Bellefonte Area High School

Bellefonte, PA

Mark Demianovich

Construction Management

Thesis – Spring 2007

Bellefonte Area High School Bellefonte, Pa

Reynolds : BUILDING A DIFFERENCE

Project Team

CM: Reynolds Construction

Architect: Crabtree, Rohrbaugh, & Assc.

Civil: ELA Group

Structural/MEP: Centerpoint Engineering

Project Features

Cost: 35 million

Duration: 2.5 years.

Function: Education, 9th-12th grades

Facility Houses: Classrooms, media centers, gyms, music room, theater

MEP/Structural

Mechanical: 34 rooftop units pushing 270000c.f.m. total

Electrical: 86 panel boards 100-400amps

Structural: 10 inch reinforced CMU

Flooring: 10 inch hollow core planks

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Acknowledgments

Executive Summary

The construction project discussed in this thesis is the Bellefonte Area High School. It also includes critical issues research methods describing the goal of future research as well as technical analysis methods that describe the problems also stated in this report. This report will tackle four man issues that relate to the Bellefonte Area High School construction project. The first issue will include an in depth analysis of construction management issues faced in replacing an existing structural CMU classroom wall with steel members to increase window size. The second and third will be a breadth analysis of an addition of a green roof and how it relates to the existing HVAC system and a breadth analysis of installing a new lighting system that corresponds to more direct day-lighting and automatic energy saving devices dispersed through the project. Also, the report will be detailing a critical issue currently facing the industry. I will be looking at the green building industry and current hurdles that inhibit its progression. I will also identify several possible problems with the Bellefonte Area High School and describe possible solutions and research methods for obtaining results.

These topics of research will stress in some way a critical issue facing the industry today, a value engineering analysis to increase the value of the building, a constructability review and schedule reduction. A cost and methods analysis will give a detailed breakdown for many different aspects of the Bellefonte Area High School building project. This detailed cost and methods analysis will help achieve a better

understanding of project execution and project details. This will include a detailed project schedule that will be used at a later time for cost loading. The information ascertained will be utilized for data for later research topics. It will also include a site-planning layout.

The most important finding of the construction project for the Bellefonte area high school was that the project is a multiphase project that includes more than simply building a new high school. This project is also a demolition project, a renovation project, and a new construction project. The old Bellefonte High School needed to be larger to contain enough space for the growing student population. Upon inspection of the building for renovation purposes, asbestos was found to be present on the site. This construction project will remove asbestos from the old school, perform renovations on parts of the school, and build new wings to meet growing demand for more space for more students. Additional parking will also be a goal of this construction project because the current capacity is not sufficient in hading the parking needs of the school. When dealing with any school district, money will always be an important factor to consider, especially in performing additions that are heavy on upfront costs. The budget of this project could have a very large affect on the ability to make LEED changes to the building. The building itself is not LEED rated and the new additions will not be either. Time and occupancy factors will have the greatest impact on the site concerning completion of the project on time, under budget, and with the utmost safety precautions. This project has multiple parts and renovations to multiple areas, but I will be focusing on the classroom space as my space of interest. This will be the most dynamic area after construction has been completed, contains the majority of the workload existing on the project, and will be the main focus of my future research.

Project Background

Site work for this project will have erosion control and cuts for the foundations prior to any construction or renovations being performed. After this site work has been completed, the site takes on many different aspects of the project at the same time. Renovations to the technology area begin demolition first, while at the same time in the new classroom area, foundations and MEP rough-in is being completed. Demolition, renovations, and construction continue throughout the site at the same time, effectively trade stacking the entire project, not just interior trades. The structural systems for each phase are started and completed at different times in different areas.

There is demolition required on the project that includes the removal of asbestos and materials containing asbestos from the site. The demolition required is to add new wings to the existing structure. The structural system of the building is not steel but will be concrete. The new construction on site will have a structural system made up of CMU blocks and pre-cast hollow core planks. The main floor and roof composites are made of hollow core concrete planks. The cast in place on site will used exclusively for the footings of the building and for slab on grades. The formwork will be wood used to form the footings for CMU walls and slab on grades. All formwork will follow ACI 301 for construction. All footings and slab on grades will be a direct pour.

The pre-cast concrete will come from a concrete pre-cast fabricator and be delivered to and stored on site by trucks to ensure continuity of installation. The crane for the pre-cast will be a mobile crane with a 100 foot reach and will be needed on numerous locations on site (see site plan for locations).

The Mechanical system is made up of 28 new air-handling units, 22 of which have energy recovery ventilator capabilities. The units are dispersed upon the rooftops in practical locations. The total volume handled by all the units is 271,590 C.F.M. which distributes air through duct work. This duct work is attached to the ceiling with vibration isolation hangers. A 400,000 dollar sprinkler system is also being installed for fire suppression.

The massive 3 million dollar electrical system contains 86 panel boards spread throughout the building in 10 different rooms. Although they are located in many different locations, there are 4 main rooms that contain most of the panel boards and electrical equipment. The main bus for each of the panel boards varies from 100 to 225 to 400 amps, while the minimum A.I.C. is at least 42000 for each panel.

The masonry used in this project will be located primarily in the structural wall consisting of CMU as well as face brick used for decorative purposes. Reinforcing for the CMU will be according to specs, and the connections will be hot-dip galvanized carbon-steel wire and anchors are ¼ inch diameter crimped steel wire. There are only two floors, so limited scaffolding will be needed.

Although curtain walls are not prevalent in this project, there is one large curtain wall construction on the second floor of the gym. The curtain wall system will use an aluminum framing system and steel reinforcement. Design responsibility is on the P.E. Andrew Douma.

The dewatering system will be mainly composed of a pump, and needs to be present at all times while work is being completed. Temporary dewatering systems redirecting surface drainage can only be removed after the excavation work has been backfilled. Excavation support systems can use machinery where applicable, but safety to existing structure is of the utmost importance, so much of the excavation and backfill may need to be done by hand.

Project Cost Evaluation

Construction Costs:	$29,277, 928
Total Project Cost:	$35,793,428
HVAC Cost:	$4,323,000
Plumbing Cost:	$1,223450
Electrical Cost:	$3,184,290
Structural Cost:	$1,213,992
Sprinkler Cost:	$427, 900

Thesis Analysis Introduction

This report will present the main areas of my thesis project. The research will include depth and breadth of the construction industry as it relates to the Bellefonte Area High School. These topics of research will stress in some way a critical issue facing the industry today, a value engineering analysis to increase the value of the building, a constructability review and schedule reduction. The topics that I will be using for these devices are a new structural wall design in the classroom areas to increase day lighting, some new aspects to the electrical system to make them more energy efficient, and the use of the roof as a green roof for insulation to cut down on heating and cooling costs of the building. This report will give steps by which data is to be obtained and how it will be used to relate these topics to the building industry.

I will also be covering a critical industry issue and how I will apply it to my research. A survey of the general public's knowledge about the green building industry will also be conducted in an attempt to finding the readiness with which people are willing to learn about the green building industry and find out how willing that public is to see steps taken to help insure that future construction be green.

Technical Analysis #1

Structural CMU for Classrooms: Currently in the wall design for the structural system of the classrooms, there are plans drawn up for solid grouted CMU to be used. This will be matched in other areas not needing structural CMU with decorative CMUs. . A steel system will be analyzed, allowing for more square footage to go to windows and decorative CMU used to match wall design in other areas. Cost data would need to be looked at in depth to determine if there were any cost differences for the steel system as compared to the current system. Also, acquiring the steel to fit with the current schedule will have to be compared to what schedule reduction is accomplished with using a different system. Some research would also be done in the benefits for students in classrooms with abundant day lighting. Assuming that the steel system would be comparable to the current system, benefits in classroom performance may be possible with a new wall design, as well as achieving a design scheme that would ease coordination problems.

It may be possible that steel is not needed for the change in the building façade. This will also be investigated and the best course of action chosen.

Technical Analysis #2

Electrical System change: With the enormous amount of energy that schools consume daily, energy saving devices put in place could greatly reduce the cost of electricity. According to the EPA Green Lights Program, green lights lighting upgrades save 48% of a buildings lighting energy on average. Other buildings with green lighting systems have also made on average 36 cents internal returns on Simple motion activated switches similar to those used by The Pennsylvania State University could decrease energy consumption. Similar systems that have automatic shut-off capabilities during certain times of the day could also be utilized to save energy. An analysis would have to be done on the change in cost versus specific savings that would be incurred. Research done in unused high school rooms that maintain lights on during the day will have to be compiled. The classroom areas will be studied to see if there are any cost saving methods that can be improved upon with the addition of more day lighting. A new lighting system will be designed to allow for a greener system to be installed.

