AEI Team #04-2013

February 22, 2013

Building Integration Design

ASCE | STUDENT COMPETITION

Team 04-2013

Our one true aim is to enhance the quality of the communities we work with through innovative ideas and an integrated design approach.

Ingenuity | Quality | Enjoyment | Integrity

Table of Contents

Executive Summary: The Challenge

Our team has addressed the design and construction issues that were essential for the development of a new construction elementary school project to be located in the urban setting of Reading, Pennsylvania. Per the competition guidelines, the submittal addresses the following items:

1) Construction and design issues related to a high performance building that meet the needs of both the school district and community. In the Energy Independence and Security Act of 2007, section 401, a high performance building is defined as follows:

The term 'high-performance building' means a building that integrates and optimizes on a life cycle basis all major high performance attributes, including energy conservation, environment, safety, security, durability, accessibility, cost-benefit, productivity, sustainability, functionality, and operational considerations.

> Our team's Innovative Building Design choices are showcased in the **Innovative Building Systems** section within this submittal. These systems include a Rammed Aggregate Pier Foundation System, Economical Structural Steel System, Prefabricated Concrete Enclosure System, and lightweight green roof system. Additionally, our team proposes to renovate the existing elementary school for the indoor community natatorium and clinical space. This strategy is explained in the Master Plan section of the proposal.

2) The school board would like the new building to achieve Leadership in Energy and Environmental Design (LEED) certification under the LEED 2009 for Schools New Construction and Major Renovations. (LEED 2008)

> Based upon our LEED analysis, our team will deliver a LEED Silver building under the LEED 2009 for School New Construction and Major Renovations. The design and construction of the elementary school is currently achieving 52 points *without significant added cost to the project*. Please reference Appendix P in the supporting documents for a breakdown of the earned points and example documentation for achieving a LEED point.

3) Provide a budget for the school district for the design and construction of the project focusing on both the short term and lifetime cost-benefits of the design solution.

> The construction budget for the new construction elementary school is set at $16,000,000, with an add/alternate for the indoor natatorium and clinical space budgeted for $3,000,000. The construction schedule for the new elementary school begins with Notice to Proceed on June 1, 2013 and concludes July 24, 2014 before the new school year, totaling 14 months. The add/alternate schedule for the natatorium and clinical space begins June 2, 2014 and concludes September, 19 2014. If the add/alternate is chosen the total construction schedule spans 16 months. This budget breakdown is justified in Appendix B in the supporting documents and the Innovative Construction Management and Construction Methods Report can be referenced for a foldout of the schedule.

In addition to these requirements, our team has responded to the context in which this project will exist. The interest of the community was heavily considered in the design and construction planning of the building. The design provides creative solutions for an indoor pool, 24 hour clinic, multi-purpose space, and green roof. Our team validates that our final design is sustainable, accessible, and secure for the occupants of the buildings and Reading community.

Additionally, the population of Reading is approximately 88,000 people, making it the fifth largest city in the state of Pennsylvania. According to the 2010 census, Reading has the largest share of citizens living in poverty in the nation at approximately 37% and a crime index of 480.8 when compared to the U.S. average of 319.1. Because of these statistics, security is a large design factor for the building. (United States Census Bureau 2013)

Introduction: Reading Elementary School is the focus of the Annual Architectural Engineering Student Design Competition for 2013. Located in an urban setting in Reading, Pennsylvania, the three story elementary school has been shaped by the integrative design and construction strategies of our team with the goal of achieving a constructable and affordable high performance building for both the school district and the community.

The mission of our team is wide spread, but strives to be purposeful in creating a building that can be flexible for the school district and provide a space with multiple resources that help a community thrive. The design of Reading Elementary has been carefully planned to meet several goals. These goals include: helping students learn and increasing test scores, increasing daily attendance from students, improving teacher satisfaction and overall employee retention, improving operations and maintenance costs over the life cycle of the building while building the school at a median cost as compared to recently constructed Pennsylvania schools.

Team Mission Statement

Our one true aim is to enhance the quality of the communities we work with through innovative ideas and an integrated design approach.

Team Core Values

Ingenuity | Quality | Enjoyment | Integrity

Project Goals: The city of Reading is in need of a catalyst to propel it into forward movement towards a healthy and thriving community. The team approached this project as an opportunity to provide just that. The excitement and enjoyment surrounding this project would encourage learning at an elementary level, setting Reading's families and its youngest citizens on a path toward education, success and a bright future.

Based on this thought process, the developed team goal was *to create an innovative, high-performance environment in a way that stimulates involvement in both education and the community.* To achieve this main goal, detailed project goals were developed to guide the design process and major team decisions. These three project goals included **Functionality**, **Efficiency** and **Appeal**. Refer to Figure 1 for our Project Goal Visual.

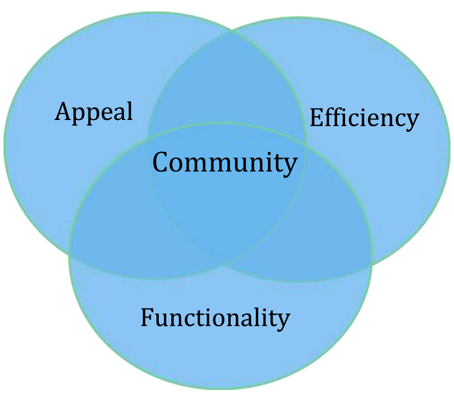


Figure 1: Project Goal Visual

The first goal was to design all building systems and components to best serve their specific functions within the building. This was achieved by breaking down the building into smaller packages which have distinct, unique and identifiable functions which drove the design of the building systems within each package. A few examples of the packages that were developed include Building Enclosure, Classrooms, Administration, Multi-Purpose Room and Pool and Clinic Renovation. The team defined the most critical functions of each of these packages, and made sure to refer back to this definition whenever design issues or questions came about. These ideas were manifested in the project goal of **Functionality**.

The next goal was create a building which is affordable and long lasting, allowing the community to get optimal use out of the building. This is achieved by designing and engineering building systems which will best serve the building's inhabitants over an extended building lifecycle. Analysis of all systems using life cycle cost assessments and sound engineering judgment also led to the accomplishment of this goal. These ideas were manifested in the project goal of **Efficiency**.

The third and final goal was to create an appealing building design which attracts people to it both inside and out of the community. By creating this appeal, students, families and faculty will be more inclined to be a part of this positive learning environment. This was achieved by creating a visually appealing and comfortable environment that accommodates all occupants. These ideas were manifested in the project goal of **Appeal**.

One major hurdle when working through the design and construction planning of the project was balancing the three previously defined project goals. For instance, the most efficient mechanical system might be a major hindrance on achieving the function of the classroom. Or, what might be an appealing design architecturally may not be the most energy efficient. Successful team integration and communication was extremely helpful in having insight from multiple design specialties in deciding what was best for the overall outcome of the project. In these instances, we also made sure to keep in mind the overarching team goal as defined previously of providing an innovative, high-performance environment in a way that stimulates involvement in both education and the **Community**.

Summary Results:

Figure 2 below is a summary of implemented building design and construction systems:

Building Design and Construction Systems	
Structural • Structural steel frame, typical classroom 28'x30' • W10 and W12 columns spliced at 3rd floor • Beams range from W8's to W14's • Braced frames and reinforced masonry shear walls • Composite metal deck floors and roofs	**Construction** • Multiple Prime with CM Agency • Construction Budget: $19,000,000 • 16 Month Schedule • Construction Safety Program • Rammed Aggregate Pier Foundation • Prefabricated Concrete Wall Panels
Mechanical • Ground Source Heat Pump System • 5 Dedicated Outdoor Air Units serving 5 zones • Outdoor air units take majority of sensible and latent loads • Ventilation and Terminal Unit split system • Heat Pumps range in size from ¾ - 3 tons • Variable Refrigerant Volume with Heat Recovery for Clinic	**Lighting/Electrical** • Building Automation System • Emergency fixtures serve as normal power and default to emergency when necessary • 277/480V Lighting, 120/208V Electrical Panels • Interior building transformer and generator • On-site High Voltage transformer; secondary • Overhead power lines supply building
Architectural • Brick & Limestone Facade (Regional Materials) • Clerestories • Ribbon Windows • Atrium • Outdoor Green Roof Space	**Security** • Vandal Resistant Security Cameras • Building Integrated Control System • Building Access Control • Glass Break Sensors and Transmitters • Secured Building Entries • Bullet proof glass

Figure 2: Building Design and Construction Systems Matrix

The team executed a tangible means of measuring the success of the project. By staying true to both the team and project goals, the following measurable results are expected:

- Increased attendance and standardized test scores
- Lower median construction and operational costs
- Improved teacher/student/community satisfaction
- LEED Silver certification/Sustainable Design
- Safer environment

Project Delivery Goals: The team stressed the importance of organization and planning deliverables from the very beginning of the project. The team also wanted to create innovative and creative engineering designs through the use of Building Information Modeling. These desires resulted in the team creating a supplementary goal of developing a BIM Execution Plan. This plan is based on the CIC BIM Project Execution Planning Guide Version 2.0. Capabilities and benefits which were planned to be utilized through the use of BIM included the following:

1. Review Design Concepts
2. Evaluate Constructability
3. Detect Collisions
4. Schedule Tasks and Activities
5. Perform Engineering Analyses[2]

When utilizing BIM through these capabilities, the team was provided with a multitude of new computer-based tools to assist in accomplishing original team and project goals. With this wide array of powerful computer based resources at hand, the BIM Execution Plan was a great means of producing a plan for properly utilizing these technologies. The purpose of the plan was to define exactly what the goals were in using BIM technologies, to what level of detail the modeling of our project was most appropriate, and how to best communicate while using these technologies. Some examples of this included defining the team's mission statement, core values and project overview. The plan is broken down into 12 sections which outline in detail topics such as BIM Roles and Organization, BIM Process Design and Quality Control Procedures, among others. Below is a list of the twelve sections of the team's BIM Execution Plan:

Greater detail of our BIM Execution Plan can be found in Appendix C of our supporting documentation.

With specific regard to the BIM aspect of the BIM Execution Plan, the plan lays out how the team intended to properly manage modeling for the project, as well as team members' specific responsibilities and points of interaction. Team responsibilities are listed first, and are most critical to the success of BIM uses. Following this, responsibilities for specific team members are laid out for how and what each member is expected to use and produce in the model.

The outcome of sticking to the team's developed BIM Execution Plan was a better understanding of how all of the building's components worked together and affected each other. This also directly translated to realizations of how the team was achieving the project goals of functionality, efficiency and appeal. Through virtual mock-ups, the team got a great sense for how specific rooms were intended to meet their function. Refer to Figure 3 and Appendix D for views of the team's virtual mockups. Energy and load calculations were determined using BIM software to ensure that efficiency demands were properly met. Renderings and walkthroughs were developed to help determine if the team's intended appeal for the designed spaces were properly met. Clash detections were performed to mitigate constructability issues

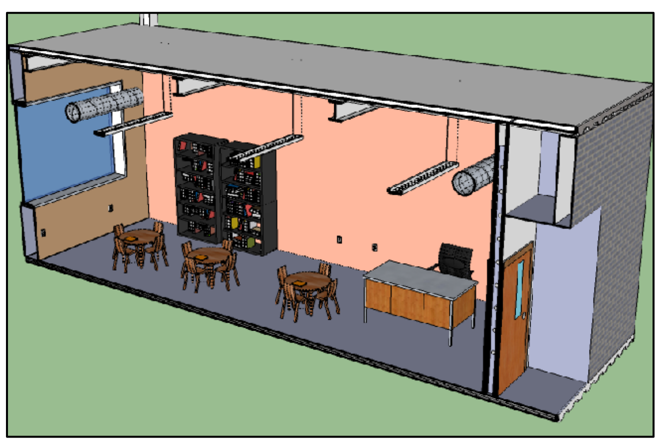


Figure 3: Virtual Mock-Up of a typical classroom

and ensure proper layout of building systems. This is only a handful of the direct benefits of the BIM Execution Plan guiding the team toward achieving its project goals.

BIM Utilization Process: An Integration Flow Chart was developed separate from the BIM Execution Plan. The purpose of creating the chart was to get the team fully on board with how and when the use if BIM technologies would be utilized. It also created an awareness of how the success and progress of each team member's work was essential to the fulfillment of utilizing BIM to its fullest potential. Table 1 below is a BIM Software Applications breakdown which lays out all of the software used during the project, as well as each software use. This table was included in the main report to emphasize the power and abundance of applications implemented throughout the project. Refer to the Drawing I-109 for the Integration Flow Chart. For reference, LOD is defined as 'Level of Detail,' a standard which was developed by the American Institute of Architects. Refer to the team's BIM Execution Plan for a detailed breakdown of each LOD.

Table 1: BIM Software Applications

Symbol	Name	Software Uses	Symbol	Name	Software Uses
	AutoCAD	2D Drawing/Modeling		SKM	Arc Flash Studies
	Trane Trace	Mechanical Load Calculations		Trimble SketchUp	Virtual Mock-Ups
	Autodesk Revit	3D Drawing/Modeling		Microsoft Project	Construction Scheduling
	Daysim	Daylighting and Electrical Analysis		RSMeans CostWorks	Construction Estimation
	Bentley RAM	Structural System Design		Oracle P6	Construction Scheduling
	AGi32	Lighting Calculations		3ds Max	3D Model Rendering
	ETABS	Lateral Structural System Design		Autodesk Navisworks	3D Coordination & 4D Modeling
	Microsoft Excel	Mechanical & Structural Calculations & Estimate Organizational Tool			

Group Formation and Competition Delivery Method: The team was formed as a multidisciplinary group of architectural engineers working together to create a high performance elementary school in response to the 2013 ASCE Charles Pankow Foundation annual architectural engineering student competition. The team consists of eight individuals whose educational experience is based on a sound understanding of architectural engineering in a broad sense. With this foundation, students have developed more specialized skillsets in an array of specific building systems and processes. This includes team members with specializations in mechanical, structural, lighting and electrical, and construction engineering. Each team member brought a specialized skillset to contribute to this project, while also being able to effectively communicate with all other team members on any and all building engineering related issues that arose. The individuals of this group have worked on numerous projects together over the past several years. With this past experience, the team believed that it was a perfect fit to succeed in the collaborative environment that the competition encouraged. Refer to Figure 4 below for the team's Competition Organization Chart. Architectural adjustments and design were considered a group effort and were often driven by engineering systems that helped to meet the team's project goals. Team members met with the architectural advisor on a need-by-need basis to discuss architectural considerations when making design alterations.

Group Organization and Decision Making: No singular person was elected as the 'leader' of the group. The team believed that structuring the team in this manner would not be effective in creating a collaborative and integrative environment or utilizing each team member's stills to their fullest potential. Coordination Meetings never felt like one singular person was leading.. As a result there was typically a person that acted more as a facilitator to guide the discussion and to make sure time was being used effectively.

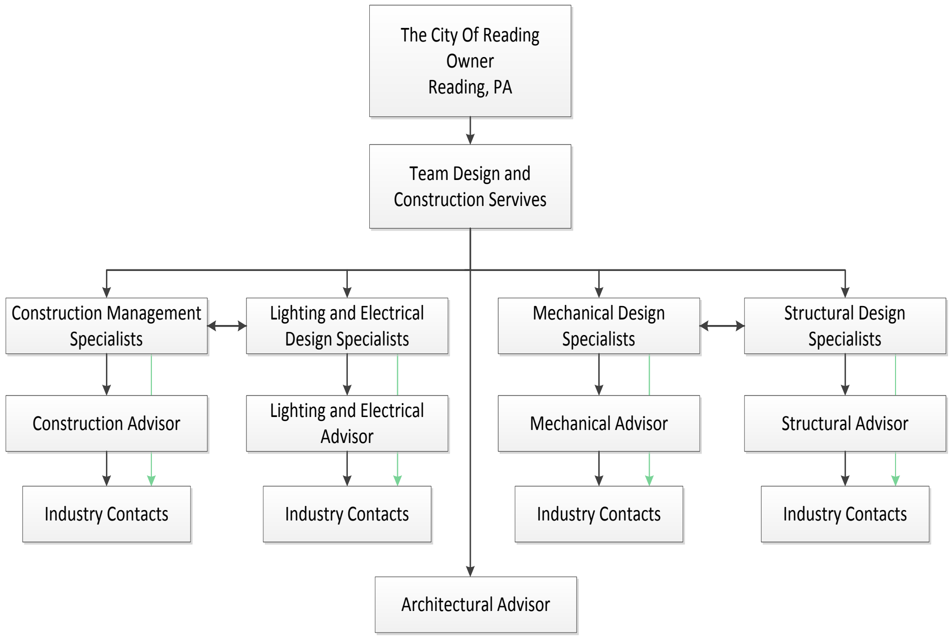


Figure 4: Competition Team Organization Chart

Decision-making happened naturally. A critical decision was usually made after a long discussion of all the pros and cons of each solution. Team members were also constantly encouraged to keep in mind the *project goals*. Due to the group's sound understanding of the different building systems, debates over the pro's and con's for systems and their effect on achieving project and team goals were well communicated and productive. Large differences in opinions were an indication that the issue needed to be further considered until the team could agree on a decision which best adhered to the project goals. The team *never* used a democratic vote to make group decisions. The belief behind this decision was that the 'majority rules' environment encouraged individual system goals much more than project goals, a lack of comprehensive understanding for building systems among all group members and a tendency for disintegration rather than integration.

Communication and Information Sharing: Communication is an important aspect of accomplishing any task. The team invested significant thought and energy into how we were going to effectively and reliably communicate information, model, and share data.

Table 2: Group Communication and Information Sharing

Symbol	Name	Software Uses
	University Server	Store and share large files and backups, organize documents
	Revit Central Model	Integrated modeling
Google Drive	Google Drive	Group communication and small document sharing
	GroupMe Application	Informal and 'instant access' group communication
	External Hard Drive	Backup all project documents

Team members utilized a university owned computer server that students used to store and share files. The team created an organized and detailed folder on this server dedicated to this project. All files were backed up by team members personal external hard drives and USB flash drives to ensure that files would not be lost if the server crashed.

An Autodesk Revit Central Model with the ability to link all the different design specialties was created. All changes were constantly updated into the central model, which ensured that team members would have the most up to date version of the model whenever more updating took place.

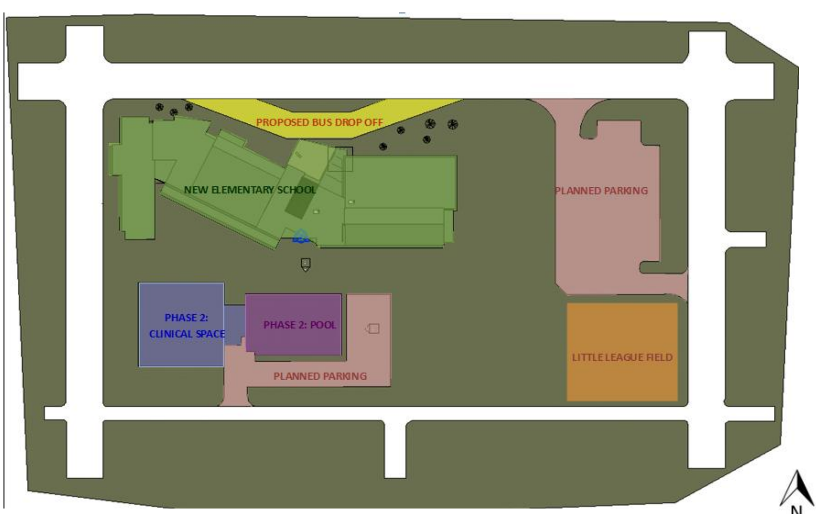
Google Drive was utilized for communication and smaller documents. All meeting minutes were kept on Google Drive for every member of the group to share. A group email was created so that members could easily contact the entire group with one single click.

A 'GroupMe' text messaging group was also formed. The group was formed in a way that all group members were alerted whenever another group member sent a text message. This form of communication was used primarily as an informal forum where the team could interact and stay informed on daily activities and news relevant to the project and each other.

