis report is an in depth study of Coppin State University's Health and Human Services Building in Baltimore, Maryland. Research about a critical industry issue affecting this building is included as well as two technical analyses. The technical analyses address how a proposed change affects the systems of the building. A cost analysis of the proposed change is provided with a recommendation of whether or not to implement the proposed change.

The critical industry issue affecting the Health and Human Services Building at Coppin State University is the volatility of escalating construction costs. The risk associated with the escalation of construction costs has been analyzed by interviewing contractors, construction managers, designers and owners regarding the current strategies of managing this risk. Through the interview process it was found that some risk is passed to each party starting with the owner and ending with the vendor. As the risk is passed costs are increased to compensate for the escalation of material and labor costs. In the end, the owner pays a premium for cost escalation that may never occur. The proposed solution is for the owner to control more of the risk and implement changes in the contractor's procurement and bid process.

The first technical analysis examines the affects of lowering and extending the 5th floor's existing sunshade. Lowering the sunshade to the head of the window and extending the sunshade beyond its current length of four feet increases the percentage of shaded glazing which in turn decreases the amount of solar heat gain. The structural connection of the sunshade to the building needs to be altered to accommodate the lower sunshade. It was found that a total of 30,008 pounds of steel needs to be added to the building in the form of 156 steel plates to support the lowered sunshade. The first year's mechanical savings from lowering the sunshade totals $20,498 and decreases to a yearly savings of $3,220 for every year succeeding the first. The one time initial cost of the addition of steel is $6,017. The extension of the sunshade beyond five feet requires a payback period of eight years due to the additional costs of material and labor. It is recommended that the sunshade be lowered to the head of the window and left at its current overhang length of four feet.

The second technical analysis alters the lighting scheme of the overhead pedestrian bridge that spans W. North Avenue and connects the college's current campus to its new campus. The bridge is a unique architectural feature that signifies the presence of Coppin State University in the community. The Health and Human Services Building contains outreach programs that will service the community which include a daycare center and a clinic. The redesigned lighting scheme highlights the prominent architectural and structural features of the bridge while shining a beacon of light into the community.

PROJECT OVERVIEW

The Health and Human Services Building at Coppin State University, located at 2500 W. North Avenue in Baltimore, Maryland, is the first building of many to be located on the future south campus. The University's campus currently exists only on the north side of W. North Avenue. The project also includes an overhead pedestrian bridge to connect the two campuses. The building will house many different academic programs. Construction of this 150,000 gross square feet building began in January 2006 and will be completed in June 2008. The estimated cost of this five-story facility is $48.6 million.

PROJECT TEAM

Owner – University of Maryland, Baltimore
Client – Coppin State University
Construction Manager – Barton Malow Company
Architect – Design Collective, Inc
Structural Engineer – Hope Furrer Associates
MEP Engineer – RMF Engineering
Civil Engineer – Site Resources, Inc

CLIENT INFORMATION

Coppin State University is one of many colleges in the University System of Maryland. The college offers a comprehensive, urban, liberal arts institution with a commitment to excellence in teaching, research and continuing service to its community. The number of commuter students has been increasing over the past five years. The University has decided to respond to this by creating a south campus and updating their athletic facilities. At the present time the campus consists of eight buildings residing on the north side of W. North Avenue. In years to come the University has devised a Master Plan to add twenty-one new facilities and expand campus to the south side of W. North Avenue. The Health and Human Services Building will be the first building on the new South Campus.

The map and list of new and old facilities is available on the next page.

Coppin State University

2 5 0 0 W E S T N O R T H A V E N U E
B A L T I M O R E M A R Y L A N D 2 1 2 1 6

ESTABLISHED 1900

PROPOSED FACILITIES MASTER PLAN

EXISTING FACILITIES:

DA - Daley (Residence) Hall
DE - Dedmond (Residence) Hall
DF - Dining Facility
GJ - Grace Hill Jacobs Office Classroom Lab Building (OCL)
JJ - James Weldon Johnson Auditorium Building
JT - J. Millard Tawes College Center
MC - Miles Connor Administration Building
PM - Parlett Longworth Moore Library

NEW FACILITIES:

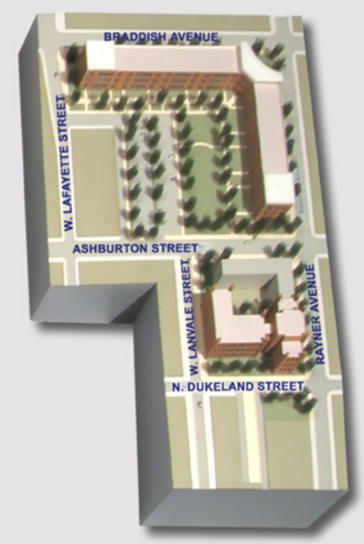
BF - Baseball Field
COC - Cross Over Connection
EC - Education Center
HHSB - Health & Human Services Building
PAC - Performing Arts Center
RH3 - Residence Hall #3
RH4 - Residence Hall #4
SC - Student Center
SF - Softball Field
STC - Science and Technology Center
TC - Tennis Courts
TF - Track Field

PHYSICAL EDUCATION COMPLEX:

FM - Facilities Management / Public Safety
PEB - Physical Education Building

PARKING:

A - Parking Lot A
D - Parking Lot D
E - Parking Lot E
F – Parking Lot F
PS1 - Parking Structure #1
PS2 - Parking Structure #2



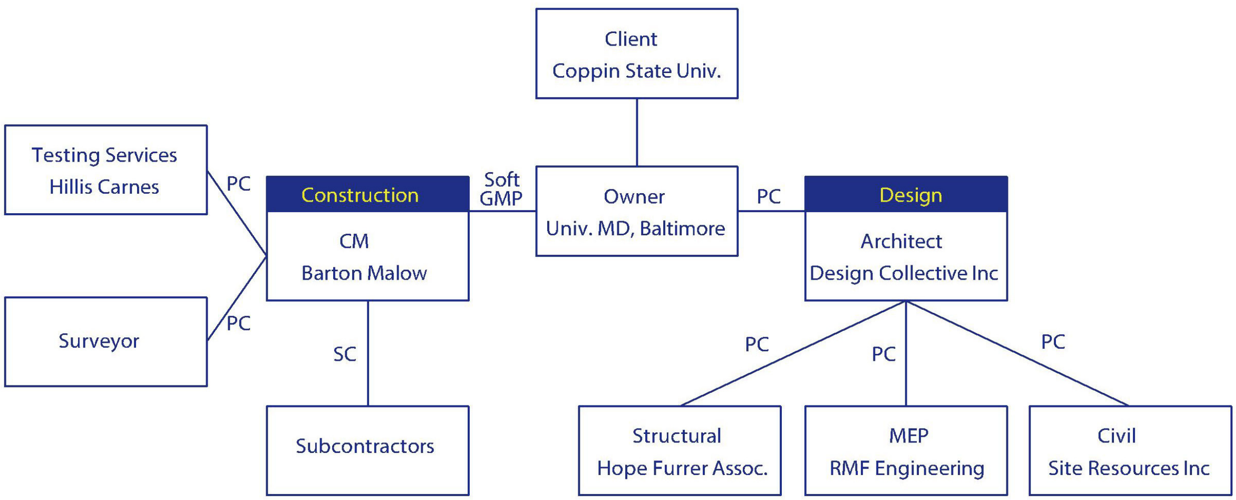
CSU
LUTHERAN SITE

JANUARY 2005

Project Delivery Method

Coppin State University is part of the University System of Maryland. The state of Maryland requires the construction of all new buildings in the University of Maryland System are to be controlled by The University of Maryland. Therefore the contract for the building is held by The University of Maryland, Baltimore. Barton Malow Company has been chosen as the construction manager at risk for the project. A soft guaranteed maximum price (GMP) was established between Barton Malow and The University of Maryland, Baltimore. This means a fee was decided upon, the project was bid by contractors and then a GMP was established based on the total bid amounts by the accepted contractors.

The organizational chart below shows the members involved in the delivery of the project and the type of contract between the two parties. A Professional Contract (PC) has a fee associated with it for the professional services provided and a Services Contract (SC) is a GMP that was hard bid.



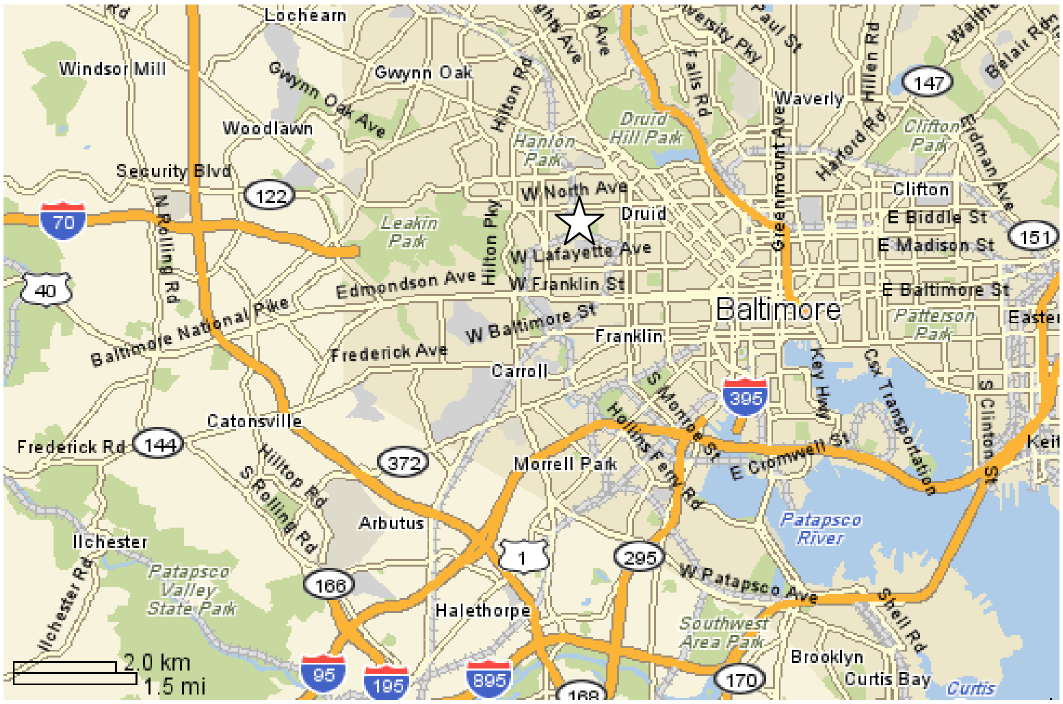
Organizational Chart of Delivery System

The project was bid to the contractors in three different phases at three different times according to trade. A new GMP was agreed upon between Barton Malow Company and University of Baltimore, Maryland after each phase was bid. The table on the next page depicts which trade was bid in each phase.

Phase I	Phase II	Phase III
Excavation and Grading Demolition Deep Foundations Concrete Structural Steel Elevators	Fireproofing Glass Systems Fire Protection Mechanical Electrical	Final Sitework Landscaping Masonry Misc. Metals Carpentry & Woodwork Metal Panels Roofing Doors, Frames and Hardware Partitions and Ceilings Ceramic Tile Painting and Coating Lab Casework

Site Plan and Existing Conditions

The Health and Human Services Building is located at 2500 W. North Avenue in Baltimore, Maryland. This is located northwest of the Inner Harbor. The urban setting limits the availability of parking. Geologically there are rocks near the surface and the design team thought blasting was going to be necessary. The site is ten to fifteen miles from the Inner Harbor which caused the water table to not be an issue.

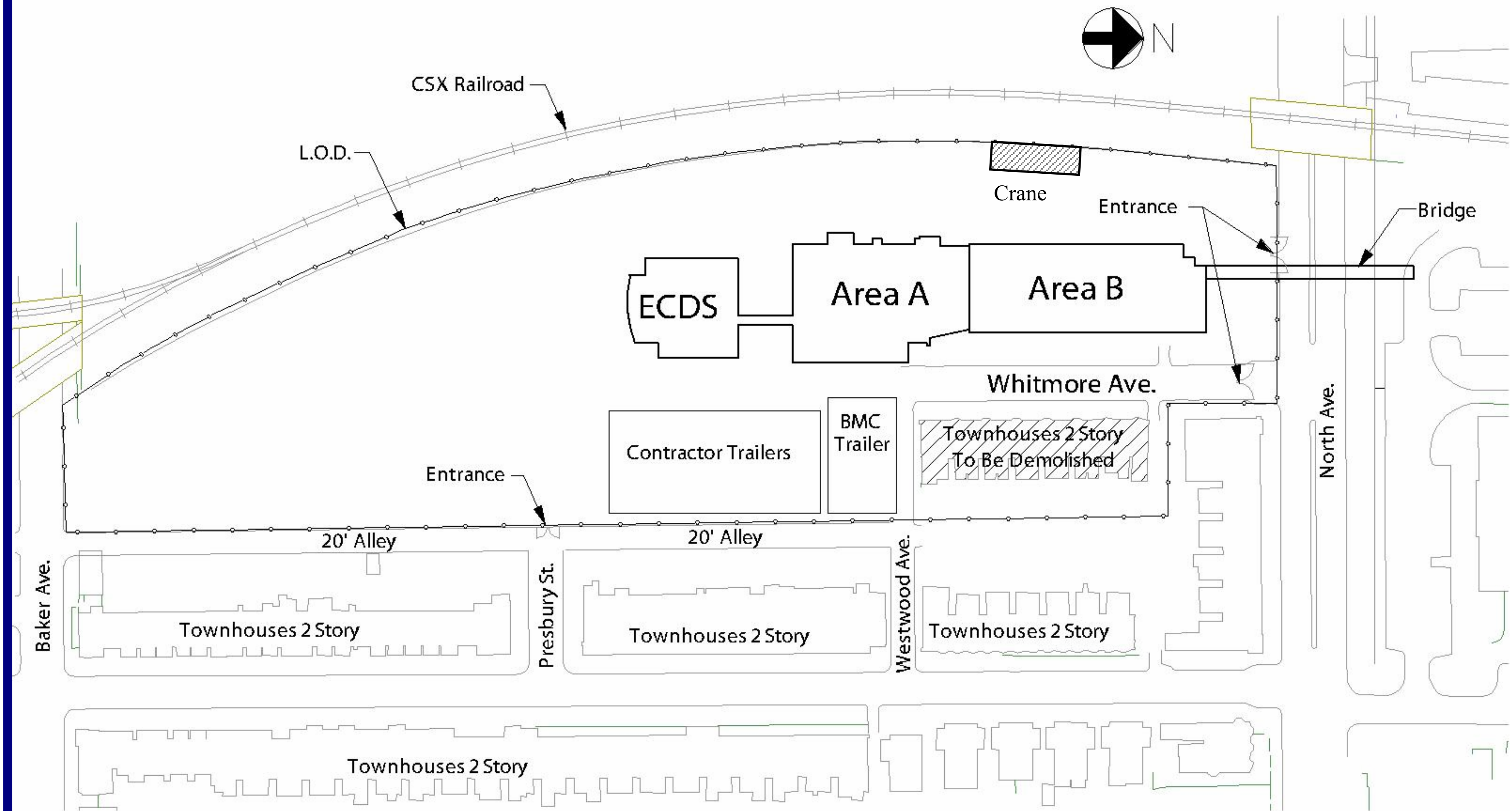


Map of Baltimore, Maryland

The layout and logistics of the site have changed from the original plans. The townhouses located on the east side of Whitmore Avenue were to be demolished in April 2006. Unfortunately, the University has not been able to acquire these properties. This has restricted Barton Malow Company's on site storage as well as the lay-down and shake-out area. The crawler crane was originally planned to move up and down Whitmore Avenue erecting steel. The un-demolished houses have forced the crane to erect steel from the opposite side of the building. The crane will now travel along the west side of the building.

The three entrances to the site allow all entering trucks to make a loop within the site. This reduces congestion because the trucks to not need to turn around. All trucks enter the site on Whitmore Avenue and must pass the Barton Malow Company trailer. Wheel washes are located at the other two entrances for sediment control. Dumpsters are located near the entrances to allow for easy trash removal.

The site plan can be seen on the next page.



Coppin State University

Health and Human Services Building

Site Plan

Building Systems Summary

Architectural Design and Function

The building program provides classroom, research, meeting and office space for various departments of the College which include Divisions of Graduate Studies, Nursing, Criminal Justice, Social Work and Applied Psychology and Rehabilitation Counseling. Also included in the building is space for various community outreach and clinical programs that are an integral part of the College.

The first floor of the new academic building will consist of a child-care center demonstration suite, lecture halls, meeting rooms and an outpatient health clinic. The second floor will house additional outreach offices, classrooms and labs. Classrooms, labs, graduate student and faculty offices will be located on the third, fourth and fifth floors. Air-handling units and cooling towers will be located on the roof which is accessible by a stair tower. Chillers and boilers will be located in the basement along with electrical equipment. This building will serve as a future hub for South campus telecommunications and water service. An overhead connector for pedestrians will join the second floor of the new academic building with a future parking garage on the other side of W. North Avenue.

Structural System

The structural system is primarily ASTM A992 Structural Steel with composite metal decking. The metal decking carries a 3" 3500psi reinforced lightweight concrete slab. The foundation is a system of cast in place concrete caissons and grade beams.

Building Envelope

The building exterior consists of glazed aluminum curtain wall and storefront, brick face veneer in a masonry cavity wall construction, cast stone panels and pre-finished insulated metal wall panels with exposed flashings and copings. Two different metal wall type panels exist with 2" insulated panels. All panels, copings and flashings are pre-finished to match a custom color. The face brick is a running bond accented with stack bond window jambs and cast stone headers, sills and copings. The roof-top equipment is screened by a pre-finished insulated metal-panel screen wall. Structural tube framing supports the screen wall vertically. The feature wall at the Early Childhood Demonstration Suite is constructed of segmented glazed aluminum curtain wall accented with insulated art-glass units of varying colors and textures. Generally, throughout the building, large vertical spans of curtain wall are braced by steel tube framing behind to limit the depth of units to 7-1/2". All curtain wall and storefront are factory finished to match a custom color.

Electrical System

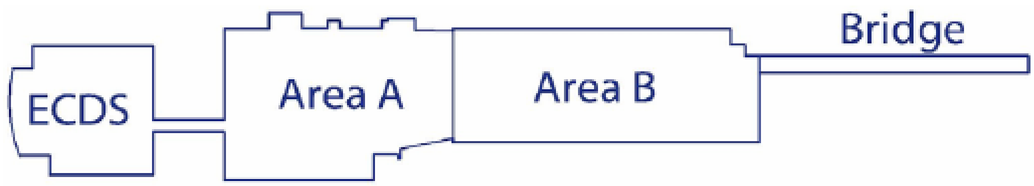
The building ties into the north campus by running the lines underneath the overhead pedestrian bridge that crosses W. North Avenue. The service is 3000A with a 3-Phase 4-wire system. It runs at 480/277 Volts. All panel and switchboards are located in the basement of the building. There is a 400kW emergency back-up generator.

Mechanical System

All mechanical equipment is located on the roof or in the basement of the building. Two 1200 GPM 400ton cooling towers are on the roof of the building with seven air handling units ranging from 12000 to 28000 CFM. There is also an eighth 1500 CFM air handling unit for make-up air in the kitchen located on the first floor. Two 6700MBH natural gas fired boilers are in the basement with two 400 ton chillers. The VAV boxes throughout the building are equipped with reheat coils. The distribution system is that of a supply duct and an open air return plenum. There are transfer ducts for non-critical spaces, such as storage, closets and hallways. Climate control is regulated by thermostats. Baseboard heating exists throughout the building. The fire suppression system is both wet and dry and there is a 750 GPM 125HP Motor wet pipe system.

Project Schedule Summary

A detailed project schedule is provided in Appendix A. Construction of the building began in January 2006 and will be completed in June 2008. The building is broken down into four different areas. As shown in the picture below.



Coppin State University Health and Human Services Building's Construction Area

The ECDS is the Early Childhood Development Center. It is a one story building that will house childhood day care. Although it is only one story, careful consideration has been taken in the selection of materials and products because it will be primarily used by children. One of these special features is a heated floor slab because the designers assumed the younger children would be crawling on the floor. The university has gone back and forth on the decision to save money or keep the one-story building included in the scope of work. This has made scheduling for the project difficult at times. Sub-contractors that were awarded with Bid-Package 3 were told not to include the ECDS when ordering materials.

The main building is divided into two areas. – Area A and Area B. Area A is the southern part of the main building. It is the only part of the building that has a sub-grade level. Area B is the northern part of the main building. The main building is 5 stories with mechanical equipment on the roof shielded by a metal screen wall.

The connection bridge is a pedestrian walkway that spans W. North Avenue. It connects the current Coppin State campus to the new part of campus. The walkway allows building occupants to exit the 2nd floor and walk across W. North Avenue without having to worry about traffic. The bridge will be constructed in a parking lot on the north side of W. North Avenue and then be lifted into place by a crane. W. North Avenue will be closed for the weekend to allow the placement of the bridge to occur.

Foundation

The foundation system in the Health and Human Services Building is concrete. The deep foundation system utilized is caissons. Caisson caps and grade beams sit on top of the caissons. The basement walls are cast-in-place concrete. The basement only exists in the south end of the main building. Construction of the foundation system started in the basement, continued to the north end of the main building and completed in the Early Childhood Development Center (ECDS).

Structural

The steel erection system divides the building into three sections. As mentioned above in the foundation summary, the south end of the main building with the basement is considered 'Area A', the north end of the main building is considered 'Area B' and the Early Childhood Development Center referred to as ECDS. Floors one through three will be erected in Area A, followed by floors one through three in Area B. The remaining fourth and fifth floors will be completed in a similar matter by completing Area A and then Area B. The ECDS is the last part of the building to be completed.