Technical Analysis #3

Unused Roof: The current roof system is only utilized for holding the HVAC equipment and the roof covering itself. The presence of a green roof could greatly decrease the amount of energy used to heat the building in the winter and cool the building during the hotter months. A cost analysis would need to be done comparing the results of savings from other schools with green roofs to the extra cost incurred by adding and maintaining the green roof, as well as possible additional structural support needed to carry the load from the green roof. Also, relocation of HVAC units may need to be considered if it would interfere with green roof construction. All this data will be used to determine if adding energy saving devices are an efficient use of value engineering to increase the value of the school while still aiding the environment. Additional loads from the green roof will be the most important factor in determining what is needed for a green roof. The cost of additional reinforcement will be directly compared to the energy savings to determine any additional value added to the building and the mechanical system will be looked at to determine if any changes are necessary due to the green roof.

Industry Critical Topic:

Myths and rumors, as well as barriers in communication and a general lack of knowledge about the green building industry readily available to the public inhibit the ease with which owners, contractors, and subcontractors are willing to switch or adopt green construction products and methods. Some of the possible myths include increased cost for constructability of green systems, difficulty of installing and using green products and systems, and that attaining a LEED rating is not worth the effort and produces a building not much different form a non-LEED rated building. Much of these myths inhibit communication about green building systems because people have a preformed bias about these systems. A survey posted online will be geared towards college students that are not architectural engineers. The reasoning behind this being to determine if what is generally considered the “educated” populous is, in fact, educated on the green building industry. The public holds large amounts of sway with the way big businesses run their companies, so I pose that a more informed educated public will be more likely to insist, through boycotts, protests, or general unhappiness towards a company to make their buildings comply with practices used in the green building industry. We have already seen some steps towards this with the Wal-Mart cooperation and their recent increased interest in making their buildings green. The general public would also be more likely to build their own homes and business buildings using green techniques if they were more informed about the benefits/existence of environmentally friendly building techniques. The online survey will determine the depth of knowledge that non-AE majors have about the green building industry and the LEED rating program. It will also discover the educated public's opinion about using the government or other institutions to educate the general public about the green building industry.

While the technical analysis of the Bellefonte High School looks at value engineering, constructability, schedule reduction and even critical issues of the industry, an overall goal will also be accomplished. Through this additional value and technical data, an overall step toward discovering the benefits of the green building industry will be discovered. My thesis will attempt to cover all aspects of improving a building through the core thesis investigation areas while also attempting to connect them to the green building industry. I believe that more projects can become green buildings without losing value or function.

Improved Lighting System

Lighting systems in recent decades have grown by leaps and bounds. The technological development of automated systems allows for larger more flexible systems to be used effectively and energy efficiently. The most important aspect of a lighting system is a good control and wiring system to produce the desired affect for whatever space you are choosing to light. There are three main aspects to the lighting system applicable to the Bellefonte Area High School. Below is a chart that helps to describe three main controls and how they affect the lighting system and area that it is being lit.

Control	Input	Decision-making	Output
Occupancy sensor	Sensor detects presence or absence or people	Decide whether to turn on or shut off lights	Sends signal to relay, which closes or opens circuit
Control station and dimming panel	User presses button to recall preset scene	Control station recalls scene from memory and sends signal to dimmer at dimming panel	Dimmer adjusts light output to desired level
Dimmable ballast	Controller provides signal to dim	Ballast is instructed to dim, and by how much	Ballast alters the current to the lamps, dimming them

A building's interior lighting system can affect both the physical and emotional well-being of the building occupants. Interior Lighting in buildings makes up a large portion of the country's energy consumption as well as is a large contributor to a building's source of internal heat. According to the National Institute of Building Sciences, about 25% of the electricity budget is spent on lighting alone. They also state that "Specifying a high quality energy efficient lighting system that utilizes both natural and electric sources as well as lighting controls can provide a comfortable yet visually interesting environment for the occupants of a space." This belief of combining both natural and artificial light with flexible lighting controls will be the main focus of my changes to the classroom space lighting system.

While my original idea to improve the lighting system in the classrooms of Bellefonte Area High School was to change their current lighting arrangement to one that used indoor occupancy sensors, I found that the planned lighting system already included indoor occupancy sensors to add to energy savings for lighting the classroom spaces. The sensors will be wall mounted solid state units with a separate relay and a variable time delay ranging from 1 to 15 minutes depending on the preferred setting. The detector sensitivity has a 6inch minimum movement of any portion of the human body that presents a target of not less than 36 square inches. The sensor is capable of covering a circular area of 1000 square feet when mounted on an 8 foot ceiling, so the 22 ft. by 24 ft. classrooms will be covered by a single sensor.

I noticed that in combining my structural wall change to include a larger window area in the classrooms, the planned lighting system would actual use more energy and produce more light than was necessary to light the space. The current lighting system used in the Bellefonte Area High School classroom space consists of 9 Cooper Lighting Metalux GR8's that house (2) 32W fluorescent bulbs.

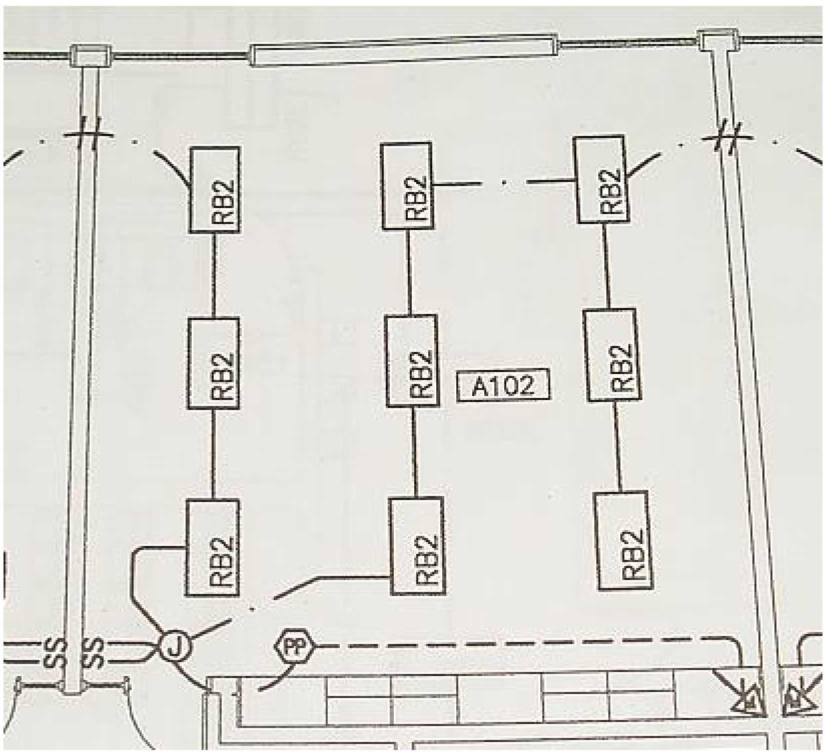


Figure 1

This lighting system is wired in a simple 2 series circuit, with no real leeway on varying the light output from the luminaries. Even if the current lighting system were to stay in place, the wiring should be done differently to better maximize the use of the windows on the classroom. The current lighting system has a string of three lights on one switch running perpendicular to the windows, negating the benefit of day-lighting. The exact same lighting configuration can be used, but wired so that the three lights farthest form the windows can be turned on separately. There are 4 possible lighting situations that can be created with the current system.

1. No lights on
2. The 3 lights in the front of the classroom are on, all others off
3. The rear lights are on while the front lights are off
4. All lights are on

In the majority of classrooms, there are only 2 windows that extend from the floor to ceiling and are approximately 4 feet in width. This leaves about 15 feet of exposed wall to the outside that does not contain any windows. The total area of the windows is 64 square feet of the 210 square feet of wall exposed to the outside, or about 25%. As a general rule, windows are able to daylight classrooms to their required levels of 500 lux to a distance inside the room from the window of 2.5 times that of the height of the window.

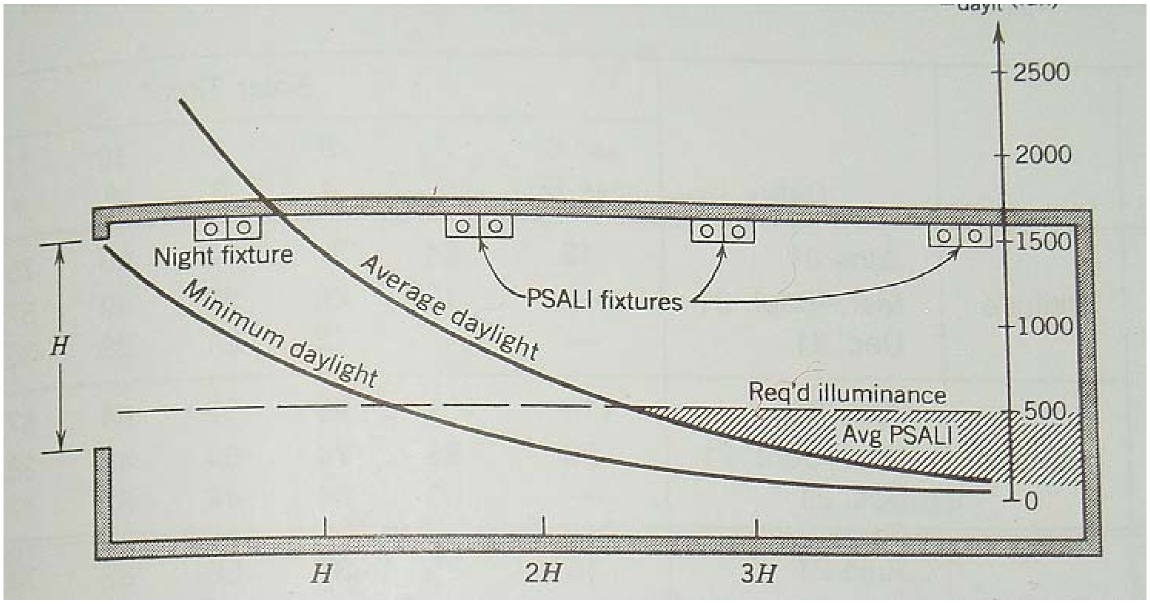


Figure 2

This means that the current window system can light about 60% of the classroom without the aide of electrical luminaries. With the addition of another window to the classroom, about 75% of the classroom can be lit without the aid of interior lighting.