Master Plan: The master plan for the project was developed over the course of the entire project. Preliminary investigations and research of the documents provided by AEI, including basic site plans, architectural drawings and a soils report were conducted by the team. Once the team was familiar with the documents provided and the team had developed its team and project goals well enough, some of the 'big ideas' for the master plan of the new Reading Elementary School as well as the clinical space and community swimming pool started to evolve. The basis for our master plan consists of the idea to:

1. Build the new construction project, consisting of the new Elementary School
2. Concurrently renovate the existing elementary school to house a 24-hour clinic and community pool

The west wing of the existing elementary school will be demolished and rebuilt to house the community swimming pool. The east wing will be renovated to house the 24 hour clinic and administrative space. The decisions to renovate the building versus construct a separate structure were largely due to the need to preserve open space for elementary school students. Due to the nature of the construction sequencing, the existing elementary school renovation work is referred to as Phase 2. Construction for the new elementary school will begin with excavation and foundations in the footprint which encloses the basement area. Construction will then proceed from east to west for the structure and enclosure. Demolition and renovation for Phase 2 of the project will take place after the completion of the elementary school Refer to the team construction paper for a more detailed breakdown of construction sequencing, means and methods. Refer to Figure 5 for the Master Plan.



KEY	
	Proposed Bus Drop Off
	New Elementary
	Phase 2
	Phase 2: Natatorium
	Little League Field

Figure 5: Master Plan

Site Plan: The Reading Elementary School project will be located at the intersection of 13^{th} and Amity Street. This block is located in a residential area nearby other public spaces. There are also two public bus stops conveniently located near the campus.

The site layout was configured based upon the central idea to flip the entire footprint of the building along the east/west axis. The main reason for this change was to position the multipurpose spaces (gymnasium and cafeteria) in the school next to the planned parking lot on the east end of the property. Also, the building has been oriented to maximize open outdoor space and the opportunity to harvest the benefits of daylight while still minimizing the effects of increased cooling loads from southern exposure.

Figure 6: New Site Plan

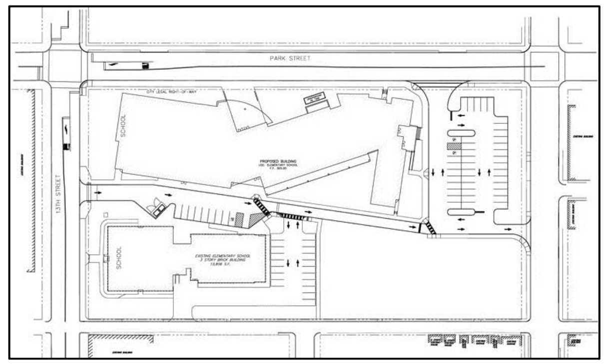


Figure 7: Original Site Plan

The bus loop has also been eliminated from the center of the property and relocated to the north of the site where buses will enter and exit utilizing Amity Street. Visitors of the building after school hours, when the multipurpose space is in use, will be able to access the space using the east set of doors conveniently located adjacent to the public parking lot. We believe this change to be a security and safety advantage to the rest of the school as well by minimizing traffic flow within the building. During school hours, visitors will still utilize the east parking lot, but then proceed to access the building through the main entrance in order to check in at the administration office.

During early phases of design, the team was already considering the use of a ground source geothermal mechanical system. The site was laid in a manner which would be conducive to a geothermal system, in terms of both minimizing energy losses and ensuring constructability. Refer to Figures 6 and 7 to view both the original and new site plans for a more visual description of the changes described.

Security Measures: Reading, Pennsylvania's violent crime rate for the city is more than 150% greater than the national violent crime rate (cityrating.com, 2013) and school shootings in the United States are at an all-time high. We will install a building security management system that records and controls all building entrances with card swipes, and security cameras around the school. Cameras will be located both inside and outside the school to monitor possible criminal activity and keep the children safe. Identification card access controllers will be at all four building entrances.

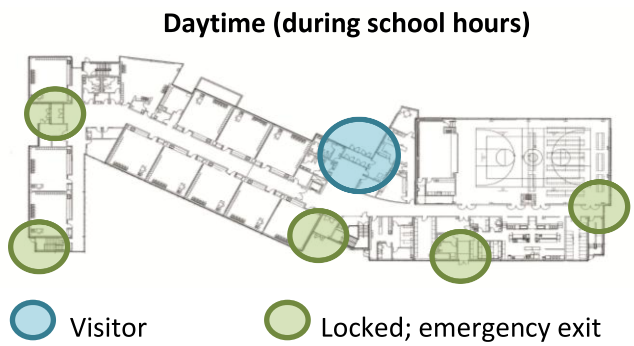


Figure 8: Daytime Entrance Security Visual

During school hours there will be one central visitor entrance. This will allow for all visitors to be signed in through the main office. There will be an intercom system allowing office personnel to interact with visitors before entering the building. Teachers and staff will be able to enter other doors with an identification card. Refer to Figure 8 for an example of one entrance security layout, and Appendix E for a complete layout of all entrance security layouts.

Along with access control, we also incorporated intrusion and property protection measures. We will be implementing glass break acoustic and motion detector sensors that will connect to the security management system and alert building personnel and local police if a window or door is broken. We will be installing bullet proof glass at the main entrance, main office and inside vestibule of the building. This will protect the main office and entry way in case of intrusion. Although using bullet proof glass on all building windows would be ideal, the cost of the glass would be extreme and unfeasible, and would also have a significant impact of interior light levels and thermal resistance. Refer to “Snapshot H” in Drawing I101 for a close up view of the main entrance.

Fire protection and building announcement systems will also be installed per 2012 National Fire Protection Agency Requirements (Harrington & Collette, 2012). All classrooms will have visual devices and speaker alerts. The building speaker system will be integrated with the fire protection system. This will allow for both building alarms and building announcements to be displayed over the same system. Fire suppression systems will also be installed per code requirements.

Innovative Building Systems

Foundation: The main concern when selecting a foundation system was the multitude of sinkholes found within close proximity of the site. Two of the suggested foundation systems from the provided Geotechnical Report were excavation and placement of engineered soils, and compaction grouting. These options were eliminated due to unpredictable and high costs, as well as issues which would arise if sinkholes did develop within the footprint of the building. A Rammed Aggregate Pier system was selected for the elementary school due to significant savings in both construction cost and schedule when compared to micro piles. Refer to Figure 9 for a construction visual of the Rammed Aggregate Pier System.

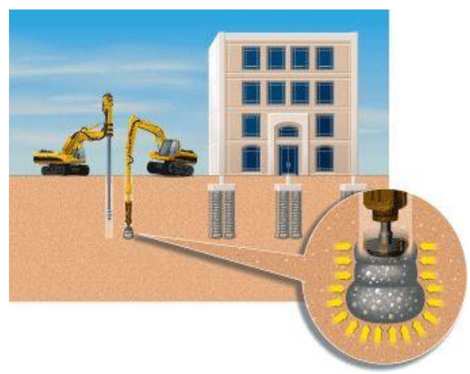


Figure 9: Rammed Aggregate Pier Construction Visual (Building Green, Inc. 2012)

A rammed Aggregate Pier system offers many advantages to a site stressed by unsuitable soil conditions. When implemented successfully, this foundation system can increase the strength to 7000-10000PSF. This is a much greater capacity than the expected allowable bearing pressure of 3,000 after compaction grouting or mechanical compaction reported in the geotechnical report. Piers can be installed at a rate of 30-60 piers per day and allow for the possibility of savings of 20-50% (Geopier Foundation Company 2012). Rammed Aggregate Piers are also sustainable in that they use local and recycle aggregates. Once the piers are installed, concrete spread footings will be poured over the piers to finish the foundation system.

Façade: The need for a functional and high performance façade for the building brought together all four disciplines, as well as architectural design in order to create and implement the best system. The electrical and mechanical design specialists worked together to find a balance between daylighting requirements and heating and cooling loads. The team balanced ideas such as how window glazing would affect the heat loss or gain throughout the building. Optimal ratio of window to wall area to provide adequate daylighting into the school while still keeping low heating and cooling loads. Appendix

F can be referenced for more information on glazing selection and Figure 10 depicts the main entrance of the building.

Figure 10: Main entrance view

The team determined that a precast concrete panel system would be ideal based on the requirements previously discussed and ease of construction. Although using prefabricated panels requires greater design precision and less flexibility on site, a shorter schedule would be possible. The panels chosen are non-loadbearing and will be connected to the steel structure with bolted connections, while a continuous air and moisture barrier will be maintained across all joints. See Figure 11 for a detailed section of a typical panel. Carbon fiber shear reinforcement resists lateral wind and earthquake loads and bolted connections transfer these forces to the main lateral system which includes a combination of braced frames and masonry shear walls. See Appendix G for more details on the precast panel connections to the main structure of the building.

Permanent shading devices also impacted the mechanical and structural design of the building. Providing shading for south facing windows to allow for the minimum amount of direct sunlight to enter the space, reducing glare and veiling reflections while keeping the interior cooler. For daylight level calculations and shading device performance refer to Appendix H.

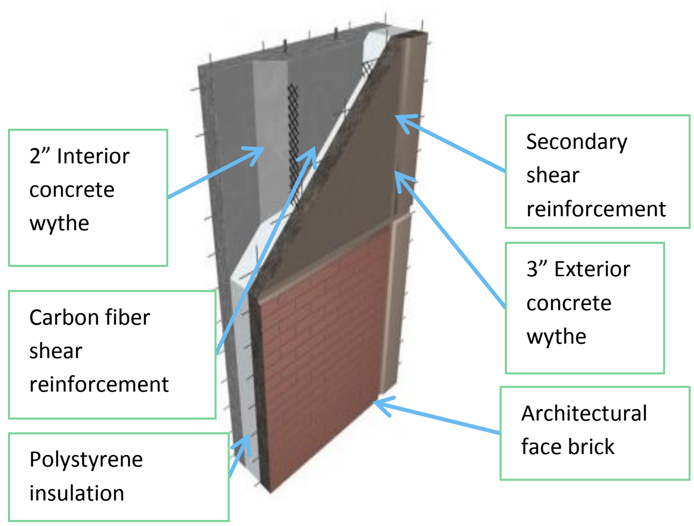


Figure 11: Typical Precast Panel Section (High Concrete Group LLC 2010)

The team decided it would be beneficial to our project goals of appeal and function to add an atrium to the main entrance. The space will act as a universal gathering space for building occupants and provide a memorable experience for guests. Energy efficiency and architectural attraction were balanced meticulously in this space with regard to the large amount of glazing. The atrium roof was also originally kalwall, but due to the high mechanical loads and inability to manage such a large amount of direct sunlight, it was best to move forward with an opaque roof. Refer to Appendix I for daylight calculations and additional images.

Roof: The roof design goal was to achieve a target U-Value of 0.048 as specified by ASHRAE 90.1, while minimizing additional structure costs and optimizing energy efficiency and constructability. Some of the major design considerations for the roof design were:

- Location of air handling units and other mechanical equipment
- Addition of clerestories over classroom wings
- Green roof location, size, weight and accessibility
- Multipurpose room

The flat roofs on the elementary school design will utilize a Protected Membrane Roofing system. With this system, the arrangement of roofing components is roof deck, waterproofing membrane, moisture-resistant insulation. This system is also commonly referred to as an "upside down roof" and protects the waterproofing membrane from harsh weather, temperature, roof traffic, and other elements. Refer to Figure 12 for the final building roof plan.

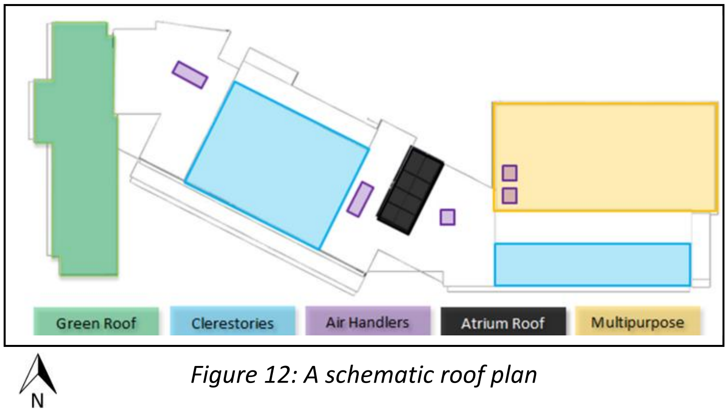


Figure 12: A schematic roof plan

Air handling units were placed in locations which would not impede on other design elements such as clerestories. They also had to be within close proximity of their respective zones. Clerestories were added in two classroom wings to increase natural daylighting and decrease energy loads. Although the addition of clerestories increased the cost of steel framing on the third floor, it was decided by the team that overall the benefits outweighed this additional cost. The project goal of Appeal was an important factor considered in this decision. Refer to drawing I107 for isometric views of the roof. The green roof was placed in a safe location which is easily accessible to students and faculty and can be used as a teaching tool and example of sustainability. The green roof was located on the two story west wing roof of the elementary school. The larger dead load created by the green roof will only impact two levels of columns, as opposed to three levels if the green roof were placed elsewhere. The team was therefore able to keep the cost of structural steel lower and avoid the use of deeper beams which may have interfered with mechanical duct work had the green roof been located on a third floor roof. Skylights are being proposed as an Add/Alternate to the multi-purpose room roof. If the owner chooses to move forward with this Add/Alternate the additional cost has been estimated to approximately $2,000 per skylight, including shading devices (Reed Construction Data Inc., 2013). Occupants will benefit greatly from higher daylight levels and a more even distribution of light. Skylights would also allow for energy savings because the electric light could be turned completely off for most of the year. Lighting specialists worked with structural and mechanical engineers to coordinate roof truss spacing and depth, skylight locations and duct spacing. Further information on the skylight system, as well as a systems layout for the multipurpose room can be found in Appendix J and Drawing I102. Please refer to the mechanical report for more detailed analysis on load calculations, as well as the lighting report for details on glazing analyses.

Interior: The interior of the building involved a significant amount of integrated design. Figure 13 shows a rendering of the final design for a typical classroom. Lighting and electrical team members worked specifically with mechanical team members to provide an optimum layout for lighting, ducts, and electrical equipment in the plenum spaces. The engineering was influenced by the chosen structural system as well. For example, beams depths were limited in members that spanned classrooms and corridors in order to maximize plenum space for MEP equipment. All corridors and classrooms will have

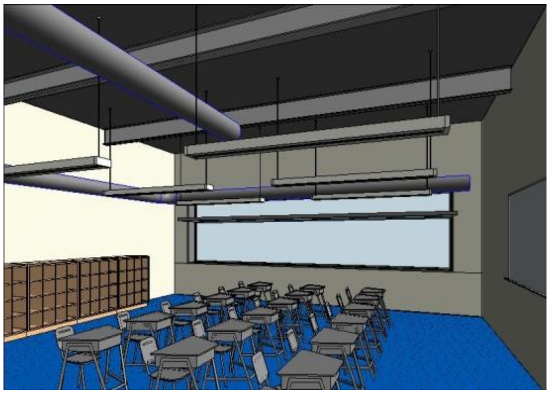


Figure 13: Interior rendering of a classroom

exposed ceilings. With exposed ceilings, acoustics have also been considered and acoustical metal decking will absorb sound in these areas.

Electrical team members worked hand in hand with mechanical team members to design an adequate electrical system to meet the electrical loads of the building. Working together, team members chose the most efficient equipment for the building. This included decisions pertaining to switchgear, air handling units, kitchen equipment, computers, commercial copiers and other equipment to sustain the interior functions while being mindful of the added cooling load from these demands.

Another major interior focus was integrating the lighting design with the LEED certification process. Lighting team members focused on reducing the electrical consumption of the building by developing classroom based scene controls, daylight harvesting equipment, occupancy sensors and an overall energy efficient lighting system. Refer to Appendix K for more details on lighting controls and electrical savings, and Drawings I103 and I104 for integrated plans of a typical classroom and the library.

As design progressed, the team was conscious of code requirements affecting building components such as ventilation, fire protection, receptacle layouts, and electrical system planning, among many others.

Coordination among trades involved in the above ceiling plenum space was conducted. Structural team members designed accordingly to account for increased volume of equipment in the corridors by limiting beam depths to eight inches. Mechanical and lighting/electrical team members coordinated the placement of above-ceiling mechanical piping, duct work, electrical conduit and lighting fixtures.

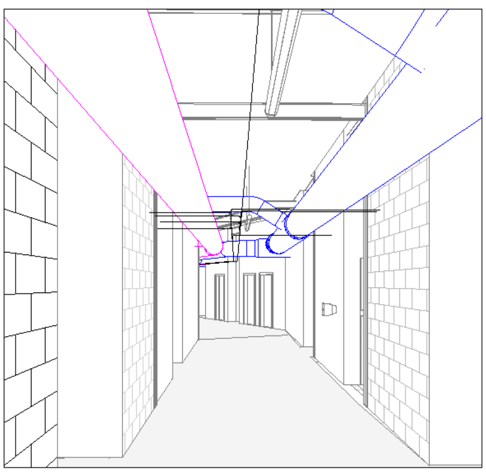


Figure 14: A screenshot depicting a clash between a column and duct

Coordination between structural and mechanical engineers was required during the design of the lateral system of the elementary school, and aesthetic appeal was also considered. Masonry shear walls provide and inexpensive and effective solution, as long as openings for duct runs were planned ahead of time. Braced frames were also used based on the modular layout of classrooms within the building. Diagonal bracing could therefore be hidden within classroom walls without interrupting large open spaces. See Appendix L for a basic layout of braced frames and masonry shear walls, as well as a comparison of concrete and structural systems for the new building.

More specifically, a series of clash detection analyses were performed throughout the preconstruction process as design developed. Critical spaces were determined by designers and construction specialists. These areas included MEP intensive areas such as corridor plenums, as well as critical and unique spaces such as classrooms and the multipurpose room. Constructability issues and critical design adjustments were addressed at the preconstruction stage rather than in the field. This provides benefits to the owner in both minimized schedule delays and cost savings on wasted equipment. Figure 14 shows an example of a clash that was discovered in the first clash detection between a column and duct run.

Light Weight Green Roof Design: A cost analysis was conducted on the green roof to analyze energy savings from a deeper green roof versus larger structural members due to larger dead loads. This information can be found in Appendix M. A lightweight, 4 inch system was selected for the green roof which requires minimal maintenance and has the capability to retain rainwater during droughts. The green roof also provides an appealing space for students to utilize and provides a learning opportunity, increasing the roof's functionality. This has been done by planning a space with walkways, hardscaping pavers and benches for an interactive learning environment. The paving system will be constructed so that the rainwater runs through the open joint assembly and beneath into the roofing a slightly sloped deck where the water will be guiding to the drains. Figure 15 and 16 show the assemblies for these combined systems to create the rooftop learning environment.

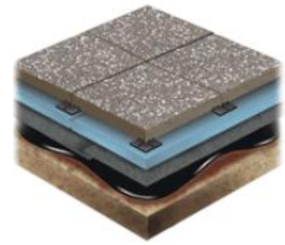


Figure 15: Ultimate Assembly for Plazas (American Hydrotech Inc., 2013)

A proprietary system, American Hydrotech, or equivalent system, is the proposed supplier of the green roof system and remainder of the roofing system for Reading Elementary School. The advantage of using a proprietary system is that all the components are from one manufacturer and designed to work together. This is an advantage with the occupiable green roof since the manufacturer will now confirm the warranty for the entire system. Hydrotech's Garden Roof (American Hydrotech Inc., 2013) will transform our flat roof above the west wing of the building into an actual learning environment for students. The system is designed as a lightweight, low profile Garden roof Assembly.

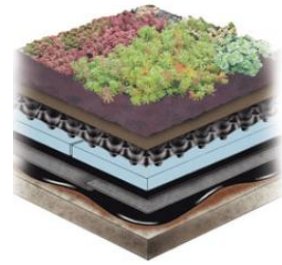


Figure 16: Extensive Assembly (American Hydrotech Inc., 2013)

The Extensive Assembly system by Hydrotech utilizes 3"-4" of growing media and requires little maintenance. The system helps to mitigate the urban heat island effect and reduces storm water runoff. Rainwater is stored in the drainage layer and will sustain plants for short periods of time in between rainfall. This system combined with Hydrotech's

Figure 17: Hydrotech Garden Roof Assembly (American Hydrotech Inc., 2013)

Ultimate Assembly for Plazas and Roof Terraces will create the roof terrace space needed for the proposed educational space. Figure 17 depicts a similar green roof space that the team is proposing.

The flat roofs on the elementary school design will utilize a Protected Membrane Roofing system. With this system, the arrangement of roofing components is roof deck, waterproofing membrane, moisture-resistant insulation. This system is also commonly referred to as an "upside down roof" and protects the waterproofing membrane from harsh weather, temperature, roof traffic, and other elements.

There were several sustainable options considered for the Reading Elementary including photovoltaic panels. Please review Appendix N for a rundown of calculations and cost analysis for the decision to not incorporate PV panels in the school design.