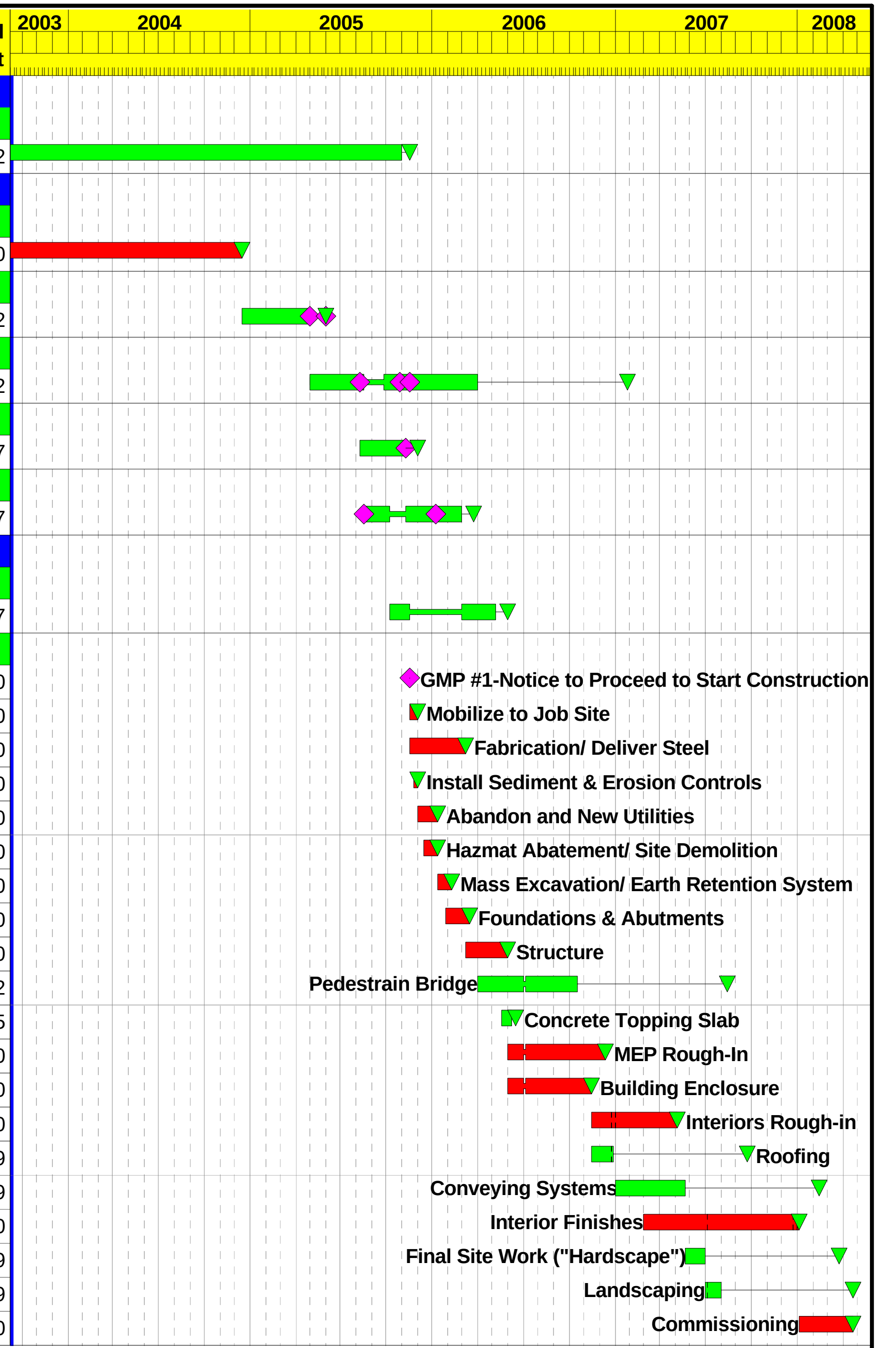
Finishes

MEP coordination was completed with weekly team meetings using a light table. Once all of the major units are put into place finishes will begin. Finishes will be sequenced in the same manner as the steel was erected. The contractors will complete the finishes in the following order:

-Metal Studs
-MEP Rough-in
-Gypsum Board
-Ceiling Grid
-Electrical and Lighting Fixtures
-Ceiling Tiles
-Painting
-Floor Finishes (Carpet, Tile, etc.)
-Furniture

A summary of the project schedule is provided on the next page.

Activity ID	Activity Description	Orig Dur	Rem Dur	%	Early Start	Early Finish	Total Float
Owner Property Acquisition							
+ Schematic Design							
		556	556	0	09SEP03	31OCT05	12
Pre-Construction							
+ Schematic Design							
		329	329	0	09SEP03	15DEC04	0
+ Design Development							
		119	119	0	16DEC04	31MAY05	2
+ 50% Construction Documents							
		239	239	0	02MAY05	31MAR06	212
+ 95% Construction Documents							
		65	65	0	10AUG05	08NOV05	17
+ 100% Construction Documents							
		139	139	0	17AUG05	27FEB06	17
Construction							
+ Submittal Phase							
		153	153	0	06OCT05	08MAY06	17
Construction							
1269	GMP #1-Notice to Proceed to Start Construction	0	0	0	17NOV05		0
1270	Mobilize to Job Site	10	10	0	17NOV05	30NOV05	0
1335	Fabrication/ Deliver Steel	80	80	0	17NOV05	08MAR06	0
1300	Install Sediment & Erosion Controls	5	5	0	24NOV05	30NOV05	0
1310	Abandon and New Utilities	30	30	0	01DEC05	11JAN06	0
1315	Hazmat Abatement/ Site Demolition	20	20	0	15DEC05	11JAN06	0
1320	Mass Excavation/ Earth Retention System	20	20	0	12JAN06	08FEB06	0
1330	Foundations & Abutments	35	35	0	26JAN06	15MAR06	0
1340	Structure	60	60	0	09MAR06	31MAY06	0
1360	Pedestrain Bridge	140	140	0	03APR06	16OCT06	212
1345	Concrete Topping Slab	15	15	0	18MAY06	07JUN06	5
1350	MEP Rough-In	140	140	0	01JUN06	14DEC06	0
1370	Building Enclosure	120	120	0	01JUN06	16NOV06	0
1380	Interiors Rough-in	120	120	0	17NOV06	07MAY07	0
1390	Roofing	30	30	0	17NOV06	29DEC06	189
1400	Conveying Systems	100	100	0	02JAN07	21MAY07	189
1410	Interior Finishes	220	220	0	27FEB07	03JAN08	0
1420	Final Site Work ("Hardscape")	30	30	0	22MAY07	02JUL07	189
1440	Landscaping	20	20	0	03JUL07	31JUL07	189
1430	Commissioning	79	79	0	04JAN08	23APR08	0



Start Date	09SEP03
Finish Date	23APR08
Data Date	09SEP03
Run Date	05OCT06 14:49

Early Bar
Float Bar
Progress Bar
Critical Activity

CORI

Sheet 1 of 1

Barton Malow Company

CSC Health & Human Service Building

Date	Revision	Checked	Approved

Project Cost Summary

The project was bid out to subcontractors in three separate bid packages. When construction began in January 2006 the cost of the building was $41.95 million since then the cost has inflated to $48.6 million. This means that at the current time the construction cost of the building is **$324/SF**. The building system costs for each bid category are listed below:

Building System Costs	
Excavation and Grading	$3,272,000
Demolition	$63,290
Deep Foundations	$400,750
Concrete (building)	$3,031,600
Structural Steel	$3,618,375
Spray Fireproofing	$168,000
Elevators	$734,685
Final Sitework (includes sidewalk concrete)	$899,383
Landscaping	$276,316
Masonry	$2,505,700
Misc. Metals	$484,018
Carpentry & Millwork	$690,014
Metal Panels	$1,256,700
Roofing	$320,655
Doors, Frames, Hardware and General Trades	$1,601,600
Glass Systems	$2,902,720
Partitions and Ceilings	$3,315,470
Ceramic Tile	$126,652
Terrazzo	$229,610
Carpet & Resilient Flooring	$442,286
Painting and Coating	$317,560
Lab Casework	$171,240
Fire Protection	$487,200
Mechanical	$9,799,140

VOLATILITY OF ESCALATING CONSTRUCTION COSTS ANALYSIS

PROBLEM

The volatility of the cost of construction materials in the current market coupled with the escalation of labor wages has increased the risk of maintaining the estimated budget throughout the duration of a project. This was especially true for the budget of the Health and Human Services Building at Coppin State University because the project was bid in three phases over a ten month period and Hurricane Katrina hit weeks after the estimate was performed. The University System of Maryland needed to ask the State of Maryland to increase the budget. The owner considered removing the Early Childhood Demonstration Center in order to lower the new estimated budget to the original budget.

SOLUTION

Altering the way contractors bid on projects will allow the owner to pay the true inflation and escalation costs of material and labor. Increasing the simplicity of bid documents and changing the selection process of contractors will increase competition and therefore help to lower cost.

METHODOLOGY

The market conditions for the last decade were researched focusing on the cost escalation of materials and labor. A list of questions for contractors, construction managers, designers and owners was developed from the knowledge gained during research. A list of questions for each party is located in Appendix B. An email was sent to industry professionals requesting a phone interview. The cover letter is available in Appendix B. Contractors, construction managers, designers, and owners as well as an economist were then interviewed about their opinions and current practices. The notes from each interview can be viewed in Appendix B. The results from both research and interviews were then compiled to produce a recommendation.

RESOURCES & TOOLS

Dr. Michael Horman – The Pennsylvania State University
Dr. David Riley – The Pennsylvania State University
Interview Participants Listed in Table 1
Multiple Issues of ENR – Engineering News Record

The Associated General Contractors of America (AGC) Construction Inflation Alert

Contacts for Material Escalation Interview		
Brian Barnes	Contractor	Finishes, Inc
John Bechtel	Owner	The Pennsylvania State University
Brook Behner	Contractor	Homewood General Contractors, Inc
Lee Evey	Construction Manager	Design Build Institute of America
Sarah Forrest	Estimator	Hensel Phelps Construction Co.
Scott Franckowiak	Contractor	MBR Construction
Hope Furrer	Designer	Hope Furrer Associates
Bob Grottenthaler	Construction Manager	Barton Malow Company
Merton Harris	Designer	RMF
Matt Herbert	Designer	Design Collective, Inc
Telly Koutris	Contractor	David Allen Company
Keith Lambert	Contractor	Zephyr Aluminum
Mike Miller	Construction Manager	Southland
Jorge Scotti	Owner	University of Maryland, Baltimore
Ken Simonson	Economist	AGC Chief Economist
Todd Sody	Contractor	Sody Concrete
Todd Vochinsky	Estimator	Barton Malow Company

Table 1: Interview Participants

Market Conditions

The construction industry has been plagued with the escalation of material prices since early 2004 until mid-2006. This was a drastic change from the almost inflation-free era between 2001 and 2003. In the last few months cost escalation has decreased. However by the end of 2007, material costs are expected to rise between six and eight percent and labor wages are predicted to increase five percent.

The cost of construction has increased for every trade due to the increase in fuel prices. The price of diesel gas has escalated which, in turn, has escalated the price of any material that is being shipped or hauled for both raw and finished products. Ports, rail lines, and trucking companies have recently experienced demand surges that have pushed up the delivery cost for materials. The material costs that have impacted the industry the most have been the cost of steel, concrete, copper, aluminum, glass, gypsum board and lumber. All petroleum products, including roofing/waterproofing, PVC pipe, and asphalt, have also been affected by fuel cost escalation.

The cost of cast-in-place concrete is influenced by multiple factors. The direct factors contributing to this escalation are cost of cement and steel. The escalation of steel reinforcing prices escalates the overall cost of cast-in-place concrete. The escalation of lumber has indirectly increased cost of cast-in-place concrete due to its use as formwork. The use of reusable forms like gang forms and steel framed forms with plywood can be costly. In today's market, it is becoming increasingly more difficult to find a low-cost solution for forming cast-in-place concrete. The price of cement has increased by ten percent each year in the last three years. This dramatic increase is due to the large amount of energy needed for processing and shipping. The cost escalation of sand, gravel and crushed stone has also added to the cost escalation of concrete. As the materials used to produce concrete escalate in cost the cost of concrete rises as well.

The change in the global economy has also increased material cost escalation. The demand for finished structural steel, as well as all other construction commodities, has increased in past years, which has lead to a shortage of these materials. The economic growth of India and China has lead to a higher demand for materials worldwide. The consumption of materials by Asia coupled with the United States boom in residential building has lead to an extremely high demand. The demand has spanned industry-wide in both commercial and residential construction. Materials like copper, aluminum, glass, gypsum board, and lumber that are used in both commercial and residential construction are experiencing an even higher demand. This high demand has increased the procurement time of items form between one and two weeks to between six and eight weeks. Barton Malow has experienced difficulty in receiving full orders. The high demand has forced suppliers to deliver orders in installments. The increase in product lead time has either lengthened project schedules or increased costs in order to stay on track.

While material prices have been escalating labor costs have increased as well, which has only contributed to a higher overall building construction cost. In the past decade the construction industry has created one out of every ten new jobs. However, in recent years new employment has decreased and wages have increased. According to the AGC, in the last year alone, hourly wages have increased 4.8% and employment levels have decreased 0.2%. Most recently the residential boom has subsided. This decline in residential construction has eliminated the lower paying, unskilled job positions while boosting the higher paid, highly-skilled non-residential job positions. The economy is experiencing low levels of unemployment which will decrease the number of applicants. Recently, Baltimore in particular, has experienced a shortage of skilled masons. The shortage of apprentices in past years coupled with the retirement of the older, experienced, and highly skilled masons has left the field stagnant and non-renewable. There are few skilled workers left in the field to be teachers for entering apprentices. Not only are there fewer laborers, but the amount of work in the area has increased. This allows contracting firms to demand and to receive higher fees. In the end, the result is higher wages with lower productivity.

With the economic growth continuing to increase in the United States and Asia the high material demand will only continue to escalate. Low levels of unemployment and the retirement of the current skilled workforce will increase the scarcity of the labor force. Although there may be a few sporadic monthly lulls, overall the cost of construction will continue to escalate in future years. The volatile escalation of construction costs will make it difficult to manage project budgets over extended periods of time.

Current Strategies

Material escalation is a risk for contractors, construction managers, designers, owners and suppliers involved in the construction process. Currently, the typical way to mange this risk in our industry is to pass it on to another party. The party who is absorbing the risk usually requires monetary compensation. In the end, the owner is paying a premium for something that may never happen through a contingency or an escalated bid.

Recently, the University System of Maryland decided that Coppin State University would build a new Health and Human Services Building. An architect, Design Collective, Inc, was hired and the estimated cost of the new building was calculated. This calculated cost was then multiplied by a certain percentage for inflation. The design process continued as the University System of Maryland asked the state of Maryland for enough money to cover the estimated cost plus inflation. A construction management firm, Barton Malow Company, was hired with a soft guaranteed maximum price (GMP) contract. Barton Malow's fee for the project was established for the estimated cost of the building. After contractors were awarded the project a fixed GMP was established between the University of Maryland and Barton Malow.

The owner, University of Maryland, had already included a standard inflation multiplier in their cost estimate based on the size and duration of the project and assumed that it is enough money to cover the cost of the building. The University of Maryland passed any additional cost escalation exceeding their inflation multiplier onto the contractor who in turn passes a portion of the risk to the vendor. The contractor is expected to hold the bid price for ninety days. Some vendors/suppliers, depending on the cost volatility of the material, will only hold their price for seven days. The contractor increases the bid amount enough to cover any escalation exceeding seven days and the vendor has already included a premium for the cost escalation over the seven day period in the price given to the contractor. The owner has passed risk onto three different parties and each of these parties has demanded higher compensation to cover this risk. The actual cost of inflation and material escalation for the duration of the project may be significantly lower than the combined total the owner pays in the end. The figure below (Figure 1) depicts the events that have occurred through the bidding process.

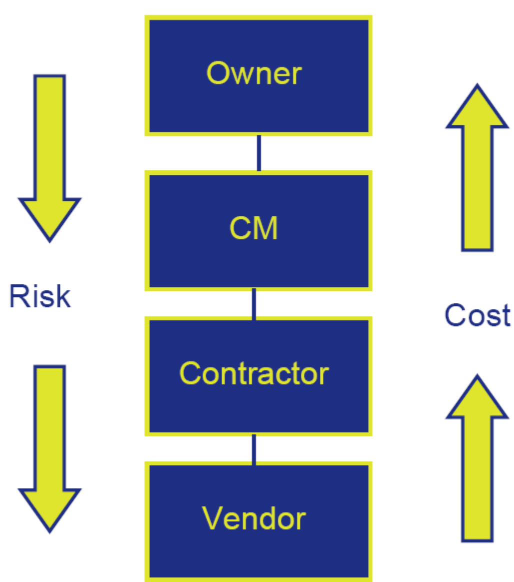


Figure 1

Conclusion & Recommendation

It is likely that the owner will end up paying significantly more money for the luxury of passing on the risk involved with material and labor escalation. The alteration of the current contractor bidding process will allow the owner to manage the risk of escalating construction costs more cost effectively. The items included in the contractor's bid price and the contractor selection process needs to change in order to allow the owner to manage this risk. The contractor should give a bid price based on the current cost of materials and labor including overhead and profit and the owner should compensate the contractor according to the actual inflated and escalated cost. The contractor should be selected through an interview process.

The contract between the owner and the contractor should specify either a given rate of material escalation per quarter or preferably a specific commodity index that will reflect the amount of increase that has occurred for the past quarter. The contractor's last pay application for that quarter should then reflect the change (increase or decrease) in material prices only for the materials purchased that quarter. The contract between the owner and the contractor should also address the increases in labor wages. Typically employees receive a raise yearly. The owner should apply the same concept for material escalation as labor wage escalation but re-evaluate the change on a yearly or bi-yearly basis rather than quarterly. This solution will allow the owner to pay the true cost of inflation and material and labor escalation which could essentially allow the owner to get more building for the same budget.

Altering the selection process of contractors will help to increase competition which will help decrease the problem of high wages with low productivity. The first step is to ensure that the designer and the construction manager complete a thorough constructability review and coordinate the documents that contractors will utilize to bid the job. A more simplistic set of documents that do not need to have additional addendums is likely to increase the number of contractors who submit a bid. An effective way to accomplish this is to involve a contractor in the constructability review. Involvement of a contractor will also ensure that the current estimate is in line with the current market. A contractor pre-qualification system should conduct a review of the contractors past projects. The contractor should be evaluated on their past performance and how it relates to the current project based on recent completion a high quality and relevant project. Once pre-qualified, the contractor will be asked to participate in an interview and to submit a fee proposal and a technical submission. The interview, the fee proposal, and the technical submission will be scored separately and then the contractor with the highest overall score will be awarded the job.

The owner does not need to be involved in the implementation of these two solutions. Involvement of the owner in these processes can be dependent on the level of experience of the owner. The construction manager should be capable of executing both solutions without the help of the owner. Alteration of the selection process of contractors will increase the quality of a project while lowering the cost.

Solar Shading Analysis

Problem

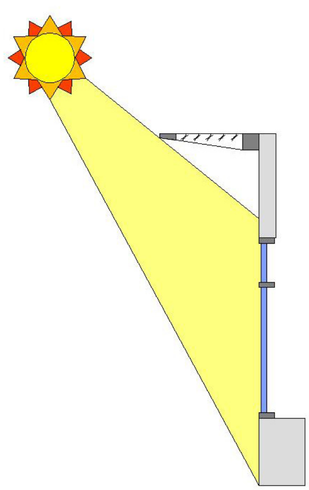
An existing sunshade runs along the perimeter of the fifth floor of the Health and Human Services Building. The current sunshade's primary function is to serve as a capitol to complete the aesthetic look that the architect is trying to achieve. The actual efficiency of the sunshade is debatable. The overhang of the sunshade is 4'-0" and it is located 4'-1 ¾" above the head of the window.

Solution

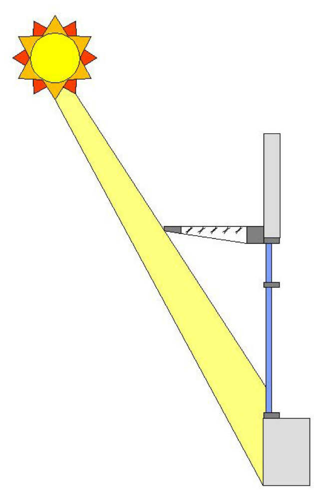
The goal of this analysis is to find the optimal length of the sunshade that will minimize the solar heat gain while minimizing the installation cost and the operating cost of the chiller. A Microsoft Excel program will be written to calculate the yearly solar gain for a building located in Baltimore, Maryland. The program will allow the user to change the height (distance above head of window) and length of the sunshade. The extended length of the overhang will create extra loading on the connection. The connection of the sunshade to the building will be analyzed to see if the additional length has an effect.

Methodology

The first step will be to lower the sunshade to the head of the window. This will allow the window to receive the most amount of shade with the same length overhang. As shown the picture below. The increased amount of shade will decrease



Sunshade at 4'-1 ¾" above Head of Window



Sunshade lowered to Head of Window

the load on the chiller. This load will be calculated in Microsoft Excel in Btu/h. Lowering the sunshade will cause the connection of the sunshade to the building to change. The sunshade will be mounted to a structural steel plate instead of the girder.

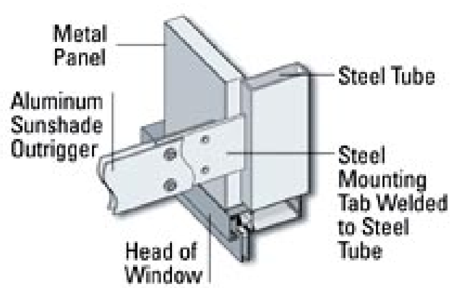
The next step will be to determine the change of solar heat gain as the length of the shade increases. A Microsoft Excel program will be written to calculate the monthly heat gain in Btu/h. The change in Btu/h of the original sunshade design will then be compared to the changed design. The change will be converted to the dollar savings for the cost of electricity. The cost savings in electricity will be compared to the cost of increasing the length of the sunshade to find the optimal length.

Resources & Tools

Dr. Moses Ling
Microsoft Excel
Sunshade Manufacturer – Construction Specialties, Inc
Sunshade Installer – AC Dellovade, Inc
Stein Reynolds – Mechanical and Electrical Equipment for Buildings *Ninth Edition*

Existing Conditions

The current sunshade is designed and produced by Construction Specialties, Inc. A steel tab is welded onto the structural steel which is provided by the steel contractor (S.A. Halac Iron Works, Inc.). A different contractor (A.C. Dellovade, Inc) installs the sunshade and the metal panels. In the connection detail provided the head of the window is located inches below the mounting of the sunshade and steel mounting tab is welded to a steel tube. The existing Health and Human Services Building's design requires the head of the window to be 4'-1 ¾" below the mounting and the steel mounting tab to be welded to a girder.



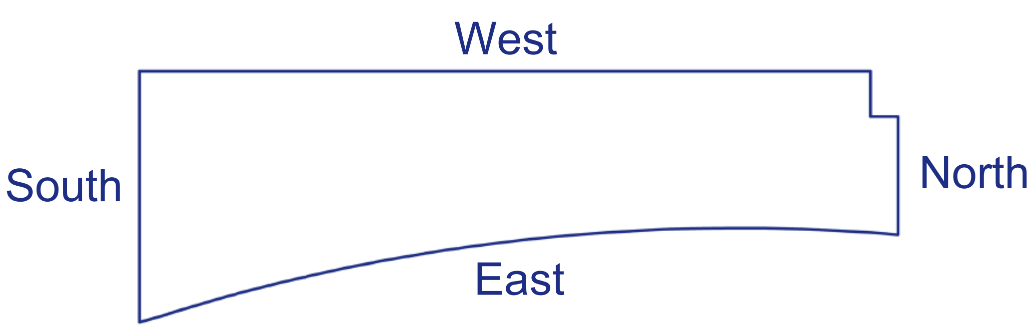
Original Design Connection Conditions

The only thing that will be changed on the sunshade with the redesign will be the length of the tapered outrigger. The current distance between outriggers is five feet. A tapered outrigger with a 4" air foil blade is used in the current design and the redesign.

Specified Outrigger and Airfoil

Installed Steel Mounting Tabs at Coppin State University Health and Human Services Building

The Health and Human Services Building's exposure is in line with the north/south axis. This means that the north side of the building faces due north. The north side of the building is always shaded. Therefore, only the east, west and south sides of the building will be considered in the re-calculation of solar gain.



Health and Human Services Building's Fifth Floor Exposure

Mechanical Impacts

Lowering the Sunshade

The only affect of moving the sunshade down 4'-1 ¾" is that it increases the amount of shade on the window. This in turn reduces the load that the chiller is required to cool. Table 1 shows the existing load in monthly increments and a yearly total. Table 2 shows the monthly and yearly total when the sun shade is lowered. Table 3 is a calculation of the difference in Btu per year. The month by month calculations can be found in Appendix B.

