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Construction Management
Thesis Final Report
April 2006
The Pennsylvania State University Recreation Hall Wrestling
and Student Fitness Center

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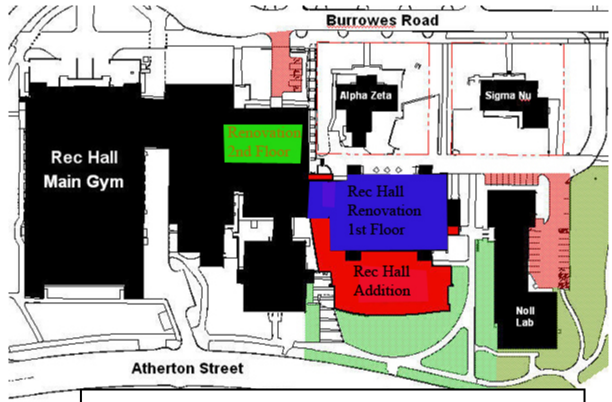
Introduction



Plan A.1 -The Rec Hall Project

The Pennsylvania State Recreation Hall Wrestling and Student Fitness Center Addition and Renovation Project is located at University Park, Pennsylvania. The owner for this project is The Pennsylvania State University, with additional funding provided by the Intercolegiate Athletics Association. The renovation phase of the project will mainly serve the Penn State Wrestling team, but will also provide training facilities to the men and women's soccer and volleyball team. The addition portion of the project will act as a fitness center open to all Penn State students, faculty and staff. The Architect/Engineer on this project was L. Robert Kimball of Ebensburg, Pennsylvania. The construction of the project was led by Gilbane Building Company, a construction management firm located in Lawrenceville, New Jersey. The project delivery system is a Fast Track Method with a project cost of $13,145,206.00 and a schedule of 18 months. The project began on April 1, 2005 and is scheduled for substantial completion on September 1, 2006. The addition phase of the project is striving for LEED certification, with a silver rating. The LEED credits will be earned through various design features including, use of day-lighting, a high thermal performance envelope, energy consumption reduction and the reuse of the existing building shell. Credits will also be gained through construction practices, such as recycling of materials, soil erosion control and the use of locally abstracted materials. The renovation portion of this project is an alternate to the contract and therefore will not affect nor requires LEED certification.

Background

The Rec Hall Project consists of 19,794ft2 addition area and 28,587ft^2 of renovation area. The addition has a ground floor and mezzanine level, which encompasses half of the ground floor. The renovation phase of the project includes the demolition of the existing faculty weight room, expansion of the existing wrestling area, addition of an aerobics room, and renovation of the existing training facility, wrestling team locker room and equipment rooms. The renovation portion of the project will be completed while the building remains occupied. Work in occupied spaces of the existing building also includes the relocation of hot, cold and domestic water lines to service the addition.

Structural

The building rests on a foundation system composed of mini piles, on average 60' in length, which are capped with pile caps. A reinforced fill system is designed at the interior of a large portion of the foundation walls, which will resist the surcharge forces produced by the slab on grade and compact fill. Resting upon the pile caps are a series of cast in place grade beams, which support the foundation walls and the slab on grade. The above grade structure is structural steel, consisting of tube steel columns, W shape beams and open web joists. The mezzanine level is made of metal decking and a cast in place slab. The roof system is composed of metal acoustical decking, three layers of rigid insulation and a single ply membrane.

Rendering A.1 -A Rendering of the Recreation Hall Addition

Façade

A large portion of the façade is an aluminum curtain wall system, incorporating spandrel and ceramic frit glass. The remainder of the shell is corrugated metal panels and brick walls with cast stone caps.

Sitework

Site work for the project entails the removal of an existing parking lot for the addition, demolition of the existing parking lot and construction of a new brick paver parking lot for Celos Laboratory, and the construction of brick paver walkways and fire lane.

Electrical

The electrical feed to the building is 480/277 and is provided from the existing high voltage utility feed. Upon entering the building the voltage will be reduced to 120/208 by two transformers. The existing switchgear will be replaced with a 100 amp, 480V, 3 phase switchboard.

Mechanical

The mechanical system consists of four air handling units and four fan coil units for the addition. The renovation phase also consists of four fan coil units and four air handling units. Two mechanical rooms are located in the addition phase of the project, located directly between the addition and the existing building, one on the first floor and the second directly above it on the mezzanine level. The AHUs precondition outside air to supply the building. The heating system makes use of the existing campus steam line through a steam-to-heating hot water converter. The cooling system employs the campus chilled water distribution feed, which is supplied from an on campus chiller plant.

Estimate

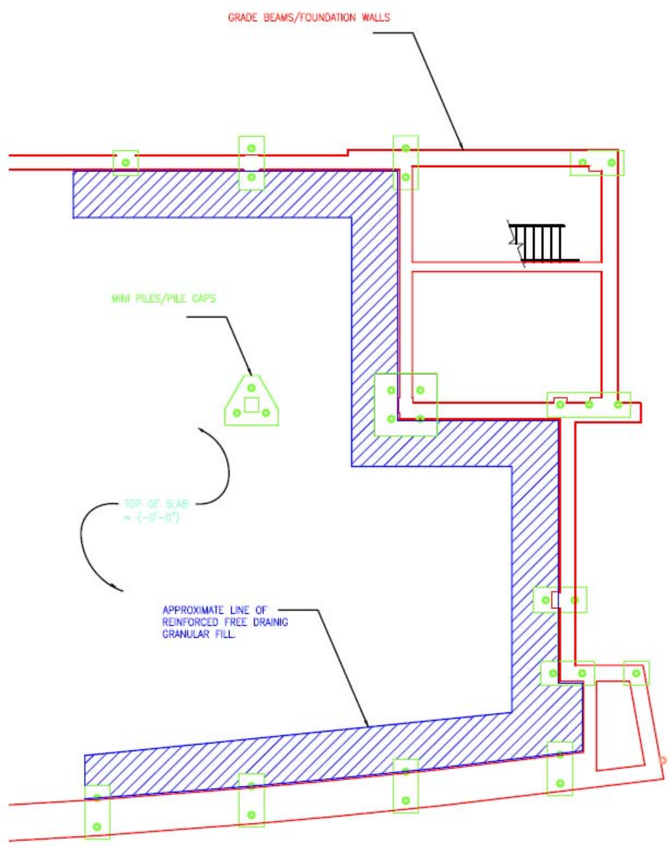
The following chart shows the cost for each package on the Recreation Hall project, it does not include the costs for Alternate 1 and Alternate 2.