Natatorium and Clinical Space: The natatorium is being proposed as an Add/Alternate to the elementary school project. This facility will be located where the existing elementary school is placed on the property. Figure 18 shows the repurposed existing

Figure 18: View from Little League Field

elementary school and new elementary school.

Referencing the master plan, the east end of the building will be demolished and the new structure will house the community swimming pool. See Figure 19 for a view of the north facing sloped curtain wall on the proposed natatorium addition, and Figure 20 for an isometric section. This new structure will now be completely separate from the east wing where the clinical space will be in the existing elementary school. In order to move forward with the design of the clinic space renovation, several assumptions were made about the existing building. See Appendix O for a list of the team's assumptions. The team's initial idea for the structure of the natatorium was a large curved space frame to span the width of the pool. However due to the limited budget of Reading school district, a less expensive alternative was chosen that would still achieve the same aesthetic goal of a large curved roof structure. Prefabricated curved roof beams and purlins will be supported by vertical and angled hollow steel columns. Refer to Drawings I105, I106 and I108 for plans and isometric views of the natatorium and clinical space.

Figure 19: Rendering of curtain wall

A renovation of the west side of the existing elementary school will prepare the structure to be repurposed for the clinical space. The first floor interior will be demolished, and a floor plan has been developed to plan the space for the needs of the community. Figure 20 shows an isometric section of the natatorium.

Adhering to the team's assumptions for conditions of the existing school, the mechanical team chose to retrofit the mechanical system to keep the clinical project low cost with as many other benefits as possible. The proposed system of variable refrigerant volume (VRV) with heat recovery is designed for low maintenance and a long life while offering redundancy, energy efficiency, and sustainability. The mechanical system for the natatorium will utilize a separate system with a pool specific air handling unit to control the humidity and temperature in the pool area. The energy and cost savings of the proposed pool air handling system can be found in Appendix Q.

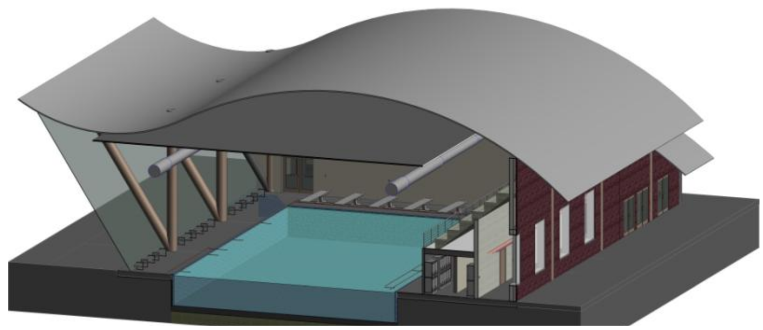


Figure 20: Isometric section of natatorium

Lighting and electrical team members designed a system that aimed to create a user friendly and functional environment that meets the ever changing needs of a medical space, while working adjacent to a school administration office. All lighting fixtures on the second and third floors are existing to remain. Light levels were met in all newly designed spaces. For a detailed lighting plans and calculations for the first floor and the pool area, reference the Lighting/Electrical write-up. Emergency panels were added to the first floor in order to handle all emergency equipment. Life Safety loads in the Natatorium and Clinic spaces are 3122VA at 277/480V. The Clinic standby power designed loads are 1974VA at 120/208V and 28kVA at 277/480V.

Disability or discomfort glare was a huge factor for the pool due to the large curtain wall. A daylighting analysis was performed on this space in Daysim. Since the curtain wall is facing north, direct sunlight was not a problem. If the owner feels necessary, frit can be added to the curtain wall for an additional cost.

The construction of the combined natatorium and clinical space will begin in June 2, 2014. This milestone date is coordinated with the substantial completion of the new elementary school construction. Interior demolition of the first floor for the clinical space and demolition of the existing building to prepare for the indoor swimming pool will begin concurrently. The substantial completion date is September 5, 2014 for this proposed construction plan. Construction concludes in time for the 2014 school year.

LEED Silver Certification: In order to create the most functional, efficient and appealing project while staying within the allotted budget, the team determined that LEED Silver is the best option to pursue. Many LEED points were easily obtained during the design process by simply following our project goals at little to no extra cost. An anticipated 52 LEED points will be earned on this project, which succeeds at reaching LEED Silver Certification, based on LEED 2009 for School – New Construction and Major Renovations (LEED 2008). Refer to Appendix P for a point breakdown, as well as an example of detailed documentation for receiving points.

Conclusion: In conclusion, the most appropriate measure of success would be an evaluation of the project goals achieved.

Functionality was achieved with interactive green roofs that provide a learning space while reducing energy loads. Window and lighting designs maximize natural daylighting to increase productivity while minimizing loads and the building's carbon footprint. Security systems were designed to maximize building safety while maintaining accessibility for occupants. Exposed ceilings minimize construction costs while providing an interactive learning experience between the students and the school.

Efficiency was achieved with advanced engineered systems. Ground Source Heat Pumps will minimize energy usage for heating and cooling loads. Lighting control systems such as dimmers and occupancy sensors will reduce electrical loads. Precast insulated architectural panels provide exceptional insulation properties while also minimizing the construction schedule. Passive solar systems, such as overhangs, were designed which harness the sun's energy in the winter while minimizing its heat during the summer.

Appeal was achieved with a modified site plan which better utilizes the space provided. The community natatorium rests in a unique and appealing structure. The redesigned open school atrium provides the school with an architectural attraction at the main entrance for all occupants to experience.

Our team can confidently say that in successfully achieving these three project goals, we have accomplished our overarching team goal of *creating an innovative, high-performance environment in a way that stimulates involvement in both education & the community.* The integrated structure and culture exhibited as well as detailed implementation of BIM by our team throughout the course of this project have resulted in a submission that successfully answered Reading School District's needs in a superior manner.

Our one true aim is to enhance the quality of the communities we work with through innovative ideas and an integrated design approach.

Ingenuity / Quality / Enjoyment / Integrity

Contents

Appendix A – References

American Hydrotech Inc. (2013). *Garden Roof Assembly.* Spring 2013. Web. <http://www.hydrotechusa.com/assemblies/garden-roof-assembly>.

Building Green, Inc. (2013). *Geopier Rammed Aggregate Pier System*. Fall 2012. Web. <http://www.buildinggreen.com/auth/productDetail.cfm?PRODUCTID=4847>.

CityRating.com (2013). *Reading Crime Statistics: Pennsylvania (PA)*. Fall 2012. Web. <http://www.cityrating.com/crime-statistics/pennsylvania/reading.html>.

The Computer Integrated Construction Program (2011). *BIM Project Execution Plan Version 1.0.* Fall 2012.

Geopier Foundation Company (2012). *Geopier Rampact System.* Fall 2012. Web. <http://www.geopier.com/Geopier-Systems/Rammed-Aggregate-Pier-System/Rampact-System>.

"Green Roof Energy Calculator." *Green Building Research Laboratory*. Portland State University, n.d. Web. 15 Sept. 2012.

Harrington, Gregory E., and Kristin Collette (2012). *NFPA 1 Fire Code Handbook*. Quincy, MA: National Fire Protection Association, Fall 2012. Print.

High Concrete Group, LLC (2010). *CarbonCast® Insulated Wall Panels*. Fall 2012. Web. <http://www.highconcrete.com/products/Components/structural/CarbonCast-High-Performance-Insulated-Wall-Panels.cfm>.

"Indoor Pool Design Guide." Dry-O-Tron. Dectron, 02 Dec. 2006. Web. 22 Sept. 2012.

Leadership in Energy and Environmental Design (2008). *LEED 2009 For Schools New Construction and Major Renovations.* Fall 2012. Web. <http://www.usgbc.org/ShowFile.aspx?DocumentID=5547>.

National Precast Concrete Association (2012). *Architectural Precast Concrete Wall Panels Connection Guide.* Fall 2012. Web. <http://precast.org/wp-content/uploads/2012/01/ArchitecturalConnectionsGuide.pdf>.

Reed Construction Data Inc. (2013). *RSMeans Online Version 5.0.1.* Fall 2012 – Spring 2013. Web. <http://www.rsmeansonline.com/SearchData>.

United States Census Bureau (2013). *Reading (city) QuickFacts from the US Census Bureau*. Fall 2012. Web. <http://quickfacts.census.gov/qfd/states/42/4263624.html>.

Appendix B - Project Budget & General Conditions

Project Budget - Renovation			
Division/Subdivision	**Base Cost**	**%**	**SF Cost**
Bidding Requirements	$ 86,700.00	2.89%	$ 4.34
General Requirements	$ 183,000.00	6.10%	$ 9.15
Concrete	$ 158,400.00	5.28%	$ 7.92
Masonry	$ 357,300.00	11.91%	$ 17.87
Metals	$ 336,300.00	11.21%	$ 16.82
Woods & Plastics	$ 34,200.00	1.14%	$ 1.71
Thermal & Moisture Protection	$ 107,100.00	3.57%	$ 5.36
Doors & Windows	$ 135,600.00	4.52%	$ 6.78
Finishes	$ 309,600.00	10.32%	$ 15.48
Specialities	$ 51,600.00	1.72%	$ 2.58
Equipment	$ 129,000.00	4.30%	$ 6.45
Furnishings	$ 85,200.00	2.84%	$ 4.26
Conveying Systems	$ 60,000.00	2.00%	$ 3.00
Plumbing	$ 186,000.00	6.20%	$ 9.30
HVAC	$ 405,000.00	13.50%	$ 20.25
Electrical	$ 375,000.00	12.50%	$ 18.75
Total Building Budget	**$ 3,000,000.00**	**100.00%**	$ 150.00

Project Budget - New Elementary School			
Division/Subdivision	**Base Cost**	**%**	**SF Cost**
Bidding Requirements	$ 462,400.00	2.89%	$ 4.74
General Requirements	$ 976,000.00	6.10%	$ 10.01
Concrete	$ 844,800.00	5.28%	$ 8.66
Masonry	$ 1,905,600.00	11.91%	$ 19.54
Metals	$ 1,793,600.00	11.21%	$ 18.40
Woods & Plastics	$ 182,400.00	1.14%	$ 1.87
Thermal & Moisture Protection	$ 571,200.00	3.57%	$ 5.86
Doors & Windows	$ 723,200.00	4.52%	$ 7.42
Finishes	$ 1,651,200.00	10.32%	$ 16.94
Specialities	$ 275,200.00	1.72%	$ 2.82
Equipment	$ 688,000.00	4.30%	$ 7.06
Furnishings	$ 454,400.00	2.84%	$ 4.66
Conveying Systems	$ 320,000.00	2.00%	$ 3.28
Plumbing	$ 992,000.00	6.20%	$ 10.17
HVAC	$ 2,160,000.00	13.50%	$ 22.15
Electrical	$ 2,000,000.00	12.50%	$ 20.51
Total Building Budget	**$ 16,000,000.00**	**100.00%**	**$ 164.10**

The Project Budget was based on combing several resources such as RS Means Data, Reading School District Spending and similar project data. Then using this budget, costs for different divisions were determined. This budget was used to help make decisions that affected the cost of the overall building.

Reading Elementary GC Summary	
General Conditions	**Cost**
Staffing	$ 673,880.00
CM Reimbursables	$ 229,040.00
Temporary Utilities	$ 157,667.00
Temporary Facilities	$ 60,400.00
Total Cost:	**$ 1,120,987.00**

Project Contingency	
Contingency	**Cost**
Contingency (5%)	$ 950,000.00

The General Conditions were also determined for the project. The summary table to the left shows a total of $1,120,987.00. The tables following depict further cost detail.

Reading Elementary Temporary Utilities				
Temporary Utilities	**QTY**	**Unit**	**Unit Cost**	**Total Cost**
Initial Tie In	1	LS	$ 2,500.00	$ 2,500.00
Electrical Power	1100	CSF/Floor	$ 51.50	$ 56,650.00
Water	16	Month	$ 69.50	$ 1,112.00
Lighting	1100	CSF/Floor	$ 42.95	$ 47,245.00
Heating	1100	CSF/Floor	$ 45.60	$ 50,160.00
			Total Cost:	**$ 157,667.00**

Reading Elementary Staffing Strategy						
Personnel	**Hours**	**Rate/HR**	**Weeks**	**Rate/Wk**	**Months**	**Cost**
Field Office						
Project Superintendent	40	$ 81.88	64	$ 3,275.00	15	$ 209,600.00
Project Manager	40	$ 81.88	64	$ 3,275.00	15	$ 209,600.00
Project Engineer - (LEED AP)	40	$ 50.00	60	$ 2,000.00	14	$ 120,000.00
Safety Superintendent	8	$ 81.88	56	$ 655.00	13	$ 36,680.00
Administration	40	$ 30.00	60	$ 1,200.00	14	$ 72,000.00
BIM Engineer	10	$ 50.00	52	$ 500.00	12	$ 26,000.00
				Total Cost:		**$ 673,880.00**

Reading Elementary Reimbursable Costs				
Construction Reimbursables	**QTY**	**Units**	**Unit Cost**	**Cost**
Janitorial Services	60	Weeks	$ 800.00	$ 48,000.00
Office Supplies	16	Month	$ 75.00	$ 1,200.00
Office Equipment	16	Month	$ 210.00	$ 3,360.00
Personal Computers	16	Month	$ 1,250.00	$ 20,000.00
Internet	16	Month	$ 125.00	$ 2,000.00
Computer Software	1	LS	$ 10,000.00	$ 10,000.00
Personal Phones	16	Month	$ 600.00	$ 9,600.00
Drawings/Specifications	1	LS	$ 10,000.00	$ 10,000.00
Postage/Shipping	16	Month	$ 700.00	$ 11,200.00
Vehicles				
Project Superintendent	16	Month	$ 550.00	$ 8,800.00
Project Manager	16	Month	$ 550.00	$ 8,800.00
Job Site Storage	16	Month	$ 100.00	$ 1,600.00
First Aid Supplies	16	Month	$ 55.00	$ 880.00
Travel	1	LS	$ 8,500.00	$ 8,500.00
Water/Coffee	16	Month	$ 75.00	$ 1,200.00
PPE	1	LS	$ 2,000.00	$ 2,000.00
Small Tools	16	Month	$ 300.00	$ 4,800.00
Fire Extinguishers	1	LS	$ 1,000.00	$ 1,000.00
Site Drinking Water	16	Month	$ 225.00	$ 3,600.00
Snow Removal	1	LS	$ 7,500.00	$ 7,500.00
Truck Wash	1	LS	$ 65,000.00	$ 65,000.00
			Total Cost:	**$ 229,040.00**

Reading Elementary Temporary Facilities				
Temporary Facilities	**QTY**	**Units**	**Unit Cost**	**Cost**
Office Trailers	2	Each	$ 10,525.00	$ 21,050.00
Office Furniture	16	Month	$ 1,200.00	$ 19,200.00
Temporary Fencing		LF		$ -
Construction Signage	50	Each	$ 75.00	$ 3,750.00
Sanitary Facilities	12	Each	$ 200.00	$ 2,400.00
Parking	40	Space	$ 350.00	$ 14,000.00
			Total Cost:	**$ 60,400.00**

Reading Elementary Bonds & Insurances				
Bonds & Insurances	**QTY**	**Units**	**Project Cost**	**Cost**
Payment & Performance Bond	1	%	$ 19,000,000.00	$ 190,000.00
Insurance				
General Liability	0.75	%	$ 19,000,000.00	$ 142,500.00
Automobile	0.25	%	$ 19,000,000.00	$ 47,500.00
Builder's Risk	0.25	%	$ 19,000,000.00	$ 47,500.00
Permits	0.5	%	$ 19,000,000.00	$ 95,000.00
			Total Cost:	**$ 522,500.00**

Note: Bonds & Insurances and Project Contingency is not included in the summary GC Costs above.

Appendix C – Bim Execution Plan

The BIM Execution Plan was created based on information supplied by an existing template which is used by the several organizations for the execution of design and construction projects. Below are a few snapshots of noteworthy sections of the twenty three page document.

2.5 PROJECT MILESTONES

PROJECT MILESTONE	ESTIMATED START	ESTIMATED COMPLETION	PROJECT DELIVERABLE	INVOLVED PROJECT STAKEHOLDERS
Preliminary Planning	9/1/12	9/14/12	Presentation 1	MEP, Struct, CM
Schematic Design	9/14/12	10/3/12	Presentation 2	MEP, Struct, CM
Design Development	10/3/12	10/24/12	Presentation3	MEP, Struct, CM
Construction Documents	10/24/12	11/12/12	Proposal	MEP, Struct, CM
AEI Submission	11/12/12	2/22/12	Electronic Submission	MEP, Struct, CM
Short List Selection	2/22/12	3/8/12	None	MEP, Struct, CM
Finalist Presentation	3/8/12	4/3/12	Final Presentation	MEP, Struct, CM
Award	4/5/12	4/5/12	None	MEP, Struct, CM

To the left is a subsection snapshot from the Project Information Section of the BIM Execution Plan, outlining our major milestones identified for completing the ASCE student competition.

To the right is a snapshot of our 'BIM Uses During Planning' layout (5.2.1). This table laid out and distributed necessary responsibilities to team members for BIM Uses. A 'BIM Uses During Design' layout was also developed, but is too large for this document

5.2.1 BIM USES DURING PLANNING

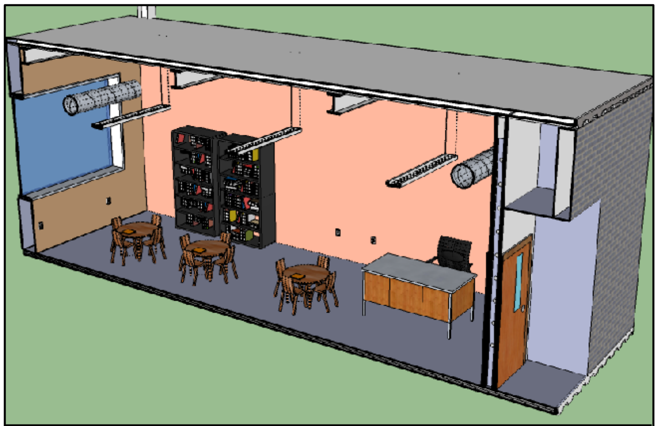
BIM USE	OBJECTIVE	RESPONSIBLE PARTY	EFFORT
Schematic Model	Develop preliminary model based off plans supplied by AEI. This model will be altered throughout the design process; however a basic understanding of the building characteristics will be developed.	**All Members**	**Significant Effort**
Preliminary Site Logistics	Brainstorm possible site logistics layouts based on schematic model. Develop advantages and possible issues with various logistics layouts.	**CM**	**Significant Effort**
Energy Analysis	Develop energy analysis based on building size, expected occupancy and other loading factors. This will narrow design options for each discipline.	**L/E, HVAC, Structural**	**Significant Effort**

4.1.3 BIM RESOURCE ALLOCATION PLAN

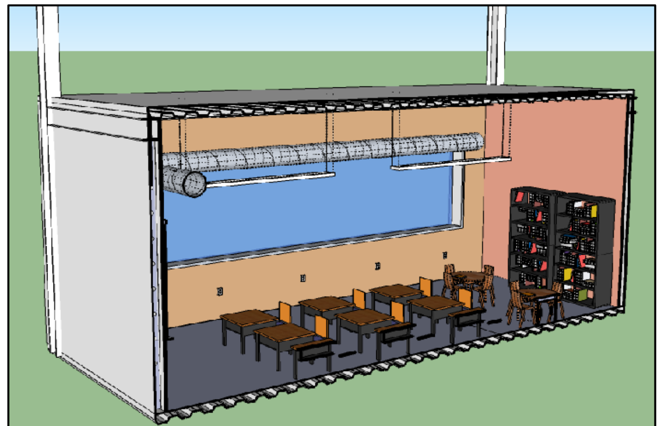
TASK	ROLE	Staff Size	Hours Planned	Weeks
Model Development	Architect(Collaborative)	8	2 hrs/wk	3
	CM	2	8 hrs/wk	8
	Electrical	2	8 hrs/wk	8
	Lighting	2	8 hrs/wk	8
	Mechanical	2	8 hrs/wk	8
	Structural	2	8 hrs/wk	8
Model Review	CM	2	1 hr/wk	16
	Electrical	2	1 hr/wk	16
	Lighting	2	1 hr/wk	16
	Mechanical	2	1 hr/wk	16
	Structural	2	1 hr/wk	16
Structural Analysis & Design	Structural	2	10 hrs/wk	8
Lighting/Electrical Analysis & Design	Lighting/Electrical	2	10 hrs/wk	8
Mechanical Analysis & Design	Mechanical	2	10 hrs/wk	8
LEED Certification Plus+ Reviews	Collaborative	8	4 hrs/wk	6
Schedule	Construction	2	5 hrs/wk	2

To the left is a subsection snapshot for our 'BIM Resource Allocation Plan' (4.1.3). This lays out the expected time commitments for each option, based on necessary tasks. Although the hours planned and weeks were flexible, this layout was extremely beneficial in keeping team members on track to meet such a large quantity of the team goals that were developed with BIM.

