Thesis Report
Architectural Engineering
Construction Management

Dave Fox

Wrangle Hill Elementary School
Faculty Advisor: Dr. Riley
Spring 2008

Project Overview

Wrangle Hill Elementary School
New Castle, DE
Elementary School, housing Kindergarten through Fifth grade
Size 157,085 Square Feet

Architectural Features

- One story with a mechanical mezzanine located above each wing, only accessible from the roof.
- Grand entrance with signature bell tower
- Skylights located in many places throughout hallways, cafeteria, and kitchen to provide sunlight

Structural System

- Foundations: Shallow footings with 4000psi concrete reinforced with rebar and synthetic fibers.
- Framing: Steel columns encased in masonry pilasters supporting wide flange beams and joists
- Floors: All slab on grade floors, 4” typical, 6” in select locations, and 10” at masonry partitions and mechanical areas.
- Decking: 22 gauge with 2 ½” reinforced concrete slab at mechanical mezzanines
- Façade: Non load bearing architectural brick with masonry backup with glazed aluminum storefront entrances and windows.
- Roofing: 22 gauge metal deck with isocyanurate insulation, followed by a standing seam metal deck on the sloped roof sections, and a bitumen membrane on the flat roof.

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Construction Management

Project Team

Owner	Colonial School District
Architect	Tetra Tech, Inc.
General Contractor	EDiS Company
MEP Engineer	Paragon Engineering
Food Service	Zaralban and Assoc., Inc.
Roofing Consultant	NTH Consultants, LD

Mechanical System

- (12) Roof top air handling units totaling 52,000 cfm.
- (66) Unit Ventilators in the classroom areas
- (4) enthalpy wheels

Electrical System

- 480Y/277 V 3 phase 25 kV, 1500 kVA pad mounted transformer
- Backup Diesel engine generator, 200 kW, 250 kVA

Lighting System

- Classrooms have all florescent lights with daylight contr occupancy sensor, A/V mode, and a “Timeout” occupan sensor override switch.
- Classroom florescent light fixtures give downlight in normal mode, only uplight in A/V mode
- Gymnasiums have HID downlights

http://www.engr.psu.edu/ae/thesis/portfolios/2008/dwf137/

Table of Contents

Acknowledgements

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EDiS Company

Andy Hickey, Project Manager
Brad Cowen, Project Executive
Dominic Russo, Project Manager

Colonial School District

George Meney, Superintendent
Steve Hudson, Construction Rep.
John Gordon, Construction Rep.

Tetra Tech Architects

Tim Skibicki, Architect

Daniel J. Keating Construction

John Barnes, Project Executive
Mike Dooley, Project Manager

SlenderWall

Ashley Smith, VP of Sales and Marketing

Inovateus Development

John Cernak, Sales

Norwood Construction

Tom Seeman, Project Manager

The Pennsylvania State University

Dr. David Riley
Andreas Phelps
Dr. M. Kevin Parfitt
Robert Holland

Executive Summary

The project utilized for this thesis report is Wrangle Hill Elementary School, located just south of Wilmington, DE. This is a one story elementary school being built to accommodate an increasing population and demand for full time kindergarten rooms throughout the district. The school is under a very tight schedule, the building envelope has been examined and re-designed to find if an alternate system could alleviate the schedule concerns.

Research has been compiled regarding the use of prefabrication in the construction industry today. There are several items that need to be overcome on a typical project in order to utilize prefabrication on a more frequent basis. Suggestions have been made to combat these issues on all projects, and on Wrangle Hill. A schedule analysis has revealed that prefabrication on Wrangle Hill can have a significant influence on the project schedule.

Changing to a prefabricated system will also affect other items throughout the building. Due to the nature of the panels, the architecture has been preserved, however the mechanical performance of the wall has drastically changed. A mechanical analysis was performed in order to assure that the performance will not be greatly reduced. Thermal movement and a condensation analysis were performed in order to assure similar performance.

An additional study was performed to study the feasibility of adding a photovoltaic system onto the roof of the school. The system was designed using panels that are integrated with the standing seam metal roof. Weather data was analyzed in order to provide electrical output and to determine the feasibility of this system.

All of these studies wrap up a study on Wrangle Hill to build in a more efficient manner, with more energy efficient materials, with the possibility of using one of the most abundant natural resources, solar energy, to increase the efficiency of this school.

Introduction and Background

Project Information

Wrangle Hill Elementary School is a one story school located in Colonial School District, located in New Castle, DE, just south of Wilmington. The school is a one story, 157,000 square foot school separated into four separate wings and a central core area. The wings are in an "X" shape, with the central core in the center of the "X". The four wings of the school contain the majority of the classroom spaces varying from kindergarten all the way through fifth grade. The central core area holds the support functions including three administration areas, two cafeterias, one kitchen, a mechanical room, a storage room, library, and a large multi-purpose room.

The building consists of primarily non load bearing concrete masonry unit walls, the exterior walls are faced with hand laid face 4" brick. The interior walls are all concrete masonry unit walls, with the exception of the administration area, which are metal stud framed with gypsum board. The roof over the classroom wings is an angled standing seam metal roof, while the roof over the core area is primarily a flat roof. The structural system of the building is compromised of multiple different types of structural steel, including square hollow steel columns, wide flange beams, and joists. There is no basement to the building, allowing all floors to be simply slab on grade concrete. The concrete is then topped off with different finishing materials.

In the hallways, a durable terrazzo has been chosen, while in the classrooms vinyl composition tile has been used. The administration areas have a combination of terrazzo, VCT, and carpet. The kitchen has a special epoxy coated floor to aid in the durability of the floor in such a harsh environment. Within the hallways of the central core area, several skylights spread throughout. The windows and the entrance areas all consist of an aluminum storefront with insulating glass. All exterior doors are made from Fiberglass Reinforced Polyester.

Owner Information

The owner of Wrangle Hill Elementary School is Colonial School District. There are eight different elementary schools, three middle schools and one high school within the school district. This school district covers a large area in northern Delaware in the Wilmington area. The school district has experienced rapid growth recently and needed to expand their elementary school capacity with the addition of Wrangle Hill. Additionally, the school district has recently adopted a full day kindergarten program requiring the addition of more kindergarten classrooms throughout the district.

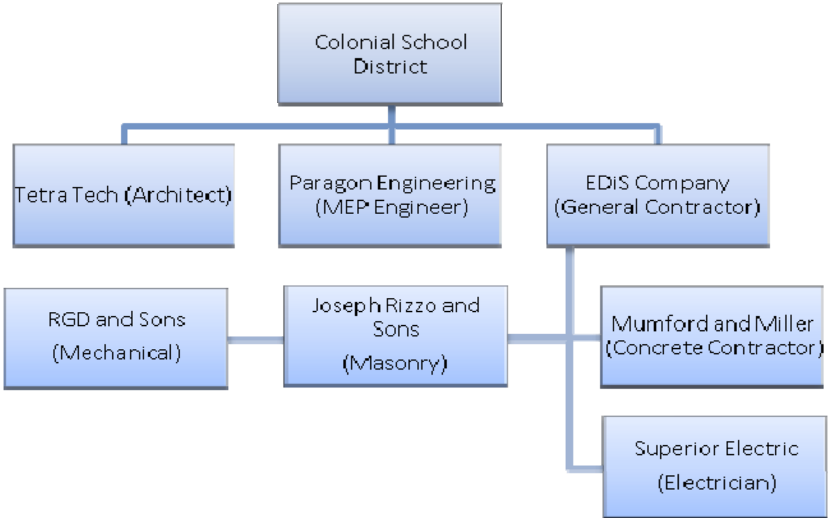
Colonial School District has chosen to re-use the architectural plans from a previous elementary school, Southern Elementary School, which finished construction in 2001. When questioned about why they chose to re-use the plans, the construction representative Steve Hudson stated that Southern Elementary was very successful and everyone in the district loved it. There would also be a significant reduction in the architects design fee since the drawings could be considered 95% complete to start.

Colonial School District is well versed in construction and has its own department to handle construction management. This department is run by Steve Hudson. Mr. Hudson oversees all of the construction projects from minor repair work to the construction of new schools. He has a vast knowledge of the construction industry, allowing the school district to eliminate the need for a construction manager. Wrangle Hill Elementary School is the first school in the district being built by a general contractor instead of a construction manager.

The school district has high expectations for this project. An identical school has already been built on time and on budget by a different contractor, so they expected no less from EDiS Company. The school district has included a $10,000 per day liquidated damage penalty if the school is not complete on August 1, 2007. Colonial School District is a construction oriented district with a desire for quality.

Project Delivery

Figure 1.1



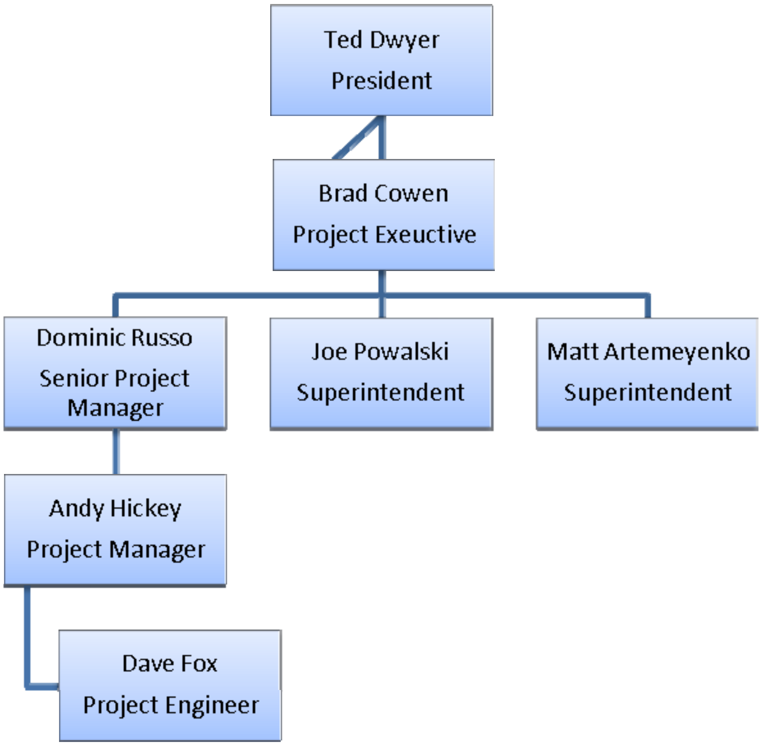
The construction of Wrangle Hill Elementary School is being delivered as a "Design-Bid-Build" project with a general contractor. This project delivery method was decided upon by the Colonial School District to try to save money, and bring the project in on time. Colonial School District feels as though when the project is delivered by a Construction Manager, they have problems with bringing the project in on budget and on time. This is a first time experiment by the school district to decide the project method for future projects.

The contracts between Colonial School District, Tetra Tech and Paragon Engineering are both cost plus fee contracts. The contract between EDiS Company and Colonial School district is a lump sum contract. All of the relationships can be seen above in Figure 1.1. EDiS's contract was awarded as a low bid public bid, based on base bid, or bid plus any combination of alternate estimates listed on proposal form. There was a 10% bid bond and a 100% performance bond required of all bidders.

The delivery method and contract method all seem to be very typical of similar public school projects. This is an affective method of managing a project because all of the involved players acclimated to this system from previous experience with public school construction.

Project Team

Figure 1.2



EDiS, the General contractor on the project, staffed the job with the necessary team due to the tight schedule that the project was under. A break down can be seen above in Figure 1.2. Dominic Russo and Andy Hickey shared project management tasks, with Dominic Russo taking more of the executive position as he was the senior member of the team. Joe Powalski and Matt Artemeyenko were superintendents and worked along side both of the project managers, and reported to the Project Executive Brad Cowen. Joe was the superintendent throughout the entire job; Matt was bought in through the heart of construction when coordination was getting difficult. Throughout the project, Andy Hickey had one onsite project engineer, and an office engineer who would help with distributing communication. This organization worked out well as all of the key players were located on site to take care of day to day issues as well as long term issues.

Project Estimate

The project estimate can be seen in Figure 1.3 below. The majority of the numbers included below are estimates; the final total was estimated as well.

Figure 1.3

Site Work	$3,457,020
Roofing	$2,409,645
Concrete	$1,265,000
Masonry	$4,475,000
Structural Steel	$2,130,000
Carpentry	$2,611,736
Joint Sealants	$137,710
Doors and Windows	$1,278,688
Flooring	$1,216,759
Finishes	$566,692
Accessories	$560950
Food Services	$800,000
HVAC	$5,100,000
Fire Protection	$295,914
Electric	$3,375,000
General Conditions	$2,858,087
Total (Approximate)	**$32,540,000**

General Conditions Estimate

The General Conditions Estimate includes all items that the general contractor would need to provide on Wrangle Hill Elementary School. Items like temporary heating and staffing costs are dependent upon the schedule, others such as blueprint copying are simple costs that are related to the size of the project. The General Conditions Estimate includes a general contractor's fee of 5% of the total project cost. The total General Conditions Estimate is **$2,858,087**, which translates into about **8.7%** of the total project cost.

Please see Appendix A for a detailed breakdown of the General Conditions

Detailed Project Schedule

Key Dates for Wrangle Hill Construction

Figure 1.4

Item	Date
Notice to Proceed	4/3/2006
Install Site Trailer	5/8/2006
Temporary Heat	11/5/2006
Substantial Completion	6/15/2007
Final Completion	7/12/2007

The schedule that has been formulated was a combination of the contractors' initial schedule, as well as including some other items. A general overview can be seen above in Figure 1.4

Please see Appendix B for a detailed project schedule.

Central Building Core

The central building core of Wrangle Hill Elementary School is broken down into three different sections. The three different sections correspond with different sections in the project documents. Core area one and core area two are identical, just mirrored about the centerline of the building. Core area three contains the cafeteria, kitchen, and mechanical room. Core area three will require more coordination between the mechanical and electrical contractors due to the mechanical room.

Building Wings

The wings of Wrangle Hill Elementary School are all identical to each other. Due to the repetition, it makes sense to break out the construction by wings. When one task has been completed in the first wing, the crew can proceed to the next wing, creating a parade of trades.

Site Layout Plan

The site layout plan was performed for interior MEP work, and interior finishing trades. This time is the most congested due to the fact that everything is taking place inside of the building. The owner also had a requirement that all of the materials must be stored in the back of the building, and everything had to be in material trailers.

At this point, the silt fence is still in place, as can be seen on the drawings. There was no site fence installed due to the safe location and the large site. All deliveries are to enter at the main entrance, and follow the loop road towards the right of the building. There is a loading dock accessible for deliveries. The delivery trucks then must leave the site as the owner did not want trucking trailers on the site.

There is a vast parking lot in the back of the building for material trailers. Contractors may use this space for equipment or material, or anything that they want to secure at the end of the day. Material staging is also available inside of the building. The two cafeterias have Masonite board protecting the flooring, allowing both of these large areas to be used.

Work that is taking place in the wings of the building may use the hallways as a staging area. As with the cafeteria, Masonite board is down to protect the flooring. Materials being used can be stored along the wide hallways, providing that they do not block a means of walking up and down the hallways.

The contractor’s trailers along with the owner’s trailer are located at the end of the South East wing. This location provides a great location to allow the contractor to access the building easily, as well as being located near the entrance of the site to provide direction for deliveries.

Please see Appendix C for a diagram of the Site Layout Plan.

Prefabrication: A Study on what needs to be done

Introduction

Prefabrication is a construction technique that can be implemented to some extent on just about any job. Prefabrication involves constructing a portion of a building either off site, or in a different location then its final installation on the building. Prefabrication has many benefits that can be seen on projects with tight schedules and a lot of repetition. There are drawbacks; however these can be minimized with a good design. There are also a lot of misconceptions that surround prefabrication and are holding it back from reaching its full potential. All of these items will be addressed in this report, based on a prefabricated façade system compared to a masonry wall system.

There are many benefits to prefabrication in the construction industry that would be beneficial to all parties involved. When implemented correctly, benefits can be seen in the schedule, cost, quality, and construction waste. The schedule can be reduced due to the fact that work can be completed offsite before that trade would be able to work on site. The cost can be cut with the standardization of the prefabricated elements. The work is also taking place in a controlled environment, allowing efficiency and quality to be maximized. The construction waste can be minimized with prefabrication due to the controlled environment and the standardization of the elements. The minimized waste makes the building construction more sustainable and environmentally friendly, an increasing trend in the industry.

The disadvantages to adopting prefabrication in the construction industry along with misconceptions hold back implementation on more projects. Some of the disadvantages include the fact that it is inflexible for design changes. Once the elements have been constructed, it is difficult to make changes to the design and coordination. Another disadvantage to owners is a perceived is a higher initial cost. Implementation is also held back due to the misconception that prefabricated elements are of a lower quality. The word “prefabrication” lends some to think about trailers and cheaply made elements.

Prefabrication has many advantages, and a few disadvantages, both of which will be covered in this report. The schedule savings and cost savings are only the tip of the iceberg when looking at the benefits of a prefabricated system. This report will look at both benefits and drawbacks for a prefabricated façade system compared to a masonry wall system.

The Issues

Upfront Design and Construction Cost

According to research in "Towards Adoption of Prefabrication in Construction," the initial construction cost is one of the most important reasons that prefabrication is not being implemented. One of the contributors to this is upfront design fees. Major decisions about the building façade need to be made early in the design. Some of these decisions include window openings, door openings, structural connections, and mechanical/electrical penetrations.

In an interview, Tom Seeman stated that "Prefabrication limits the allowable duration and flexibility of the design process since all shell decisions must be made at once and very early in the process." The necessity for major design decisions to be made upfront can result in increased costs later on in design if changes need to be made. These increased costs make owners and architects hesitant to employ a large scale prefabricated design. Deciding to use prefabricated façade panels at the very beginning of design can eliminate the costly changes in the future. Retrofitting a design will result in a largely increased cost.

The design style also requires repeatability, limiting the architect's creativity in design. According to John Barnes of Daniel J. Keating Construction, "it is tough to do custom work. Everything needs to retain some sort of repeatability in order for prefabrication to be economical." The limited design keeps architects from bringing prefabrication to the table at the beginning of design, and keeps owners from thinking about the benefits of the system.

Schedule Impacts

Using a prefabricated façade can reduce the overall schedule of a project by allowing the building façade to become enclosed faster. The prefabricated panels can simply be put in place, connected to the existing structure, and then sealed. According to Ashley Smith at SlenderWall, their precast façade systems can be erected at a rate of 360 linear feet of wall system per day. This speed will significantly reduce the construction time from a typical masonry wall system.

Employing a prefabricated façade system will allow for the wall to be erected in any weather. A masonry wall system requires extra add mixtures and care to be taken when the temperatures drop too low. The prefabricated panels by SlenderWall can be erected in just about any weather, reducing the schedule risks for the contractor.

Following the exterior wall construction, windows can be placed in the wall system almost immediately after the wall panel has been placed. Once all of the windows are installed and sealed, temperature control on the interior of the building can begin. Enclosing the building earlier can be extremely helpful in colder climates where a cold day can bring worker productivity to a standstill. For a project like Wrangle Hill Elementary school, this is a crucial benefit, allowing the interior masonry work to continue regardless of the outside weather.

Another schedule benefit to using precast façade panels instead of a masonry system is the setup time. When the precast panels are ready to be installed, they can be trucked in the very day that they are needed. With a masonry system, the materials need to be sent to site in advance, and distributed throughout the site. The masonry system also requires a scaffolding setup which takes time away from completing the masonry work. No scaffolding is needed for a precast façade system; the panels are tilted in place by a crane, and connected from the ground by workers.