Package	**Bid Package Cost**
Concrete	$512,155
Masonry	$755,000
Metals	$1,103,252
General Trades	$2,002,400
Conveying Systems	$126,800
Mechanical/Plumbing	$1,207,100
Electrical	$926,000
Curtain Wall	$1,080,600
Site Work	$1,785,285
Misc. Metals	$733,600
Roofing	$271,400
Elevators	$126,800
Testing/Balancing	$208,305
Fire Protection	$129,880
Asbestos	$28,400
Piles	$407,000
Total	$10,670,377

Structural Analysis – The Removal of the Reinforced Fill System

Background

Tensar Earth Technologies' SierraScape system is a reinforcing fill system, most commonly used for road and bridge construction where a large amount of soil needs to be retained. The system resists the surcharge forces caused by fill behind the wall. Each unit has a height of eighteen inches and length of nine feet. The system is composed of an L shaped welded wire face unit which is braced by a diagonal support strut. The system is anchored laterally by two uni-axial structural geogrids which are attached to the face unit and placed nine feet and four feet into the compact fill. Each unit is stacked directly on top of the previous unit. This allows a constant void of six inches between the face of the SierraScape system and the foundation wall. The compact fill used on the Rec Hall project was 2B stone. The fill must be placed in six inch lifts and compacted on each lift. Please see Appendix A for descriptive details of the system.



Plan B.1-The Building Footprint and Tensar Location

The system was placed at the East end of the building, at an average height of six feet. The total length of the system required was 178'. The blue region in the plan to the right is the approximate location of the SierraScape system on the Recreation Hall Project.

Proposal/Goals

I propose to remove the reinforced fill system and use the typical compact fill system in its place. The removal of this system will require the cast in place foundation wall/grade beam system to withstand the soil pressures caused by the compact fill and lateral forces imposed by the slab on grade. This may require an increase in the size of the foundation walls and grade beams, or the construction of a deeper keyway in the grade beam to resist sliding. I feel overturning will not be a problem as the slab on grade is connected to the foundation wall by way of a thickened slab and reinforcement. Please see Appendix A for a detail of the wall. If overturning is a problem, the toe and heel of the wall may need to be increased which will require a larger quantity of concrete. My goal for this analysis is to create a large cost savings and schedule reduction. The designed system is time consuming when compared to the traditional compact fill system, as it requires the assembly of each unit and layout of the geogrid prior to placement of the fill. If a schedule reduction can be determined through the removal of the reinforced fill system, the project schedule may be directly affected as the reinforced fill system is on the critical path. This system is also more costly due to the additional material and labor required to construct the system. If the calculations prove a large amount of concrete is required to resist overturning and slipping, the cost savings and schedule reduction may be largely affected and may prove the removal of the system is not beneficial to the owner.

Procedure

The first step completed for this analysis was a cost comparison of the two systems. A takeoff was developed for each system, and values determined using R.S. Means Costworks and the calculated takeoff quantities. Please see Appendix A for the takeoff and cost calculations. The cost calculations for the reinforced fill system used costs provided by Tensar Earth Technologies, Inc. This price included the material for the system and labor to construct the units, but did not include the cost for the 2B stone and placement of the fill. The decision to use this number was based on the assumption that both systems require the same quantity of fill and time to place and compact the fill. Upon completion of this comparison it was determined a large cost savings could be gained through the replacement of the reinforced fill system. The second step completed was the determining of the maximum load that would be placed on the foundation wall/grade beam system. Once these forces and moments were obtained, calculations were performed to determine if the wall was able to resist the forces. Two locations, which were typical throughout the building, were chosen for design checks. Please see Appendix A for a diagram of the load acting on the wall and the load calculations performed. The overturning moments and sliding forces were calculated. The soil density value for the soil under the foundation, the soil over the toe of the wall and the retained soil was 125pcf, as obtained from the soil report. The friction angle for all soils was obtained from the soils report as 30º. The factor of safety for sliding required was to be ≥ 1.5. The factor of safety for the larger of the two walls was determined to be 1.8 and that of the smaller wall was determined to be 1.5. Therefore, both walls were determined capable of resisting sliding. It was determined a factor safety of ≥ 3 would be required for the overturning calculations. In order to obtain this factor of safety, it was determined the resisting moment between the foundation and slab on grade would need to be 11.5 kips at the larger wall and 16.5 kips at the smaller. It was determined that the reinforcement and coverage of concrete was capable of resisting this moment at both locations. When the calculations were completed it was found the wall was able to resist overturning and sliding without increasing the size. However it was determined that the calculations had assumed a fixed pin at the top of the wall throughout the process, which was not the case. During the time period between the placement of the fill and the placement of the slab on grade, the foundation wall would be subject to overturning. A solution for this issue was determined to be shoring of the wall until the slab on grade was poured, which was determined to be a time period of less than five days. After these findings, a comparison of the schedule was completed. The time period used for the construction of the SierraScape system was the actual duration witnessed on the Recreation Hall Project. The time required for the placement of fill was calculated by using values provided in R.S. Means and the quantity determined in the takeoff.

Conclusions

The total savings that could be obtained by removing the reinforced fill system was determined to be $26,700.00. The following chart demonstrates the cost for the reinforced fill system, which translates into the total savings.

Tensar Systems - SierraScape Estimate				
Height of wall (ft)	**Length of Wall (ft)**	**Area (ft^2)**	**Cost Per Unit - Including M&L**	**Total Cost**
6'	178	1068	$25.00	$26,700.00
			Total Savings:	**$26,700.00**

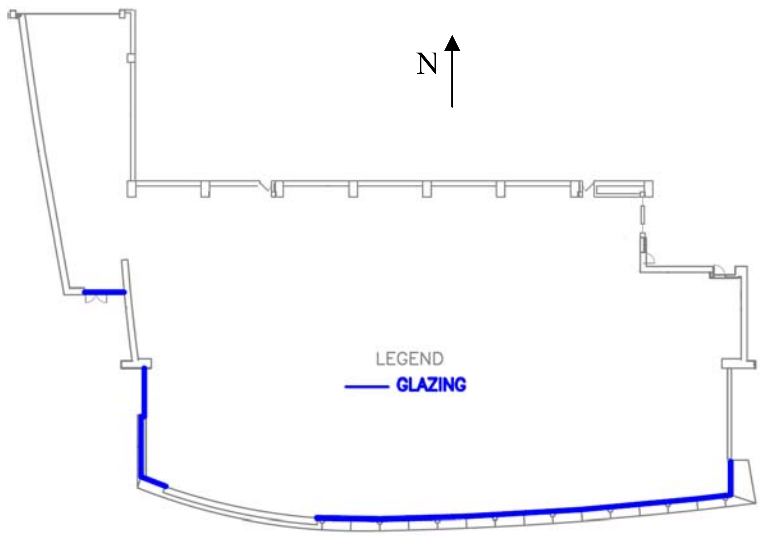
The total schedule reduction was found to be 4.5 days, assuming 8 hour days. This reduction could potentially result in the entire project being reduced by one week. The following chart shows the comparison of the durations for each system.