Table1: Existing Monthly Load

Month	Btu per Month
January	9,171,824
February	11,290,921
March	14,263,934
April	16,668,644
May	19,361,664
June	20,657,017
July	22,163,105
August	19,301,728
September	18,547,310
October	15,776,857
November	9,466,098
December	7,491,578
Total:	**184,160,679**

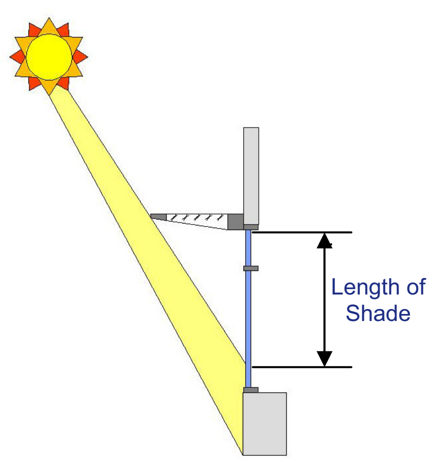
Table 2: Lowered Sunshade Monthly Load

Month	Btu per Month
January	7,068,294
February	8,293,033
March	10,217,519
April	12,269,298
May	14,496,006
June	15,572,578
July	16,679,511
August	13,533,949
September	13,680,595
October	11,807,527
November	7,278,966
December	5,849,392
Total:	**136,746,668**

Table 3: Difference in Yearly Btu from Table 1 and Table 2

Current Btu	Re-design Btu	Change in Btu
184,160,679	136,746,668	47,414,011

The azimuth, altitude, and solar heat gain factor for each solar hour during every month were taken from Reynolds' "Mechanical and Electrical Equipment for Buildings" on pages 1638 and 1648. Baltimore is located at latitude 39.18˚N so the 40˚N information was utilized. The length of shade is the vertical distance from the head of the window to the bottom of the shade projected on the window as seen below.



The length of the shade was calculated on the west and east sides of the building using the following equation:

$$\text{Length of Shade} = \tan(\text{Altitude}) \times \frac{\text{Length of Overhang}}{\cos(\text{Azimuth})}$$

The length of the shade was calculated on the south side of the building using the following equation:

$$\text{Length of Shade} = \tan(\text{Altitude}) \times \frac{\text{Length of Overhang}}{\sin(\text{Azimuth})}$$

Once the length of the shade projected onto the window was calculated the percent of glass shaded for each side was then calculated. The total horizontal linear feet for each side was calculated (Table 4) and then multiplied by the length of shade to calculate the area shaded. The shaded area was then divided by the total area to find the percentage of glass shaded.

	North	South	East	West
Height (ft)	7.33	6.83	7.33	7.33
Length (ft)	86.17	25.33	188.58	229.83
Area(ft^2)	631.89	173.11	1382.94	1685.44

Table 4: Height, Total Linear Feet and Area of Glass on 5th Floor

Solar heat gain was then calculated. All shaded areas were considered to have a heat gain of a north surface. The corresponding heat gain factor was utilized for each side. The total solar heat gain for each month was calculated for every hour using the following equation:

$$\text{Solar Heat Gain}_X \text{ (Btu)} = (1-A_{SX})A_{TX}F_X + A_{SX} A_{TX}F_N$$

Where the "X" is referring the side of the building (north, south, east and west) being calculated, A_{SX} is the percentage of shaded area for whatever side is being calculated, A_{TX} is the total area of glass for the side being calculated, F_N is the north solar heat gain factor and F_X is the solar heat gain factor for the side being calculated.

The solar heat gain calculated above was then multiplied by the solar heat gain coefficient given by the glass and the number of sunny days per month to calculate the monthly solar heat gain given in Table 1 and Table 3.

Extending the Sunshade

Extending the shade will create a longer shadow length over the window. The current length of the sunshade is four feet. The yearly Btu for each length is displayed in Table 5. The solar heat gain calculations for the increased overhang length were performed in the same way as the lowered overhang. All of the calculations in Table 5 are based on the sunshade being installed at the head of the window (a zero height above the head of the window).

Table 5: Difference in Btu/year for Different Sunshade Lengths

Length of Sunshade	Yearly Btu	Difference Between 4' and New Length (Btu)	Difference per Length Increase (Btu)
4'	136,746,668	0	0
5'	126,315,695	10,430,973	10,430,973
6'	117,007,831	19,738,837	9,307,864
7'	109,139,949	27,606,719	7,867,882
8'	102,663,315	34,083,353	6,476,634
9'	97,006,771	39,739,897	5,656,544
10'	92,129,427	44,617,241	4,877,344

Structural Impacts

Lowering the Sunshade

Currently the sunshade mounting tabs are welded to the girder. Lowering the sunshade will require a plate to be welded to the girder and the mounting tabs to be

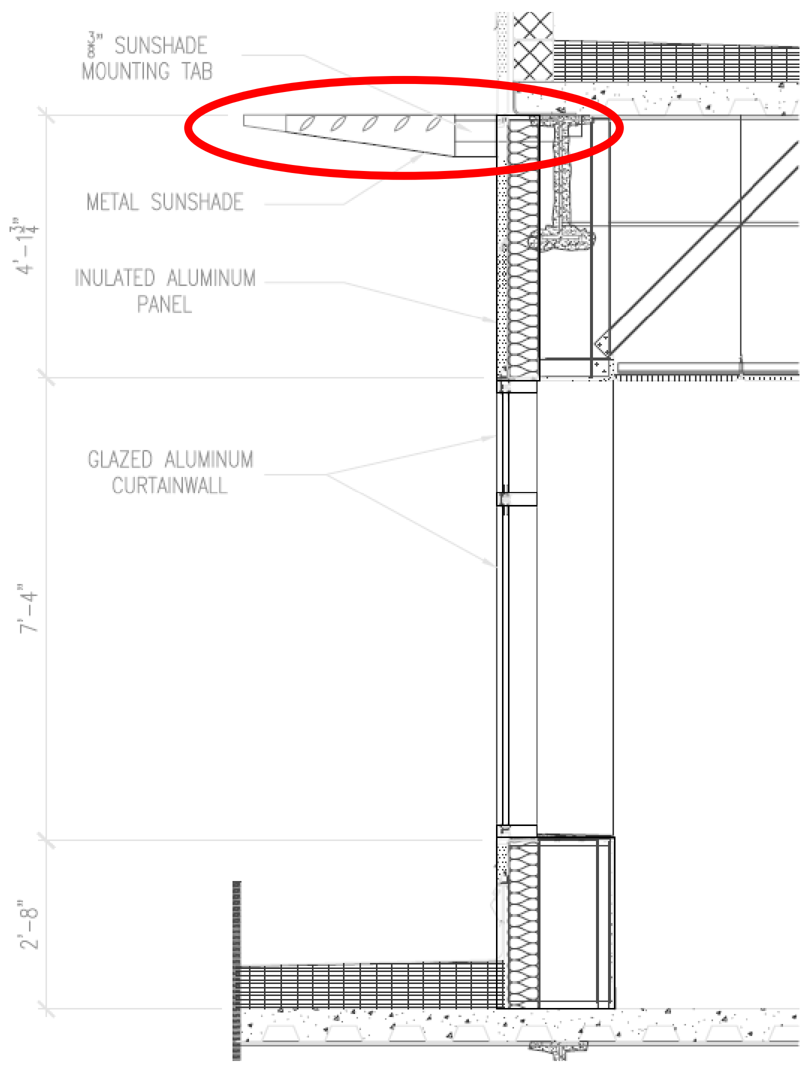


Figure1: Existing Wall Section of 5th Floor

welded to the plate. Figure 1 depicts the existing connection conditions. Figure 2 shows the redesign conditions necessary to lower the sunshade four feet. This detail will be typical around the perimeter or the 5th floor. An A36 24"x 7"x 3/8" steel plate will be welded to the girder beam directly below the original location of the mounted tab. The tabs will remain 5' on center.

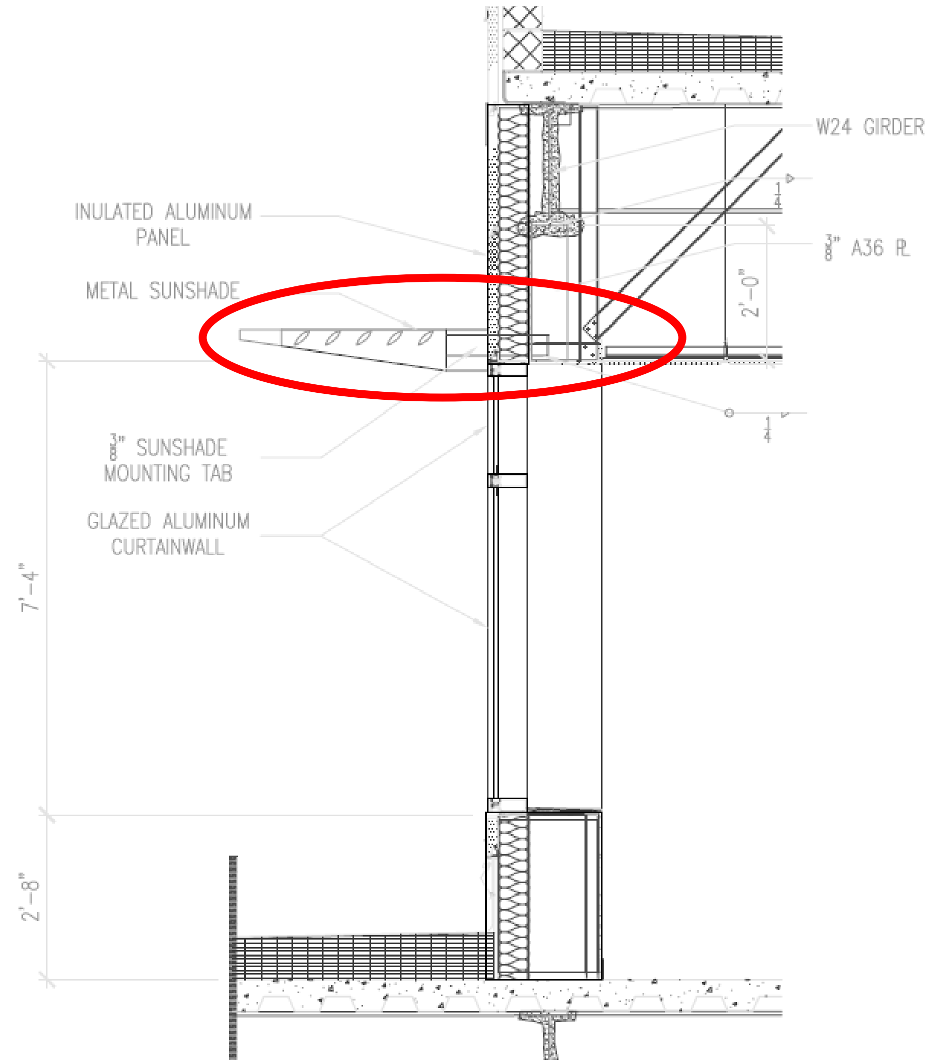


Figure 2: Redesigned Wall Section of 5th Floor

Figure 3 depicts the additional welding of the steel plate. The location of the mounting tab weld is illustrated as well.

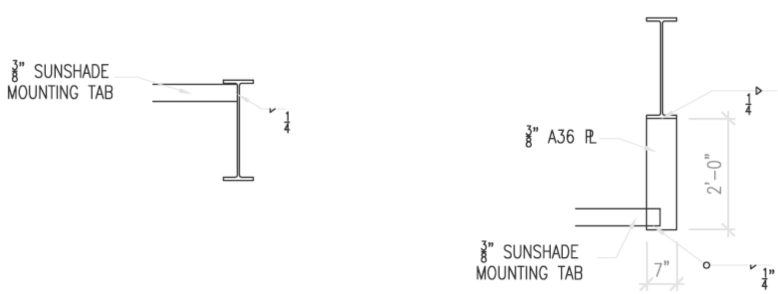


Figure 3: The left detail is the existing conditions and the right detail is the redesign conditions

Cost Analysis

The mechanical savings occur in three different ways. The cost for the amount of electricity that is saved per year, the savings from lowering the demand charge yearly and the savings for the tonnage reduction of the maximum chiller load. There are no structural savings because steel was added to the design.

Lowering the Sunshade

The electricity cost savings are depicted in Table 6 and Table 7. Table 6 calculates the change in Btu from lowering the sunshade 4'-1 ¾". The change in Btu was then divided by the chiller's coefficient of performance to change the thermal load to an electrical load. This number was then divided by 3412 Btu/kwh in order to convert from Btu to kwh. The cost was then found by multiplying by the cost of electricity which is $.0608/kwh. The savings is found to be **$141 per year**.

Table 6: Electricity Savings

Current Btu	Re-design Btu	Change in Btu	Savings
184,160,679	136,746,668	47,414,011	$141

The reduction of Btu allows the demand supply peak to be reduced as well. The difference between the lowest draw of Btu for the original and redesigned conditions was found to be 143 Btu. The decrease in Btu is converted to the number of tons consumed per year. The demand supply is lowered every month for a total of **$3,079** per year.

Table 7: Demand Savings

Current Lowest Hourly Btu	Re-design Lowest Hourly	Difference in Hourly Btu	Change in Tons Required	Demand Charge Saved
7191	7048	143	4.29	$3,079

CostWorks was used to estimate the cost per square foot for a chiller for the 5th floor space the cost was found to be $8.95 per square foot. The total amount of load saved in tons is 4.29. This was then converted to square feet using a multiplier of 450SF/ton. Then the total savings was calculated by multiplying the cost ($/SF) by the number of square feet. The calculation of this savings is depicted in Table 8.

Table 8: Tonnage Reduction Savings

Amount Saved (Tons)	Number of Square Feet per Ton	Cost ($/SF)	Total Initial Savings ($)
4.29	450	$8.95	$17,277.98

Lowering the sunshade required 156 A36 24"x 7"x 3/8" steel plates to be welded to the 5th floor girder. The volume of steel per plate was calculated in cubic feet by multiplying its dimensions. The steel fabricator, S.A. Halac, estimated an increase of 15% in the cubic footage to account for labor. The total cubic footage was then multiplied by 460 pounds per cubic foot to obtain the weight per plate of steel. The number of plates was then multiplied by the weight per plate to calculate the total weight. The total weight was then multiplied by a cost factor, provided by S.A. Halac, of $2.00/lb to find the total cost. The total cost of the additional steel including the labor to install all 156 steel plates is $6,017. Table 9 illustrates the quantities found during this calculation process.

Table 9: Structural Cost for Addition of Steel Plates

Weight of Steel (lb/ft^3)	Volume of Steel per Plate (ft^3)	15% for Labor (ft^3)	Weight per Plate (lb)	Number of Plates	Cost ($/lb)	Cost ($)
460	0.036458333	0.00546875	19.28645833	156	$2.00	$6,017.38

Table 10 provides a summary of the savings and costs from lowering the sunshade. The yearly savings is the electricity saved per year ($141) and the demand supply charge saved per year ($3,079) which totals **$3,220**. The initial cost of adding the structural steel ($6,017) and the savings in chiller tonnage ($17,278) totals for an initial savings of **$11,261**. The initial cost savings is **$14,480** and the yearly savings after that is **$3,220**.

Table 10: Total Savings from Lowered Overhang

Item	Savings
Initial One Time Tonnage Savings	$17,278
Initial One Time Steel Plate Cost	-$6,017
Electricity Savings per Year	$141
Demand Charge Savings per Year	$3,079
Total Savings ($):	**$14,480**

Extending the Sunshade

The mechanical savings per additional foot of sunshade extension are illustrated in Table 9. The electricity, demand supply savings and tonnage savings were calculated in the same way as they were for lowering the sunshade.   Savings for each length were calculated using the change in Btu for each additional length.

Table 9: Mechanical Savings for each Additional Foot of Sunshade Extension

Length of Sunshade	Yearly Btu	Difference Between 4' and New Length (Btu)	Difference per Length Increase (Btu)	Electric Cost Savings	Demand Charge	Tonnage Savings per Length Increase($)
4'	136,746,668	0	0	$141	$3,079	$17,278
5'	126,315,695	10,430,973	10,430,973	$172	$3,854	$21,628
6'	117,007,831	19,738,837	9,307,864	$200	$4,629	$25,977
7'	109,139,949	27,606,719	7,867,882	$224	$5,382	$30,206
8'	102,663,315	34,083,353	6,476,634	$243	$6,157	$34,556
9'	97,006,771	39,739,897	5,656,544	$260	$6,932	$38,906
10'	92,129,427	44,617,241	4,877,344	$274	$7,707	$43,255

The one time material and labor cost per additional foot of sunshade extension is depicted in Table 10. A cost per square foot ($41.56) for labor and materials was provided by the contractor, A.C. Dellovade.

Table 10: Cost of Material and Labor for each Additional Foot of Sunshade Extension

Sunshade Length (ft)	Area of Sunshade (SF)	Cost ($)
4'	3,188	$0
5'	4,006	$33,998
6'	4,833	$68,370
7'	5,669	$103,116
8'	6,512	$138,152
9'	7,364	$173,563
10'	8,225	$209,348

The savings per additional foot of sunshade is illustrated in Table 11. The cost of the sunshade labor and materials for the extension of the sunshade is significantly larger than the amount of savings per year. The payback period was calculated by subtracting the cost from the total savings (electric, demand charge, and total tonnage) then dividing the sum (which was negative for most lengths) by the yearly savings (electric cost plus demand charge).

Table 11: Savings per Additional Foot of Sunshade Extension

Sunshade Length (ft)	Cost ($)	Electric Cost Savings	Demand Charge	Total Initial Tonnage Savings ($)	Total Savings	Payback Period
4'	$0	$141	$3,079	$17,278	$20,497	0
5'	-$33,998	$172	$3,854	$21,628	-$8,345	2
6'	-$68,370	$200	$4,629	$25,977	-$37,564	8
7'	-$103,116	$224	$5,382	$30,206	-$67,303	12
8'	-$138,152	$243	$6,157	$34,556	-$97,196	15
9'	-$173,563	$260	$6,932	$38,906	-$127,466	18
10'	-$209,348	$274	$7,707	$43,255	-$158,112	20

Conclusion & Recommendation

Lowering the sunshade provides an initial savings and a yearly savings. However, extending the sunshade has an initial cost and a payback period. Therefore the calculations conclude that lowering the sunshade is feasible but extending the sunshade beyond five feet is unfeasible.

OVERHEAD PEDESTRIAN BRIDGE ILLUMINATION STUDY

PROBLEM

The overhead pedestrian bridge that crosses over W. North Avenue is a unique architectural feature that signifies the presence of Coppin State University in the community. The bridge connects the current campus to the new campus. Coppin State University has planned to build at a minimum four more buildings in the new part of campus in future years. The bridge will experience even more traffic once the new parking garage on the other side of the bridge is completed. The Health and Human Services Building contains outreach programs that will service the community which include a daycare center and a clinic. Currently this structure is lit in a dull industrious fashion.

SOLUTION

The goal of the lighting redesign is to create a prestigious symbol for the college. Everyone who drives down W. North Avenue will be captivated by the new lighting scheme. The bridge literally connects old campus to new campus and signifies the college's effort to rebuild the area surrounding new campus. The luminaires selected blend into the structure to hide the source of the light. The redesigned lighting scheme highlights the prominent architectural and structural features of the building while shining a beacon of light into the community.

METHODOLOGY

The fixtures and layout were chosen to produce a certain illuminance level, while accentuating the architectural features of the bridge. The illuminance levels were designed according to the IESNA Lighting Handbook, which recommends that an exterior active walkway of a building should maintain a horizontal illuminance of 5 footcandles and a vertical illuminance of 3 footcandles. These light levels are important to reach for safety, security and facial recognition. The fixtures are manually controlled and time controlled to turn on at 4 pm and off at 7am.

The new fixtures were then circuited to the respective panel board (LPN2) which is 480/277 volts. The current circuit (number 4) was then redesigned. Emergency fixtures with emergency ballasts were utilized in the redesign process the same way as the original design. The emergency ballasts have the ability to become battery operated when the power goes off. The last step was to analyze the cost and maintenance of the new design.

Resources & Tools

AGI Lighting Software
Alexis Kreft – Electrical/Lighting 5th Year Student
AutoCAD
Gardco – Fixture Manufacturer
Illumination Engineering Society of North America (IESNA) Handbook
Microsoft Excel
National Electric Code written by the National Fire Protection Agency

Lighting Impacts

Existing Conditions

The existing lighting design is depicted in Figure 1, Figure 2 and Figure 3. Forty pendant mounted fixtures are mounted in the center of the ceiling. The existing fixtures can be seen from the road below and do not highlight the truss system and the unique architecture.