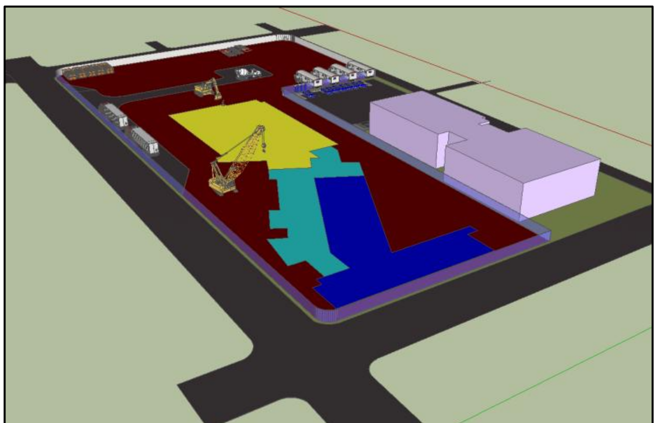
Appendix D – Virtual Mockups



Virtual MockUp 1: Typical Classroom



Virtual MockUp 2: Typical Classroom



Virtual MockUp 3: Phase 1 Site Logistics

Virtual MockUp 4: Phase 2 Site Logistics

Virtual MockUp 5: Substantial Completion

Above are four examples of virtual mockups which were modeled to help communicate and better understand some of the team's design and ideas. The virtual mockups of the typical classroom were beneficial in planning coordination between the teams' engineered systems and interior layout and space planning. The logistics mockups were beneficial in space planning during construction. This visualization helped the team better layout spaces for material deliveries, trailer locations, laydown areas and crane placement. The substantial completion MockUp was useful for architectural purposes as a more time-efficient means of portraying ideas prior to

Appendix E – Security Diagrams

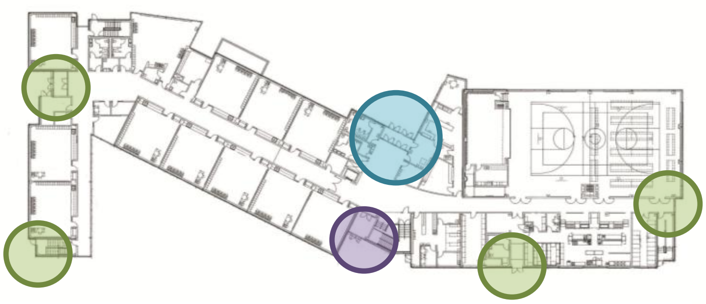
Visitor entrance, guests must be buzzed in and sign in at front desk

Unlocked for public access

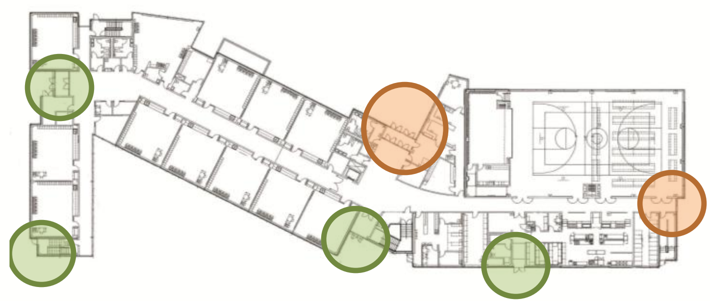
Locked; faculty card swipe access only

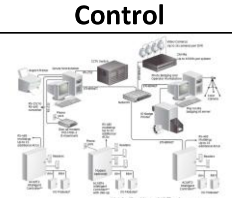
Locked; emergency exit only

Morning (6:00 am – 5:00 pm)



Evenings / Weekends (access to public spaces only)



Security Cameras	Topaz Access Control	Card Readers	Glass Break Sensor
			
Vandal Resistant Security Cameras	Building Control System	Building Access Control	Acoustic and PIR Glass Break Sensor and Transmitter

These security measures will help to ensure the safety and security of the Reading Elementary School students, faculty, and staff. The devices above will be implemented, along with bullet proof glass at the building entry. These devices will prevent unwanted entry, as well as prevent vandalism and violence in the school. The main building security devices will all tie into the Topaz Access Control system. This encourage monitoring of all of the systems from one location. It will also allow for a quick dispatch of announcements to the students, as well as emergency response teams.

Appendix F – Glazing Selection

ASHRAE Standard 90.1 Building Envelope Requirements		
Vertical Glazing Type	**Assembly Max. U**	**Assembly Max SHGC**
Non-metal Framing (all)	0.35	0.40
Metal Framing (Curtain Wall)	0.45	0.40
Metal Framing (all other)	0.55	0.40

Table 1: Building Envelope Requirements

Glazing Types	Assembly U-Value	Assembly SHGC	VT
Double High Performance Tint (Argon)	0.54	0.390	0.607
Double Low Solar Low-E Clear (Air)	0.40	0.382	0.701
Double Glazed Triple Silver Low-E (Argon)	0.35	0.272	0.638

Table 2: Glazing Types and Properties

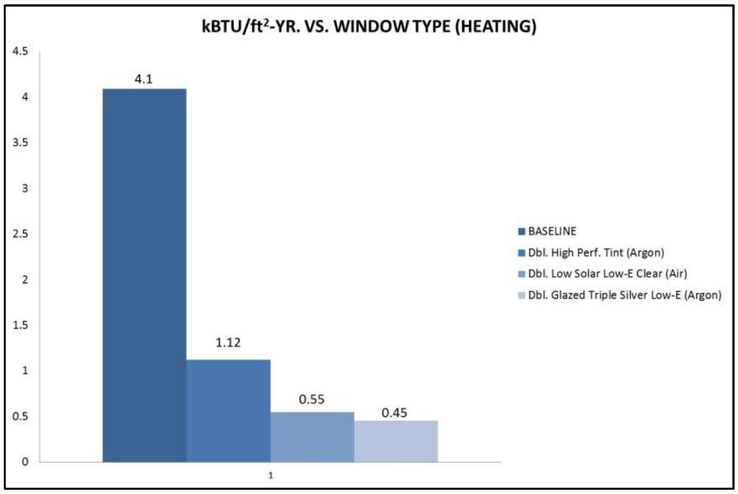


Figure 1: Glazing's Effect on Heating Load

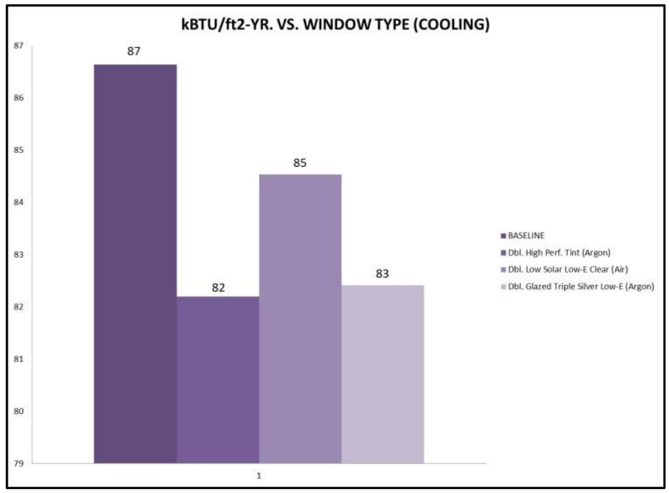


Figure 2: Glazing's Effect on Cooling Load

Glazing Prices		
Type	**Price per SF**	**Total Cost of Glazing**
Double High Performance Tint (Argon)	$6.85	$82,384.95
Double Low Solar Low-E Clear (Air)	$9.10	$109,445.70
Double Glazed Triple Silver Low-E (Argon)	>> $9.10	>> $109,445.70

* Low volume pricing; does not include mark-up, framing, triple silver coating, etc

Table 3: Glazing Prices

Three types of glazing were selected for further observation. **Table 1** shows the ASHRAE 2010 Standard 90.1 requirements for glazing. All three options tested meet these requirements and also have a good visible transmittance (VT) for daylighting and views, shown in **Table 2**. **Figures 1 and 2** compare the effects of each glazing on the heating and cooling loads, respectively. Since the elementary school will be in cooling mode for a majority of the year, it was important to choose a glazing that least negatively affected the cooling load. Cost also impacted the final decision. **Table 3** shows the cost break down. Double High Performance Tint with an Argon fill was selected for the final glazing.

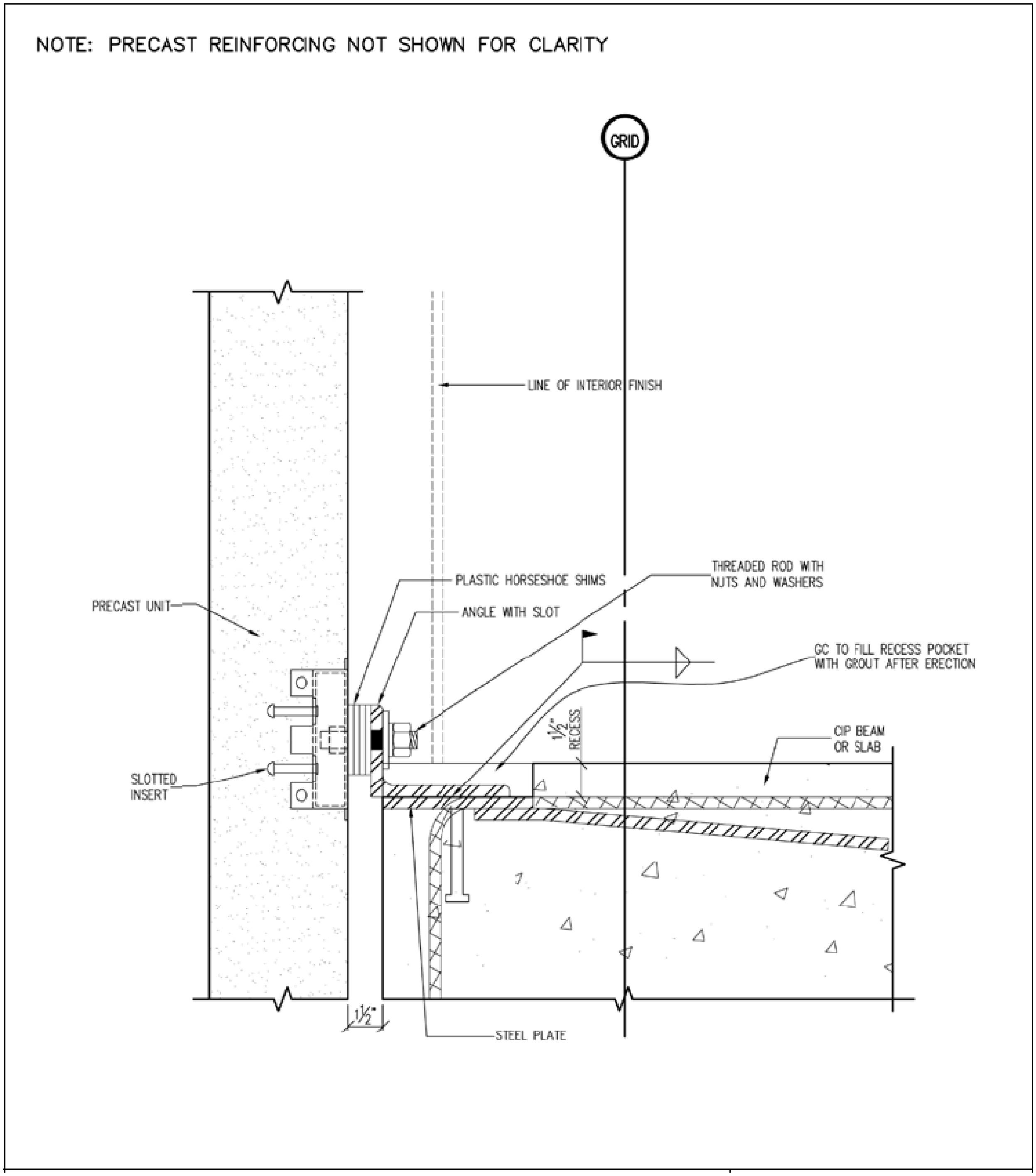
Design Criteria	
Window-to-Wall Ratio	< 40%
Our Facade	
Window-to-Wall Ratio	**29.5%**

Table 4: Window-to-Wall Ratio

It is required by ASHRAE that the Window-to-Wall Ratio is no greater than 40%. After the façade design was finalized, our Window-to-Wall Ratio is about 29.5%. This is also ideal for daylighting purposes, where the Window-to-Wall Ratio should typically fall above 20% or 25%.

Appendix G- Precast Panel Connections

Each panel is independently supported by steel tieback connections that are able to transfer load to the supporting structure and provide stability. Design criteria considered in the panel connections included strength, volume change accommodations, fire resistance, constructability, among others. Joints between panels will be filled with sealant, and each concrete wythe acts as a vapor and air barrier. Oversized holes in plates and angles will allow for dimensional variations and sufficient construction tolerances.



(Connection detail courtesy of NPCA Connection Guide)

Appendix H – Shading Device Analysis

Multiple static shading devices were tested on each classroom orientation. It was important that not only would these shading devices help block direct sunlight, but they must not negatively hinder the building's architecture. For the sake of space, **Figures 1 – 4** and **Tables 1 and 2** only show the West facing classrooms. For every classroom analysis, please refer to the Lighting/Electrical write-up. For the West facing classrooms, a lightshelf and fins were analyzed. **Figures 3 and 4** show annual metrics represented with Daylight Autonomy contours from Daysim. Daylight Autonomy (DA) is the measure of the percentage of hours that a certain daylight level is reached throughout the year. For example, DA_{400lux} is how often the space exceeds 400 lux. DA "provides a measure of how well daylight can replace electric light" when using photosensors to dim the lights. It was also important to ensure that there was not too much direct sunlight entering the space. Using information that was output to us from Daysim, we were able to determine how many hours out of the year that direct sunlight was interfering with the space. These values can be seen in **Tables 1 and 2**. For the final design of the West classrooms, it was decided that lightshelves would be used.

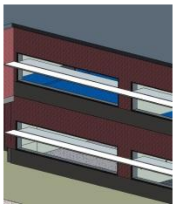


Figure 1: Lightshelf

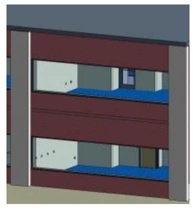


Figure 2: Vertical Fins

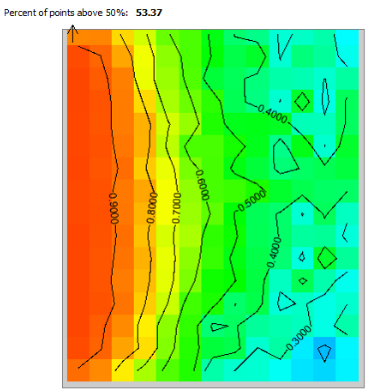


Figure 3: DA_{400lux}

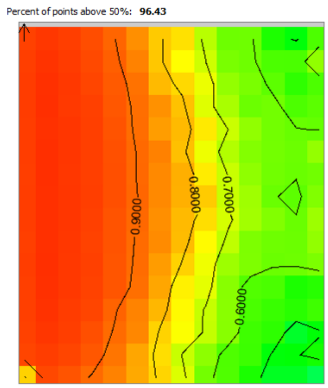
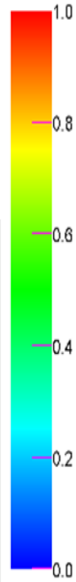


Figure 4: DA_{400lux}



Hours of Direct Sunlight per School Year
540 hrs/School Year
33% of the School Year

Table 1: DA_{200lux}

Hours of Direct Sunlight per School Year
800 hrs/School Year
50% of the School Year

Table 2: DA_{200lux}

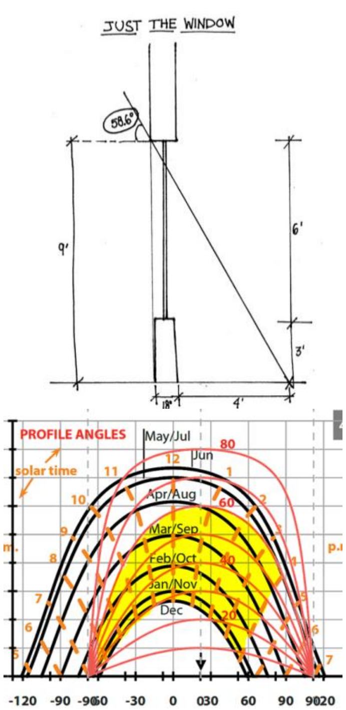


***Figure 5**: Window w/o lightshelf*

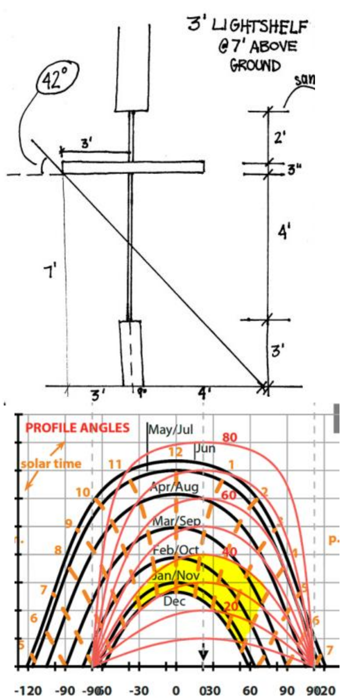


***Figure 6**: Window w/ lightshelf*

The graphs in **Figure 5** and **Figure 6** show a simple analysis for the lightshelf design. The yellow represents the amount of time direct sunlight is hitting the façade (in this example, the South facing façade). It is clear in **Figure 6** that a 3' lightshelf does an effective job in reducing the amount of direct sunlight hitting the façade. It also limits the direct sunlight to the winter months. In that case, cloth roller shades will be used to stop the direct sunlight from entering the space. The direct sun hitting the glass in the winter months can actually help reduce the HVAC heating loads. For further details, reference the Lighting/Electrical write-up.

Appendix I – Atrium Daylight

Figure 1: 3D Section of Atrium

December 21st @ Noon
Average Illuminance = 25 fc

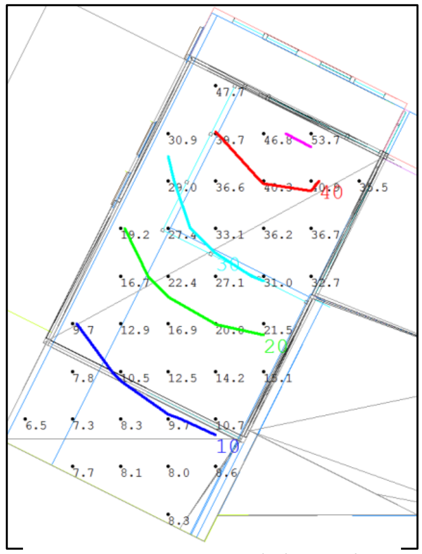


Figure 2: Atrium Daylight Levels

June 21st @ Noon
Average Illuminance = 53 fc

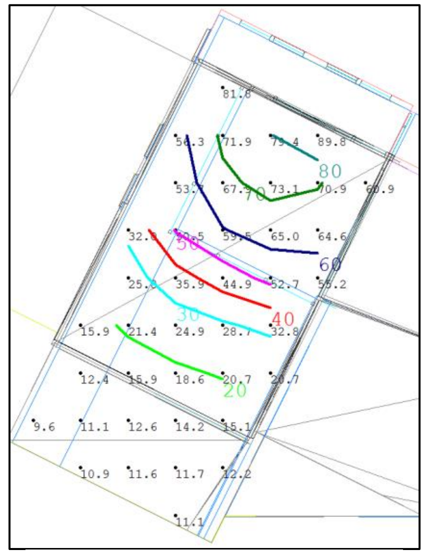


Figure 3: Atrium Daylight Levels

As stated in previously in the report, it was intended originally to use Kalwall to construct the roof of the atrium. All of the glazing and Kalwall in the atrium space was negatively affecting the HVAC loads. In order to correct this, calculations were run with an opaque roof. If adequate daylight levels were reached with a solid roof material, then there was no reason for the Kalwall roof. **Figure 2** and **Figure 3** are showing AGi32 calculations (daylight only) in December and June with an opaque roof material. The design criteria for an atrium (recommended in the IESNA Lighting Handbook) is 10 fc. Therefore, these calculations show that even without the Kalwall roof, the daylight levels are well above what is recommended. This will still allow for all lights in the atrium to be off during the day.