Despite all of the schedule benefits, there are some drawbacks to a precast façade system. Utilizing a precast façade system can put a project schedule at the mercy of the prefabricator. If the prefabricator is delayed in the construction of the panels, there is going to be a schedule delay. As Tom Seeman stated, “If a prefabricator just got awarded that fifty story building, at the same time as your project, there will be a schedule delay. The flexibility of outsourcing is more limited in prefabrication firms.” The single source for prefabricated panels can introduce schedule risks of its own if the prefabricator becomes overloaded. This is different from other trades like structural steel. If a structural steel contractor becomes delayed, outsourcing to a different fabricator is relatively easy.

Quality

“The words "Prefabrication" gives the impression of trailers and/or modular housing. It is viewed as something that one must settle for when they can not afford real construction” –Tom Seeman. This quote explains how many view prefabrication today; however it is a view that seems to be slowly disappearing as more and more projects are being completed. The “assembly line” construction of a prefabricated unit can actually lead to higher quality work, something that many members of industry are starting to realize.

The construction representative for Colonial School District, Steve Hudson realizes the increased quality, and stated in an interview that “Assembly line construction seems to have better quality, and can be delivered on a more dependable basis.” John Barnes, a Project Executive in the Philadelphia area has a very similar idea about prefabrication. He noted that on one project he worked on the quality of the prefabricated elements met the same quality of the work put in place on the jobsite. He had also mentioned that quality control is significantly easier to manage because the workers are all located in one area; supervisors do not have to chase down workers. He stated “Because everything is done in a controlled environment, elements can be made to precision just like with car production.”

Labor Force

The labor force used for prefabricated elements brings another dynamic to construction. When unions have disputes and go on strike, work can stop on a typical jobsite. However, due to the fact that most prefabrication is done with non-union labor work can continue. This can help enable a schedule to stay on track despite strikes. Even though the workforce can be seen as a positive, it also can have negative consequences. In highly areas with highly unionized labor like Philadelphia, the use of prefabrication is very limited. According to John Barnes, unions usually will not allow pre-wired, pre-assembled wall panels to be put in place, especially if the panel was not constructed with union labor.

Reduction in Construction Waste

An issue that is not emphasized as much as a benefit of prefabrication is the reduction of construction waste. With the recent trends like LEED, pushing buildings towards more sustainable design, prefabrication can produce huge benefits. There are LEED credits for diverting waste from landfills and also for re-using materials, both of which are very easy to accomplish with prefabrication. The assembly line construction allows workers to determine how to reduce construction waste, and re-use items that otherwise would have gone right to the dumpster.

The Solution

The ultimate decision to use a prefabricated façade system lies with the owner. It is our job as construction specialists to inform owners of the benefits of a prefabricated system so they can make it clear to architects and designers to look at these systems. As Tom Seeman stated, prefabrication can be optimized if “the owner is showed a prefabricated building that would be similar to his building.” This would help ease the owners preconceived notions of what a building with prefabricated panels would look like. Showing pictures like the one below in Figure 2.1 would help show that prefabricated façade panels don’t have to look prefabricated.

Figure 2.1

Another suggestion from Tom Seeman suggests a great way to aid owners in achieving a building that looks and functions as they would like, without increasing the architect's design cost dramatically. "Since prefabrication is a relatively new thing in the market, the fabricator should offer four weeks of design services for the package." Having prefabricators meet with owners prior to the bidding of a building design can make it clear to the architects that the owner wants a building that includes prefabricated building elements from X Company. This is how many successful prefabricated designs have begun, such as the Chester County parking garage that Tom Seeman was in charge of. Bringing in the prefabricator designers early in the design stage of a building can help mitigate the extra design fees and or construction costs with changes later in design.

As it Relates to Wrangle Hill Elementary School

SlenderWall panels were proposed to be used on Wrangle Hill Elementary School primarily for the schedule benefits. The school was under a very tough schedule and the contractor was looking for any possible way to save time. The existing design is a hand laid brick façade with a concrete masonry unit backup. The system is non load bearing and simply rests on the slab on grade floor system. SlenderWall panels would fit in very similar to a masonry system, yet would erect much quicker then a masonry wall. The schedule savings could help reduce the burden on the construction manager and potentially reduce increased fees due to the original risk.

It was important to contact the owner, Colonial School District in order to determine why a prefabricated system was not looked into in the initial design. When prefabrication was mentioned to Steve Hudson, the construction representative, he stated that the main reason that the school had not looked into prefabrication was money. He stated that due to the school being financed by public money, it can be difficult for the school district to have the increased money flow at a beginning of a project using prefabrication. He also mentioned that the architect's fee would have been increased due to the upfront engineering involved in using a prefabricated system. Clearly something needs to be done to provide the public projects with an easier method of using prefabrication.

Tom Seeman suggested an idea that would help Colonial School District get a step closer to using prefabrication in their buildings. He said that "since prefabrication is a relatively new thing in the market, the fabricator should offer four weeks of design services for the package." This would help to reduce the architect's fee and create a well rounded design with the new prefabricated panels. The issue of money flow at the beginning of a project needs to be addressed as well. Delays in the funds for the panels would result in a delay on the project schedule. Having the fabricator aid with design services could also help this situation. The fabricator could help provide a billing schedule to the owner prior to construction even beginning. This would allow the school district to appropriate the required funds on time.

The schedule benefits from using a prefabricated system on Wrangle Hill Elementary School have been reported in the following section. It is definite that using SlenderWalls will reduce the schedule and provide the contractor with a slightly relaxed schedule to deal with. Bringing on the prefabricator early in the design phase would aid Colonial School District. The prefabricator would be able to work with the architect to change the design to include the new panels. It is also hoped that the prefabricator would be able to provide the owner with a preliminary billing schedule to prepare the school district for future billings. These suggestions should help Wrangle Hill Elementary School become a more successful project.

Future Research

There are many benefits and drawbacks to a prefabricated system, determining the extent to which some of the proposed solutions would help is essential. One of the major factors that deterred Colonial School District from pursuing prefabrication was cash flow. The suggestion of bringing a prefabricator into the design at the beginning of the design seems like a great solution. Research could be completed to determine if bringing the prefabricator into design early on will actually affect design fees.

References

Tom Seeman, Project Manager, Norwood Construction

John Barnes, Project Executive, Daniel J. Keating Construction

Mike Dooley, Project Manager, Daniel J. Keating Construction

Andy Hickey, Project Manager, EDiS

Steve Hudson, Construction Representative, Colonial School District

Tim Skibicki, Architect, Tetra Tech

Ashley Smith, VP of Sales, SlenderWall

Tam, Vivian, “Towards Adoption of Prefabrication in Construction,” Science Direct, 11 October, 2006.

Prefabrication: Construction Management Issues at Wrangle Hill

Problem

Wrangle Hill Elementary School is under a tight schedule with extreme penalties of $10,000 per day if the project is not delivered on time. The construction managers have made it clear that any method to save time on the construction of this school would be worth the extra cost, within reason.

Solution

Prefabrication is not being implemented on projects even when it would be the most economical and feasible way to construct the building. Wrangle Hill Elementary School is no exception to this. Wrangle Hill Elementary School is a very large school that is extremely repetitive. The classroom spaces are just about all identical and there are four different wings which are all exactly the same as one another. I have proposed to use a prefabricated exterior wall on Wrangle Hill Elementary School in hopes to reduce the project schedule. The wall panels that will be used are made and erected by SlenderWall.

Methodology

The project schedule will be examined and modified in order to accommodate the new SlenderWall panels for the four wings of the building. A cost analysis will also be performed in order to determine any increases or savings with switching to the new system. If the new system costs too much, it would not be feasible, but if it within reason, it would be an option to explore further.

Resources and Tools

Ashley B. Smith, VP Sales, SlenderWall
Microsoft Project
Microsoft Excel
R.S. Means 2007

Schedule Impacts

The main purpose behind switching the façade system to a prefabricated system was to save time on the schedule. After analyzing the schedule, it was clear that the exterior masonry construction was on the critical path for each of the wings. Switching to the quicker prefabricated system would yield a much quicker construction time. After speaking with a representative from SlenderWall, Ashley Smith, it was determined that the prefabricated panels could be installed within three days per wing, being followed by the caulking sealants between each panel.

Figure 3.1

Schedule Item	Prefabricated Start Date	Masonry Start Date
Concrete Foundations	6/12	6/12
Slab on Grade	7/6	7/6
Structural Steel	7/14	7/14
Prefabricated Panels	8/3	-
CMU Backup	-	8/3
Brick	-	8/16
Standing Seam Metal Roof	8/28	9/7
Windows	8/10	9/13
Temp. Heat and Conditioning	9/5	10/9

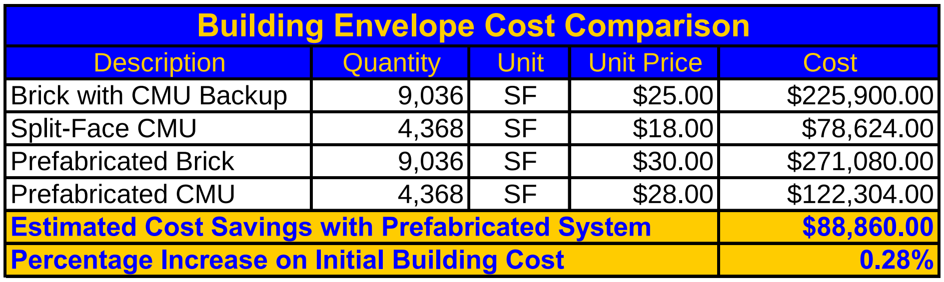
As can be seen above in Figure 3.1, the schedule savings can potentially be huge for the project. The above schedule is only for the first of the wings to be completed, wings that will be completed later in the winter will see a more significant benefit due to the interior spaces being heated. This not only will reduce the overall schedule for the entire project but it will also reduce the weather related risks in the project, likely reducing the general contractors overall fee. The reduction of the construction time for the first wing was found to be 34 days. After analyzing the intial project schedule, this reduction is carried through the entire project, but no additional days are saved during separate wings. This savings will make a large difference however, as the substantial completion date has moved from July 15th, to June 11th. This savings is huge, and will give the contractor more time to complete other items, including the punch list.

Please see Appendix D for a detailed schedule of a typical wing.

Cost Impacts

Prefabricated façade panels can introduce changes in the construction cost, determining the quantity of these changes is important in order to make an informed decision. As can be seen below, in Figure 3.2, the new prefabricated system will cost more then the existing masonry design. A cost comparison was performed for the building wings, as these are the most repetitive, and consume the most time on the project schedule.

Figure 3.2



Building Envelope Cost Comparison

Description	Quantity	Unit	Unit Price	Cost
Brick with CMU Backup	9,036	SF	$25.00	$225,900.00
Split-Face CMU	4,368	SF	$18.00	$78,624.00
Prefabricated Brick	9,036	SF	$30.00	$271,080.00
Prefabricated CMU	4,368	SF	$28.00	$122,304.00
Estimated Cost Savings with Prefabricated System				**$88,860.00**
Percentage Increase on Initial Building Cost				**0.28%**

The overall cost differential between the prefabricated panels and the existing masonry design is very minimal. There is a 29 percent increase in the cost of the façade, however only a 0.28 percent increase in the overall building cost of $32.1 million.

Conclusion and Recommendation

The schedule benefits from switching to a prefabricated system are apparent. The general contractor, EDiS, stated that the project had such a demanding schedule; something should be done to reduce the construction time. With the interior spaces of the wings being heated over a month earlier with the new prefabricated system, it seems as though it would be the route to follow. The cost increases are very minimal and the schedule increases are generous. The reduced risk in the project schedule could also reduce the general contractors overhead enough to offset the additional cost of the prefabricated system.

I believe that the prefabricated SlenderWall panels should be introduced to the design of Wrangle Hill Elementary or other similar schools in the future.

Mechanical Analysis of a Prefabricated Wall Panel (Breadth Study)

Problem

The existing design for the building envelope is made a hand laid masonry cavity wall system. This design remains consistent with other schools located within Colonial School District and continues the masonry aesthetic. Wrangle Hill Elementary School has a very strict schedule, placing the contractor under a serious deadline, potentially reducing quality and/or increasing the cost.

Solution

I have recommended the use of SlenderWall panels. SlenderWall panels incorporate a steel stud wall system with a precast concrete cladding with a brick reproduction finish. Due to the fact that the prefabricated panels incorporate a steel stud wall, a mechanical analysis is necessary to ensure that the switch will not affect the heating and cooling loads.

Methodology

A U-Value analysis was performed on both the existing masonry design as well as the suggested new SlenderWall panels. The analysis was simplified to simply a comparison of the wall systems, instead of including the windows. The change will not have any impact on the window panels, or any other part of the building enclosure.

A dew point analysis was performed in order to ensure that condensation will not be a problem. Metal stud walls are notorious for creating condensation which will lead to mold problems in the future. The condensation is formed because the metal stud walls are at such a low temperature in the winter time that it is lower then the dew point of the interior air. Condensation is also introduced from vapor pressures formed as water diffuses through the envelope system. Ensuring that this will not be an issue is imperative.

Resources and Tools

SlenderWall Panels

- www.slenderwall.com
- Ashley B. Smith, Vice President of Sales and Marketing

Mechanical Analysis and Calculations

- Andreas Phelps, Graduate Student
- Avoiding Thermal Bridging and Moisture Problems in BVSS Wall Design, James B. Posey, www.buildingenvelopeforum.com.
- www.npga.org

Calculations

- Microsoft Excel
- ASHRAE Psychrometric Chart

Energy Transfer Impacts

Please see Appendix E for detailed mechanical calculations.

Existing Conditions

The existing design is a hand laid masonry cavity wall system, consisting of 4” face brick, polystyrene insulation and 8” CMU backup. The existing wall was intended to be a mass wall, the main insulation values from the wall came from the 2” of polystyrene insulation.

A U-Value analysis was performed on the wall for both summer and winter conditions. Brief results are included below for a typical classroom exterior wall. As can be seen in Figure 4.1 the energy transfer through the wall results in a cost of approximately $32.53 for the entire year.

Figure 4.1

Calculation Results		
Average R-Value	12.8	hr*ft^2°F/ Btu
Overall Heat Flow Rate	787.6	Btu / hr

Annual Heating and Cooling Energy Losses			
Cooling (Summer)		386,636	Btu/Yr
Heating (Winter)		1,679,889	Btu/Yr
Total		2,066,524	Btu/Year

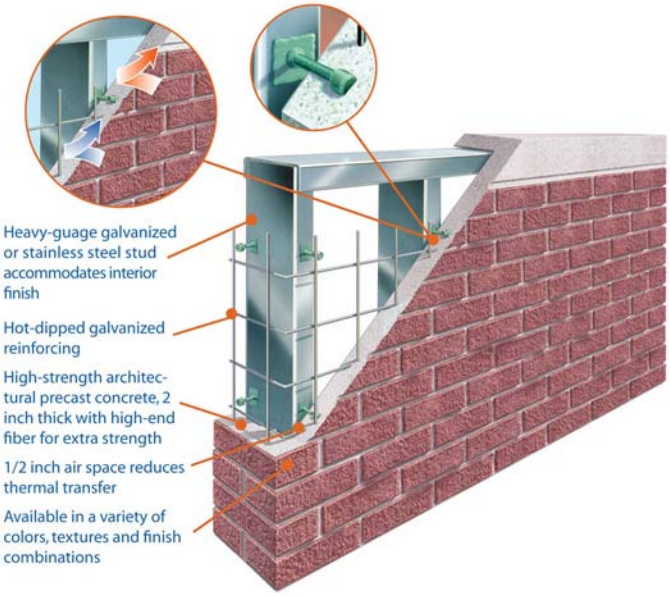
Energy Cost	**$32.53**

Prefabricated Design

The prefabricated design consists of 2" of precast concrete, an air gap, metal studs in filled with insulation, and gypsum board on the interior of the wall. This system provides a decent insulation value, a slight improvement from the existing masonry design, however there are some drawbacks. Due to the use of metal stud framing, thermal bridging has been created making thermal calculations difficult. This has been accounted for by assuming that metal studs will make up 30% of the wall by area, when this is obviously not the case due to how thin the studs are. There is also a concern for condensation as will be analyzed in the Dew Point Analysis further in this report.

Figure 4.2 below illustrates the SlenderWall panel construction. SlenderWall uses an epoxy coated metal anchor which holds the precast concrete, which eliminates thermal bridging from the precast concrete to the metal studs. For this analysis I have taken this into account, and will treat the ½" air space as simply an air space, without the metal anchor.

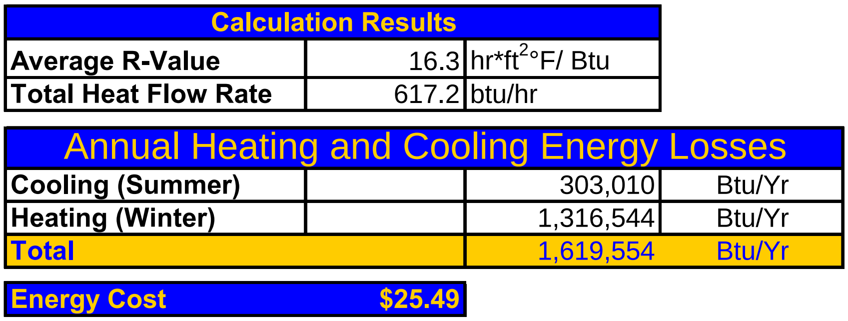
Figure 4.2



(Image courtesy of SlenderWall)

An R-Value analysis was performed on the wall, details can be seen in Appendix E. Brief results are included below for a typical classroom exterior wall. As can be seen in Figure 4.3 the energy transfer through the wall results in a cost of approximately $27.10 for the entire year. This value is slightly lower then the existing design, showing a savings in operating costs.

Figure 4.3



Calculation Results		
Average R-Value	16.3	hr*ft^2°F/ Btu
Total Heat Flow Rate	617.2	btu/hr

Annual Heating and Cooling Energy Losses			
Cooling (Summer)		303,010	Btu/Yr
Heating (Winter)		1,316,544	Btu/Yr
Total		1,619,554	Btu/Yr

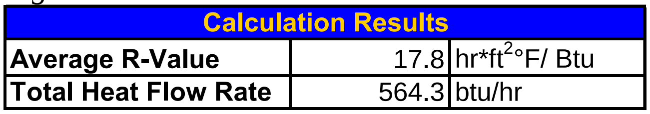
Energy Cost	**$25.49**

Prefabricated Design with Insulation

The prefabricated design with insulation is identical to the prefabricated design; however the air gap seen in Figure 4.2 above will be replaced with ½" insulation. This will significantly increase the temperature of the metal studs and reduce if not eliminate the potential for condensation. This measure will also reduce the effects of thermal bridging due to the metal studs. This change can be made, at a small price if it is deemed necessary.

An R-Value analysis was performed on the wall, details can be seen in Appendix E. Brief results are included below for a typical classroom exterior wall. As can be seen in Figure 4.4 the energy transfer through the wall results in a cost of approximately $23.31 for the entire year. This value is significantly lower then the existing masonry design, indicating a large savings when adjusted for the entire building.

