New Middle School

Geneva, IL

Greg Kemerer

The Pennsylvania State University
Construction Management - Riley
Spring 2006

Geneva, IL CUSD #304

1357 Viking Drive, Geneva, IL 60134

NEW MIDDLE SCHOOL

Project Data

Size: 196,008 sq ft

Dates Of Construction: 5/16/05 – 8/29/06

Hard Cost: $27,065,000

Delivery Method: Design-Bid-Build, CM Agency

Aerial Photo: 10/3/05

Photo by McShane Fleming Studios, Chicago, IL

Project Team

Owner: Geneva Community Unit School District #304

Architect: Larson and Darby Group

Construction Manager: Bovis Lend Lease

Engineering Consultants: Rempe-Sharpe and KJWW

Aerial Photo: 4/9/05

Photo by McShane Fleming Studios, Chicago, IL

Mechanical

HVAC: (2) 300 ton air cooled chillers, 6 AHUs, dust control system

Heating: 2-pipe heated water system, (2) 250 BHP boilers, individual fan coil units throughout

Additional Heating: 2,340 linear ft. of radiant ceiling panels

Electrical

Main Distribution: 4,000A, 480/277, 3 Phase

Generator: 250 KVA, 480/277

Structural

Unit A/C: Single story. 12" CMU load bearing masonry on concrete strip footings.

Unit B: Two story. Structural steel with combination architectural precast and face brick. Flooring is 12" hollow core precast w/ 3" poured slab topping. The basement utilizes step footings to match CMU coursings.

Greg Kemerer

Construction Management

AE Senior Thesis

http://www.arche.psu.edu/thesis/eportfolio/current/portfolios/gek114

<u>Executive Summary</u>

The following is a senior thesis report for the department of Architectural Engineering at the Pennsylvania State University. This report focuses on the New Middle School at Geneva Community Unit School District #304 in Geneva, IL. A large portion of the essential building statistics and information, which is discussed in depth in the first 12 pages of this report, can be found on the previous page.

The rest of the report is dedicated to three specific analyses with respect to the New Middle School. The first analysis explores the implications of switching from the current burnished face CMU wall system in building B to a lighter metal stud wall system. Factors such as cost, constructability, and impact on the structural system were considered. This analysis shows that by switching to a metal stud wall a savings of $465,000. Most of this savings was realized in the wall type, although minimal savings were made by re-sizing the steel beams. If this system were also utilized on the first floor of building B, the savings could be extended to roughly $850,000.

The second analysis concerns the exterior wall type for building B. The existing wall type is a combination wall with CMU, 3” of rigid foam insulation, and a course of face brick. Alternate wall types will be analyzed with respect to cost impact, schedule impact, and energy impact due to changed R-values. These wall types will include precast concrete with face brick, tilt-up wall panels with a Nitterhouse brick façade system, and a Slenderwall system from Smith Midland precast concrete manufacturer. The analysis shows that although the existing wall system takes the longest to complete, it is the least expensive and has the best insulation performance. The tilt-up system proved to be infeasible for this project. The other wall systems had a lower overall R-value and more expensive which offset the benefits of their schedule reduction.

The third analysis takes a closer look at the process by which school districts build new buildings. Specifically focusing on green design and construction and why more schools aren’t built green. In completing this research, I found that all of the projects that were green or LEED certified were the direct result of the architect pushing the idea to the school district. These architects all had previous experience designing green. Most of the school districts also seemed unaware of government incentives for building green. I believe that all architects should become better educated in green design and building materials. I also found that more could be done with government incentive programs, to encourage schools to build green with the green of money.

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Introduction

The following is a senior thesis report for the department of Architectural Engineering at the Pennsylvania State University. This report focuses on the New Middle School at Geneva Community Unit School District #304 in Geneva, IL.

The first portion of this report is dedicated to the project background. This includes information on how the project is being delivered, general building information, client background, and local conditions.

The rest of the report is dedicated to three specific analyses with respect to the New Middle School. The first analysis explores the implications of switching from the current burnished face CMU wall system in building B to a lighter metal stud wall system. Factors such as cost, constructability, and impact on the structural system were considered.

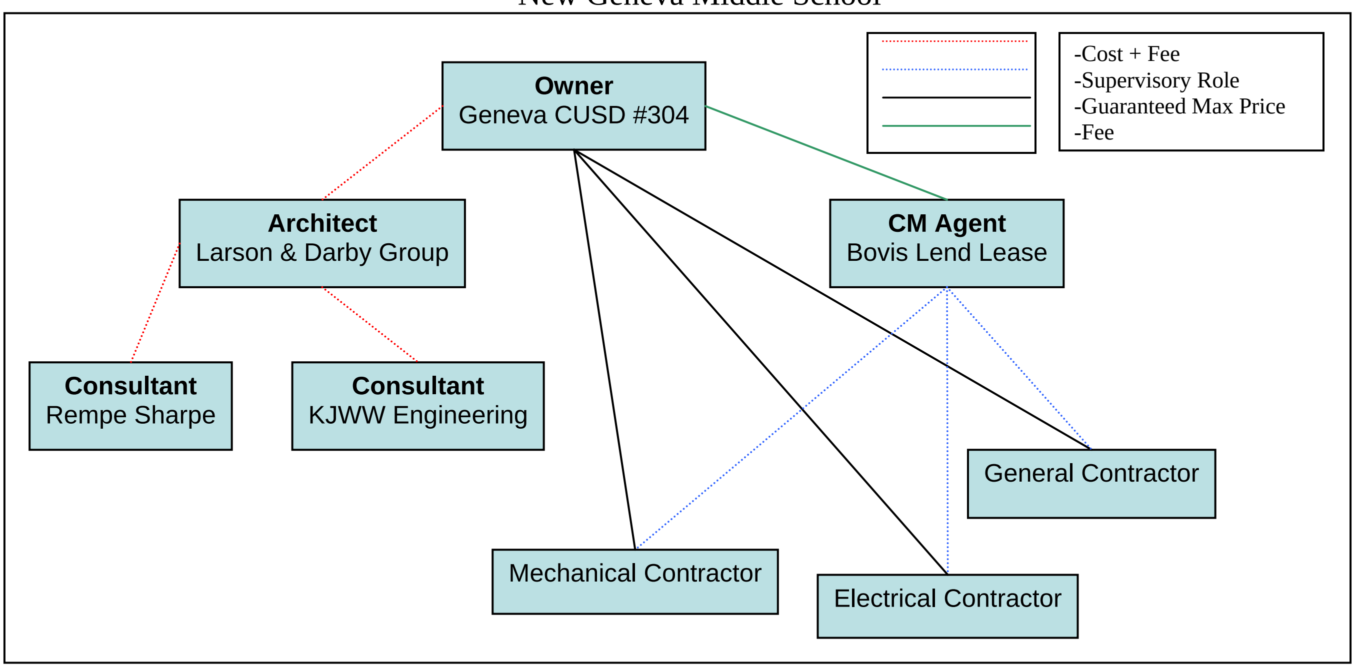
The second analysis concerns the exterior wall type for building B. The existing wall type is a combination wall with CMU, 3” of rigid foam insulation, and a course of face brick. Alternate wall types will be analyzed with respect to cost impact, schedule impact, and energy impact due to changed R-values. These wall types will include precast concrete with face brick, tilt-up wall panels with a Nitterhouse brick façade system, and a Slenderwall system from Smith Midland precast concrete manufacturer.

The third analysis delves into the process by which school districts go about building schools. The specific interest of this analysis is green schools, and why more new schools aren’t being built with green design.

Project Delivery System

The new Geneva Middle School is being delivered using a traditional design-bid-build system with a CM agent. This process allowed the school board to select the building type they wanted and then seek competitive bids on the project. All major contractors bidding on the project were required to be bonded. A CM agent was hired due to the fact that while the owner is relatively experienced with construction, the school district does not have any full time employees familiar with managing a construction project. I believe the contract structure being utilized is appropriate for this application. While the school district still holds all the contracts, the actual management of the construction is left to a CM agent with much more experience in educational construction.

Organizational Chart
New Geneva Middle School



Building Systems Summary

Structural Steel Frame

- A steel frame structural system is used to building B and for all roof trusses.
- Beam connections are bolted or E70XX welding standards.
- Angle steel is used for bracing around the atrium skylights and roof deck of building B, as well as along the top of masonry walls as a closure angle.
- All reinforcing steel is “deformed new billet steel bars”
- Cross-braced connections use tensioned steel straps.
- Steel will be erected using a 60 ton crawler crane.
- The cast-in-place topping slab over the structural precast concrete floor in building B is a composite slab.

Cast In Place Concrete

- Wooden edge forms are used for the slab on grade pours.
- Other wooden formwork is used to form column footings.

Mechanical Systems

- Major mechanical components are located throughout the middle school: on the roof of building A, the basement of building B, and in the boiler room of building C.
- Cooling is provided by a forced air system powered by (2) 300 ton air cooled chillers and 6 AHUs.
- Heating is provided by a 2-pipe heated water system with (2) 250 BHP boilers. The heated water is circulated through fan coil units in the perimeter of the classrooms. Additional heating is provided by 2,340 linear feet of radiant ceiling panels.
- Fire protection is provided by a wet sprinkler system which is broken down in to 4 zones. In addition the building is fully outfitted with smoke detectors and alarms.

Electrical

- Electrical power is supplied from a 2732 KVA 480/277v line
- The main panel, a 4,000A bolt-on panel, branches off to several other 480/277v panels as well as (2) 500 KVA transformers and a 225 KVA transformers.
- Backup power is provided by a 250 KVA generator which is cross-linked to the existing middle schools emergency generator.

Masonry

- The new Geneva middle school uses a combination of bearing and non-bearing masonry walls.
- Buildings A and C use a load bearing masonry wall structural system with a course of face brick on the exterior
- Many non-load bearing interior walls use burnished CMU as a finish material
- Building B uses a non-load bearing cavity wall with embedded pieces of precast concrete.

Support of Excavation

- Dewatering will likely be necessary for the excavation of the basement area of building B and will be completed by means of surface pumping.

Project Cost Evaluation

Building Construction Cost
- $28,800,000
- $146.93 /SF

Contingency
- $2,706,500

Architect and Engineering Cost
- $2,224,776

Bovis Lend Lease General Conditions and Fee
- $2,122,000

Systems Costs

Plumbing Cost
- $2,070,000
- $10.56 /SF

HVAC Cost
- $4,385,000
- $22.37 /SF

Electrical Systems Cost
- $3,135,000
- $15.99 /SF

Structural Systems Cost
- $6,710,000
- $34.23 /SF

Fire Protection Cost
- $610,000
- $3.11 /SF

D4Cost 2002 Estimate

A smart estimate of 3 middle schools and high schools between 150 and 250,000 square feet.

CSI Division	Area	D4 Cost Estimate
1	Bidding Requirements	$ 2,513,239.00
2	General Requirements	$ 545,680.00
3	Concrete	$ 1,711,480.00
4	Masonry	$ 2,210,905.00
5	Metals	$ 2,245,798.00
6	Wood & Plastics	$ 946,534.00
7	Thermal/Moisture Protection	$ 1,757,437.00
8	Doors & Windows	$ 492,831.00
9	Finishes	$ 1,857,364.00
10	Specialties	$ 528,466.00
11	Equipment	$ 152,798.00
14	Conveying Systems	$ 27,976.00
15	Mechanical	$ 3,175,613.00
16	Electrical	$ 2,230,254.00
Estimated Actual Cost		**$20,396,375.00**
Estimated Total Project Cost		**$21,818,029.00**

R.S. Means 2005 SF Estimate

Schools – Jr. High & Middle

Square Foot Cost: $ 102/SF
Total Cost: $ 19,993,000

Location multiplier: La Salle, IL (closest) – 1.016

Adjusted total cost: $ 20,313,000

Comparison of Estimates

Two estimates were generated in this analysis. Using the D4 Cost estimating software, a smart average of several schools was used to parametrically estimate the cost of the New Geneva Middle School. The size and date of the project were adjusted to reflect the project start date and location of the New Geneva Middle School. A national average square foot estimate was used from R.S. Means to find a general estimate as well.

