nexus

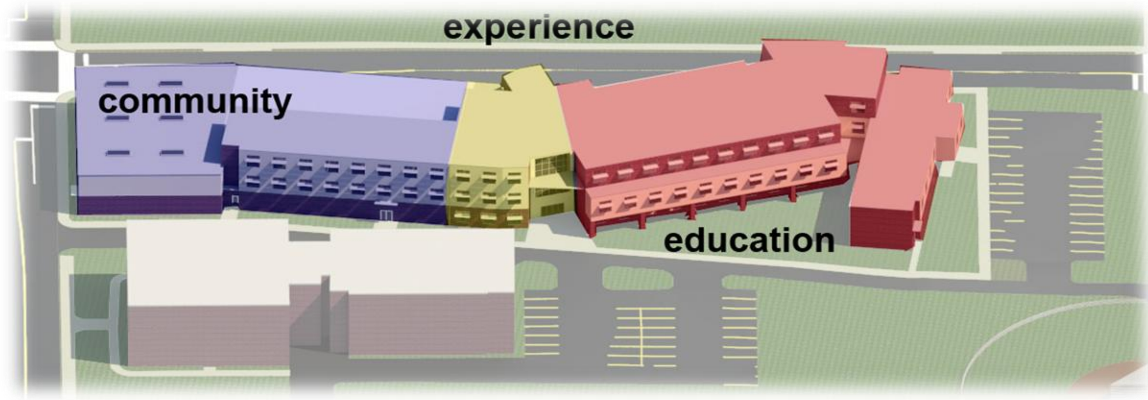
Submission Category: Building Integration

Date: 14 December 2012

Contents

The requirements of a typical elementary school, in conjunction with the socioeconomic conditions of the Reading school district, necessitated unique design decisions and innovative solutions. To achieve these solutions, a set of categories was created to define the purpose of each space in the school. It was determined that the three major functions of the building included **Experience**, **Community**, and **Education** spaces. The function of these three unique spaces dictated the integrated design of the various building systems, as well as the manner of dividing the building in terms of system types and discipline coordination. As such, these three sections will be the key areas of discussion and integration in the following content.

1. Executive Summary



1.1 Introduction

The experience aspect of Nexus' design encompasses the façade and lobby portions of the school building. The integration of insulated concrete form exterior bearing walls, exterior window louvers, and metal panels create a distinctive aesthetic appearance for the new elementary school. An inviting three-story lobby welcomes students and community members into the main throughway of the school. This lobby acts as a bridge between the community and education portions of the school. The lobby is also a critical point for the building systems as it acts as the dividing zone for the mechanical system and an essential discontinuity in the structural system to satisfy lateral loads.

Community involvement is an integral aspect of Nexus' school design. The West end of the school contains a 24-hour health center, multi-purpose gymnasium, and a proposed second construction phase natatorium which is available to community members after school hours. These community areas are separate from the education portion of the building to ensure student safety and school security. Moreover, this portion of the building is serviced by separate mechanical and electrical systems along with an enhanced structural system. The proximity of the health center to the multi-purpose room is convenient since the multi-purpose room functions as a shelter in the case of a natural disaster.

As it is the primary purpose of the school building, the educational portion is the most innovative part of Nexus' design. The main focus of this area was to create a learning environment that is augmented by the building systems. Designing to maximize efficient daylighting and an exposed ceiling creates an open-air environment conducive to early childhood education. This open-air feel is heightened by a mechanical system that provides more fresh air along with a lean structural system that allows for classroom flexibility. All of these aspects combine to create learning spaces that excite young learners and encourage them to attend and participate in school.

1.2 BIM Execution Plan

The inception of this project involved understanding the given data and information regarding the new elementary school in Reading, Pennsylvania. Nexus developed a "BIM Execution Plan" to help all four disciplines integrate their building systems. This execution plan specifically defines the roles to be fulfilled by the construction managers, structural engineers, mechanical engineers, and lighting/electrical engineers (see Appendix 2). In creating the BIM Execution plan each design discipline created their own independent goals to achieve the overall team Nexus goals (as shown in Figure 1). In addition, The BIM Execution Plan defines the information exchanges between the four disciplines. This facilitated progress by recognizing the individual discipline decisions that comprise the overall building design and are crucial to maintain progress of the critical path during the design process. (see Appendix 4).

Figure 1: BIM Roles & Responsibilities

Outlining objectives and goals was necessary to facilitate each discipline's ability to work independently and produce their respective system designs. By defining these goals, each of Nexus' disciplines had a mutual understanding of the expectations of the team's final product. This prevented the team from having to perform unnecessary or additional work. Increasing the team's efficiency and effectiveness was critical throughout this project for each discipline to meet the several interim submissions scheduled by Nexus. Thus, the time spent planning in the early phases of this competition's project facilitated more productive team communication and progress meetings. Thus, the interrelatedness of Nexus' building systems reduces redundancy and enhances the architecture of the school building (See Figure 2).

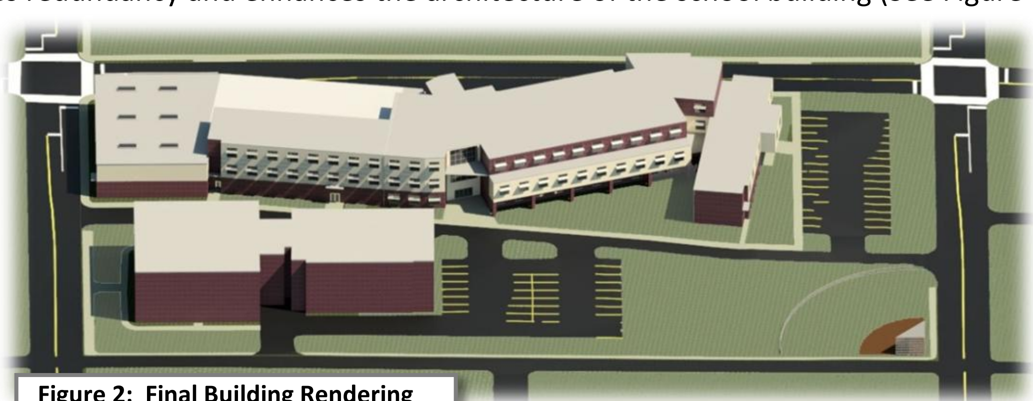


Figure 2: Final Building Rendering

1.3 Owner Goals

Nexus defined several owner objectives for the construction of Reading School District's new elementary school. The objectives can be lumped into three categories below:

safety & security

First, safety is a concern for Reading School District, the parents in the community, and most importantly the students of the district. By increasing the safety on the elementary school campus, students feel more comfortable and willing to come to school. As a result, student attendance rates are expected to rise with Nexus' design. In addition, having a sense of 'unseen' security will enhance the feeling of safety in the new building.

lifecycle & maintenance

Second, Reading School District desires a building that can endure for 100 years. Yet, this building must be adaptable and flexible with new emerging technologies, learning styles, and teaching techniques. The flexibility of the spaces helps prolong the buildings lifecycle while the systems selected minimize the need for routine maintenance. Reading School District also needs buildings systems that their maintenance personnel can be trained to operate properly.

cost effective

Third, Reading School District wants a building that is both cost effective in the short term, but also cost efficient in the long term. The city of Reading is economically disadvantaged and therefore does not have the necessary funds to support the construction of a new elementary school. Moreover, they receive little state and federal funding due to the poor testing performance of their students. By reducing initial cost, and maintaining a low life-cycle (operations and maintenance) cost, Reading will be able to afford this much needed elementary school and reduce its impact on their future budget. Nexus' building system and material selections alleviate first costs, while maintaining the integrity and affordability in the long run.

All of these goals are continually reiterated through the design decisions for the Reading Elementary school. As such, in considering these goals with the utmost importance, it was decided that the following Mission Statement be the foundation and guideline for the Nexus design decisions.

Team Nexus Mission Statement:

Nexus' mission is to develop a design that merges education with the community in a facility that is safe and cost effective while functioning as a learning tool.

1.4 Nexus Project Goals

Nexus' project goals help achieve the owner objectives and are supported by the individual discipline goals. Nexus' project goals can also be separated into three main categories, as can be seen below:

integration

First, integration is the all-encompassing goal of meeting the owner's objectives. Integration involves not only team work and collaboration, but also the integration of the building systems and components. As the main theme of the architecture of the building was already established, Nexus focused on integrating the structural, mechanical, and electrical aspects of the building through predefined discipline goals and established information exchanges.

reduce, recover, reuse

Second, this holistic building integration was produced through lean practices. These lean practices include reduce, reuse, recover. Reduce, reuse, recover involves all disciplines. Construction management will save on schedule time and building cost, structural engineering with materials, and mechanical and lighting/electrical engineering with energy.

learning tool

Third, Nexus desired to create a building that could be used as a learning tool for the end users. The building has exposed ceilings, painted and exposed structural, mechanical, and electrical elements, along with an exterior façade and site that can be used as teaching tools. All of these items were coordinated through extensive planning and team performance requirements.

Narrative Description of Systems/Solutions

1.5 Site & Building Considerations

In order to meet the owner's objectives of safety and flexibility, Nexus deemed it necessary to reposition the building on the site. Prior to further developing a learning environment, establishing site safety was imperative to all end-users. Reading is near the top of the crime rate list in Pennsylvania, so Nexus focused heavily on the importance of maintaining the safety and security of the students. As seen in Figure 3, the main entrance was originally along a busy road. In order to maintain the secure feel, Nexus turned the educational campus in on itself to shelter the students (see Figure 4).

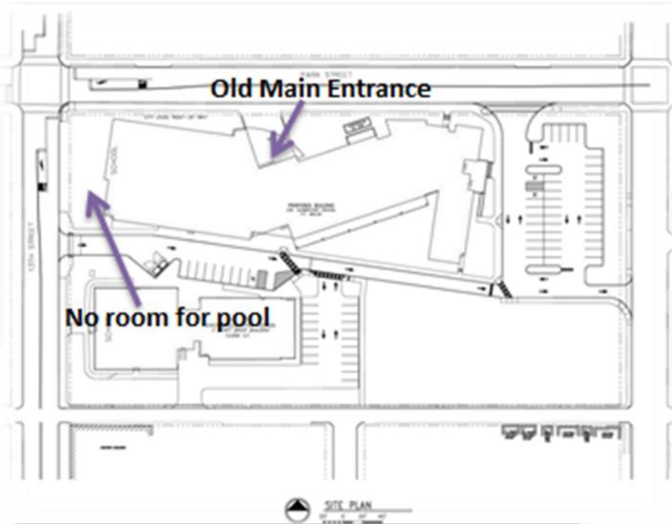


Figure 3: Site Plan provided by AEI Competition

This inward turn moved the main entrance from the north to the south facade creating a large group congregation space on the inside of the campus. This area allows students to congregate away from the main roads and the dangers of the community.

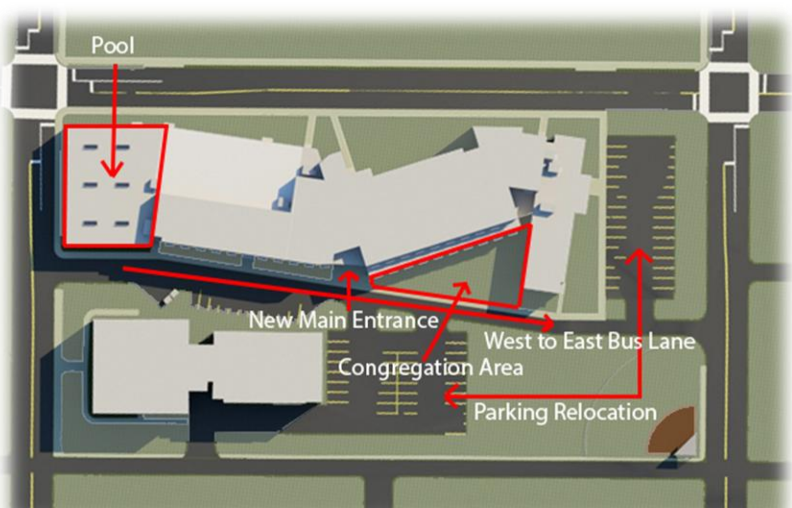


Figure 4: Nexus site plan (building moved east, parking reallocated, pool addition)

The original site plan also did not provide sufficient space for a pool. Figure 4 shows how the building was shifted to the east in order to make room for the proposed pool. This shift displaced some of the parking which has been relocated in the southern lot. This relocation of the parking brings more parking closer to the new main entrance of the building as an added benefit of this design. The baseball field proportions were not affected, thus maintaining the existing playground area. The bus lane will remain one way, with traffic progressing from west to east.

1.6 Experience

An integrated approach was taken when forming the façade of the building. Ultimately a brick on concrete bearing wall system was chosen. The concrete wall is made with Insulated Concrete Forms (ICFs). This decision was made with the input of all team members as each discipline is affected. Insulated Concrete Forms are stay-in-place concrete forms that consist of two pieces of rigid insulation bridged with plastic bridging in between on which to place rebar. The entire façade consists of the insulated concrete forms, which is six-inches of concrete in between two pieces of inch-and-a-half rigid insulation, a half in air space and exterior brick on most of the building and colored aluminum in some places, while the interior is impact resistant gypsum wall board (as shown in Figure 6.)