Figure 4.4



Calculation Results		
Average R-Value	17.8	hr*ft^2°F/ Btu
Total Heat Flow Rate	564.3	btu/hr

Annual Heating and Cooling Energy Losses			
Cooling (Summer)		277,018	Btu/Yr
Heating (Winter)		1,203,612	Btu/Yr
Total		1,480,629	Btu/Yr

Energy Cost	**$23.31**

Condensation Analysis

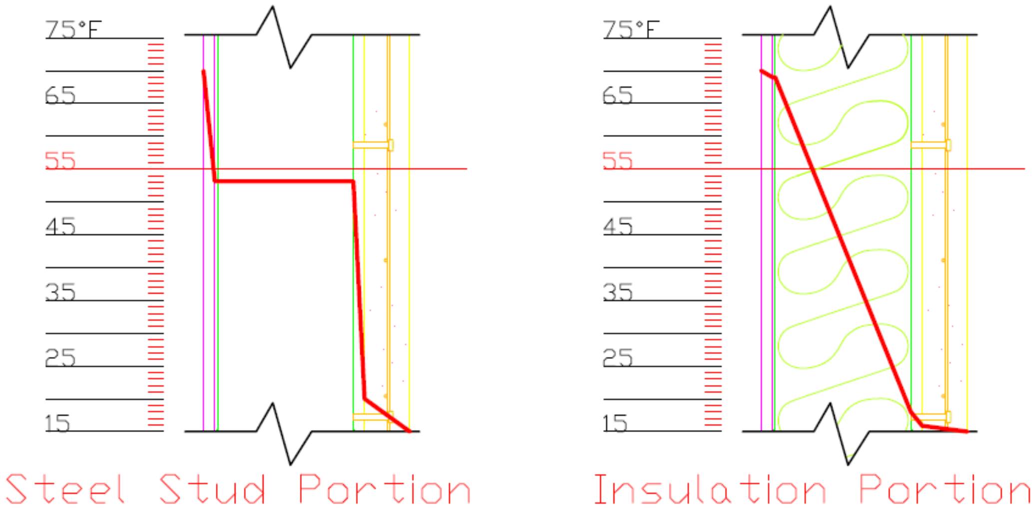
Please see Appendix E for detailed mechanical calculations.

Due to the use of metal stud framing, a dew point analysis is essential to determine the risks for condensation within the wall system. The metal studs will reach all the way in to the gypsum board, and moisture in the air touching the metal studs will condense if the temperature of the stud is too low. As stated above, two different prefabricated systems will be analyzed to determine which should be employed in this situation.

For the dew point analysis, some assumptions had to be made for the internal air temperature and the temperature difference across the wall. A 70°F internal air temperature with a 50% relative humidity was assumed. Using this data on the ASHRAE Psychrometric Chart, the dew point for this air condition is approximately 55°F which is highlighted by the horizontal red line in Figures 4.5 and 4.6 below. If the metal studs reach a temperature lower then 55°F, there is a potential for condensation and future mold problems.

Design without Additional Insulation

Figure 4.5



Design with Additional ½" of Insulation

Figure 4.6

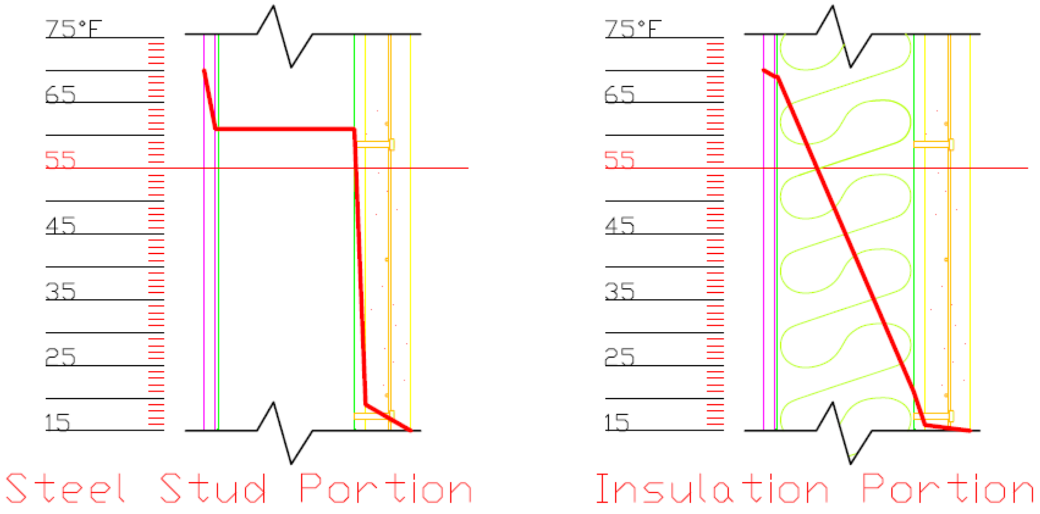


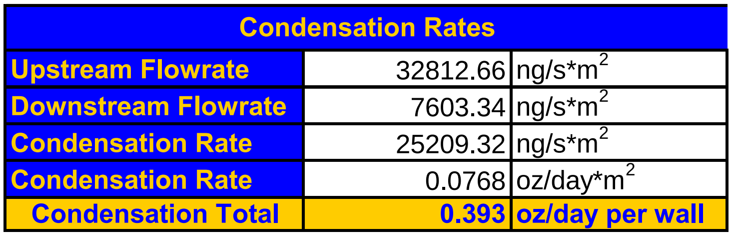
Figure 4.7

Temperature Comparison		
	Temperature of Metal Studs	Dew Point
Design Without Insulation	53.9	55.0 °F
Design With Insulation	61.7	55.0 °F

As can be seen in the temperature comparison in Figure 4.7 above, the initial prefabricated panel design without the ½" of extra insulation will have a risk for condensation. The temperature of 53.8°F is below the dew point and any interior air that seems through a crack in the drywall will cause immediate condensation on the studs. Due to this it will be imperative to add the extra insulation to these prefabricated panels.

As can be seen above in figure 4.7, the dew point temperature will be reached within the fiberglass insulation. Calculating the vapor flow throughout each element in the wall system will provide information regarding where the condensation will occur, and how much. If the amount of condensation is low enough, it can be assumed that within a few temperature cycles the condensation will have the chance to evaporate and eliminate any risk of mold. The condensation calculations have been performed for the wall system with the extra ½" of insulation.

Figure 4.8



Condensation Rates		
Upstream Flowrate	32812.66	$ng/s*m^2$
Downstream Flowrate	7603.34	$ng/s*m^2$
Condensation Rate	25209.32	$ng/s*m^2$
Condensation Rate	0.0768	$oz/day*m^2$
Condensation Total	**0.393**	**oz/day per wall**

The results of the condensation calculations can be seen above in Figure 4.8. The detailed calculations can be seen in Appendix E. The calculations show that in a 183 square foot wall, there is only .4 ounces of water condensing. The condensation would occur between the board insulation and the fiberglass insulation. This is such a low quantity it can be assumed that the condensation will evaporate within just a few days when the exterior temperature changes.

Conclusion and Recommendation

After analyzing the three proposed systems, the modified prefabricated panel has the best performance and will aid in reducing the cost spent heating and cooling the school. Adding the half inch of insulation in between the precast concrete and the metal stud walls greatly reduced the effect of thermal bridging, as well as reduced the quantity of condensation in the wall system. From a purely mechanical standpoint the modified prefabricated wall performs better then the existing design and should be pursued.

Integration of a Photovoltaic System

(Breadth Study)

Problem

Escalating fuel prices are driving up the price of electricity. Everyone is affected by the rising cost of electricity, and starting to look towards renewable sources of energy, solar power being one of the up and coming new systems. A statement needs to be made in the community to make it known to the residents that the schools are doing something good for the environment.

Solution

Adding a set of photovoltaics to the roof of Wrangle Hill Elementary School would be beneficial to the community, as well as help to reduce the electric demand from the school. Due to the orientation of the school, the roof over the multipurpose room would be ideal for southern exposure. This would allow the panels to be visible from the entrance of the school as well as the main road that runs in front of the school, allowing the photovoltaic to be showcased for the community. The elementary school students can learn about the benefits of the photovoltaic system in science classes and help to inform every one of the benefits.

Methodology

The first step in determining the feasibility of adding a photovoltaic system to the school is to pick out a system that would work with the standing seam metal roof. There are many different companies that manufacture photovoltaic panels that integrate with a standing seam metal roof; however, I chose to use Uni-Solar products due to the fact that they can be put on at the time of construction or as a retrofit later on if the school can't afford the money at the time of construction. The Uni-Solar products I have chosen to use are the PVL-136 and PVL-124. These products are solar laminates that are simply laid on top of the existing standing seam metal roof. Due to the area I have chosen for the solar panels an array of 80 PVL-136 panels, 40 wide by 2 panels deep, can fit on the roof. I also determined that there was a section of the roof over the north east classroom wing which could hold 80 PVL-124 panels if the school wished to increase the solar power output.

The second step in this study was to determine the actual output that would be generated by these panels. For this information, I used a photovoltaic system performance calculator provided by the National Renewable Energy Laboratory entitled PVWatts. This calculator analyzed the location of the school, orientation of the building, slope of the roof, size of the roof panels, de-rating for the power inverters, and weather data for the school. This calculator provided approximate cost savings per year for the addition of the solar panels.

Now that the savings per year data has been calculated, I needed to determine if there were any federal and state rebates available for installing such a system. I determined that there is a 30% federal rebate, as well as a 50% state rebate for total cost of the installation of a photovoltaic system. This significantly reduced the cost of the system to the owner. I then took the total cost, and savings per year and calculated how long it would take for the system to pay itself off.

Resources and Tools

Solar Panel Data and Information
    http://www.uni-solar.com/
Inverter and Array Sizing
    http://www.xantrex.com/support/gtsizing/index.asp?lang=eng#calculator
Photovoltaic System Performance Calculator
    http://rredc.nrel.gov/solar/codes_algs/PVWATTS/
Solar Panel Details and Pricing Information
    http://preview.inovateus.com/
Delaware State Incentive Information
    http://www.delaware-energy.com/
Microsoft Excel

Products Chosen

Solar Panels

Uni-Solar PVL-136	Uni-Solar PVL-124
136 Watts/Panel	124 Watts/Panel
216” x 15.5”	197.1” x 15.5”
33 Vac Max	30 Vac Max
4.1 Aac Max	4.1 Aac Max

Inverter

SatCon PowerGate AE50-60PV-A

Max DC Amps: 160Adc

Max DC Volts: 600Vdc

Volt Output: 480 Vac

Architectural Implications

While the installation of the solar panels will have minimal effects on the aesthetics of the school, they must be examined. A picture of the existing school has been edited in order to include the proposed photovoltaics.

Before

After

As can be seen from these simple photos, the addition of the photovoltaic system will have minimal effects on the aesthetics of the school entrance. The addition of these will make a statement to everyone who enters the school.

Calculations

Please see Appendix F for detailed photovoltaic calculations.

Energy Produced

Calculating the output of the system throughout the year is crucial. PVWatts was used to calculate the effective energy produced by the solar array throughout the entire year. PVWatts uses hourly Typical Meteorological Year weather data for a given location in order to provide energy produced throughout the year. Figure 5.1 below includes information from the analysis provided by PVWatts regarding the cost savings for the energy produced.

Figure 5.1

Energy Analysis per Year

Array	kWh Produced	Energy Cost	Total Energy Savings
Multipurpose Room	26116	10 ¢/kWh	$2,612
NE Wing	23721	10 ¢/kWh	$2,372

Cost Impacts

A cost analysis was performed in order to determine the amount of years it would take for the proposed solar array to pay itself off. This calculation includes a rebate from the state of Delaware as well as from the Federal Government for the purchase of the system. As can be seen in Figure 5.2, it will take approximately 10 years after the rebates in order for the systems to be paid off. This is a long time; however for an elementary school which is going to be around for many years to come this would start generating money for the school after the first ten years. This calculation did not incorporate inflation due to the nature of the funds generated by the school. The funds to pay for the school were raised from taxes which will rise along with the inflation rate.

Figure 5.2

Cost Comparison

	Multipurpose Room	NE Wing
Number of Panels	160	160
Cost per panel	$563.00	$521.00
Panel Type	PVL-136	PVL-124
Voltage per panel	136 W	124 W
Inverter Costs	$22,500	$22,500
Total System Cost	$112,580	$105,860
DE State Grant	$56,290	$52,930
Federal Tax Credit	$33,774	$31,758
Total Cost of System	$22,516	$21,172
Annual Savings	$2,612	$2,372
Years to Pay Off	8.6	8.9

Conclusion and Recommendation

In conclusion this system does not seem to generate a significant amount of electricity; however, the benefits from including a photovoltaic system on the elementary school far exceed just an energy savings. The school district would be emphasizing to the community that they are dedicated to using natural resources for power. The students would also have the ability of seeing and learning about a system in place on the very school they attend. The benefits of this are hard to estimate; however they will extend far into the future as generations pass through the school with a new understanding of natural resources.

From an economic basis, the photovoltaic panels are not a great investment; however they could have a much greater impact on the residents of the area and the students. Further research would need to be done to determine these benefits and comparing them to the additional costs. At this time it is not a beneficial improvement, however the building can be retrofitted with these panels at any time.

Conclusions

This thesis has analyzed prefabrication in the construction industry and how it relates to Wrangle Hill Elementary School. The adoption of a prefabricated façade system would yield a significant schedule savings of approximately 34 days. The reduction of the schedule will aid the contractor in providing a higher quality, more complete building to the owner when required. It helps the contractor to avoid the huge $10,000 per day liquidated damages if the schedule is delayed in the slightest. The extra cost for the prefabricated panels was so low it could almost be ignored.

The mechanical analysis showed that the new prefabricated system actually out performed the intial masonry design, and had little to no condensation occurring throughout the wall. From a mechanical standpoint, the prefabricated design was superior and should be used.

The photovoltaic system did not prove to yield large cost savings in the electricity bill. The system could have other impacts on the community and on each of the students; however that would need to be researched further. From an economical standpoint, the panels would pay themselves off in approximately 9 years, at which point they would start saving the school money.

The thesis analyzed multiple different methods of making the construction of Wrangle Hill more efficient, with more efficient building materials. The photovoltaics even took the efficiency to a new level, having the building create its own power.

Appendix A
General Conditions Estimate

General Conditions Estimate

Wrangle Hill Elementary School
New Castle, DE

Schedule:	14 Months
Approximate Budget:	$29,767,000
Building Size	60,000 SF

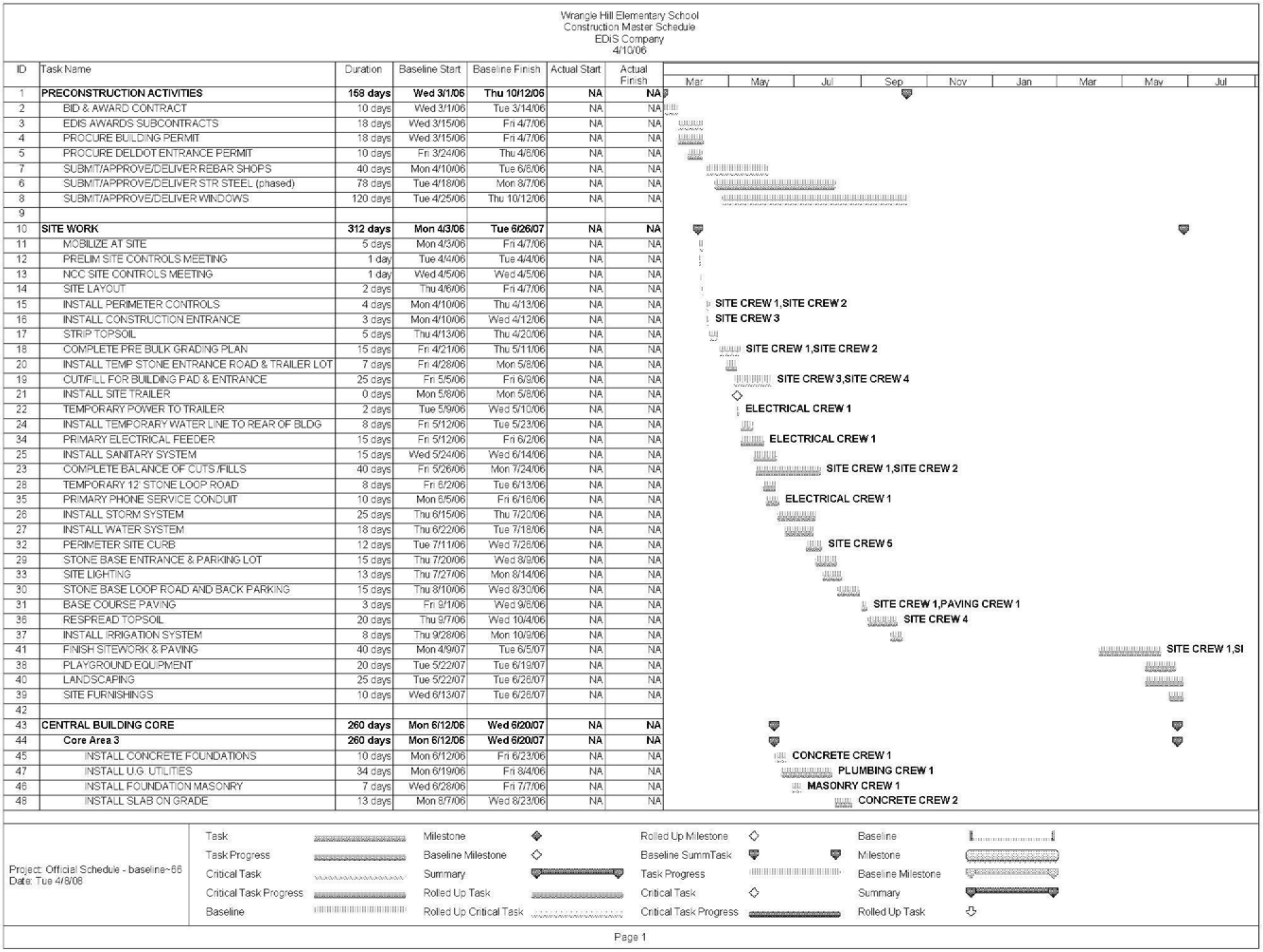
Items		Total Cost
Tools and Miscellaneous Supplies		$1,000
Safety and Protection Supplies		$15,000
Scaffolding and Shoring	By Trade	-
Material Hoists and Lifts	By Trade	-
Cleaning and Dumpsters		$10,000
Jobsite Identification and Signs		$1,000
Jobsite Fence, Gates, and Locks		$6,000
Temporary Heat, Water, Electricity, and Phone		$60,000
Temporary Toilets		$9,000
Jobsite and Building Progress Photos		$2,000
Temporary Roads	By Trade	-
Jobsite Trailers and Office		$18,900
Office Supplies, Equipment and Furniture		$25,000
Building and Site Surveys		$12,000
Budget and Schedule Maintainence		$5,000
Project Staff - Base		$508,480
Project Staff - Fringes and Benefits		$203,392
Blueprint Copying and Shipping		$33,000
Relocation and Travel		$15,000
Building Permits	By Owner	-
General Liability Insurance		$148,835
Workers Compensation		$66,000
Builders Risk Insurance	By Owner	-
Auto/Employers Liability Insurance		$20,000
Bonds and Surety		$208,369
Tax		$1,761
Item Sub-Total		$1,369,737
Fee	**5%**	$1,488,350
Total General Conditions Estimate		**$2,858,087**

Projected Staff Monitor

Wrangle Hill Elementary School
New Castle, DE

Months of Construction	PC1	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Vice President	10%	10%	10%	10%											
Director of Pre-Construction	25%														
Estimator	100%	50%	25%												
Project Executive	25%	25%	25%	25%	25%	10%	10%	10%							
Senior Project Manager	25%	50%	50%	50%	50%	50%	50%	50%	50%	50%	25%	25%	25%	25%	25%
Project Manager		50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Project Engineer		50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Superintendent	10%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Assistant Superintendent		50%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	50%	50%