Schedule Comparison				
System	**Units**	**Quantity Per Day**	**Total Quantity**	**Total Days**
Tensar Systems - Sierra Scape	Section	16	80	5
Compact Fill	C.Y.	800	366.2	0.5
	Schedule Reduction:			**4.5 Days**

Mechanical Analysis – Double Pane Glazing vs. Triple Pane Glazing

Background

The Recreation Hall façade is composed of 5,172 ft^2 of curtain wall. The south side and a small portion of the East side of the building consist of an interior and exterior curtain wall. The diagram to the right shows the amount of glass, blue line, in the Rec Hall addition. The interior curtain wall, which extends to seven feet above finished floor, is composed of aluminum framing, manufactured by Kawneer Co., with double pane ceramic frit glass. The exterior curtain wall, which extends from six feet above finished floor to 26' above finished floor, consists of aluminum framing with double pane spandrel/opaque glass. The double pane glass is produced by Viracon and is made of two ¼" panes of glass with a ½" airspace separating the two panes. Please see Appendix B for a detail of this curtain wall. The remainder of the glazing that covers the façade of the building is double pane spandrel/opaque glass. Due to this large portion of glass, energy loss throughout the building becomes an issue.



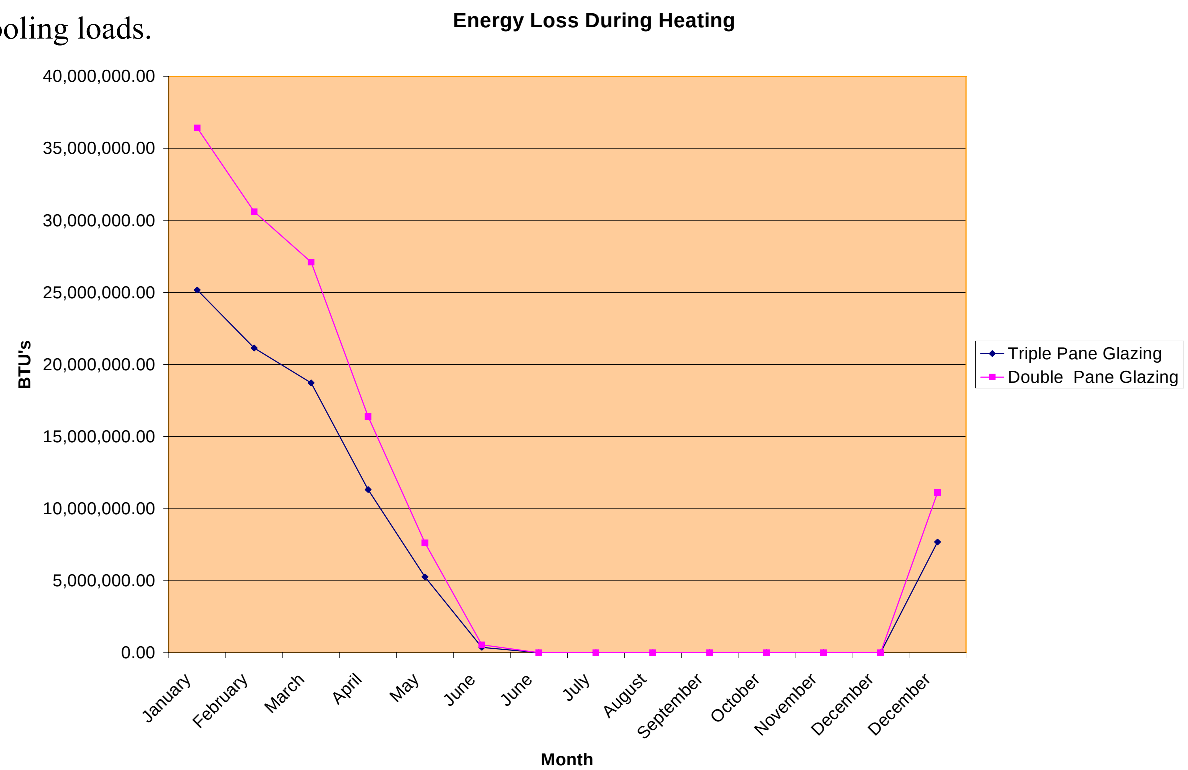
Rec Hall Addition Footprint

Proposal/Goals

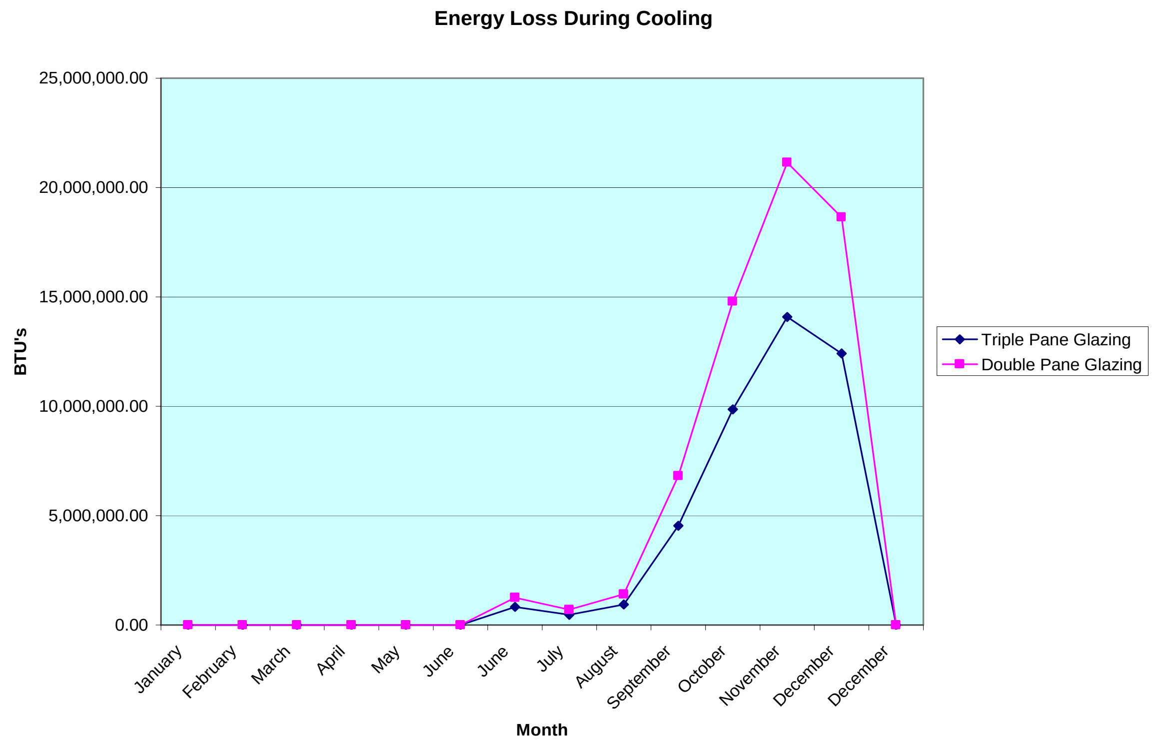
In order to reduce the energy loss through the large amount of glass, I propose to increase the glazing from double pane to triple pane. I believe there will be a higher initial cost for this upgrade, as triple pane glass is more expensive, but I hope to offset that cost through a short payback period, caused by the energy savings. I hope to find the payback period is less than ten years, which would allow the remainder life of the glass to be a savings to the owner. The same patterns of glass, Ceramic Frit and Spandrel, will be used for the triple pane which will allow the same quantity of radiation into the building. The largest affect will be an increase in the thermal resistance, therefore reducing the energy loss and energy cost. The schedule will be unaffected by this change, as the quantity of glass panels and aluminum framing members will not change.