Figure 5: Main Entrance on South Façade

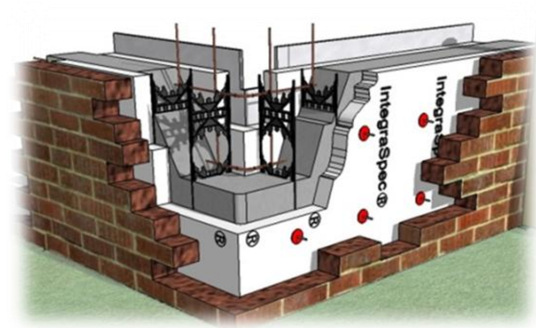


Figure 6: ICF Isometric Section: (www.integraspec.ie)

By putting the main entrance on the interior part of the site increases the 'unseen' sense of security. The theme of safety was carried into the building by maintaining one secure entrance as shown in Figure 5. The one entrance ensures that no unwanted visitors enter the school, which is crucial at an elementary school with small, school-aged children. This is the only secure point of entry into the building during school hours. All visitors must come in through the double doors and then turn left and check in at the front desk. This can be seen in Figure 7. There is also an entrance to the community side of the building that is accessible to the public during off hours to prevent visitors from entering the classroom wing.

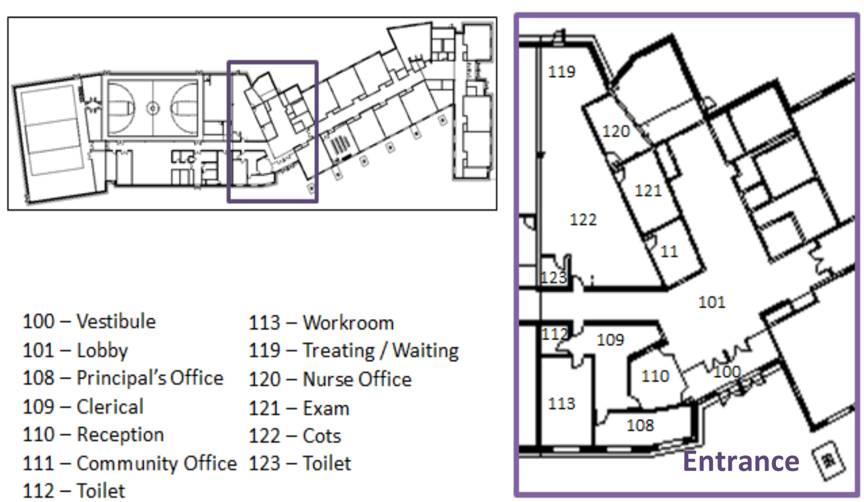


Figure 7: First Floor Plan with Enlarged Image of Redesigned Lobby

1.7 Community

The multipurpose room is one of the most interesting spaces in the school as it is used in many different ways. During school, this space functions as the cafeteria for the students during lunch. One consequence of using the space as a cafeteria is the increased thermal load, which was addressed during the design of the mechanical system.

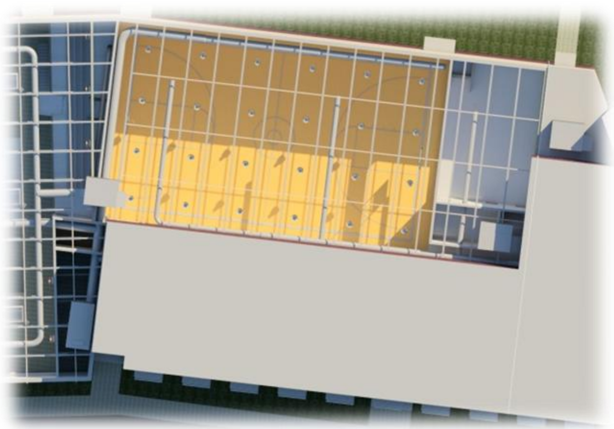


Figure 8: Aerial Section of Multipurpose Room

Another obvious purpose for the room is its use as a gymnasium for classes and after-school sporting events. The depth of the roof joists was limited to 40 inches, and the mechanical ducts are nestled between the walls and the joists so that they do not interfere with sporting events. The design for the multipurpose space also includes a stage for performances. Therefore, acoustics in the space were another design factor. To improve the acoustic quality of the space, slotted CMU walls and acoustical roof deck will be used. Since the performances in the space will call for versatility in the lighting system, the space uses compact fluorescent lamps that have a short restrike time. This way, the lighting in the space can be adjusted easily depending on how the room used.

The multipurpose room also acts as an emergency shelter. One of the requirements of the shelter is that it cannot include windows in the event of potential projectiles. The room also requires strong exterior walls, which are adequately provided by the exterior ICF walls. Lastly, the roof structure of the building must be heavy enough to resist uplift during wind storms. Therefore, the same slab and deck system used for the floors elsewhere in the building is used to achieve the required mass.

Figure 9: View of pool from balcony

The swimming pool functions as a direct link to the community. The pool is six lanes which will be used primarily for recreational purposes. The trusses in this space are similar to the gym, however they are 5' deep and spaced 8.5' apart. This allows for the mechanical ductwork to run directly through the trusses. The conditioned air will be supplied along the perimeter of the pool enclosure. As per ASHRAE HVAC Applications, the pool water will be heated to 80°F and the air temperature will be conditioned to approximately 82°F. This space has a peak heating load of approximately 350 MBh.

There is one large window on the north size of the pool enclosure. This will allow daylight to penetrate the space while not allowing direct glare. Six skylights will be constructed in the ceiling to provide additional daylight. The lighting fixtures will be wall-mounted and placed along the perimeter of the entire enclosure.

1.8 Education

With **Education** obviously being the most important component of our building, this became our key area of focus in terms of integrating systems to provide an optimized learning environment. This area too, presented some of the most challenges as the academic design is the driving factor in the owner and team Nexus goals. To ensure the building acts as learning tool, the decision was made to expose discipline systems in the classrooms to facilitate an understanding of how the building works. This alone presented many challenges in maintaining a practical functionality of the space and balancing system efficiency with architectural aesthetics.

As is visible in Figure 10, by exposing the ceiling in the classroom, the 14' ceiling height creates a large open feeling. As previously mentioned students will be able to see the color coded systems that comprise the space, starting with the 20" deep structural steel members that support the acoustic metal decking for the floor above.

Figure 10: Student classroom perspective

Additionally the students will be able to see the exposed ductwork conditioning the space. The space will utilize a 100% outdoor air system as studies show that increased ventilation rates improve teacher and student performance. This system we are able to decrease the size of the ductwork which allows for more a more compact design within a lateral chase running along the hallways, as well as a decrease in initial costs. This section is also where the mechanical system splits from the **Public** and **Experience** parts of the building. One supply outdoor air handler will be coupled with one exhaust outdoor air handler so that they may be turned down or even off when this side of the facility is not being used.

Figure 11: Teacher classroom perspective

An additional aspect of increasing the quality of this environment was to bring natural light into the space. Studies show that daylighting is an intrinsic part of improving overall learning capabilities of students. Increased daylighting too, will save money by reducing electrical lighting costs. Special considerations were made in the functionality of each window to allow for optimized solar penetration at each façade. The south facing windows are designed with both an exterior overhang and an interior light shelf as is shown in Figure 12. The exterior overhang will prevent direct penetration into the classroom during the summer. The interior light shelf will reflect the solar rays up and into the space so that it is lit with ambient daylighting.

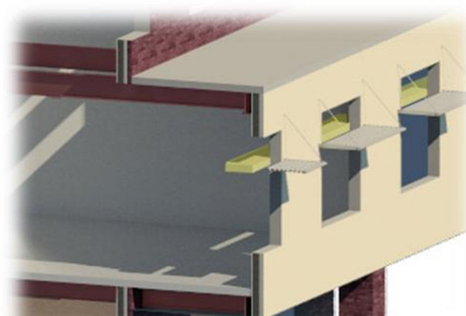


Figure 12: Close-up of windows with solar shading

The classrooms will also have manual shades that the teacher can use to control the amount of daylight. The primary lighting sources are the two rows of direct-indirect T5 pendants. The second electrical lighting source is a wall-mounted indirect uplight that runs along the top of the black board to prevent glare.

2. Rationale for Systems/Solutions

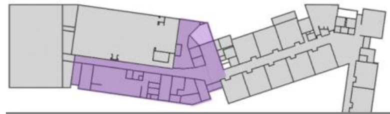


Figure 13: Experience highlighted on first floor plan

2.1 Experience

The façade of our building is a very integrated facet of the building design and it took input from all of the disciplines to make it work. As previously stated, the building façade is an exterior brick on concrete bearing wall system and again, the concrete wall is made with Insulated Concrete Forms (ICFs). From a construction management standpoint, ICFs are easily transportable and lightweight in addition to being easily erected. The ICFs too, provide different structural purposes. They serve as bearing walls in the gravity structural system in addition to being shear walls for the lateral structural system. Moreover, other than the ICF stairwell, the structural system is comprised of all steel.

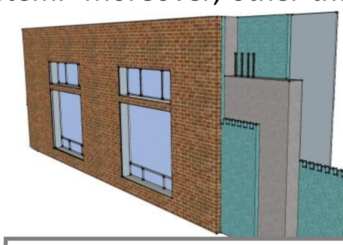


Figure 14: Isometric Section of Nexus ICF wall

One of the primary focuses in designing the façade was ensuring it improved the energy efficiency of the building. The ICF's have an R-value of twenty-four which is more than double that of a typical façade system and greatly exceeds the minimum R-values recommended by ASHRAE for this region. Along with being a good thermal insulator, ICFs are also very airtight and do not need additional waterproofing due to the extruded polystyrene insulation on both sides of the concrete as shown in Figure 14.

One of the project goals was to provide plenty of daylight to the classroom spaces to promote an enjoyable learning environment, but typically having large windows is not possible in a concrete bearing wall system. In response to this, a window system was developed that both provided enough daylight and worked with the gravity structural system. Seven foot wide window with seven foot spacing were implemented into the classrooms. These windows fit into the structural system perfectly so that only one beam falls over each window and the concrete wall is deep enough to carry the load from the beam. Also, the seven foot wide windows with seven foot spacing create a repetitive pattern which is desirable for construction.

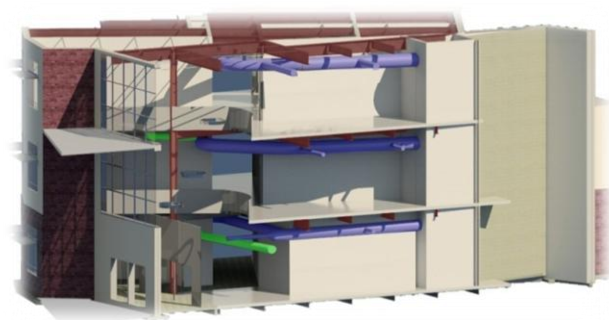


Figure 15: Building System

The cantilever over the entrance serves as an architectural element to welcome students into the building. It too serves the purpose of blocking direct solar heat gain during the summer. The atrium allows sunlight into the core of the building and further into the corridors. This requires the necessity of fewer luminaires. The lobby serves as the "knuckle" to the building because it is where both the structure and the mechanical system split. The ducts then run through the hallway below the structural grid. The addition of the atrium also created flexible learning space on the second and third floors that was not included in the original scope. This area can be seen behind the female in Figure 16. These spaces can be used as a reading nook or allow teachers to get their students out of the classroom and into a new more open space. These spaces are well lit thanks to the hanging pendants and the daylight that filters in through the curtain wall.

Figure 16: Site Plan provided by AEI

2.2 Community

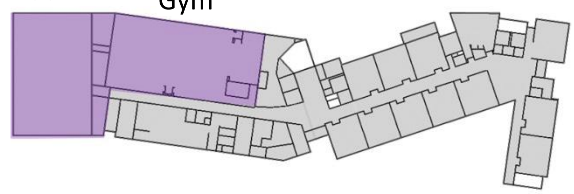


Figure 17: Community Wing Highlighted on First Floor Plan

This project is being funded primarily through public means, so having a public space within the building that could be used by the community was an important feature that Nexus wanted to include. The first of these is the multipurpose room which is designed to be used in a number of different ways. Thus flexibility was the largest design consideration for this space. The use of roof joists that are 40 inches deep was decided to also provide space for mechanical ductwork. Although the design team wanted to minimize the overall height of the roof structure, the depth was decided to integrate the mechanical system with the required strength for the heavier roof structure due to the emergency shelter design criteria.

Another difficult decision made was the exclusion of windows from the space. Since the space is also serves as an emergency shelter, it was determined that the safest and most cost-effective solution for protecting against projectiles would be to exclude windows and skylights from the space. This decision made the need for a flexible lighting system even greater. For this reason a fluorescent lighting system was chosen for the room. The exterior walls of the building also meet the projectile requirements. Although designing this space as an emergency shelter introduced added costs, these costs will be minimal and will give back to the community. This too will meet the project goals of increasing safety and security of not just the students but the community as well. The multipurpose room is truly a centerpiece of the Nexus triangle of community, experience, and education. It provides members of the community with a place to play pick-up basketball games in the evenings and a safe place to go during emergency situations. It too gives students and parents a place to experience school plays and band performances while also providing increased opportunities for physical health and education.