Appendix B
Project Schedule



Wrangle Hill Elementary School
Construction Master Schedule
EDiS Company
4/10/06

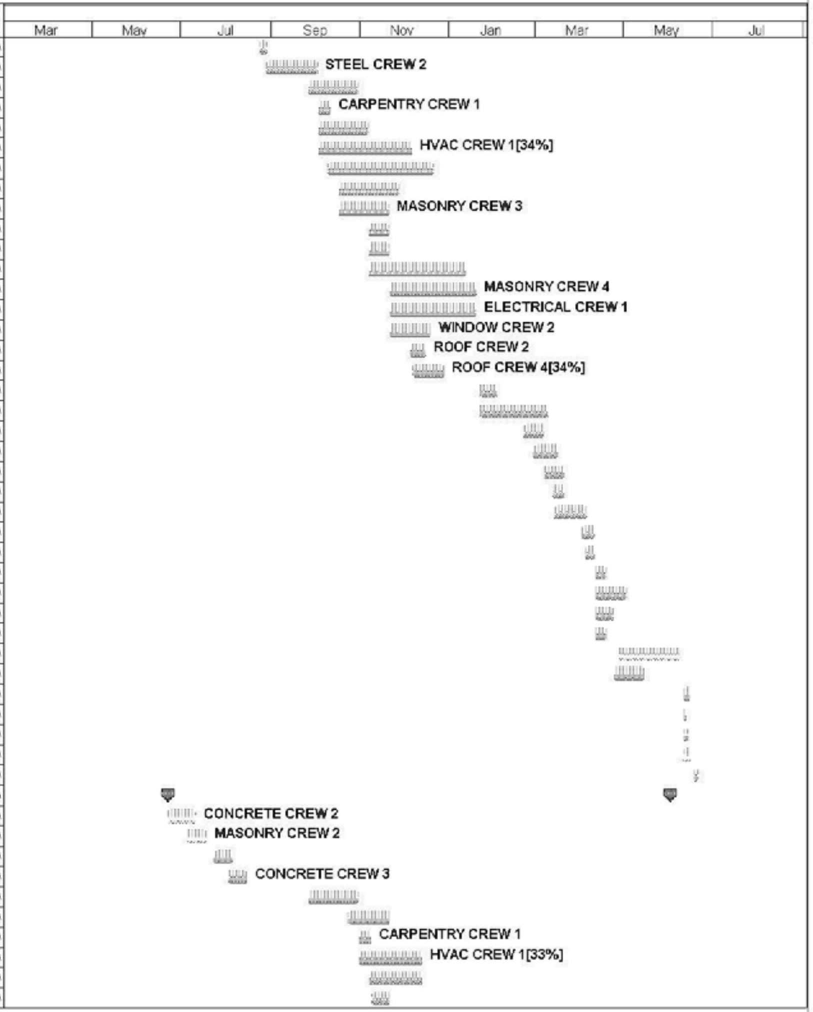
ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
1	**PRECONSTRUCTION ACTIVITIES**	**158 days**	**Wed 3/1/06**	**Thu 10/12/06**	**NA**	**NA**
2	BID & AWARD CONTRACT	10 days	Wed 3/1/06	Tue 3/14/06	NA	NA
3	EDIS AWARDS SUBCONTRACTS	18 days	Wed 3/15/06	Fri 4/7/06	NA	NA
4	PROCURE BUILDING PERMIT	18 days	Wed 3/15/06	Fri 4/7/06	NA	NA
5	PROCURE DELDOT ENTRANCE PERMIT	10 days	Fri 3/24/06	Thu 4/6/06	NA	NA
7	SUBMIT/APPROVE/DELIVER REBAR SHOPS	40 days	Mon 4/10/06	Tue 6/6/06	NA	NA
6	SUBMIT/APPROVE/DELIVER STR STEEL (phased)	78 days	Tue 4/18/06	Mon 8/7/06	NA	NA
8	SUBMIT/APPROVE/DELIVER WINDOWS	120 days	Tue 4/25/06	Thu 10/12/06	NA	NA
9						
10	**SITE WORK**	**312 days**	**Mon 4/3/06**	**Tue 6/26/07**	**NA**	**NA**
11	MOBILIZE AT SITE	5 days	Mon 4/3/06	Fri 4/7/06	NA	NA
12	PRELIM SITE CONTROLS MEETING	1 day	Tue 4/4/06	Tue 4/4/06	NA	NA
13	NCC SITE CONTROLS MEETING	1 day	Wed 4/5/06	Wed 4/5/06	NA	NA
14	SITE LAYOUT	2 days	Thu 4/6/06	Fri 4/7/06	NA	NA
15	INSTALL PERIMETER CONTROLS	4 days	Mon 4/10/06	Thu 4/13/06	NA	NA
16	INSTALL CONSTRUCTION ENTRANCE	3 days	Mon 4/10/06	Wed 4/12/06	NA	NA
17	STRIP TOPSOIL	5 days	Thu 4/13/06	Thu 4/20/06	NA	NA
18	COMPLETE PRE BULK GRADING PLAN	15 days	Fri 4/21/06	Thu 5/11/06	NA	NA
20	INSTALL TEMP STONE ENTRANCE ROAD & TRAILER LOT	7 days	Fri 4/28/06	Mon 5/8/06	NA	NA
19	CUT/FILL FOR BUILDING PAD & ENTRANCE	25 days	Fri 5/5/06	Fri 6/9/06	NA	NA
21	INSTALL SITE TRAILER	0 days	Mon 5/8/06	Mon 5/8/06	NA	NA
22	TEMPORARY POWER TO TRAILER	2 days	Tue 5/9/06	Wed 5/10/06	NA	NA
24	INSTALL TEMPORARY WATER LINE TO REAR OF BLDG	8 days	Fri 5/12/06	Tue 5/23/06	NA	NA
34	PRIMARY ELECTRICAL FEEDER	15 days	Fri 5/12/06	Fri 6/2/06	NA	NA
25	INSTALL SANITARY SYSTEM	15 days	Wed 5/24/06	Wed 6/14/06	NA	NA
23	COMPLETE BALANCE OF CUTS /FILLS	40 days	Fri 5/26/06	Mon 7/24/06	NA	NA
28	TEMPORARY 12' STONE LOOP ROAD	8 days	Fri 6/2/06	Tue 6/13/06	NA	NA
35	PRIMARY PHONE SERVICE CONDUIT	10 days	Mon 6/5/06	Fri 6/16/06	NA	NA
26	INSTALL STORM SYSTEM	25 days	Thu 6/15/06	Thu 7/20/06	NA	NA
27	INSTALL WATER SYSTEM	18 days	Thu 6/22/06	Tue 7/18/06	NA	NA
32	PERIMETER SITE CURB	12 days	Tue 7/11/06	Wed 7/26/06	NA	NA
29	STONE BASE ENTRANCE & PARKING LOT	15 days	Thu 7/20/06	Wed 8/9/06	NA	NA
33	SITE LIGHTING	13 days	Thu 7/27/06	Mon 8/14/06	NA	NA
30	STONE BASE LOOP ROAD AND BACK PARKING	15 days	Thu 8/10/06	Wed 8/30/06	NA	NA
31	BASE COURSE PAVING	3 days	Fri 9/1/06	Wed 9/6/06	NA	NA
36	RESPREAD TOPSOIL	20 days	Thu 9/7/06	Wed 10/4/06	NA	NA
37	INSTALL IRRIGATION SYSTEM	8 days	Thu 9/28/06	Mon 10/9/06	NA	NA
41	FINISH SITEWORK & PAVING	40 days	Mon 4/9/07	Tue 6/5/07	NA	NA
38	PLAYGROUND EQUIPMENT	20 days	Tue 5/22/07	Tue 6/19/07	NA	NA
40	LANDSCAPING	25 days	Tue 5/22/07	Tue 6/26/07	NA	NA
39	SITE FURNISHINGS	10 days	Wed 6/13/07	Tue 6/26/07	NA	NA
42						
43	**CENTRAL BUILDING CORE**	**260 days**	**Mon 6/12/06**	**Wed 6/20/07**	**NA**	**NA**
44	**Core Area 3**	**260 days**	**Mon 6/12/06**	**Wed 6/20/07**	**NA**	**NA**
45	INSTALL CONCRETE FOUNDATIONS	10 days	Mon 6/12/06	Fri 6/23/06	NA	NA
47	INSTALL U.G. UTILITIES	34 days	Mon 6/19/06	Fri 8/4/06	NA	NA
46	INSTALL FOUNDATION MASONRY	7 days	Wed 6/28/06	Fri 7/7/06	NA	NA
48	INSTALL SLAB ON GRADE	13 days	Mon 8/7/06	Wed 8/23/06	NA	NA

Project: Official Schedule - baseline~66
Date: Tue 4/8/08

Page 1

Wrangle Hill Elementary School
Construction Master Schedule
EDiS Company
4/10/06

ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
60	INSTALL OIL TANKS	3 days	Thu 8/24/06	Mon 8/28/06	NA	NA
49	ERECT STRUCTURAL STEEL	25 days	Mon 8/28/06	Mon 10/2/06	NA	NA
50	PERIMETER CMU BACK-UP	25 days	Tue 9/26/06	Mon 10/30/06	NA	NA
54	INSTALL BLOCKING FOR FASCIA	7 days	Tue 10/3/06	Wed 10/11/06	NA	NA
58	INSTALL FLAT ROOF BASE SHEET	25 days	Tue 10/3/06	Mon 11/6/06	NA	NA
65	ROUGH IN HVAC DUCT	45 days	Tue 10/3/06	Wed 12/6/06	NA	NA
64	ROUGH IN MECHANICAL PIPING	50 days	Tue 10/10/06	Wed 12/20/06	NA	NA
67	ROUGH IN SPRINKLER	28 days	Tue 10/17/06	Mon 11/27/06	NA	NA
51	PERIMETER FACE BRICK	25 days	Tue 10/17/06	Mon 11/20/06	NA	NA
55	INSTALL MECHANICAL UNITS	10 days	Tue 11/7/06	Mon 11/20/06	NA	NA
56	INSTALL BOILERS	10 days	Tue 11/7/06	Mon 11/20/06	NA	NA
66	ROUGH IN PLUMBING	45 days	Tue 11/7/06	Fri 1/12/07	NA	NA
52	INTERIOR MASONRY	40 days	Tue 11/21/06	Fri 1/19/07	NA	NA
62	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	40 days	Tue 11/21/06	Fri 1/19/07	NA	NA
61	INSTALL WINDOWS	19 days	Tue 11/21/06	Tue 12/19/06	NA	NA
57	INSTALL ROOF FASCIA	9 days	Tue 12/5/06	Fri 12/15/06	NA	NA
59	INSTALL FLAT ROOF FINISH PRODUCT	15 days	Thu 12/7/06	Thu 12/28/06	NA	NA
53	METAL STUDS & DRYWALL	10 days	Mon 1/22/07	Fri 2/2/07	NA	NA
63	ROUGH IN ELECTRICAL SYSTEMS	35 days	Mon 1/22/07	Fri 3/9/07	NA	NA
68	1ST COAT PAINT	10 days	Wed 2/21/07	Tue 3/6/07	NA	NA
69	ACOUSTIC CEILING GRID	13 days	Wed 2/28/07	Fri 3/16/07	NA	NA
85	LIGHTS	10 days	Wed 3/7/07	Tue 3/20/07	NA	NA
84	GRILLES REGISTERS DIFFUSERS	6 days	Tue 3/13/07	Tue 3/20/07	NA	NA
70	FINISH PAINT	17 days	Wed 3/14/07	Thu 4/5/07	NA	NA
82	ACOUSTIC CEILING TILES	7 days	Mon 4/2/07	Tue 4/10/07	NA	NA
71	CASEWORK	5 days	Wed 4/4/07	Tue 4/10/07	NA	NA
72	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Wed 4/11/07	Wed 4/18/07	NA	NA
74	CARPET & VCT	15 days	Wed 4/11/07	Wed 5/2/07	NA	NA
79	EPOXY FLOOR	8 days	Wed 4/11/07	Mon 4/23/07	NA	NA
83	CERAMIC TILE	5 days	Wed 4/11/07	Wed 4/18/07	NA	NA
73	TERRAZZO	30 days	Fri 4/27/07	Fri 6/8/07	NA	NA
80	FOOD SERVICE EQUIPMENT	15 days	Tue 4/24/07	Mon 5/14/07	NA	NA
75	INSTALL PLUMBING FIXTURES	5 days	Mon 6/11/07	Fri 6/15/07	NA	NA
77	INSTALL WINDOW TREATMENTS	2 days	Mon 6/11/07	Tue 6/12/07	NA	NA
78	INSTALL ENTRANCE MATS	3 days	Mon 6/11/07	Wed 6/13/07	NA	NA
81	DOORS AND HARDWARE	5 days	Mon 6/11/07	Fri 6/15/07	NA	NA
76	TOILET PARTITIONS & ACCESS	3 days	Mon 6/18/07	Wed 6/20/07	NA	NA
129	**Core Area 1**	**239 days**	**Thu 6/22/06**	**Fri 6/1/07**	**NA**	**NA**
130	INSTALL CONCRETE FOUNDATIONS	12 days	Thu 6/22/06	Mon 7/10/06	NA	NA
131	INSTALL FOUNDATION MASONRY	10 days	Wed 7/5/06	Tue 7/18/06	NA	NA
132	INSTALL U.G. UTILITIES	10 days	Mon 7/24/06	Fri 8/4/06	NA	NA
133	INSTALL SLAB ON GRADE	10 days	Wed 8/2/06	Tue 8/15/06	NA	NA
134	ERECT STRUCTURAL STEEL	25 days	Tue 9/26/06	Mon 10/30/06	NA	NA
136	PERIMETER CMU BACK-UP	21 days	Tue 10/24/06	Tue 11/21/06	NA	NA
139	INSTALL BLOCKING FOR FASCIA	7 days	Tue 10/31/06	Wed 11/8/06	NA	NA
149	ROUGH IN HVAC DUCT	30 days	Tue 10/31/06	Wed 12/13/06	NA	NA
148	ROUGH IN MECHANICAL PIPING	25 days	Tue 11/7/06	Wed 12/13/06	NA	NA
140	INSTALL ROOF FASCIA	9 days	Thu 11/9/06	Tue 11/21/06	NA	NA



Project: Official Schedule - baseline~66
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Task	Milestone ◆	Rolled Up Milestone ◇	Baseline
Task Progress	Baseline Milestone ◇	Baseline SummTask	Milestone
Critical Task	Summary	Task Progress	Baseline Milestone
Critical Task Progress	Rolled Up Task	Critical Task ◇	Summary
Baseline	Rolled Up Critical Task	Critical Task Progress	Rolled Up Task ⇩

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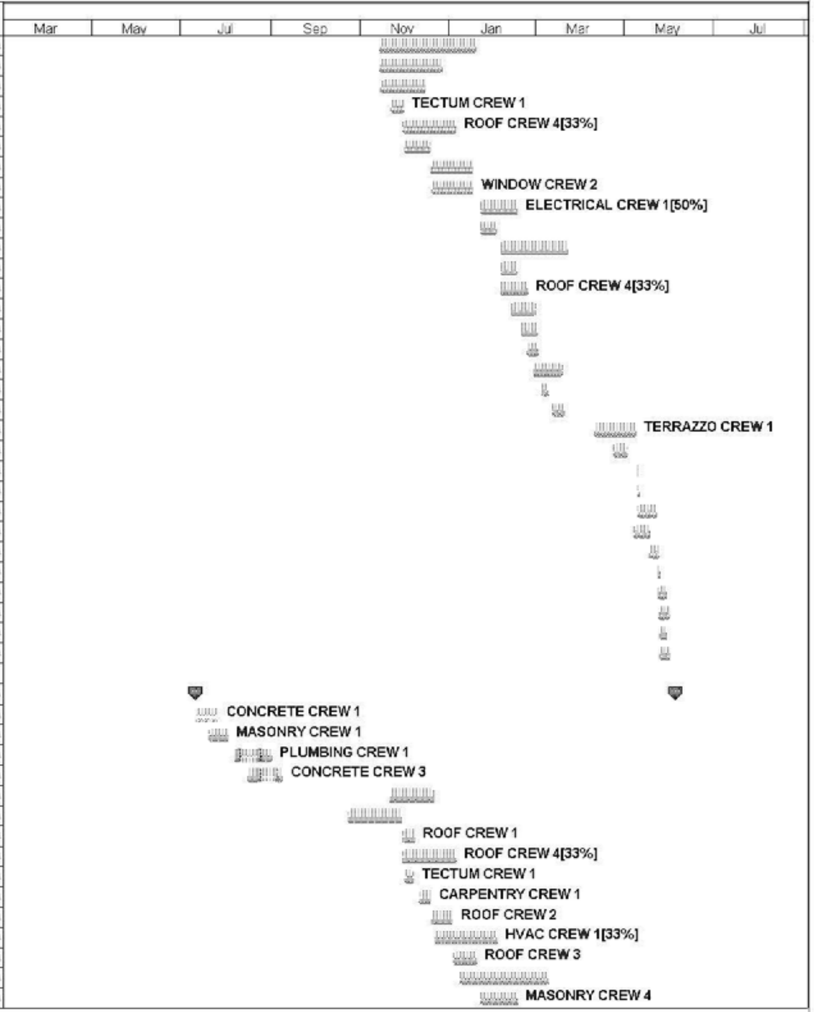
ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
150	ROUGH IN PLUMBING	45 days	Tue 11/14/06	Fri 1/19/07	NA	NA
151	ROUGH IN SPRINKLER	28 days	Tue 11/14/06	Tue 12/26/06	NA	NA
137	PERIMETER FACE BRICK	21 days	Wed 11/15/06	Fri 12/15/06	NA	NA
135	INSTALL TECTUM DECK	5 days	Wed 11/22/06	Thu 11/30/06	NA	NA
143	INSTALL FLAT ROOF BASE SHEET	25 days	Thu 11/30/06	Fri 1/5/07	NA	NA
141	INSTALL METAL PANELS	12 days	Fri 12/1/06	Mon 12/18/06	NA	NA
138	INTERIOR MASONRY	20 days	Tue 12/19/06	Wed 1/17/07	NA	NA
145	INSTALL WINDOWS	19 days	Wed 12/20/06	Wed 1/17/07	NA	NA
146	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	20 days	Mon 1/22/07	Fri 2/16/07	NA	NA
142	DRYWALL CEILINGS	10 days	Mon 1/22/07	Fri 2/2/07	NA	NA
147	ROUGH IN ELECTRICAL SYSTEMS	35 days	Mon 2/5/07	Fri 3/23/07	NA	NA
152	1ST COAT PAINT	10 days	Mon 2/5/07	Fri 2/16/07	NA	NA
144	INSTALL FLAT ROOF FINISH PRODUCT	15 days	Mon 2/5/07	Fri 2/23/07	NA	NA
161	ACOUSTIC CEILING GRID	13 days	Mon 2/12/07	Wed 2/28/07	NA	NA
162	LIGHTS	10 days	Mon 2/19/07	Fri 3/2/07	NA	NA
163	GRILLES REGISTERS DIFFUSERS	6 days	Fri 2/23/07	Fri 3/2/07	NA	NA
167	FINISH PAINT	15 days	Tue 2/27/07	Mon 3/19/07	NA	NA
165	CERAMIC TILE	5 days	Mon 3/5/07	Fri 3/9/07	NA	NA
164	ACOUSTIC CEILING TILES	7 days	Mon 3/12/07	Tue 3/20/07	NA	NA
160	TERRAZZO	20 days	Tue 4/10/07	Tue 5/8/07	NA	NA
154	GYMNASIUM EQUIPMENT	8 days	Mon 4/23/07	Wed 5/2/07	NA	NA
156	INSTALL WINDOW TREATMENTS	2 days	Wed 5/9/07	Thu 5/10/07	NA	NA
157	INSTALL ENTRANCE MATS	3 days	Wed 5/9/07	Fri 5/11/07	NA	NA
166	CARPET & VCT	10 days	Wed 5/9/07	Tue 5/22/07	NA	NA
155	GYMNASIUM FLOOR	10 days	Mon 5/7/07	Fri 5/18/07	NA	NA
168	INSTALL PLUMBING FIXTURES	5 days	Fri 5/18/07	Thu 5/24/07	NA	NA
153	INSTALL FOLDING PARTITION	3 days	Wed 5/23/07	Fri 5/25/07	NA	NA
158	CASEWORK	5 days	Wed 5/23/07	Wed 5/30/07	NA	NA
159	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Thu 5/24/07	Thu 5/31/07	NA	NA
169	INSTALL TOILET PARTITIONS	3 days	Fri 5/25/07	Wed 5/30/07	NA	NA
170	DOORS AND HARDWARE	5 days	Fri 5/25/07	Fri 6/1/07	NA	NA
86						
87	**Core Area 2**	**228 days**	**Tue 7/11/06**	**Mon 6/4/07**	**NA**	**NA**
88	INSTALL CONCRETE FOUNDATIONS	12 days	Tue 7/11/06	Wed 7/26/06	NA	NA
89	INSTALL FOUNDATION MASONRY	10 days	Thu 7/20/06	Wed 8/2/06	NA	NA
90	INSTALL U.G. UTILITIES	10 days	Mon 8/7/06	Fri 9/1/06	NA	NA
91	INSTALL SLAB ON GRADE	10 days	Wed 8/16/06	Fri 9/8/06	NA	NA
94	PERIMETER CMU BACK-UP	21 days	Tue 11/21/06	Thu 12/21/06	NA	NA
92	ERECT STRUCTURAL STEEL	25 days	Tue 10/24/06	Wed 11/29/06	NA	NA
97	INSTALL FELT PADS ON SLOPED ROOF	7 days	Thu 11/30/06	Fri 12/8/06	NA	NA
101	INSTALL FLAT ROOF BASE SHEET	25 days	Thu 11/30/06	Fri 1/5/07	NA	NA
93	INSTALL TECTUM DECK	5 days	Fri 12/1/06	Thu 12/7/06	NA	NA
98	INSTALL BLOCKING FOR FASCIA	7 days	Mon 12/11/06	Tue 12/19/06	NA	NA
99	INSTALL ROOF FASCIA	9 days	Wed 12/20/06	Wed 1/3/07	NA	NA
124	ROUGH IN HVAC DUCT	30 days	Thu 12/21/06	Fri 2/2/07	NA	NA
100	INSTALL METAL PANELS	12 days	Thu 1/4/07	Fri 1/19/07	NA	NA
125	ROUGH IN PLUMBING	45 days	Mon 1/8/07	Fri 3/9/07	NA	NA
96	INTERIOR MASONRY	20 days	Mon 1/22/07	Fri 2/16/07	NA	NA