In a standard situation with all the classroom lights turned on, (18) 32w bulbs with an output of 2800 lumens per bulb combined with the current window system creates an illuminance of 1500 (lux) for most of the area, well above the required amount for a classroom. This standard situation uses 600w, and over the course of a day, will use 5400w-hrs for a nine hour day. Considering that this large energy consumption produces more light than needed, a different arrangement would be preferable.

Adding another window to the classroom area would mean that during the span of a standard day, only 250 (lux) would need to be created by the lighting fixtures to reach an above acceptable level of lighting in the classroom. Replacing the (9) two bulb 32w luminaries wired in series with (6) three bulb 32w luminaries wired so that only 1 of the 3 bulbs can be turned on will produce an additional 330 (lux). Combining that output with the additional window day-lighting will leave the entire 500 square foot space illuminated above 500 (lux) while only having a combined use of 1728w-hrs for a nine hour day. This usage is one third of the existing structures output, a vast savings on energy consumption. While this system decreases energy consumption and installation costs, it still provides the flexibility to provide additional lighting if necessary by turning on all bulbs in the 3 bulb assembly. During the night, or during a severely overcast day where almost no day-lighting is available, 2 different lighting configurations will provide enough light for the entire classroom. To have 2 of the three bulbs on in each light assembly provides 660(lux), and all three lights will provide 1000(lux) to the classroom space, more than is required for general lighting usage.

The cost comparison from MC^2 for installation and assembly cost for each classroom is as follows:

Product	**Installation**	**Product Cost**	**Total Cost**
9 Cooper 2GR8 232W	$207.90	9@112.98	$1224.72
6 Cooper 3GR8 332W	$158.40	6@109.98	$818.28

When applied throughout the entire school wherever adding an additional window was plausible, while the total product cost and installation savings for 100 classrooms is only $40,500, the energy savings are approximately 370kWh per day, or 66600kWh for a standard school year. At a rate of $0.04286 per kWh for generation and transmission charges, the total yearly energy savings are $2855.00 for the classroom lighting facilities alone. Compared to the overall cost of the project (30million), these savings are not very large. In a span of 20 years, assuming constant energy prices, the reduced cost for lighting the classrooms is only $65,000. While this may not seem like much on a 30 million dollar project, a school district with an extra $65,000 in its long-term budget can buy extra computers or other learning supplies that aid the overall performance of the school. It may not need to cut funding to certain after school activities, or could be able to buy new uniforms to increase moral of the student population. It also starts a trend of decreased energy costs that can be applied to multiple facets of the building industry.

Structural System

The existing structural system used for the classroom area consists of 10 inch concrete masonry units (CMUs) reinforced by continuous #4 bars spaced every 4 feet for both interior and exterior walls. These walls are used to support both the floor and roof structures. The second floor consists of 10 inch pre-cast panels with a thin 2 inch layer of concrete on top of the panels. (Seen in figure below) This current arrangement compliments the style of the existing structure and is more than adequate in handling all the loading for the classroom space just as the school is now.

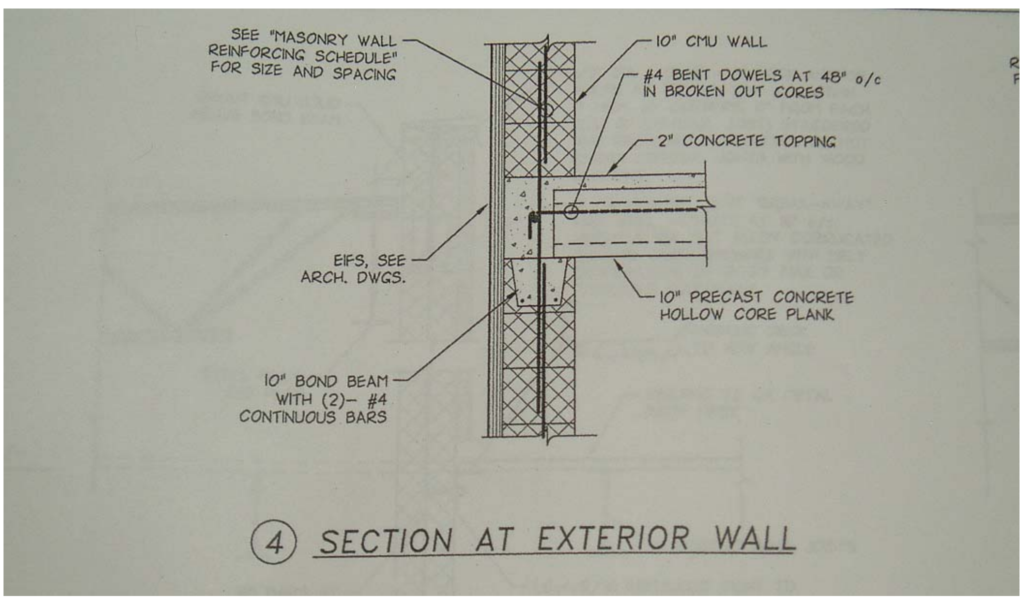


Figure 3

There are several factors in providing a motive for redesigning the current CMU structural wall. The first, and most important, is the allowance for a green roof addition to be made to the rooftop above the classroom space. The second, and almost equally important, is the addition of another window in the classrooms to allow for the change in the lighting system. The addition of another window to increase day-lighting has many advantages. Another window to increase day-lighting in the classrooms not only provides the needed light to decrease the energy consumption of lighting system in the classrooms, but also has proven to increase moral and performance of students occupying the space. Even companies like Wal-Mart are starting to use day-lighting in their new facilities because they noticed that products have sold better when lit by natural light. Recovery time for patients in hospitals has also been slated as a benefit from natural light. Among these benefits is student performance in the classroom while under natural lighting conditions.

A study done by the National Renewable Energy Laboratory(NREL) analyzed the test scores of over 21,000 students from several different states under different lighting conditions. They found that the classrooms with the most day-lighting had test scores that were 15% higher than those with less day-lighting from the same school. They also compared the test results of students who attended day lit schools to those who attended school that were not very well lit by natural light. The students in the day lit school outperformed the other students by almost 10%. Natural light for students has also been documented as increasing the physical heath of students. Conclusions from the study by the NREL stated that "The results indicate work in classrooms without daylight may upset the basic hormone pattern and this in turn may influence the children's ability to concentrate or cooperate, and also eventually have an impact on annual body growth and absenteeism."

Also, while it will cost money to add additional day-lighting, a study done in 1997 by the National Institute of Building Sciences showed that day-lighting saved $0.05 to $0.20 per square foot annually. The actual cost benefits to adding an additional window to the classroom space can be seen in the lighting section of this report.

An additional window can be added to achieve these benefits, but to do so a reworking of the entire structural system might need to be done. To add another window would leave only 10 of 25 feet composed of structural CMU to support the loading for 2 floors and a green roof. A live load for schools is 80 pounds per square foot, the pre-cast hollow core floor with a layer of concrete on it contains a dead load of 100 pounds per square foot.