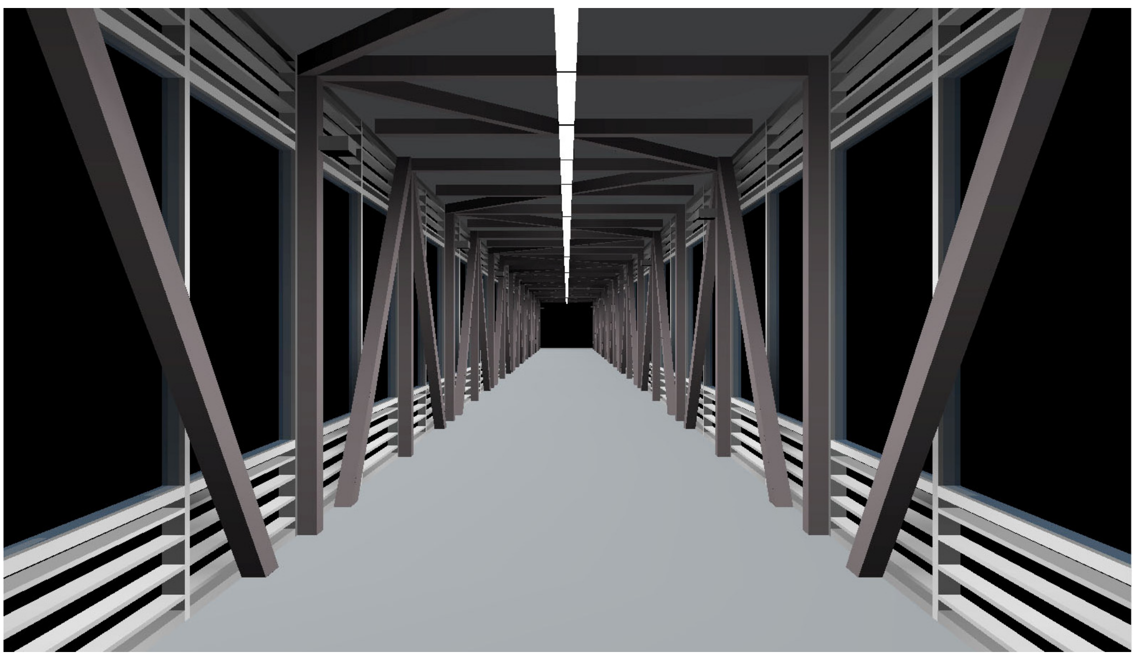


Figure 1: Interior View of Existing Lighting Design

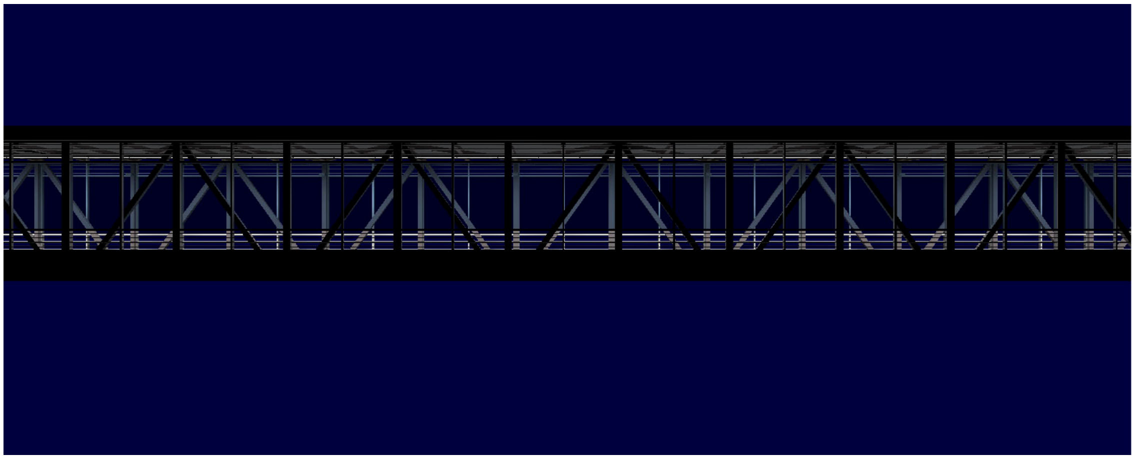


Figure 2: Exterior View of Existing Lighting Design

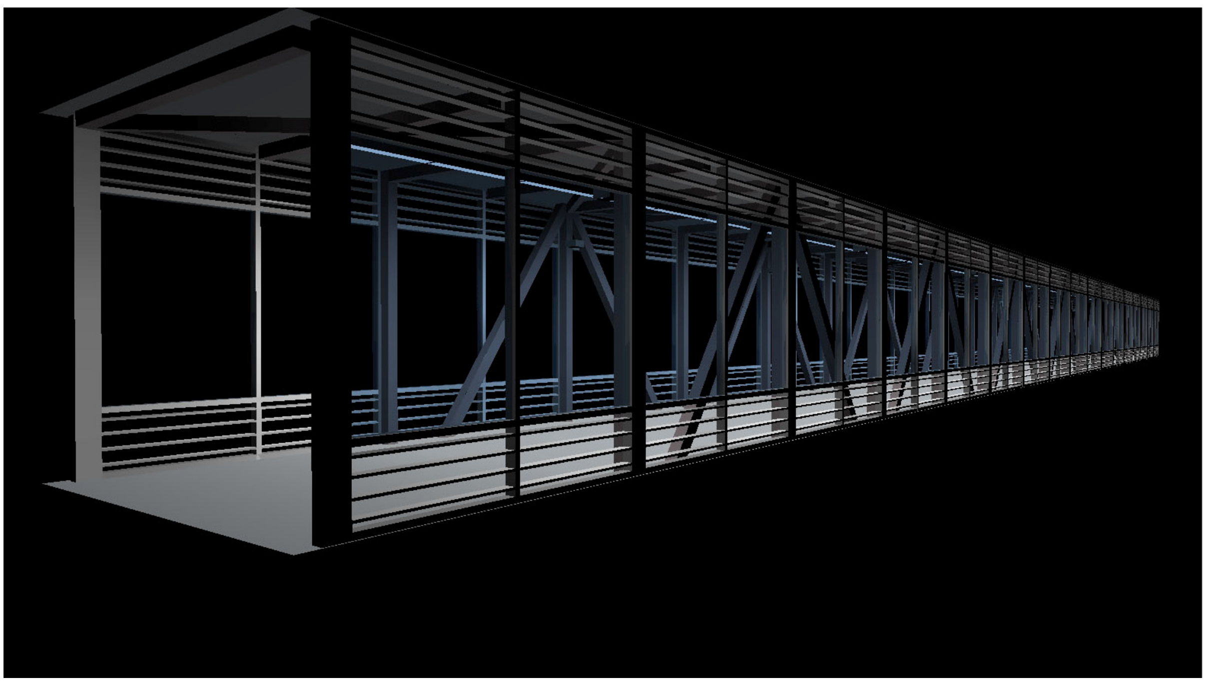


Figure 3: Exterior View of Existing Lighting Design

Figure 4 illustrates the existing illuminance levels in a pseudo color rendering. The color scale, seen on the left, represents the illuminance in footcandles. The current design focuses most of the light on the floor.

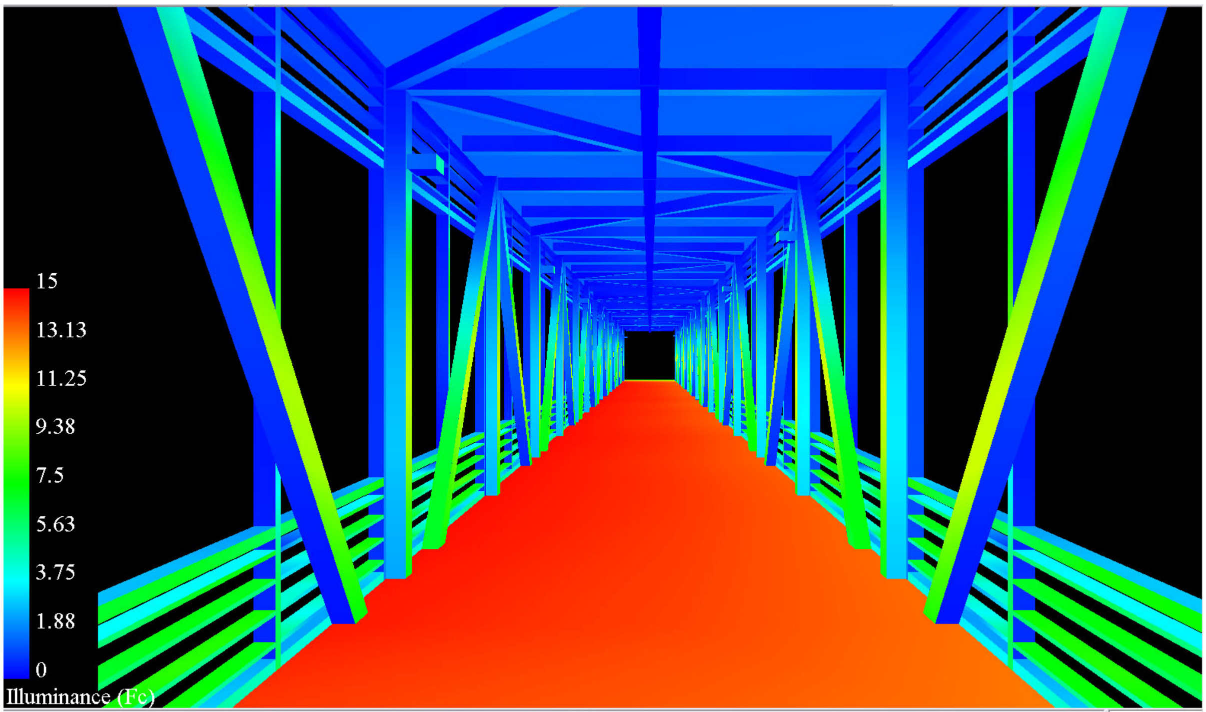


Figure 4: Interior Illuminance Levels

Redesigned Conditions

The selected fixtures were chosen because they blend into the space and provide the illusion that the source of light is unknown. From most angles the fixtures cannot be seen. In places where the fixtures can be seen, they are painted the same light gray color as the truss system. The down light in Figure 5 is mounted on the ceiling every twenty feet. Figure 6 is the up/down light mounted on the wall every ten feet on alternate sides. The cut sheets for these fixtures can be found in Appendix D. Table 1 provides the details of each fixture. Figure 7, Figure 8, and Figure 9 illustrate the new design of the bridge.

Figure 5: Down Light

Figure 6: Up/Down Light

Table 1: Light Fixture Schedule

Label	Description	Catalogue NO.	Lamp			Ballast		Voltage	Fixture Qty.
			NO.	Type	Watts	Type	Lamps		
FF-1	Diecast Aluminum, Ceiling Surface Mounted Downlight	Gardco Lighting-300/O/CR/50MH/277/NP	1	50W MH	50W	Electronic	1	277	7
FF-2	Diecast Aluminum, Wall Surface Mounted Downlight	Gardco Lighting-301/O/W/50MH/277/NP	1	50W MH	50W	Electronic	1	277	16

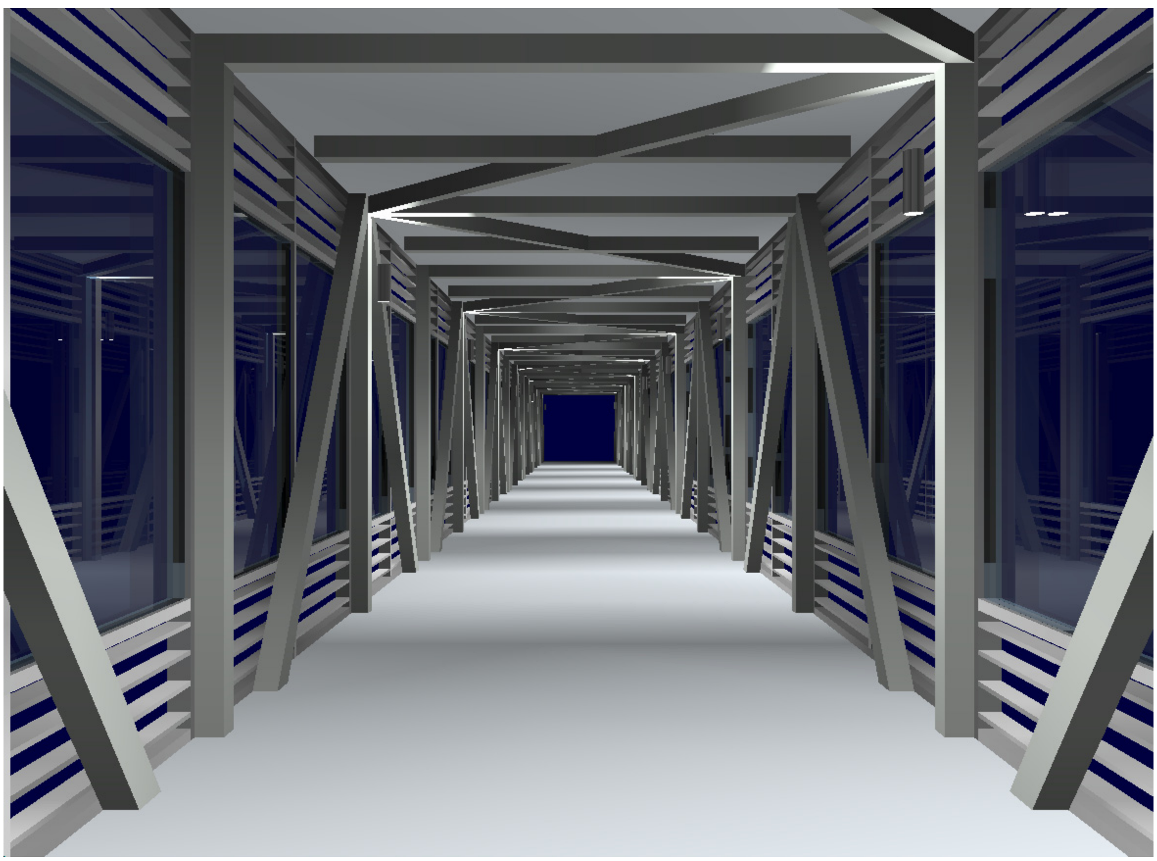


Figure 7: Interior View of Redesigned Lighting Scheme

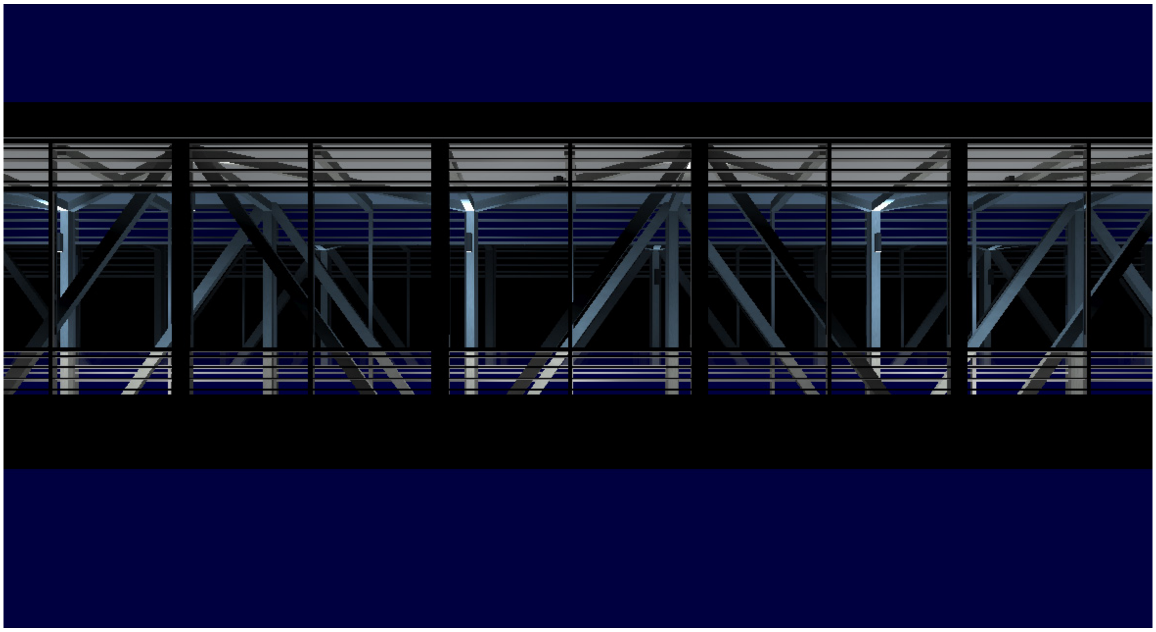


Figure 8: Exterior View of Redesigned Lighting Scheme

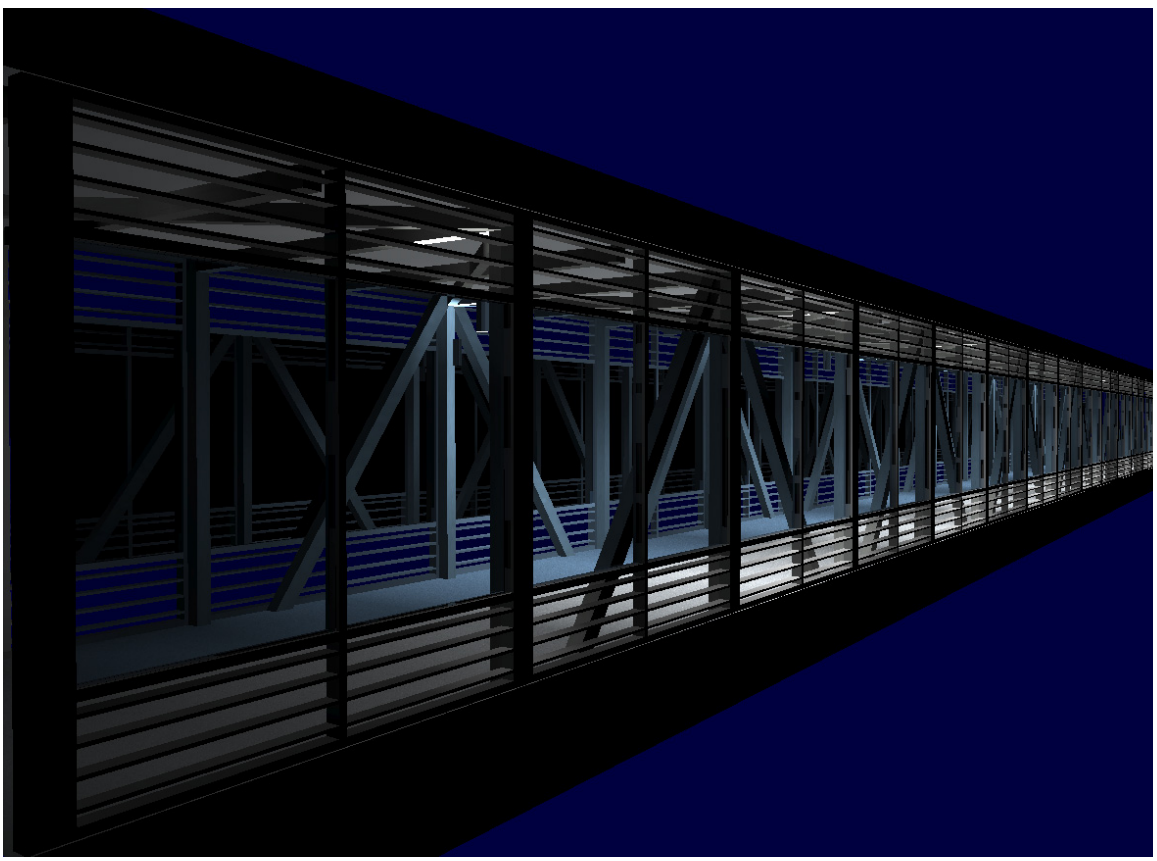


Figure 9: Exterior View of Redesigned Lighting Scheme

Figure 10 illustrates the redesigned illuminance levels in a pseudo color rendering. The color scale, seen on the left, represents the illuminance in footcandles. The redesigned space highlights the structure of the bridge. The average illuminance value is 6.18 footcandles with a maximum value of 11.6 footcandles.

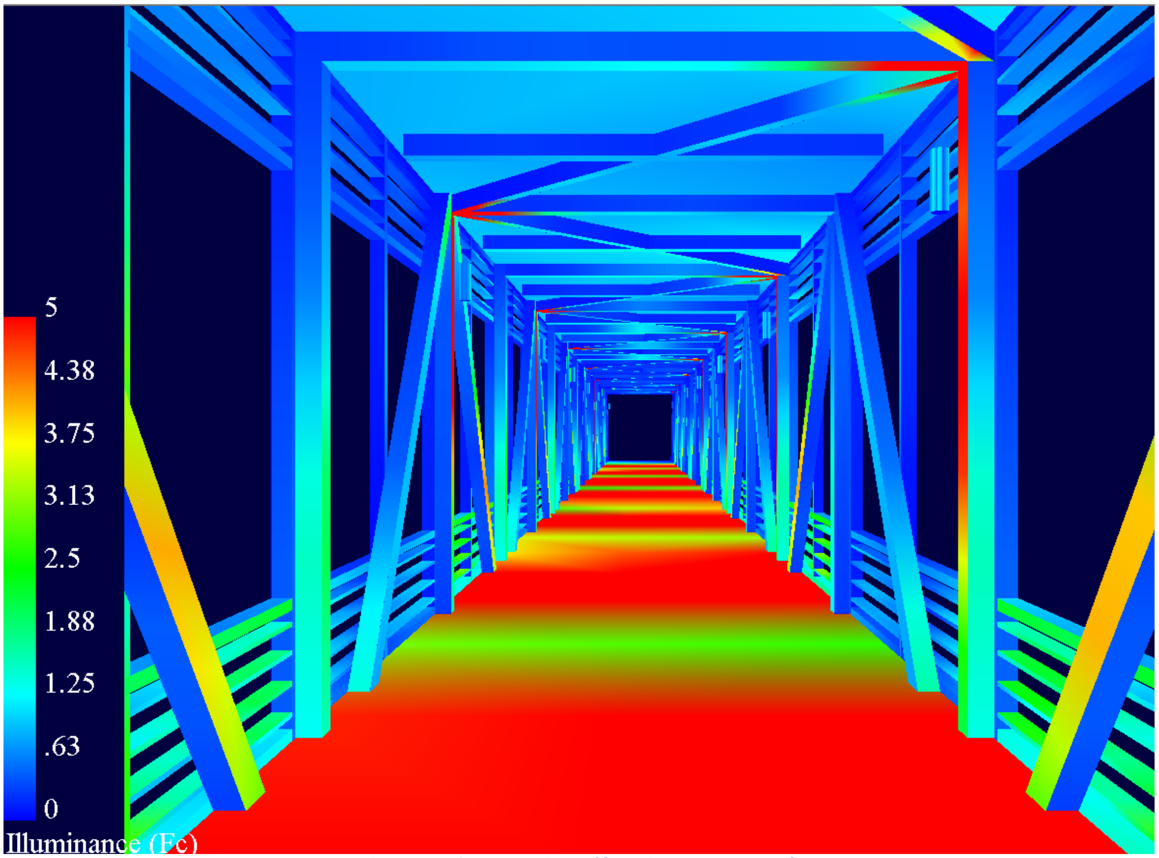


Figure 10: Interior Illuminance Levels

Calculation Points

Light Loss Factors

In order to produce an accurate pseudo color rendering (Figure 10) in AGI light loss factors (LLF) need to be taken into consideration for each fixture. Table 2 illustrates the LLF for each luminaire.

Table 2: Calculated Light Loss Factors

Luminaire Label	Maintenance Category	LLD	LDD	RSDD	BF	Total LLF
FF-1	IV	0.7	0.85	-	0.98	0.5831
FF-2	III	0.7	0.88	-	0.98	0.60368
Assume : 24 month cleaning interval and a clean environment.						

Power Density

ASHRAE 90.1 recommends an allowable power density for active building entrances to be less than or equal to $3W/ft^2$. The power density of the redesigned bridge is 0.586 W/ft^2 which is 80% below the allowable. Table 3 depicts calculation of the redesigned power density.

Table 3: Power Density of Redesign

Label	Qty	Watts	Total Watts
FF-1	7	52	364
FF-2	16	52	832
		Total:	1196
		Sq Ft:	2040
		Power Density:	**0.586275**

Electrical Impacts

After redesigning the lighting layout, the new electrical system had to be taken into consideration. The lighting was circuited to panel board LPN2. Circuit 4 ,a 20A single pole 277V system, was then redesigned. According to National Electric Code (NEC) a 20A single pole should only be circuited to 80% of its maximum ampacity. Therefore, only 16A should be on one circuit. In order to calculate the allowable total wattage on one circuit the following equation was used.

16A x 277V x 1 (Power Factor) x 0.8 (for growth) = 3,600 Watts

The total wattage for all luminaires was found to be 1,196 watts. This was found by multiplying the number of fixtures (23) by the amount of watts (52). Since 1,196 watts is less than 3,600 watts all of the fixtures can be circuited together. Figure 11 is a panel board displaying the new lighting load on circuit 4. The circuit breaker is 30A and the feeder requires (3) #10 wires in ¾" rigid PVC conduit. The main distribution feeder was sized for an over-current protection device based on design load from panel. The circuited layout plan of the bridge is depicted in Figure 12.