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Task	▨	Milestone	◆	Rolled Up Milestone	◇	Baseline	▭
Task Progress	▬	Baseline Milestone	◇	Baseline SummTask	▼ ▼	Milestone	▨
Critical Task	▨	Summary	▬	Task Progress	▨	Baseline Milestone	▨
Critical Task Progress	▬	Rolled Up Task	▨	Critical Task	◇	Summary	▬
Baseline	▨	Rolled Up Critical Task	▨	Critical Task Progress	▬	Rolled Up Task	⇩

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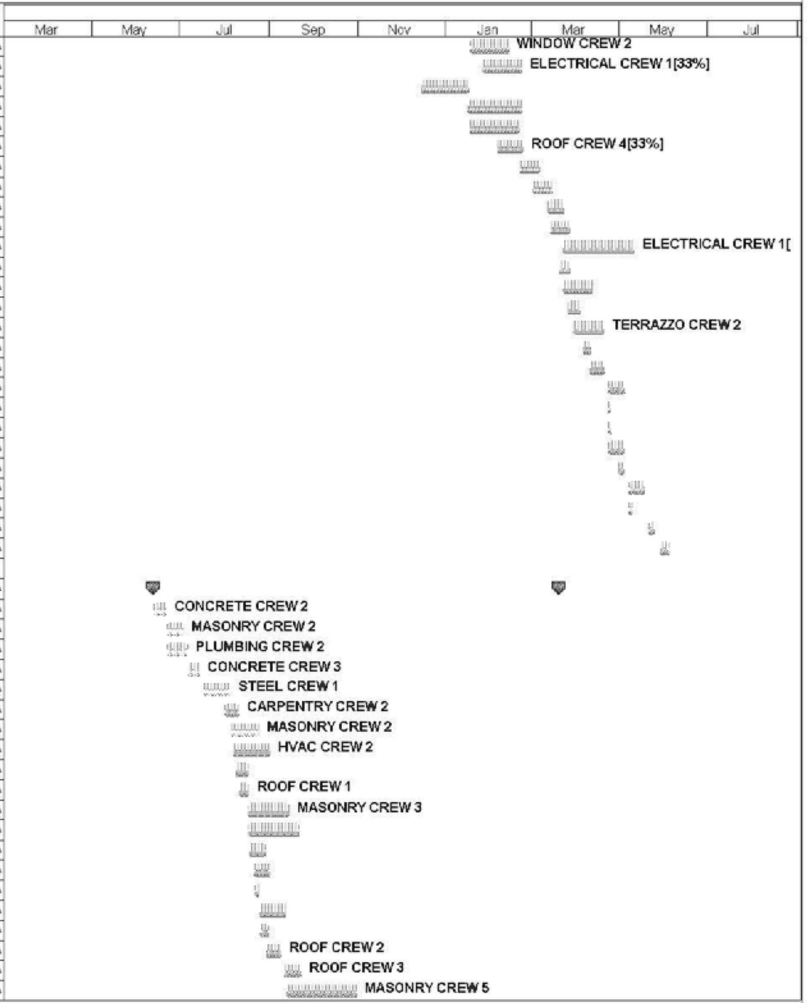
ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
103	INSTALL WINDOWS	19 days	Thu 1/18/07	Tue 2/13/07	NA	NA
104	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	20 days	Fri 1/26/07	Thu 2/22/07	NA	NA
95	PERIMETER FACE BRICK	21 days	Fri 12/15/06	Tue 1/16/07	NA	NA
126	ROUGH IN SPRINKLER	28 days	Tue 1/16/07	Thu 2/22/07	NA	NA
123	ROUGH IN MECHANICAL PIPING	25 days	Wed 1/17/07	Tue 2/20/07	NA	NA
102	INSTALL FLAT ROOF FINISH PRODUCT	15 days	Mon 2/5/07	Fri 2/23/07	NA	NA
105	DRYWALL CEILINGS	10 days	Wed 2/21/07	Tue 3/6/07	NA	NA
127	1ST COAT PAINT	10 days	Fri 3/2/07	Thu 3/15/07	NA	NA
128	ACOUSTIC CEILING GRID	10 days	Mon 3/12/07	Fri 3/23/07	NA	NA
106	LIGHTS	10 days	Wed 3/14/07	Tue 3/27/07	NA	NA
122	ROUGH IN ELECTRICAL SYSTEMS	35 days	Fri 3/23/07	Fri 5/11/07	NA	NA
107	GRILLES REGISTERS DIFFUSERS	6 days	Tue 3/20/07	Tue 3/27/07	NA	NA
112	FINISH PAINT	15 days	Fri 3/23/07	Thu 4/12/07	NA	NA
108	ACOUSTIC CEILING TILES	7 days	Mon 3/26/07	Tue 4/3/07	NA	NA
110	TERRAZZO	15 days	Fri 3/30/07	Fri 4/20/07	NA	NA
113	CERAMIC TILE	5 days	Thu 4/5/07	Wed 4/11/07	NA	NA
109	GYMNASIUM EQUIPMENT	8 days	Tue 4/10/07	Fri 4/20/07	NA	NA
111	GYMNASIUM FLOOR	10 days	Mon 4/23/07	Fri 5/4/07	NA	NA
117	INSTALL WINDOW TREATMENTS	2 days	Mon 4/23/07	Tue 4/24/07	NA	NA
118	INSTALL ENTRANCE MATS	3 days	Mon 4/23/07	Wed 4/25/07	NA	NA
119	CARPET & VCT	10 days	Mon 4/23/07	Fri 5/4/07	NA	NA
120	INSTALL PLUMBING FIXTURES	5 days	Mon 4/30/07	Fri 5/4/07	NA	NA
114	CASEWORK	10 days	Mon 5/7/07	Fri 5/18/07	NA	NA
121	TOILET PARTITIONS & ACCESS	3 days	Mon 5/7/07	Wed 5/9/07	NA	NA
115	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Mon 5/21/07	Fri 5/25/07	NA	NA
116	DOORS AND HARDWARE	5 days	Tue 5/29/07	Mon 6/4/07	NA	NA
171						
172	**NORTHEAST WING**	**195 days**	**Mon 6/12/06**	**Mon 3/19/07**	**NA**	**NA**
173	INSTALL CONCRETE FOUNDATIONS	8 days	Mon 6/12/06	Wed 6/21/06	NA	NA
174	INSTALL FOUNDATION MASONRY	8 days	Thu 6/22/06	Mon 7/3/06	NA	NA
175	INSTALL U.G. UTILITIES	10 days	Thu 6/22/06	Thu 7/6/06	NA	NA
176	INSTALL SLAB ON GRADE	6 days	Fri 7/7/06	Fri 7/14/06	NA	NA
177	ERECT STRUCTURAL STEEL	15 days	Mon 7/17/06	Fri 8/4/06	NA	NA
185	INSTALL BLOCKING FOR FASCIA	8 days	Tue 8/1/06	Thu 8/10/06	NA	NA
179	PERIMETER CMU BACK-UP	15 days	Fri 8/4/06	Thu 8/24/06	NA	NA
195	ROUGH IN HVAC DUCT	20 days	Mon 8/7/06	Fri 9/1/06	NA	NA
186	INSTALL ROOF FASCIA METAL STUDS	8 days	Tue 8/8/06	Thu 8/17/06	NA	NA
183	INSTALL FELT PADS ON SLOPED ROOF	5 days	Fri 8/11/06	Thu 8/17/06	NA	NA
180	PERIMETER FACE BRICK	20 days	Thu 8/17/06	Thu 9/14/06	NA	NA
196	ROUGH IN PLUMBING	25 days	Thu 8/17/06	Thu 9/21/06	NA	NA
207	INSTALL GUTTERS	7 days	Fri 8/18/06	Mon 8/28/06	NA	NA
197	ROUGH IN SPRINKLER	10 days	Mon 8/21/06	Fri 9/1/06	NA	NA
193	LAYOUT INTERIOR WALLS	3 days	Tue 8/22/06	Thu 8/24/06	NA	NA
192	ROUGH IN MECHANICAL PIPING	12 days	Fri 8/25/06	Tue 9/12/06	NA	NA
194	INSTALL INTERIOR DOOR FRAMES	5 days	Fri 8/25/06	Thu 8/31/06	NA	NA
187	INSTALL ROOF FASCIA	8 days	Tue 8/29/06	Fri 9/8/06	NA	NA
188	INSTALL METAL PANELS	10 days	Mon 9/11/06	Fri 9/22/06	NA	NA
181	INTERIOR MASONRY	35 days	Wed 9/13/06	Tue 10/31/06	NA	NA



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Task	▨	Milestone	◆	Rolled Up Milestone	◇	Baseline	▭
Task Progress	▨	Baseline Milestone	◇	Baseline SummTask	▼	Milestone	▭
Critical Task	▨	Summary	▬	Task Progress	▨	Baseline Milestone	▭
Critical Task Progress	▨	Rolled Up Task	▨	Critical Task	◇	Summary	▬
Baseline	▨	Rolled Up Critical Task	▨	Critical Task Progress	▬	Rolled Up Task	⇩

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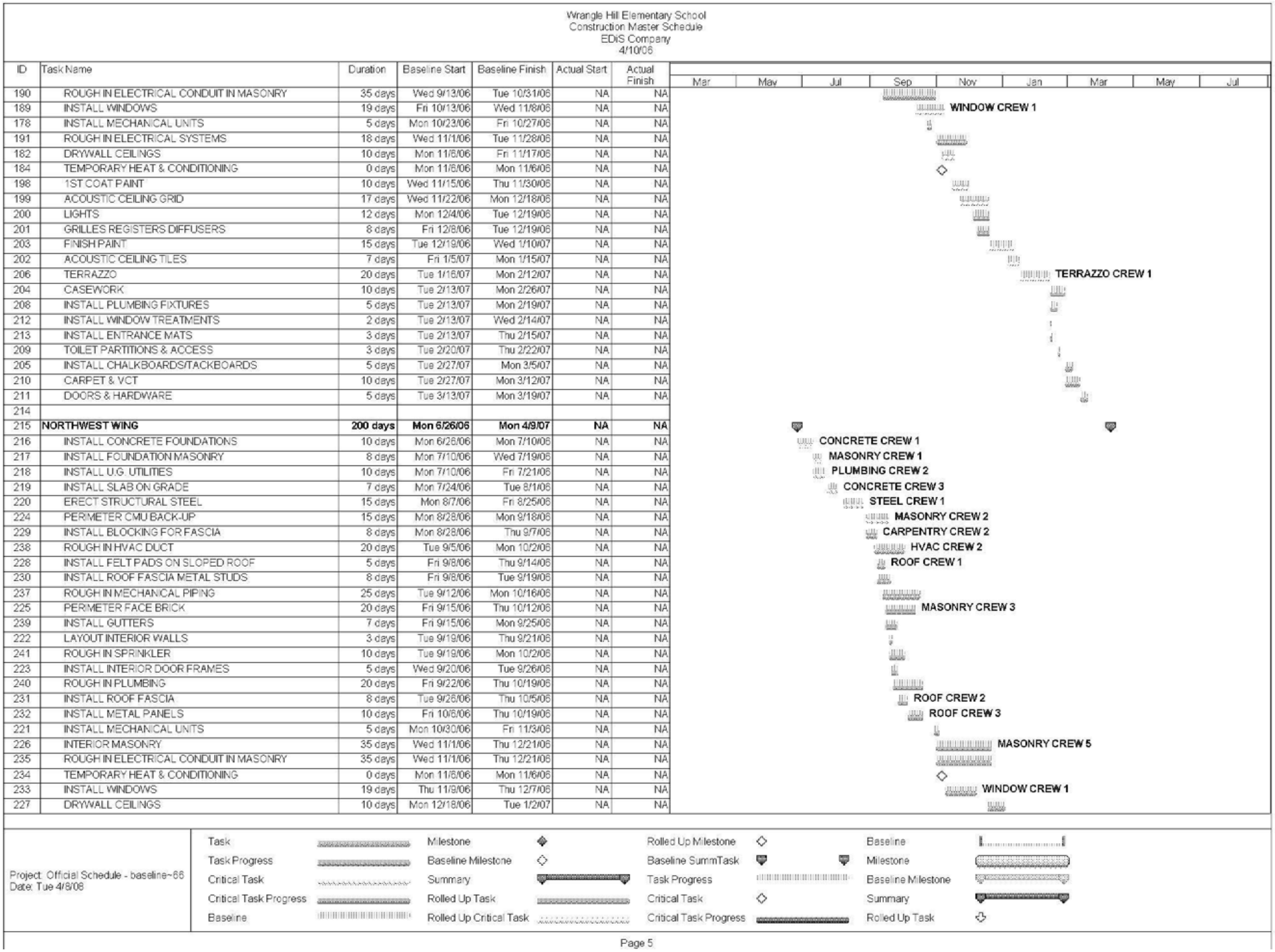

Wrangle Hill Elementary School
Construction Master Schedule
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ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
190	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	35 days	Wed 9/13/06	Tue 10/31/06	NA	NA
189	INSTALL WINDOWS	19 days	Fri 10/13/06	Wed 11/8/06	NA	NA
178	INSTALL MECHANICAL UNITS	5 days	Mon 10/23/06	Fri 10/27/06	NA	NA
191	ROUGH IN ELECTRICAL SYSTEMS	18 days	Wed 11/1/06	Tue 11/28/06	NA	NA
182	DRYWALL CEILINGS	10 days	Mon 11/6/06	Fri 11/17/06	NA	NA
184	TEMPORARY HEAT & CONDITIONING	0 days	Mon 11/6/06	Mon 11/6/06	NA	NA
198	1ST COAT PAINT	10 days	Wed 11/15/06	Thu 11/30/06	NA	NA
199	ACOUSTIC CEILING GRID	17 days	Wed 11/22/06	Mon 12/18/06	NA	NA
200	LIGHTS	12 days	Mon 12/4/06	Tue 12/19/06	NA	NA
201	GRILLES REGISTERS DIFFUSERS	8 days	Fri 12/8/06	Tue 12/19/06	NA	NA
203	FINISH PAINT	15 days	Tue 12/19/06	Wed 1/10/07	NA	NA
202	ACOUSTIC CEILING TILES	7 days	Fri 1/5/07	Mon 1/15/07	NA	NA
206	TERRAZZO	20 days	Tue 1/16/07	Mon 2/12/07	NA	NA
204	CASEWORK	10 days	Tue 2/13/07	Mon 2/26/07	NA	NA
208	INSTALL PLUMBING FIXTURES	5 days	Tue 2/13/07	Mon 2/19/07	NA	NA
212	INSTALL WINDOW TREATMENTS	2 days	Tue 2/13/07	Wed 2/14/07	NA	NA
213	INSTALL ENTRANCE MATS	3 days	Tue 2/13/07	Thu 2/15/07	NA	NA
209	TOILET PARTITIONS & ACCESS	3 days	Tue 2/20/07	Thu 2/22/07	NA	NA
205	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Tue 2/27/07	Mon 3/5/07	NA	NA
210	CARPET & VCT	10 days	Tue 2/27/07	Mon 3/12/07	NA	NA
211	DOORS & HARDWARE	5 days	Tue 3/13/07	Mon 3/19/07	NA	NA
214						
215	**NORTHWEST WING**	**200 days**	**Mon 6/26/06**	**Mon 4/9/07**	**NA**	**NA**
216	INSTALL CONCRETE FOUNDATIONS	10 days	Mon 6/26/06	Mon 7/10/06	NA	NA
217	INSTALL FOUNDATION MASONRY	8 days	Mon 7/10/06	Wed 7/19/06	NA	NA
218	INSTALL U.G. UTILITIES	10 days	Mon 7/10/06	Fri 7/21/06	NA	NA
219	INSTALL SLAB ON GRADE	7 days	Mon 7/24/06	Tue 8/1/06	NA	NA
220	ERECT STRUCTURAL STEEL	15 days	Mon 8/7/06	Fri 8/25/06	NA	NA
224	PERIMETER CMU BACK-UP	15 days	Mon 8/28/06	Mon 9/18/06	NA	NA
229	INSTALL BLOCKING FOR FASCIA	8 days	Mon 8/28/06	Thu 9/7/06	NA	NA
238	ROUGH IN HVAC DUCT	20 days	Tue 9/5/06	Mon 10/2/06	NA	NA
228	INSTALL FELT PADS ON SLOPED ROOF	5 days	Fri 9/8/06	Thu 9/14/06	NA	NA
230	INSTALL ROOF FASCIA METAL STUDS	8 days	Fri 9/8/06	Tue 9/19/06	NA	NA
237	ROUGH IN MECHANICAL PIPING	25 days	Tue 9/12/06	Mon 10/16/06	NA	NA
225	PERIMETER FACE BRICK	20 days	Fri 9/15/06	Thu 10/12/06	NA	NA
239	INSTALL GUTTERS	7 days	Fri 9/15/06	Mon 9/25/06	NA	NA
222	LAYOUT INTERIOR WALLS	3 days	Tue 9/19/06	Thu 9/21/06	NA	NA
241	ROUGH IN SPRINKLER	10 days	Tue 9/19/06	Mon 10/2/06	NA	NA
223	INSTALL INTERIOR DOOR FRAMES	5 days	Wed 9/20/06	Tue 9/26/06	NA	NA
240	ROUGH IN PLUMBING	20 days	Fri 9/22/06	Thu 10/19/06	NA	NA
231	INSTALL ROOF FASCIA	8 days	Tue 9/26/06	Thu 10/5/06	NA	NA
232	INSTALL METAL PANELS	10 days	Fri 10/6/06	Thu 10/19/06	NA	NA
221	INSTALL MECHANICAL UNITS	5 days	Mon 10/30/06	Fri 11/3/06	NA	NA
226	INTERIOR MASONRY	35 days	Wed 11/1/06	Thu 12/21/06	NA	NA
235	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	35 days	Wed 11/1/06	Thu 12/21/06	NA	NA
234	TEMPORARY HEAT & CONDITIONING	0 days	Mon 11/6/06	Mon 11/6/06	NA	NA
233	INSTALL WINDOWS	19 days	Thu 11/9/06	Thu 12/7/06	NA	NA
227	DRYWALL CEILINGS	10 days	Mon 12/18/06	Tue 1/2/07	NA	NA