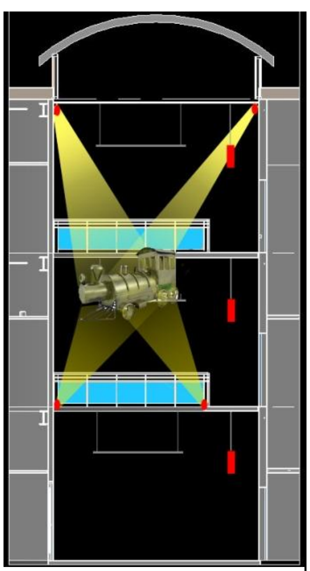


Figure 4: Schematic Lighting Design

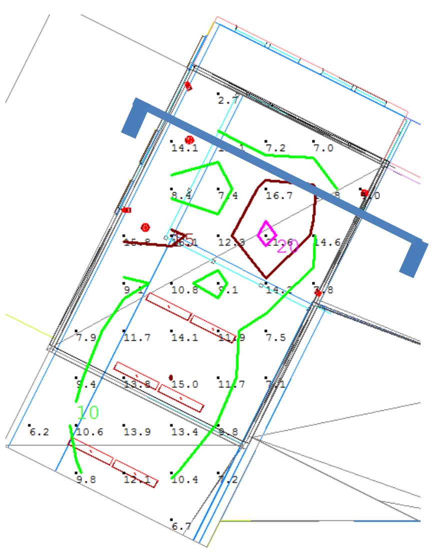


Figure 5: AGi32 Calculations (Electric Ligh
Criteria: Avg – 10 fc, Avg: Min - 4:1
Actual: Avg – 10.93 fc, Avg:Min – 4.05

Figure 4 and 5 were added for a little more information on the atrium design. A big design idea was to suspend a piece of artwork by Robert Ian Pepper (local Reading artist). LED fixtures would be used to illuminate the artwork. In this case, the artwork would be a train to represent the Reading Railroad. Illuminating this center piece will not only allow for an interesting dynamic within the space, but will provide a passerby with an interesting scene. This is just another way to bring together both the school and the **community**. Additional light fixtures must also be used to reach the required light levels in the atrium. **Figure 5** shows the light level calculations from AGi32. For more detailed information on the specific lighting layout and fixtures used, please reference the Lighting/Electrical write-up.

Appendix J – Skylight

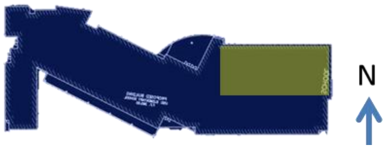


Figure 1: Exterior Rendering of Gym

Daysim was used to analyze the daylight levels in the multi-purpose room. To the left are illuminance contours for the multi-purpose room with and without skylights. **Figure 2** shows that without skylights (and only the window on the north façade) the daylight distribution is not very even across the space. The images in **Figure 3** show a more uniform daylight distribution. Skylights also double daylight levels, this will allow for reduction of electric light levels throughout the day.

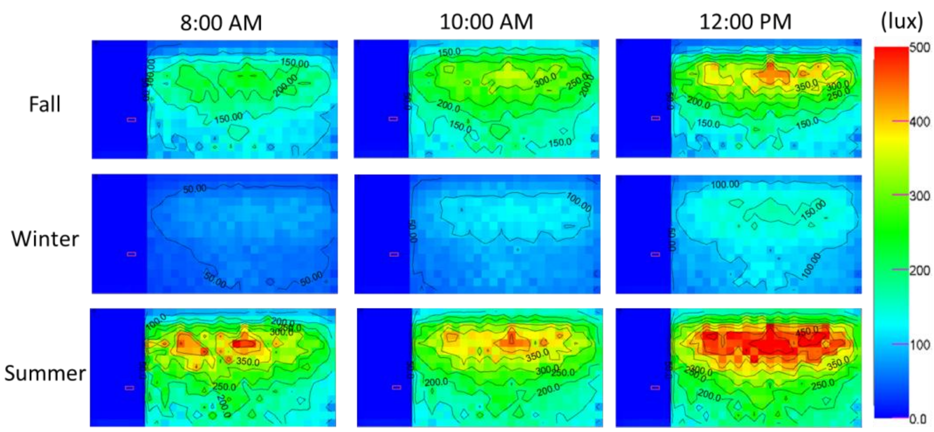


Figure 2: Illuminance contours without skylights

Figure 4 is a plan of our systems layout, showing coordination between all systems.

If the owner choses to move forward with skylights, our team suggests implementing fixed skylights flush with the roof line as opposed to a skylight well. While you can get efficient skylight wells, the most efficient skylight is a fixed skylight. The daylight will have the ability to come right in without taking bounces off of skylight well walls.

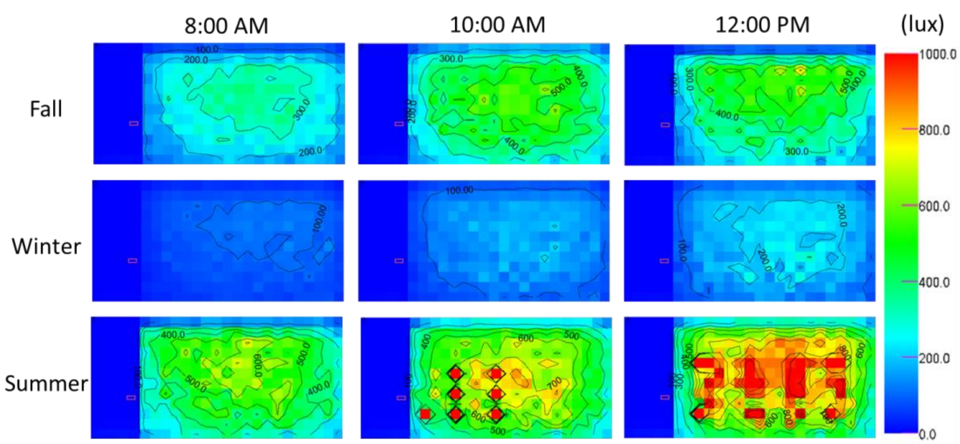


Figure 3: Illuminance contours with skylights

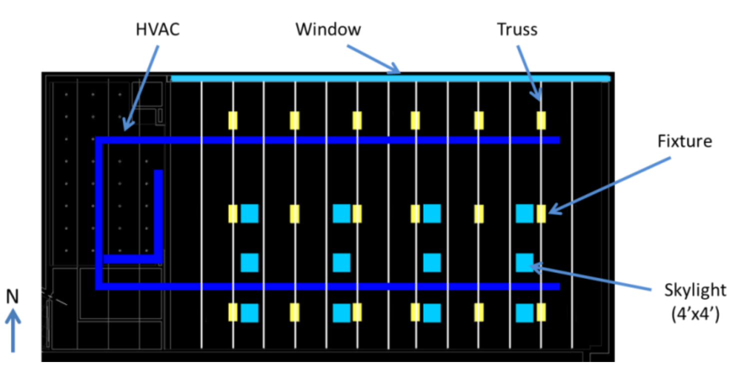


Figure 4: Systems Layout

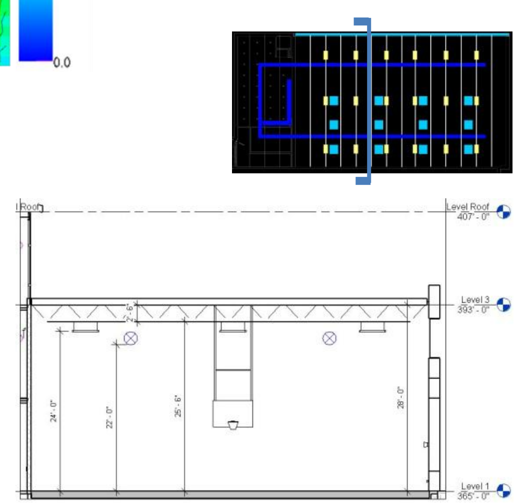


Figure 5: Section View

Appendix K – Lighting Controls/Electrical Savings

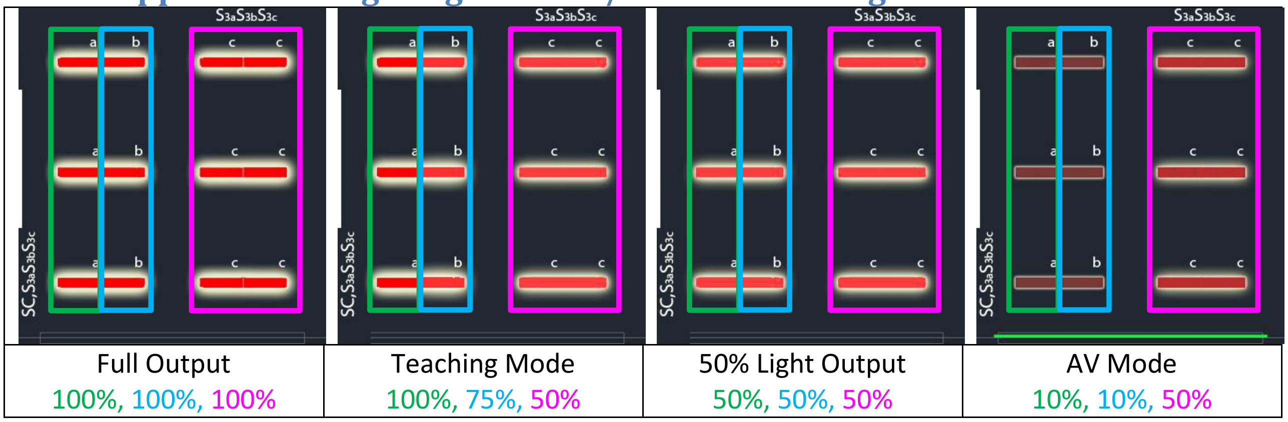


Figure 1: Classroom Scene Settings NOTE: Different colored boxes represent the different zones

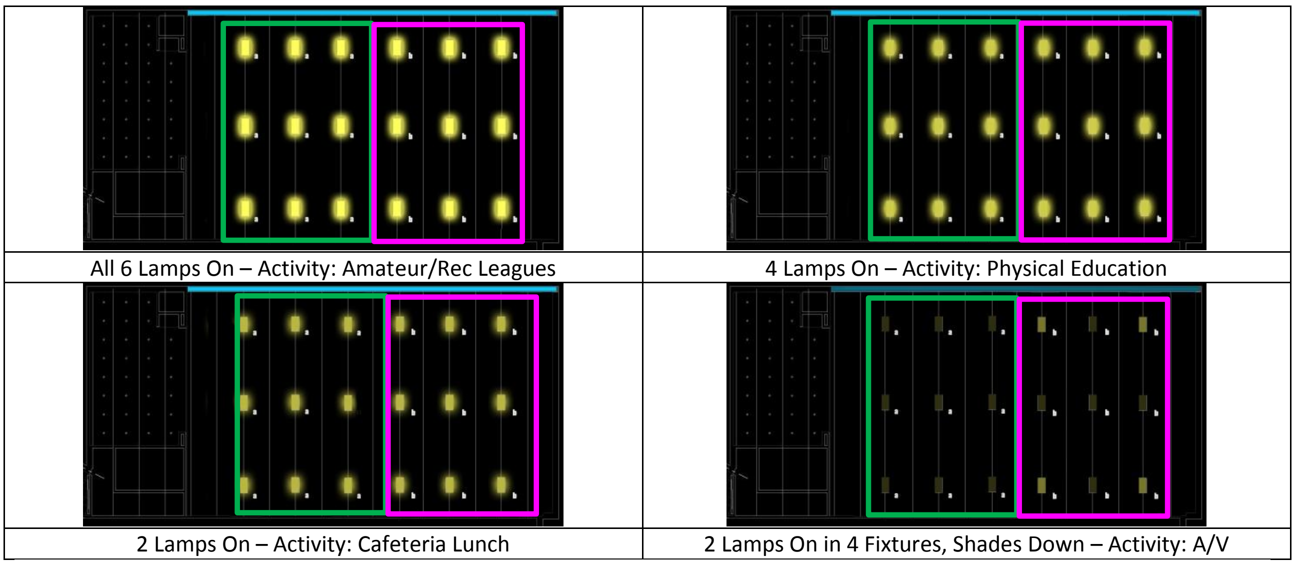


Figure 2: Multi-Purpose Room Scene Settings NOTE: Different colored boxes represent the different zones

<u>Total Classroom Energy Savings for 36 Classrooms</u>

= 28,360 kWh/Year

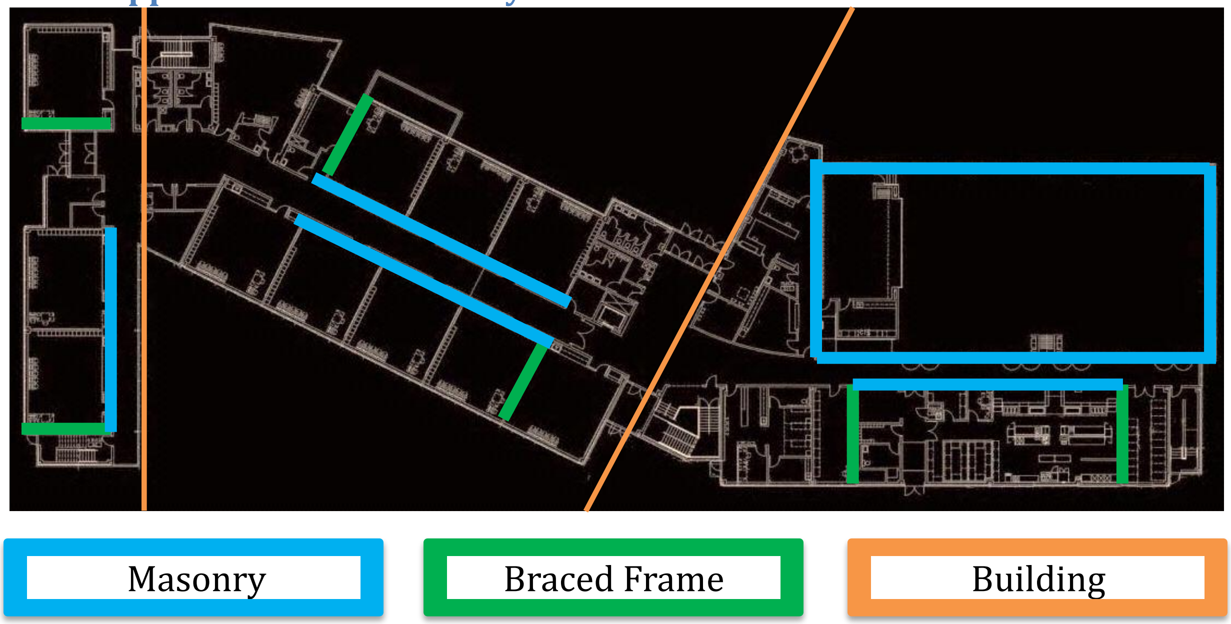
= $1,900/Year

Photosensors were used on all perimeter rooms. For all classrooms the two rows of fixtures closest to the window were controlled by photocells. Using Daysim we were able to estimate the energy savings from dimming the electric light only. This was analyzed for every major space that utilized photocells. Above, is only the numbers for the classrooms. Additional information is in the Lighting/Electrical write-up.

All lighting controls in the elementary school follow the ASHRAE 2010 Standard 90.1 Lighting Controls Requirements stated in Section 9.4.1. This includes the use of occupancy/vacancy sensors and photocells where required. The whole building is also on a Building Management System for ease of adjustments. More control system information can be found in the Lighting/Electrical write-up.

A scene control panel was implemented in each classroom. A big reason energy savings sometimes fall short of expectation is because the users don't correctly utilize these elements, so it is important that the system is user friendly. A scene control panel will allow for change in classroom settings by the push of a button. **Figure 1** shows 4 of the 5 settings (on/off not shown) that can be selected on the WattStopper Scene Switch. The same type of scene control will be located in the multi-purpose room. **Figure 2** shows the different settings available. Since there is a divider that will sometimes be running down the middle of the space, there will be two separate scene control switches for each half of the gym. They will both contain the same scene options.

Appendix L – Structural Systems



The lateral system that was designed consists of a combination of braced frames and masonry shear walls. The building was divided into four smaller buildings for the design of the lateral system: the west green roof wing, central wing, east wing, and multipurpose space. Two braced frames with HSS steel sections within the classroom dividing walls in one direction were utilized for the first three buildings. These were paired with concrete masonry shear walls parallel to corridors. Braced frames and floor diaphragms were modeled in ETABS to find forces to size members. Each shear wall mas modeled in RAM Element with openings for doors and mechanical equipment to find the required rebar. Lengths of shear walls were based on the required lateral resistance as well as aesthetic appeal within the corridors. The multipurpose space acts as its own independent structure, with 10" reinforced masonry walls that act as both the lateral and gravity system.

	Reinforced Concrete	Steel
Pros	• Utilizes local resources and materials • Does not require additional fire proofing	• Lighter weight • Uses recycled material • Shorter schedule
Cons	• Requires larger foundation to accommodate weight • Greater CO_2 emissions compared to steel	• Needs additional fire proofing

Decking Types		
Typical Floor	2VLI20	4.5" Composite Deck w/o studs
Typical Roof	1.5B20	Metal Non-composite
Multipurpose Space Roof	2VLI18	5.5" Composite Deck w/o studs
Green Roof	1.5B16	Metal Non-composite

Appendix M – Green Roof Cost Analysis

A cost analysis was conducted on the green roof to analyze energy savings from a deeper green roof versus larger structural members due to larger dead loads. Using a green roof cost analysis software created by Green Building Energy Research Library of Portland State University (Green Roof Energy Calculator), the tradeoff between energy savings and depth of the green roof were calculated and compared. See Table 1 below for the various depths and conditions tested. Energy prices of $.165 electricity per kWh and $1.20 utility (piped) gas per therm were used to calculate the energy savings of various green roof depths. The analysis was based on a roof area of 5313 SF of which the green roof covers 80%. The remaining 20% would have pavers for the school children to access and have class.

Table 1. Green Roof Cost Analysis

Depth (in)	Irrigated?	Energy Savings compared to Dark Roof	Energy Savings Compared to White Roof	Runoff (in) [1]
2 in	No	$408.63	$244.25	16.5
2 in	Yes	$419.48	$255.10	25.0
4 in	No	$433.09	$268.71	14.6
4 in	Yes	$444.28	$279.20	22.6
6 in	No	$445.14	$280.76	11.0
6 in	Yes	$455.40	$291.02	18.6
8 in	No	$470.77	$306.39	10.6

[1]For reference, a conventional roof had 39.6 in of runoff annually.

A lightweight, 4 inch system was selected for the green roof. This was determined to be the best tradeoff between roof weight and energy savings. A non-irrigated roof allows for less runoff, easier and less maintenance and less initial cost. A typical assembly of the green roof system can be seen in figure 1. Compared to the typical dark roof of a school building, the elementary school will save approximately $433.09 per year and save approximately 3179.2 kWh in electricity.

Providing savings was not the only consideration for utilizing a green roof system. Allowing the students and faculty to access and utilize the roof for learning opportunities was important. 20% of the roof was allocated for hardscaping pavers designed for walkways and interactive learning stations. A typical assembly of the pavers for the green roof can be seen in figure 2.