Figure 18: The multipurpose room can be used for stage performances or basketball games

The second community space is the pool which being designed as an add-alternate should the community want to build it at a later date due to funding restrictions. This falls under special construction, which accounts for approximately 12% of the overall building cost as shown in Table 1 below. If the school board chooses not to move forward with constructing the pool, the extra $2,500,000 could be allocated at the school board’s discretion.

A major decision that had to be made early on was the design of the windows for this space. Concerns included the possibility of direct glare in swimmers eyes and also the heat loss that would occur through the glazing. Therefore, one large window on the north wall was deemed the best solution as shown in Figure 19. This window will allow daylight to penetrate the space with no direct glare. The glass chosen has a low U-value of 0.28 and solar heat gain coefficient of 0.23. The skylights will be constructed using diffuse glass to again ensure no direct glare will affect the swimmer's experience.

Cost Breakdown w/ Pool				
		Cost/SF	% of Cost	Cost
Division 1	General Requirements	$ 11.73	6%	$ 1,050,000
Division 2	Existing Conditions	$ 5.86	3%	$ 525,000
Division 3	Concrete	$ 31.28	16%	$ 2,800,000
Division 4	Masonry	$ 15.64	8%	$ 1,400,000
Division 5	Metals	$ 15.64	8%	$ 1,400,000
Division 6	Wood, Plastics, and Composites	$ 1.95	1%	$ 175,000
Division 7	Thermal and Moisture Protection	$ 7.82	4%	$ 700,000
Division 8	Openings	$ 11.73	6%	$ 1,050,000
Division 9	Finishes	$ 7.82	4%	$ 700,000
Division 10	Specialties	$ 1.95	1%	$ 175,000
Division 11	Equipment	$ 1.95	1%	$ 175,000
Division 12	Furnishings	$ 3.91	2%	$ 350,000
Division 13	Special Construction	$ 1.95	1%	$ 175,000
	Pool	$ 27.93	-	$ 2,500,000
Division 14	Conveying Equipment	$ 1.95	1%	$ 175,000
Division 21	Fire Supression	$ 1.95	1%	$ 175,000
Division 22	Plumbing	$ 15.64	8%	$ 1,400,000
Division 23	HVAC	$ 33.23	17%	$ 2,975,000
Division 26	Electrical	$ 17.59	9%	$ 1,575,000
Division 28	Electronic Safety and Security	$ 3.91	2%	$ 350,000
Division 32	Exterior Improvements	$ 1.95	1%	$ 175,000
	Cost / SF	**$ 223.41**	**Total**	**$ 20,000,000**

Table 1: Cost Break Down with Pool

The ductwork layout was designed to keep continuous airflow over the window to prevent condensation. This will also prevent drafts from directly hitting the swimmers in the pool, as this could be uncomfortable. Another concern of the mechanical design was the chemicals used to treat the pool water. The evaporated tri-chloramines from the pool water can cause air quality problems that link to eye, nose, and throat irritation. These chemicals are also corrosive to the building system and equipment. Protective coatings will be applied to the necessary structure and mechanical systems to ensure the removal of these vapors while protecting the integrity and longevity of the systems.

Figure 19: Interior pool perspective rendering

The proposed pool design meets many of our stated goals. The lighting scheme was designed with operation and maintenance in mind. No fixtures were placed over the pool surface; there are wall-mounted fixtures lining the perimeter. This will allow for ease of maintenance because no bulbs will need to be changed over the water surface. The pool was also one of the spaces the different disciplines that make up Nexus worked together the most. As previously mentioned, the window design impacted both the lighting and the mechanical systems. The truss structure was sized with the ductwork in mind. The openings in the trusses are large enough for the mechanical ductwork to run through unencumbered.

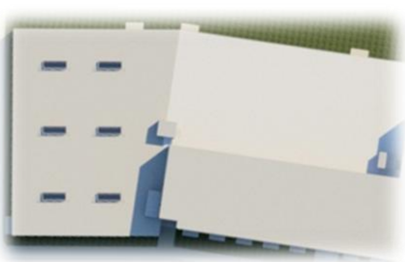


Figure 20: Aerial view of pool skylight layout

2.3 Education

Figure 21: Education Wing Highlighted on Building Floor Plan with Structural Bay Redesign Called out in Red

As with the other aspects of our building design we first looked into initial costs and potential savings that could be made from the original drawings. It was determined that a method of modularization be developed to decrease construction schedule as well as the associated labor costs. The reasoning for this decision was based on the redundancy and continuity of each classroom in this side of the building. It made sense to standardize these rooms in a method of facilitating and expediting the construction process as all of these spaces will require the same design considerations. To achieve this, the first unique component was the redesign of the structural system. The original building design called for two rows of interior columns that lined the internal corridor as is shown in Figure 22.

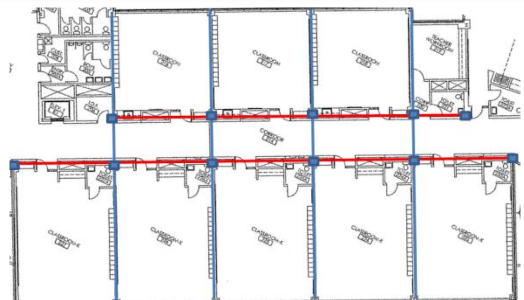


Figure 22: Original Structural Configuration

It was determined that one of these column lines be eliminated as to create a standardized bay size and an axis of symmetry along the column line as is shown in Figure 23. This standardization of the structural grid will greatly expedite the manufacturing and construction process while reduces the possibility for errors.

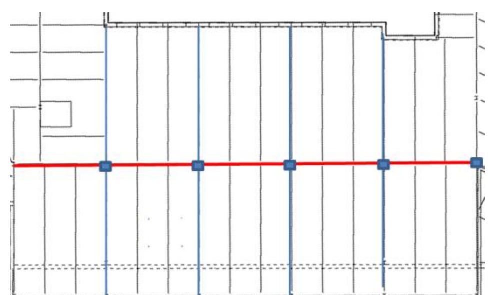


Figure 23: Revised Structural Grid

In order to achieve this, several other components had to be taken into account with regard to other disciplines. Although the original structural grid configuration had more columns, connections, and footings (ultimately driving up initial cost and construction time), this initial configuration provided a large plenum space to run the necessary ductwork and piping along the corridors. As such, in continuation of the modularization of this section of the building, lateral mechanical chases were developed to run the supply and exhaust ductwork for the 100% OA mechanical system. These chases run on either side of the corridor and allow for a continuous duct runs along the length of this part of the building as is shown in Figure 24.

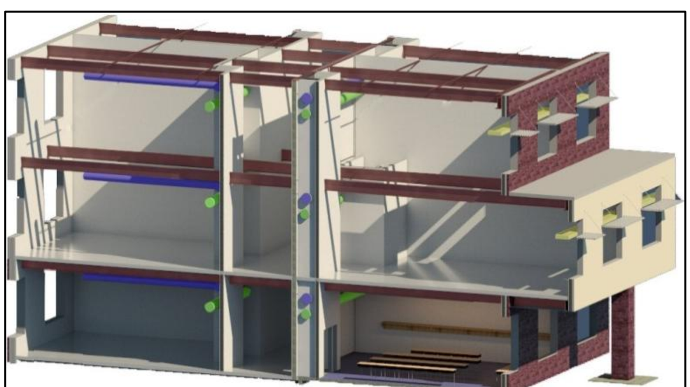


Figure 24: Building Section showing Mechanical System running along hallway in lateral chase

As can be seen in the above figures, the mechanical system will utilize round duct work. Round duct work is actually cheaper to make and install. This will allow for savings in initial and construction costs. Additionally, round duct provides more an aesthetic finish than that of utilitarian rectangular applications. Because of this, it was decided to expose these round ducts in certain areas of the lateral chase to increase the design goal of making the building a learning tool. This is too will save on costs of building a bulkhead to house this lateral chase along the span of the corridor.

2.4 Sustainability / LEED

LEED 2009 for Schools New Construction and Major Renovations

Project Checklist

Project Name

Date

Y	?	N		Sustainable Sites	Possible Points: 24
Y			Prereq 1	Construction Activity Pollution Prevention	
Y			Prereq 2	Environmental Site Assessment	
			Credit 1	Site Selection	1
			Credit 2	Development Density and Community Connectivity	4
			Credit 3	Brownfield Redevelopment	1
			Credit 4.1	Alternative Transportation—Public Transportation Access	4
			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
			Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	2
			Credit 4.4	Alternative Transportation—Parking Capacity	2
			Credit 5.1	Site Development—Protect or Restore Habitat	1
			Credit 5.2	Site Development—Maximize Open Space	1
			Credit 6.1	Stormwater Design—Quantity Control	1
			Credit 6.2	Stormwater Design—Quality Control	1
			Credit 7.1	Heat Island Effect—Non-roof	1
			Credit 7.2	Heat Island Effect—Roof	1
			Credit 8	Light Pollution Reduction	1
			Credit 9	Site Master Plan	1
			Credit 10	Joint Use of Facilities	1

				Water Efficiency	Possible Points: 11
Y			Prereq 1	Water Use Reduction—20% Reduction	
			Credit 1	Water Efficient Landscaping	2 to 4
			Credit 2	Innovative Wastewater Technologies	2
			Credit 3	Water Use Reduction	2 to 4
			Credit 3	Process Water Use Reduction	1

				Energy and Atmosphere	Possible Points: 33
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
			Credit 1	Optimize Energy Performance	1 to 19
			Credit 2	On-Site Renewable Energy	1 to 7
			Credit 3	Enhanced Commissioning	2
			Credit 4	Enhanced Refrigerant Management	1
			Credit 5	Measurement and Verification	2
			Credit 6	Green Power	2

				Materials and Resources	Possible Points: 13
Y			Prereq 1	Storage and Collection of Recyclables	
			Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 2
			Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
			Credit 2	Construction Waste Management	1 to 2

Y	?	N		Materials and Resources, Continued	
			Credit 3	Materials Reuse	1 to 2
			Credit 4	Recycled Content	1 to 2
			Credit 5	Regional Materials	1 to 2
			Credit 6	Rapidly Renewable Materials	1
			Credit 7	Certified Wood	1

				Indoor Environmental Quality	Possible Points: 19
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
Y			Prereq 3	Minimum Acoustical Performance	
			Credit 1	Outdoor Air Delivery Monitoring	1
			Credit 2	Increased Ventilation	1
			Credit 3.1	Construction IAQ Management Plan—During Construction	1
			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
			Credit 4	Low-Emitting Materials	1 to 4
			Credit 5	Indoor Chemical and Pollutant Source Control	1
			Credit 6.1	Controllability of Systems—Lighting	1
			Credit 6.2	Controllability of Systems—Thermal Comfort	1
			Credit 7.1	Thermal Comfort—Design	1
			Credit 7.2	Thermal Comfort—Verification	1
			Credit 8.1	Daylight and Views—Daylight	1 to 3
			Credit 8.2	Daylight and Views—Views	1
			Credit 9	Enhanced Acoustical Performance	1
			Credit 10	Mold Prevention	1

				Innovation and Design Process	Possible Points: 6
			Credit 1.1	Innovation in Design: Specific Title	1
			Credit 1.2	Innovation in Design: Specific Title	1
			Credit 1.3	Innovation in Design: Specific Title	1
			Credit 1.4	Innovation in Design: Specific Title	1
			Credit 2	LEED Accredited Professional	1
			Credit 3	The School as a Teaching Tool	1

				Regional Priority Credits	Possible Points: 4
			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1

				Total	Possible Points: 110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

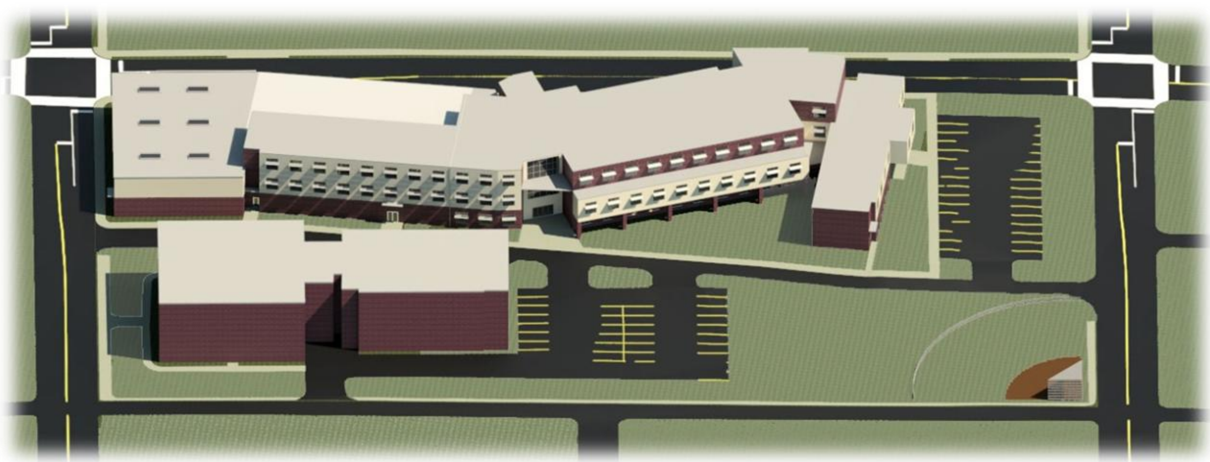
Figure 25: LEED Checklist

It is believed that this building, in our inclusion of many sustainable and cost effective methods due to the integrated design of Team Nexus will be able to achieve a minimum of LEED Certification. It is a goal to push the building performance and material selection to a degree of achieving LEED Silver. This will provide the school with a $500,000 Credit that will help to offset the overall building construction costs. Achieving LEED certification helps meet the district's objective of lifecycle savings. Nexus took the approach of focusing on the learning environment in order to meet this requirement. An excellent example of this is the mechanical system. In order to create a comfortable learning environment the mechanical system had to be sized to improve indoor air quality by increasing the amount of outside air provided. The motive for this was improving the learning environment but it in turn also helped us meet LEED requirements under the indoor environmental quality category. The learning environment mentality also applies to the water efficiency, energy and atmosphere, materials and resources, and sustainable site categories. Additionally the mechanical system will reduce energy costs by up to 65% percent while the facility is in use during the academic school year. This provides tremendous savings to the school district. If the school were to be in full use year round the mechanical system would still be able to reduce energy costs associated with the building loads by about 50%. See Figure 25 LEED Checklist. In total, the decisions made in the integrated design process facilitate an improved learning environment while practicing sustainable methods that will ultimately improve the quality experienced by the occupants.