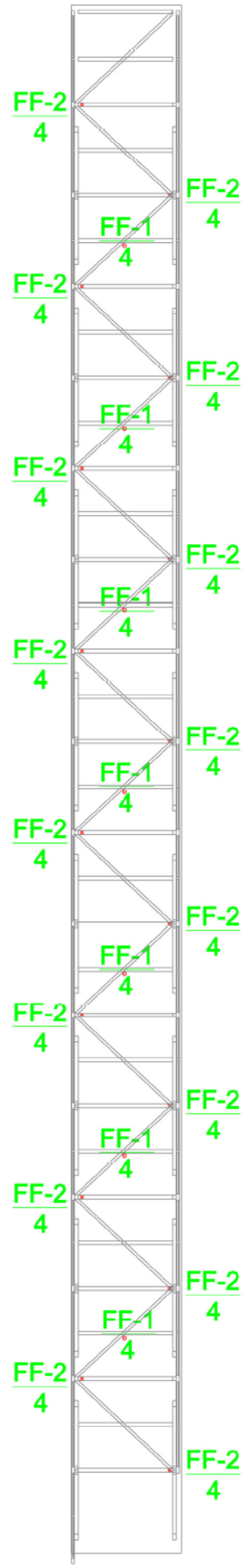
PANELBOARD SCHEDULE

VOLTAGE: 480Y/277V,3PH,4W SIZE/TYPE BUS: 150A SIZE/TYPE MAIN: 150A/3P C/B	PANEL TAG: LPN2 PANEL LOCATION: Room 212 PANEL MOUNTING: SURFACE	MIN. C/B AIC: 10K OPTIONS: PROVIDE FEED THROUGH LUGS FOR PANELBOARD 1L1B

DESCRIPTION	LOCATION	LOAD (WATTS)	C/B SIZE	POS. NO.	A	B	C	POS. NO.	C/B SIZE	LOAD (WATTS)	LOCATION	DESCRIPTION
Lighting	Offices	2900	20A/1P	1	*			2	20A/1P	1800	Corridor	Lighting
Lighting	Offices	2100	20A/1P	3		*		4	20A/1P	1196	Bridge	Lighting
Lighting	Exterior	500	20A/1P	5			*	6	20A/1P	1100	Cove	Lighting
Lighting	Control Panel	2900	20A/1P	7	*			8	20A/1P	0	0	Lighting
Lighting	Control Panel	2900	20A/1P	9		*		10	20A/1P	0		
Spare		0	20A/1P	11			*	12	20A/1P	0		
Spare		0	20A/1P	13	*			14	20A/1P	0		
Spare		0	20A/1P	15		*		16	20A/1P	0		
Spare		0	20A/1P	17			*	18	20A/1P	0		
Spare		0	20A/1P	19	*			20	20A/1P	0		
Spare		0	20A/1P	21		*		22	20A/1P	0		
Spare		0	20A/1P	23			*	24	20A/1P	0		
Spare		0	20A/1P	25	*			26	20A/1P	0		
Spare		0	20A/1P	27		*		28	20A/1P	0		
Spare		0	20A/1P	29			*	30	20A/1P	0		
Spare		0	20A/1P	31	*			32	20A/1P	0		
Spare		0	20A/1P	33		*		34	20A/1P	0		
Spare		0	20A/1P	35			*	36	20A/1P	0		
Spare		0	20A/1P	37	*			38	20A/1P	0		
Spare		0	20A/1P	39		*		40	20A/1P	0		
Spare		0	20A/1P	41			*	42	20A/1P	0		

CONNECTED LOAD (KW) - A	7.60	TOTAL DESIGN LOAD (KW)	23.09
CONNECTED LOAD (KW) - B	6.20	POWER FACTOR	1.00
CONNECTED LOAD (KW) - C	1.60	TOTAL DESIGN LOAD (AMPS)	28

Figure 12: Circuited Layout Plan of Bridge



Conclusion & Recommendation

It is recommended that the redesigned lighting scheme be utilized for the overhead pedestrian bridge at Coppin State University. The redesigned power density is slightly lower than original design's power density so the cost of electricity for lighting the bridge will remain the same. Although the exact costs of the existing and redesigned fixtures could not be determined the number of fixtures is reduced from 40 to 23. The added benefit of creating an architectural feature that symbolizes the college's community service greatly outweighs any costs that will be incurred.

Additional Possible Analysis

Unitized Glazing System

Problem

The exterior skin system consists of masonry, metal panels, glass curtain wall, and glass storefront. Most of the masonry applications are with CMU back-up. There is a sunshade surrounding the building and the roof consists of three different types of material – EPDM, built-up and metal panel. The numerous materials cause multiple interfaces with difficult connection details. The building is stick built which can cause quality issues. Facades are vital for keeping water out of the building.

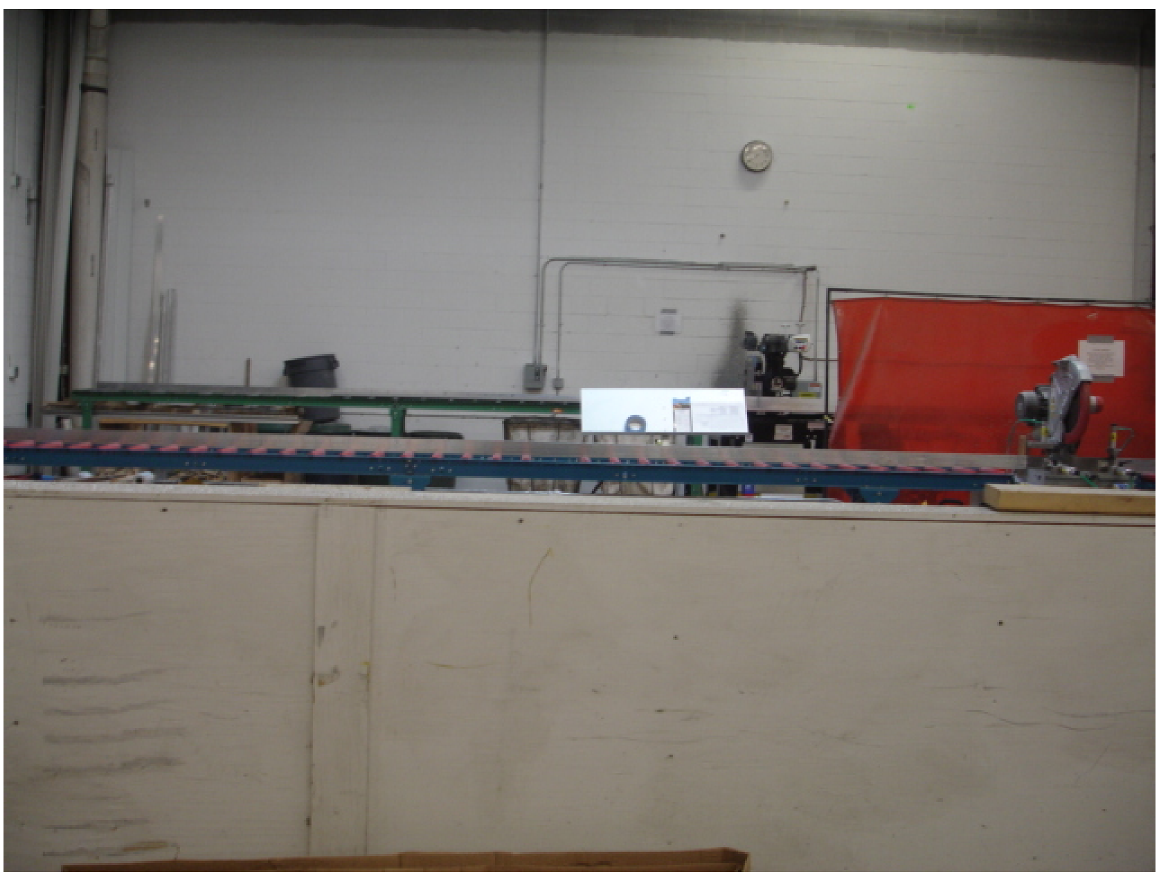
Goal

The goal is to redesign the building envelope to improve the constructability and quality of the glass curtain wall using a unitized system. The unitized glass system will provide a better quality because all conditions are controlled in a factory however it requires a longer lead time. Once the unitized panels are on site they can be installed very quickly. A mock up of the system would also be beneficial for identifying key areas where the design needs improvement.

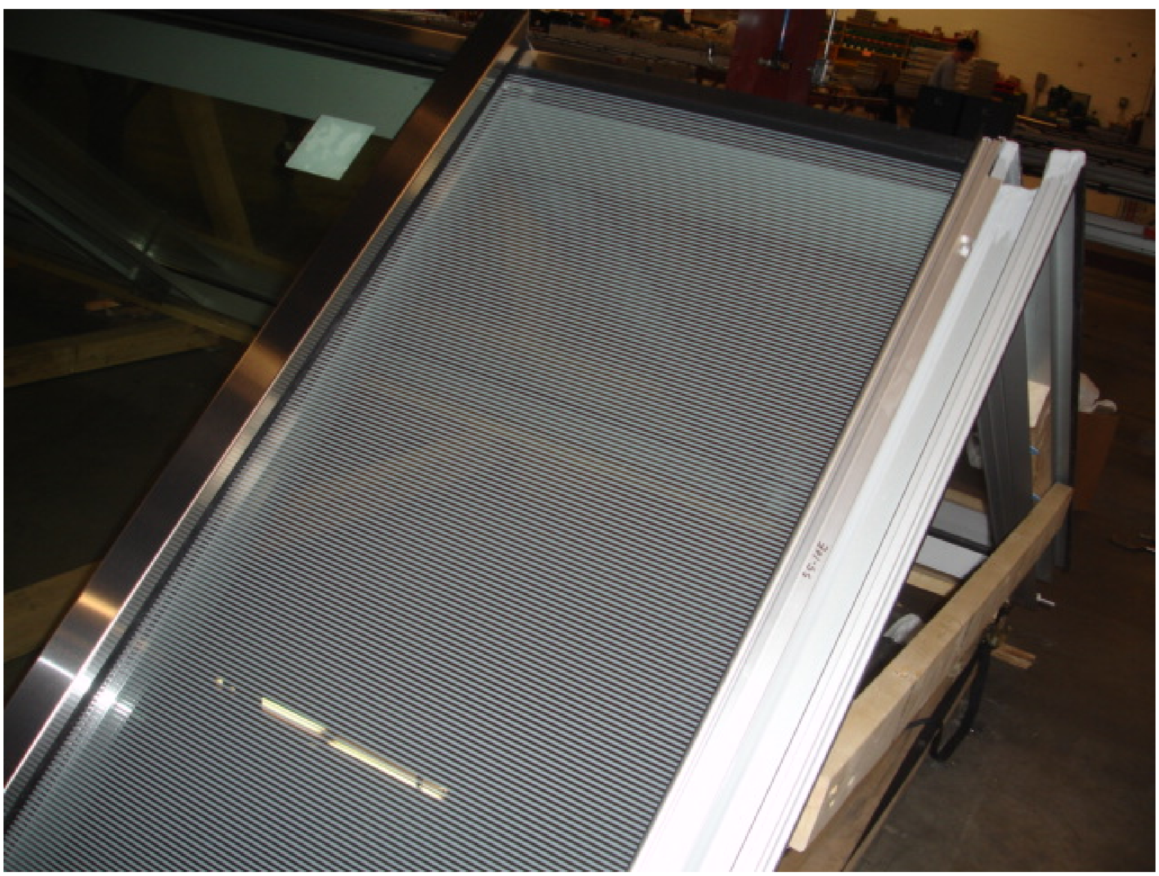
Research

A visit to Harmon, Inc was made to view the process of fabricating a unitized system. Implementation of the unitized glazing system will impact the schedule. The length of on site construction is dramatically decreased but the lead time is significantly increased. The quality of the window is increased because all conditions are controlled in the factory.

This analysis was not comprehensive enough for a structural breadth because the same materials in both the stick built system and the unitized system. The weight of the façade remains the same. Therefore, there is no change in loading to analyze. Pictures from the visit to Harmon, Inc are provided on pages 44-49.




HARMON



SUMMARY AND CONCLUSIONS

The critical industry issue affecting the Health and Human Services Building at Coppin State University is the volatility of escalating construction costs. The risk associated with the escalation of construction costs has been analyzed by interviewing contractors, construction managers, designers and owners regarding the current strategies of managing this risk. Through the interview process it was found that some risk is passed to each party starting with the owner and ending with the vendor. As the risk is passed costs are increased to compensate for the escalation of material and labor costs. In the end, the owner pays a premium for cost escalation that may never occur. The proposed solution is for the owner to control more of the risk and implement changes in the contractor's procurement and bid process.

The first technical analysis examines the affects of lowering and extending the 5^{th} floor's existing sunshade. Lowering the sunshade to the head of the window and extending the sunshade beyond its current length of four feet increases the percentage of shaded glazing which in turn decreases the amount of solar heat gain. The structural connection of the sunshade to the building needs to be altered to accommodate the lower sunshade. It was found that a total of 30,008 pounds of steel needs to be added to the building in the form of 156 steel plates to support the lowered sunshade. The first year's mechanical savings from lowering the sunshade totals $20,498 and decreases to a yearly savings of $3,220 for every year succeeding the first. The one time initial cost of the addition of steel is $6,017. The extension of the sunshade beyond five feet requires a payback period of eight years due to the additional costs of material and labor. It is recommended that the sunshade be lowered to the head of the window and left at its current overhang length of four feet.

The second technical analysis alters the lighting scheme of the overhead pedestrian bridge that spans W. North Avenue and connects the college's current campus to its new campus. The bridge is a unique architectural feature that signifies the presence of Coppin State University in the community. The Health and Human Services Building contains outreach programs that will service the community which include a daycare center and a clinic. The redesigned lighting scheme highlights the prominent architectural and structural features of the bridge while shining a beacon of light into the community.

APPENDIX A

DETAILED PROJECT SCHEDULE

Activity ID	Activity Description	Orig Dur
1000	Schematic Design Development	83
0900	Ownership of All Homes	382
1005	Delay In Schematic Design	184
1006	A/E Remobilizes Team and	1
1007	Schematic Design Development -	50
1010	SD University/Coppin Review &	10
1020	Schematic Design Estimate	10
1025	SD Constructability Review	1
1030	SD Estimate	1
1045	Receive Authorization from	1
1050	Design Development Documents	77
0950	Closure of Whitmore Avenue	174
1060	DD University/ Coppin Review &	10
1070	Design Development Estimate	15
1075	DD Constructability Review	10
1080	DD Estimate Review/	5
1090	Receive Authorization from	0
1055	Sediment/Erosion Control &	1
1100	50% Construction Documents	54
1091	Receive 100% Civil Documents	0
1110	50% CD University/ Coppin	15
1120	50% CD Estimate	15
1125	50% CD Constructability Review	10
1105	A/E Bid Package 1-Demo, Site,	12
1150	CSU/UMB/BMC Review - A/E	10
1130	50% CD Estimate Review	2
1140	Receive Authorization from	0
1160	95% Construction Documents	47
1255	Receive Bid Pack #1 Documents	0
1256	Bid Pack#1/ GMP Preparation	25
1257	GMP #1 Review	10
1250	Submit For Franchise Agreement	135
1258	GMP #1 - Approval- "Letter of	1
1280	Constructoin Substructure	60
1170	95% CD University/ Coppin	15
1180	95% CD Estimate	15
1185	95% CD Constructability Review	10
1097	Recieve Sediment/Erosion	0
1190	95% CD Estimate Review	3

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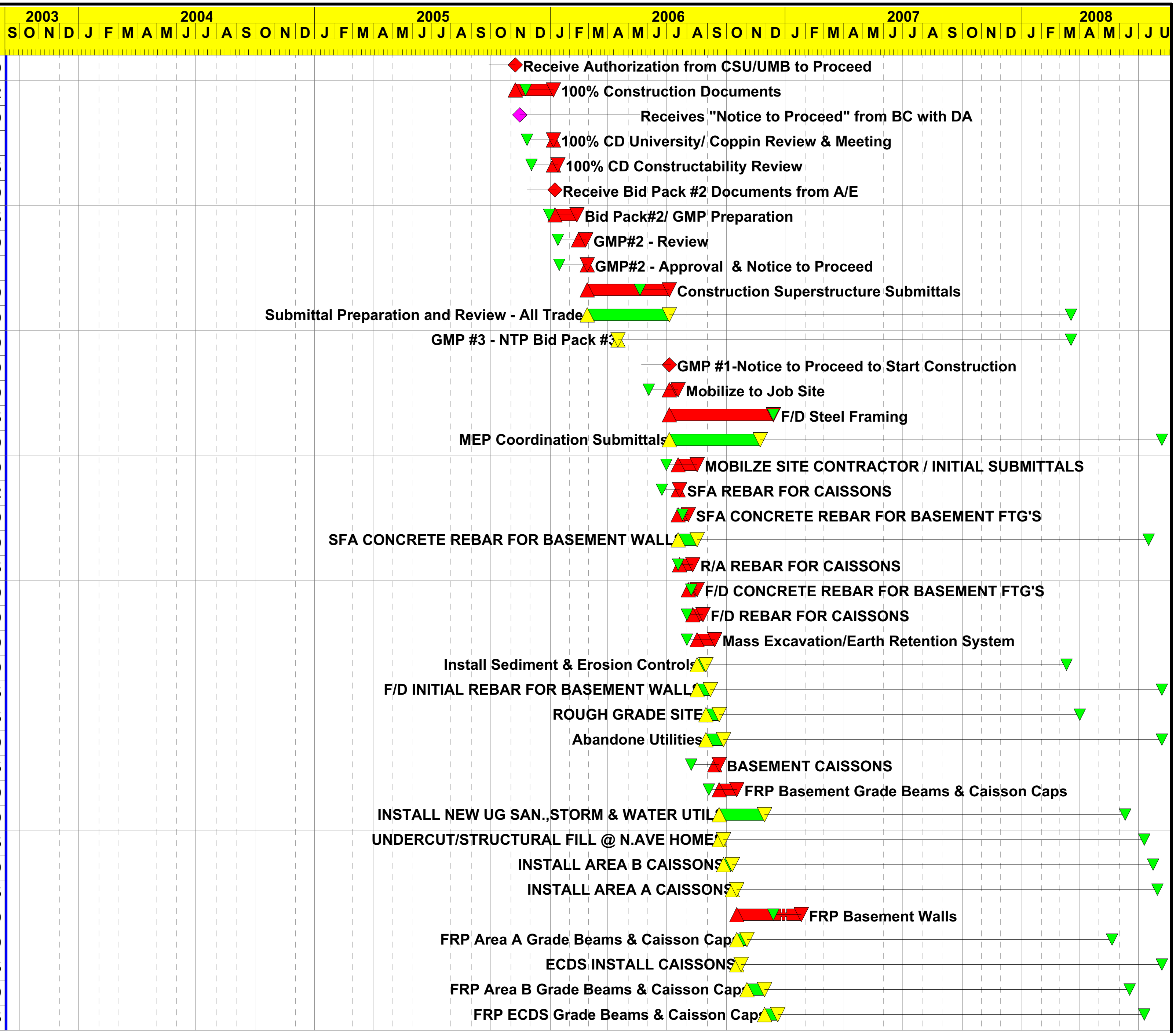
Finish Date	06AUG08	Float Bar	Sheet 1 of 5
Data Date	09SEP03	Progress Bar	Barton Malow Company
Run Date	30OCT06 20:08	Critical Activity	CSC Health & Human Service Building
			Classic Schedule Layout

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur
1200	Receive Authorization from	0
1220	100% Construction Documents	42
1098	Receives "Notice to Proceed"	0
1230	100% CD University/ Coppin	1
1240	100% CD Constructability Review	5
1490	Receive Bid Pack #2 Documents	0
1491	Bid Pack#2/ GMP Preparation	25
1492	GMP#2 - Review	10
1493	GMP#2 - Approval & Notice to	1
1290	Construction Superstructure	90
1295	Submittal Preparation and	90
1300	GMP #3 - NTP Bid Pack #3	0
1269	GMP #1-Notice to Proceed to	0
1270	Mobilize to Job Site	10
1370	F/D Steel Framing	115
1296	MEP Coordination Submittals	100
2010	MOBILZE SITE CONTRACTOR /	20
100	SFA REBAR FOR CAISSONS	2
110	SFA CONCRETE REBAR FOR	10
120	SFA CONCRETE REBAR FOR	20
104	R/A REBAR FOR CAISSONS	15
118	F/D CONCRETE REBAR FOR	10
108	F/D REBAR FOR CAISSONS	10
2070	Mass Excavation/Earth Retention	20
2030	Install Sediment & Erosion	10
128	F/D INITIAL REBAR FOR	15
2080	ROUGH GRADE SITE	15
2040	Abandone Utilities	20
2500	BASEMENT CAISSONS	5
1310	FRP Basement Grade Beams &	20
2090	INSTALL NEW UG SAN.,STORM	50
2055	UNDERCUT/STRUCTURAL FILL	5
2520	INSTALL AREA B CAISSONS	10
2510	INSTALL AREA A CAISSONS	5
1320	FRP Basement Walls	70
1330	FRP Area A Grade Beams &	10
4500	ECDS INSTALL CAISSONS	5
1340	FRP Area B Grade Beams &	20
1350	FRP ECDS Grade Beams &	15



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CRI2 Sheet 2 of 5

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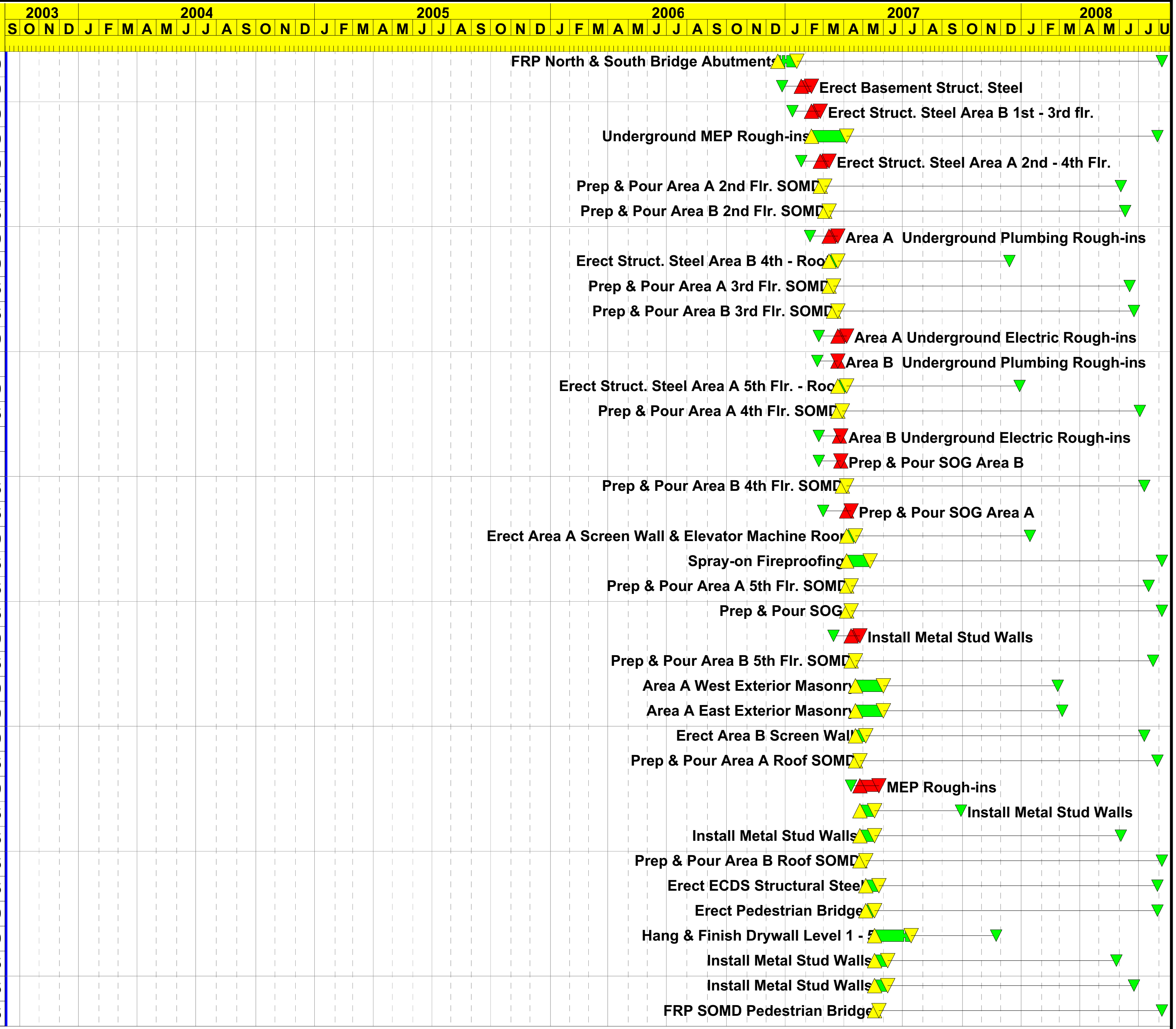
CSC Health & Human Service Building