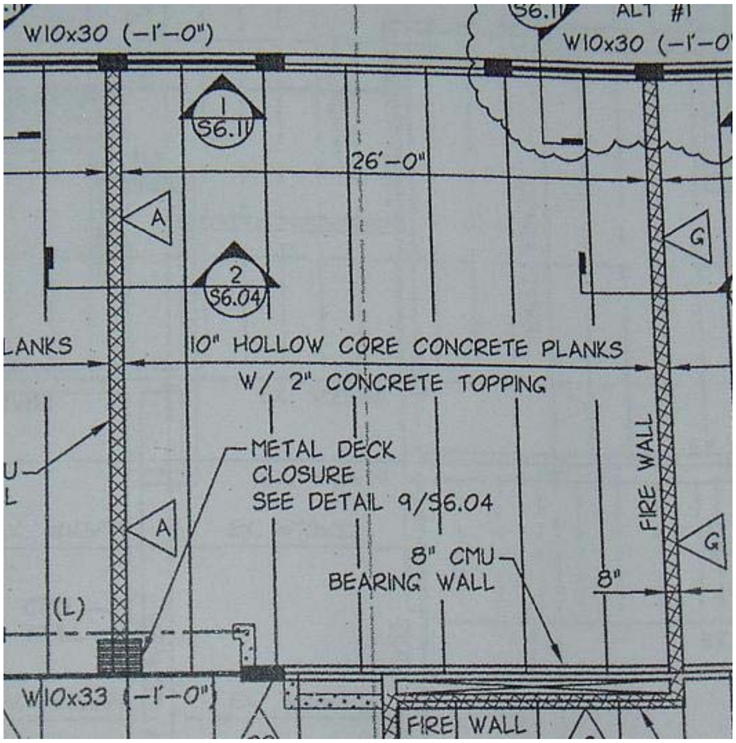


Figure 4

The current roof load will be about the same as the floor dead load. Additional dead loads from the green roof and mechanical equipment add another 65 pounds per square foot, and a snow load of 20 pounds per square foot will also be taken into account. Since W16x40s are already being used in the gymnasium area, loading calculations were done to see if W16x40s could be used as columns spaced every 25 feet supporting beams that spanned the same distance and were also W16x40s. Also, calculations were done on to see if the 10 inch CMU walls would be able to hold the new roof loads with the decreased CMU area.

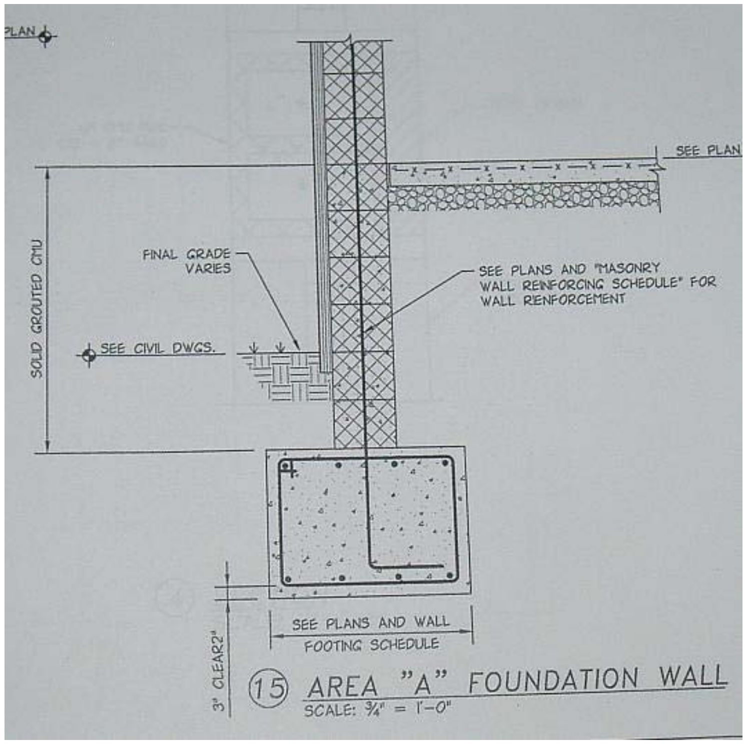


Figure 5

Using ACI 530 Sec. 6.3, the load capacity for a bearing wall subjected to concrete axial loading, the loading was found to be around 50psi, still well within the loading capacity of the CMU when the CMU is grouted. Plans for decreasing the CMU used, but time allowances for the extra grouted need to be taken into account.

Wall construction is a very important factor when determining the time estimates for the entire construction project. The current schedule allows 60 days for the construction of the masonry walls for the classroom areas on the project. It also allows for one week to place the structural steel. The structural steel will be used as lentils over the window areas in the classroom. Adding additional windows to the classroom will decrease the amount of CMU that need to be placed, but will increase the amount of steel lentils needed. Since steel construction is already taking planning on placing members in the classroom area, very little time will be added to the schedule to place one extra steel member per classroom. In fact, the amount of time added to place the steel members will be less than the time saved by placing less CMUs, adding an extra day or two of leeway in the construction schedule.

Using additional steel in the area means that the steel staging area will need to be able to hold the additional members prior to their construction. Crane locations will not have to be changed at all since they are already planning to be in the area. The steel staging area on site is already very large, so should have no problem storing several extra steel members. Space is not a problem in general on the Bellefonte Area High School project due to the large site that the building is already on.

Removing several linear feet of CMU and replacing with a window to add day lighting to the classroom area does very little to impact the overall construction schedule. Site work, major construction elements, manpower, cost, and the schedule remain virtually unaffected by this minor change. Despite this change, major benefits can be seen for long-term use of the new elements. Most of these benefits will show in later years when less energy consumption due to these changes is apparent.

Green Roof Design for Decreased HVAC Loads

With current demands for the decreased use of energy throughout the country, many construction trends have moved toward a "greener" approach to building. One of the fast growing trends is the green roof design; otherwise know as a roof that contains soil so that vegetation may be planted in it. The idea behind using green roofs with vegetation is that there are many benefits to the structure. One of these benefits is reflectivity of the rooftop for building heat gain. A green roof is typically more reflective than normal roofs so that the heat gain from the sun is less. This is also true of green roofs used as insulation for the inside building temperature. The added insulation, in the summer time, will keep the indoors cooler and minimize the building heat gain. The converse is also true in the winter time, as the green roof structure will help keep heat bottled up indoors so that the building heat loss is reduced compared to a normal roof. These factors can decrease a building's energy consumption for heating in the winter and cooling in the summer.

There are also several difficulties that must be planned for and overcome for a green roof to work well. One of the shortcomings that need to be addressed with a green roof design is the additional load that it creates. Normal rooftops do not contain the loads that a roof with 6inches of soil on top does. The existing structural system needs to be analyzed to see if it can hold the additional soil load, and often times will need to be changed or reinforced. Also, weatherproofing and drainage needs to be considered for a green roof design. Six inches of soil on the roof makes repairs to leaking roofs difficult, so superior waterproofing should be used. Upkeep must also be considered when installing a green roof. Roof access needs to be available so that any grass that may be growing on top can be reached to cut.

The green roof that will be put onto the Bellefonte Area High School will be an extensive green roof, otherwise known as a Low-profile or Ecoroof. This differs from Intensive green roof in that an Ecoroof is 6 inches deep or less, contains low growing plants, has low water requirements, and has relatively low maintenance, while the intensive is deeper than 6 inches, can contain larger plant life, and requires more water and maintenance.

The first and most important aspect of installing a green roof at the Bellefonte Area High School is the additional loading that the roof will create. Calculations will be done using a 4 inch layer of soil over the classroom areas, where the largest contingent of people will be occupying during the day. Since there will be times that it rains and the soil will get wet, to do loading calculations, a saturated soil condition will be used. Saturated potting soil weighs approximately 125 pounds per cubic foot. The roof area to be covered over the main classroom area is approximately 75 feet by 225 feet, or about 15000 square feet. If the area where covered in saturated soil 4 inches deep, an additional 42 pounds per square foot dead load would have to be accounted for. This is detailed more extensively in the structural system change.

The next factor to consider with the installation of a green roof is the HVAC loading benefits that will be gained. The following chart derived from ABC Supply, Inc shows the varying daytime temperatures underneath a 4 inch green roof as compared to other roof designs and the ambient temperature throughout the year. To determine the year long benefits for a 4 inch green roof compared to white membrane temperature, a net change in temperature will be calculated from 65 degrees will be used. A best fit hyperbole will be used for each temperature curve, then the difference between that curve and a constant 65 degrees will be calculated by integrating each equation for the curve and subtracting the result. This will yield a net change that will be needed to be handled by the HVAC system.