4 Concluding Summarization

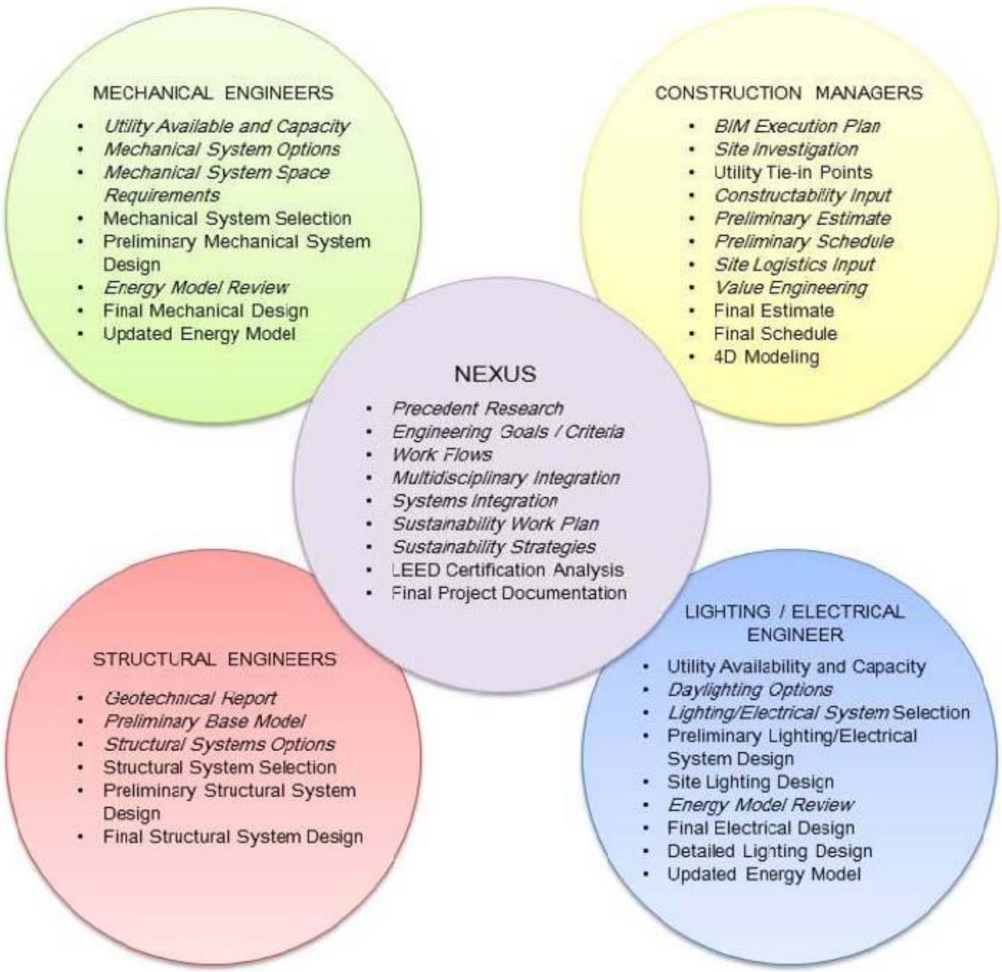
In conclusion, Nexus believes it has met Reading School District's owner objectives through the support of the project and discipline specific goals. The goals set forth by Nexus were created in order to deliver a building that satisfies the needs of the students, teachers, and community members. Nexus is confident that the proposed elementary school successfully achieves and exceeds the district's objectives. The Reading Elementary school contains a plethora of examples of innovative design solutions through each of the integrated disciplines working on the project.

The distinguishing figure below represents the union of the experience, community, and education portions of the school building. Each building section operates amongst itself to service a distinctive function while also supporting its two other building section counterparts. The experience portion welcomes all individuals onto the campus and creates a sense of security. This leads people to the community portion of the school where essential needs are met for the local area. Most importantly, the educational portion of the school is bolstered by the efficient building systems and support areas, while serving as the foundation of each individual student's first learning endeavor, developing them into productive community members.

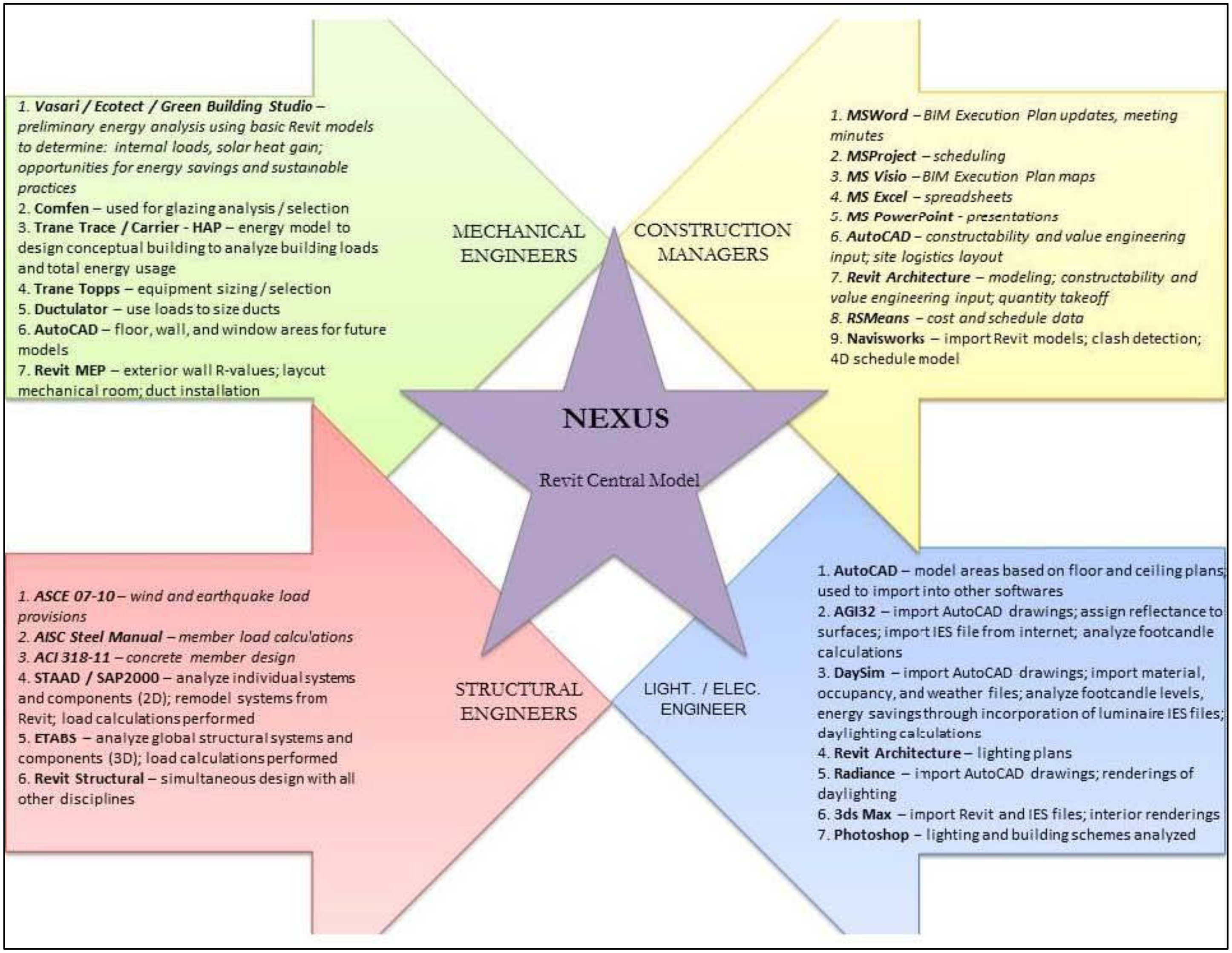


II. Supporting Documentation

Appendix A : Nexus Discipline Roles and Responsibilities



Appendix A: Nexus Software Information Exchanges



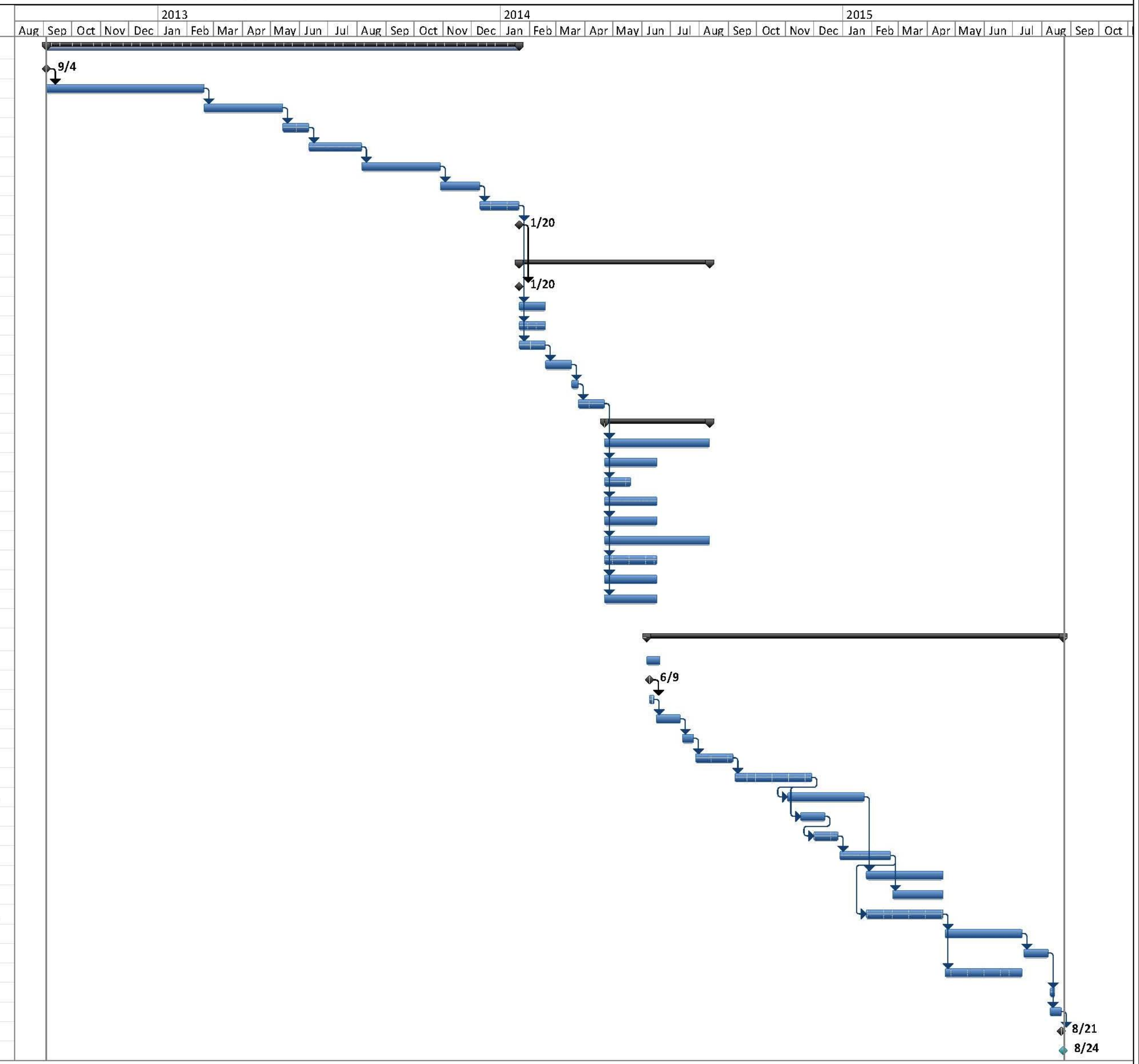
Appendix B: Cost Breakdown (without pool)