Classic Schedule Layout

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur
1360	FRP North & South Bridge	20
1380	Erect Basement Struct. Steel	10
1390	Erect Struct. Steel Area B 1st -	10
1550	Underground MEP Rough-ins	40
1400	Erect Struct. Steel Area A 2nd -	10
1500	Prep & Pour Area A 2nd Flr.	5
1540	Prep & Pour Area B 2nd Flr.	5
1460	Area A Underground Plumbing	10
1410	Erect Struct. Steel Area B 4th -	10
1830	Prep & Pour Area A 3rd Flr.	5
1840	Prep & Pour Area B 3rd Flr.	5
1470	Area A Underground Electric	10
1510	Area B Underground Plumbing	1
1420	Erect Struct. Steel Area A 5th Flr.	10
1850	Prep & Pour Area A 4th Flr.	5
1520	Area B Underground Electric	1
1530	Prep & Pour SOG Area B	1
1860	Prep & Pour Area B 4th Flr.	5
1480	Prep & Pour SOG Area A	5
1430	Erect Area A Screen Wall &	10
1920	Spray-on Fireproofing	25
1870	Prep & Pour Area A 5th Flr.	5
1560	Prep & Pour SOG	5
1930	Install Metal Stud Walls	10
1880	Prep & Pour Area B 5th Flr.	5
1580	Area A West Exterior Masonry	30
1570	Area A East Exterior Masonry	30
1440	Erect Area B Screen Wall	10
1890	Prep & Pour Area A Roof SOMD	5
1940	MEP Rough-ins	20
2000	Install Metal Stud Walls	15
4530	Install Metal Stud Walls	15
1900	Prep & Pour Area B Roof SOMD	5
1450	Erect ECDS Structural Steel	15
1730	Erect Pedestrian Bridge	10
1950	Hang & Finish Drywall Level 1 - 5	40
4550	Install Metal Stud Walls	15
4570	Install Metal Stud Walls	15
1740	FRP SOMD Pedestrian Bridge	5



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CRI2 — Sheet 3 of 5

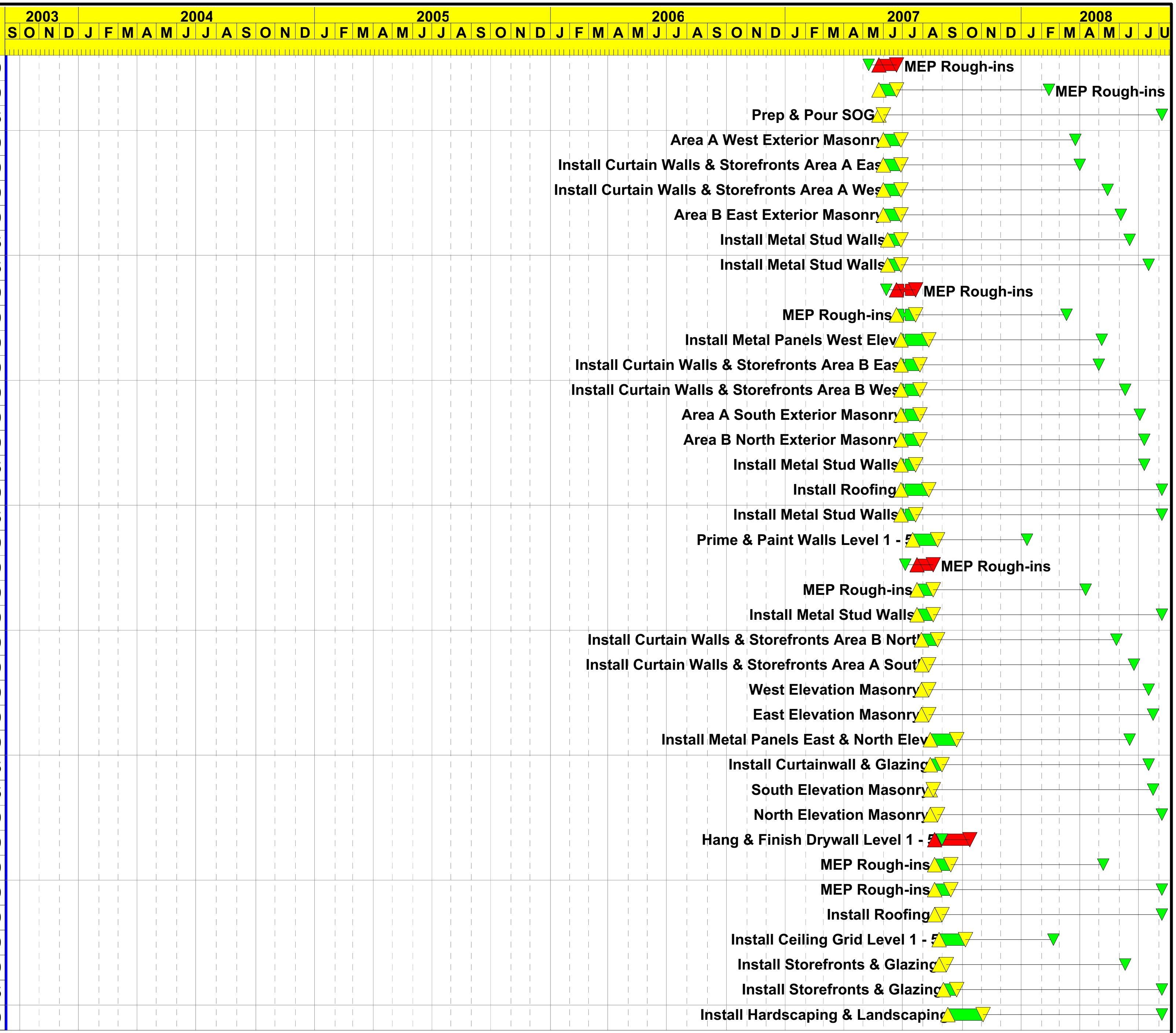
Barton Malow Company

CSC Health & Human Service Building

Classic Schedule Layout

Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur
4540	MEP Rough-ins	20
2020	MEP Rough-ins	20
1910	Prep & Pour SOG	5
1600	Area A West Exterior Masonry	20
1630	Install Curtain Walls & Storefronts	20
1640	Install Curtain Walls & Storefronts	20
1590	Area B East Exterior Masonry	20
4590	Install Metal Stud Walls	15
4610	Install Metal Stud Walls	15
4580	MEP Rough-ins	20
4560	MEP Rough-ins	20
1700	Install Metal Panels West Elev.	30
1650	Install Curtain Walls & Storefronts	20
1660	Install Curtain Walls & Storefronts	20
1620	Area A South Exterior Masonry	20
1610	Area B North Exterior Masonry	20
4650	Install Metal Stud Walls	15
1690	Install Roofing	30
4630	Install Metal Stud Walls	15
1960	Prime & Paint Walls Level 1 - 5	30
4620	MEP Rough-ins	20
4600	MEP Rough-ins	20
4670	Install Metal Stud Walls	20
1670	Install Curtain Walls & Storefronts	20
1680	Install Curtain Walls & Storefronts	10
1750	West Elevation Masonry	10
1760	East Elevation Masonry	10
1710	Install Metal Panels East & North	30
4520	Install Curtainwall & Glazing	15
1780	South Elevation Masonry	5
1770	North Elevation Masonry	10
2050	Hang & Finish Drywall Level 1 - 5	40
4660	MEP Rough-ins	20
4640	MEP Rough-ins	20
1790	Install Roofing	10
1970	Install Ceiling Grid Level 1 - 5	30
4510	Install Storefronts & Glazing	10
1800	Install Storefronts & Glazing	15
2210	Install Hardscaping &	40



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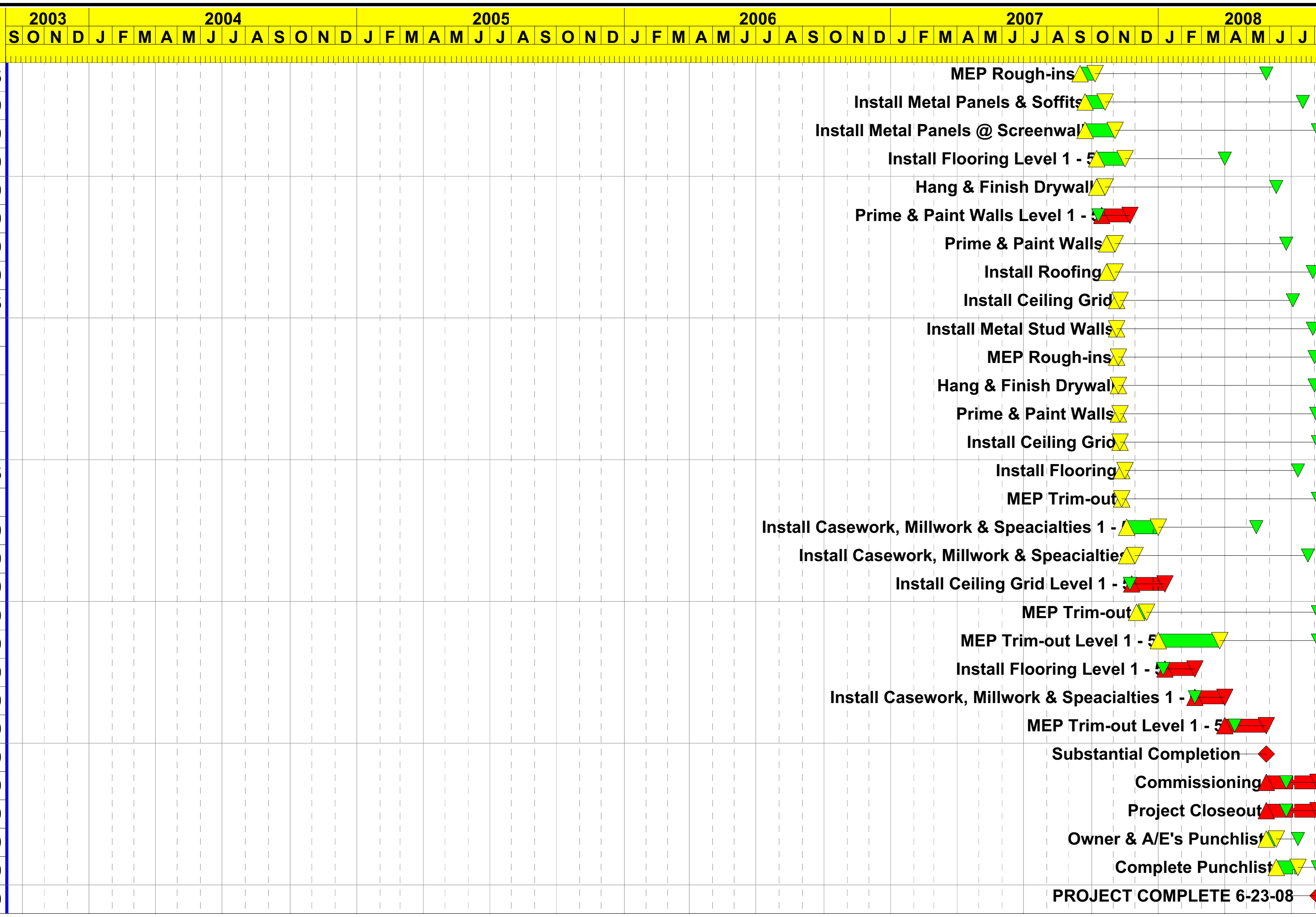
Date	Revision	Checked	Approved

Activity ID	Activity Description	Orig Dur
4680	MEP Rough-ins	15
1810	Install Metal Panels & Soffits	20
1720	Install Metal Panels @	30
2140	Install Flooring Level 1 - 5	30
4690	Hang & Finish Drywall	10
2060	Prime & Paint Walls Level 1 - 5	30
4700	Prime & Paint Walls	10
1820	Install Roofing	10
4710	Install Ceiling Grid	5
2150	Install Metal Stud Walls	1
2160	MEP Rough-ins	1
2170	Hang & Finish Drywall	1
2190	Prime & Paint Walls	1
2180	Install Ceiling Grid	1
4720	Install Flooring	5
2200	MEP Trim-out	1
1980	Install Casework, Millwork &	30
4730	Install Casework, Millwork &	10
2100	Install Ceiling Grid Level 1 - 5	30
4740	MEP Trim-out	10
1990	MEP Trim-out Level 1 - 5	60
2130	Install Flooring Level 1 - 5	30
2110	Install Casework, Millwork &	30
2120	MEP Trim-out Level 1 - 5	40
40000	Substantial Completion	0
40050	Commissioning	50
50000	Project Closeout	50
40100	Owner & A/E's Punchlist	10
40500	Complete Punchlist	20
51000	PROJECT COMPLETE 6-23-08	0



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Barton Malow Company

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APPENDIX B

INTERVIEW MATERIAL

Cover letter
Survey Questions
Interview Notes

Management of the Risk Associated with Material Cost Escalation

My name is Corinne Ambler and I am currently a senior architectural engineering student at The Pennsylvania State University. I am pursing a bachelor degree in the construction management option; one of the requirements is to perform a senior capstone project that relates to a current construction project.

The construction project that my thesis focuses on is a five-story academic facility for Coppin State University located in Baltimore, Maryland. The project had some difficulties with material escalation especially because Hurricane Katrina hit during the bidding of the project. I am expanding my research to include the entire industry.

The goal of this research project is to address the following questions:

1. How can owners, designers, construction managers, and contractors manage the risk of volatile materials?
2. How will using alternate materials impact the construction process?

After analyzing the answers of the four different parties, I will propose a tool that will allow each party to evaluate the risk associated with the use of each volatile material in the project.

By responding, I would like to schedule a thirty-minute phone conversation to discuss this study. Please let me know your availability. Thank you in advance for taking the time to participate in this study. Your insight will allow for a better understanding of the issues associated with this topic. Please feel free to contact me with any questions.

Respectfully,

Corinne Ambler
The Pennsylvania State University
Bachelor of Architectural Engineering Candidate
Phone: 215.850.6755
Email: cra140@psu.edu
http://www.arche.psu.edu/thesis/eportfolio/2007/portfolios/CRA140/

Material Escalation Survey for Contractors

Name of Company:

Please check your area(s) of construction expertise.

- [ ] Mechanical
- [ ] Concrete
- [ ] Electrical
- [ ] Masonry
- [ ] Steel
- [ ] Miscellaneous Metals
- [ ] Glass Systems
- [ ] Fire Protection
- [ ] Metal Panels
- [ ] Ceilings and Partitions

Which material(s) create the most risk when bidding/procuring a project?

- [ ] Copper
- [ ] Steel
- [ ] Glass
- [ ] Drywall
- [ ] Aluminum
- [ ] Concrete

How do you manage the risk involved with material cost escalation (check all that apply)?

- [ ] Pre-purchase of volatile materials in bulk
- [ ] Contract Clauses
- [ ] Increased bid

Do you incorporate a multiplier in your material estimate for the escalation of material prices?

- [ ] Yes
- [ ] No

If yes, how much of your total bid?

- [ ] 1-5%
- [ ] 5-10%
- [ ] 15-20%
- [ ] 20-30%

How many different suppliers do you typically have for one material?

- [ ] 1
- [ ] 3
- [ ] 2
- [ ] 4+

How long will a supplier hold their price?

- [ ] 1-14 Days
- [ ] 15-29 Days
- [ ] 30-59 days
- [ ] > 60 Days

Please list any other methods used to combat material escalation or any comments you have.

____

____

____

____

Material Escalation Survey for Designers

What is your area of design expertise?

- [ ] Architect
- [ ] Mechanical
- [ ] Structural
- [ ] Electrical
- [ ] Other ______________________

Please check your area(s) of expertise.

- [ ] Academic - University
- [ ] Office Building
- [ ] Acade University
- [ ] Specialty
- [ ] Health Care/Lab
- [ ] Sports Facility
- [ ] Hotel/Condo
- [ ] Other
- [ ] Industrial

Is volitatity of material prices a factor in the design process?

- [ ] Yes
- [ ] No

Please rank the materials as they affect the design. (1-Most 6-Least)

- [ ] Copper
- [ ] Steel
- [ ] Glass
- [ ] Drywall
- [ ] Aluminum
- [ ] Concrete

Material Escalation Survey for Construction Managers

Who is your typical owner?

☐ Public ☐ Private ☐ Both

What types of buildings do you build (check all that apply)?

☐ Academic ☐ Office Building

☐ Health Care/Lab ☐ Specialty

☐ Hotel/Condo ☐ Sports Facility

☐ Industrial ☐ Other

What material prices typically affect the budget the most?

☐ Copper ☐ Steel

☐ Glass ☐ Drywall

☐ Aluminum ☐ Concrete

How do you compensate for the cost of material escalation (check all that apply)?

☐ Value Engineering

☐ Pre-purchase of volatile materials

☐ Contingency for each material

☐ General Contingency

☐ Contract Clause

For hard bid projects (GMP) do you include a mark-up for material escalation?

☐ Yes ☐ No

If yes, how much of the project cost?

☐ 1-5%

☐ 5-10%

☐ 15-20%

☐ 20-30%

After project award, do you re-estimate the cost before bidding the project to sub-contractors?

☐ Yes ☐ No

Material Escalation for Owners

How are your projects typically funded?

☐ Public ☐ Private

What types of buildings do you own/build (check all that apply)?

☐ Academic ☐ Office Building
☐ Health Care/Lab ☐ Specialty
☐ Hotel/Condo ☐ Sports Facility
☐ Industrial ☐ Other

Do you take cost escalation into account when planning a project?

☐ Yes - Just General Inflation
☐ Yes - Inflation and Cost Escalation
☐ No

Do you put money aside for the increase in material prices when allocating your budget?

☐ Yes ☐ No

If yes, how much of your budget?

☐ 1-5%
☐ 5-10%
☐ 15-20%
☐ 20-30%

Which would you prefer?

☐ A higher and more accurate cost estimate
☐ A lower cost estimate that has the ability to change at any given time

If you would prefer a higher but more accurate cost estimate

What percent more of your total bidget are you willing to pay?

☐ 1-5%
☐ 5-10%
☐ 15-20%
☐ 20-30%

Would you prefer contractors to have a separate contingency for material escalation?

☐ Yes ☐ No

Material Escalation interview Notes

Construction Managers

Bob Grottenthaler

-Glass- long lead time for raw materials mean very long lead time for finished product
-Steel used for structure and reinforcing – has no good alternate
-Concrete – increased due to petroleum prices more expensive to manufacture & truck
-Copper – just for pipes and wire
-Masonry – Expensive due to lack of skilled masons – labor cost very high
-Global economy changed – 1-2 weeks started taking 6-8 weeks some suppliers only gave part of order (30 of 50 valves at first) can delay schedule
-Value Engineering – happens after bid – if budget is over 5% or less
-Pre-purchase of materials – contractor has better relationship with supplier to lock in. Risky and harder for CM to get a better price
-CM needs to make sure all scopes cover everything and don't double cover if pre-purchase mechanical equipment make sure contractor has start-up and training in scope
-General Contingency – established in GMP – Market Contingency – owner can store too much money and then not have enough for brick and mortar
-Have contractor do base bid and then deduct/add alternates according to material prices too may alternates are undesirable to contractor make base bid due first and alternate after vendors like to give price at last minute especially light fixtures and gear
-China has bought up a lot of materials which leaves shortages
-Create a reasonable escalation percentage during estimate phase
-Architects and Designers make it difficult with proprietary specifications which makes it difficult for the contractor to acquire materials
-Award to subcontractors as early as possible
-After project awarded to CM scope is written then each scope is estimated to compare to actual bid received from contractor
-Budget way over after bid – owner sometimes ask shell out area and will fit it out later
-Work with low bidder to let them know they are the lowest but they are still over budget – allows contractor to know they can get the work if they need it
-Re-bid to get in budget sometimes after 2-3 weeks can get new contractors – need to reject all from first bid and increase competition
-In a hard bid may not get a bid for each spec section
-Hard for contractor to hold bid price and keep bid bond

Lee Evey

- -Escalation is a function of time – the longer it takes to produce the more expensive it becomes
- -Design Build's duration is shorter than design-bid-build so the time is already decreased
- -CIAA – Sanveto and Mark Conchar paper
  - -6% less expensive then design-bid-build
  - -12% saved in construction
  - -33% saved in program
- -Usually everyone pushes off the risk to someone else and the owner starts the push – it gets pushed all the way down to the contractor
- -Design Build gives each party an appropriate portion of risk
- -It is effective because it enables interaction between people which causes communications about software and materials
- -when oriented as a TEAM more likely to solve problems together which reduces the total risk
- -Example- Pentagon
  - -Create and Award Fee and incentive features – causes more teamwork and reliance on other parties
  - -Award fee is a profit opportunity
  - -Owner/CM controls the fee and contractors bid on pure cost without inflation
  - -Materials basket used for cost escalation
  - -Design-bid-build there is no motivation for contractor to work with owner – the owner just wants the lowest cost and the project is more likely to have change orders because the contractor under-bid the project
  - -each contractor is asked to propose the best product the contractor knows the budget and his fee and needs to respond to owners – goal, challenges, problems, constraints, and budget
- -This method forces contractors to think outside of the box and come up with good solutions to earn their 10% fee (which is unheard of)
  - -owner has already set aside 10% of budget for fees
  - -contractors want to be part of the project because it is a great opportunity to make a big profit
- -gets everyone away from price based competition and focuses on more solutions for a successful project
- -Contractor is evaluated on quality, effective communication, and safety every three months – must pass evaluation to receive all of profit (live up to their end of the agreement)
- -Forms a high quality project from good behaviors
- -if the contractor can do what he said he can do and save money then the contractor and owner split the savings 50/50
- -establishes a strong relationship between the owner and the contractors
- -Escalation controlled by a source selection process
- -Two parts of the bidding
- -First part anyone can bid and the owner looks at past performance – includes team and experience – recently, relevancy, quality
- -Three parties are selected to compete in next part of selection
- -Phase two is when the 3 competitors respond to the goals, challenges, problems, constraints, and budget
- -A performance requirement is agreed upon – quiet, clean and quality – all pre-defined
- -Everyone has a fair proportion of risk otherwise game of roulette for contractors

- -Price everything in today's prices and then take escalation into accountant each quarter
- -Market Basket- steel, concrete, drywall, and copper – escalation covered by owner
- -Current bids- "rip them and read them" award to the biggest liar
- -BIM, VE, Sustainability, Commissioning operate poorly in design bid build
- -BIM is a database and produces a report for design, material list, renderings, schedules
- -Design Build decreases/eliminates schedule over-run litigation