Procedure

The first step completed for this analysis was the obtaining of the U-values for the designed glass, double pane Spandrel and Ceramic Frit glass and triple pane Spandrel and Ceramic Frit glass, from the glass manufacturer, Viracon. Please see Appendix B for the list of U-values. Upon obtaining these values the total area of each pattern of glass was calculated, 4,248ft^2 of Spandrel/Opaque glass and 924ft^2 of Ceramic Frit glass. The design temperature for the building was decided to be 68° F for the winter months and 72° F for the summer months. This value was obtained through discussions with L. Robert Kimball's mechanical engineer. The next task completed for this analysis was the acquiring of the average temperatures for the previous ten years for State College, PA from the National Weather service. Once all required values were obtained, the energy loss per month was calculated using the equation q=(U-value)x(ΔT)x(Area of glass). The energy losses per hour values were then multiplied by the number of hours for each month, producing the energy loss per each month. The cooling load was assumed to begin on the first day of summer, June 21 as well as the heating load to begin on the first day of winter, Dec 21. This allowed the values to be separated into heating and cooling loads. The following graphs illustrate the energy loss per month for both heating and cooling loads.



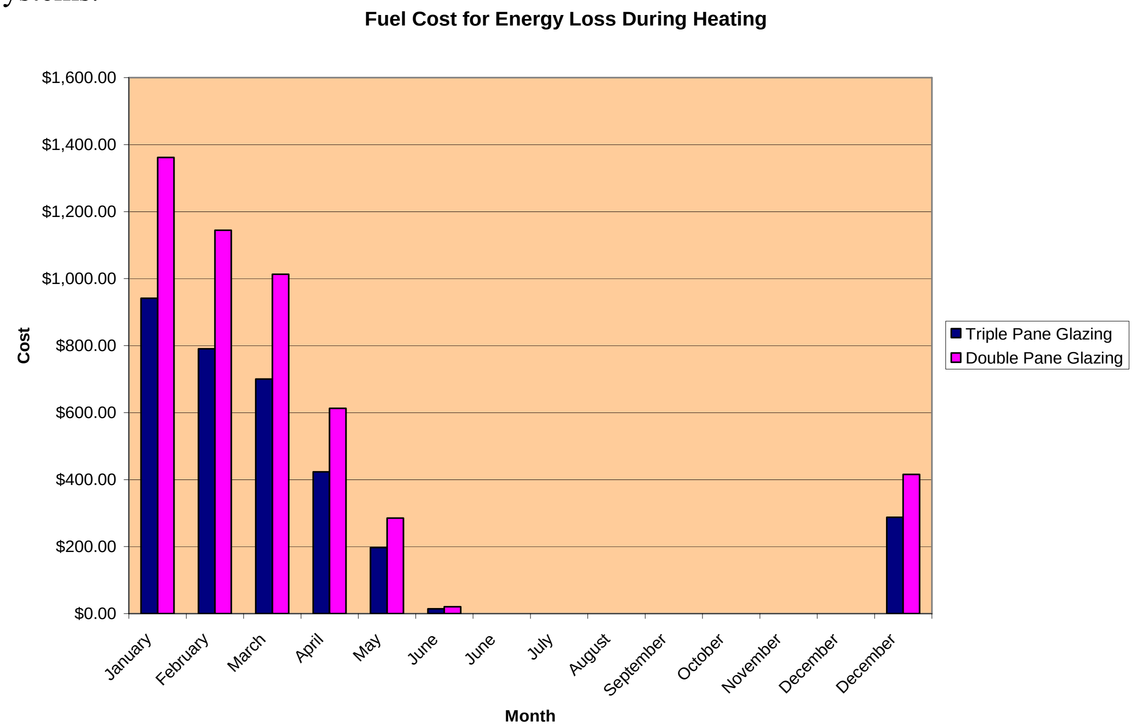
Graph A.1 – Heating Energy Loss per Month for Triple and Double Pane Glass