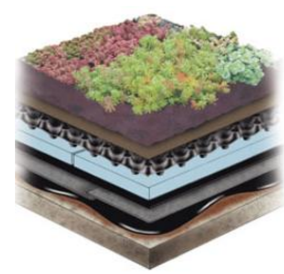


Figure 1: Ultimate Assembly for Plazas
(American Hydrotech Inc., 2013)

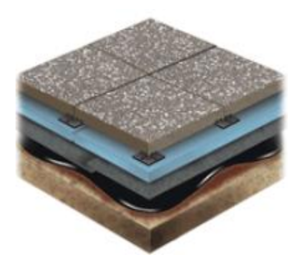


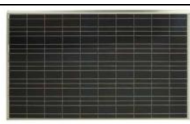
Figure 2: Extensive Assembly
(American Hydrotech Inc., 2013)

Appendix N – Photovoltaic Panel Calculations

Solar Panel Type	Max Power	Tilt Angle	Azimuth	Cost/Panel	# Panels	Total Energy Savings/Year	Unit	Cost/kWh	Energy Savings / Year	Payback Period
Uni-solar	68W	15°	180°	$120	362	32,518	kWh	$0.06601	$2,146.51	20.2
Uni-solar	68W	15°	150°	$120	448	32,518	kWh	$0.06601	$2,146.51	25.0
Uni-solar	144W	15°	180°	$250	188	35,900	kWh	$0.06601	$2,369.76	19.8
Uni-solar	144W	15°	150°	$250	233	44,610	kWh	$0.06601	$2,944.71	19.8
Sharp	235W	15°	180°	$400	247	76,500	kWh	$0.06601	$5,049.77	19.6
Sharp	235W	15°	150°	$400	306	92,500	kWh	$0.06601	$6,105.93	20.0
Sanyo	225W	15°	180°	$650	332	96,900	kWh	$0.06601	$6,396.37	33.7
Sanyo	225W	15°	150°	$650	399	113,000	kWh	$0.06601	$7,459.13	34.8

There was much research put into sustainable design and renewable energy systems in the elementary school design. A study was performed to research the ideal slope for a photovoltaic system on the roof and the best slope for the clerestories for inside the building. We decided that about a 15° slope would be best to accommodate both systems. We also calculated that there would be about 10,500 sqft of roof area facing either south or south west.

Multiple options were considered for a photovoltaic panel layout and type for this roof. Using the chart above, the total energy savings per year per system is calculated with the help of an online solar calculator called PVWatts. The payback periods proved to be so high, and rebate/stimulus money so low, that the system will not be ideal for this project. Unless more funding can be found in the future, the solar panel design will not be implemented.

 **Sharp and Sanyo Multi-Purpose PV Panels**	• Conventional PV panels mounted directly to 15* roof slope • Multiple Max Power options • High cost • High installation time • High output per square foot • Affected greatly when overcast or partially shaded	• Good option for Reading if funding can be acquired. • Most energy efficient, but also the most heavy and expensive.
 **Uni-Solar ePVL PowerBond**	• Flexible panels adhering directly to 15* roof slope • Two lengths with different power outputs for different spaces • Low Cost • Easy Installation • Low output per square foot • Works best when diffuse light	• Best option for Reading, PA if funding can be acquired. • Light and easy to install, plus they work best in diffuse light conditions.
 **OnysSolar PV Transparent Glass**	• Solar Collector Glass • Many shapes, sizes, colors, and transparencies • High Cost • New Technology • Must be south facing • Low output per square foot • Direct sunlight required	• Not an option for this school. • There is not enough vertical south facing glass.

Appendix O – Phase 2 Assumptions

The following assumptions were made about the existing elementary school on site in order to proceed with the Phase 2 design of the project.

- Existing three story elementary school
- 14' floor to floor height
- Gymnasium located on East Wing/Slab on Grade
- Structural steel frame with moment connections
- Asbestos Abatement Plan in construction report
- Existing Air Handling Unit will be disconnected from existing first floor and will remain in use for the second and third floors
- Existing exhaust fans are adequately sized to account for the clinic space. Clinic space will tap into exhaust shaft where previous first floor connected.
- Similar soil conditions and foundation system for pool
- Clinical space roof can support second Air Handling Unit for pool
- Electrical panels for lighting loads on every floor of renovation area
- Emergency Panel on first floor
- Lighting for second and third floors will remain the same
- 120/208 Volt, 3 phase power
- Exterior façade will remain the same for clinic space
    - Walls and windows closely resembled the standard set forth by ASHRAE 90.1

Figure 1: Elementary School and Existing Elementary School (Pool) – View from Little League Field

Appendix P – LEED Point Breakdown

Point Breakdown

Category	Points Possible	Points Earned	Comments
Sustainable Sites	25	19	
Water Efficiency	10	4	
Energy & Atmosphere	35	13	
Materials & Resources	14	5	
Indoor Environment Quality	15	9	
Innovative Design	6	1	
Regional Priority	4	1	
Total:	109	52	LEED Silver

The above table was compiled after doing extensive research and reviewing LEED 2009 For Schools New Construction and Major Renovations. The points determined to be achievable were agreed upon by our integrated team and incorporated into our design and construction goals.

Backup Example of Point Attainment:
Water Use Reduction Calculation for LEED Credit- 2 points

Water Closets						
FTE	Female Ratio	Uses/Day	FTE	Male Ratio	Uses/Day	Total Uses
1323	0.5	3	1323	0.5	1	2646
Urinals						
FTE	Female Ratio	Uses/Day	FTE	Male Ratio	Uses/Day	Total Uses
1323	0.5	0	1323	0.5	2	1323
Lavatory Faucet						
FTE	Duration	Uses/Day	FTE	Male Ratio	Uses/Day	Total Uses (min)
1323	30	3				1984.5

LEED Baseline (gpf)	Baseline usage (gal)	Baseline Cost	Our Design (gpf)	Our Design Usage (gal)	Our Cost	Savings
1.6	4233.6	$22.95	1.1	2910.6	$15.78	**$7.17**
LEED Baseline (gpf)	**Baseline usage(gal)**	**Baseline Cost**	**Our Design (gpf)**	**Our Design Usage (gal)**	**Our Cost**	**Savings**
1	1323	$7.17	0	0	$0.00	**$7.17**
LEED Baseline (gpm)	**Baseline usage (gal)**	**Baseline Cost**	**Our Design (gpm)**	**Our Design Usage (gal)**	**Our Cost**	**Savings**
1.5	2976.75	$16.13	0.5	992.25	$5.38	**$10.76**
Savings Per Year	**$9,160.52**					
Water Use Reduction	**45.74%**					

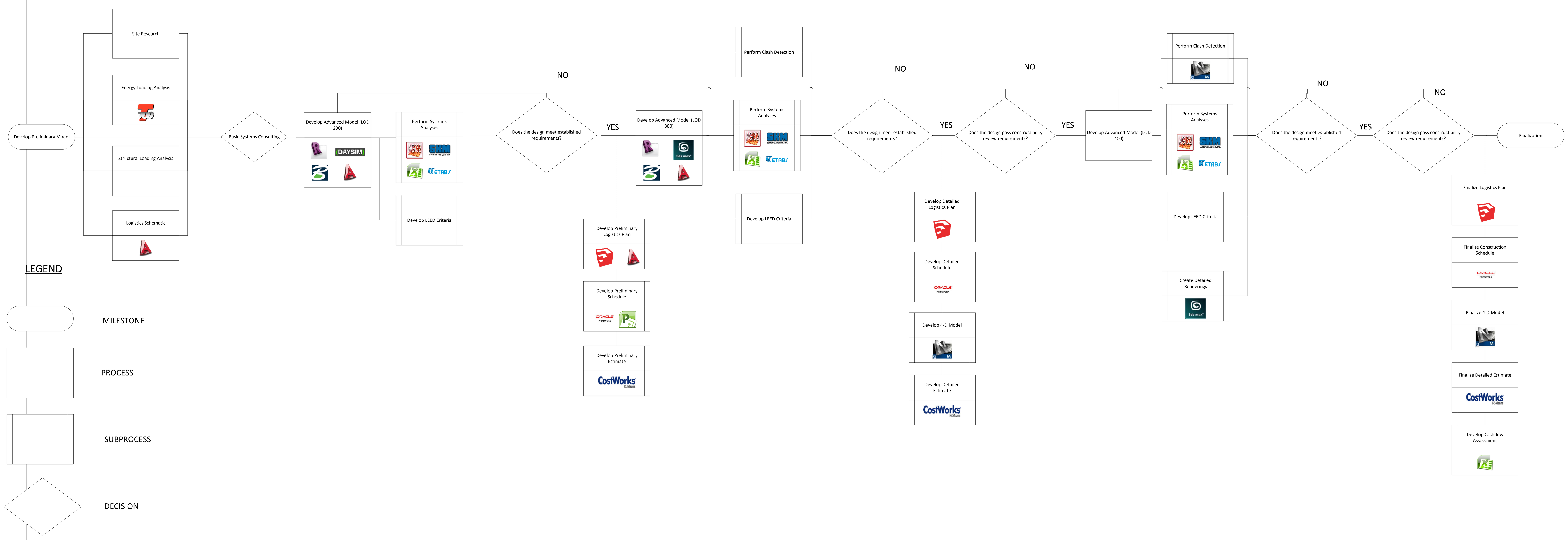
Appendix Q – Pool Savings Calculation

The mechanical system for the natatorium will utilize a separate system with a pool specific air handling unit to control the humidity and temperature in the pool area. Due to the space being used for both general school/community use as well as competition events, it must have the ability to address both event situations. To save energy, it offers reduced ventilation during unoccupied times. The air handler chosen for the pool area encompasses a prepackaged exhaust and purge fan to allow for the pool to be "shocked" with chlorine in case of any accidents. The air handler offers wall condensate prevention to maintain structural integrity and aesthetic appeal. Due to its economizer as well as pool water heating ability, the owner is able to save both energy and money. For detailed energy and cost savings of the proposed pool air handling system, see table 1. Dectron's Indoor Pool Design Guide was used as a basis for this analysis.

Table 1. Pool Savings Calculation

Pool Savings Calculation					
Givens:					
Tp	Pool Water Temperature	80	F		
Ta	Air Temperature	82	F		
ERF60	ERF (Active Hours-60% RH)	0.036	lb/h/sf		
ERF50	ERF (Non-Active Hours-50% RH)	0.048	lb/h/sf		
H60	Number of Active Hours	11	h		
H50	Number of Non-Active Hours	13	h		
AF	Activity Factor	1			
ERFavg	Average Evaporation Rate Factor	0.0295	lb/h/sf		
Ap	Pool Water Surface Area	4920	sf		
ER	Pool Evaporation Rate	145.14	lb/h		
Ecp	Energy Consumption to Heat Pool Water	1398569040	Btu/yr	549535.9686	HP
$$$	Convert Pool Energy Usage into Annual Heating Cost				
	Heat Pool Using Gas: (@$1.192/CCF)	**$ 22,227.92**	$/yr		
	Savings from using this equipment	$ 1,648.61	$/yr	$ 20,579.32	$/yr
	Heat Pool Using Electric: (@$0.172/kWh)	**$ 70,481.65**	$/yr		
	Savings from using this equipment	$ 3,846.75	$/yr	$ 66,634.90	$/yr

The pool air handler is able to reduce the energy consumption by 1398 MMBTU or approximately $3,846 if using electric heating.



Software Symbol	Software Name	Software Uses
	AutoCAD	2D Drawing/Modeling
	Trane Trace	Mechanical Load Calculations
	Autodesk Revit	3D Drawing/Modeling
	Daysim	Daylighting and Electrical Analysis
	Bentley RAM	Structural System Design
	AGi32	Lighting Calculations
	ETABS	Lateral Structural System Design
	Microsoft Excel	Mechanical & Structural Calculations & Estimate Organizational Tool
	SKM	Arc Flash Studies
	Trimble SketchUp	Virtual Mock-Ups
	Microsoft Project	Construction Scheduling
	RSMeans CostWorks	Construction Estimation
	Oracle P6	Construction Scheduling
	3ds Max	3D Model Rendering
	Autodesk Navisworks	3D Coordination & 4D Modeling