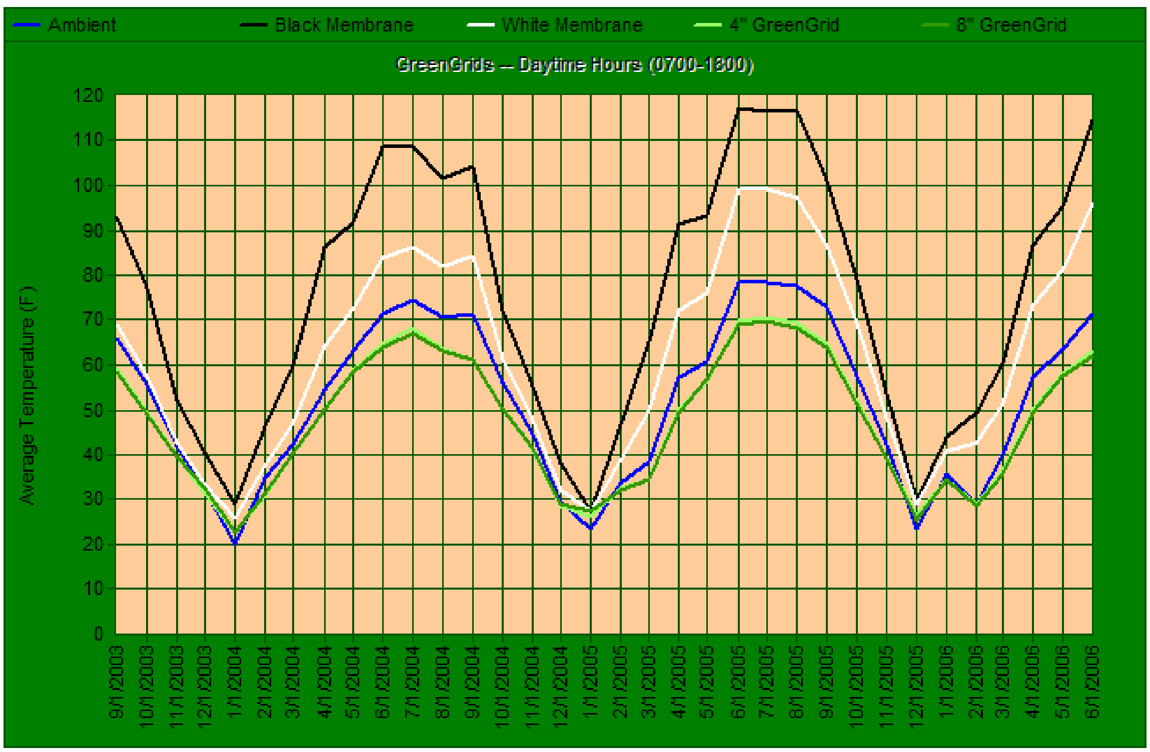


Figure 6

Best fit hyperbole for white membrane: -(x^2)+60

Best fir hyperbole for 4 inch green roof: -0.7(x^2)+40

Using this best fit hyperbole method, the workload necessary for the HVAC with the 4 inch green roof is 15% less then the workload of the white membrane roof. This directly correlates to a 15% decreased energy consumption by the HVAC system. Although this would also change the amount of air handling units needed to heat and cool the classroom space by decreasing the necessary workload, the volume of air needed to circulate throughout the school requires that the size of the air handling units does not change, only the amount of work that they do will change.

The chart below from the University of Wisconsin details the cost break down of a green roof structure for an Extensive Green roof. The total costs come to about $15 per square foot to install an extensive green roof.

Green Roof Costs: An Example of the Typical Extensive Green Roof

#	*Component*	*Costs*	*Cost Factors*
1	**Design & Specifications**	5 - 10 % (of total roofing cost)	The size/complexity of the project and the number/type of consultants needed.
2	**Project Administration & Site Review**	2.5 - 5 % of total roofing cost	The size/complexity of the project and the number/type of consultants needed.
3	**Re-roofing with root-repelling membrane**	$ 10.00 - $15.00 / ft 2	The type of existing roof, type of new roof system, and roof accessibility.
4	**Green Roof System (drainage, filtering, paving, growing medium)**	$ 5.00 - $10.00 / ft 2	Growing medium (type and depth), pavers (size and type), and square footage of the green roof (project size).
5	**Plants**	$ 1.00 - $3.00 / ft 2	Season of installation, type of plants, and size of seeds being planted.
6	**Installation and Labor**	$ 3.00 - $8.00 / ft 2	Equipment necessary to move materials on to the roof (E.g. crane, if rented is: $ 4,000.00 /day), project size, design
7	**Maintenance**	$ 1.25 - $2.00 / ft 2 (only for the first two years)	Project size, installation schedule, irrigation system, and plants (type and size)
8	**Irrigation System**	$ 2.00 - $4.00 / ft 2	Since extensive roofs require little irrigation (E.g. sprinkler system or drip system), this component is optional.

Covering an area of 15000 square feet, the cost of installing an extensive green room over the classroom space will cost approximately $225,000. According to the Princeton Energy Resources, space conditioning (the heating, cooling, and ventilation) uses about 65% of a school's energy consumption. The average energy cost for a high school in Pennsylvania is approximately $200 per student. The Bellefonte Area High School will house around 1500 students upon completion, putting their energy bills around $300,000 per year. The HVAC costs alone will be $200,000 per year. Since no quantified numbers were available for energy costs for portions of the Bellefonte High School, a square footage estimate was used for the cost of heating, cooling and ventilating the classroom space. The classroom/ computer lab space is the largest and most dynamic space in a school, using some 70% of the school's total energy consumption. Placing a green roof structure over the classroom space will decrease the school's yearly energy bill by $15,000 a year. With the rising energy prices due to increasing fossil fuel prices, the green roof structure will pay for itself in just under 15 years.

Industry Critical Issue

Toady there is a growing demand for the increase of energy efficient products. Cars are asked to become more fuel friendly, programs to turn off lights in buildings are more commonplace, and recycling is at an all time high. This idea has almost been carried over to the building industry. Yet not all buildings that are being built are considered green, let alone are considered for a LEED rating. Why does the building industry still face problems in getting its products to be completely green? The simplest answer, in this case, is probably the correct one. People outside of the building industry do not know tat it is possible to make environmentally friendly buildings. Just about the entire populous knows what a hybrid is and that hybrids use less gas, yet many do not even know what a green building is.

I created a survey on survelum.com called Green Construction and distributed it online using facebook.com as my main means of getting it out to people. I created an event that contained the link to the survey, and then invited all my friends to the event. I made it an open event, meaning other people can invite their friends after they have accepted the event. I got several of my friends to invite all of their friends as well, and in a matter of about an hour, over 1000 people had been invited to partake in the survey. In about 2 days, I received over 400 responses to my survey. My final count ended at 437 responses.

The survey was directed at a certain demographic on purpose. College students were targeted because they are what is considered the future of the thinking world. In the future, businesses will be run by current college students. Office buildings and houses will be needed by current college students. Future senators, presidents, mayors, teachers will all be current college students. They will make up the educated populous, in charge of making the majority of decisions in regards to almost everything. My survey was made specifically to see just how much this "educated populous" knows about green construction. If the people who make decisions do not know that a green building is an option, how can they ever choose to endorse or use such a product? Much to my dismay, my original premise that the educated public does not know much about the green building industry was proven to be true in the results of my survey. 40% of all people asked did not know what a green building was, and 85% of all people asked did not know what it meant to be LEED rated.

After finding out the extent of their knowledge, the survey then informed people about the green building industry, told them what green buildings were, and then asked them if they thought all new buildings should be green buildings. 75% of people thought that all new buildings should be green. 75% of people thought that the government should put requirements on new building construction to make them green. 93% percent of people would buy a home if the initial cost were increased by 5% if the energy bills were decreased by 10%. 95% of people thought that someone should more inform the general public about the green building industry. If so many people do not know what it means to be green, yet so many are willing to purchase green products and learn more about the green building industry, and even put requirements on making all new buildings green ones, why is the green building industry not more well known?

Education is the answer. Public school systems should start informing their children early about the benefits of the green building industry. This is very easily accomplished if schools were all green buildings themselves. It would be very easy to educate children about the green building industry if they spent the majority of their time is a green building. Science teachers would have an easy time walking their students around the school and pointing out green industry techniques if they were right down the hallway. That is were the government should step in on this issue. Brochures, TV commercials, public announcements, none of these would be as effective as having a green school for students to learn in. The government, the source of money for funding new schools and renovations on old ones like the Bellefonte Area School District, should spend the extra money to make their school systems green.

Green Construction

Data collected: 437 responses
Click on underlined response options to use corellation filters

Intro Questions

Do you know what a green building is? (Hint: it is not a building that is the color green)

Yes	(270; 62%)
No	(167; 38%)

Do you know what it means to be LEED rated?

Yes	(72; 16%)
No	(365; 84%)

Would you be upset/dislike if you learned that your house/apartment/workplace was not LEED rated?

Yes	(102; 23%)
No	(335; 77%)

In depth questions

Do you think if it is possible that all buildings should be green buildings?

Yes	(317; 73%)
No	(120; 27%)

Do you think the government should put requirements on new building construction to make them green?

Yes	(328; 75%)
No	(109; 25%)

Would you purchase a green home if it increased the initial cost of the house by 5%, but decreased energy bills by 10%?