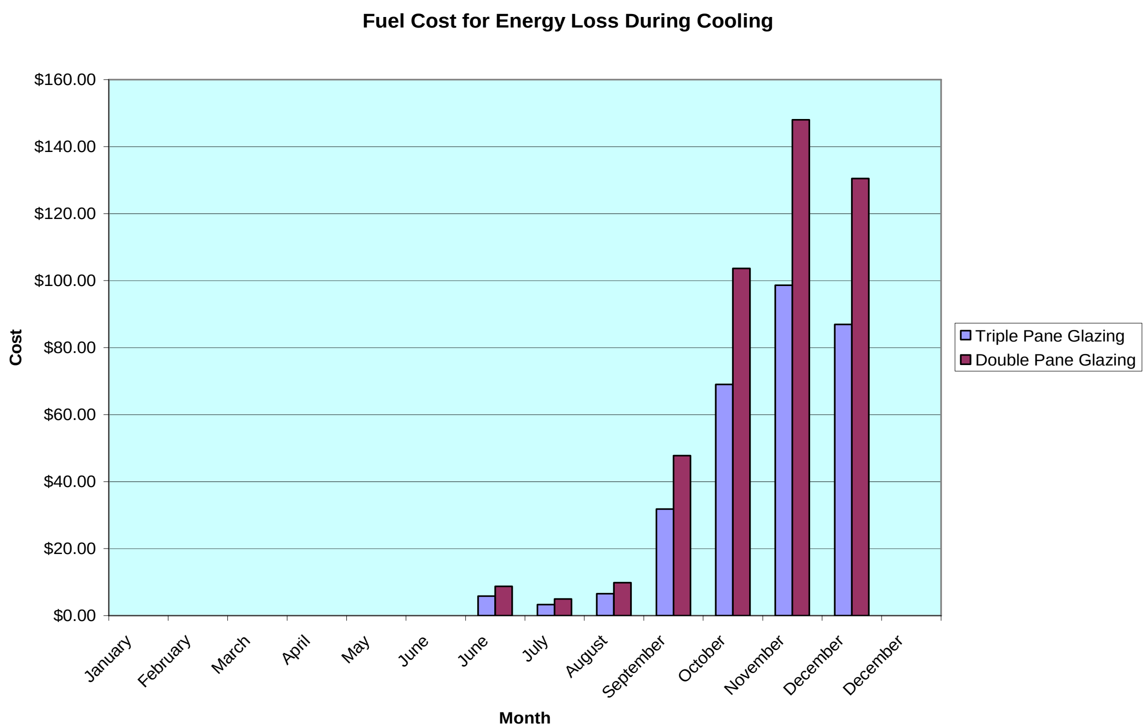
Graph A.2 – Heating Energy Loss per Month for Triple and Double Pane Glass

Rec Hall's heating system is fueled through the use of the campus wide steam system. It was assumed the efficiency for this system is 85%, which was multiplied by the heating load energy loss values to determine the actual heat loss. The cooling system for Rec Hall is fueled by the electrical system. This efficiency factor was assumed to be 80%, which was multiplied by the cooling load energy loss values to establish the true cooling load energy losses. The following step in performing this analysis was to determine the price that Penn State University pays for fuel; coal, natural gas and electricity. These numbers were obtained by contacting Paul Moser with Penn States Utility Services Department. He was able to provide estimates for the cost of each fuel; which were approximately $90 per ton of coal, $0.0234 per KWH of electricity and approximately $6 per MCF of natural gas. Using the assumption the cooling load is fueled by electricity 100% of the time and the heating load is fueled by coal 83% of the time and natural gas 17% of the time. These percentages were determined using the

Office of Physical Plants statistics for the fuel use during the year 2004-2005. The following graphs compare the energy loss costs for the double and triple pane glass systems.



Graph B.1 – A Cost Comparison of Heating Energy Costs for Triple and Double Pane Glass



Graph B.2 – A Cost Comparison of Cooling Energy Costs for Triple and Double Pane Glass

When the total energy loss costs were completed, the difference in initial cost was determined. The cost difference was only present in the material costs, as it was assumed it would not require more labor to install the triple pane glass. The costs for the material were provided by the glass manufacturer's, Viracon, estimating department. The following chart presents the difference in cost for the double pane and triple pane system.

Description	Area	Cost/Area ($/ft^2)	Cost ($)
Double Pane Spandrel/Opaque Glass	4,248.00	10.25	$43,542.00
Double Pane Ceramic Frit Glass	924.00	10.25	$9,471.00
Total:	**5,172.00**	**----**	**$53,013.00**

Description	Area	Cost/Area ($/ft^2)	Cost ($)
Triple Pane Spandrel/Opaque Glass	4,248.00	17.25	$73,278.00
Triple Pane Ceramic Frit Glass	924.00	17.25	$15,939.00
Total:	**5,172.00**	**----**	**$89,217.00**

Table C.1 – A Table Displaying the Difference in Initial Cost for Triple and Double Pane Glass

The final undertaking for this analysis was the calculating of the payback period. Three conditions were used when performing these calculations; present energy costs, energy costs at a 5% increase and energy costs at a 10% increase. Prior to making the decision if the change would be beneficial to the owner, calculations were completed to assure the structural system would be capable of holding the added weight of a triple pane system. A comparison of the loads determined the weight difference was minimal and the structural system was able to withstand the extra loading. The following table shows the loads each system would impose on the structural system.

Description	Weight (lb/ft^2)	Area (ft^2)	Total Weight (lb)
Actual Design-Double Pane Glass w/ Aluminum Framing (7525 Wall)	13.00	5172	67,236.00
Proposed Design-Triple Pane Glass w/ Aluminum Framing (7550 Wall)	16.30	5172	84,303.60
Total Weight Difference:	3.30	-----	17,067.60

Table C.2 – A Table Displaying the Difference in Loading for Triple and Double Pane Glass

Conclusion

The period required for the savings in energy costs to offset the higher initial cost was not as short as I had anticipated. The following table shows the payback periods for the change from a double pane system to a triple pane system for each of the previously mentioned conditions.

2005 Prices

System	Heating Fuel Cost/Year	Cooling Fuel Cost/Year	Total Fuel Cost/Year	Initial Cost
Double Pane Glazing	$4,853.06	$453.38	$5,306.44	$53,013.00
Triple Pane Glazing	$3,353.66	$302.02	$3,655.68	$89,217.00
Difference	**$1,499.40**	**$151.36**	**$1,650.76**	**$36,204.00**
Payback Period		***22 Years***		

5% Increase from 2005

System	Heating Fuel Cost/Year	Cooling Fuel Cost/Year	Total Fuel Cost/Year	Initial Cost
Double Pane Glazing	$5,095.71	$476.05	$5,571.76	$53,013.00
Triple Pane Glazing	$3,521.34	$317.12	$3,838.46	$89,217.00
Difference	**$1,574.37**	**$158.93**	**$1,733.30**	**$36,204.00**
Payback Period		***21 Years***		

10% Increase from 2005

System	Heating Fuel Cost/Year	Cooling Fuel Cost/Year	Total Fuel Cost/Year	Initial Cost
Double Pane Glazing	$5,338.37	$498.72	$5,837.08	$53,013.00
Triple Pane Glazing	$3,689.03	$332.22	$4,021.25	$89,217.00
Difference	**$1,649.34**	**$166.50**	**$1,815.84**	**$36,204.00**
Payback Period		***20 Years***		

Table C.3 – The Payback Period for Changing from a Double Pane System to a Triple Pane System

Construction Management Analysis – The Use of ProPress Fittings

Background

The renovation phase of the Recreation Hall project involves a large amount of relocating existing domestic water lines and installation of new domestic water lines. As previously mentioned the area the majority of this work needed to be completed was in occupied spaces. This required extensive coordination with the owner to schedule times, such as nights and weekends, to perform the work. This portion of work required the shutting down of the domestic water system to the whole building, to allow tie-ins to be made. The bid for this section of work had initially assumed the work would be completed with solder fittings. Using solder fittings requires the lines where the tie-ins are being performed to be completely drained and dry, often taking many hours. Due to occupancy of the building, the scheduled time periods for this work were very short which made it very difficult to complete the work since a large portion of time was wasted waiting for the system to drain. Therefore, it was decided the best option would be to make use of the ProPress system. Rather than soldering, the ProPress system uses a pressing tool, shown on the right, to crimp the fittings to the pipe. This system does not require the line to be drained completely, as does the soldering method. The fittings for this system are manufactured by Viega and the tool for applying the fittings is manufactured by Ridgid. At this time the Viega does not manufacture valves that can be used with the pressing tool. The fittings available for this system are 90° elbows, 45° elbows, tees, couplings, reducers, caps and adapters. On the Recreation Hall project the ProPress system was used for domestic water pipe sizes two inches and smaller. The soldering method was used for domestic water lines larger than two inches.