Both the R.S. Means estimate and the D4Cost software returned estimates of around $20.3 million. This is considerably lower than the $28.8 million that the project is actually being constructed for. By the R.S. Means national averages, the new Geneva Middle School is well into the upper quarter of middle school construction in regards to cost. Disparities are apparent in the D4 Cost estimate for mechanical and electrical systems. The mechanical system is estimated at just over $3 million while the actual project cost is closer to $6.5 million. The electrical system also had a large difference where the estimate was $2.2 million and the actual cost was closer to $3.1 million. Additionally, the greater cost of durable materials such as the terrazzo tiled flooring and burnished CMU block could account for the lower total cost found in the estimates.

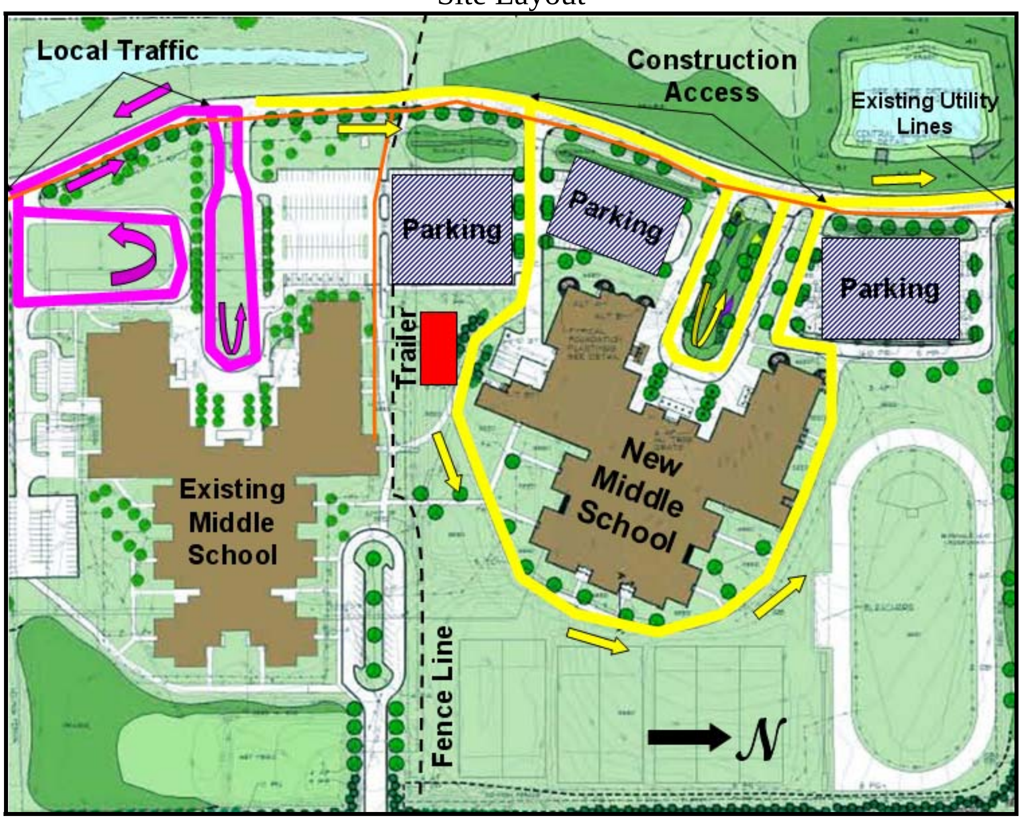
Local Conditions

Located 40 miles west of Chicago, Geneva, IL still maintains its quiet town charm. It is a relatively small town of around 20,000 that is drifting away from its rural past. Although it is small, it has seen substantial growth and development, both in residential areas as well as commercial and industrial sectors. Given its close proximity to a major metropolitan area, the town is able to enjoy all the benefits of a much larger town.

Due to its location, the town was able to draw from a large pool of construction expertise from the Chicagoland area. While Chicago tends to be a concrete town, the area has experience in many types of construction. Chicago itself grew from smaller wood framed buildings, to massive masonry buildings, and eventually into towering skyscrapers of steel and glass. Therefore, it is no surprise that the new middle school in Geneva utilizes both masonry and steel systems.

The site of the new construction is directly adjacent to the existing middle school on open land that used to be farmland. The open fields surrounding the schools provide excellent space for parking and staging of materials, especially when school is not in session. There are existing parking lots as well as an existing detention pond to the west of the school. Local recycling and tipping fees are higher than in surrounding areas, so it is likely that material from the site will be hauled to neighboring towns for processing.

Site Layout



The soil at the new middle school was found to be 1-3ft of topsoil and then a varying mix of clays and silty clay. The end result of this soil type is that some of the footings had to be undercut by 2 feet and filled with crushed stone structural fill. Groundwater was found at depths as shallow as 2 to 10 feet; therefore site dewatering could become a major issue.

Client Information

The owner of the new middle school in Geneva will be the Community Unit School District #304 of Geneva, IL. As an owner they are fairly knowledgeable and experienced, as they are currently overseeing 5 elementary schools, 1 middle school, and a high school. The construction of the new middle school comes about directly as a result of the growth of the area. With 5 elementary schools feeding a single middle school, overcrowding became a problem. In the 2004-2005 school year trailers were used outside the existing middle school to supplement classroom space. The new middle school comes as only a part of the expansion plan for CUSD #304.

The new building will double the amount of class, gym, and cafeteria space that is currently available, and it is the hope of the school district that the similar design of the buildings will keep a sense of equity between students.

Aside from their need for space, cost, durability, safety, and schedule were the chief concerns of the community. Obviously, because this is a public building paid for largely through local tax dollars, cost was obviously a major concern. The school district opened the project to competitive bidding to find the best value contractors.

Durability of materials was another major concern. In selecting materials, the architect used very durable material such as terrazzo tiled flooring and burnished CMU block for interior walls in major walkways. Both of these materials are highly durable and will be relatively easy to replace if a block or tile does become damaged.

Safety was also a major concern. The Geneva school district expects nothing less than zero incidents involving students being injured on the adjacent construction site while in class next door. To help assure site safety, chain link fencing was installed along the border of the construction site adjacent to the current middle school. As construction progresses, a night security guard may be hired to keep the site secure.

The omnipresent deadline associated with the construction of any new school is the beginning of the following school year. In the case of the new middle school, classes will begin August 29th, 2006. The middle school, if completed to schedule, will spend the month of August completing the punch list to hand the building over.

Architecture

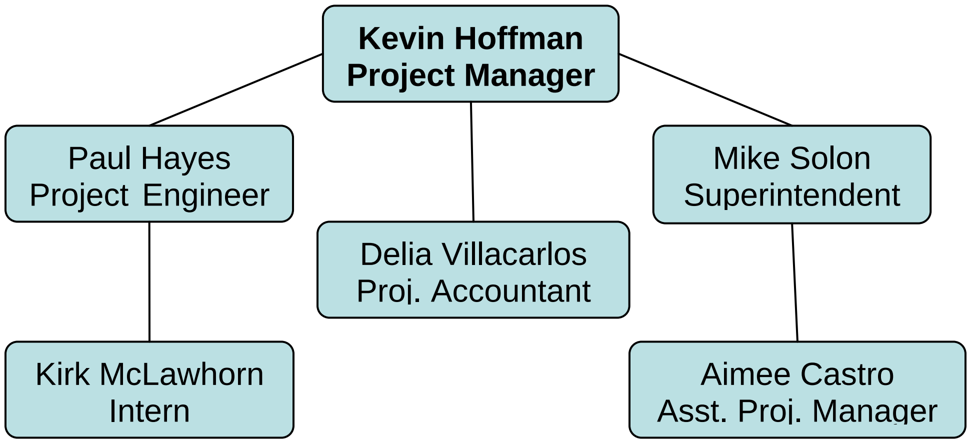
The new middle school in Geneva, IL will be a familiar sight to its residents when it is completed. Located directly adjacent to the existing middle school, completed in August of 1994, the new middle school will be a fraternal twin. It is being constructed from the same design documents from the first middle school, with some minor improvements including an expanded gymnasium and a re-designed entry to allow easier accessibility.

The building has 3 separate sections that provide different functions. Section A is a single story, and includes the gymnasium and weight/cardio room as well as the locker rooms. Section B is a two story section that includes the classrooms, library, and administration offices. The classrooms are grouped into "cores," 4 on each floor, consisting of 5 classrooms each. Students are assigned to a particular core for each school year. Section C houses the mechanical systems, the cafeteria/auditorium, kitchen, music rooms, and the shop classrooms. In this way, the noisy sections of the middle school are physically distanced from the quiet learning classrooms of section B.

The building will have a red face brick façade for all sections, with some panels of precast concrete on two story section B. The roofing system is predominantly a built-up roof, although the gymnasium features a trussed roof.

A detailed project schedule can be found in the appendix.

Bovis Lend Lease Staffing Plan



The one man responsible for the entire project running smoothly is Kevin Hoffman, the project manager. Working under him is a new hire, Paul Hayes, and Kirk McLawhorn, an intern over the summer of 2005. These employees work on the contractual side of the project.

Working the field side of operations are Mike Solon and Aimee Castro. They are responsible for ensuring that the work in the field meets specifications, that all work is properly coordinated, and that all work is completed in a safe manner.

All work is to be executed in the field from the job trailer.

Analysis 1 – Building B Interior Wall Type

Background

Building B of the New Geneva Middle School is a two story building where the library and core classrooms are located. The architect designated that the interior wall types be either 6” or 8” burnished face concrete masonry units (CMU). The interior walls in building B are all non-load bearing.

Due to the high cost of burnished face CMU and its relatively high weight, there could be large savings made by switching to an alternate wall system.

The purpose of this analysis was to determine the implications of switching to a metal stud wall system. Factors such as coordination issues, cost, and impact of the structural system were considered.

Wall Type Information

Burnished Face CMU

Burnished face CMU, also known as ground face or honed face CMU, is desirable to architects and designers due to its durability and its smooth finished texture. It is manufactured by grinding off the top 1/16” off the face of a standard block. It is often used as a cheaper alternative to marble or tile.

Advantages of Burnished Face CMU

- Durable
- Attractive finished surface
- Can be laid the same as normal block
- High fire rating

Disadvantages of Burnished Face CMU

- More expensive than most other wall types
- Can cause coordination issues between trades – especially any work that must be installed in the walls such as electrical conduit or data cables.
- Heavier than other wall types

Metal Stud Wall

Metal studs are roll-formed from corrosion resistant steel and are primarily used interior non-loadbearing walls, although heavier gauges of metal studs have excellent structural properties. These studs are used in a similar manner as typical wood studs, but are assembles using metal screws instead of nails. Metal studs come with punch outs that ease the installation of electrical conduit and small piping.

Advantages of Metal Stud Walls
- Light weight components
- Faster construction time
- Easier coordination for work installed in the walls

Disadvantages of Metal Stud Walls
- Less durable than CMU
- Possible sound transmission problems
- Increased thermal bridging

Takeoff Data & Weight Calculations

Wall Takeoff

	8" Burnished CMU	6" Burnished CMU
Total Linear Feet	2,247.5	147
Typ. Wall Height	9.66	9.66
Total Square Feet SA	21,711	1,420

CMU Weight

Weight information for the burnished face CMU block was taken from the 2005 Chicago Area Masonry Cost Guide. 6" CMU was specified at a weight of 29 PSF and the 8" CMU was specified at a weight range of 39-54 PSF. For the 8" CMU, a mean value of 46.5 PSF was selected.

CMU Weight

	Sq Ft SA	PSF	Total Weight
8" Burnished CMU	21,711	46.5	1,009,561.5
6" Burnished CMU	1,420	29	41,180
			1,050,741.5

Metal Stud Wall Weight

Weight information for the metal stud wall was taken from the current Marino\Ware product catalog. 3 5/8" 20 gauge studs were selected for this analysis as well as 2 courses of 5/8" drywall. Product specifications were taken from the current Marino\Ware product catalog.