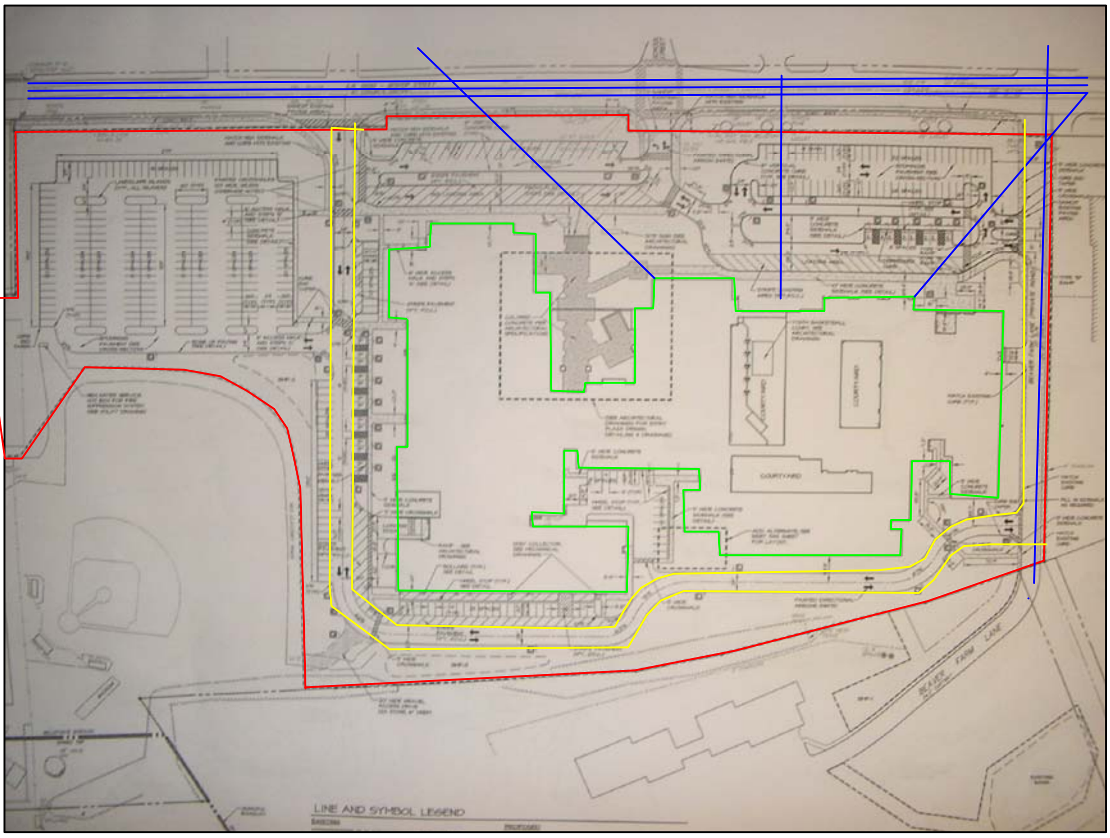
Yes	(406; 93%)
No	(31; 7%)

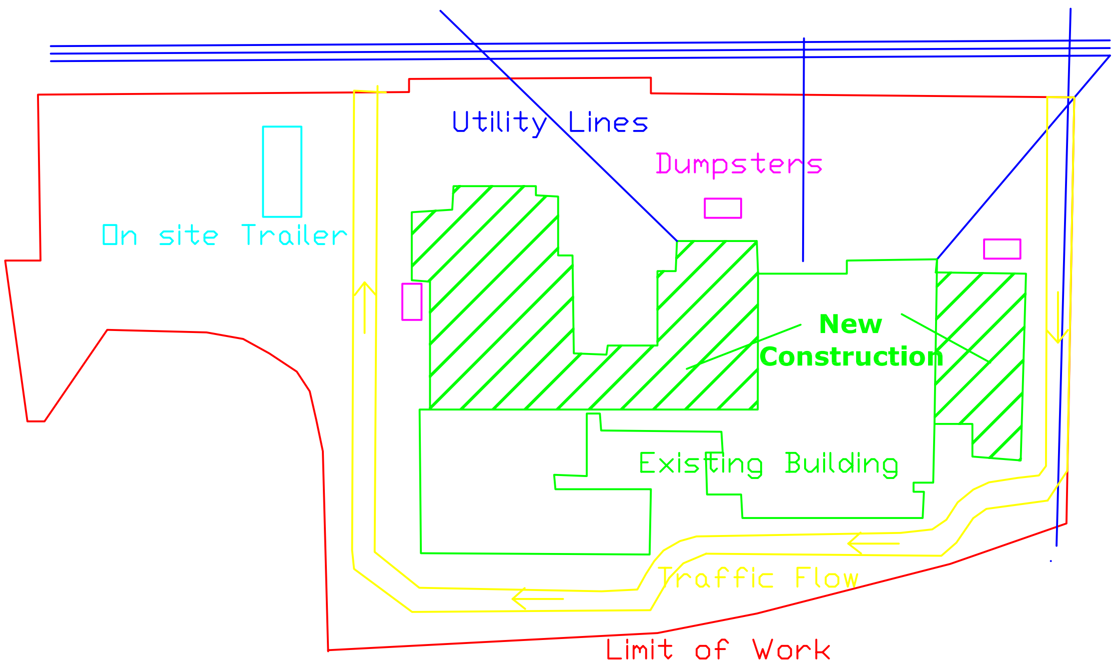
Do you think that the government shoud inform the public more about the green building industry?

Yes	(369; 84%)
No	(68; 16%)

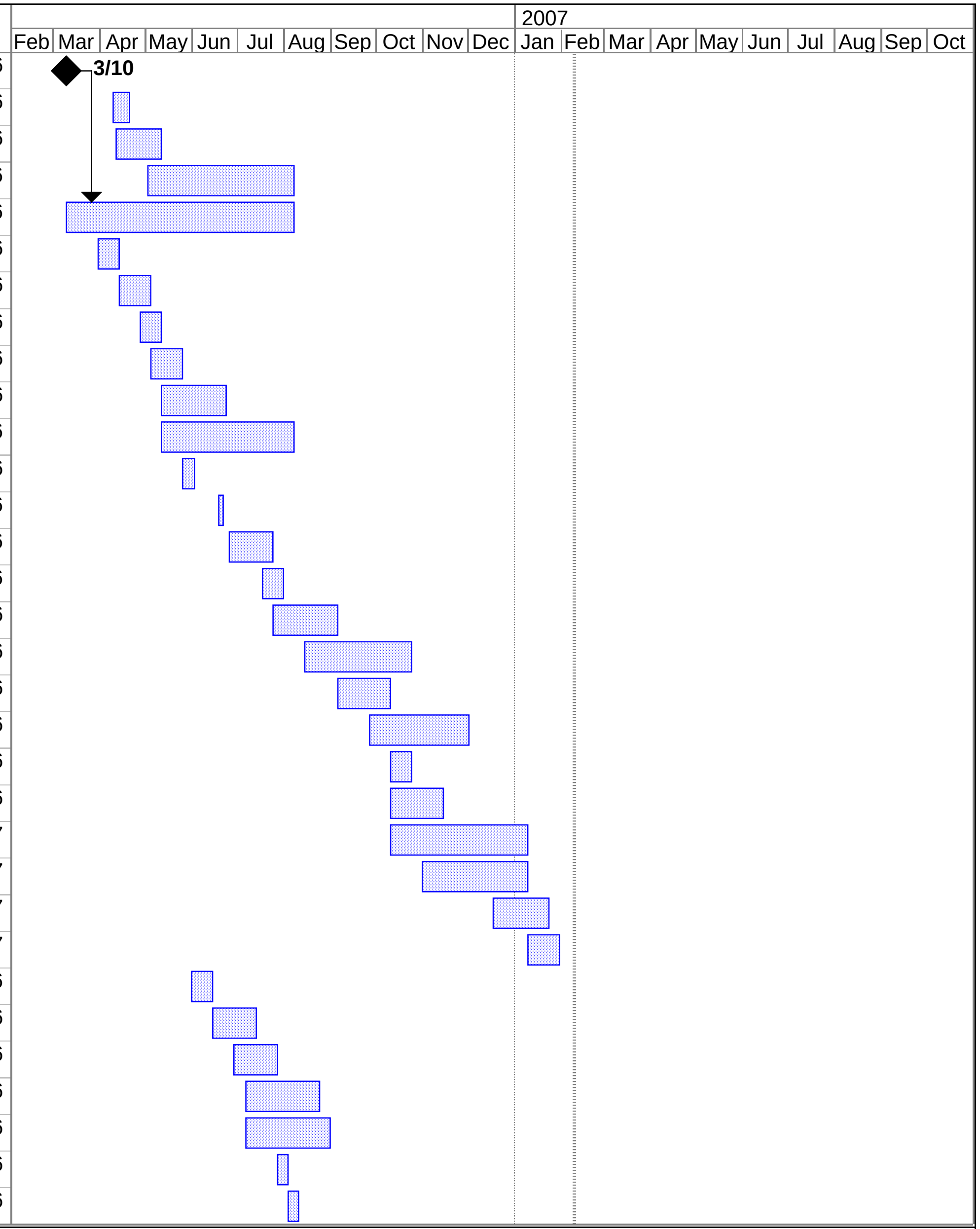
Do you think some institution other than the government should inform the public about the green building industry?