Picture C.1 – Ridgid's 320 E Battery Press Tool

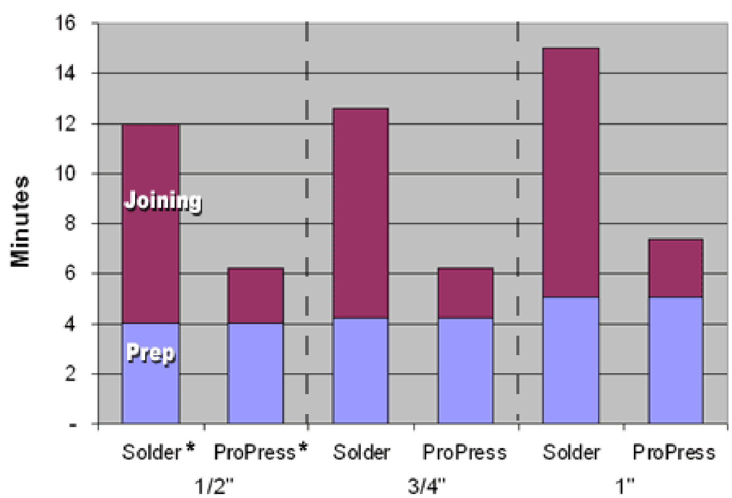
Picture C.1 – Viega's ProPress Fittings

Proposal/Goals

I propose to use the ProPress system on all sizes of piping for the domestic water lines. The time savings that were witnessed during the plumbing of domestic water lines two inches and smaller make me believe using the system on pipe sizes larger than 2 ½" would carry the same benefits. My goal is to determine the savings acquired by implementing the ProPress system for the domestic water lines mentioned. I also hope to determine the savings, if any, that could have been gained by using the system on the larger pipe sizes. Through this analysis I will determine if the correct choice was made to use the ProPress system as well as the choice to use it on certain sizes of pipe.

Procedure

The first stage of this analysis was to do a takeoff on the entire domestic water system, splitting the work into renovation and addition phases. Once the quantities of fittings required were determined the cost for ProPress material was calculated, using costs directly from Viega's catalog. The cost for solder fittings was then estimated using numbers obtained from R.S. Means, which included material and labor costs. R.S. Means was also used to determine the duration required to install each fitting. A graph located at the ProPress sytem website provided the information necessary for determining the appropriate installation time for each ProPress fitting. Using this installation time and the cost for labor, obtained from R.S. Means, the cost to install the ProPress fittings was determined. Please see Appendix C for all calculations involving this analysis. Upon completion of these calculations, a comparison of three options was formed. The first option, the option implemented on the Recreation Hall project, was to use the ProPress system on pipe sizes ½" to 2" and to solder all fittings larger than 2". The second option was to solder all joints on the domestic water



*Source: PHCC-NA Labor Calculator 2000

system. The third option was to use the ProPress system on all domestic water line fittings. Upon finding the results, I researched into other advantages of the ProPress system, which included information sessions on the product, discussions with the plumbing subcontractor who is using the system and personal observation. Upon gathering all the information I formed a conclusion on the system.

Conclusion

Although there was a reduction in cost of the domestic water system, the difference was not as large as I had initially hoped. The following table shows the cost difference for each option previously mentioned.

Option #1	Material Cost	Labor Cost	Total Cost
Renovation ProPress w/o XL Fittings:	$1,311.15	$1,611.88	$2,923.03
Renovation Solder XL Fittings:	**$1,510.50**	**$1,199.50**	**$2,710.00**
Renovation Option #1 Total:	***$2,821.65***	***$2,811.38***	***$5,633.03***
Addition ProPress w/o XL Fittings:	$1,003.65	$1,333.48	$2,337.13
Addition Solder XL Fittings:	***$1,775.70***	***$3,567.50***	***$5,343.20***
Addition Option #1 Total:	***$2,779.35***	***$4,900.98***	***$7,680.33***
Option #1 Total:	***$5,601.00***	***$7,712.36***	***$13,313.36***

Option #2	Material Cost	Labor Cost	Total Cost
Renovation Option #2 Total:	***$2,237.12***	***$4,407.75***	***$6,644.87***
Additon Option #2 Total:	***$2,237.80***	***$6,301.25***	***$8,539.05***
Option #2 Total:	***$4,474.92***	***$10,709.00***	***$15,183.92***

Option #3	Material Cost	Labor Cost	Total Cost
Renovation Option #3 Total :	***$3,252.90***	***1079.46***	***$4,332.36***
Addition Option #3 Total:	***$4,266.65***	***$4,266.65***	***$8,533.30***
Option #3 Total:	***$7,519.55***	***$5,346.11***	***$12,865.66***

Option #1 Description -Consists of ProPress Fittings for Pipe Sizes 1/2" to 2" and Solder Joint Fittings for Pipe Sizes 2-1/2" to 4".
Option #2 Description -Consists of ALL Solder Joint Fittings
Option #3 Description -Consists of ALL ProPress Fittings.

Table C.1 – Cost Comparison of Three Options for Domestic Water System Installation

Although the savings were not a large amount, implementing the ProPress system on all pipe sizes rather than soldering all joints would have reduced the schedule, for domestic water line installation, by 50%. The reduction in time that would have been seen by using all ProPress fittings rather than ProPress fittings on pipe sizes 2" and smaller would have been 30%. The following chart shows the comparison in time required for installation for each system.