Metal Stud Wall Weight

	Calculation	PLF
C-Channel Track	From Catalog	0.39
Vertical Studs	1 Stud/2' (.66PLF x 9.66)	3.19
Drywall	2 x 2.6psf x 9.66	50.23
		53.81

	Calculation	Total Weight
Total Weight	53.81plf x 2,394.5lf	128,848

With an existing wall weight of 1,050,741.5 lbs and a theoretical wall weight of 128,848 lbs, the weight savings on the wall type along is 921,893.5 lbs. This is equivalent to 461 tons or 18.43 psf savings in dead load for structural calculations.

Steel Beam Redesign Weight Reduction

Using design information found on the structural drawings, as well as the 18.43 psf reduction in dead load due to the wall redesign, the structural steel beams were redesigned. Calculations were done using the z-tables from the AISC Steel Construction Manual. These calculations can be found in the appendix.

Beam Weight Savings

Member	Quantity	Member Length	Weight Savings	Total Savings	
W 21 x 44	78	34.66	4	10813.92	
W 18 x 35	26	27.33	4	2842.32	
W 18 x 40	18	27.33	9	4427.46	
				18083.7	**lbs**
				9.04185	**tons**

<u>Cost Savings</u>

Switching to a metal stud wall would save $444,500 in material and labor and $21,000 in structural steel. Detailed cost savings calculations can be found in the appendix.

<u>Conclusion</u>

The huge cost savings made by switching to a metal stud wall system can not be ignored. A savings of $465,000 would be created by changed wall types on the second floor of building B alone. These savings would increase to approximately $850,000 if the first floor of building B was also switched to a metal stud wall system. In addition to cost savings made through materials, labor, and resizing the structural steel - the reduction in overall weight of the building could also lead to savings in resizing the foundation.

Aside from the cost savings, there are other benefits. The schedule would be positively impacted due to the fact that metal stud walls can be erected many times faster than masonry walls. There would also be decreased coordination issues with installing in-wall work. In addition, due to the fact that the resized steel is 2-3 inches shorter than the previous beams, there would be a small increase in the available plenum space between floors.

The only major downside to this change is the drastic reduction of durability in the material type. Gypsum board is much more likely to be damaged by middle school students than masonry block. While this issue is a concern, I do not believe it offsets the potential $850,000 savings. This concern is further reduced due to the face that a large portion of the walls are at least partially covered by casework, whiteboard, lockers, and furniture.

I fully recommend switching to a metal stud wall system on both floors of building B.

Analysis 2 – Building B Exterior Wall Type

Background

The exterior wall system for building B of the New Geneva Middle School consists of a course of 8" CMU, 3" of rigid foam insulation, and a course of face brick. In some areas 3 5/8" architectural precast is specified in place of the face brick. The current schedule sets aside 50 work days for laying the CMU and another 30 work days for the face brick.

The goal of this analysis is to find a faster, cheaper, and potentially more energy efficient wall type for building B. The main challenge in doing this is the aesthetic requirements for the building. Being that the New Geneva Middle School is directly adjacent to its already existing twin; any noticeable change in the exterior appearance would be unacceptable.

The following wall types will be examined:

- Tilt-up concrete with Nitterhouse brick facade
- Precast concrete with face brick
- Smith Midland Slenderwall

Wall Type Information

CMU Wall with Face Brick

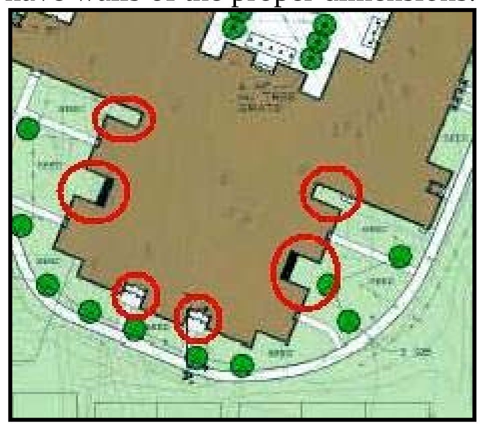
This is the existing wall type for building B as described above. Its main advantages are its durability and the fact that it is a more common wall system that many people in the construction industry are familiar with. The face that this system has been used many times in the past gives it a reputable track record for performance. Durability has also been proven over time.

The main disadvantage of this system is how time consuming the process is. Each CMU block must be hand laid and leveled. Then the rigid insulation is fixed before the face brick can be laid. To place the CMU and brick, a scaffolding system will need to be used.

Tilt-up Concrete Panel Wall with a Nitterhouse Brick Façade

The original intent of my thesis research for the exterior walls of building B focused on utilizing tilt-up concrete panels in concordance with a panelizes brick façade system from Nitterhouse. Tilt-up concrete panels have been used due to the low cost of forms and placing concrete reinforcing. Wall sections are formed around the perimeter of the building, reinforcement is placed, and concrete is poured and broom finished. Embeds would be requires to anchor the face brick wall to the concrete wall. After 5-7 days of curing time, the panels can be tilted into place using a crane or hoist system. The main advantages of this system are quick wall erection times and relatively low cost.

Unfortunately the disadvantages outweigh the potential advantages of using this system. The largest obstacle to using this system is the amount of space required. Tilt-up panels obviously require the same area on the ground during assembly as they will take up when lifted to their vertical position. However, due to the non-linear nature of the perimeter of building B, it would be impossible in some places to have walls of the proper dimensions. In places where the perimeter dips inward, only 20' of ground space would be available for a panel that needs to be 30' tall. Even if there were enough room for one of these panels, only one panel could be poured at a time where 3 panels would eventually need to be erected. This set up would absolutely wreak havoc on a schedule.



Tilt-up Problem Locations

The Nitterhouse panelized brick façade system would potentially alleviate some of the problems associated with laying a course of face brick. This unique panelized system is manufactured off site in shop conditions. Panels are then shipped and hoisted in place on site. Labor time is drastically reduced. Unfortunately this system too has its faults. Due to its panelized nature, the seams of the panels are visible and can reduce the illusion of actual brick. This is simply not acceptable in this instance, due to its proximity to the existing middle school. These seams would be blatantly obvious to any passerby. Therefore, this system is not acceptable in this application.

Although neither of these systems will work in this case, I chose to continue the estimate on an academic basis. For tilt-up panels to be actually utilized for this project, the perimeter of the building would have to have its dimensions altered to a more linear design. Because the Nitterhouse system would be inappropriate here, a single course of face brick was used in the calculations.

Precast Concrete Wall with Face Brick

Precast concrete has many advantages over a CMU wall. This particular analysis will consider insulated precast concrete, which has a 2" layer of polystyrene insulation sandwiched between two 2" layers of concrete. This allows for a much better insulation than CMU while still maintaining a high degree of structural strength. The panels, similar to the Nitterhouse system, are manufactured off site. This allows them to be manufactured to exacting tolerances and dimensions. An added benefit to the precast being manufactured off site is a decrease in the amount of site congestion. Material such as CMU block that might otherwise be surrounding the perimeter of the building would not be there. The panels are shipped to the site where they are hoisted into place and fastened to the structural system.

Disadvantages to this system are relatively few. The panels do tend to have a high cost of manufacturing. This is due to the extensive formwork that is needed. The panels must also be shipped on site which adds yet another cost. However, the higher cost of manufacturing and shipping is usually more than offset by the savings in labor. Problems in manufacturing can lead to major headaches on site. If a panel is not formed to the right dimensions, long delays can result while the job waits for a properly fitting piece. In addition, due to the fact that the precast panels are attached to the structural system (in this case the steel frame), the added load may require re-sizing the structure and foundation size.

Smith Midland Slenderwall

Slenderwall is a wall system that combines a 2” layer of architectural precast concrete, hot-dipped galvanized welded wire, insulated anchors, and heavy gauge galvanized or stainless steel studs. The outer 2” layer of architectural precast provides the exterior skin of the wall system. This precise concrete, according to Smith Midland, has unlimited color, texture, and finish combinations. This would allow an exact match to the brick used elsewhere on the middle school as well as on the neighboring building. The precast concrete is attached to the metal studs by way of insulated anchors. This added insulation cuts down on thermal transfer by approximately 25%. Slender wall has all the benefits of architectural precast including precision manufacturing and reduced erection time. In addition, due to its lightweight nature, smaller cranes can be used in erection and there is a potential for reducing the size of the foundation.

Problems are relatively few but are worrisome. There is potential for problems matching the architectural precast concrete to the proper brick size and color. This panelized system had fewer problems concealing seams in panels, but there is still a chance that the seams could be visible. The cost of shipping is likely to be high, as the closest Smith Midland location is in Maryland. In addition, due to the fact that this is a relatively new system, there is not much long term data on it. There is a potential for problems down the road, even though Smith Midland seems confident there won’t be. Although the data looks good, it has not been time tested outside of laboratory conditions. Another problem with this new system is that few people have experience building with it. The learning curve could prove to be an expensive one.

Cost and Schedule Impact

To compare each wall type, estimates for schedule and cost were compiled. These were compared against a similar estimate for the existing wall type specified. Values for most materials were found using R.S. means assembly and unit cost data. Some information was also taken from Cost Works. Information for the Smith Midland Slenderwall system was found through direct contact with the company. All data and calculations for that system reflect their information.

Below is a table detailing the overall cost and schedule duration for each wall type that was discussed above. Calculations can be found in the appendix.

Existing Wall Type

	Total Cost	Total Weeks
CMU, normal weight, 8"	$187,450.00	12
3" Rigid Insulation, R 13	$ 80,270.00	6.3
1" Air Space		
Face Brick	$242,190.00	7.6
	$509,910.00	**25.9**

Insulated Precast Concrete with Face Brick

	Total Cost	Total Weeks
4" Precast, 2" polystyrene	$529,460.00	6
1" Air Space		
Face Brick	$242,190.00	7.6
	$771,650.00	**13.6**

Tilt Up Construction w/ Face Brick

	Total Cost	Total Weeks
Tilt-up conc. panels, 5.5"	$192,740.00	5.5
3" Rigid Insulation, R 13	$ 80,270.00	6.3
1" Air Space		
Face Brick	$242,190.00	7.6
	$515,200.00	**19.4**

Slenderwall

	Total Cost	Total Weeks
Slenderwall	$621,000.00	0.8
R13 Batt Insulation	$ 80,270.00	2.9
5/8" Gypsum Board	$ 27,140.00	4.8
	$728,410.00	**8.5**

The most obvious implication of this analysis is that none of the alternative wall systems are any cheaper than the existing one. The tilt-up system was nominally more expensive and resulted in a schedule savings of roughly 6 weeks. However, as previously discussed, this system would not be feasible for this application. In addition, the schedule estimate for the existing system is slightly skewed. By overlapping the insulation installation with laying the CMU, and similarly overlapping the face brick installation with the insulation installation, a schedule savings of roughly 6 weeks could be attained.

Energy Impacts of Changed Wall Types

The impact on heating and cooling loads was also considered for this analysis. To accomplish this, R-values and U-values were calculated for each wall type using Carriers' HAP42 program. R-value is defined as a materials resistance to heat transfer. A higher value indicates better resistance and therefore increased efficiency for the mechanical system. The U-value is the reciprocal of the R-value and is defined as the rate of heat loss, in British Thermal Units (BTU) per hour, per square foot of surface area. R-values were also calculated for the insulated windows, and were averaged with the values for the different wall types with concern to their respective areas. Only changes in envelope loads were considered as the space loads should remain constant with respect to design.

The U-values were then used in combination with the total surface area A, T_i, the indoor air temp and T_o, the outdoor air temp. The formula used was $q = U A (T_i - T_o)$. The resultant q is in BTU/hr.

In order to obtain an accurate prediction of thermal loads, the q value was put in a spread sheet which utilizes BIN data. This spread sheet takes the complete range of exterior dry bulb temperatures for a given location and includes information on how many hours per year the system is likely to be operating within those parameters. This gives a better prediction than simply using the extremes of winter and summer as the both the temperature extremes and durations are fully accounted for. The following pages show the R-values for each wall type as well as their total energy impact on.