Sarah Forrest - Estimator

- -Calculation of material escalation depends on material of building and time frame
  - -if notice to proceed is soon may not include anything for material escalation
  - -if long negotiated job then use Beck's index (historical index) and have relationship with new-core steel mill to get flyer monthly with the change (up or down) in steel prices – new core works with structural shapes and rebar
- -HP has graphed the monthly reports from new core as an extra tool
- -3 months ago steel leveled off now it has started to increase again
- -have a similar process for tracking cement
- -rely heavily on subs for copper and drywall escalation
- -ENR has index and can be good reference for copper and drywall
- -Can become a problem in volatile market, pay too much of a premium for something that will never happen
- -Past example: agreement with sub for rebar HP would get a quartly review of price increase and adjust payment to sub accordingly for the amount delivered to site that quarter
- -If owner is willing can change materials – copper to aluminum or aluminum to copper
- -In some contracts owners carry risk and create a similar situation with HP as the rebar sub
- -For a GMP give most of the risk to the subs
- -If early enough in design HP will take risk and manage it until they can sell it off to the subs
- -Design Build is a very good way to manage material escalation
- -work hard with architect and check budget daily to manage costs
- -one project concrete and steel was designed and then picked according to price

Mike Miller

- -Pre-purchase steel and copper that can be used on most jobs.
- -Buy in bulk using a 30-day look ahead
- -Hurricane Katrina impact on oil rigs increased price of PVC piping
- -Supplier and Contractor have include escalation in price
- -Commodity items can hold price for 90 days
- -Buy from multiple vendors/mills based on supply and demand
- -Carry contingency for escalation
- -Can change materials for VE – Copper, Galvanized, and Stainless Steel
- -Cast iron very high consider using plastic
- -95% of projects are in-house design and construction
- -In-house helps with over designs that waste material and creates more constructible solutions
- -Keep the same amount of contingency for escalation

Economist

Ken Simonson

-Chief economist for Associated General Contractors of America
-Job is to keep people informed about material price inflation and trends
-Provide documentation for owners on behalf of contractor to justify dramatic increase in material prices
-Membership of organization is all contractors so that is who he mainly deals with
-Contractors have varied opinions on willingness to participate in design build
-Best way contractor manage risk
  -work with owner and designer at early phase to allow them to realize volatility
  -owner can consider providing separate pricing to reduce contractor risk
  -allow contractor to buy materials early to lock in price
  -contractor includes widest range in price
-CM risk depends on flexibility of the owner to get more money
-Very little to no designer interaction (unfortunately more true than should be)
-Owners need to increase their awareness in order to adapt to availability of materials
-Katrina and Rita cause PVC pipe and insulation harder to make due to increase
    -steel, diesel fuel, gypsum, copper
    -cement increase 10% each year in last 3 years lots of energy goes into processing and shipping

Owner

Jorge Scotti

-Develop cost of building then develop percentage for escalation.
-General inflation and market conditions taken into account
-Amount depends on size and length of project around 3-6%
-Take out a contingency for unforeseen conditions
-Bid out to contractors and assume that escalation is taken into their bid amount
-Contractor responsible for all of risk
-Award to lowest bidder
-If bid comes in high – ask state for more money or revise scope of project
-State of Maryland will not approve a higher price unless documentation is provided
-Contract is fixed number
-10-15% of projects are design build

Designer

Merton Harris – Mechanical

-Designs academic, and health care/lab facilities
-Steel is the #1 most volatile
-Takes the volatility of materials into consideration when designing but can't say how
-Will change the design if the budget is over as long as the building is still functional
-Some materials come into play when asked to VE but most are un-changeable

Matt Herbert - Architect

-DCI has own estimator who checked BMC's estimate after each submission

-Building material is picked to perform a certain way and the budget is a second consideration

-The right design is addressed first for the area/campus/owner

-Building envelope tends to affect the budget the most

Hope Furrer - Structural

-Two or three alternate studies (systems) are considered

-An estimate is performed by the construction manager for each system

-Then a system is selected

Contractor

David Allen Company – Ceramic, Terrazzo, marble

-Pre-purchase volatile materials in bulk

-Increases bid

-Multiplies bid by 5-10% for escalation of material prices

-3 different suppliers

-Supplier will hold price for ceramics for one year and 60 days for stone

Homewood General Contractors – Concrete, Lumber, Specialty (doors and hardware)

-Uses contract clauses for specialty items

-Increases bid for lumber and concrete

-Multiplies 5-10% for escalation of material prices

-Uses just one supplier

-Supplier will hold price for 30-59 days

Finishes Inc – Ceilings and Partitions

-Believes drywall and steel create most risk when bidding and procuring

-Uses contract clauses to manage risk

-Multiplies bid by 5-10% for escalation of material prices

-Uses one supplier

-Supplier will hold prices for sixty days or more

-After letter of intent is sent ask vendors for "vendor quote sheets" so prices can be compared. Tell vendor how long they need them to hold prices but most will not hold for more than one year

Zephyr Aluminum – Glass Systems

-Believe that glass and aluminum is the riskiest

-Uses contract clauses and increases bid to manage the risk

-Does not incorporate multiplier for material escalation

-Uses three different suppliers

-Supplier will hold price for 30-59 days

MBR Construction Services - Electrical

-Believes copper, aluminum, and steel have most risk

-Pre-purchases volatile materials in bulk

-Multiplies bid by 5-10% for material escalation

-Uses 3 different suppliers

-Supplier will hold price for 1-14 days

-Electrical is a two step process – run the raceway (being conduit or cable tray made of steel or aluminum) and install the process thru the first system being copper, aluminum, or fiber cable

Sody Concrete

-Concrete and rebar

-It is a back and forth whether cost of cement or steel (rebar) is the driver for increase in concrete bids (relative to the time of year)

-Rebar escalation $25/ton increase per quarter – projected escalation

-Cement Escalation – on average 3-5% increase

-Uses contract clauses a little mainly increases bid (padding 5-10%)

-Price of lumber for formwork has also escalated which in turn increases concrete bid

-4 different ready mix vendors

-Use 2 rebar subs mainly 1 due to a good relationship

-Ready Mix vender will hold prices for one year

-Rebar vendor will hold price for 2-3 months

Appendix C

Monthly Solar Heat Gain Tables

The tables in this appendix are for a four foot overhang and a distance of zero between the sunshade and the head of the window.

January

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
8	8.1	55.3	1.00	0.69	0.00	0.15	0.09	0.00	5	75	111	5	3159	11210	139665	8427	0.4	12	779816
9	16.8	44	1.68	1.74	0.00	0.25	0.24	0.00	12	160	154	12	7583	21403	166418	20225	0.4	12	1035021
10	23.8	30.9	2.06	3.44	0.00	0.30	0.47	0.00	16	213	124	16	10110	26612	101517	26967	0.4	12	792987
11	28.4	16	2.25	7.85	0.00	0.33	1.00	0.00	19	244	61	19	12006	29414	26276	32023	0.4	12	478654
12	30	0	2.31	0.00	0.00	0.34	0.00	0.00	20	254	21	21	12638	30280	29042	35394	0.4	12	515299
1	28.4	16	2.25	0.00	7.85	0.33	0.00	1.00	19	244	19	61	12006	29414	26276	32023	0.4	12	478654
2	23.8	30.9	2.06	0.00	3.44	0.30	0.00	0.47	16	213	16	124	10110	26612	22127	123722	0.4	12	876341
3	16.8	44	1.68	0.00	1.74	0.25	0.00	0.24	12	160	12	154	7583	21403	16595	202820	0.4	12	1192325
4	8.1	55.3	1.00	0.00	0.69	0.15	0.00	0.09	5	75	5	111	3159	11210	6915	170215	0.4	12	919196
																		Total Btu:	**7068294**

February

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
7	4.8	72.7	1.13	0.35	0.00	0.17	0.05	0.00	2	14	1	51	1264	2080	1449	85958	0.4	11.5	417454
8	15.4	62.2	2.36	1.25	0.00	0.35	0.17	0.00	10	94	183	10	6319	11245	212443	16854	0.4	11.5	1135564
9	25	50.2	2.91	2.43	0.00	0.43	0.33	0.00	16	157	186	16	10110	16770	179395	26967	0.4	11.5	1072913
10	32.8	35.9	3.18	4.40	0.00	0.47	0.60	0.00	21	203	143	21	13270	20469	96616	35394	0.4	11.5	762447
11	38.1	18.9	3.32	9.68	0.00	0.49	1.00	0.00	23	231	71	23	14533	22520	31808	38765	0.4	11.5	495082
12	40	0	3.36	0.00	0.00	0.49	0.00	0.00	24	241	25	25	15165	23269	34574	42136	0.4	11.5	529661
1	38.1	18.9	3.32	0.00	9.68	0.49	0.00	1.00	23	231	23	71	14533	22520	31808	38765	0.4	11.5	495082
2	32.8	35.9	3.18	0.00	4.40	0.47	0.00	0.60	21	203	21	143	13270	20469	29042	117750	0.4	11.5	830439
3	25	50.2	2.91	0.00	2.43	0.43	0.00	0.33	16	157	16	186	10110	16770	22127	218635	0.4	11.5	1231154
4	15.4	62.2	2.36	0.00	1.25	0.35	0.00	0.17	10	94	10	183	6319	11245	13829	258912	0.4	11.5	1335406
5	4.8	72.7	1.13	0.00	0.35	0.17	0.00	0.05	2	14	51	2	1264	2080	2766	81996	0.4	11.5	405286
																		Total Btu:	**8293033**

March

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
7	11.4	80.2	4.74	0.82	0.00	0.69	0.11	0.00	9	22	8	163	5687	2248	11218	274727	0.4	12.5	1469401
8	22.5	69.6	4.75	1.77	0.00	0.70	0.24	0.00	16	74	218	16	10110	5826	234143	26967	0.4	12.5	1385230
9	32.8	57.3	4.77	3.06	0.00	0.70	0.42	0.00	21	128	203	21	13270	9224	175598	35394	0.4	12.5	1167428
10	41.6	41.9	4.77	5.32	0.00	0.70	0.73	0.00	25	171	153	25	15797	11954	83227	42136	0.4	12.5	765574
11	47.7	22.6	4.76	11.44	0.00	0.70	1.00	0.00	28	197	78	28	17693	13717	38722	47192	0.4	12.5	586624
12	50	0	4.77	0.00	0.00	0.70	0.00	0.00	29	206	31	31	18325	14286	42871	52249	0.4	12.5	638652
1	47.7	22.6	4.76	0.00	11.44	0.70	0.00	1.00	28	197	28	78	17693	13717	38722	47192	0.4	12.5	586624
2	41.6	41.9	4.77	0.00	5.32	0.70	0.00	0.73	25	171	25	153	15797	11954	34574	101432	0.4	12.5	818786
3	32.8	57.3	4.77	0.00	3.06	0.70	0.00	0.42	21	128	21	203	13270	9224	29042	214007	0.4	12.5	1327713
4	22.5	69.6	4.75	0.00	1.77	0.70	0.00	0.24	16	74	16	218	10110	5826	22127	285358	0.4	12.5	1617107
5	11.4	80.2	4.74	0.00	0.82	0.69	0.00	0.11	9	22	163	8	5687	2248	11064	245758	0.4	12.5	1323781
																		Total Btu:	**10217519**

April

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
6	7.4	98.9	-3.36	0.53	0.00	0.00	0.07	0.00	11	5	88	5	6951	866	114063	8427	0.4	12.5	651535
7	18.9	89.5	156.94	1.37	0.00	1.00	0.19	0.00	16	16	201	14	10110	2770	230191	23596	0.4	12.5	1333335
8	30.3	79.3	12.59	2.38	0.00	1.00	0.32	0.00	22	41	224	21	13902	3808	219163	35394	0.4	12.5	1361337
9	41.3	67.2	9.07	3.81	0.00	1.00	0.52	0.00	27	83	202	27	17061	4674	153553	45507	0.4	12.5	1103974
10	51.2	51.4	7.97	6.37	0.00	1.00	0.87	0.00	31	121	152	31	19589	5366	64949	52249	0.4	12.5	710765
11	58.7	29.2	7.54	13.49	0.00	1.00	1.00	0.00	33	146	81	33	20852	5713	45637	55620	0.4	12.5	639109
12	61.6	0	7.40	0.00	0.00	1.00	0.00	0.00	34	154	36	36	21484	5886	49786	60676	0.4	12.5	689160
1	58.7	29.2	7.54	13.49	13.49	1.00	1.00	1.00	33	146	33	81	20852	5713	45637	55620	0.4	12.5	639109
2	51.2	51.4	7.97	0.00	6.37	1.00	0.00	0.87	31	121	31	152	19589	5366	42871	79156	0.4	12.5	734911
3	41.3	67.2	9.07	0.00	3.81	1.00	0.00	0.52	27	83	27	202	17061	4674	37340	187140	0.4	12.5	1231075
4	30.3	79.3	12.59	0.00	2.38	1.00	0.00	0.32	22	41	21	224	13902	3808	29042	267102	0.4	12.5	1569269
5	18.9	89.5	156.94	0.00	1.37	1.00	0.00	0.19	16	16	14	201	10110	2770	19361	280542	0.4	12.5	1563915
6	7.4	98.9	-3.36	0.00	0.53	0.00	0.00	0.07	11	5	5	88	6951	866	121699	9152	0.4	12.5	693339
																		Total Btu:	**12269298**

May

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
5	1.9	114.7	-0.32	0.15	0.00	0.00	0.02	0.00	0	0	1	0	0	0	1355	0	0.4	13	7048
6	12.7	105.6	-3.35	0.94	0.00	0.00	0.13	0.00	36	10	141	10	22748	1731	176463	16854	0.4	13	1132541
7	24	96.6	-15.49	1.79	0.00	0.00	0.24	0.00	28	20	209	19	17693	3462	227841	32023	0.4	13	1461301
8	35.4	87.2	58.19	2.85	0.00	1.00	0.39	0.00	27	29	220	25	17061	4674	200661	42136	0.4	13	1375568
9	46.8	76	17.61	4.39	0.00	1.00	0.60	0.00	31	53	197	30	19589	5366	135013	50563	0.4	13	1094762
10	57.5	60.9	12.91	7.19	0.00	1.00	0.98	0.00	34	83	148	34	21484	5886	50192	57305	0.4	13	701310
11	66.2	37.1	11.37	15.03	0.00	1.00	1.00	0.00	36	105	81	36	22748	6232	49786	60676	0.4	13	725098
12	70	0	10.99	0.00	0.00	1.00	0.00	0.00	37	113	40	40	23380	6405	55318	67418	0.4	13	793107
1	66.2	37.1	11.37	0.00	15.03	1.00	0.00	1.00	36	105	36	81	22748	6232	49786	60676	0.4	13	725098
2	57.5	60.9	12.91	0.00	7.19	1.00	0.00	0.98	34	83	34	148	21484	5886	47020	61171	0.4	13	704917
3	46.8	76	17.61	0.00	4.39	1.00	0.00	0.60	31	53	30	197	19589	5366	41488	164545	0.4	13	1201139
4	35.4	87.2	58.19	0.00	2.85	1.00	0.00	0.39	27	29	25	220	17061	4674	34574	244553	0.4	13	1564481
5	24	96.6	-15.49	0.00	1.79	0.00	0.00	0.24	28	20	19	209	17693	3462	26276	277678	0.4	13	1690566
6	12.7	105.6	-3.35	0.00	0.94	0.00	0.00	0.13	36	10	10	141	22748	1731	13829	215062	0.4	13	1317525
7	1.9	114.7	-0.32	0.00	0.15	0.00	0.00	0.02	0	0	0	1	0	0	0	1652	0.4	13	8590
																		Total Btu:	**14496006**

June

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
5	4.2	117.3	-0.64	0.33	0.00	0.00	0.05	0.00	10	1	20	1	6319	173	27036	1685	0.4	13.5	190150
6	14.8	108.4	-3.35	1.11	0.00	0.00	0.15	0.00	48	13	151	13	30331	2250	187190	21911	0.4	13.5	1305084
7	26	99.7	-11.58	1.98	0.00	0.00	0.27	0.00	37	22	207	21	23380	3808	222817	35394	0.4	13.5	1541159
8	37.4	90.7	-250.33	3.06	0.00	0.00	0.42	0.00	30	29	216	27	18957	5020	191436	45507	0.4	13.5	1408967
9	48.8	80.2	26.84	4.64	0.00	1.00	0.63	0.00	33	45	192	32	20852	5713	126491	53934	0.4	13.5	1117749
10	59.8	65.8	16.77	7.53	0.00	1.00	1.00	0.00	35	69	145	35	22116	6059	48403	58991	0.4	13.5	732071
11	69.2	41.9	14.15	15.77	0.00	1.00	1.00	0.00	38	88	81	38	24012	6578	52552	64047	0.4	13.5	794819
12	73.5	0	13.50	0.00	0.00	1.00	0.00	0.00	38	95	41	41	24012	6578	56701	69103	0.4	13.5	844527
1	69.2	41.9	14.15	0.00	15.77	1.00	0.00	1.00	38	88	38	81	24012	6578	52552	64047	0.4	13.5	794819
2	59.8	65.8	16.77	0.00	7.53	1.00	0.00	1.00	35	69	35	145	22116	6059	48403	58991	0.4	13.5	732071
3	48.8	80.2	26.84	0.00	4.64	1.00	0.00	0.63	33	45	32	192	20852	5713	44254	154160	0.4	13.5	1214885
4	37.4	90.7	-250.33	0.00	3.06	0.00	0.00	0.42	30	29	27	216	18957	5020	37340	233310	0.4	13.5	1590982
5	26	99.7	-11.58	0.00	1.98	0.00	0.00	0.27	37	22	21	207	23380	3808	29042	271555	0.4	13.5	1770042
6	14.8	108.4	-3.35	0.00	1.11	0.00	0.00	0.15	48	13	13	151	30331	2250	17978	228136	0.4	13.5	1504953
7	4.2	117.3	-0.64	0.00	0.33	0.00	0.00	0.05	10	1	1	20	6319	173	1383	32949	0.4	13.5	220450
																		Total Btu:	**15572578**

July

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
5	2.3	115.2	-0.38	0.18	0.00	0.00	0.02	0.00	1	0	2	0	632	0	2732	0	0.4	15	20186
6	13.1	106.1	-3.36	0.97	0.00	0.00	0.13	0.00	37	11	137	11	23380	1904	171193	18540	0.4	15	1290102
7	24.3	97.2	-14.41	1.82	0.00	0.00	0.25	0.00	30	21	201	20	18957	3635	219267	33709	0.4	15	1653409
8	35.8	87.8	75.15	2.89	0.00	1.00	0.39	0.00	28	30	216	26	17693	4847	196361	43822	0.4	15	1576333
9	47.2	76.7	18.78	4.44	0.00	1.00	0.61	0.00	32	52	193	31	20220	5540	132142	52249	0.4	15	1260906
10	57.9	61.7	13.45	7.24	0.00	1.00	0.99	0.00	35	81	146	35	22116	6059	50312	58991	0.4	15	824864
11	66.7	37.9	11.77	15.12	0.00	1.00	1.00	0.00	37	102	81	37	23380	6405	51169	62361	0.4	15	859892
12	70.6	0	11.36	0.00	0.00	1.00	0.00	0.00	38	109	41	41	24012	6578	56701	69103	0.4	15	938364
1	66.7	37.9	11.77	0.00	15.12	1.00	0.00	1.00	37	102	37	81	23380	6405	51169	62361	0.4	15	859892
2	57.9	61.7	13.45	0.00	7.24	1.00	0.00	0.99	35	81	35	146	22116	6059	48403	61317	0.4	15	827369
3	47.2	76.7	18.78	0.00	4.44	1.00	0.00	0.61	32	52	31	193	20220	5540	42871	161046	0.4	15	1378066
4	35.8	87.8	75.15	0.00	2.89	1.00	0.00	0.39	28	30	26	216	17693	4847	35957	239312	0.4	15	1786850
5	24.3	97.2	-14.41	0.00	1.82	0.00	0.00	0.25	30	21	20	201	18957	3635	27659	267229	0.4	15	1904879
6	13.1	106.1	-3.36	0.00	0.97	0.00	0.00	0.13	37	11	11	137	23380	1904	15212	208639	0.4	15	1494813
7	2.3	115.2	-0.38	0.00	0.18	0.00	0.00	0.02	1	0	0	2	632	0	0	3330	0.4	15	23772
																		Total Btu:	16679511

August

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
6	7.9	99.5	-3.36	0.56	0.00	0.00	0.08	0.00	12	6	82	5	7583	1039	104858	8427	0.4	14.5	707060
7	19.3	90.1	-802.59	1.40	0.00	0.00	0.19	0.00	17	17	191	16	10742	2943	214249	26967	0.4	14.5	1478427
8	30.7	79.9	13.54	2.41	0.00	1.00	0.33	0.00	24	41	216	23	15165	4155	201816	38765	0.4	14.5	1507425
9	41.8	67.9	9.51	3.86	0.00	1.00	0.53	0.00	28	80	197	28	17693	4847	131588	47192	0.4	14.5	1167661
10	51.7	52.1	8.25	6.42	0.00	1.00	0.88	0.00	32	116	150	32	20220	5540	30722	53934	0.4	14.5	640413
11	59.3	29.7	7.76	13.60	0.00	1.00	1.00	0.00	35	141	81	35	22116	6059	6059	58991	0.4	14.5	540702
12	62.3	0	7.62	0.00	0.00	1.00	0.00	0.00	35	149	38	38	22116	6059	52552	64047	0.4	14.5	839688
1	59.3	29.7	7.76	0.00	13.60	1.00	0.00	1.00	35	141	35	81	22116	6059	48403	6059	0.4	14.5	479294
2	51.7	52.1	8.25	0.00	6.42	1.00	0.00	0.88	32	116	32	150	20220	5540	44254	36381	0.4	14.5	617094
3	41.8	67.9	9.51	0.00	3.86	1.00	0.00	0.53	28	80	28	197	17693	4847	38722	159813	0.4	14.5	1282240
4	30.7	79.9	13.54	0.00	2.41	1.00	0.00	0.33	24	41	23	216	15165	4155	31808	245661	0.4	14.5	1721375
5	19.3	90.1	-802.59	0.00	1.40	0.00	0.00	0.19	17	17	16	191	10742	2943	22127	260990	0.4	14.5	1721454
6	7.9	99.5	-3.36	0.00	0.56	0.00	0.00	0.08	12	6	5	82	7583	1039	6915	127760	0.4	14.5	831116
																		Total Btu:	13533949

September

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
7	11.4	80.2	4.74	0.82	0.00	0.69	0.11	0.00	9	21	146	9	5687	2195	180764	15169	0.4	15.5	1263649
8	22.5	69.6	4.75	1.77	0.00	0.70	0.24	0.00	17	71	205	17	10742	5788	220831	28653	0.4	15.5	1649290
9	32.8	57.3	4.77	3.06	0.00	0.70	0.42	0.00	22	124	194	22	13902	9136	168928	37080	0.4	15.5	1420081
10	41.6	41.9	4.77	5.32	0.00	0.70	0.73	0.00	27	165	148	27	17061	11883	83332	45507	0.4	15.5	978255
11	47.7	22.6	4.76	11.44	0.00	0.70	1.00	0.00	29	191	78	29	18325	13523	40105	48878	0.4	15.5	749151
12	50	0	4.77	0.00	0.00	0.70	0.00	0.00	30	200	32	32	18957	14092	44254	53934	0.4	15.5	813672
1	47.7	22.6	4.76	0.00	11.44	0.70	0.00	1.00	29	191	29	78	18325	13523	40105	48878	0.4	15.5	749151
2	41.6	41.9	4.77	0.00	5.32	0.70	0.00	0.73	27	165	27	148	17061	11883	37340	101560	0.4	15.5	1040628
3	32.8	57.3	4.77	0.00	3.06	0.70	0.00	0.42	22	124	22	194	13902	9136	30425	205879	0.4	15.5	1607914
4	22.5	69.6	4.75	0.00	1.77	0.70	0.00	0.24	17	71	17	205	10742	5788	23510	269135	0.4	15.5	1916890
5	11.4	80.2	4.74	0.00	0.82	0.69	0.00	0.11	9	21	9	146	5687	2195	12447	220303	0.4	15.5	1491915
																		Total Btu:	13680595