Yes	(413; 95%)
No	(24; 5%)


LINE AND SYMBOL LEGEND


Utility Lines
Dumpsters
On site Trailer
New Construction
Existing Building
Traffic Flow
Limit of Work

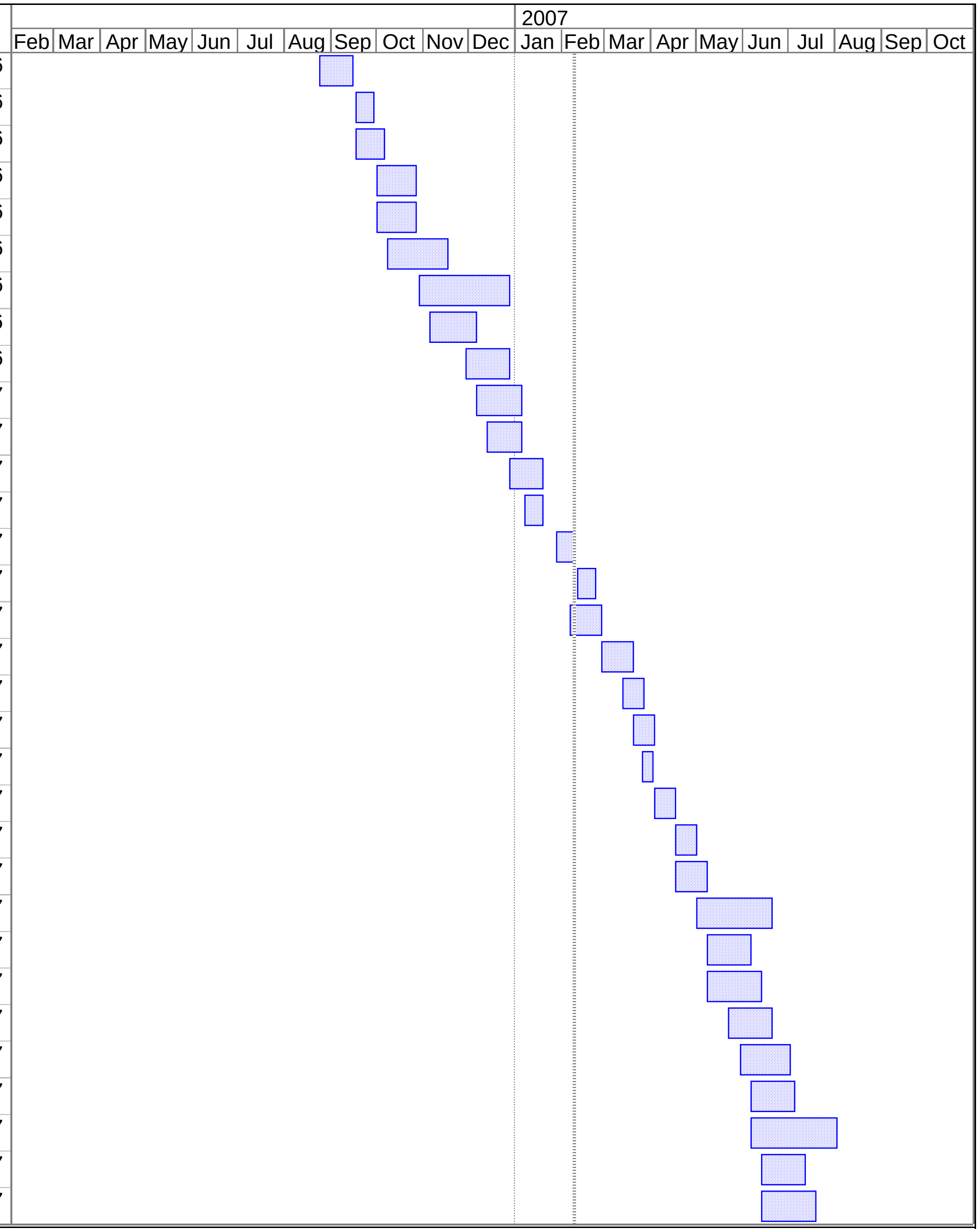
ID		Task Name	Duration	Start	Finish
1		Notice to Proceed	0 days	Fri 3/10/06	Fri 3/10/06
2		Drawing Submittals	9 days?	Mon 4/10/06	Thu 4/20/06
3		Reviews and Approvals	22 days?	Wed 4/12/06	Thu 5/11/06
4		Delivery and fabrication of mate	69 days?	Wed 5/3/06	Mon 8/7/06
5		Site work	107 days?	Fri 3/10/06	Mon 8/7/06
6		Classroom demolition	10 days?	Fri 3/31/06	Thu 4/13/06
7		Classroom footing	15 days?	Fri 4/14/06	Thu 5/4/06
8		Classroom masonry foundation	10 days?	Fri 4/28/06	Thu 5/11/06
9		Underslab MEP	15 days?	Fri 5/5/06	Thu 5/25/06
10		Masonry 1st level	31 days?	Fri 5/12/06	Fri 6/23/06
11		MEP rough-in walls	62 days?	Fri 5/12/06	Mon 8/7/06
12		Stone for SOG	6 days?	Fri 5/26/06	Fri 6/2/06
13		Structural Steel	3 days?	Mon 6/19/06	Wed 6/21/06
14		Pre-cast Plank	21 days?	Mon 6/26/06	Mon 7/24/06
15		SOG	10 days?	Tue 7/18/06	Mon 7/31/06
16		Masonry 2nd level	31 days?	Tue 7/25/06	Tue 9/5/06
17		MEP rough-in overhead	51 days?	Tue 8/15/06	Tue 10/24/06
18		Roofing/joist-deck	25 days?	Wed 9/6/06	Tue 10/10/06
19		Painting	48 days?	Wed 9/27/06	Fri 12/1/06
20		HVAC equipment	10 days?	Wed 10/11/06	Tue 10/24/06
21		Windows and entrances	25 days?	Wed 10/11/06	Tue 11/14/06
22		MEP trim	65 days?	Wed 10/11/06	Tue 1/9/07
23		Ceiling-grid, tiles, inspection	50 days?	Wed 11/1/06	Tue 1/9/07
24		Flooring	27 days?	Mon 12/18/06	Tue 1/23/07
25		Hardware & Accessories	15 days?	Wed 1/10/07	Tue 1/30/07
26		Gym Demolition and Site prep	10 days?	Thu 6/1/06	Wed 6/14/06
27		Gym foundations	21 days?	Thu 6/15/06	Thu 7/13/06
28		Underslab MEP	21 days?	Thu 6/29/06	Thu 7/27/06
29		Load Bearing CMU	35 days?	Fri 7/7/06	Thu 8/24/06
30		MEP rough-in walls	40 days?	Fri 7/7/06	Thu 8/31/06
31		Stone for SOG	5 days?	Fri 7/28/06	Thu 8/3/06
32		Precast Plank	5 days?	Fri 8/4/06	Thu 8/10/06



Project: Overall Project Schedulefinal.
Date: Fri 2/9/07

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

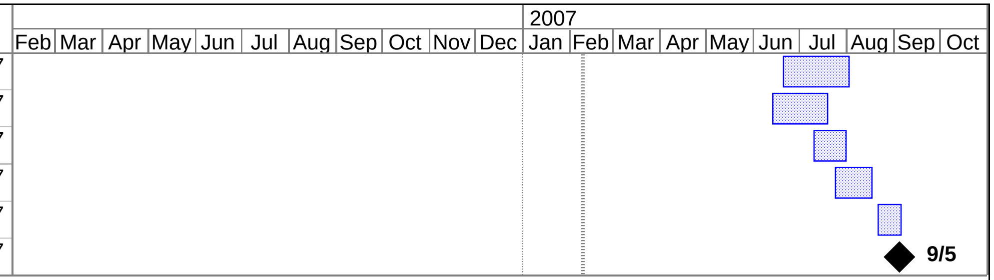
ID		Task Name	Duration	Start	Finish
33		Trusses, joists, deck	16 days?	Fri 8/25/06	Fri 9/15/06
34		CMU parapet	10 days?	Mon 9/18/06	Fri 9/29/06
35		SOG	15 days?	Mon 9/18/06	Fri 10/6/06
36		Roofing	20 days?	Mon 10/2/06	Fri 10/27/06
37		Brick Veneer	20 days?	Mon 10/2/06	Fri 10/27/06
38		MEP rough-in overhead	30 days?	Mon 10/9/06	Fri 11/17/06
39		Paint	44 days?	Mon 10/30/06	Thu 12/28/06
40		Glass and Glazing	23 days?	Mon 11/6/06	Wed 12/6/06
41		Wood Floor	21 days?	Thu 11/30/06	Thu 12/28/06
42		Ceiling Grid	22 days?	Thu 12/7/06	Fri 1/5/07
43		MEP trim	17 days?	Thu 12/14/06	Fri 1/5/07
44		Bleachers and equipment	16 days?	Fri 12/29/06	Fri 1/19/07
45		Ceiling Tile	10 days?	Mon 1/8/07	Fri 1/19/07
46		Flooring	10 days?	Mon 1/29/07	Fri 2/9/07
47		Doors and Hardware	10 days?	Mon 2/12/07	Fri 2/23/07
48		Media Center demolition	15 days?	Wed 2/7/07	Tue 2/27/07
49		Footing, Foundation Walls	16 days?	Wed 2/28/07	Tue 3/20/07
50		Underground MEP	10 days?	Wed 3/14/07	Tue 3/27/07
51		Erect Steel	10 days?	Wed 3/21/07	Tue 4/3/07
52		Stone for SOG	5 days?	Tue 3/27/07	Mon 4/2/07
53		Steel Decking	10 days?	Wed 4/4/07	Tue 4/17/07
54		SOG, SOD	10 days?	Wed 4/18/07	Tue 5/1/07
55		Membrane Roofing	15 days?	Wed 4/18/07	Tue 5/8/07
56		MEP rough-in	36 days?	Wed 5/2/07	Wed 6/20/07
57		HVAC equipment installed	21 days?	Wed 5/9/07	Wed 6/6/07
58		Masonry Veneer	26 days?	Wed 5/9/07	Wed 6/13/07
59		Interior Drywall	21 days?	Wed 5/23/07	Wed 6/20/07
60		Windows	23 days?	Thu 5/31/07	Mon 7/2/07
61		Terrazzo	21 days?	Thu 6/7/07	Thu 7/5/07
62		MEP Trim	41 days?	Thu 6/7/07	Thu 8/2/07
63		Roofing	21 days?	Thu 6/14/07	Thu 7/12/07
64		Painting	26 days?	Thu 6/14/07	Thu 7/19/07