R-Values

Existing Wall Type

	R
CMU, normal weight, 8"	2.02
3" Rigid Insulation, R 13	13
1" Air Space	0.91
Face Brick	0.43
	16.36

Precast Concrete, Insulated with Face Brick

	R
4" Precast, 2" polystyrene	10.4
1" Air Space	0.91
Face Brick	0.43
	11.74

Tilt Up Construction w/ Face Brick

	R
Tilt-up conc. panels, 5.5" thick	0.67
3" Rigid Insulation, R 13	13
1" Air Space	0.91
Face Brick	0.43
	15.01

Smith Midland Slenderwall

	R
Slenderwall	0.2
R13 Batt Insulation	13
5/8" Gypsum Board	0.56
	13.76

Annual Energy Impact

	Total BTUs/Year	% Delta
Existing Wall Type	1,633,462,105.00	0
Precast	1,794,832,353.00	9.9
Tilt-up	1,728,966,946.00	5.8
Slenderwall	1,811,298,705.00	10.9

The cost impact of the BTU differences is not readily apparent. To be able to put a dollar value with these BTU values, a cost per BTU is needed. The U-value and BIN data calculations showed that the cooling load accounts for approximately 3% of the energy demand, while heating accounts for 97%. Because the cooling system runs off electric energy, Department Of Energy values for electrical cost per BTU will be used. This value is $28.75 per million BTU. The heating system utilizes a two-pipe hot water system fed by two 250 BHP gas powered boilers. Therefore, the heating cost will be calculated using the Department Of Energy values for natural gas. The cost for natural gas is $14.15 per million BTU.

Annual Energy Cost Impact

	Heating Cost	Cooling Cost	Total Cost	10 Yr Delta
Existing Wall Type	$22,420	$1,409	$23,829	0
Precast	$24,635	$1,548	$26,183	$23,540.69
Tilt-up	$23,731	$1,491	$25,222	$13,932.25
Slenderwall	$24,861	$1,562	$26,423	$25,942.80

Conclusion

After completing this analysis, it is clear that the existing wall type is the cheapest and most energy efficient of the wall types reviewed. As was noted before, the main problem with this wall type is its long duration.

The precast system proved to be approximately $260,000 more expensive and had an R-value roughly 4 points lower than the existing wall system. This difference amounts to a $2,300 a year difference in energy costs for building B. While this may appear to be an insignificant amount, it will continue to add up as the years go on. Because the Geneva school district will be the sole owner of this building for its lifetime. After 40 years, taking into account the time value of money at a low 3%, this minor energy difference would cost the school district $178,000. The schedule reduction of roughly 6 weeks would not be enough to offset this cost.

The tilt-up system is virtually identical in cost to the existing wall type. In addition, it had the second highest R-value and a small schedule savings. Once again, all of this information is superfluous as this system is not feasible for this project.

The unique Slenderwall system from Smith Midland would add roughly $219,000 to the total project cost and an increase of $2,594 per year. Once again, considering the time value of money to be 3%, the 40 year cost would be $196,000. The main benefit of this wall system is the drastically reduced schedule. This wall system could be in place in roughly one third of the time to install the CMU and face brick wall. However, due to the increased cost of construction and the reduced energy value, I do not consider this system to be cost effective – especially because the schedule is not so critical as to warrant the extra expenditure.

I would recommend this system if it was known that there would be significant project delays ahead of construction. These delays would have to be known far enough in advance to bid the project out to Smith Midland and avoid any contractual problems with a masonry subcontractor already signed on to the job.

Due to its lower cost and higher R-value, I recommend staying with the current wall system for this project. This system also ensures the closest appearance to the existing middle school. There would be fewer problems in matching bricks than in creating a façade that mimics the bricks.

Analysis 3 –Obstacles to Building Green Schools

Introduction

As new schools are built, many are still being built without green values – as was the case with the New Geneva Middle School. While building green can add to the initial cost of construction, the benefits to green construction are numerous: reduced energy bills, increased awareness of environmental issues, reduced impact on the environment, and some research even shows that students actually perform better when learning in a daylit environment.

Benefits of Green Schools

Common sense would tell you that these things would likely to be true, but there is documented research that backs up these claims. In Massachusetts, a study showed that while building green schools would add between 1.5-2.5% to the initial cost, the energy savings generated would pay back the difference 8 times over in a 20-year life cycle. In California, a study compared end-of-grade tests and California Achievement Test results for students in daylit and non-daylit schools in the same county. This study showed that the students that had been in a daylit learning environment for 2-3 years outperformed those who had not by 14%. Other research shows this percentage to be as high as 25%. That is clearly a significant advantage. Many schools that go through the LEED certification process actually add environmental lessons learned from the building to their curriculum. This increases students' knowledge of how their surroundings impact the environment.

Research Process

With all these benefits, I was confused as to why many schools were not being built more green. The aim of my research was to learn more about the process by which schools build new buildings and to see what obstacles, if any, were blocking more schools from being built green. To accomplish this, I called school districts with new schools all over the country. Some of them built green schools, others did not. I spoke with administrative officials, superintendents, and maintenance staff. I spoke with the architects who designed the buildings. By speaking with key individuals involved in the process, I gained an insight into the environment in which schools are constructed. I also noticed a few interesting trends.

Results & Discussion

Although I learned that the process varied slightly from location to location, there were some general similarities in all. Although some school districts, such as State College, could operate with a high degree of autonomy, most required some level of input from the community. In Geneva, Illinois, the new middle school could not have been built without voter approval. A referendum on the cost and general scope of the new buildings had to be passed. This referendum was not passed until it had been amended twice. Many other school districts in Alabama, Virginia, Oregon, and New Mexico required a community forum where the school board would gauge community approval or opposition. These forums provided an opportunity to anyone from the community to come and voice opinions or concerns. Many school administrators complained of the input received from community members who were also members of the construction or design communities at these forums.

At the time of community input, the level of project development varied. At some locations, only general information such as size and overall cost were discussed. At other locations, designs were already largely completed and the community was there to voice opinion. Obviously, if the design has already been completed before the community has had its opportunity to weigh in; it is difficult to influence the design to be green.

Almost every school district hired an outside architect to design their building. Only one school district, Geneva, Illinois, had a full time architect on staff.

When talking to people involved with the various school projects, I asked what their level of input into the design was. The overwhelming response was “high.” They insisted that they had as much input as they wanted. When asked what kind of input they gave, almost all listed basic requirements for the school – such as number of classrooms, size of classrooms, and electronic technology desired. Absolutely none of the school administrators or personnel ever mentioned specifying that the building be built with green initiatives or even specifying certain materials to be used. This was left solely to the design team.

Another trend I noticed was that the owner side of the construction equation seemed to be generally ignorant of the benefits of building green and of government incentives to build green. Most school officials I spoke to only spoke very generally of reduced energy bills and of a reduced environmental impact. Most did appreciate the positive impact that a green building had on their community image. Learning that school administrators were generally unaware of the benefits of green buildings came as little surprise however. Their line of work is in construction only sporadically, when their needs outgrow their available space resources. Their main focus is generally elsewhere, on running the school district. While there is a massive amount of solid information on the benefits of green buildings available, unfortunately, those motivated to sift through it are usually those involved in the design and construction industry as it impacts them more than most. While it would be beneficial for all owners to be experienced and well educated – it is simply not the case. It is especially not the case in school construction where the owners do not see a lot of new construction.

As far as the knowledge of green incentive programs, I found the level of knowledge to be understandable, but unacceptable. I found this understandable as most school districts are used to funding all of their own projects through tax dollars. I found it unacceptable because much of these resources go ignored. My own research found incentives at the state and federal level in most places, although finding them was not always easy. I generally found that there were few centralized locations where information on incentives or financial resources could be found.

In speaking with the architects involved in the construction projects I noticed one blaring trend: those who built green schools were the ones that introduced the idea to the schools. Those that did this also had previous experience designing green buildings. In bringing the idea of a green building to the school districts, most said that they received some resistance at first and had to do “some convincing” to use their words. All the architects I spoke with insisted that green design is the way of future design. The architects seemed to be the common thread in green and LEED certified school buildings. Some had more success than others. In these cases the school district and the community was not resistant to green design at all. For the Clearview Elementary School in Hanover, PA, the community actually demanded that the architect design more green elements into the design. This middle school ended up with a LEED gold rating.

In schools that were not LEED certified, the overwhelming response I got was that green was still on their minds. Whether or not this is mostly a public relations prompted response is unknown. In the case of the New Geneva Middle School, the main intent was to preserve equity between the existing school and the new one being constructed. As the site was to become the new “middle school campus” the design for the new school was almost an exact replication of the existing middle school. In State College, the new high school that is scheduled to begin construction in 2007 is not current destined to become a LEED certified building. In talking to various school officials, they insisted that green elements were being incorporated into the design, but they had not decided whether or not to seek certification. At the beginning of April, 2006, I was told that the State College school district was looking through the LEED point checklist to see which and how many points would likely be able to be awarded.

While it is good that more buildings are being built with green elements, I believe that schools especially should take the lead in greener design. As centers of learning for the community, they should take the lead in educating on reducing energy impact as well as reading, writing, and arithmetic. As technology advances, it is inevitable that certain elements of a building become more efficient and therefore greener – but this does not equate to having a green building. Green principles should be a driving element in the design.

Conclusion

Green buildings are the wave of the future, unfortunately that wave is just traveling a little slower than we'd like. In fact, it may be best to describe it less as a wave and more of a cultural drift. In completing this research, I found no single "smoking gun" as to why more schools weren't being built to a higher standard of green. I found fault with the designers, the owners, and even the government.

One of my most striking, and basic conclusions was that you can not have a green school without a green design. While the schools that were built green or became LEED certified were all a result of architects pushing the notion, there were still some that were not. I believe that more of those non-green schools would have been built green if the architects on those projects had more of a background in green design. While many architects put it on themselves to educate themselves on green materials and design ideas, many do not. All architects should be educated on the benefits and practices of designing green.

While the owners were not especially aware of green design and construction - this *is* the real world that most of us live in. I believe it is unreasonable to expect owners of this sort to be extremely experienced or educated. Much of the responsibility in educating owners should come from the construction industry: by means of architects, engineers, and construction managers. These design and construction professionals are invaluable in educating these owners on the type of the building that best suits their needs. For this to occur, they need to be brought in early on the project for consulting.