Option #1	Total Manhours	Total Days
Renovation ProPress w/o XL Fittings:	41.9235	5.5
Renovation Solder XL Fittings:	34.619	4.5
Renovation Option #1 Total:	*76.5425*	*10*
Addition ProPress w/o XL Fittings:	35.9665	4.5
Addition Solder XL Fittings:	*103.329*	*13*
Addition Option #1 Total:	*139.2955*	*17.5*
Option #1 Total:	*215.838*	*27.5*

Option #2	Total Manhours	Total Days
Renovation Option #2 Total:	*118.467*	*15*
Additon Option #2 Total:	*175.262*	*22*
Option #2 Total:	*293.729*	*37*

Option #3	Total Manhours	Total Days
Renovation Option #3 Total :	*59.2335*	*7.5*
Addition Option #3 Total:	*87.631*	*11*
Option #3 Total:	*146.8645*	*18.5*

Option #1 Description

-Consists of ProPress Fittings for Pipe Sizes 1/2" to 2" and Solder Joint Fittings for Pipe Sizes 2-1/2" to 4".

Option #2 Description

-Consists of ALL Solder Joint Fittings

Option #3 Description

-Consists of ALL ProPress Fittings.

Notes: -Days were rounded to the nearest 1/2 day.

Table C.1 – Schedule Comparison of Three Options for Domestic Water System Installation

In addition the cost savings and schedule reduction, the ProPress system offers a higher quality product as well as a safer atmosphere. Due to the crimping system, the chances of a leak in the system greatly declined. A high quality solder fitting requires a skilled workman. If the fitting is not soldered correctly, the joint will leak. Since the ProPress system is completed by a tool making a crimp 100% around the fitting, the chance for error is greatly reduced. Through the hundreds of fittings installed using the ProPress system on the Recreation Hall project, only one leaked which was due to the forgetting to crimp the fittings. Safety is also a benefit provided by the ProPress system. When working in the occupied spaces, the work was often performed in the ceiling space which was very cramped with materials. When soldering the fittings in these spaces there is a high risk of misplacing the torch and starting a fire or having solder fall onto finished products. The ProPress system eliminates these problems, as no torch is required to install ProPress fittings.

Recommendations

Structural Analysis – The Removal of the Reinforced Fill System

Upon completion of analyzing the advantages and disadvantages of removing the designed reinforced fill system, I have decided to recommend the removal of the system. The savings in deleting this system equal $26,700.00. Although the calculations show the Tensar system reducing the Recreation Hall schedule, further analysis showed the schedule would be unaffected as the concrete work was phased in a way that allowed the Tensar system to be placed while the remaining foundation walls were poured. Removing the reinforced fill system would have required shoring of the wall which would reduce the savings minimally. Also the needing for shoring on an already tight site could create a problem, but I feel the time period the shoring would be required would not affect other work. In order to retain the original schedule and reduce the time that shoring is required, I would suggest the placement of these foundation walls last. This would allow the slab on grade to be poured quickly after completion of the walls, which would allow the shoring to be removed. The slab on grade was also used for a layout area during steel erection; therefore the shoring would not cause problems with the crane path.

Mechanical Analysis – Double Pane Glazing vs. Triple Pane Glazing

The energy savings that would be acquired through the changing of double pane glazing to triple pane glazing is not as large as I had initially thought. The time required for the energy savings to offset the higher initial cost of the triple pane glass is much longer than I feel is necessary. Therefore, I would not recommend the changing of the exterior glass. I feel the payback period would need to be approximately 10 years for this option to be beneficial to the owner. Within the payback period of 20 years, the owner faces the risk of replacing panes of broken glass which will increase the payback time.

Construction Management Analysis – The Use of ProPress Fittings

I recommend the use of ProPress fittings on all pipe sizes for the domestic water lines. This action would produce a small reduction in cost, but most importantly cause a higher quality of work and lower safety risk. Along with improved quality and safety, the time required in occupied spaces would be decreased. When working in occupied spaces every day that is able to be cut from the schedule is beneficial, as the occupants are not disturbed by construction as much. Therefore, I think the decision to use the ProPress system was correct but I think the system should have been implemented on all pipe sizes.

Research Study – Reducing LEED Costs

Introduction

Two of the main objectives when designing and constructing buildings are high quality and low cost, which are often directly related. A school of thought that has become very popular in many areas is the idea of Green Buildings. The goal for such designs is to construct a building that is environmentally friendly, which in turn causes lower long term maintenance costs. The problem with LEED Certified buildings, Green Buildings, is they often demand a higher initial cost. This case study will discuss practices that can lower initial design and construction costs, established by John W. Mogge Jr. in Breaking Through The First Cost Barriers of Sustainable Planning, Design and Construction and by Anthony R. Lapinski, Michael J. Horman and David R. Riley in Lean Processes for Sustainable Project Delivery, and compare to those implemented on the Pennsylvania State University Recreation Hall Wrestling & Fitness Center Addition Project.

Background

The Penn State Recreation Hall Project consists of an addition and renovation phase. The addition phase will be LEED Certified with a silver rating, but the renovation phase will not be certified. Therefore, this study will focus on the addition segment of the project, which consists of approximately 20,000 SF. The cost for the addition phase is roughly $11,000,000, and is scheduled for 18 months. The design process encompasses many aspects that will earn LEED points, which include Energy Star Roofing, Day Lighting design, high performance windows and curtain wall, the reuse of the existing building shell, a concrete mixture that replaces 40% of the Portland cement with slag, and a high performance thermal envelope. The construction practices executed to achieve LEED points will be discussed individually throughout this paper.

Site Planning

Many key practices that will reduce the initial cost of a Green Building are developed prior to the start of construction. An example of these practices is the development of an appropriate site plan. This task, which can result in an initial cost reduction for LEED projects, relies on appropriate location of the project, proper design of the site by the architect, as well as the execution of the design by the construction team. The main points that need consideration when designing a site plan for a LEED project are; direct development to environmentally appropriate areas, maintaining and enhancing the biodiversity and ecology of the site, the use of microclimate and environmentally responsive site design strategies, the use of native trees, shrubs and plants, and the use of resource efficient modes of transportation. Due to the location of the new building, the Rec Hall Project was at a great advantage and able to incorporate many of these points into the achieving of LEED points. As previously mentioned the addition was able to use a large part of the shell of the existing building, this allowed the reduction of new materials required, as well as the recycling of the existing building. Also the location of the addition was previously a parking lot. Due to the existing parking lot, the area did not require a large amount of excavation for the building. Also due to the existing parking lot the design team was able to incorporate the existing drainage system into the addition drainage requirements. This reduction of required excavation and drainage system installation allowed the initial cost of site work to be reduced. Also due to the existing parking lot and design of the building, many of the existing trees and shrubs were able to remain. Since the project is located on Penn State University, the construction team was able to make use of the campus transportation system, CATA Buses. The tradesmen were encouraged to carpool when able as well as to park their vehicles at a lot off campus and ride the CATA bus to work. This implementation of carpooling and use of public transportation did not have a direct affect on the initial cost of the building, but may help the Rec Hall Project in the completing of LEED points as well as helped to keep the parking on site to a minimum.