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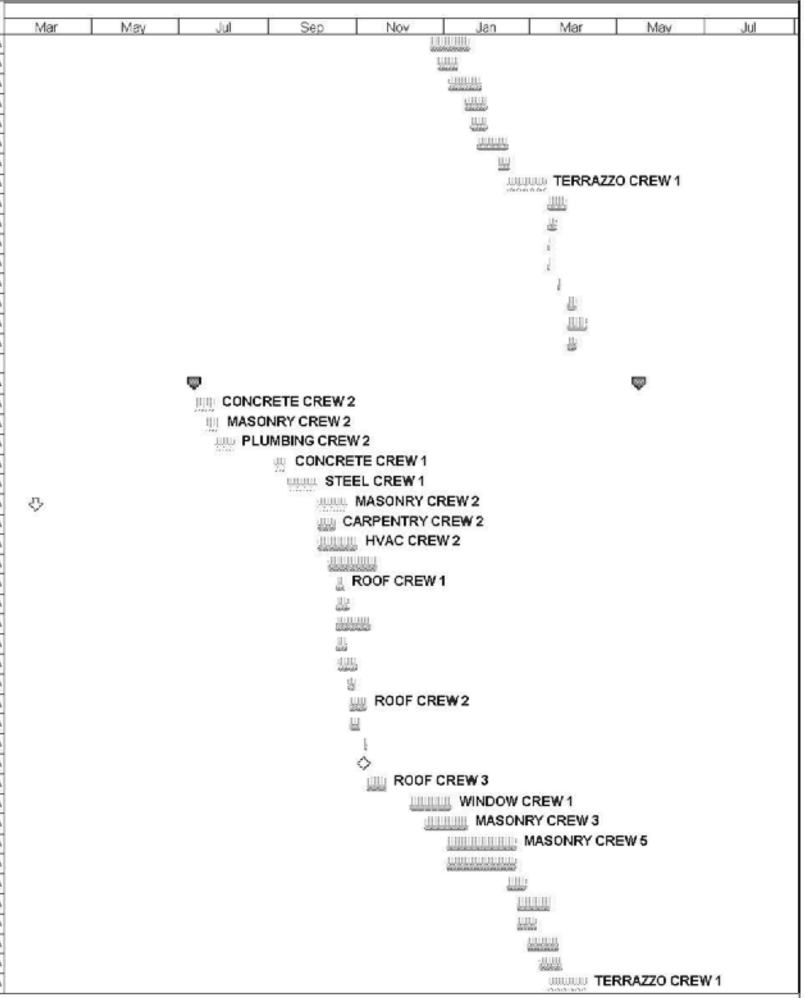
ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
236	ROUGH IN ELECTRICAL SYSTEMS	18 days	Fri 12/22/06	Thu 1/18/07	NA	NA
242	1ST COAT PAINT	10 days	Wed 12/27/06	Wed 1/10/07	NA	NA
243	ACOUSTIC CEILING GRID	17 days	Thu 1/4/07	Fri 1/26/07	NA	NA
247	LIGHTS	12 days	Mon 1/15/07	Tue 1/30/07	NA	NA
248	GRILLES REGISTERS DIFFUSERS	8 days	Fri 1/19/07	Tue 1/30/07	NA	NA
250	FINISH PAINT	15 days	Wed 1/24/07	Tue 2/13/07	NA	NA
249	ACOUSTIC CEILING TILES	7 days	Wed 2/7/07	Thu 2/15/07	NA	NA
251	TERRAZZO	20 days	Tue 2/13/07	Mon 3/12/07	NA	NA
244	CASEWORK	10 days	Tue 3/13/07	Mon 3/26/07	NA	NA
252	INSTALL PLUMBING FIXTURES	5 days	Tue 3/13/07	Mon 3/19/07	NA	NA
255	INSTALL WINDOW TREATMENTS	2 days	Tue 3/13/07	Wed 3/14/07	NA	NA
256	INSTALL ENTRANCE MATS	3 days	Tue 3/13/07	Thu 3/15/07	NA	NA
253	TOILET PARTITIONS & ACCESS	3 days	Tue 3/20/07	Thu 3/22/07	NA	NA
245	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Tue 3/27/07	Mon 4/2/07	NA	NA
246	CARPET & VCT	10 days	Tue 3/27/07	Mon 4/9/07	NA	NA
254	DOORS & HARDWARE	5 days	Tue 3/27/07	Mon 4/2/07	NA	NA
257						
258	**SOUTHEAST WING**	**215 days**	**Tue 7/11/06**	**Tue 5/15/07**	**NA**	**NA**
259	INSTALL CONCRETE FOUNDATIONS	10 days	Tue 7/11/06	Mon 7/24/06	NA	NA
260	INSTALL FOUNDATION MASONRY	8 days	Wed 7/19/06	Fri 7/28/06	NA	NA
261	INSTALL U.G. UTILITIES	10 days	Tue 7/25/06	Mon 8/7/06	NA	NA
262	INSTALL SLAB ON GRADE	7 days	Tue 9/5/06	Wed 9/13/06	NA	NA
263	ERECT STRUCTURAL STEEL	15 days	Thu 9/14/06	Wed 10/4/06	NA	NA
265	PERIMETER CMU BACK-UP	15 days	Thu 10/5/06	Wed 10/25/06	NA	NA
270	INSTALL BLOCKING FOR FASCIA	8 days	Thu 10/5/06	Mon 10/16/06	NA	NA
281	ROUGH IN HVAC DUCT	20 days	Thu 10/5/06	Wed 11/1/06	NA	NA
280	ROUGH IN MECHANICAL PIPING	25 days	Thu 10/12/06	Wed 11/15/06	NA	NA
269	INSTALL FELT PADS ON SLOPED ROOF	5 days	Tue 10/17/06	Mon 10/23/06	NA	NA
271	INSTALL ROOF FASCIA METAL STUDS	8 days	Tue 10/17/06	Thu 10/26/06	NA	NA
282	ROUGH IN PLUMBING	19 days	Tue 10/17/06	Fri 11/10/06	NA	NA
284	INSTALL GUTTERS	7 days	Tue 10/17/06	Wed 10/25/06	NA	NA
283	ROUGH IN SPRINKLER	10 days	Thu 10/19/06	Wed 11/1/06	NA	NA
274	LAYOUT INTERIOR WALLS	3 days	Thu 10/26/06	Mon 10/30/06	NA	NA
272	INSTALL ROOF FASCIA	8 days	Fri 10/27/06	Tue 11/7/06	NA	NA
275	INSTALL INTERIOR DOOR FRAMES	5 days	Fri 10/27/06	Thu 11/2/06	NA	NA
264	INSTALL MECHANICAL UNITS	3 days	Mon 11/6/06	Wed 11/8/06	NA	NA
277	TEMPORARY HEAT & CONDITIONING	0 days	Mon 11/6/06	Mon 11/6/06	NA	NA
273	INSTALL METAL PANELS	10 days	Wed 11/8/06	Tue 11/21/06	NA	NA
276	INSTALL WINDOWS	19 days	Fri 12/8/06	Fri 1/5/07	NA	NA
266	PERIMETER FACE BRICK	20 days	Mon 12/18/06	Tue 1/16/07	NA	NA
267	INTERIOR MASONRY	35 days	Tue 1/2/07	Mon 2/19/07	NA	NA
278	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	35 days	Tue 1/2/07	Mon 2/19/07	NA	NA
268	DRYWALL CEILINGS	10 days	Tue 2/13/07	Mon 2/26/07	NA	NA
279	ROUGH IN ELECTRICAL SYSTEMS	18 days	Tue 2/20/07	Thu 3/15/07	NA	NA
285	1ST COAT PAINT	10 days	Tue 2/20/07	Mon 3/5/07	NA	NA
286	ACOUSTIC CEILING GRID	17 days	Tue 2/27/07	Wed 3/21/07	NA	NA
287	LIGHTS	12 days	Thu 3/8/07	Fri 3/23/07	NA	NA
294	TERRAZZO	20 days	Tue 3/13/07	Mon 4/9/07	NA	NA

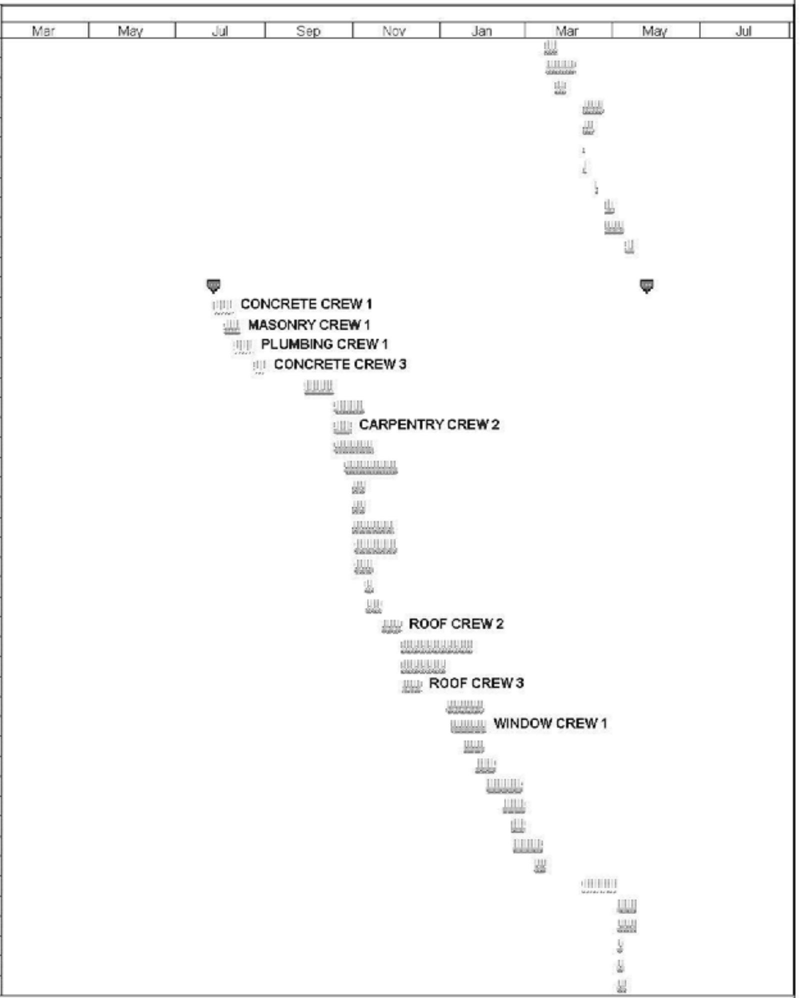


Project: Official Schedule - baseline~66
Date: Tue 4/8/08

Task	▨	Milestone	◆	Rolled Up Milestone	◇	Baseline	▭
Task Progress	▬	Baseline Milestone	◇	Baseline SummTask	▼	Milestone	▭
Critical Task	▨	Summary	▬	Task Progress	▭	Baseline Milestone	▽
Critical Task Progress	▬	Rolled Up Task	▬	Critical Task	◇	Summary	▬
Baseline	▭	Rolled Up Critical Task	▨	Critical Task Progress	▬	Rolled Up Task	⇩

Wrangle Hill Elementary School
Construction Master Schedule
EDiS Company
4/10/06

ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
288	GRILLES REGISTERS DIFFUSERS	8 days	Wed 3/14/07	Fri 3/23/07	NA	NA
290	FINISH PAINT	15 days	Thu 3/15/07	Wed 4/4/07	NA	NA
289	ACOUSTIC CEILING TILES	7 days	Wed 3/21/07	Thu 3/29/07	NA	NA
291	CASEWORK	10 days	Tue 4/10/07	Tue 4/24/07	NA	NA
295	INSTALL PLUMBING FIXTURES	5 days	Tue 4/10/07	Tue 4/17/07	NA	NA
298	INSTALL WINDOW TREATMENTS	2 days	Tue 4/10/07	Wed 4/11/07	NA	NA
299	INSTALL ENTRANCE MATS	3 days	Tue 4/10/07	Thu 4/12/07	NA	NA
296	TOILET PARTITIONS & ACCESS	3 days	Wed 4/18/07	Fri 4/20/07	NA	NA
292	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Wed 4/25/07	Tue 5/1/07	NA	NA
293	CARPET & VCT	10 days	Wed 4/25/07	Tue 5/8/07	NA	NA
297	DOORS & HARDWARE	5 days	Wed 5/9/07	Tue 5/15/07	NA	NA
300						
301	**SOUTHWEST WING**	**210 days**	**Thu 7/27/06**	**Thu 5/24/07**	**NA**	**NA**
302	INSTALL CONCRETE FOUNDATIONS	10 days	Thu 7/27/06	Wed 8/9/06	NA	NA
303	INSTALL FOUNDATION MASONRY	8 days	Thu 8/3/06	Mon 8/14/06	NA	NA
304	INSTALL U.G. UTILITIES	10 days	Thu 8/10/06	Wed 8/23/06	NA	NA
305	INSTALL SLAB ON GRADE	7 days	Thu 8/24/06	Fri 9/1/06	NA	NA
306	ERECT STRUCTURAL STEEL	15 days	Thu 9/28/06	Wed 10/18/06	NA	NA
307	PERIMETER CMU BACK-UP	15 days	Thu 10/19/06	Wed 11/8/06	NA	NA
313	INSTALL BLOCKING FOR FASCIA	8 days	Thu 10/19/06	Mon 10/30/06	NA	NA
324	ROUGH IN HVAC DUCT	20 days	Thu 10/19/06	Wed 11/15/06	NA	NA
323	ROUGH IN MECHANICAL PIPING	25 days	Thu 10/26/06	Fri 12/1/06	NA	NA
312	INSTALL FELT PADS ON SLOPED ROOF	8 days	Tue 10/31/06	Thu 11/9/06	NA	NA
314	INSTALL ROOF FASCIA METAL STUDS	8 days	Tue 10/31/06	Thu 11/9/06	NA	NA
325	ROUGH IN PLUMBING	20 days	Tue 10/31/06	Wed 11/29/06	NA	NA
308	PERIMETER FACE BRICK	20 days	Thu 11/2/06	Fri 12/1/06	NA	NA
326	ROUGH IN SPRINKLER	10 days	Thu 11/2/06	Wed 11/15/06	NA	NA
311	INSTALL MECHANICAL UNITS	5 days	Thu 11/9/06	Wed 11/15/06	NA	NA
315	INSTALL GUTTERS	7 days	Fri 11/10/06	Mon 11/20/06	NA	NA
316	INSTALL ROOF FASCIA	8 days	Tue 11/21/06	Mon 12/4/06	NA	NA
309	INTERIOR MASONRY	35 days	Mon 12/4/06	Tue 1/23/07	NA	NA
321	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	22 days	Mon 12/4/06	Thu 1/4/07	NA	NA
317	INSTALL METAL PANELS	10 days	Tue 12/5/06	Mon 12/18/06	NA	NA
322	ROUGH IN ELECTRICAL SYSTEMS	18 days	Fri 1/5/07	Tue 1/30/07	NA	NA
320	INSTALL WINDOWS	19 days	Mon 1/8/07	Thu 2/1/07	NA	NA
310	DRYWALL CEILINGS	10 days	Wed 1/17/07	Tue 1/30/07	NA	NA
327	1ST COAT PAINT	10 days	Thu 1/25/07	Wed 2/7/07	NA	NA
328	ACOUSTIC CEILING GRID	17 days	Fri 2/2/07	Mon 2/26/07	NA	NA
329	LIGHTS	12 days	Tue 2/13/07	Wed 2/28/07	NA	NA
330	GRILLES REGISTERS DIFFUSERS	8 days	Mon 2/19/07	Wed 2/28/07	NA	NA
332	FINISH PAINT	15 days	Tue 2/20/07	Mon 3/12/07	NA	NA
331	ACOUSTIC CEILING TILES	7 days	Wed 3/7/07	Thu 3/15/07	NA	NA
337	TERRAZZO	18 days	Mon 4/9/07	Thu 5/3/07	NA	NA
318	CARPET & VCT	10 days	Fri 5/4/07	Thu 5/17/07	NA	NA
333	CASEWORK	10 days	Fri 5/4/07	Thu 5/17/07	NA	NA
335	INSTALL WINDOW TREATMENTS	2 days	Fri 5/4/07	Mon 5/7/07	NA	NA
336	INSTALL ENTRANCE MATS	3 days	Fri 5/4/07	Tue 5/8/07	NA	NA
338	INSTALL PLUMBING FIXTURES	5 days	Fri 5/4/07	Thu 5/10/07	NA	NA

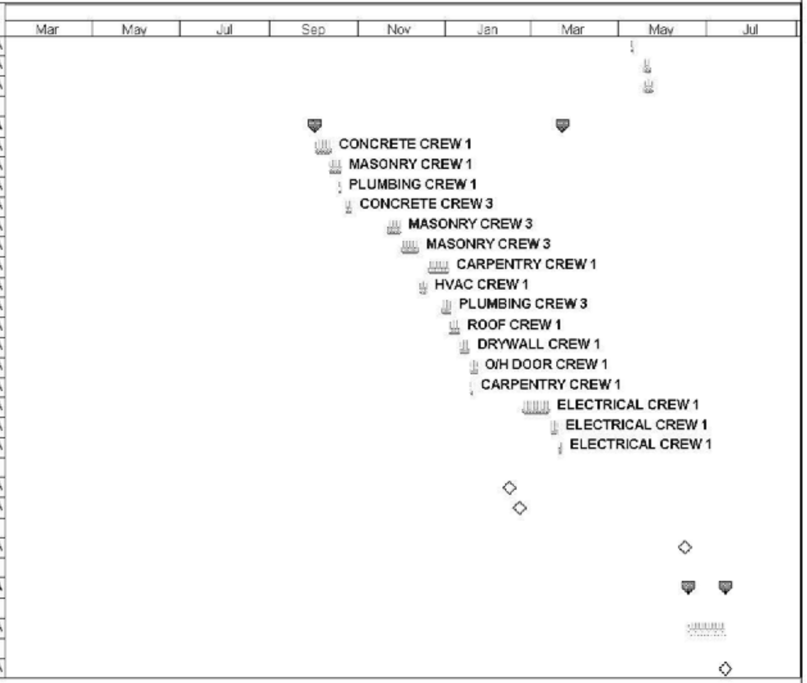


Project: Official Schedule - baseline~66
Date: Tue 4/8/08

Task	▨	Milestone	◆	Rolled Up Milestone	◇	Baseline	▭
Task Progress	▨	Baseline Milestone	◇	Baseline SummTask	▼ ▼	Milestone	▭
Critical Task	▨	Summary	▼	Task Progress	▨	Baseline Milestone	▭
Critical Task Progress	▨	Rolled Up Task	▨	Critical Task	◇	Summary	▼
Baseline	▨	Rolled Up Critical Task	▨	Critical Task Progress	▨	Rolled Up Task	⇩