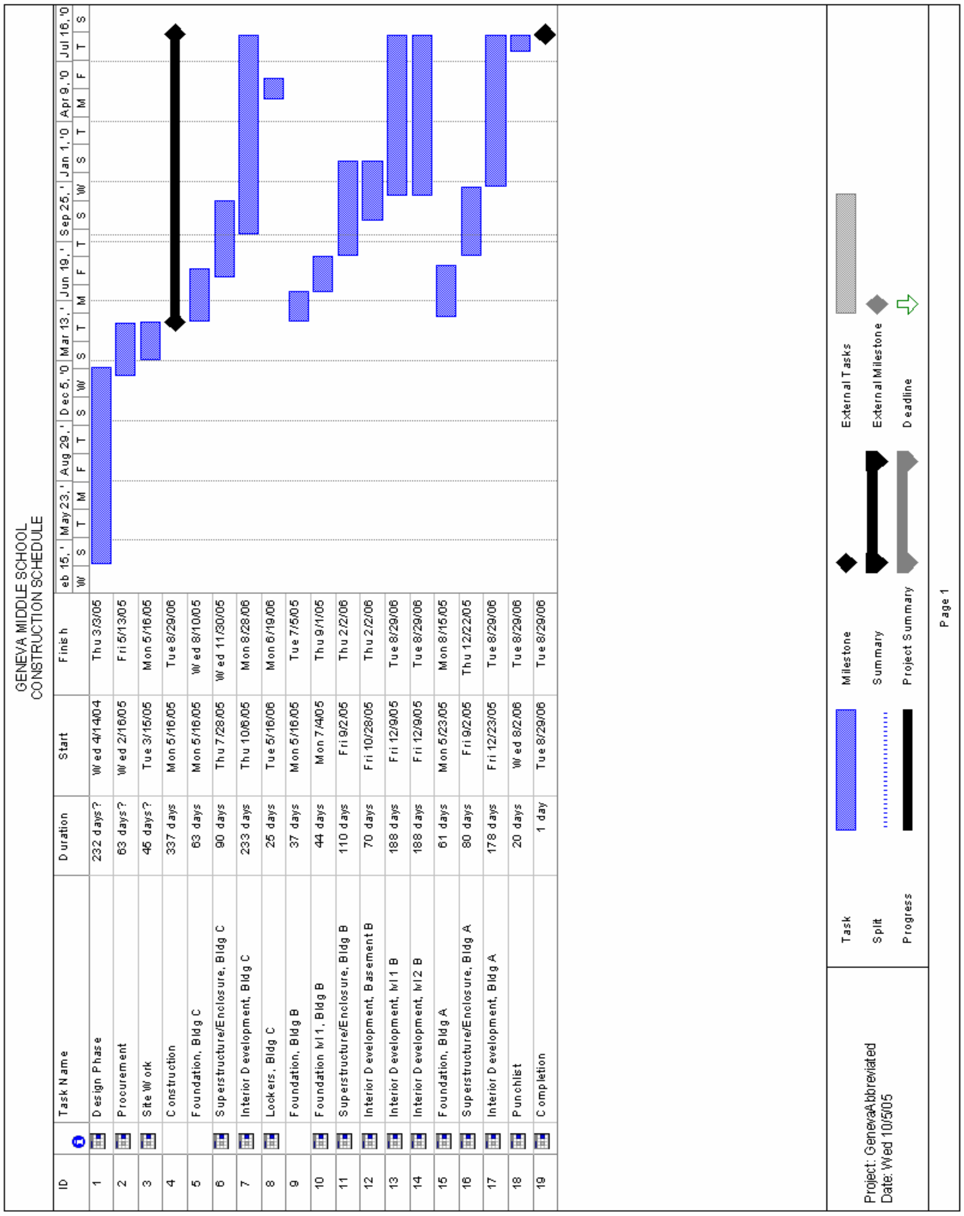
I also believe that government could do a better job with incentives. The school districts could be lured into green construction by the green of money. The idea behind the incentives is that the government ultimately benefits. Reduced energy consumption in the public equates to reduced strain on the current energy infrastructure. By offering these monetary incentives, the hurdle of increased cost of a green building is reduced and the benefits of cost savings in reduced energy use increases. This makes a more attractive scenario for the school districts. Hopefully, this would make the schools approach the architects about green designs instead of the other way around. Programs like this already exist. I believe they should be expanded, and more should be done to increase awareness of the available incentives through mailings and advertising.

Acknowledgements

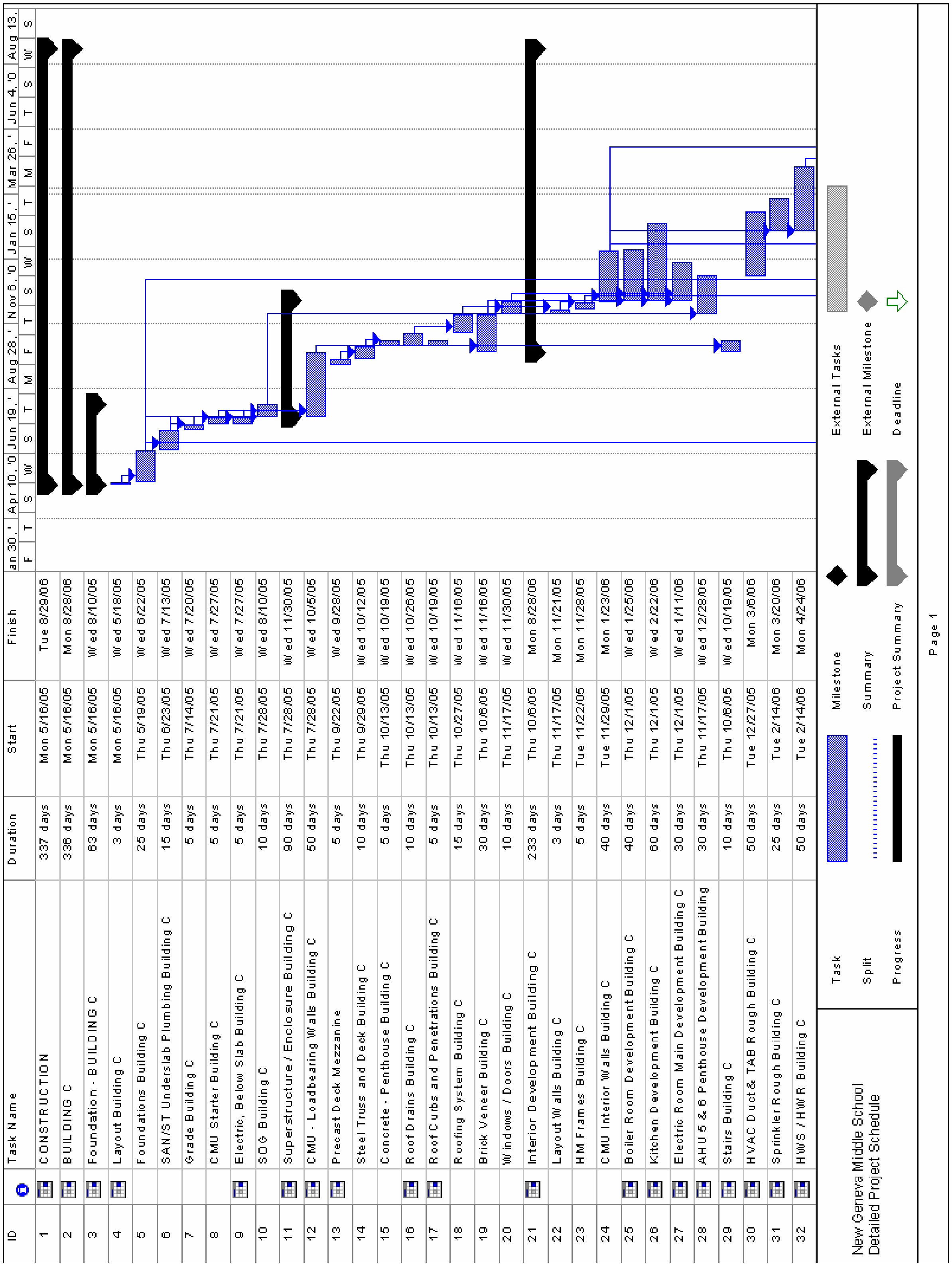
I'd like to thank Dr. Riley, my thesis advisor, for helping me along the way. I'd also like to thank Kevin Hoffman and Jim Miller from Bovis Lend Lease for the drawings, my construction documents, and feeding me useful information these past few months. Also thanks to all my interviewees for taking time out of their day to answer questions. Special thanks to McLanahans Market for keeping me fed and the makers of Arizona Green Tea – you do fine work.

Appendix

Abbreviated Schedule

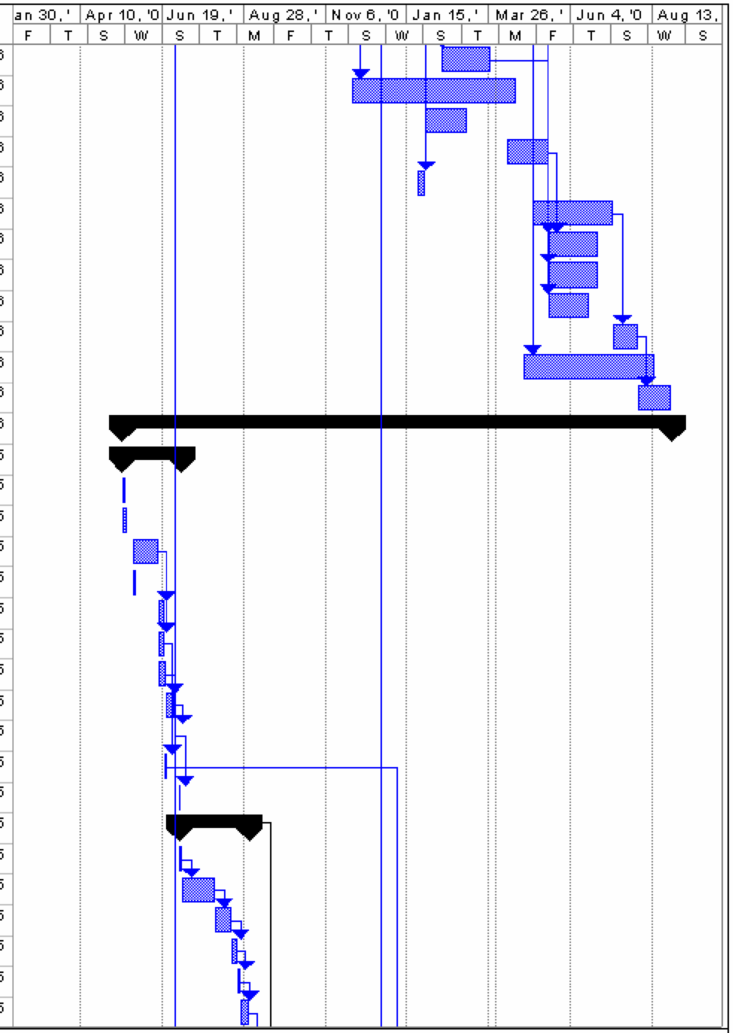


Detailed Schedule



ID	Task Name	Duration	Start	Finish
1	CONSTRUCTION	337 days	Mon 5/16/05	Tue 8/29/06
2	BUILDING C	336 days	Mon 5/16/05	Mon 8/28/06
3	Foundation - BUILDING C	63 days	Mon 5/16/05	Wed 8/10/05
4	Layout Building C	3 days	Mon 5/16/05	Wed 5/18/05
5	Foundations Building C	25 days	Thu 5/19/05	Wed 6/22/05
6	SAN/ST Underslab Plumbing Building C	15 days	Thu 6/23/05	Wed 7/13/05
7	Grade Building C	5 days	Thu 7/14/05	Wed 7/20/05
8	CMU Starter Building C	5 days	Thu 7/21/05	Wed 7/27/05
9	Electric, Below Slab Building C	5 days	Thu 7/21/05	Wed 7/27/05
10	SOG Building C	10 days	Thu 7/28/05	Wed 8/10/05
11	Superstructure / Enclosure Building C	90 days	Thu 7/28/05	Wed 11/30/05
12	CMU - Loadbearing Walls Building C	50 days	Thu 7/28/05	Wed 10/5/05
13	Precast Deck Mezzanine	5 days	Thu 9/22/05	Wed 9/28/05
14	Steel Truss and Deck Building C	10 days	Thu 9/29/05	Wed 10/12/05
15	Concrete - Penthouse Building C	5 days	Thu 10/13/05	Wed 10/19/05
16	Roof Drains Building C	10 days	Thu 10/13/05	Wed 10/26/05
17	Roof Curbs and Penetrations Building C	5 days	Thu 10/13/05	Wed 10/19/05
18	Roofing System Building C	15 days	Thu 10/27/05	Wed 11/16/05
19	Brick Veneer Building C	30 days	Thu 10/6/05	Wed 11/16/05
20	Windows / Doors Building C	10 days	Thu 11/17/05	Wed 11/30/05
21	Interior Development Building C	233 days	Thu 10/6/05	Mon 8/28/06
22	Layout Walls Building C	3 days	Thu 11/17/05	Mon 11/21/05
23	HM Frames Building C	5 days	Tue 11/22/05	Mon 11/28/05
24	CMU Interior Walls Building C	40 days	Tue 11/29/05	Mon 1/23/06
25	Boiler Room Development Building C	40 days	Thu 12/1/05	Wed 1/25/06
26	Kitchen Development Building C	60 days	Thu 12/1/05	Wed 2/22/06
27	Electric Room Main Development Building C	30 days	Thu 12/1/05	Wed 1/11/06
28	AHU 5 & 6 Penthouse Development Building	30 days	Thu 11/17/05	Wed 12/28/05
29	Stairs Building C	10 days	Thu 10/6/05	Wed 10/19/05
30	HVAC Duct & TAB Rough Building C	50 days	Tue 12/27/05	Mon 3/6/06
31	Sprinkler Rough Building C	25 days	Tue 2/14/06	Mon 3/20/06
32	HWS / HWR Building C	50 days	Tue 2/14/06	Mon 4/24/06