Cost Breakdown				
		Cost/SF	% of Cost	Cost
Division 1	General Requirements	$ 11.73	6%	$ 1,050,000
Division 2	Existing Conditions	$ 5.86	3%	$ 525,000
Division 3	Concrete	$ 29.32	15%	$ 2,625,000
Division 4	Masonry	$ 15.64	8%	$ 1,400,000
Division 5	Metals	$ 17.59	9%	$ 1,575,000
Division 6	Wood, Plastics, and Composites	$ 1.95	1%	$ 175,000
Division 7	Thermal and Moisture Protection	$ 7.82	4%	$ 700,000
Division 8	Openings	$ 11.73	6%	$ 1,050,000
Division 9	Finishes	$ 7.82	4%	$ 700,000
Division 10	Specialties	$ 1.95	1%	$ 175,000
Division 11	Equipment	$ 1.95	1%	$ 175,000
Division 12	Furnishings	$ 3.91	2%	$ 350,000
Division 13	Special Construction	$ 1.95	1%	$ 175,000
Division 14	Conveying Equipment	$ 1.95	1%	$ 175,000
Division 21	Fire Supression	$ 1.95	1%	$ 175,000
Division 22	Plumbing	$ 15.64	8%	$ 1,400,000
Division 23	HVAC	$ 31.28	16%	$ 2,800,000
Division 26	Electrical	$ 17.59	9%	$ 1,575,000
Division 28	Electronic Safety and Security	$ 3.91	2%	$ 350,000
Division 32	Exterior Improvements	$ 3.91	2%	$ 350,000
	Cost / SF	**$195.48**	**Total**	**$ 17,500,000**

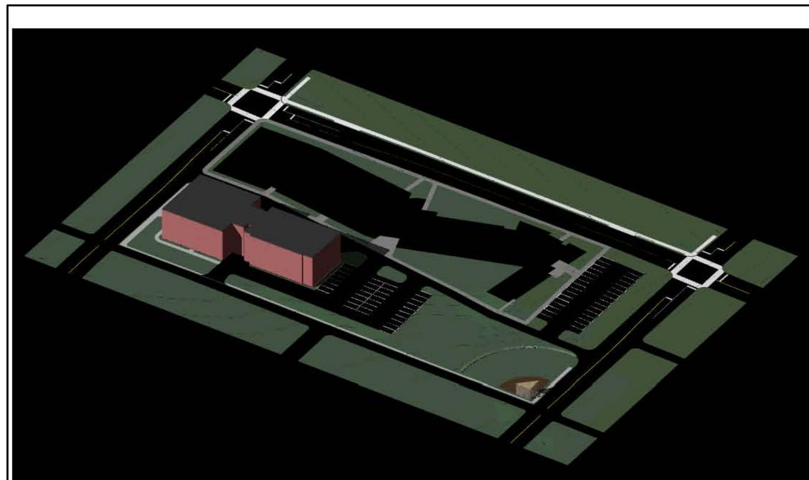
Appendix C: Design, Preconstruction, and Milestone Construction Schedule

Reading Area School District
New Elementary School

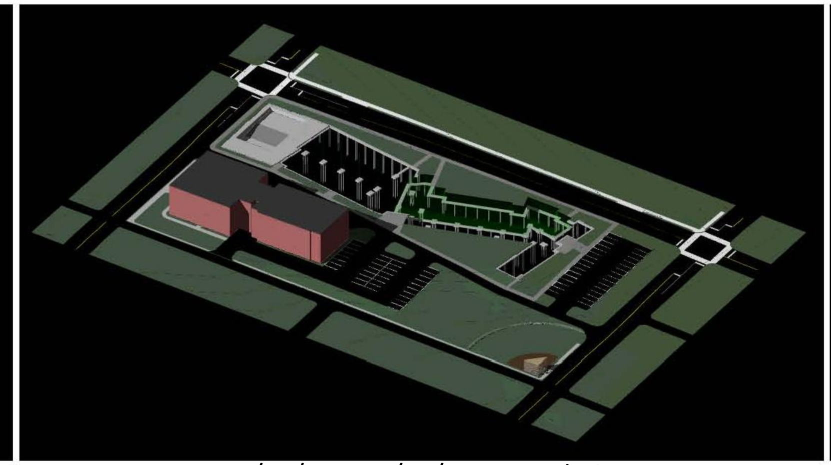
ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			**Design**	**360 days**	**Tue 9/4/12**	**Mon 1/20/14**	
2			*Notice to Proceed*	0 days	Tue 9/4/12	Tue 9/4/12	
3			Feasibility Study	6 mons	Tue 9/4/12	Mon 2/18/13	2
4			Programming	3 mons	Tue 2/19/13	Mon 5/13/13	3
5			Conceptual Design	1 mon	Tue 5/14/13	Mon 6/10/13	4
6			Schematic Design	2 mons	Tue 6/11/13	Mon 8/5/13	5
7			Design Development	3 mons	Tue 8/6/13	Mon 10/28/13	6
8			50% Construction Documents	1.5 mons	Tue 10/29/13	Mon 12/9/13	7
9			Construction Documents	1.5 mons	Tue 12/10/13	Mon 1/20/14	8
10			*Substantial Completion*	0 days	Mon 1/20/14	Mon 1/20/14	9
11							
12			**Preconstruction**	**145 days**	**Mon 1/20/14**	**Mon 8/11/14**	
13			Design Complete	0 days	Mon 1/20/14	Mon 1/20/14	10
14			Estimate Complete	1 mon	Tue 1/21/14	Mon 2/17/14	9
15			Bid Schedule Complete	1 mon	Tue 1/21/14	Mon 2/17/14	9
16			Scopes of Work Defined	1 mon	Tue 1/21/14	Mon 2/17/14	9
17			Invitation to Bid	1 mon	Tue 2/18/14	Mon 3/17/14	16
18			Subcontractor Awarding	1 wk	Tue 3/18/14	Mon 3/24/14	17
19			Submittals	1 mon	Tue 3/25/14	Mon 4/21/14	18
20			Lead Times - Delivery Times	**80 days**	**Tue 4/22/14**	**Mon 8/11/14**	
21			Steel Mill Order	4 mons	Tue 4/22/14	Mon 8/11/14	19
22			ICF Order	2 mons	Tue 4/22/14	Mon 6/16/14	19
23			Concrete Order	1 mon	Tue 4/22/14	Mon 5/19/14	19
24			Sheetmetal	2 mons	Tue 4/22/14	Mon 6/16/14	19
25			Fans	2 mons	Tue 4/22/14	Mon 6/16/14	19
26			AHUs	4 mons	Tue 4/22/14	Mon 8/11/14	19
27			Pumps	2 mons	Tue 4/22/14	Mon 6/16/14	19
28			Cooling Tower	2 mons	Tue 4/22/14	Mon 6/16/14	19
29			Boiler	2 mons	Tue 4/22/14	Mon 6/16/14	19
30							
31			**Construction**	**316 days**	**Fri 6/6/14**	**Mon 8/24/15**	
32			Last Day of School	10 days	Fri 6/6/14	Thu 6/19/14	
33			*Notice to Proceed*	0 days	Mon 6/9/14	Mon 6/9/14	
34			*Mobilization*	1 wk	Mon 6/9/14	Fri 6/13/14	33
35			Excavation	1 mon	Mon 6/16/14	Fri 7/11/14	34
36			Utilities	2 wks	Mon 7/14/14	Fri 7/25/14	35
37			Foundation	1.5 mons	Mon 7/28/14	Fri 9/5/14	36
38			ICF Walls	3 mons	Mon 9/8/14	Fri 11/28/14	37
39			Structural Steel	3 mons	Mon 11/3/14	Fri 1/23/15	38FS-1 mon
40			Metal Decking	1 mon	Mon 11/17/14	Fri 12/12/14	38FS-2 wks
41			Slab-On-Deck	1 mon	Mon 12/1/14	Fri 12/26/14	40FS-2 wks
42			Roofing	2 mons	Mon 12/29/14	Fri 2/20/15	41
43			Building Façade	3 mons	Mon 1/26/15	Fri 4/17/15	39
44			Glazing	2 mons	Mon 2/23/15	Fri 4/17/15	42
45			MEP Rough-Ins	3 mons	Mon 1/26/15	Fri 4/17/15	42FS-1 mon
46			Interiors	3 mons	Mon 4/20/15	Fri 7/10/15	45
47			Finishes	1 mon	Mon 7/13/15	Fri 8/7/15	46
48			Commissioning	3 mons	Mon 4/20/15	Fri 7/10/15	45
49			*Demobilization*	1 wk	Mon 8/10/15	Fri 8/14/15	47
50			*FF&E*	2 wks	Mon 8/10/15	Fri 8/21/15	47
51			*Substantial Completion*	0 days	Fri 8/21/15	Fri 8/21/15	50
52			**First Day of School**	0 days	Mon 8/24/15	Mon 8/24/15	



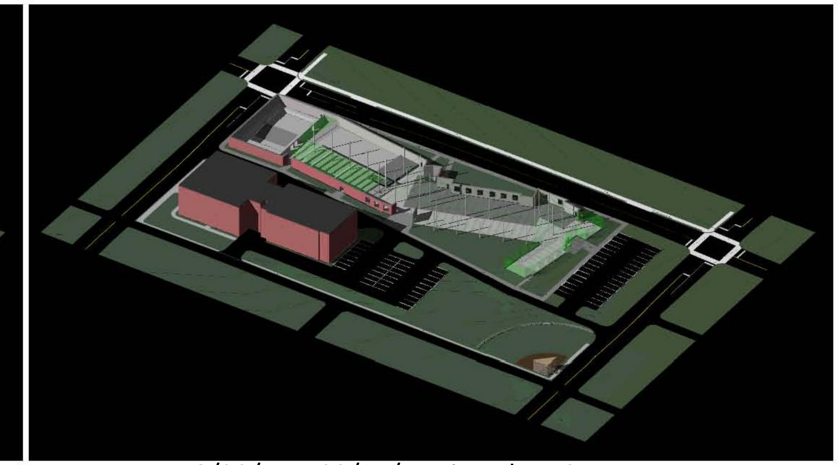
Appendix D: Navisworks 4D model (construction sequencing)



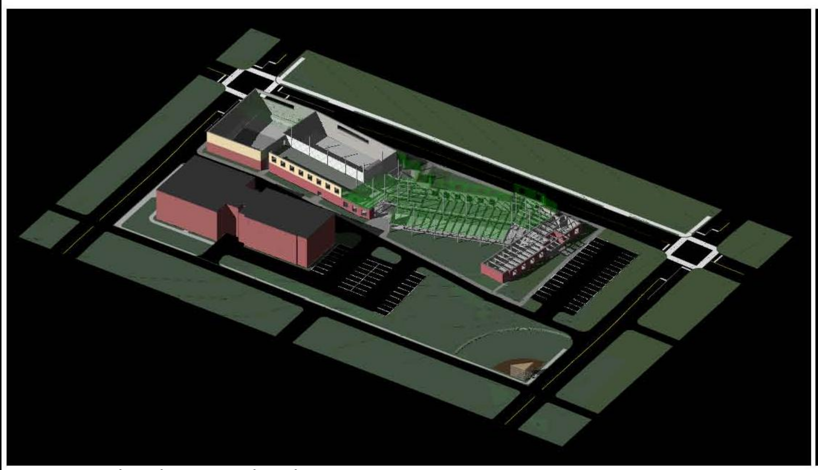
06/09/14 - Mobilization



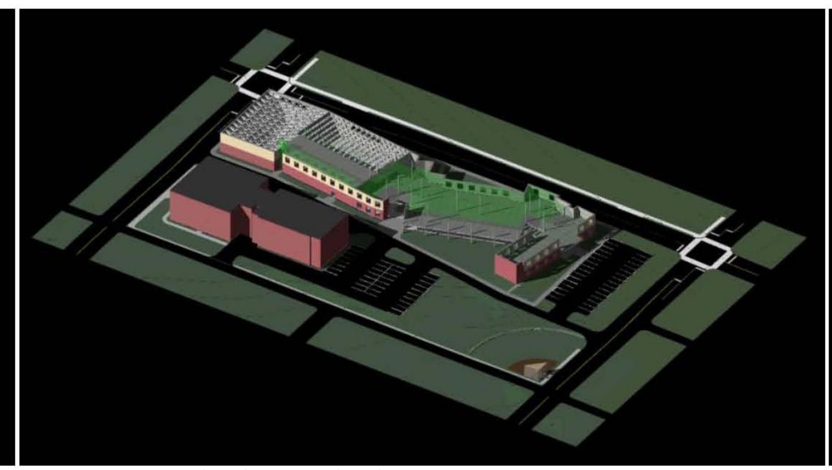
08/05/14 – 08/25/14 - Foundation



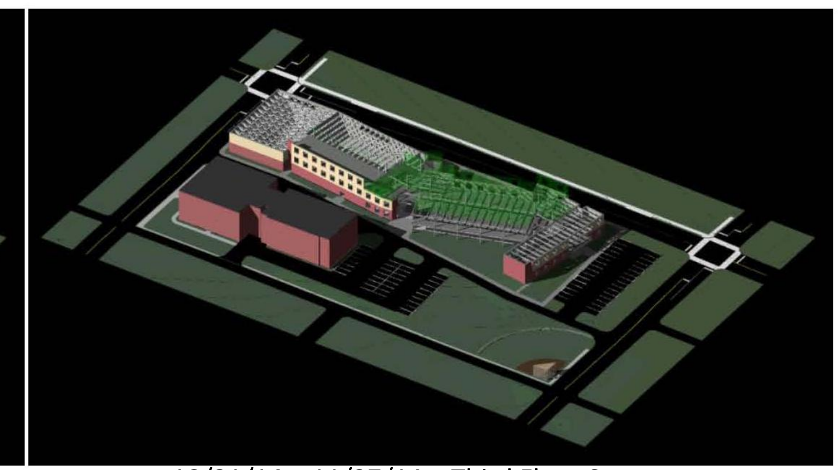
8/29/14 – 09/17/14 First Floor Structure