October

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
7	4.5	72.3	1.04	0.33	0.00	0.15	0.05	0.00	2	12	45	2	1264	1815	59553	3371	0.4	16	422416
8	15	61.9	2.28	1.22	0.00	0.33	0.17	0.00	11	89	173	11	6951	10910	202130	18540	0.4	16	1526600
9	24.5	49.8	2.82	2.39	0.00	0.41	0.33	0.00	17	151	180	17	10742	16553	175567	28653	0.4	16	1481690
10	32.4	35.6	3.12	4.36	0.00	0.46	0.59	0.00	21	196	139	21	13270	20089	95191	35394	0.4	16	1049241
11	37.6	18.7	3.25	9.61	0.00	0.48	1.00	0.00	24	224	71	24	15165	22300	33191	40451	0.4	16	711080
12	39.5	0	3.30	0.00	0.00	0.48	0.00	0.00	25	234	27	27	15797	23050	37340	45507	0.4	16	778838
1	37.6	18.7	3.25	0.00	9.61	0.48	0.00	1.00	24	224	24	71	15165	22300	33191	40451	0.4	16	711080
2	32.4	35.6	3.12	0.00	4.36	0.46	0.00	0.59	21	196	21	139	13270	20089	29042	116013	0.4	16	1141844
3	24.5	49.8	2.82	0.00	2.39	0.41	0.00	0.33	17	151	17	180	10742	16553	23510	213970	0.4	16	1694557
4	15	61.9	2.28	0.00	1.22	0.33	0.00	0.17	11	89	11	173	6951	10910	15212	246343	0.4	16	1788268
5	4.5	72.3	1.04	0.00	0.33	0.15	0.00	0.05	2	12	2	45	1264	1815	2766	72579	0.4	16	501913
																		Total Btu:	**11807527**

November

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
8	8.2	55.4	1.02	0.70	0.00	0.15	0.10	0.00	5	72	108	5	3159	10741	135756	8427	0.4	12	758802
9	17	44.1	1.70	1.76	0.00	0.25	0.24	0.00	12	156	181	12	7583	20793	194307	20225	0.4	12	1165958
10	24	31	2.08	3.46	0.00	0.30	0.47	0.00	16	209	122	16	10110	26022	99598	26967	0.4	12	780945
11	28.6	16.1	2.27	7.86	0.00	0.33	1.00	0.00	19	240	61	19	12006	28838	26276	32023	0.4	12	475889
12	30.2	0	2.33	0.00	0.00	0.34	0.00	0.00	20	250	21	21	12638	29713	29042	35394	0.4	12	512577
1	28.6	16.1	2.27	0.00	7.86	0.33	0.00	1.00	19	240	19	61	12006	28838	26276	32023	0.4	12	475889
2	24	31	2.08	0.00	3.46	0.30	0.00	0.47	16	209	16	122	10110	26022	22127	121383	0.4	12	862284
3	17	44.1	1.70	0.00	1.76	0.25	0.00	0.24	12	156	12	181	7583	20793	16595	236809	0.4	12	1352544
4	8.2	55.4	1.02	0.00	0.70	0.15	0.00	0.10	5	72	5	108	3159	10741	6915	165451	0.4	12	894077
																		Total Btu:	**7278966**

December

Solar Time	Altitude (degrees)	Azimuth (degrees)	Shadow Length (ft)			Percent Shaded (SF)			Solar Heat Gain Factor (Btu/h-ft2)				Solar Heat Gain (Btu)				Solar Heat Gain Coefficient	Sunny Days per Month	Hourly Btu
			South	East	West	South	East	West	North	South	East	West	North	South	East	West			
8	5.5	53	0.64	0.48	0.00	0.09	0.07	0.00	3	50	67	3	1896	7894	86837	5056	0.4	11.5	467738
9	14	41.9	1.34	1.49	0.00	0.20	0.20	0.00	10	151	135	10	6319	21354	151495	16854	0.4	11.5	901700
10	20.7	29.4	1.73	3.08	0.00	0.25	0.42	0.00	14	210	113	14	8846	27739	98789	23596	0.4	11.5	731266
11	25	15.2	1.93	7.11	0.00	0.28	0.97	0.00	17	242	56	17	10742	30876	25123	28653	0.4	11.5	438808
12	26.6	0	2.00	0.00	0.00	0.29	0.00	0.00	18	253	19	19	11374	31872	26276	32023	0.4	11.5	467110
1	25	15.2	1.93	0.00	7.11	0.28	0.00	0.97	17	242	17	56	10742	30876	23510	30618	0.4	11.5	440431
2	20.7	29.4	1.73	0.00	3.08	0.25	0.00	0.42	14	210	14	113	8846	27739	19361	120398	0.4	11.5	811185
3	14	41.9	1.34	0.00	1.49	0.20	0.00	0.20	10	151	10	135	6319	21354	13829	184632	0.4	11.5	1040217
4	5.5	53	0.64	0.00	0.48	0.09	0.00	0.07	3	50	3	67	1896	7894	4149	105831	0.4	11.5	550937
																		Total Btu:	**5849392**

APPENDIX D

LUMINAIRE CUT SHEETS

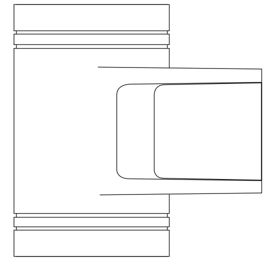
Notes:

Job:

Type:

CYLINDERS

301 LINE UP/DOWN



GENERAL DESCRIPTION: The Gardco 301 LINE is a series of high performance up/down wall mounted cylinders. Each luminaire utilizes a single high intensity discharge lamp and provides illumination above and below. Housings are diecast aluminum with twin architectural reveals at both the lower and upper apertures. Six (6) downlight and two (2) uplight optical systems are available. The unique optional "Spike" downlight and/or uplight distribution creates a dramatic narrow stripe of illumination on the wall or column. Luminaires are finished with a fade and abrasion resistant polyester powder coat offered in 5 standard colors.

ORDERING

PREFIX	MODEL	MOUNTING	TRIMS	WATTAGE	VOLTAGE	FINISH	OPTIONS

Enter the order code into the appropriate box above. Note: Gardco reserves the right to refuse a configuration. Not all combinations and configurations are valid. Refer to notes below for exclusions and limitations. For questions or concerns, please consult the factory.

PREFIX

301

MODEL

E Fully Enclosed

O Open Downlight

MOUNTING

W Wall Mount

TRIMS

Fully Enclosed "E" Units Only

L Obscuring lenses on uplight and downlight. Soft symmetrical distributions

LL Egg crate louvers on downlight. Obscuring lenses on uplight and downlight.

SD Spike downlight distribution. Obscuring lens on uplight

SU Spike uplight distribution. Obscuring lens on downlight

SB Spike uplight and downlight distributions.

FT Forward throw downlight distributions. Soft uplight glow. FT Trims utilize T6 lamps. Lamps are supplied with the luminaire

Open Downlight "O" Units Only

R Reflector produces medium downlight distribution with sharp cutoff to lamp and images. Obscuring lens on uplight.

B Black baffled downlight. Obscuring lens on uplight.

WATTAGE

Fully Enclosed "E" Units
(N/A with FT Trims)

50MH[1]
70MH
100MH
150MH
50HPS
70HPS
100HPS
150HPS[2]

FT Trims Only

T70MH
T150MH

Open Downlight "O" Units

50MH[1]
70MH
100MH
150MH
50HPS
70HPS
100HPS
150HPS

MH Metal Halide
HPS High Pressure Sodium

1. N/A with 347V
2. Contact factory for availabilty of 150HPS w/SD, SU or SB Trims

VOLTAGE

120
208
240
277
347

FINISH

BRP Bronze Paint
BLP Black Paint
WP White Paint
NP Natural Aluminum Paint
BGP Beige Paint
VP Verde Green Paint
OC Optional Color Paint
Specify RAL designation ex: OC-RAL7024
SC Special Color Paint
Specify Must supply color chip

OPTIONS

F Fusing
RCA Round Column Mounting Adapter
WS Wall Mounted J-Box for Surface Conduit

Gardco Lighting reserves the right to change materials or modify the design of its product without notification as part of the company's continuing product improvement program.

A Genlyte Company

Gardco Lighting
2661 Alvarado Street
San Leandro, CA 94577

800/227-0758
510/357-6900 in California
Fax: 510/357-3088
www.sitelighting.com

GARDCO LIGHTING

79115-112/0604

CYLINDERS

301 LINE UP/DOWN

SPECIFICATIONS

HOUSINGS:
Housings are single-piece diecast aluminum cylindrical forms with integral side wall mounting canopy / ballast chambers. Provided mounting brackets are galvanized steel.

OPTICAL SYSTEMS:
Lens (L): The uplight and downlight components both utilize twin (four total per luminaire) spun specular Alzak reflectors which provide the symmetrical distributions. The uplight-obscuring lens is flush mounted and the downlight-obscuring lens is regressed. The lenses soften the distribution and conceal the optical system and internal hardware.

Louvers (LL): Diecast aluminum egg crate louvers are installed over the downlight-obscuring lens. All other optical elements are as described in the Lens (L) option.

Spike Downlight (SD): Inner and outer spun specular Alzak reflectors provide a very narrow spot beam at nadir. Uplight optical system is as described in the Lens (L) option.

Spike Uplight (SU): Inner and outer spun specular Alzak reflectors provide a very narrow spot at zenith. Downlight optical system is as described in the Lens (L) option.

Spike Both Uplight and Downlight (SB): Two sets of inner and outer spun specular Alzak reflectors provide very narrow spot beams at nadir and zenith.

Reflector (R): Spun specular Alzak reflector produces a medium symmetrical downlight distribution with sharp cutoff to lamp and lamp images. Uplight optical system is as described in the Lens (L) option.

Baffle (B): Upper spun specular Alzak reflector and lower black baffle produce a medium symmetrical downlight distribution with exceptional control of high angle brightness. Uplight optical system is as described in the Lens (L) option.

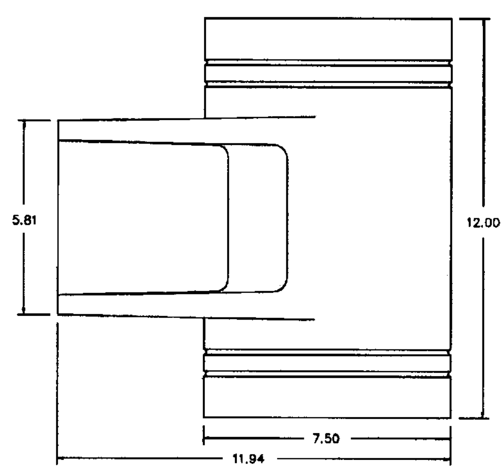
Forward Throw (FT) Faceted specular Alzak reflector system produces an asymmetric forward projecting distribution. Secondary optical system with obscuring lens produces a soft uplight glow.

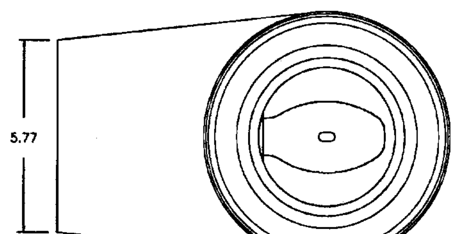
ELECTRICAL:
All luminaires utilize magnetic HID ballasts that are high power factor and designed for reliable lamp starting to -20° F. Pulse rated sockets are glazed porcelain with nickel plated screw shells.

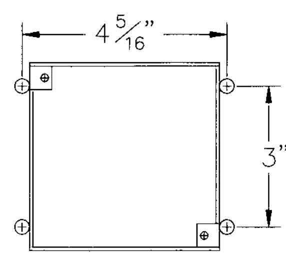
FINISH:
Each luminaire receives a fade and abrasion resistant electrostatically applied, thermally cured, (TGIC) polyester powder coat finish. Standard finishes are textured.

LABELS:
All fixtures bear UL or CUL (where applicable) Wet Location labels.

DIMENSIONS AND MOUNTING DETAIL







MOUNTING BOLT PATTERN

Gardco Lighting reserves the right to change materials or modify the design of its product without notification as part of the company's continuing product improvement program.

Genlyte Thomas Group LLC

Gardco Lighting
2661 Alvarado Street
San Leandro, CA 94577

800/227-0758
510/357-6900 in California
Fax: 510/357-3088
www.sitelighting.com

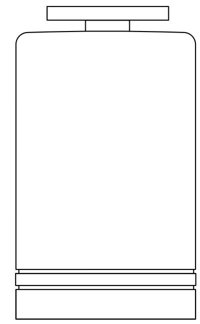
GARDCO LIGHTING

79115-112/0604

Notes:	Job:
	Type:

CYLINDERS

300 LINE OPEN DOWNLIGHT



GENERAL DESCRIPTION: The Gardco 300 LINE is a series of compact, high performance cylinder luminaires in a variety of styles and mounting configurations. The Open Downlight style uses high intensity discharge, incandescent or fluorescent lamps. Housings are diecast aluminum with twin architectural reveals located near the luminaire apertures. A choice of two (2) light control styles and three (3) mounting options is available. Luminaires are finished with a fade and abrasion resistant polyester powder coat offered in five standard colors.

ORDERING

300 Open Downlight Luminaires installed in the normal downlight position meet IESNA Full Cutoff criteria.

PREFIX	MODEL	MOUNTING	TRIMS	LAMP	VOLTAGE	FINISH	OPTIONS

Enter the order code into the appropriate box above. Note: Gardco reserves the right to refuse a configuration. Not all combinations and configurations are valid. Refer to notes below for exclusions and limitations. For questions or concerns, please consult the factory.

PREFIX

300

MODEL

O Open Downlight

MOUNTING

C Ceiling

P Pendant

Standard pendant length is 18". Stated length is the distance from the ceiling to the top of the luminaire and takes into account the mounting hardware. For other stem lengths, add desired length in inches after "P". ex. 300-D-P24-L-50HPS-120-BRP (for 24").

W Wall Mount

TRIMS

R Reflector

B Black Baffle *(n/a with Fluorescent)*

Luminaires cannot be field modified to change optics or lamp types.

LAMP/VOLTAGE CHART

LAMP/VOLTAGE CHART

Voltage:	120	208	240	277	347	480
E17						
50MH[2]	●			●	●	
70MH[2]	●	●	●	●	●	
100MH[2]	●	●	●	●	●	●
50HPS	●			●	●	
70HPS	●	●	●	●	●	
100HPS	●	●	●	●		
PAR38						
P70MH[1]	●	●	●	●	●	
P100MH[1]	●	●	●	●	●	●
P70HPS[1]	●	●	●	●	●	
Fluorescent *(Type "R" Trim only)*						
26QF[3]	●	●	●	●	●	
32TRF[3]	●	●	●	●	●	
42TRF[3]	●	●	●	●	●	
Incandescent						
250PAR38[1]	●					
300R40[1]	●					

MH - Metal Halide HPS - High Pressure Sodium
QF - Quad Fluorescent TRF - Triple Tube Fluorescent

Luminaires cannot be field modified to change optics or lamp types.

1. *Not available with reflector (R) trim.*
2. *Must use open fixture rated E-17 Metal Halide lamps.*
3. *Fluorescent units feature an electronic fluorescent ballast that accepts 120V through 277V or 347V only. Starting temperature is 0°F.*

FINISH

BRP	Bronze Paint	**OC**	Optional Color Paint *Specify RAL designation ex: OC-RAL7024*
BLP	Black Paint		
WP	White Paint		
NP	Natural Aluminum Paint	**SC**	Special Color Paint *Specify. Must supply color chip*
BGP	Beige Paint		
VP	Verde Green Paint		

OPTIONS

F Fusing

PCB Button Type Photocontrol *(Contact factory for availability)*

WS Wall Mounted Box for Surface Conduit

Gardco Lighting reserves the right to change materials or modify the design of its product without notification as part of the company's continuing product improvement program.

Genlyte Thomas Group LLC

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GARDCO LIGHTING

79115-105/1104

CYLINDERS

300 LINE OPEN DOWNLIGHT

SPECIFICATIONS

HOUSING: Housings are diecast aluminum in a single-piece cylindrical form of corrosion resistant alloy, 1/8" min. wall thickness. Units are 7.5" in diameter and 12" in height, nominal measurements.

MOUNTING:

Ceiling (C): Provides for direct ceiling mount as shown.

Pendant Assembly (P): Swivel pendant assembly with locking set screws. Standard pendant length is 18". Stated length is the distance from the ceiling to the top of the luminaire and takes into account the mounting hardware. For other stem lengths, add desired length in inches after ``P". Can accommodate 35° sloped ceiling maximum.

Wall Bracket (W): Cast aluminum canopy with integrated aluminum arm secured to housing with (2) 5/16" bolts. Requires mounting to a structural member of the building.

LIGHT CONTROL (Trim):

Reflector (R): Reflectors are composed of spun Alzak® components, electro-polished, anodized and sealed. Reflectors for compact fluorescent lamps feature a dual stage construction.

Baffle (B): Step black baffles are die cast aluminum and finished with black TGIC powdercoat

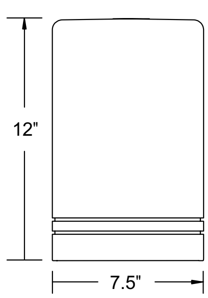
ELECTRICAL: Internal ballast will be provided based on the specified lamp configuration. Standard fluorescent ballasts are solid state. Standard and dimming fluorescent units have a starting temperature of 0°F (-18°C). Dimming range is 15% to 100% (42F/120v only).

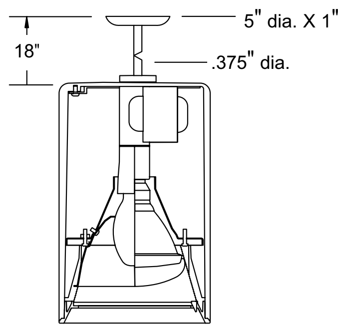
LAMPHOLDER: Pulse rated medium base lampholders are glazed porcelain with nickel-plated screw shell. Fluorescent lampholders are high temperature thermoplastic (PBT) with brass alloy contacts.

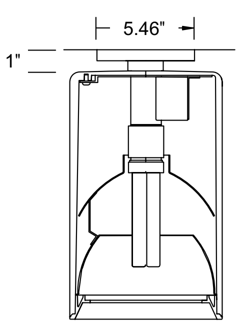
FINISH: Each luminaire receives a fade and abrasion resistant, electrostatically applied, thermally cured, textured TGIC polyester powder coat finish.

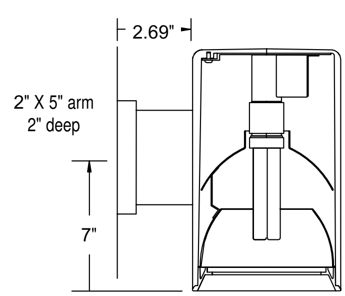
LABELS: All fixtures bear UL or CUL (where applicable) Wet Location labels

DIMENSIONS AND MOUNTING DETAIL









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87516 – GEMH50-MSF-120

GE HID UltraMax™ Electronic Low Frequency Ballast

GENERAL CHARACTERISTICS

Application	1- 50W M110 M/C148 120V High Effeciency Low Frequency Electronic HID
Category	High Intensity Discharge
Ballast Type	Electronic - Low Frequency
Line Voltage Regulation (+/-)	10 %
Ambient Temperature (MAX)	55 °C (131 °F)
Case Temperature (MAX)	90 °C (194 °F)
Ballast Factor	Normal
Circuit Type	Electronic
Sound Rating	A (20-24 decibels)
Enclosure Type	Plastic
Distance to Lamp (MAX)	8 ft
Additional Info	End of Life Protection (EOL), Thermally protected

ELECTRICAL CHARACTERISTICS

Lamp Operating Frequency	130 Hz
Supply Current Frequency	60 Hz/50

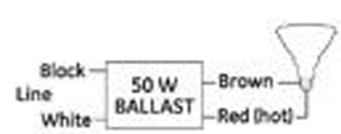
PRODUCT INFORMATION

Product Code	87516
Description	GEMH50-MSF-120
Standard Package	Case
Standard Package GTIN	10043168875162
Standard Package Quantity	10
Sales Unit	Case
No Of Items Per Sales Unit	1
No Of Items Per Standard Package	10
UPC	043168875165

View Larger

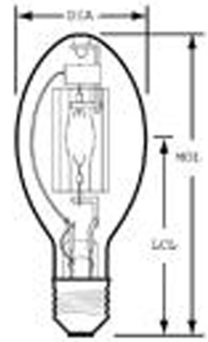
DIMENSIONS

Case dimensions			
Length (L)	3.7 in (94.99 mm)		
Width (W)	2.9 in (75.69 mm)		
Height (H)	1.2 in (30.73 mm)		
Mounting dimensions			
Mount Length (M)	3.3 in (86.10 mm)		
Mount Width (X or F)	2.5 in (63.75 mm)		
Mount Slots (MS)	0.1 in (4.31 mm)		
Weight	0.62 lbs		
Exit Type	Side		
Remote mounting distance to lamp	8 ft		
Remote Mounting Wire Gauge	18 AWG		
Lead lengths	Qty	Exit	Length (± 1 in.)
Brown	1	Right	10 in (254 mm)
Red	1	Right	10 in (254 mm)
Black	1	Left	10 in (254 mm)
White	1	Left	10 in (254 mm)



45670 – MXR50/U/MED/O

GE Protected Multi-Vapor® PulseArc® Quartz Metal Halide ED17



Bulb

Base

View Larger

GENERAL CHARACTERISTICS

Lamp type	High Intensity Discharge - Quartz Metal Halide
Bulb	ED17
Base	Medium Screw (E26)
Bulb Finish	Clear
Wattage	50
Voltage	85
Rated Life	10000 hrs
Bulb Material	Hard glass
Lamp Enclosure Type (LET)	Open or enclosed fixtures

PHOTOMETRIC CHARACTERISTICS

Initial Lumens	3400
Mean Lumens	1700
Nominal Initial Lumens per Watt	68
Color Temperature	3500 K
Color Rendering Index (CRI)	70
Effective Arc Length	0.300000 in (7.620000 mm)

ELECTRICAL CHARACTERISTICS

Burn Position	Universal burning position
Open Circuit Voltage (peak lead ballast) (MIN)	332 V
Open Circuit Voltage (RMS lag ballast) (MIN)	235 V
Warm Up Time to 90% (MIN)	2 min
Warm Up Time to 90% (MAX)	5 min
Hot Restart Time to 90% (MIN)	10 min
Hot Restart Time to 90% (MAX)	15 min

DIMENSIONS

Maximum Overall Length (MOL)	5.4300 in (137.9 mm)
Nominal Length	5.430 in (137.9 mm)
Bulb Diameter (DIA)	2.125 in (53.9 mm)
Light Center Length (LCL)	3.430 in (87.1 mm)

PRODUCT INFORMATION

ADDITIONAL RESOURCES

Catalogs

Testimonials

Brochures

Application/Segment Brochures

- Contractor Lighting
- Retail Lighting

Product Brochures

- HID Lamps
- Industrial Lighting

MSDS (Material Safety Data Sheets)

Disposal Policies & Recycling Information

GRAPHS & CHARTS

Spectral Power Distribution