ID		Task Name	Duration	Start	Finish
33		Waste, Vent, Water, Plumbing Building C	30 days	Tue 2/14/06	Mon 3/27/06
34		Electric Rough All Systems Building C	100 days	Tue 11/29/05	Mon 4/17/06
35		Drywall Partitions Building C	25 days	Tue 1/31/06	Mon 3/6/06
36		Ceiling Grid and Soffit Framing Building C	25 days	Tue 4/11/06	Mon 5/15/06
37		Overhead Partition Building C	5 days	Tue 1/24/06	Mon 1/30/06
38		Trim MEPs to Ceiling Building C	50 days	Tue 5/2/06	Mon 7/10/06
39		Plumbing Trim Building C	30 days	Tue 5/16/06	Mon 6/26/06
40		Casework Building C	30 days	Tue 5/16/06	Mon 6/26/06
41		Lockers Building C	25 days	Tue 5/16/06	Mon 6/19/06
42		Doors and Hardware Building C	15 days	Tue 7/11/06	Mon 7/31/06
43		Finnishes Building C	80 days	Tue 4/25/06	Mon 8/14/06
44		Punch List, Owner F F & E	20 days	Tue 8/1/06	Mon 8/28/06
45		BUILDING B (2 Story)	337 days	Mon 5/16/05	Tue 8/29/06
46		Foundation Building B Basement	37 days	Mon 5/16/05	Tue 7/5/05
47		Layout Building B Basement	3 days	Mon 5/16/05	Wed 5/18/05
48		Excavate Building B Basement	5 days	Mon 5/16/05	Fri 5/20/05
49		Foundation Walls Building B Basement	15 days	Thu 5/26/05	Wed 6/15/05
50		Elevator Shaft	2 days	Thu 5/26/05	Fri 5/27/05
51		Sump Pump / Sewage Ejector SAN / ST	3 days	Thu 6/16/05	Mon 6/20/05
52		SAN / ST Below Slab Building B Basement	3 days	Thu 6/16/05	Mon 6/20/05
53		Drain Tile Building B Basement	5 days	Thu 6/16/05	Wed 6/22/05
54		Waterproofing Building B Basement	5 days	Thu 6/23/05	Wed 6/29/05
55		Backfill Building B Basement	2 days	Thu 6/30/05	Fri 7/1/05
56		SOG Building B Basement	3 days	Tue 6/21/05	Thu 6/23/05
57		Pre-cast Planks	2 days	Mon 7/4/05	Tue 7/5/05
58		Foundations Level 1 Building B	44 days	Mon 7/4/05	Thu 9/1/05
59		Layout B/1	3 days	Mon 7/4/05	Wed 7/6/05
60		Foundations B/1	20 days	Thu 7/7/05	Wed 8/3/05
61		SAN/St Under Slab Plumbing B/1	10 days	Thu 8/4/05	Wed 8/17/05
62		Restore Grades B/1	3 days	Thu 8/18/05	Mon 8/22/05
63		Electric Below Slab Building B	3 days	Tue 8/23/05	Thu 8/25/05
64		SOG Level 1 Building B	5 days	Fri 8/26/05	Thu 9/1/05



New Geneva Middle School
Detailed Project Schedule

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

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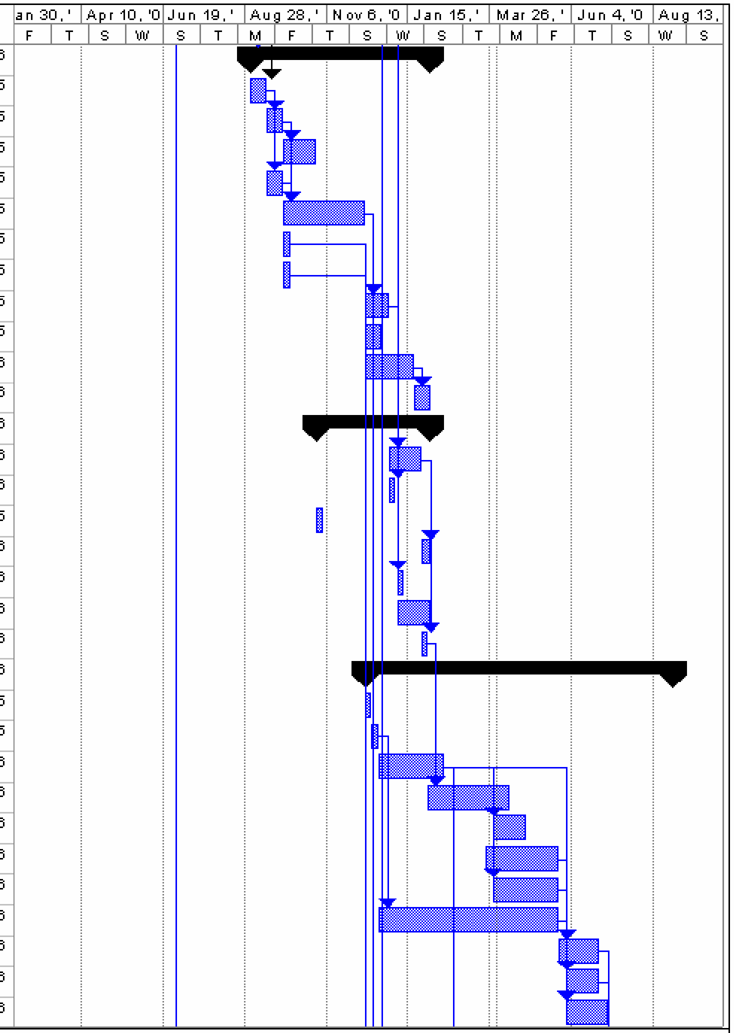
ID		Task Name	Duration	Start	Finish
65		Superstructure / Enclosure Building B	110 days	Fri 9/2/05	Thu 2/2/06
66		Steel 2nd Floor Building B	10 days	Fri 9/2/05	Thu 9/15/05
67		Steel Roof Building B	10 days	Fri 9/16/05	Thu 9/29/05
68		Stairs 1st-2nd Floor Building B	20 days	Fri 9/30/05	Thu 10/27/05
69		Concrete - 2nd Floor Deck Building B	10 days	Fri 9/16/05	Thu 9/29/05
70		CMU Exterior Walls Building B	50 days	Fri 9/30/05	Thu 12/8/05
71		Roof Drains Building B	5 days	Fri 9/30/05	Thu 10/6/05
72		Roof Curbs and Penetrations Building B	5 days	Fri 9/30/05	Thu 10/6/05
73		Roofing System Building B	15 days	Fri 12/9/05	Thu 12/29/05
74		Skylight	10 days	Fri 12/9/05	Thu 12/22/05
75		Brick Veneer Building B	30 days	Fri 12/9/05	Thu 1/19/06
76		Windows / Doors Building B	10 days	Fri 1/20/06	Thu 2/2/06
77		Interior Development Basement Building E	70 days	Fri 10/28/05	Thu 2/2/06
78		AHU 3 & 4 Development	20 days	Fri 12/30/05	Thu 1/26/06
79		Elevator Equipment	3 days	Fri 12/30/05	Tue 1/3/06
80		Stairs Basement Building B	5 days	Fri 10/28/05	Thu 11/3/05
81		CMU Walls	5 days	Fri 1/27/06	Thu 2/2/06
82		Pumps	3 days	Fri 1/6/06	Tue 1/10/06
83		Electric	20 days	Fri 1/6/06	Thu 2/2/06
84		Louvers	3 days	Fri 1/27/06	Tue 1/31/06
85		Interior Development Level 1 Building B	188 days	Fri 12/9/05	Tue 8/29/06
86		Layout Walls B/1	3 days	Fri 12/9/05	Tue 12/13/05
87		Set HM Frames B/1	5 days	Wed 12/14/05	Tue 12/20/05
88		CMU Interior Partitions B/1	40 days	Wed 12/21/05	Tue 2/14/06
89		HVAC Duct and TAB Rough B/1	50 days	Wed 2/1/06	Tue 4/11/06
90		Sprinkler Rough B/1	20 days	Wed 3/29/06	Tue 4/25/06
91		HWS / HWR B/1	45 days	Wed 3/22/06	Tue 5/23/06
92		Waste, Vent, Water Plumbing B/1	40 days	Wed 3/29/06	Tue 5/23/06
93		Electric Rough B/1	110 days	Wed 12/21/05	Tue 5/23/06
94		Ceiling Grid and Soffit Framing	25 days	Wed 5/24/06	Tue 6/27/06
95		MEP Trim to Ceiling B/1	20 days	Wed 5/31/06	Tue 6/27/06
96		Plumbing Trim B/1	25 days	Wed 5/31/06	Tue 7/4/06



New Geneva Middle School
Detailed Project Schedule

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

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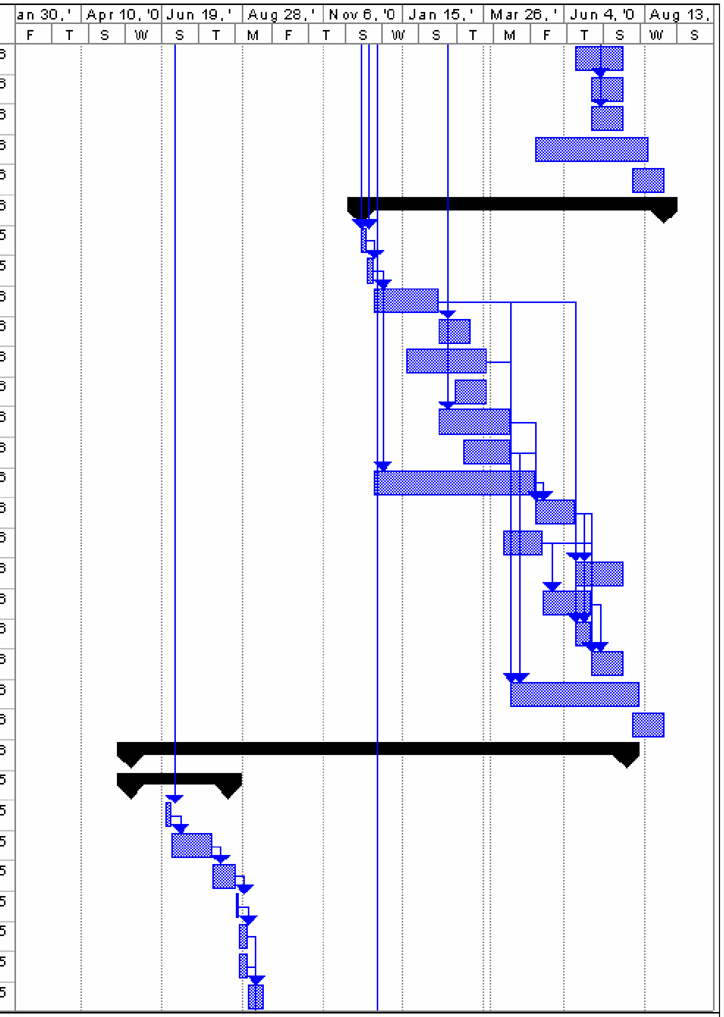
ID	Indicators	Task Name	Duration	Start	Finish
97	▦	Casework B/1	30 days	Wed 6/14/06	Tue 7/25/06
98		Lockers B/1	20 days	Wed 6/28/06	Tue 7/25/06
99		Doors and Hardware B/1	20 days	Wed 6/28/06	Tue 7/25/06
100	▦	Finishes B/1	70 days	Wed 5/10/06	Tue 8/15/06
101	▦	Punch List, Owner F F & E	20 days	Wed 8/2/06	Tue 8/29/06
102	▦	Interior Development Level 2 Building B	188 days	Fri 12/9/05	Tue 8/29/06
103	▦	Layout Walls B/2	3 days	Fri 12/9/05	Tue 12/13/05
104		HM Frames B.2	5 days	Wed 12/14/05	Tue 12/20/05
105		CMU Interior Walls B/2	40 days	Wed 12/21/05	Tue 2/14/06
106		Elevator	20 days	Wed 2/15/06	Tue 3/14/06
107	▦	HVAC Duct and TAB Rough B/2	50 days	Wed 1/18/06	Tue 3/28/06
108	▦	Sprinkler Rough B/2	20 days	Wed 3/1/06	Tue 3/28/06
109	▦	HWS / HWR B/2	45 days	Wed 2/15/06	Tue 4/18/06
110	▦	Waste, Water, Vent Plumbing B/2	30 days	Wed 3/8/06	Tue 4/18/06
111	▦	Electric Rough B/2	100 days	Wed 12/21/05	Tue 5/9/06
112	▦	Ceiling Grid and Soffit Framing B/2	25 days	Wed 5/10/06	Tue 6/13/06
113	▦	MEP Trim to Ceiling B/2	25 days	Wed 4/12/06	Tue 5/16/06
114		Plumbing Trim B/2	30 days	Wed 6/14/06	Tue 7/25/06
115		Casework B/2	30 days	Wed 5/17/06	Tue 6/27/06
116	▦	Lockers B/2	10 days	Wed 6/14/06	Tue 6/27/06
117		Doors and Hardware B/2	20 days	Wed 6/28/06	Tue 7/25/06
118		Finishes B/2	80 days	Wed 4/19/06	Tue 8/8/06
119	▦	Punch List, Owner F F & E	20 days	Wed 8/2/06	Tue 8/29/06
120	▦	BUILDING A	309 days	Mon 5/23/05	Thu 7/27/06
121	▦	Foundation Systems Building A	61 days	Mon 5/23/05	Mon 8/15/05
122	▦	Layout A	3 days	Thu 6/23/05	Mon 6/27/05
123		Foundations Building A	25 days	Tue 6/28/05	Mon 8/1/05
124		SAN/ST Below Slab Plumbing Building A	15 days	Tue 8/2/05	Mon 8/22/05
125		Grade Building A	3 days	Tue 8/23/05	Thu 8/25/05
126		Electric Below Slab Building A	5 days	Fri 8/26/05	Thu 9/1/05
127	▦	CMU Starter Building A	5 days	Fri 8/26/05	Thu 9/1/05
128		SOG Building A	10 days	Fri 9/2/05	Thu 9/15/05