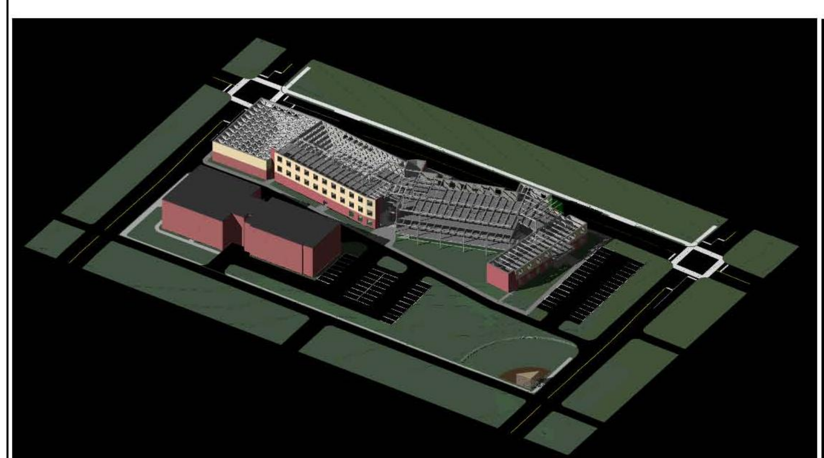
09/17/14 - 10/02/14 – First and Second Floor Structure



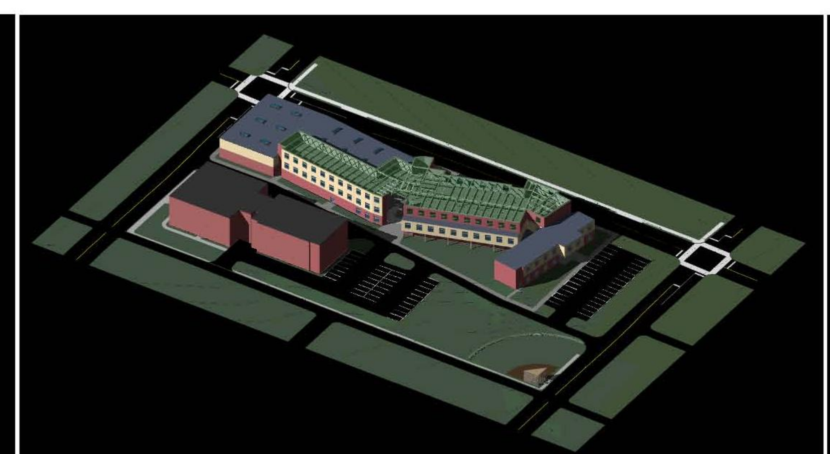
10/02/14 - 10/31/14 Second Floor Structure



10/31/14 – 11/27/14 – Third Floor Structure



11/27/14 – 1/21/15 Structure Complete

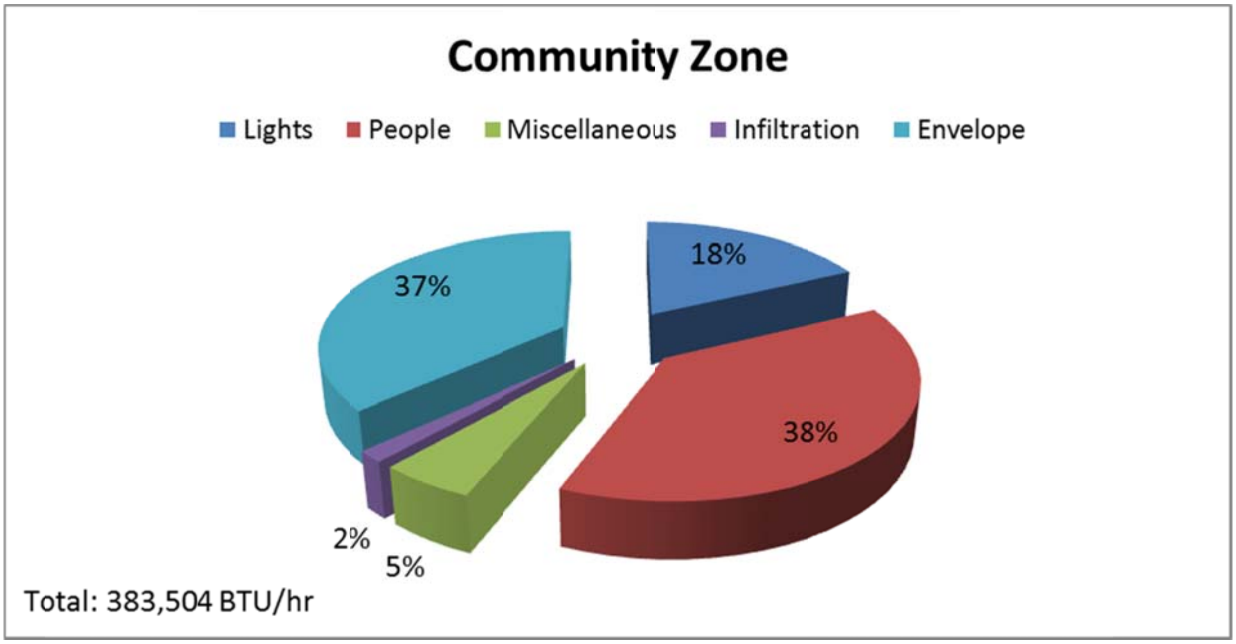


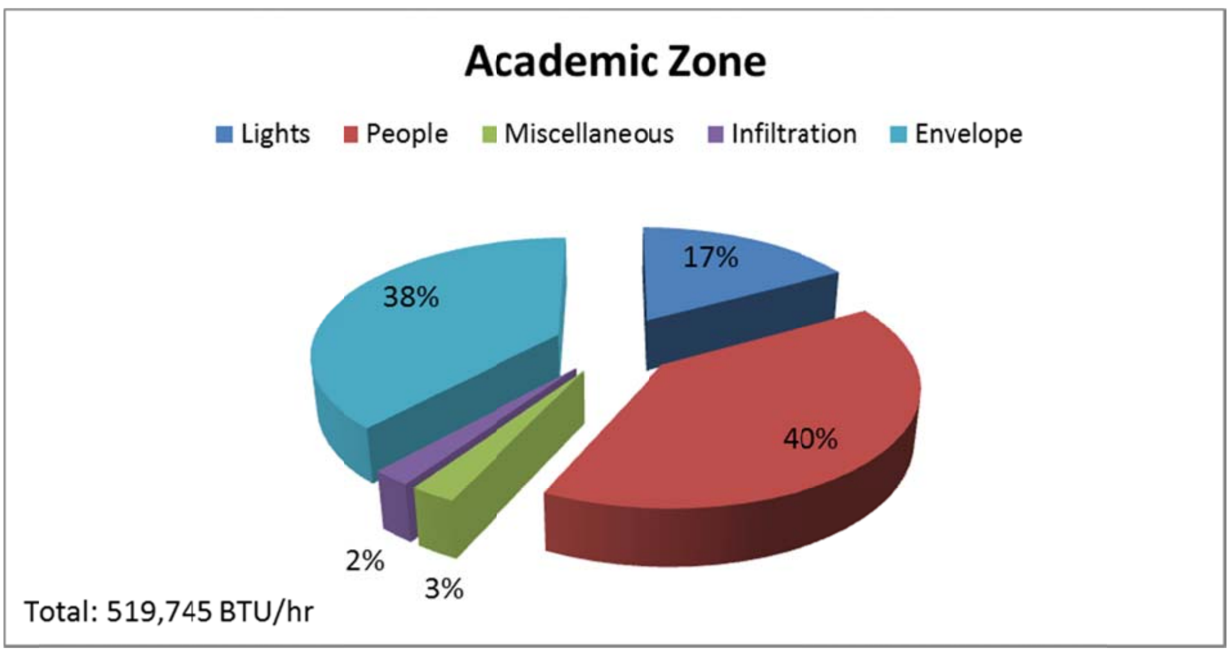
1/21/15 – 2/12/15 Roofing and Glazing

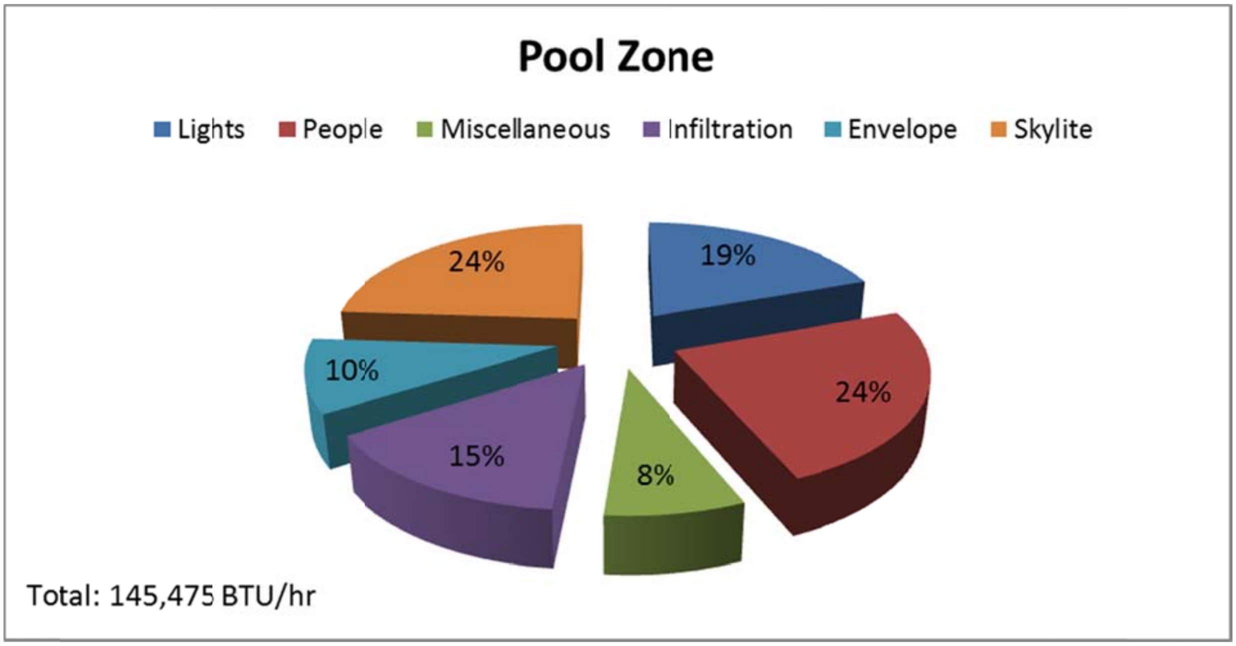
2/12/15 – 4/21/15 – Building Enclosed

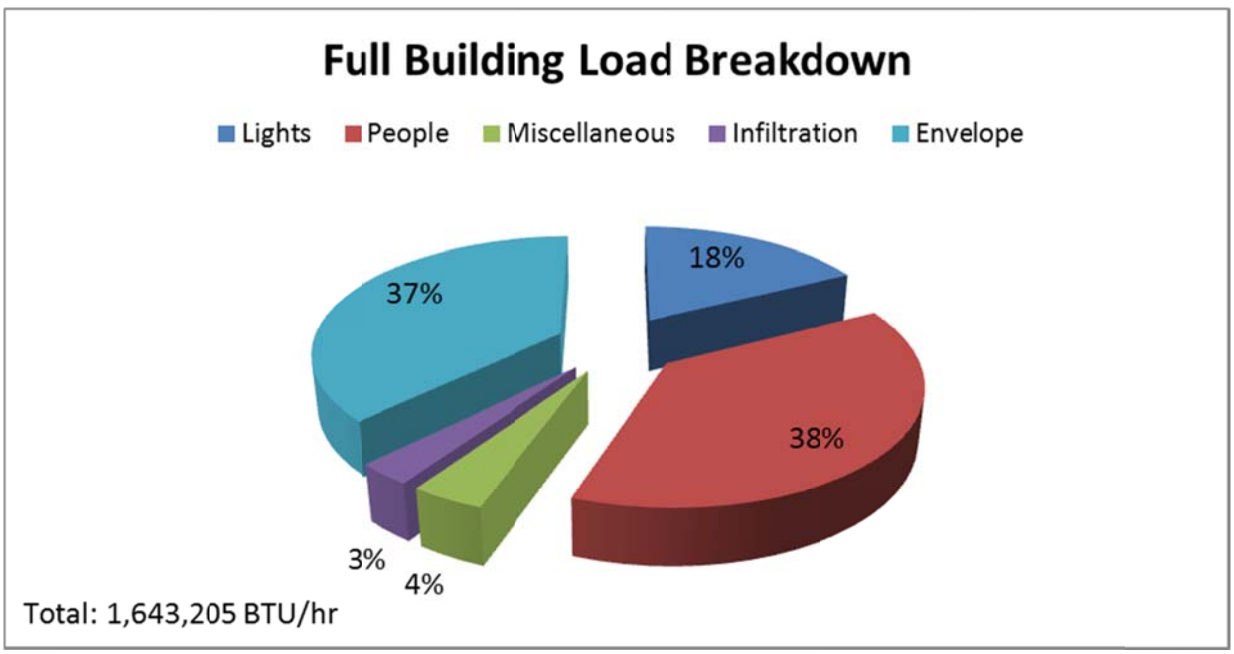
MECHANICAL APPENIX

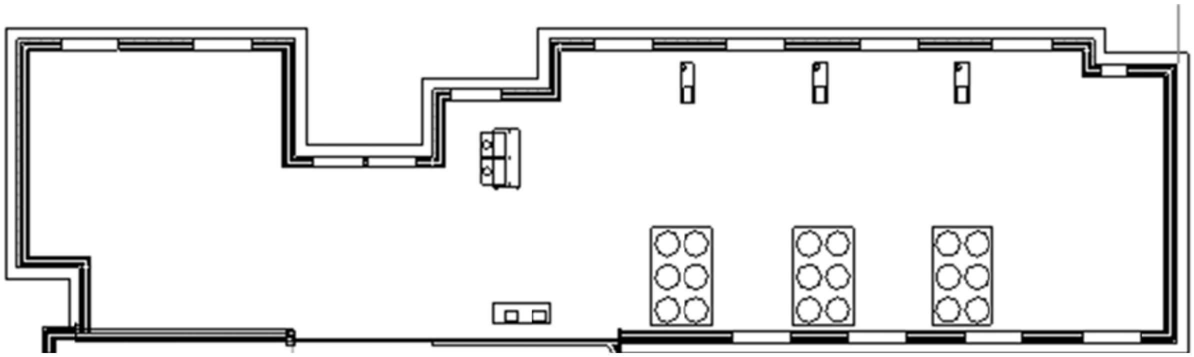
LOAD PROFILES AND BREAKDOWNS






Pool Zone
Lights
People
Miscellaneous
Infiltration
Envelope
Skylite
19%
24%
8%
15%
10%
24%
Total: 145,475 BTU/hr