Autodesk® Revit®

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

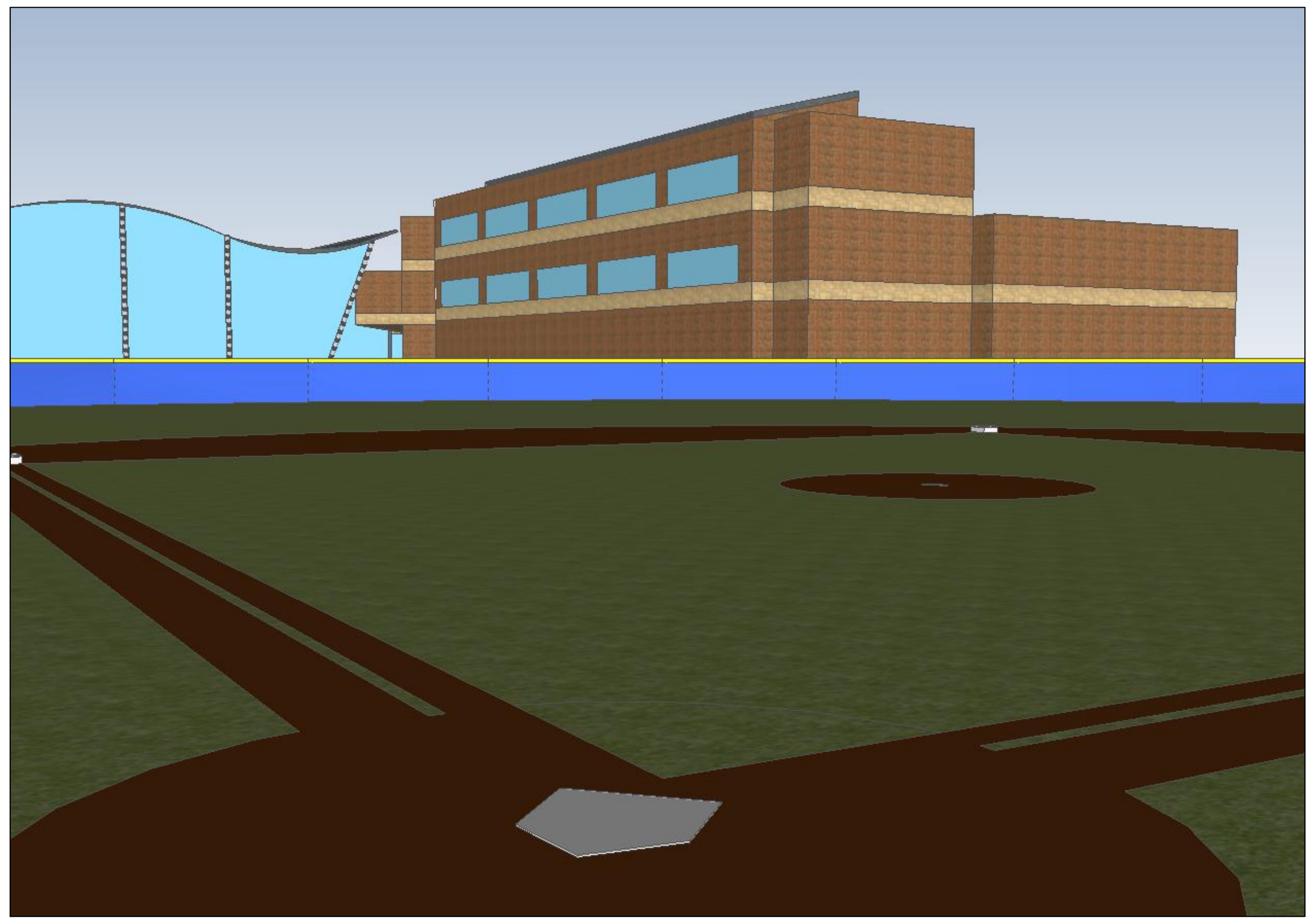
Integration Flow Chart

Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

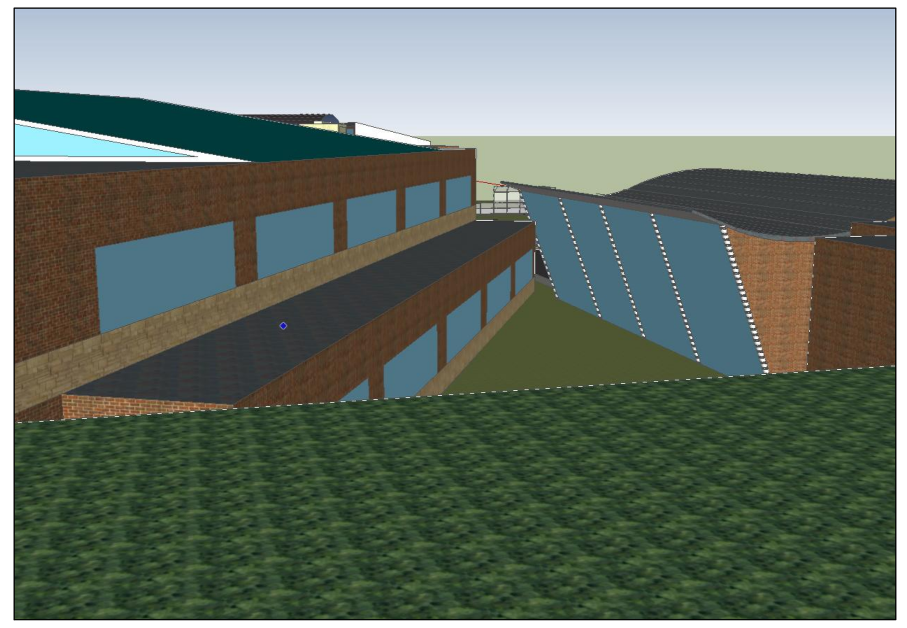
I101

Scale

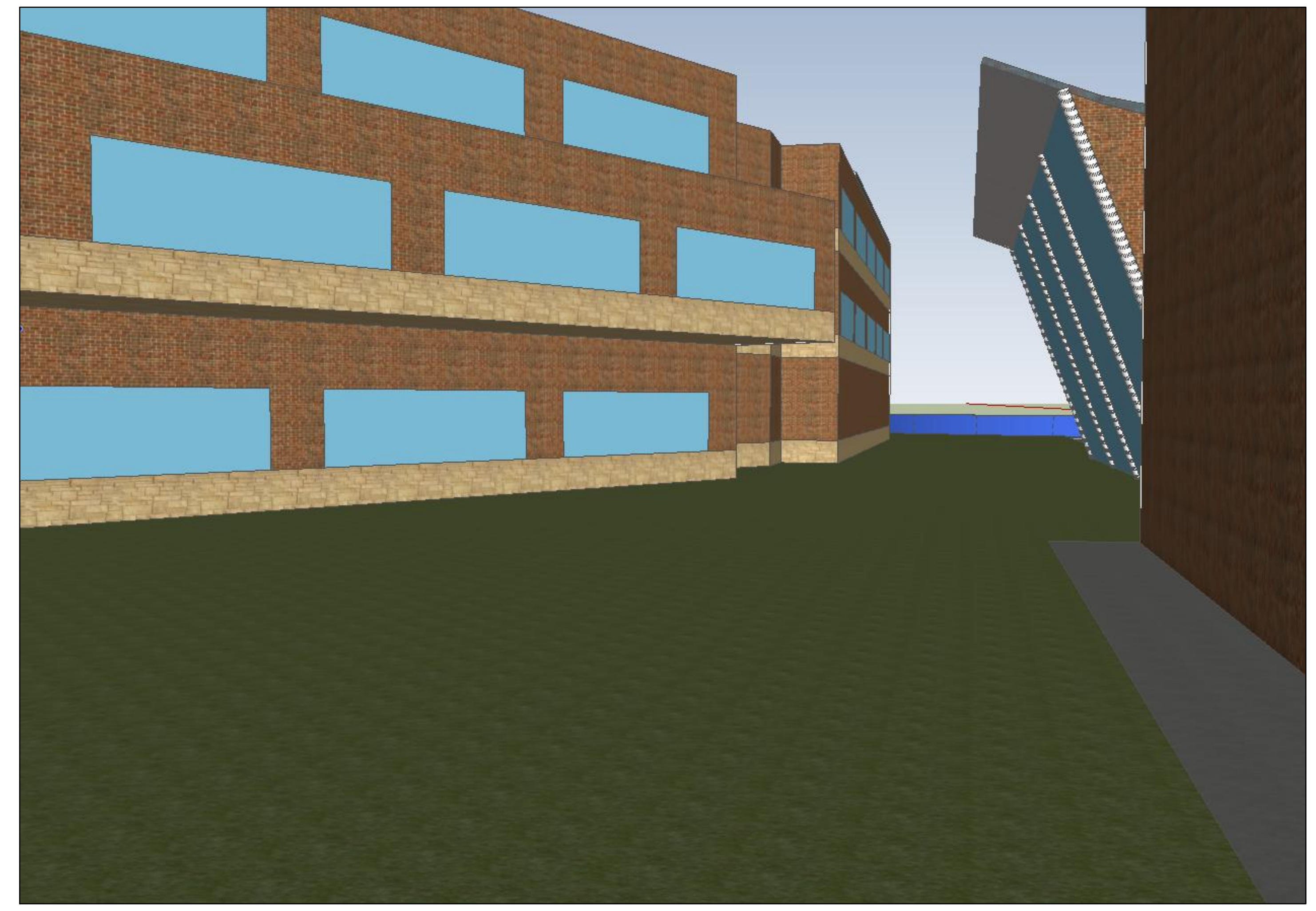
2/20/2013 3:22:21 PM



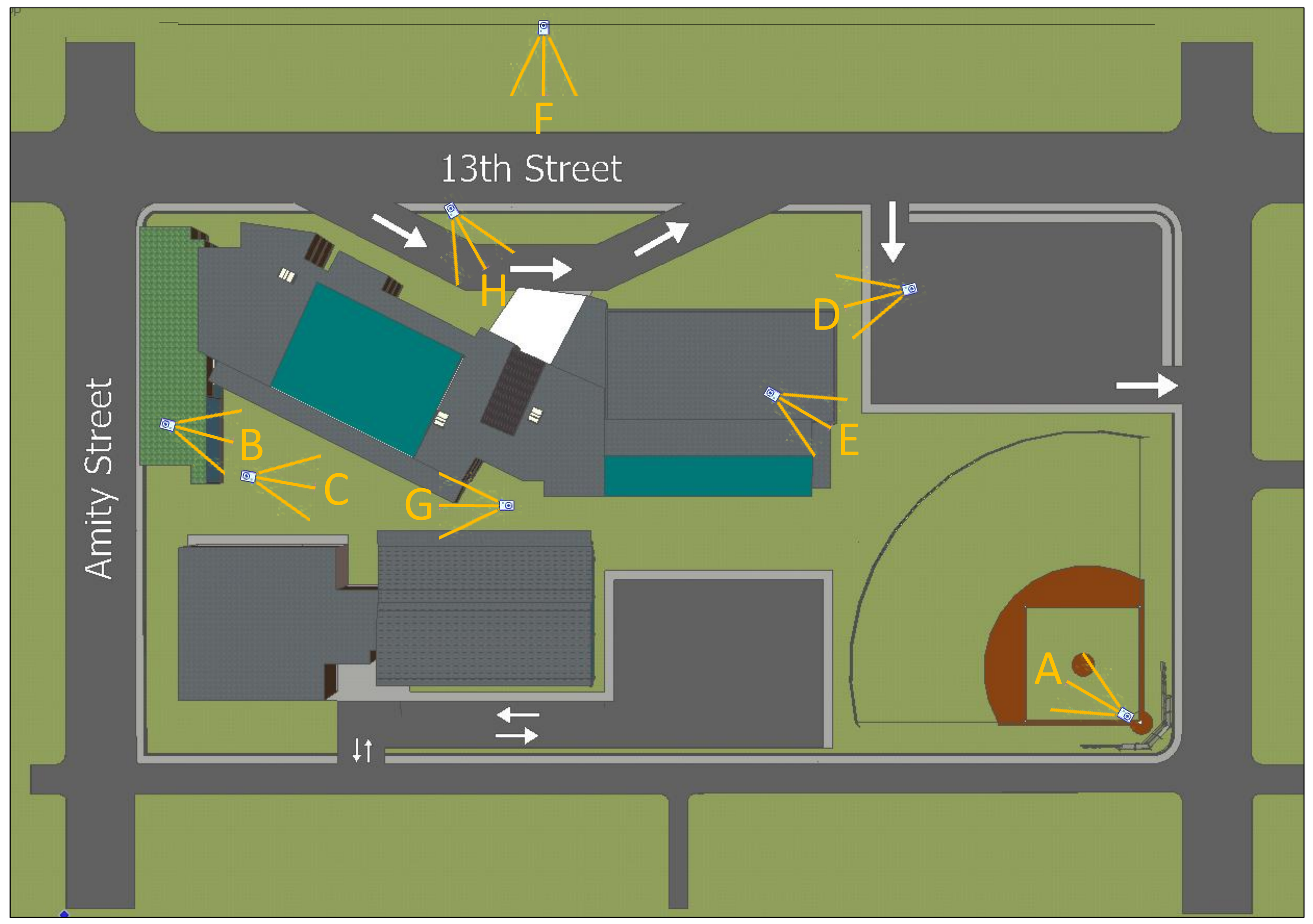
Snapshot A

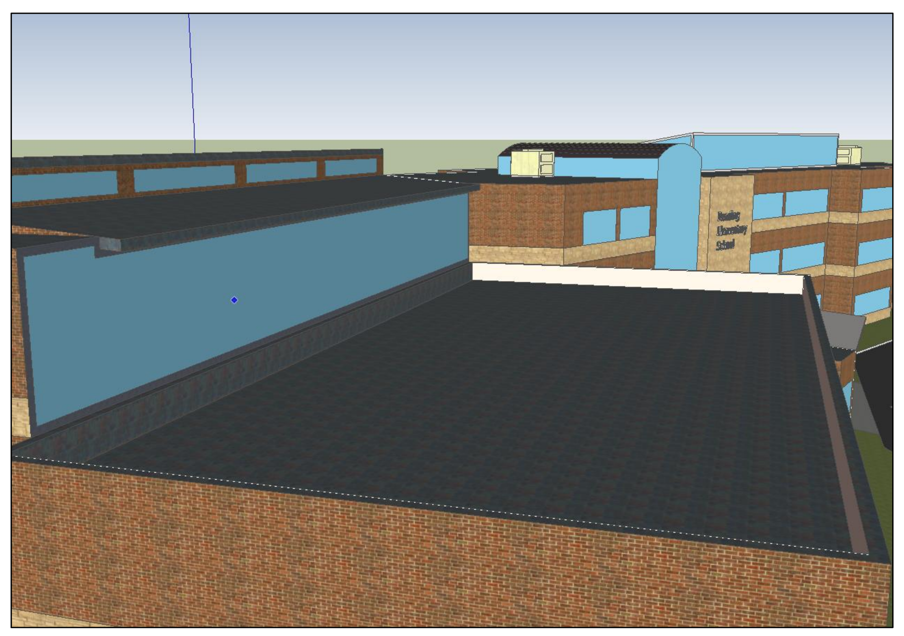


Snapshot B

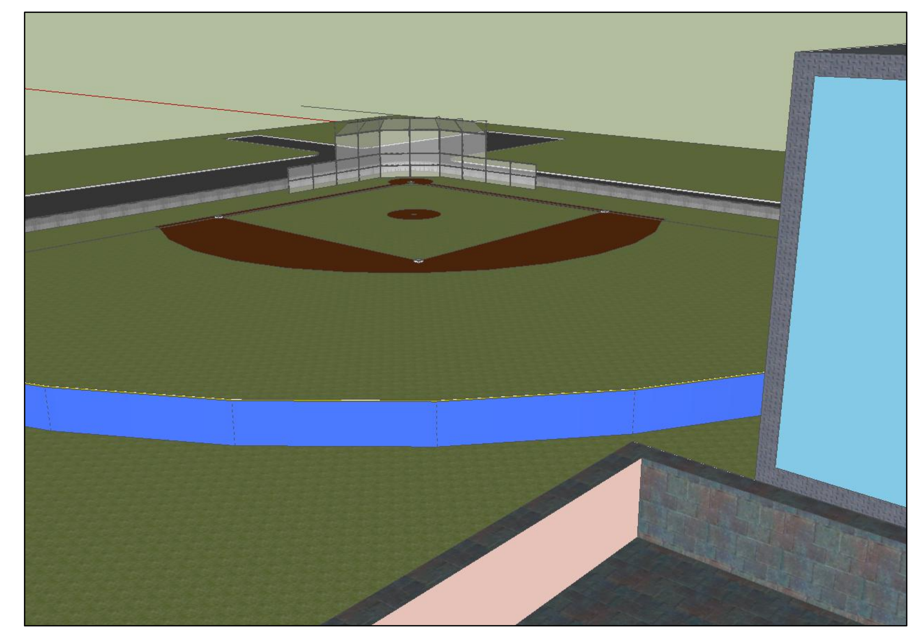


Snapshot C

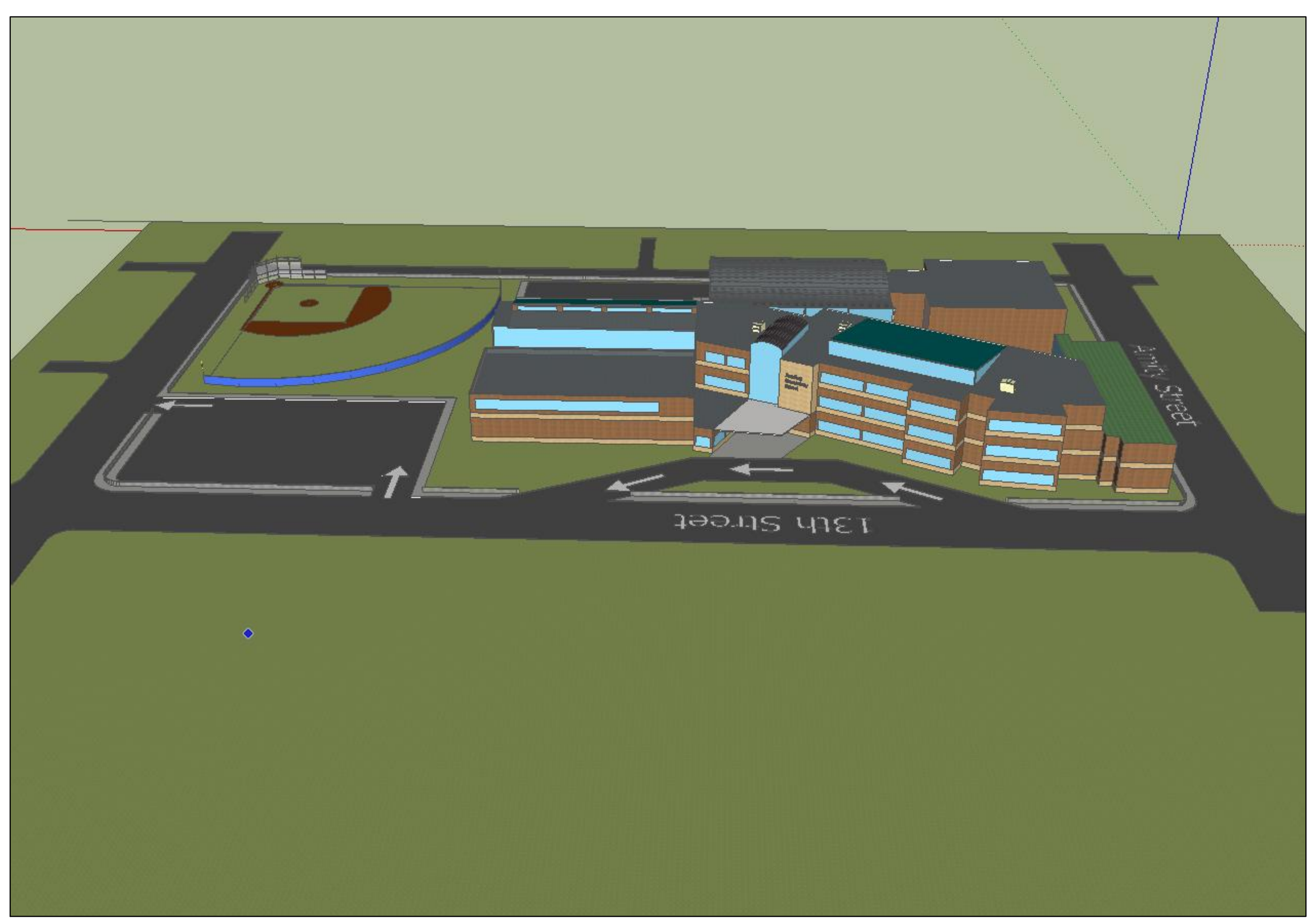




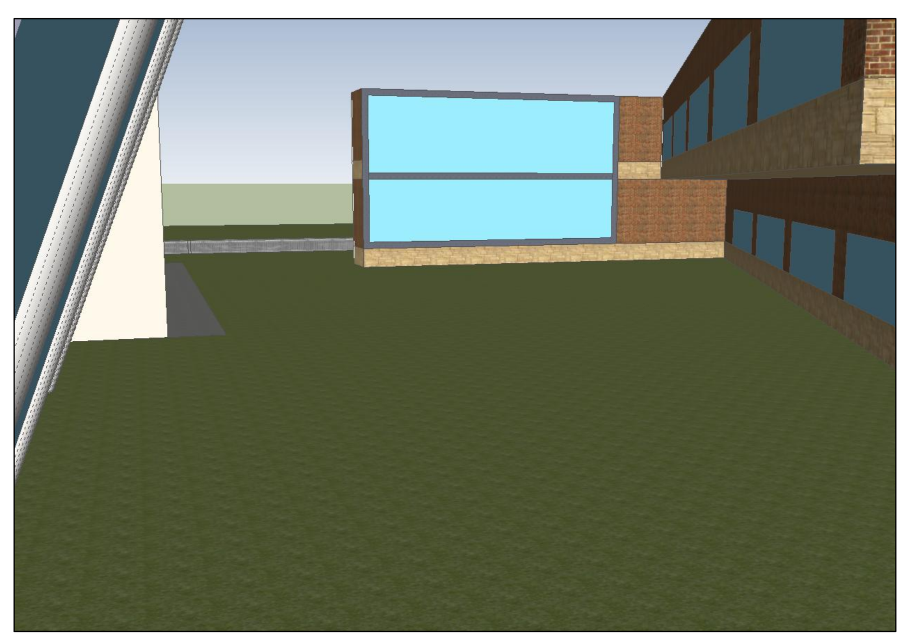
Snapshot D



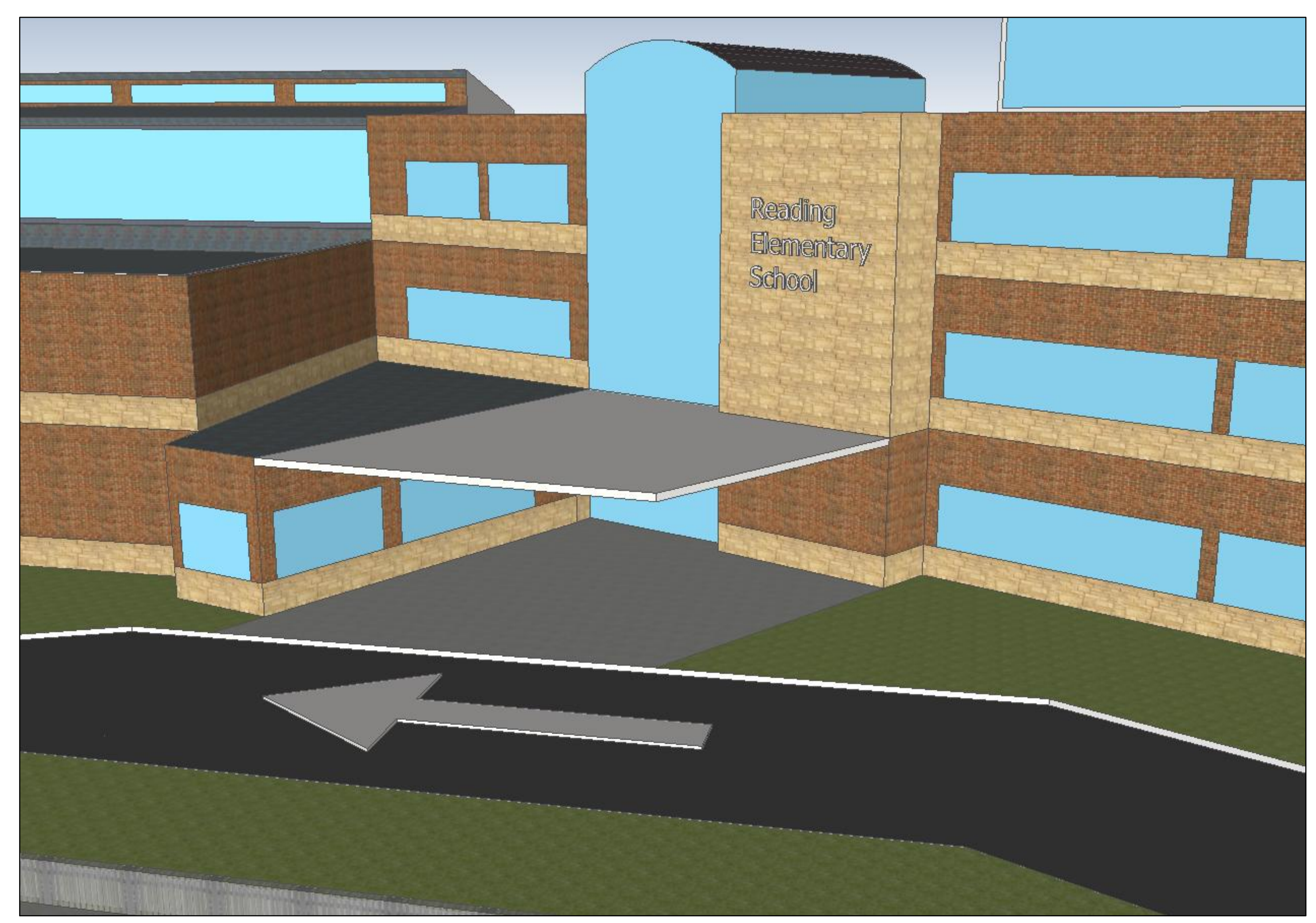