Wrangle Hill Elementary School
Construction Master Schedule
EDIS Company
4/10/06

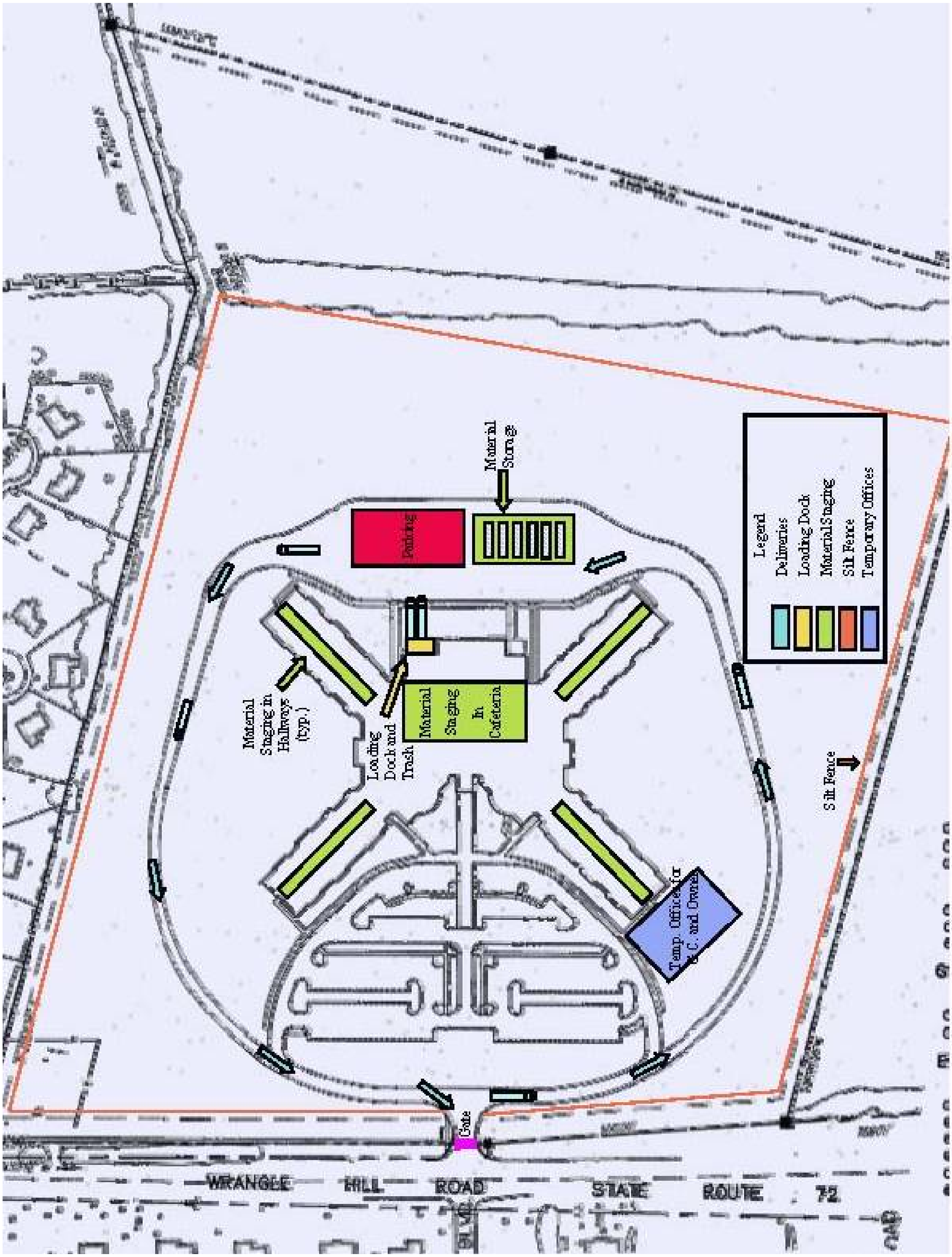
ID	Task Name	Duration	Baseline Start	Baseline Finish	Actual Start	Actual Finish
339	TOILET PARTITIONS & ACCESS	3 days	Wed 5/9/07	Fri 5/11/07	NA	NA
319	DOORS & HARDWARE	3 days	Fri 5/18/07	Tue 5/22/07	NA	NA
334	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Fri 5/18/07	Thu 5/24/07	NA	NA
349						
350	**GARAGE**	**120 days**	**Mon 10/2/06**	**Thu 3/22/07**	**NA**	**NA**
351	INSTALL CONCRETE FOUNDATIONS	10 days	Mon 10/2/06	Fri 10/13/06	NA	NA
352	INSTALL FOUNDATION MASONRY	7 days	Thu 10/12/06	Fri 10/20/06	NA	NA
353	INSTALL UG UTILITIES	2 days	Thu 10/19/06	Fri 10/20/06	NA	NA
354	INSTALL SLAB ON GRADE	5 days	Mon 10/23/06	Fri 10/27/06	NA	NA
355	PERIMETER CMU BACK-UP	6 days	Tue 11/21/06	Thu 11/30/06	NA	NA
356	INSTALL SPLIT-FACE CMU	8 days	Fri 12/1/06	Tue 12/12/06	NA	NA
357	INSTALL WOOD TRUSSES & BLOCKING	8 days	Wed 12/20/06	Tue 1/2/07	NA	NA
358	MECHANICAL	3 days	Thu 12/14/06	Mon 12/18/06	NA	NA
359	PLUMBING	4 days	Fri 12/29/06	Thu 1/4/07	NA	NA
360	INSTALL SHINGLES & SHEATHING	6 days	Wed 1/3/07	Wed 1/10/07	NA	NA
361	GWB CEILING	5 days	Thu 1/11/07	Wed 1/17/07	NA	NA
364	INSTALL OVERHEAD DOORS	3 days	Thu 1/18/07	Mon 1/22/07	NA	NA
365	DOORS & HARDWARE	2 days	Thu 1/18/07	Fri 1/19/07	NA	NA
362	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	13 days	Fri 2/23/07	Tue 3/13/07	NA	NA
363	ROUGH IN ELECTRICAL SYSTEMS	4 days	Wed 3/14/07	Mon 3/19/07	NA	NA
366	LIGHTING	3 days	Tue 3/20/07	Thu 3/22/07	NA	NA
340						
341	BUILDING ENCLOSED	0 days	Tue 2/13/07	Tue 2/13/07	NA	NA
342	BUILDING HEATED & CONDITIONED	0 days	Tue 2/20/07	Tue 2/20/07	NA	NA
343						
344	SUBSTANTIAL COMPLETION	0 days	Fri 6/15/07	Fri 6/15/07	NA	NA
345						
346	**CLOSEOUT**	**19 days**	**Mon 6/18/07**	**Fri 7/13/07**	**NA**	**NA**
347						
348	COMPLETE ALL PUNCH LIST ACTIVITIES	19 days	Mon 6/18/07	Fri 7/13/07	NA	NA
367						
368	FINAL COMPLETION	0 days	Fri 7/13/07	Fri 7/13/07	NA	NA



Project: Official Schedule - baseline~66
Date: Tue 4/8/08

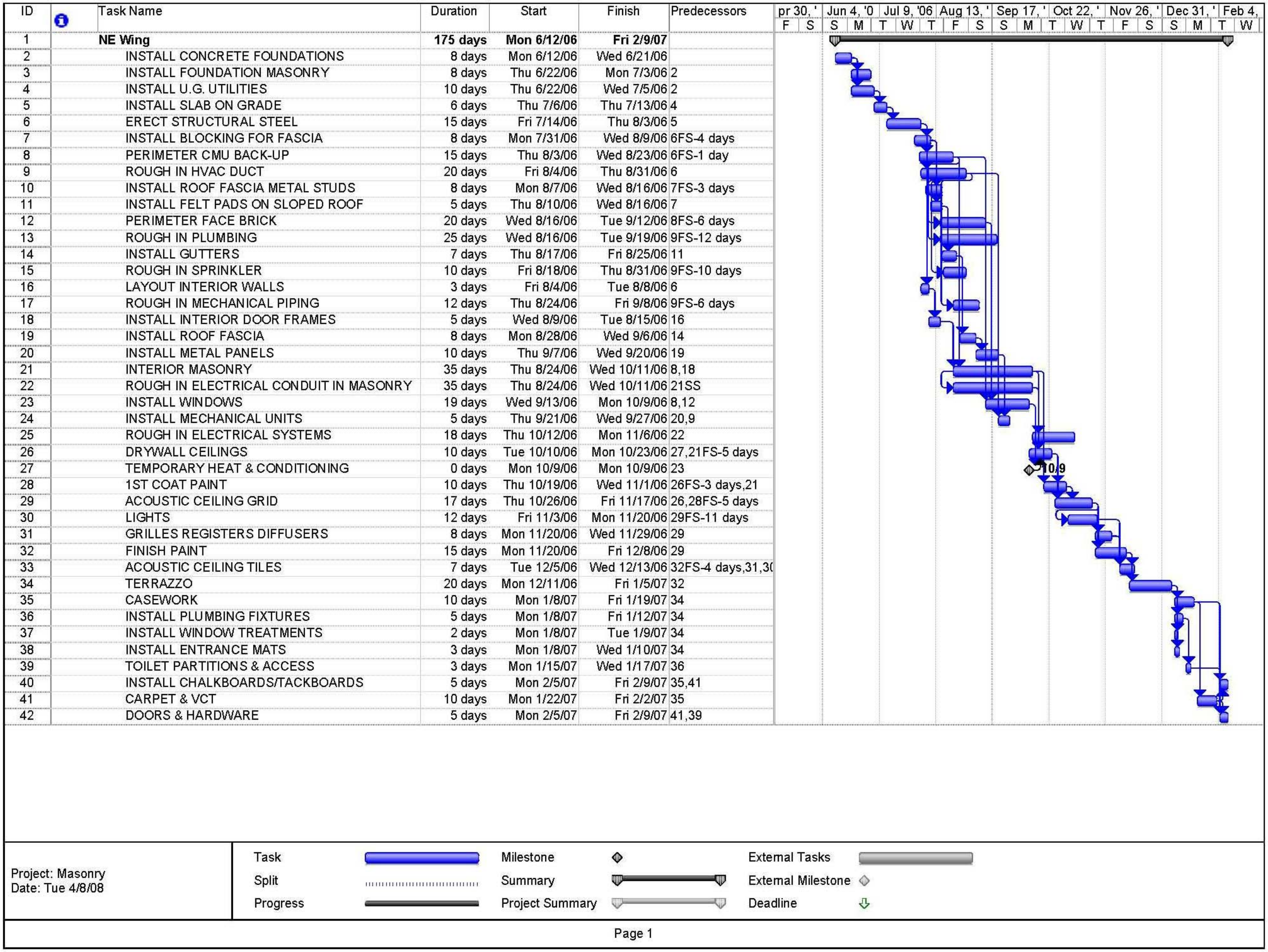
Task		Milestone	◆	Rolled Up Milestone	◇	Baseline	
Task Progress		Baseline Milestone	◇	Baseline SummTask		Milestone	
Critical Task		Summary		Task Progress		Baseline Milestone	
Critical Task Progress		Rolled Up Task		Critical Task	◇	Summary	
Baseline		Rolled Up Critical Task		Critical Task Progress		Rolled Up Task	⇩

Appendix C
Site Layout Plan



Material Storage
Parking
Legend
Deliveries
Loading Dock
Material Staging
Silt Fence
Temporary Offices
Material Staging in Hallways (typ.)
Loading Dock and Trash
Material Staging In Cafeteria
Silt Fence
Temp. Offices for G.C. and Owner
Gate
WRANGLE HILL ROAD
STATE ROUTE 72

Appendix D
Prefabrication on Wrangle Hill

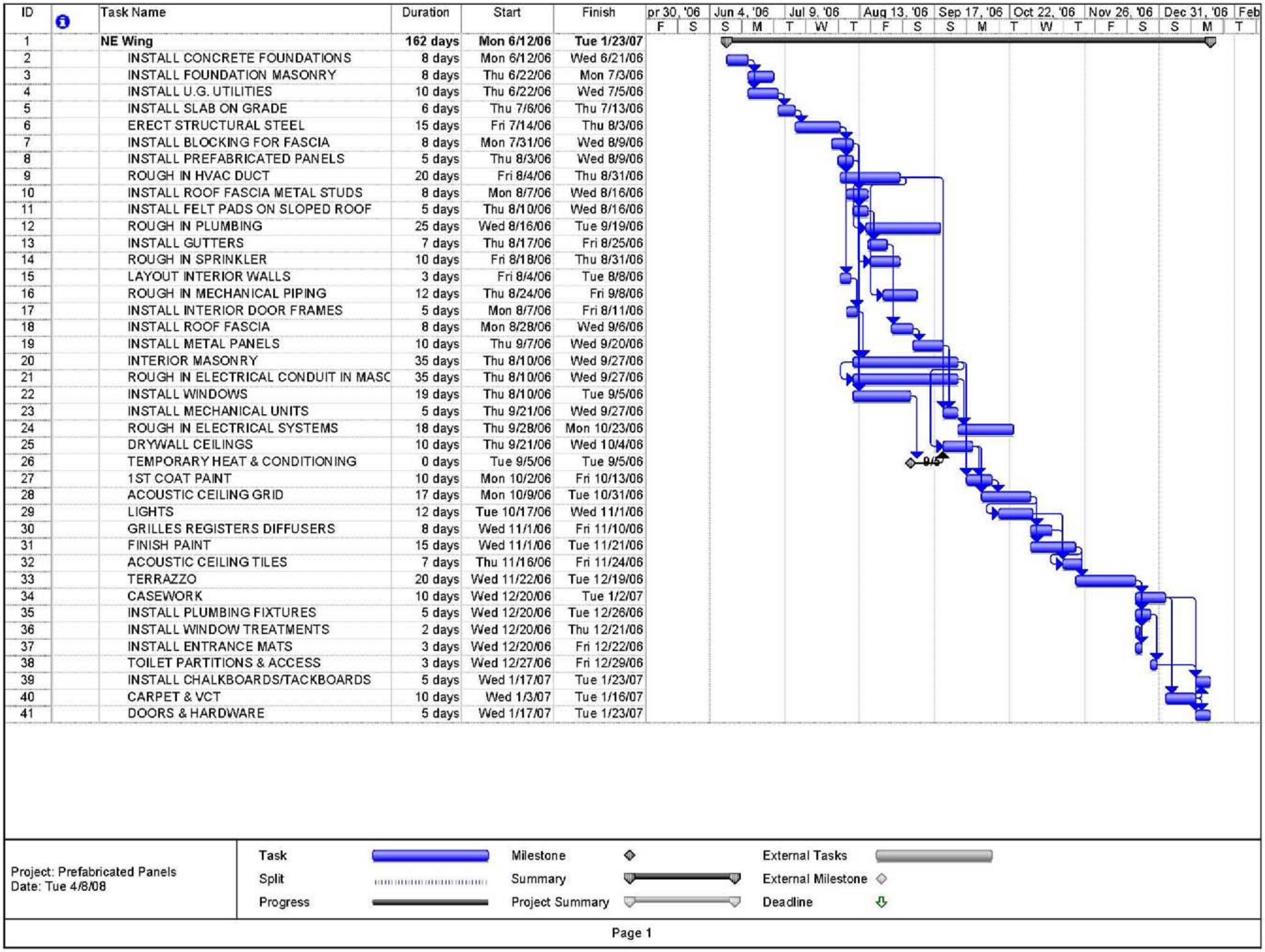


ID	Task Name	Duration	Start	Finish	Predecessors
1	**NE Wing**	**175 days**	**Mon 6/12/06**	**Fri 2/9/07**	
2	INSTALL CONCRETE FOUNDATIONS	8 days	Mon 6/12/06	Wed 6/21/06	
3	INSTALL FOUNDATION MASONRY	8 days	Thu 6/22/06	Mon 7/3/06	2
4	INSTALL U.G. UTILITIES	10 days	Thu 6/22/06	Wed 7/5/06	2
5	INSTALL SLAB ON GRADE	6 days	Thu 7/6/06	Thu 7/13/06	4
6	ERECT STRUCTURAL STEEL	15 days	Fri 7/14/06	Thu 8/3/06	5
7	INSTALL BLOCKING FOR FASCIA	8 days	Mon 7/31/06	Wed 8/9/06	6FS-4 days
8	PERIMETER CMU BACK-UP	15 days	Thu 8/3/06	Wed 8/23/06	6FS-1 day
9	ROUGH IN HVAC DUCT	20 days	Fri 8/4/06	Thu 8/31/06	6
10	INSTALL ROOF FASCIA METAL STUDS	8 days	Mon 8/7/06	Wed 8/16/06	7FS-3 days
11	INSTALL FELT PADS ON SLOPED ROOF	5 days	Thu 8/10/06	Wed 8/16/06	7
12	PERIMETER FACE BRICK	20 days	Wed 8/16/06	Tue 9/12/06	8FS-6 days
13	ROUGH IN PLUMBING	25 days	Wed 8/16/06	Tue 9/19/06	9FS-12 days
14	INSTALL GUTTERS	7 days	Thu 8/17/06	Fri 8/25/06	11
15	ROUGH IN SPRINKLER	10 days	Fri 8/18/06	Thu 8/31/06	9FS-10 days
16	LAYOUT INTERIOR WALLS	3 days	Fri 8/4/06	Tue 8/8/06	6
17	ROUGH IN MECHANICAL PIPING	12 days	Thu 8/24/06	Fri 9/8/06	9FS-6 days
18	INSTALL INTERIOR DOOR FRAMES	5 days	Wed 8/9/06	Tue 8/15/06	16
19	INSTALL ROOF FASCIA	8 days	Mon 8/28/06	Wed 9/6/06	14
20	INSTALL METAL PANELS	10 days	Thu 9/7/06	Wed 9/20/06	19
21	INTERIOR MASONRY	35 days	Thu 8/24/06	Wed 10/11/06	8,18
22	ROUGH IN ELECTRICAL CONDUIT IN MASONRY	35 days	Thu 8/24/06	Wed 10/11/06	21SS
23	INSTALL WINDOWS	19 days	Wed 9/13/06	Mon 10/9/06	8,12
24	INSTALL MECHANICAL UNITS	5 days	Thu 9/21/06	Wed 9/27/06	20,9
25	ROUGH IN ELECTRICAL SYSTEMS	18 days	Thu 10/12/06	Mon 11/6/06	22
26	DRYWALL CEILINGS	10 days	Tue 10/10/06	Mon 10/23/06	27,21FS-5 days
27	TEMPORARY HEAT & CONDITIONING	0 days	Mon 10/9/06	Mon 10/9/06	23
28	1ST COAT PAINT	10 days	Thu 10/19/06	Wed 11/1/06	26FS-3 days,21
29	ACOUSTIC CEILING GRID	17 days	Thu 10/26/06	Fri 11/17/06	26,28FS-5 days
30	LIGHTS	12 days	Fri 11/3/06	Mon 11/20/06	29FS-11 days
31	GRILLES REGISTERS DIFFUSERS	8 days	Mon 11/20/06	Wed 11/29/06	29
32	FINISH PAINT	15 days	Mon 11/20/06	Fri 12/8/06	29
33	ACOUSTIC CEILING TILES	7 days	Tue 12/5/06	Wed 12/13/06	32FS-4 days,31,3
34	TERRAZZO	20 days	Mon 12/11/06	Fri 1/5/07	32
35	CASEWORK	10 days	Mon 1/8/07	Fri 1/19/07	34
36	INSTALL PLUMBING FIXTURES	5 days	Mon 1/8/07	Fri 1/12/07	34
37	INSTALL WINDOW TREATMENTS	2 days	Mon 1/8/07	Tue 1/9/07	34
38	INSTALL ENTRANCE MATS	3 days	Mon 1/8/07	Wed 1/10/07	34
39	TOILET PARTITIONS & ACCESS	3 days	Mon 1/15/07	Wed 1/17/07	36
40	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Mon 2/5/07	Fri 2/9/07	35,41
41	CARPET & VCT	10 days	Mon 1/22/07	Fri 2/2/07	35
42	DOORS & HARDWARE	5 days	Mon 2/5/07	Fri 2/9/07	41,39