Full Building Load Breakdown
Lights
People
Miscellaneous
Infiltration
Envelope
18%
38%
4%
3%
37%
Total: 1,643,205 BTU/hr



This mechanical room will be located in the Basement. There are three chillers placed 10 feet apart, 3 inline pumps across from the chillers. There are two boilers located in the upper left hand corner and the hydronic module for the ethylene glycol system located in the bottom right. This room will be accessible from the exterior of the building for maintance purposes as well.

1.1 Equipment Cost Summary:

Equipment Breakdown			
Equipment	**Description**	**Capacity**	**Price**
Chiller-1	Rotary-Screw Water Chillers	60 Tons	$ 55,300.00
Chiller-2	Rotary-Screw Water Chillers	60 Tons	$ 55,300.00
Chiller-3	Rotary-Screw Water Chillers	60 Tons	$ 55,300.00
Cooling Tower	Axial Fan, Induced Draft	175 Tons	$ 27,375.00
Boiler-1	Gas-Fired Boiler	800 MBh	$ 16,475.00
Boiler-2	Gas-Fired Boiler	350 MBh	$ 7,725.00
OAU-1	Dedicated Outdoor Air	38,000 CFM	$ 172,400.00
OAU-2	Dedicated Outdoor Air	27,000 CFM	$ 163,200.00
OAU-3	Dedicated Outdoor Air	8,000 CFM	$ 54,400.00
EAU-1	Exhaust Air Unit	34,500 CFM	$ 12,320.00
EAU-2	Exhaust Air Unit	24,500 CFM	$ 10,540.00
EAU-3	Exhaust Air Unit	9,000 CFM	$ 5,600.00
Ethylene-Glycol System	Without Pool	65,000 CFM	$ 295,000.00
Ethylene-Glycol System	With Pool	8,000 CFM	$ 355,000.00
Total	**Without Pool**		**$ 863,210.00**
Total	**With Pool**		**$ 990,935.00**

1.2 Ethylene Glycol Energy Comparisons

Energy/Financial Comparison: Pennsylvania State AEI

OAU-1/2, EAHU-1/2

SUMMARY		Without E Recovery	Konvekta System
Winter			
Heating Energy Requirement	kWh/a	856,050	402,000
Effectiveness Heating			0.53
Summer			
Cooling Energy Requirement	kWh/a	194,610	178,410
Effectiveness Cooling/Reheat			0.08
Year			
Heating Energy	kWh/a	856,050	402,000
Cooling Energy	kWh/a	194,610	178,410
Electricity (Δ Fans, Pumps)	kWh/a	0	14,503
Total Energy Consumption	**kWh/a**	**1,050,660**	**594,913**
Effectiveness			**43%**
Peak Demand			
Cooling	kW	1,525	1,355
	tons	433	385
Heat	kW	1,340	535
	MBTU/h	4,572	1,825

Energy/Financial Comparison: Pennsylvania State AEI

OAU-1/2/3, EAHU-1/2/3

SUMMARY		Without E Recovery	Konvekta System
Winter			
Heating Energy Requirement	kWh/a	965,900	407,500
Effectiveness Heating			0.58
Summer			
Cooling Energy Requirement	kWh/a	219,660	200,460
Effectiveness Cooling/Reheat			0.09
Year			
Heating Energy	kWh/a	965,900	407,500
Cooling Energy	kWh/a	219,660	200,460
Electricity (Δ Fans, Pumps)	kWh/a	0	16,514
Total Energy Consumption	**kWh/a**	**1,185,560**	**624,474**
Effectiveness			**47%**
Peak Demand			
Cooling	kW	1,722	1,522
	tons	489	432
Heat	kW	1,512	411
	MBTU/h	5,159	1,402

Economic Summary- Trane TRACE700

Economic Summary

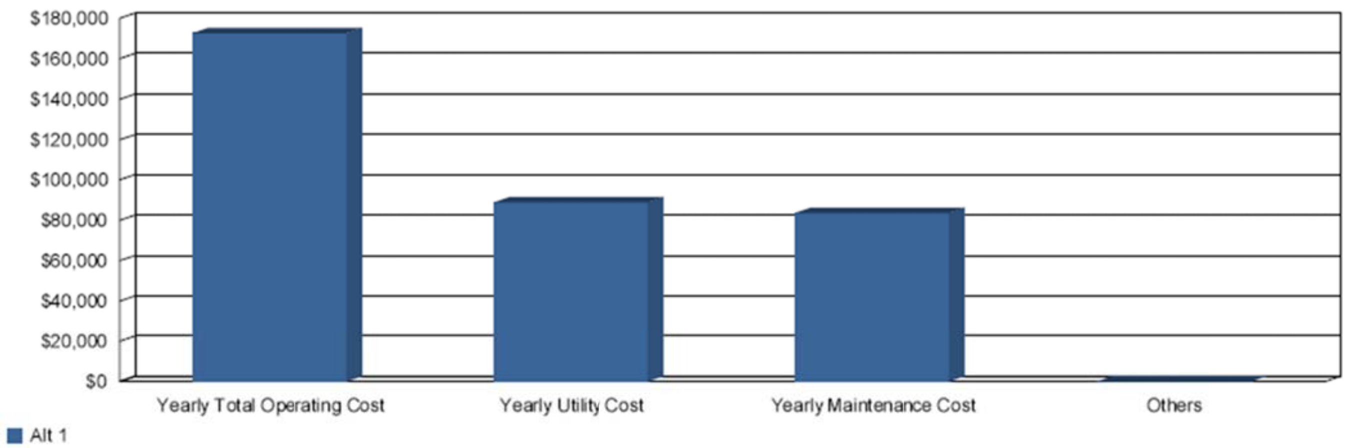
Project Information

Location	Reading, PA	Study Life:	20 years
Project Name	Elementary School	Cost of Capital:	10 %
User		Alternative 1:	Reading Elementary School
Company			
Comments			

Economic Comparison of Alternatives

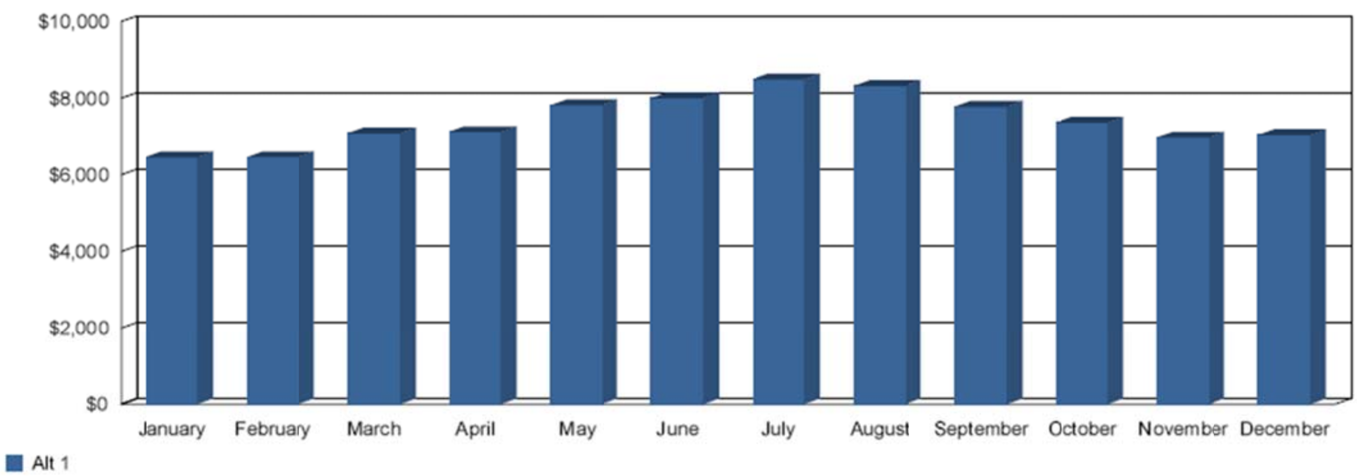
Yearly Savings ($)	First Cost Difference ($)	Cumulative Cash Flow Difference ($)	Simple Payback (yrs.)	Net Present Value ($)	Life Cycle Payback (yrs.)	Internal Rate of Return (%)	Life Cycle Cost

Annual Operating Costs



Yearly Total Operating Cost ($)	Yearly Utility Cost ($)	Yearly Maintenance Cost ($)	Plant kWh/ton-hr

Monthly Utility Costs



Sample Calculations:

C_S Coefficient Calculation

Spectral Response Acc. (from ASCE 7-05)		Building Data			Story Heights		
S_s=	0.25	Total Height:	28	ft	Roof	0	ft
S_1=	0.06	Ct value:	0.02		3rd Floor	28	ft
F_a=	2.5	x:	0.75		2nd Floor	14	ft
F_v=	3.5	Imp. Factor:	1.25				
T_L=	6	R (N-S)=	4		**Time Period (from ETABS)**		
		R (E-W)=	4		=	0.289	s

S_{DS}=	0.417
S_{D1}=	0.140
T_0=	0.067
T_L=	6
T_S=	0.336
T_a=	0.289
S_a=	0.417

N-S:		E-W:	
R=	4	R=	4
C_s=	0.1302	C_s=	0.1302
C_s=	0.1514	C_s=	0.1514
C_s=	**0.1302**	**C_s=**	**0.1302**

Earthquake Load Calulations

Loads:		
Roof dead=	30	psf
Floor dead=	60	psf
ICF Walls=	125	lbs/per sf wall area
Curtain Walls=	50	lbs/per sf wall area

Trib Areas:			
Roof Level	Roof=	0	ft^2
	Floor=	0	ft^2
	ICF Wall=	0	ft^2
	Curtain Wall=	0	ft^2
3rd Floor Level	Roof=	5048	ft^2
	Floor=	0	ft^2
	ICF Wall=	1750	ft^2
	Curtain Wall=	364	ft^2
2nd Floor Level	Roof	0	ft^2
	Floor	5048	ft^2
	ICF Wall	3500	ft^2
	Curtain Wall	784	ft^2

Roof Level Load

W= 0.0 kips

3rd Floor Load

W= 388.4 kips

2nd Floor Load

W= 779.6 kips

Total W= 1167.97 kips

Load Distributions:

N-S:			E-W:		
Base Shear=	152.1	kips	Base Shear=	152.1	kips

k= 1

C_{VR}= 0.0000

C_{V3}= 0.4991

C_{V2}= 0.5009

N-S:			E-W:		
Roof	**0.0**	kips	Roof	**0.0**	kips
3rd Floor	**75.9**	kips	3rd Floor	**75.9**	kips
2nd Floor	**76.2**	kips	2nd Floor	**76.2**	kips

ETABS Modeling:

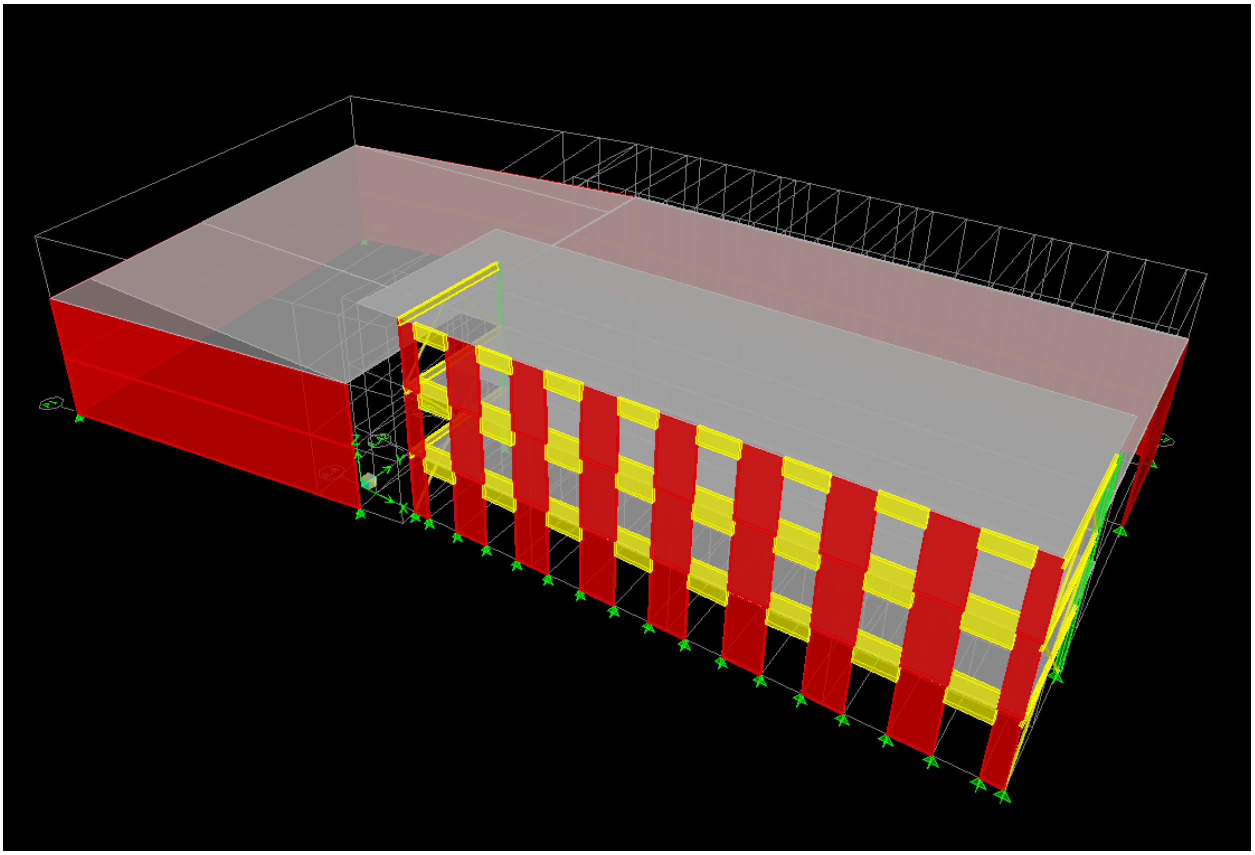


Figure 1: West Wing ETABS Model as Viewed from South Side

One of the key elements to creating an accurate ETABS model for each segment of the building was the simulation of the shear walls and their connecting elements. For this model, the team created deep coupling beams (highlighted in yellow) to connect the shear wall elements (highlighted in red) that make up the shear wall lateral force resisting system.

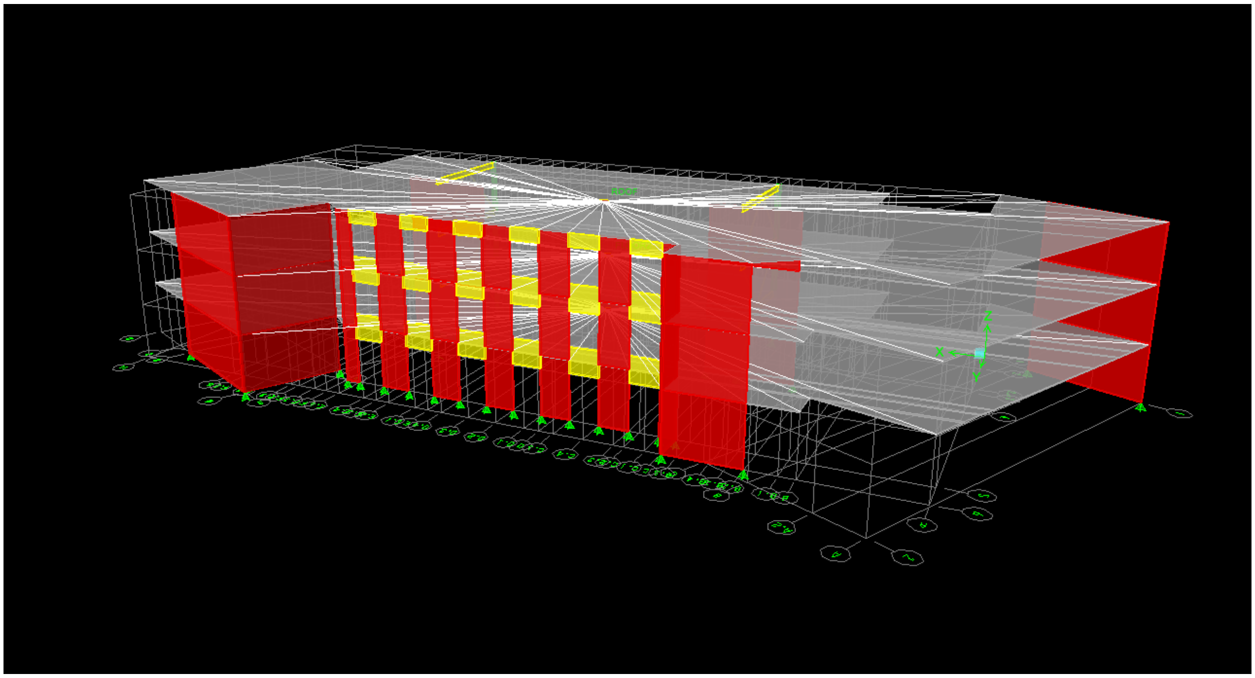


Figure 2: Central Wing ETABS Model as Viewed from North Side

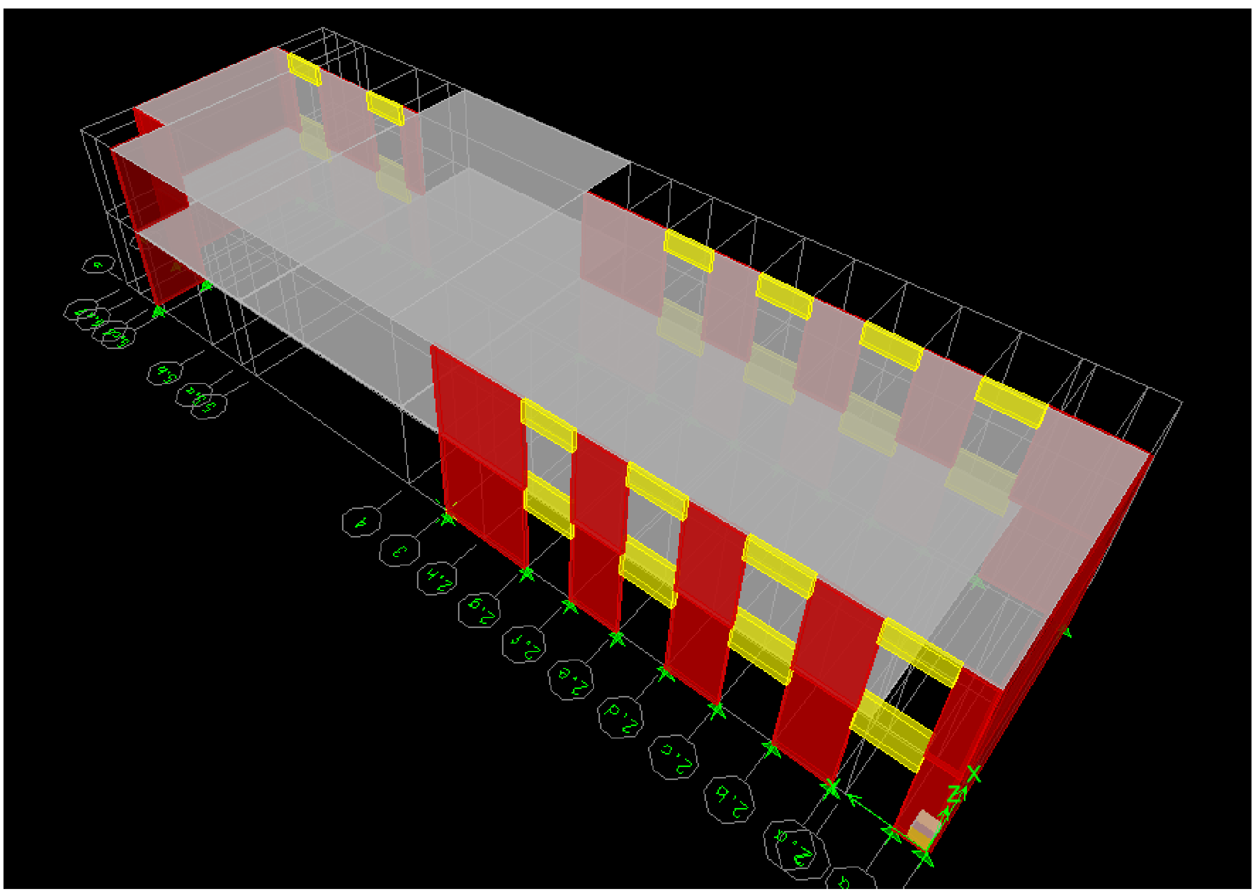


Figure 3: East Wing ETABS Model as Viewed from the Southwest Side

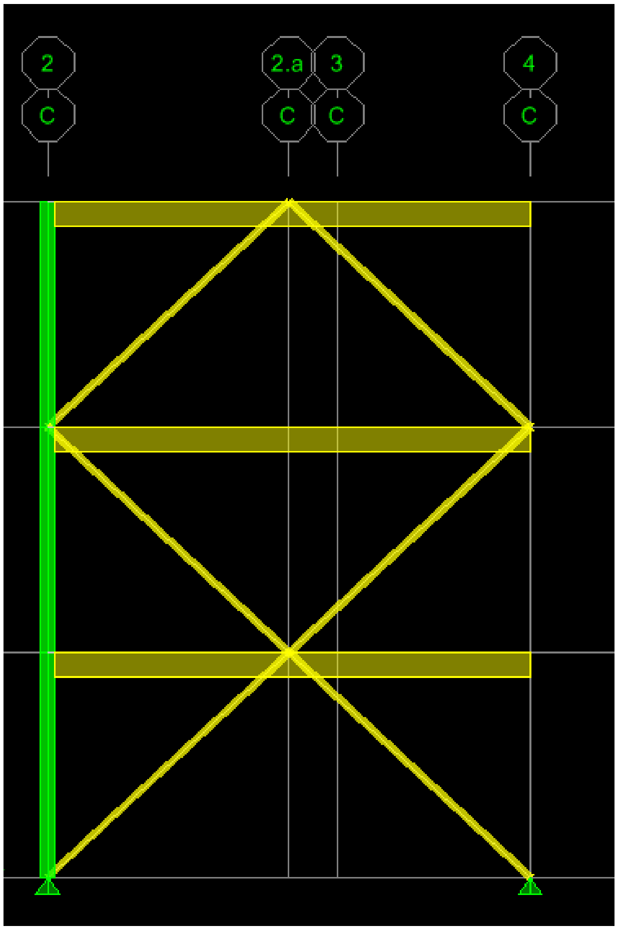


Figure 4: Typical Lateral Bracing Frame

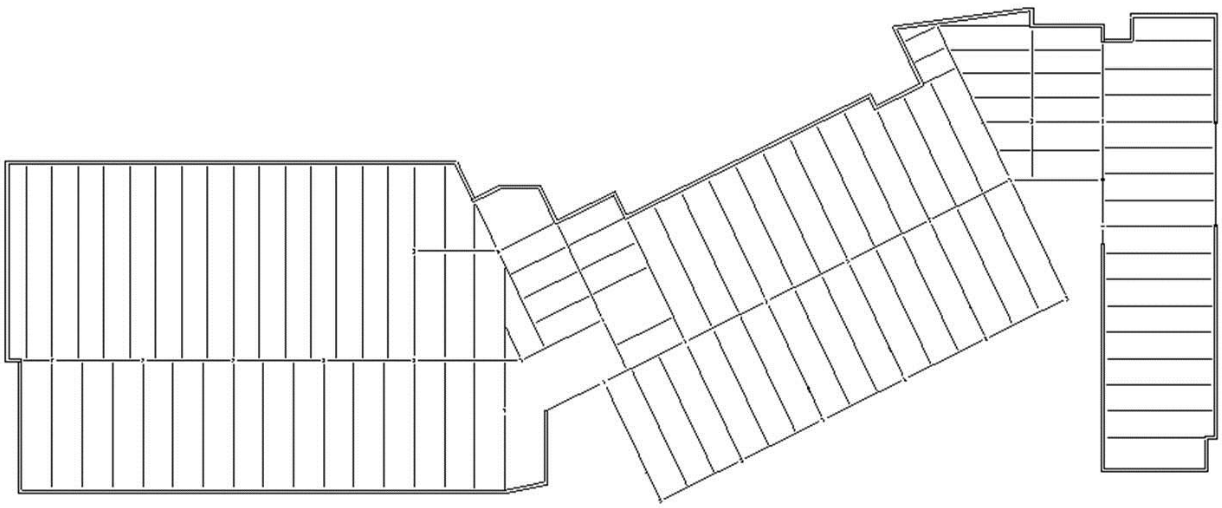


Figure 5: Sample 2nd Floor Structural Framing Layout