New Geneva Middle School
Detailed Project Schedule

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

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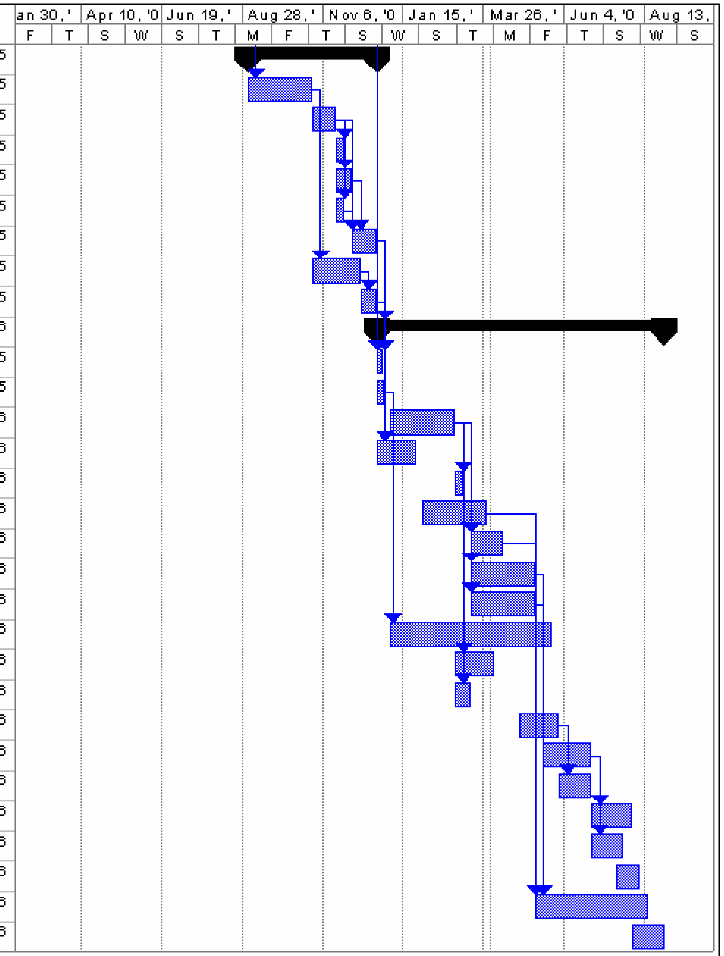
ID	Task Name	Duration	Start	Finish
129	Superstructure / Enclosure Building A	80 days	Fri 9/2/05	Thu 12/22/05
130	CMU Load Bearing Walls Building A	40 days	Fri 9/2/05	Thu 10/27/05
131	Steel Truss and Deck Building A	15 days	Fri 10/28/05	Thu 11/17/05
132	Concrete Penthouse Building A	5 days	Fri 11/18/05	Thu 11/24/05
133	Roof Drains Building A	10 days	Fri 11/18/05	Thu 12/1/05
134	Roof Curbs and Penetrations Building A	5 days	Fri 11/18/05	Thu 11/24/05
135	Roofing System Building A	15 days	Fri 12/2/05	Thu 12/22/05
136	Brick Veneer Building A	30 days	Fri 10/28/05	Thu 12/8/05
137	Windows / Doors Building A	10 days	Fri 12/9/05	Thu 12/22/05
138	Interior Development Building A	178 days	Fri 12/23/05	Tue 8/29/06
139	Layout Walls Building A	3 days	Fri 12/23/05	Tue 12/27/05
140	HM Frames Building A	5 days	Fri 12/23/05	Thu 12/29/05
141	CMU Interior Walls Building A	40 days	Wed 1/4/06	Tue 2/28/06
142	AHU 1 & 2 Penthouse Development Building	25 days	Fri 12/23/05	Thu 1/26/06
143	Stairs Building A	5 days	Wed 3/1/06	Tue 3/7/06
144	HVAC Duct and TAB Rough Building A	40 days	Wed 2/1/06	Tue 3/28/06
145	Sprinkler Rough Building A	20 days	Wed 3/15/06	Tue 4/11/06
146	HWS / HWR Rough Building A	40 days	Wed 3/15/06	Tue 5/9/06
147	Waste, Vent, Water Building A	40 days	Wed 3/15/06	Tue 5/9/06
148	Electric Rough Building A	100 days	Wed 1/4/06	Tue 5/23/06
149	Drywall Partitions Building A	25 days	Wed 3/1/06	Tue 4/4/06
150	Overhead Partitions	10 days	Wed 3/1/06	Tue 3/14/06
151	Ceiling Grid and Soffit Framing Building A	25 days	Wed 4/26/06	Tue 5/30/06
152	Trim MEPs to Ceiling Building A	30 days	Wed 5/17/06	Tue 6/27/06
153	Plumbing Trim Building A	20 days	Wed 5/31/06	Tue 6/27/06
154	Casework Building A	25 days	Wed 6/28/06	Tue 8/1/06
155	Lockers Building A	20 days	Wed 6/28/06	Tue 7/25/06
156	Doors and Hardware Building A	15 days	Wed 7/19/06	Tue 8/8/06
157	Finishes Building A	70 days	Wed 5/10/06	Tue 8/15/06
158	Punch List, Owner F F & E	20 days	Wed 8/2/06	Tue 8/29/06



New Geneva Middle School
Detailed Project Schedule

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

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Structural Calculations

BEAMS

Original Calculations

	PSF	X-Section	PLF	KLF
Live Load	80	6.5	520	0.52
Dead Load	113	6.5	734.5	0.7345
Length	34.66			
	M LL	M DL	M Max	
M Max	124.9368	176.4733	301.4101	
Z Req	80.37602		**Beam Size = W 21 x 44**	
			Z =	**95.8**
Check:	Foot Kips	Inch Kips		
M Max	307.3501	3688.201		
Phi Mn		4311	**OK**	

Re-Calc

	PSF	X-Section	PLF	KLF
Live Load	80	6.5	520	0.52
Dead Load	95	6.5	617.5	0.6175
Length	34.66			
	M LL	M DL	M Max	
M Max	124.9368	148.3625	273.2993	
Z Req	72.87981		**Beam Size = W 18 x 40**	
			Z =	**78.4**
Check:	Foot Kips	Inch Kips		
M Max	278.6993	3344.392		
Phi Mn		3528	**OK**	

Original Calculations

	PSF	X-Section	PLF	KLF
Live Load	80	6.5	520	0.52
Dead Load	113	6.5	734.5	0.7345
Length	27.33			
	M LL	M DL	M Max	
M Max	77.68061	109.7239	187.4045	
Z Req	49.97452		**Beam Size = W 18 x 35**	
			Z =	**66.5**
Check:	Foot Kips	Inch Kips		
M Max	193.3445	2320.134		
Phi Mn		2992.5	**OK**	

Re-Calc

	PSF	X-Section	PLF	KLF
Live Load	80	6.5	520	0.52
Dead Load	95	6.5	617.5	0.6175
Length	27.33			
	M LL	M DL	M Max	
M Max	77.68061	92.24572	169.9263	
Z Req	45.31369		**Beam Size = W 16 x 31**	
			Z =	**54**
Check:	Foot Kips	Inch Kips		
M Max	175.3263	2103.916		
Phi Mn		2430	**OK**	

Original Calculations

	PSF	X-Section	PLF	KLF
Live Load	80	6.5	520	0.52
Dead Load	113	6.5	734.5	0.7345
Length	27.33			
	M LL	M DL	M Max	
M Max	77.68061	109.7239	187.4045	
Z Req	49.97452		**Beam Size = W 18 x 40**	
			Z =	**78.4**
Check:	Foot Kips	Inch Kips		
M Max	193.3445	2320.134		
Phi Mn		3528	**OK**	

Re-Calc

	PSF	X-Section	PLF	KLF
Live Load	80	6.5	520	0.52
Dead Load	95	6.5	617.5	0.6175
Length	27.33			
	M LL	M DL	M Max	
M Max	77.68061	92.24572	169.9263	
Z Req	45.31369		**Beam Size = W 16 x 31**	
			Z =	**54**
Check:	Foot Kips	Inch Kips		
M Max	175.3263	2103.916		
Phi Mn		2430	**OK**	

Wall Cost Savings

Original Glazed Concrete Block	Mat.	Lab.	Equip	Total	O&P
Double Face 8x16" - 6" Thick	**$ 11.25**	**$ 4.13**	**$ -**	**$ 15.38**	**$ 19.10**
	$ 15,986.25	$ 5,868.73	$ -	$ 21,854.98	$ 27,141.10
Double Face 8x16" - 8" Thick	**$ 11.75**	**$ 4.40**	**$ -**	**$ 16.15**	**$ 20.00**
	$ 255,268.75	$ 95,590.00	$ -	$350,858.75	$434,500.00
Total	$ 271,255.00	$101,458.73	$ -	$372,713.73	$461,641.10

New Metal Studs & Track	Mat.	Lab.		Total	O&P
3 5/8" Stud - 24" OC	**$ 0.22**	**$ 0.30**	**$ -**	**$ 0.52**	**$ 0.74**
Total	$ 5,092.12	$ 6,943.80	$ -	$ 12,035.92	$ 17,128.04

Delta	**$ 266,162.88**	**$ 94,514.93**	**$ -**	**$360,677.81**	**$444,513.06**

Structural Steel Cost Savings

Original Steel Members	Mat.	Lab.	Equip.	Total	O&P
W 21 x 44	**$ 46.00**	**$ 2.96**	**$ 1.42**	**$ 50.38**	**$ 57.50**
	$ 124,384.00	$ 8,003.84	$ 3,839.68	$136,227.52	$155,480.00
W 18 x 35	**$ 36.50**	**$ 3.28**	**$ 1.58**	**$ 41.36**	**$ 47.50**
	$ 25,951.50	$ 2,332.08	$ 1,123.38	$ 29,406.96	$ 33,772.50
W 18 x 40	**$ 42.00**	**$ 3.28**	**$ 1.58**	**$ 46.86**	**$ 53.50**
	$ 20,661.48	$ 1,613.56	$ 777.27	$ 23,052.31	$ 26,318.79
Total	**$ 170,996.98**	**$ 11,949.48**	**$ 5,740.33**	**$188,686.79**	**$215,571.29**