Project: Masonry
Date: Tue 4/8/08

Task
Split
Progress
Milestone ◆
Summary
Project Summary
External Tasks
External Milestone ◇
Deadline ⇩

Page 1



ID	Task Name	Duration	Start	Finish
1	**NE Wing**	**162 days**	**Mon 6/12/06**	**Tue 1/23/07**
2	INSTALL CONCRETE FOUNDATIONS	8 days	Mon 6/12/06	Wed 6/21/06
3	INSTALL FOUNDATION MASONRY	8 days	Thu 6/22/06	Mon 7/3/06
4	INSTALL U.G. UTILITIES	10 days	Thu 6/22/06	Wed 7/5/06
5	INSTALL SLAB ON GRADE	6 days	Thu 7/6/06	Thu 7/13/06
6	ERECT STRUCTURAL STEEL	15 days	Fri 7/14/06	Thu 8/3/06
7	INSTALL BLOCKING FOR FASCIA	8 days	Mon 7/31/06	Wed 8/9/06
8	INSTALL PREFABRICATED PANELS	5 days	Thu 8/3/06	Wed 8/9/06
9	ROUGH IN HVAC DUCT	20 days	Fri 8/4/06	Thu 8/31/06
10	INSTALL ROOF FASCIA METAL STUDS	8 days	Mon 8/7/06	Wed 8/16/06
11	INSTALL FELT PADS ON SLOPED ROOF	5 days	Thu 8/10/06	Wed 8/16/06
12	ROUGH IN PLUMBING	25 days	Wed 8/16/06	Tue 9/19/06
13	INSTALL GUTTERS	7 days	Thu 8/17/06	Fri 8/25/06
14	ROUGH IN SPRINKLER	10 days	Fri 8/18/06	Thu 8/31/06
15	LAYOUT INTERIOR WALLS	3 days	Fri 8/4/06	Tue 8/8/06
16	ROUGH IN MECHANICAL PIPING	12 days	Thu 8/24/06	Fri 9/8/06
17	INSTALL INTERIOR DOOR FRAMES	5 days	Mon 8/7/06	Fri 8/11/06
18	INSTALL ROOF FASCIA	8 days	Mon 8/28/06	Wed 9/6/06
19	INSTALL METAL PANELS	10 days	Thu 9/7/06	Wed 9/20/06
20	INTERIOR MASONRY	35 days	Thu 8/10/06	Wed 9/27/06
21	ROUGH IN ELECTRICAL CONDUIT IN MASC	35 days	Thu 8/10/06	Wed 9/27/06
22	INSTALL WINDOWS	19 days	Thu 8/10/06	Tue 9/5/06
23	INSTALL MECHANICAL UNITS	5 days	Thu 9/21/06	Wed 9/27/06
24	ROUGH IN ELECTRICAL SYSTEMS	18 days	Thu 9/28/06	Mon 10/23/06
25	DRYWALL CEILINGS	10 days	Thu 9/21/06	Wed 10/4/06
26	TEMPORARY HEAT & CONDITIONING	0 days	Tue 9/5/06	Tue 9/5/06
27	1ST COAT PAINT	10 days	Mon 10/2/06	Fri 10/13/06
28	ACOUSTIC CEILING GRID	17 days	Mon 10/9/06	Tue 10/31/06
29	LIGHTS	12 days	Tue 10/17/06	Wed 11/1/06
30	GRILLES REGISTERS DIFFUSERS	8 days	Wed 11/1/06	Fri 11/10/06
31	FINISH PAINT	15 days	Wed 11/1/06	Tue 11/21/06
32	ACOUSTIC CEILING TILES	7 days	Thu 11/16/06	Fri 11/24/06
33	TERRAZZO	20 days	Wed 11/22/06	Tue 12/19/06
34	CASEWORK	10 days	Wed 12/20/06	Tue 1/2/07
35	INSTALL PLUMBING FIXTURES	5 days	Wed 12/20/06	Tue 12/26/06
36	INSTALL WINDOW TREATMENTS	2 days	Wed 12/20/06	Thu 12/21/06
37	INSTALL ENTRANCE MATS	3 days	Wed 12/20/06	Fri 12/22/06
38	TOILET PARTITIONS & ACCESS	3 days	Wed 12/27/06	Fri 12/29/06
39	INSTALL CHALKBOARDS/TACKBOARDS	5 days	Wed 1/17/07	Tue 1/23/07
40	CARPET & VCT	10 days	Wed 1/3/07	Tue 1/16/07
41	DOORS & HARDWARE	5 days	Wed 1/17/07	Tue 1/23/07

Project: Prefabricated Panels
Date: Tue 4/8/08

Task	Milestone ◆	External Tasks
Split	Summary	External Milestone ◇
Progress	Project Summary	Deadline ⇩

Page 1

Appendix E
Mechanical Analysis

Dave Fox
Dr. David Riley
2/27/2008

Wrangle Hill Elementary School
New Castle, DE
Mechanical Breadth

Calculating Heat Gain/Loss in the Existing Masonry Design
Summer

Problem Design Criteria		
Design Temp Change:	25	°F
Area of Wall	183	ft^2

Element	**Thermal Conductivity (k)**	**Thickness (L)**	**Conductance (C)**	**Thermal Resistance (R)**	**Temp. Change (ΔT)**
Units	Btu*in / hr*ft^2°F	in	Btu / hr*ft^2°F	hr*ft^2°F/ Btu	°F
Masonry Mass Wall					
Exterior Air Film	-	-	193.052	0.01	0.01
Brick	9.03	4.00	2.26	0.44	0.87
Air Gap	-	-	-	0.97	1.90
Polystyrene Insulation	0.20	2.00	0.10	10.00	19.56
CMU	-	8.00	0.75	1.34	2.62
Interior Air Film	-	-	47.13	0.02	0.04
Total		**14.00**	**0.078**	**12.8**	**25.00**

Calculation Results		
Average R-Value	12.8	hr*ft^2°F/ Btu
Overall Heat Flow Rate	358.0	Btu / hr

Dave Fox
Dr. David Riley
2/27/2008

Wrangle Hill Elementary School
New Castle, DE
Mechanical Breadth

Calculating Heat Gain/Loss in the Existing Masonry Design

Winter

Problem Design Criteria		
Design Temp Change:	55	°F
Area of Wall	183	ft^2

Element	**Thermal Conductivity (k)**	**Thickness (L)**	**Conductance (C)**	**Thermal Resistance (R)**	**Temp. Change (ΔT)**
Units	Btu*in / hr*ft^2°F	in	Btu / hr*ft^2°F	hr*ft^2°F/ Btu	°F
Masonry Mass Wall					
Exterior Air Film	-	-	193.052	0.01	0.02
Brick	9.03	4.00	2.26	0.44	1.91
Air Gap	-	-	-	0.97	4.17
Polystyrene Insulation	0.20	2.00	0.10	10.00	43.04
CMU	-	8.00	0.75	1.34	5.77
Interior Air Film	-	-	47.13	0.02	0.09
Total		**14.00**	**0.078**	**12.8**	**55.00**

Calculation Results		
Average R-Value	12.8	hr*ft^2°F/ Btu
Overall Heat Flow Rate	787.6	Btu / hr

Annual Heating and Cooling Energy Losses			
Cooling (Summer)		386,636	Btu/Yr
Heating (Winter)		1,679,889	Btu/Yr
Total		2,066,524	Btu/Year

Energy Cost	**$32.53**

Dave Fox
Dr. David Riley
2/27/2008

Wrangle Hill Elementary School
New Castle, DE
Mechanical Breadth

Calculating Heat Gain/Loss in the New Prefabricated Design
Summer

Problem Design Criteria		
Design Temp Change:	25	°F
Area of Wall	183	ft^2
Percentage Stud	30%	
Percentage Insulation	70%	

Element	**Thickness (L)**	**Conductance (C)**	**Thermal Resistance (R)**	**Temp. Change (ΔT)**	**Temperature of Interior Face**
Units	in	Btu / hr*ft^2°F	hr*ft^2°F/ Btu	°F	
Metal Stud Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.08	99.92
Precast Concrete	2.00	6.25	0.16	2.49	97.43
Air Gap	0.5		0.97	15.10	82.33
Metal Studs	6.00	-	0.00	0.00	82.33
Gypsum	0.75	2.22	0.45	7.00	75.33
Interior Air Film	-	47.13	0.02	0.33	75.00
Total	**9.25**	**0.623**	**1.6**	**25.00**	**75.00**
Insulation Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.01	99.99
Precast Concrete	2.00	6.25	0.16	0.18	99.82
Air Gap	0.5		0.97	1.07	98.74
Batt Insulation	6.00	0.05	21.00	23.22	75.52
Gypsum	0.75	2.22	0.45	0.50	75.02
Interior Air Film	-	47.13	0.02	0.02	75.00
Total	**9.25**	**0.044**	**22.6**	**25.00**	**75.00**

Calculation Results		
Average R-Value	16.3	hr*ft^2°F/ Btu
Total Heat Flow Rate	280.6	btu/hr

Dave Fox
Dr. David Riley
2/27/2008

Wrangle Hill Elementary School
New Castle, DE
Mechanical Breadth

Calculating Heat Gain/Loss in the New Prefabricated Design
Winter

Problem Design Criteria		
Design Temp Change:	55	°F
Area of Wall	183	ft^2
Percentage Stud	30%	
Percentage Insulation	70%	

Element	**Thickness (L)**	**Conductance (C)**	**Thermal Resistance (R)**	**Temp. Change (ΔT)**	**Temperature of Interior Face**
Units	in	Btu / hr*ft²°F	hr*ft²°F/ Btu	°F	
Metal Stud Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.18	15.18
Precast Concrete	2.00	6.25	0.16	5.48	20.66
Air Gap	0.5		0.97	33.21	53.87
Metal Studs	6.00	-	0.00	0.00	53.87
Gypsum	0.75	2.22	0.45	15.41	69.27
Interior Air Film	-	47.13	0.02	0.73	70.00
Total	**9.25**	**0.623**	**1.6**	**55.00**	**70.00**
Insulation Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.01	15.01
Precast Concrete	2.00	6.25	0.16	0.39	15.40
Air Gap	0.5		0.97	2.36	17.76
Batt Insulation	6.00	0.05	21.00	51.09	68.85
Gypsum	0.75	2.22	0.45	1.09	69.95
Interior Air Film	-	47.13	0.02	0.05	70.00
Total	**9.25**	**0.044**	**22.6**	**55.00**	**70.00**

Calculation Results		
Average R-Value	16.3	hr*ft²°F/ Btu
Total Heat Flow Rate	617.2	btu/hr

Annual Heating and Cooling Energy Losses			
Cooling (Summer)		303,010	Btu/Yr
Heating (Winter)		1,316,544	Btu/Yr
Total		1,619,554	Btu/Yr

Energy Cost	**$25.49**

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Wrangle Hill Elementary School
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Calculating Heat Gain/Loss in the New Prefabricated Design
Summer

Problem Design Criteria		
Design Temp Change:	25	°F
Area of Wall	183	ft^2
Percentage Stud	30%	
Percentage Insulation	70%	

Element Units	Thickness (L) in	Conductance (C) Btu / hr*ft^2°F	Thermal Resistance (R) hr*ft^2°F/ Btu	Temp. Change (ΔT) °F	Temperature of Interior Face °F
Metal Stud Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.04	99.96
Precast Concrete	2.00	6.25	0.16	1.28	98.68
Board Insulation	0.5	0.40	2.5	19.93	78.76
Metal Studs	6.00	-	0.00	0.00	78.76
Gypsum	0.75	2.22	0.45	3.59	75.17
Interior Air Film	-	47.13	0.02	0.17	75.00
Total	**9.25**	**0.319**	**3.1**	**25.00**	**75.00**
Insulation Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.01	99.99
Precast Concrete	2.00	6.25	0.16	0.17	99.83
Board Insulation	0.5	0.40	2.5	2.59	97.24
Batt Insulation	6.00	0.05	21.00	21.75	75.49
Gypsum	0.75	2.22	0.45	0.47	75.02
Interior Air Film	-	47.13	0.02	0.02	75.00
Total	**9.25**	**0.041**	**24.1**	**25.00**	**75.00**

Calculation Results		
Average R-Value	17.8	hr*ft^2°F/ Btu
Total Heat Flow Rate	256.5	btu/hr

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Calculating Heat Gain/Loss in the New Prefabricated Design
Winter

Problem Design Criteria		
Design Temp Change:	55	°F
Area of Wall	183	ft^2
Percentage Stud	30%	
Percentage Insulation	70%	

Element Units	**Thickness (L)** in	**Conductance (C)** Btu / hr*ft^2°F	**Thermal Resistance (R)** hr*ft^2°F/ Btu	**Temp. Change (ΔT)** °F	**Temperature of Interior Face** °F
Metal Stud Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.09	15.09
Precast Concrete	2.00	6.25	0.16	2.81	17.90
Board Insulation	0.5	0.40	2.5	43.84	61.74
Metal Studs	6.00	-	0.00	0.00	61.74
Gypsum	0.75	2.22	0.45	7.89	69.63
Interior Air Film	-	47.13	0.02	0.37	70.00
Total	**9.25**	**0.319**	**3.1**	**55.00**	**70.00**
Insulation Portion of Wall Section					
Exterior Air Film	-	193.052	0.01	0.01	15.01
Precast Concrete	2.00	6.25	0.16	0.36	15.38
Board Insulation	0.5	0.40	2.5	5.70	21.07
Batt Insulation	6.00	0.05	21.00	47.85	68.93
Gypsum	0.75	2.22	0.45	1.03	69.95
Interior Air Film	-	47.13	0.02	0.05	70.00
Total	**9.25**	**0.041**	**24.1**	**55.00**	**70.00**

Calculation Results		
Average R-Value	17.8	hr*ft^2°F/ Btu
Total Heat Flow Rate	564.3	btu/hr

Annual Heating and Cooling Energy Losses			
Cooling (Summer)		277,018	Btu/Yr
Heating (Winter)		1,203,612	Btu/Yr
Total		1,480,629	Btu/Yr

Energy Cost	**$23.31**

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Dew Point Analsys for Prefabricated System

Outside RH	80%	
Inside RH	50%	
Outside Pressure	130.24	Pa
Inside Pressure	595.48	Pa
Pressure Change	465.24	Pa

Element	**Thickness (L)**	**Permeability**	**Vapor Resistance (R)**	**Vapor Pressure (P)**	**Saturation Pressure**	**Interior Surface Temp**
Units	m	ng/Pasm	Pasm^2/ng	Pa	Pa	C
			Insulation Portion of Wall Section			
Precast Concrete	0.0508	6.00	8.467E-03	309.41	162.80	-9.44
Board Insulation	0.0127	7.5	1.693E-03	345.25	165.22	-9.24
Batt Insulation	0.1524	245.00	6.220E-04	358.41	207.49	-6.07
Insulation Backing	0.0050	20.00	2.500E-04	363.70	1150.28	20.51
Gypsum	0.0191	20.00	9.525E-04	383.86	1189.11	21.08
Paint	-	100.00	1.000E-02	595.48	1190.96	21.11
Total	**0.24**	**398.5**	**0.022**			

Condensation Rates		
Upstream Flowrate	32812.66	ng/s*m^2
Downstream Flowrate	7603.34	ng/s*m^2
Condensation Rate	25209.32	ng/s*m^2
Condensation Rate	0.0768	oz/day*m^2
Condensation Total	**0.393**	**oz/day per wall**

External Temperature	10 °F
Internal Temperature	70 °F
Temperature Chage	55 °F
Relative Humidity	50%

Temperature Comparison			
	Temperature of Metal Studs	Dew Point	
Design Without Insulation	53.9	55.0	°F
Design With Insulation	61.7	55.0	°F

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Cost Analysis of Energy Consumption

Square Footage in Panel	183 ft^2
Total Square Footage	36,939 ft^2

	Masonry Design	Prefabricated Design	Prefabricated With Insulation	Differential	Units
R-Value	12.8	16.3	17.8	5.1	hr*ft^2°F/ Btu
Heat Flow Rate	787.6	617.2	564.3	-223.3	Btu / hr
Cooling Energy Losses	386,636	303,010	277,018	-109,618	Btu / Yr
Heating Energy Losses	1,679,889	1,316,544	1,203,612	-476,277	Btu / Yr
Total Energy Losses	2,066,524	1,619,554	1,480,629	-585,895	Btu / Yr
Energy Cost	$32.53	$25.49	$23.31	-$9.22	

Extrapoloated Savings Per Year for All Brick and CMU Areas	**$1,861.53**

Appendix F
Photovoltaic Integration

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Results of Photovoltaic Calculation

Photovoltaic Array Located Above Multipurpose Room			
Month	**Solar Radiation ($kWh/m^2/day$)**	**AC Energy (kWh)**	**Energy Value ($)**
1	2.85	1519	$151.90
2	3.81	1844	$184.40
3	4.53	2316	$231.60
4	5.23	2538	$253.80
5	5.66	2738	$273.80
6	6.28	2820	$282.00
7	6.10	2810	$281.00
8	5.50	2530	$253.00
9	4.81	2183	$218.30
10	4.34	2135	$213.50
11	3.00	1477	$147.70
12	2.34	1206	$120.60
Year	**4.54**	**26116**	**$2,611.60**

Photovoltaic Array Located Over NE Wing			
Month	**Solar Radiation ($kWh/m^2/day$)**	**AC Energy (kWh)**	**Energy Value ($)**
1	2.85	1379	$137.90
2	3.81	1675	$167.50
3	4.53	2104	$210.40
4	5.23	2306	$230.60
5	5.66	2487	$248.70
6	6.28	2561	$256.10
7	6.10	2552	$255.20
8	5.50	2298	$229.80
9	4.81	1983	$198.30
10	4.34	1939	$193.90
11	3.00	1342	$134.20
12	2.34	1095	$109.50
Year	**4.54**	**23721**	**$2,372.10**

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PVWATTS Calculation Data

Photovoltaic Array Located Above Multipurpose Room	
City:	Wilmington
State:	DE
Latitude:	39.18° N
Longitude:	76.67° W
Elevation:	47 m
PV System Specifications	
DC Rating:	21.8 kW
DC to AC Derate Factor:	0.77
AC Rating:	16.8 kW
Array Type:	Fixed Tilt
Array Tilt:	20.0°
Array Azimuth:	170.0°
Energy Specifications	
Cost of Electricity:	10 ¢/kWh

Photovoltaic Array Located Over NE Wing	
City:	Wilmington
State:	DE
Latitude:	39.18° N
Longitude:	76.67° W
Elevation:	47 m
PV System Specifications	
DC Rating:	19.8 kW
DC to AC Derate Factor:	0.77
AC Rating:	15.3 kW
Array Type:	Fixed Tilt
Array Tilt:	20.0°
Array Azimuth:	170.0°
Energy Specifications	
Cost of Electricity:	10 ¢/kWh

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Life Cycle Cost Analysis

Cost Comparison

	Multipurpose Room	NE Wing
Number of Panels	160	160
Cost per panel	$563.00	$521.00
Panel Type	PVL-136	PVL-124
Voltage per panel	136 W	124 W
Inverter Costs	$22,500	$22,500
Total System Cost	$112,580	$105,860
DE State Grant	$56,290	$52,930
Federal Tax Credit	$33,774	$31,758
Total Cost of System	$22,516	$21,172
Annual Savings	$2,612	$2,372
Years to Pay Off	8.6	8.9