Project: Overall Project Schedulefinal.
Date: Fri 2/9/07

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

ID		Task Name	Duration	Start	Finish
65		Acoustical ceiling	31 days?	Thu 6/21/07	Thu 8/2/07
66		Painting	26 days?	Thu 6/14/07	Thu 7/19/07
67		Doors and hardware	15 days?	Wed 7/11/07	Tue 7/31/07
68		Flooring/Carpet	18 days?	Wed 7/25/07	Fri 8/17/07
69		Punch List	11 days?	Wed 8/22/07	Wed 9/5/07
70		Complete Construction	0 days	Wed 9/5/07	Wed 9/5/07



Project: Overall Project Schedulefinal.
Date: Fri 2/9/07

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

GENERAL CONDITIONS ESTIMATE					
Small Tools & Equipment	LS	1	50000	$	50,000.00
Misc. Supplies	MO	18	150	$	2,700.00
Computer equipment	MO	18	250	$	4,500.00
Office Equipment/Fax/Copier	LS	1	10000	$	10,000.00
Service & Supplies	MO	18	150	$	2,700.00
Network Equipment	LS	1	1000	$	1,000.00
Network Service	MO	18	150	$	2,700.00
Drawings & Specifications	MO	18	200	$	3,600.00
Postage & Shipping	MO	18	150	$	2,700.00
Sanitary Facilities	MO	18	100	$	1,800.00
Drinking Water	MO	18	100	$	1,800.00
Radios (two-way)	MO	18	100	$	1,800.00
Progress Photos	MO	18	1500	$	27,000.00
Field Office	MO	18	20000	$	360,000.00
Storage Trailers	MO	18	82	$	1,476.00
Telephone Service and Equipment	LS	1	5000	$	5,000.00
Telephone Charges	MO	18	250	$	4,500.00
Temporary Electric	LS	1	250000	$	250,000.00
Miscellaneous Travel	MO	18	5000	$	90,000.00
Layout/Survey(Bldg.)	LS	1	100000	$	100,000.00
Temporary Fencing	LF	1	5	$	5.00
Gates EA 2	EA	2	400	$	800.00
Project Signs	EA	4	50	$	200.00
Site Maintenance	MO	18	2000	$	36,000.00
Start-Up / Commissioning	LS	35000000	0.75%	$	262,500.00
Misc Trucking/Equipment	LS	1	15000	$	15,000.00
Dumpsters	MO	18	8000	$	144,000.00
Trash chutes	MO	18	600	$	10,800.00
Daily Clean-Up	MO	18	2000	$	36,000.00
Final Clean-up	SF	121000	1.72	$	208,120.00
Cold Weather Protection	MO	6	20000	$	120,000.00
Temp Heat in Building	MO	6	15000	$	90,000.00
Senior Project Manager	WK	18	2700	$	48,600.00
Project Manager	WK	72	2375	$	171,000.00
Assistant Project Manager	WK	72	2100	$	151,200.00
Project Engineer	WK	72	1675	$	120,600.00
MEP Engineer	WK	36	1675	$	60,300.00
Superintendent	WK	72	2175	$	156,600.00
Liability Insurance (NON OCIP)	LS	35000000	0.80%	$	280,000.00
GENERAL CONDITIONS TOTAL:					**$2,835,001.00**

Estimate Detail - Standard Construction Project

Detail - Without Taxes and Insurance

Estimator :
Project Size : sqft

ItemCode	Description	Quantity	UM	Lab.Unit	Mat.Unit	Eqp.Unit	Sub.Unit	Eqp.Rent.Unit	Temp.Mat.Unit	Other Unit	Tot.UnitCost	TotalCost
04210.011	MORTAR	400.00	CUYD		50.000						50.000	20,000.00
04210.503	ADD FOR FLEMISH BOND	180,000.00	SQFT	0.2609							0.261	46,962.00
04210.585	ADD FOR WEATHER JOINT	180,000.00	SQFT	0.2383							0.238	42,894.00
04219.101	EXTERIOR TUBULAR SCAFFOLDING	180,000.00	SQFT	0.4698		0.100					0.570	102,564.00
04219.990	* MASONRY WALL AREA *	180,000.00	SQFT									
04220.102	FILL VOIDS W/ CONCRETE	2,270.00	CUYD	20.5520	55.000						75.552	171,503.04
04220.502	8X8X16 CONC BLOCK	202,500.00	PCS	1.9929	0.630						2.623	531,137.25
04224.122	MASONRY REBAR	2,816.10	CWT	20.5520	26.750						47.302	133,207.16
04224.130	UNIT WALL TIES	104,408.35	PCS	1.0608	0.198						1.259	131,471.00
07140.011	WATERPROOFING ON MASONRY	180,000.00	SQFT	0.4983	0.358						0.857	154,206.00
Total Estimate												**1,333,944.45**

Estimate Detail - Standard Construction Project

Detail - Without Taxes and Insurance

Estimator :
Project Size : sqft

ItemCode	Description	Quantity	UM	Lab.Unit	Mat.Unit	Eqp.Unit	Sub.Unit	Eqp.Rent.Unit	Temp.Mat.Unit	Other Unit	Tot.UnitCost	TotalCost
02518.005	FIRE HYDRANT		****									
02518.014	DEPTH OF BURY 7'0"	50.00	EACH	200.4000	932.992						1,133.392	56,669.60
02518.024	W/PUMPER CONN		****									
02518.025	DEPTH OF BURY 2'6"	2.00	EACH	158.6500	910.298						1,068.948	2,137.90
13910.552	PIPE VOLUME	3,812.06	GALS									
13910.030	EXCAVATE W/BCKHOE	4,783.95	CUYD	4.3275	1.792						6.120	29,275.39
13910.035	BACKFILL BACKHOE	4,419.52	CUYD	1.1540	0.896						2.050	9,060.01
13920.010	FIRE PUMP		****									
13920.029	DIESEL W/CNTRL & JOCKEY		****									
13920.031	100HP	2.00	EACH	2,304.6000	30,080.000						32,384.600	64,769.20
13930.010	SCH 10 S STEEL PIPE		****									
13930.072	GROOVED FITTINGS		****									
13930.097	90 ELL 3"	400.00	EACH	48.0960	26.637						74.733	29,893.12
13930.170	COUPLING 3"	1,038.10	EACH	23.4802	21.414						44.895	46,604.87
13930.171	COUPLING 4"	4.76	EACH	27.2878	31.206						58.494	278.54
13930.780	SCH 80 STEEL PIPE		****									
13930.781	BLK T & C		****									
13930.789	PIPE 3"	5,000.00	LNFT	10.0200	9.280						19.300	96,500.00
13930.790	PIPE 4"	100.00	LNFT	11.0220	13.760						24.782	2,478.20
13930.796	CAST IRON SCRW FTGS 250LB		****									
13930.821	90 ELL 3"	400.00	EACH	88.8440	49.062						137.906	55,162.56
13931.131	GLAND W/T-BOLTS 3"	800.00	EACH	8.3166	16.960						25.277	20,221.28
13931.385	BOLT & GASKET SET		****									
13931.393	FLANGE PACK 3"	400.00	EACH	8.3166	7.462						15.779	6,311.60
13931.850	PIPE HANGERS STEEL		****									
13931.851	W/3' ROD & BEAM CLAMP		****									
13931.859	ADJ SPLT RING 3"	500.00	EACH	30.7280	7.091						37.819	18,909.60
Total Estimate												**438,271.86**