New Steel Members					
W 18 x 40	**$ 42.00**	**$ 3.28**	**$ 1.58**	**$ 46.86**	**$ 53.50**
	$ 113,568.00	$ 8,869.12	$ 4,272.32	$126,709.44	$144,664.00
W 16 x 31	**$ 32.50**	**$ 2.42**	**$ 1.59**	**$ 36.51**	**$ 41.50**
	$ 23,107.50	$ 1,720.62	$ 1,130.49	$ 25,958.61	$ 29,506.50
W 16 x 31	**$ 32.50**	**$ 2.42**	**$ 1.59**	**$ 36.51**	**$ 41.50**
	$ 15,988.05	$ 1,190.49	$ 782.18	$ 17,960.73	$ 20,415.51
Total	**$ 152,663.55**	**$ 11,780.23**	**$ 6,184.99**	**$170,628.78**	**$194,586.01**

Delta	**$ 18,333.43**	**$ 169.25**	**$ (444.67)**	**$ 18,058.01**	**$ 20,985.28**

Existing Wall Type

	Square Footage	Daily Output	Cost / SF	Total Cost	Total Weeks	R
CMU, normal weight, 8"	23000	360	$ 8.15	$187,450.00	12	2.02
3" Rigid Insulation, R 13	23000	730	$ 3.49	$ 80,270.00	6.3	13
1" Air Space						0.91
Face Brick	23000	600	$ 10.53	$242,190.00	7.6	0.43
				$509,910.00	**25.9**	**16.36**

Precast Concrete, Insulated with Face Brick

	Square Footage	Daily Output	Cost / SF	Total Cost	Total Weeks	R
4" Precast, 2" polystyrene	23000	768	$ 23.02	$529,460.00	6	10.4
1" Air Space						0.91
Face Brick	23000	600	$ 10.53	$242,190.00	7.6	0.43
				$771,650.00	**13.6**	**11.74**

Tilt Up Construction w/ Face Brick

	Square Footage	Daily Output	Cost / SF	Total Cost	Total Weeks	R
Tilt-up conc. panels, 5.5" thick	23000	840	$ 8.38	$192,740.00	5.5	0.67
3" Rigid Insulation, R 13	23000	730	$ 3.49	$ 80,270.00	6.3	13
1" Air Space						0.91
Face Brick	23000	600	$ 10.53	$242,190.00	7.6	0.43
				$515,200.00	**19.4**	**15.01**

Smith Midland Slenderwall

	Square Footage	Daily Output	Cost / SF	Total Cost	Total Weeks	R
Slenderwall	23000	6500	$ 27.00	$621,000.00	0.8	0.2
R13 Batt Insulation	23000	1600	$ 0.67	$ 80,270.00	2.9	13
5/8" Gypsum Board	23000	965	$ 1.18	$ 27,140.00	4.8	0.56
				$728,410.00	**8.5**	**13.76**

U-Value Calculations

	U-Values		% Area		Reaultant U-Value
	Wall	Window	Wall	Window	
Existing Wall	0.061	0.64	0.97	0.03	0.07837
Tilt-up	0.067	0.64	0.97	0.03	0.08419
Slenderwall	0.073	0.64	0.97	0.03	0.09001
Precast	0.085	0.64	0.97	0.03	0.10165

Existing Wall BTU/Year

BIN	DB Temp.	BTU/hr	Total BTU
13	85.8	107132.07	1392716.932
38	87.9	123434.78	4690521.573
62	84.6	97816.239	6064606.84
97	82.5	81513.533	7906812.682
199	79.5	58223.952	11586566.45
245	76.8	37263.329	9129515.674
323	75.8	29500.136	9528543.825
426	73	7763.1936	3307120.474
372	70.5	-11644.79	-4331862.029
433	68.6	-26394.86	-11428973.62
334	67.1	-38039.65	-12705242.65
328	64	-62105.55	-20370620.01
291	60.9	-86171.45	-25075891.65
280	58.6	-104026.8	-29127502.39
251	57.8	-110237.3	-27669574.63
247	55.8	-125763.7	-31063642.87
239	52.9	-148277	-35438202.46
273	50.1	-170013.9	-46413805.58
299	48.2	-184764	-55244438.3
271	46.3	-199514.1	-54068314.47
269	43.8	-218922.1	-58890034.01
312	41	-240659	-75085608.5
344	38.3	-261619.6	-89997150.77
375	36	-279475	-104803113.6
364	34.2	-293448.7	-106815333.4
311	32.1	-309751.4	-96332693.06
347	29.8	-327606.8	-113679549.2
278	27.6	-344685.8	-95822651.24
218	25.2	-363317.5	-79203206.38
165	23.2	-378843.8	-62509234.87
151	20.8	-397475.5	-60018802.36
151	18.8	-413001.9	-62363286.83
99	16.7	-429304.6	-42501156
65	14.7	-444831	-28914014.56
54	12.9	-458804.7	-24775456.06
43	10.8	-475107.4	-20429620.28
37	8.2	-495291.8	-18325794.81
33	6.4	-509265.5	-16805761.51
19	4.3	-525568.2	-9985795.928
22	2.4	-540318.3	-11887002.04
23	0.6	-554292	-12748716.53
17	-1.5	-570594.7	-9700110.403
14	-3.7	-587673.8	-8227432.577
21	-6.2	-607081.7	-12748716.53
7	-8	-621055.5	-4347388.416
	Total BTU per year:		**1,633,462,104.89**

sum cool
53,606,404.45
.
sum heat
1,579,855,700.44

Precast With Face Brick BTU/Year

BIN	DB Temp.	BTU/hr	Total BTU
13	85.8	117715.7	1530303.887
38	87.9	135628.9	5153899.712
62	84.6	107479.5	6663731.306
97	82.5	89566.28	8687929.257
199	79.5	63975.92	12731207.09
245	76.8	40944.59	10031423.47
323	75.8	32414.46	10469871.74
426	73	8530.122	3633831.972
372	70.5	-12795.2	-4759808.076
433	68.6	-29002.4	-12558045.61
334	67.1	-41797.6	-13960397.67
328	64	-68241	-22383040.13
291	60.9	-94684.4	-27553147.07
280	58.6	-114304	-32005017.74
251	57.8	-121128	-30403060.83
247	55.8	-138188	-34132430.17
239	52.9	-162925	-38939153.92
273	50.1	-186810	-50999040.4
299	48.2	-203017	-60702054.18
271	46.3	-219224	-59409740.69
269	43.8	-240549	-64707799.47
312	41	-264434	-82503339.98
344	38.3	-287465	-98887998.32
375	36	-307084	-115156647
364	34.2	-322439	-117367654.6
311	32.1	-340352	-105849430.9
347	29.8	-359971	-124909988.5
278	27.6	-378737	-105289001.9
218	25.2	-399210	-87027716.69
165	23.2	-416270	-68684542.34
151	20.8	-436742	-65948079.21
151	18.8	-453802	-68524176.05
99	16.7	-471716	-46699858.91
65	14.7	-488776	-31770439.39
54	12.9	-504130	-27223031.35
43	10.8	-522043	-22447869.06
37	8.2	-544222	-20136205.99
33	6.4	-559576	-18466008.11
19	4.3	-577489	-10972295.93
22	2.4	-593696	-13061322.81
23	0.6	-609051	-14008166.35
17	-1.5	-626964	-10658387.44
14	-3.7	-645730	-9040223.296
21	-6.2	-667056	-14008166.35
7	-8	-682410	-4776868.32
	Total BTU per year		**1,794,832,353.15**

sum cool
58,902,198.43
.
sum heat
1,735,930,154.72

Tilt-up With Face Brick BTU/Year

BIN	DB Temp.	BTU/hr	Total BTU

13	85.8	113395.8	1474145.946
38	87.9	130651.7	4964765.778
62	84.6	103535.3	6419190.708
97	82.5	86279.45	8369106.165
199	79.5	61628.18	12264006.83
245	76.8	39442.03	9663297.84
323	75.8	31224.94	10085656.27
426	73	8217.09	3500480.34
372	70.5	-12325.6	-4585136.22
433	68.6	-27938.1	-12097199.9
334	67.1	-40263.7	-13448089.49
328	64	-65736.7	-21561644.16
291	60.9	-91209.7	-26542022.41
280	58.6	-110109	-30830521.68
251	57.8	-116683	-29287352.18
247	55.8	-133117	-32879863.93
239	52.9	-156946	-37510194.14
273	50.1	-179954	-49127515.98
299	48.2	-195567	-58474455.86
271	46.3	-211179	-57229566.72
269	43.8	-231722	-62333201.32
312	41	-254730	-79475694.48
344	38.3	-276916	-95259080.95
375	36	-295815	-110930715
364	34.2	-310606	-113060584.7
311	32.1	-327862	-101965048.1
347	29.8	-346761	-120326135.7
278	27.6	-364839	-101425185.3
218	25.2	-384560	-83834039.02
165	23.2	-400994	-66164008.68
151	20.8	-420715	-63527966.21
151	18.8	-437149	-66009527.39
99	16.7	-454405	-44986102.62
65	14.7	-470839	-30604551.71
54	12.9	-485630	-26224021.03
43	10.8	-502886	-21624094.04
37	8.2	-524250	-19397262.65
33	6.4	-539041	-17788356.43
19	4.3	-556297	-10569642.87
22	2.4	-571909	-12582008.21
23	0.6	-586700	-13494105.2
17	-1.5	-603956	-10267253.96
14	-3.7	-622034	-8708471.982
21	-6.2	-642576	-13494105.2
7	-8	-657367	-4601570.4

sum cool
56,740,649.87
.
sum heat
1,672,226,295.83

Total BTU per year: 1,728,966,945.70

Smith Midland Slenderwall (with R13 batt insulation) BTU/Year

BIN	DB Temp.	BTU/hr	Total BTU
13	85.8	118795.6	1544343.372

38	87.9	136873.2	5201183.196
62	84.6	108465.6	6724866.456
97	82.5	90387.99	8767635.03
199	79.5	64562.85	12848007.15
245	76.8	41320.22	10123454.88
323	75.8	32711.84	10565925.61
426	73	8608.38	3667169.88
372	70.5	-12912.6	-4803476.04
433	68.6	-29268.5	-12673257.04
334	67.1	-42181.1	-14088474.71
328	64	-68867	-22588389.12
291	60.9	-95553	-27805928.24
280	58.6	-115352	-32298641.76
251	57.8	-122239	-30681988
247	55.8	-139456	-34445571.73
239	52.9	-164420	-39296393.86
273	50.1	-188524	-51466921.51
299	48.2	-204879	-61258953.76
271	46.3	-221235	-59954784.19
269	43.8	-242756	-65301449
312	41	-266860	-83260251.36
344	38.3	-290102	-99795227.66
375	36	-309902	-116213130
364	34.2	-325397	-118444422.1
311	32.1	-343474	-106820526.6
347	29.8	-363274	-126055951.7
278	27.6	-382212	-106254956
218	25.2	-402872	-87826136.11
165	23.2	-420089	-69314675.76
151	20.8	-440749	-66553107.46
151	18.8	-457966	-69152838.22
99	16.7	-476043	-47128297.99
65	14.7	-493260	-32061911.31
54	12.9	-508755	-27472783.93
43	10.8	-526833	-22653812.81
37	8.2	-549215	-20320941.83
33	6.4	-564710	-18635421.02
19	4.3	-582787	-11072959.19
22	2.4	-599143	-13181151.46
23	0.6	-614638	-14136681.64
17	-1.5	-632716	-10756170.81
14	-3.7	-651654	-9123161.124
21	-6.2	-673175	-14136681.64
7	-8	-688670	-4820692.8
	Total BTU per year:		**1,811,298,705.02**

sum cool
59,442,585.58

.

sum heat
1,751,856,119.44