Energy

The second key to reducing the costs for LEED projects is a focus on energy conservation. A large portion of this focus must be considered during design phase. Energy conservation relies on many design features, which include; the orientation of the building, the design of a high thermal performance envelope, utilizing day lighting to reduce electricity, the implementing of efficient electric lighting systems and controls, the specifying of a high performance mechanical system, reducing energy use and using renewable or other alternate energy sources. The Recreation Hall project was able to use many of these guides in the design of the building. The combination of the orientation of the building with the large amount of curtain wall façade allows a large amount of day lighting to enter the building. A large portion of the South West facing portion of the façade is composed of a glass curtain wall. This allows a large amount of radiation as well as natural lighting to enter the building. This lighting and radiation reduces the energy required to heat the building, as well as to light the building. Rec Hall's mechanical system employs the campus wide steam line. The steam is generated by coal for the majority of the time and natural gas during peak times. A more renewable energy source was unable to be used on this project, as the existing building is heated through the use of the steam source, which the addition section branches off of. The previously mentioned curtain wall is composed of double pane glazing which have U-values ranging from .22 BTU/ft^{2}xhx^{o}F to .3 BTU/ft^{2}xhx^{o}F. The high thermal resistive curtain wall along with the high performance energy star roof, allows a high thermal performance envelope. The electrical system at the Recreation Hall project, implements dimming controls. These dimming controls allow different lighting levels to be used as needed throughout the day, reducing the amount of energy that would be otherwise required. The mechanical system for the project, uses three main units; hot water radiant heating panels at the entrance vestibules, hot water fan coil units, and steam powered air handling units. Each of the mentioned units are high performance systems allowing the most production of heating and cooling while minimizing the energy consumption.

Water

Another focus point for reducing the costs for LEED projects is the conservation of water on the construction project. This task did not impose a large problem on the Recreation Hall project, as water was able to be used from the existing building. Therefore, the contractors nor construction management firm were required to provide water for construction. Gray water systems were not implemented on this project, as the difficulty of using such a system would be more costly than beneficial. The cooling system for the building is fed from an existing cooling tower on campus. Therefore, the efficiency of the plant and energy consumption was not a factor that could be controlled by the design team. Due to the small site, it was not feasible to collect and treat run off water, as the amount that would be collected would not be large enough to employ for construction.

Materials

The location of appropriate materials can often be the largest cost increase on LEED projects. Many of the materials specified were required to be composed of a portion of recycled contents. Often the manufacturers specified did not produce products that contained recycle content. This recycle content requirement along with the fact that materials were to be abstracted within a 500 mile radius of State College PA, caused a problem when locating correct materials. If the construction management team had not considered these problems early in the construction process, the costs and schedule of the project may have been drastically increased as many of the materials that were found to meet the requirements had extensive lead times. Locating adhesives and paints with the appropriate VOC content did not prove to be a challenge, as most products have a very low VOC content.

Recycling and Waste Management

The construction management team was also responsible for construction waste management. Due to the small construction site, it placed constraints on the number of dumpsters we were able to place on site. The construction management firm decided the most appropriate method for recycling would be to place three dumpsters on site, a general trash dumpster, a metals recycling dumpster and a clean fill dumpster. The general trades subcontractor was able to make an agreement with Penn State University, where the campuses recycling division would remove and dispose of cardboard from site. The wood that needed to be disposed was stored onsite until a large quantity was collected, at which time it was taken by truck load to a recycle center. The task of recycling was often a challenge during the construction process, as it was the first LEED project many of the subcontractors were involved in. Therefore, they did not fully understand the importance of documenting the quantity of recycled material and location where it was taken. Another challenge was enforcing the separating of recyclable materials and placement in the appropriate dumpsters. It was often easier for the subcontractors to place recyclable materials in the general trash dumpster, rather than spending time splitting the materials into different recyclable dumpsters. In order to enforce the recycling the construction management team would inspect the dumpsters to be sure trash was being placed in the appropriate locations.

<u>Commissioning</u>

In order to control energy consumption, commissioning is often used for LEED projects. Commissioning has become standard on all projects at Penn State University. This task can often be costly, as the commissioning team is brought in late to the project and problems that need repaired are very costly. In order to prevent such a problem, the construction management team made sure to involve the commissioning agent very early in the process. The commissioning agent and construction management firm reviewed the drawings to be sure the systems were appropriate. Also, the commissioning agent provided the construction management team with a list of requirements for the electrical and mechanical systems, which the construction management firm was able to ensure all aspects were met.

<u>Early Adoption of Environmental Considerations</u>

Allowing the construction management firm involvement early in the design process, allows many aspects to be considered for the LEED process. The construction management firm on the Recreation Hall project was not involved early in the design phase of the project, which caused input from the designer only.

<u>Early Section of Team Members w/ Sustainable Experience</u>

As previously mentioned, many of the subcontractors lacked experience with LEED projects. This lack of experience can often cause problems, both financially and achieving of a LEED rating. If the appropriate documentation and practices are not completed during the construction process, the price to achieve the LEED rating will increase or the LEED rating may not be achieved. In order to prevent this, the construction management firm assigned a LEED accredited official as the project manager for the Recreation Hall project. His knowledge and experience of the LEED process and LEED construction allowed the project to avoid many LEED challenges as well as minimize the costs associated with LEED projects.

Alignment of Team Member Goals and Project Goals

The aligning of goals for LEED projects is very important to not only the building cost, but also the project outcome. In order to assure all members of the project team had the same understanding for the goals of the project, meetings were held very early in the construction process. The owners, architects, engineers and construction management team attended the meetings to discuss and review the project goals. This discussion of project goals proved to be very beneficial throughout the project, as it allowed the architect and construction management team to gain a true understand of the owners needs. This understanding allowed the construction management team and architect to resolve problems encountered throughout construction in an less complicated manner, as they were able to picture the end product desired by the owner. This resolving of problems saves time and money on the project, as it reduces the amount of questions come across.

Conclusion

After researching the methods applied on the Recreation Hall project, I feel the correct actions and decisions were made by both the design and construction management team. I would however recommend an earlier involvement of the construction management team with the design process. This is often times difficult to accomplish, as a construction management firm is often not selected at the time this process occurs. However, the involvement of the construction management firm may reduce the number of construction problems causing a less costly and faster project. I would also recommend that the construction management firm offer classes that describe the LEED process as well as the specific goals for the project. Making these classes mandatory to the foreman for each trade, would provide a better understand of LEED processes causing a less complicated construction process for all parties.

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