Snapshot E



Snapshot F



Snapshot G



Snapshot H

Autodesk® Revit®

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

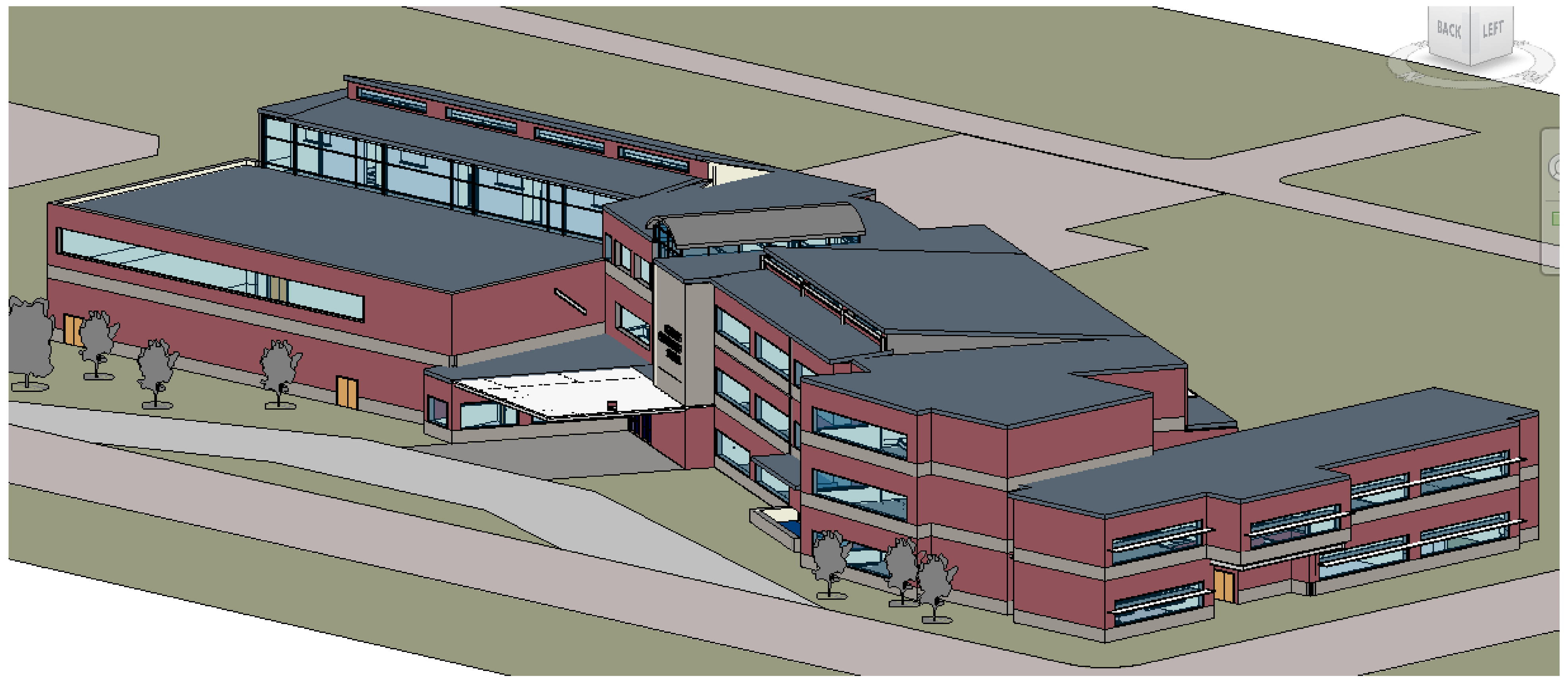
3D Project Overview

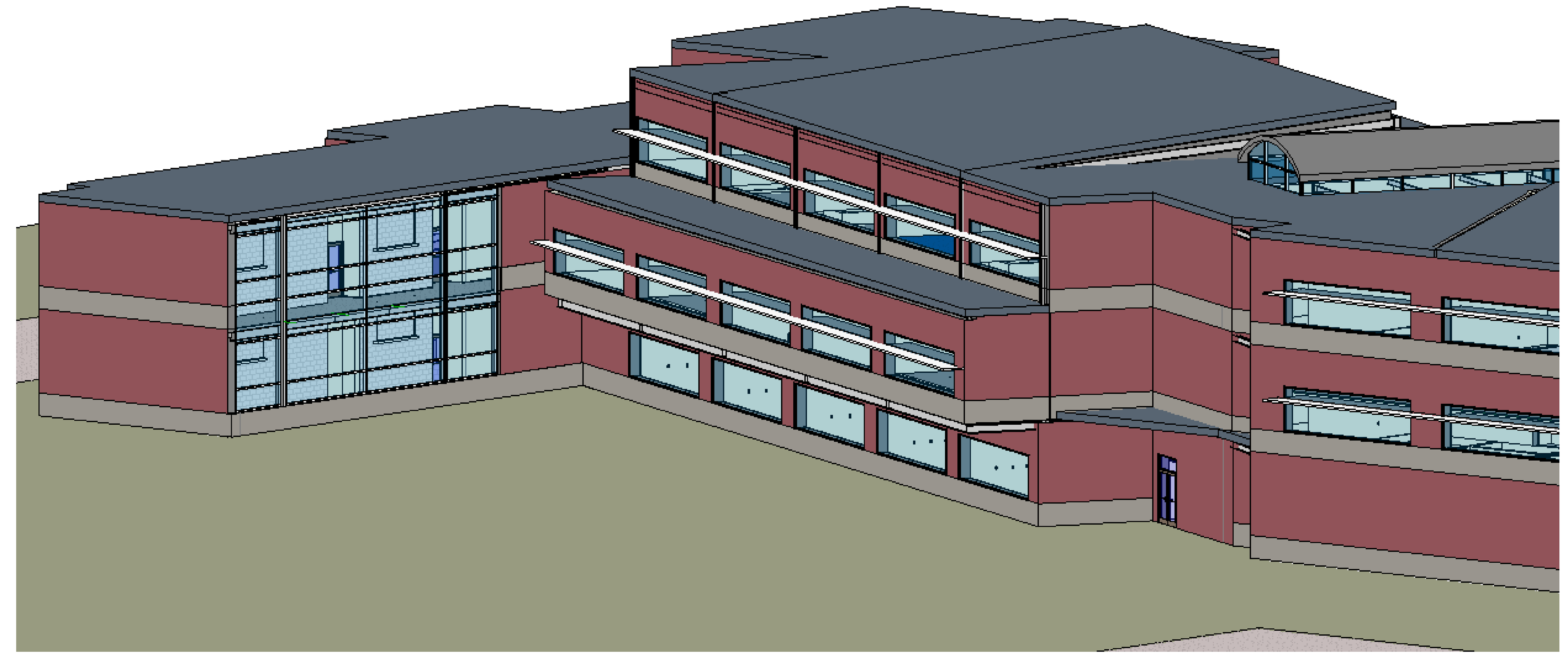
Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

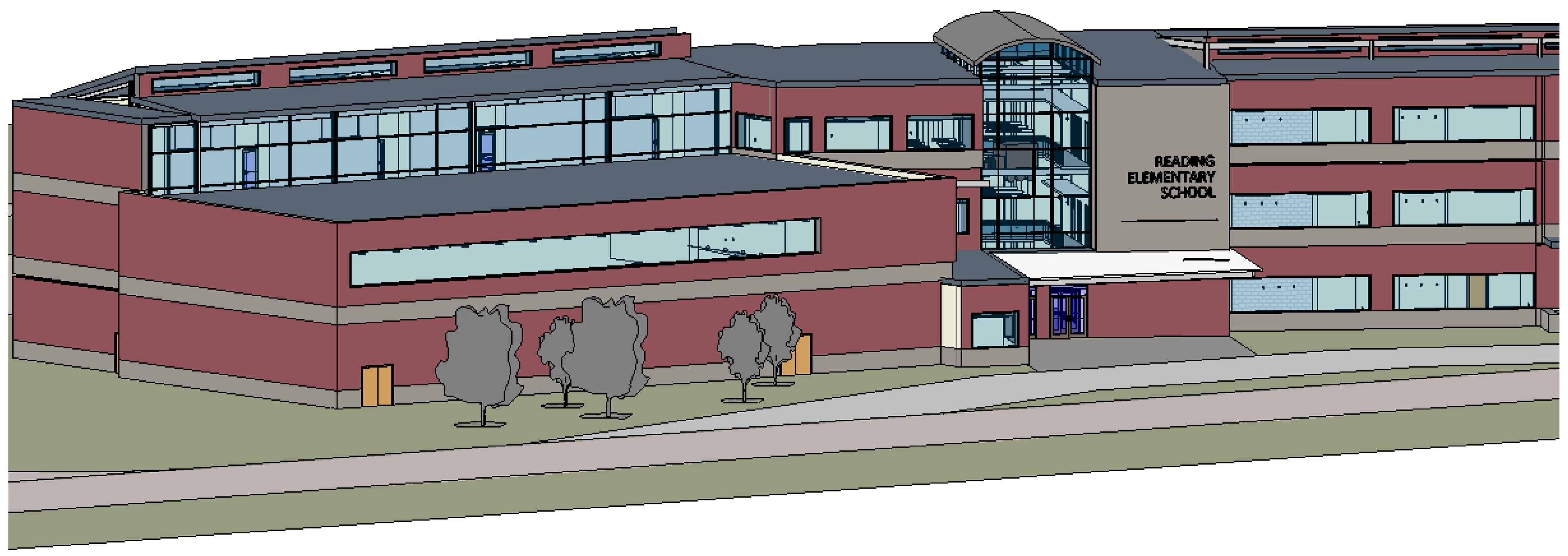
I102

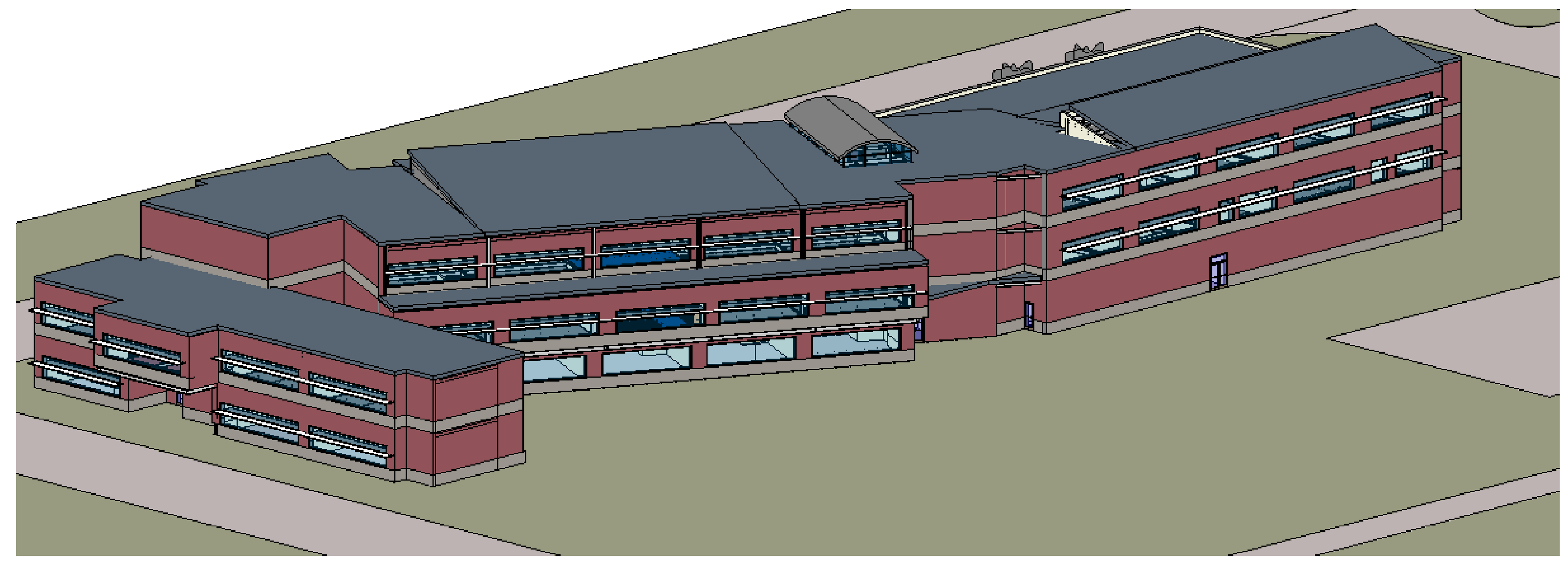
Scale

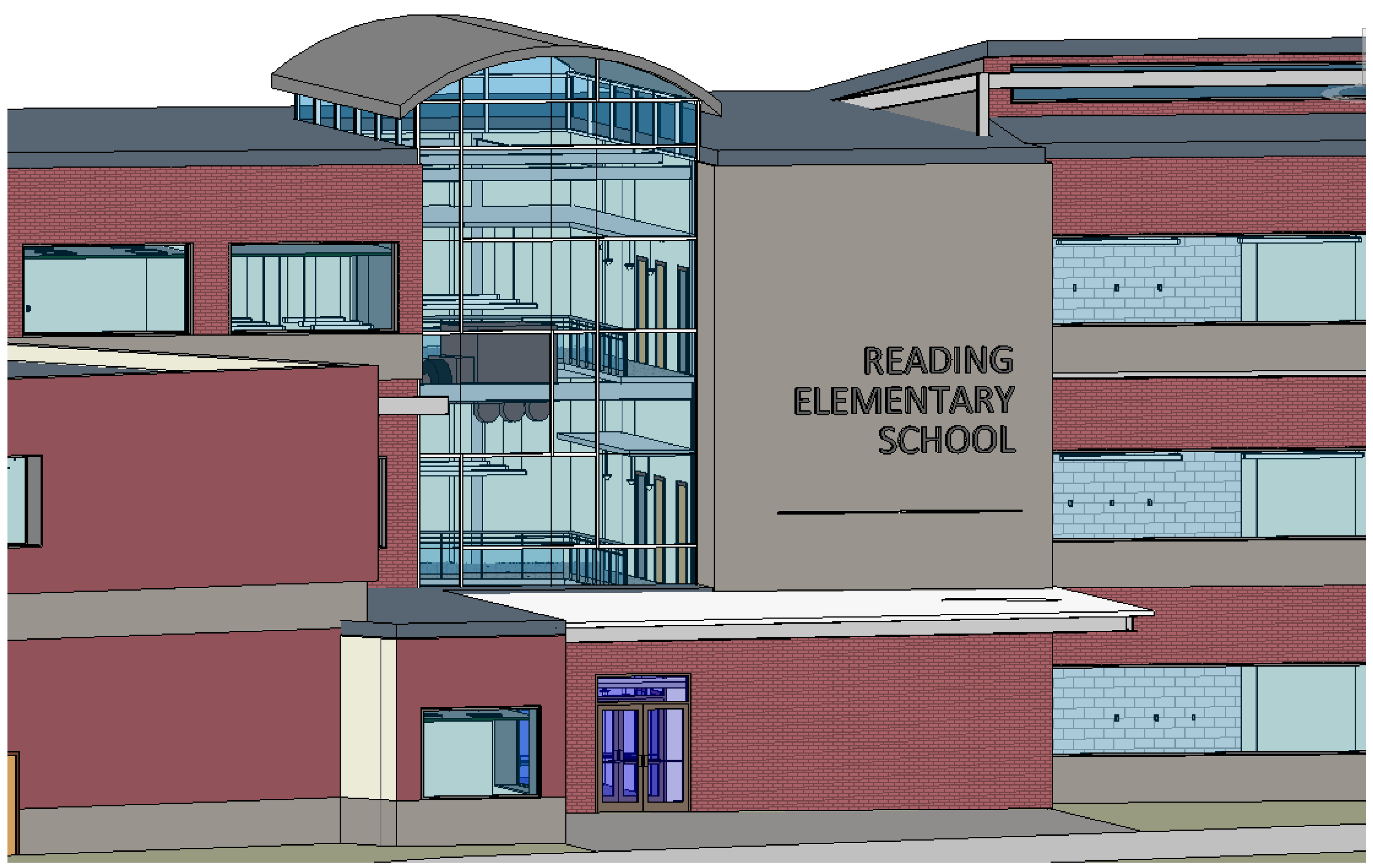
2/20/2013 3:25:43 PM

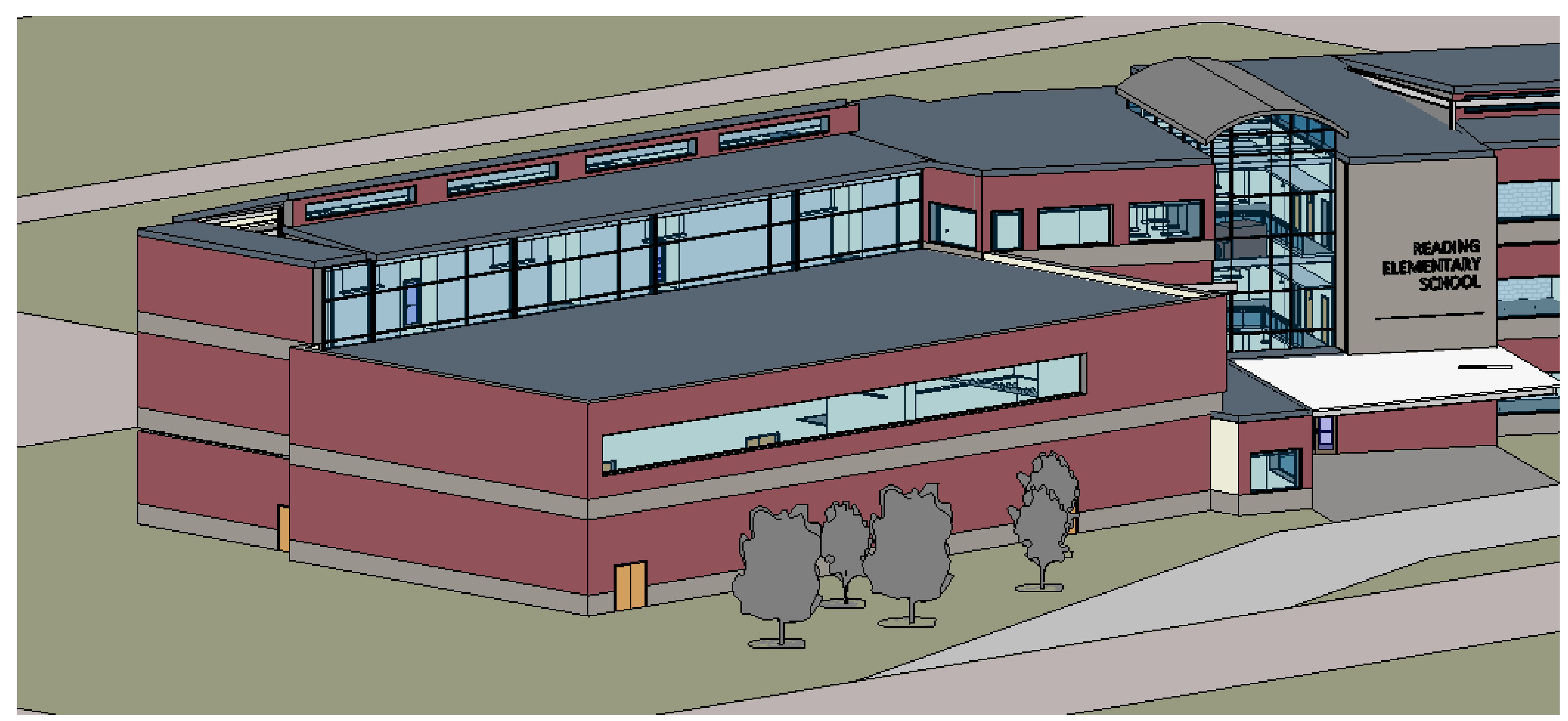












Autodesk Revit

No.	Description	Date

AEI Team #04-2013

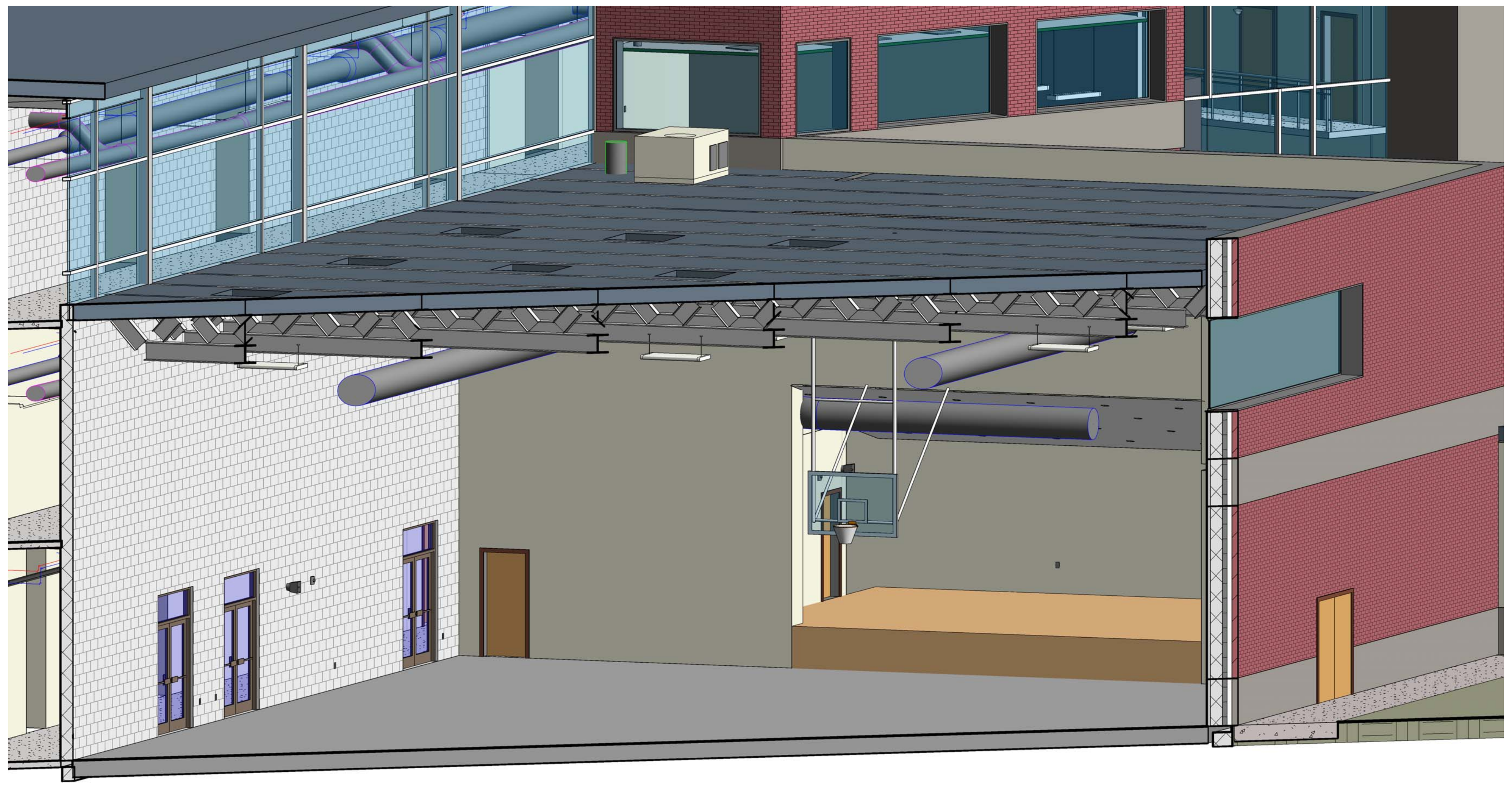
Reading Elementary School

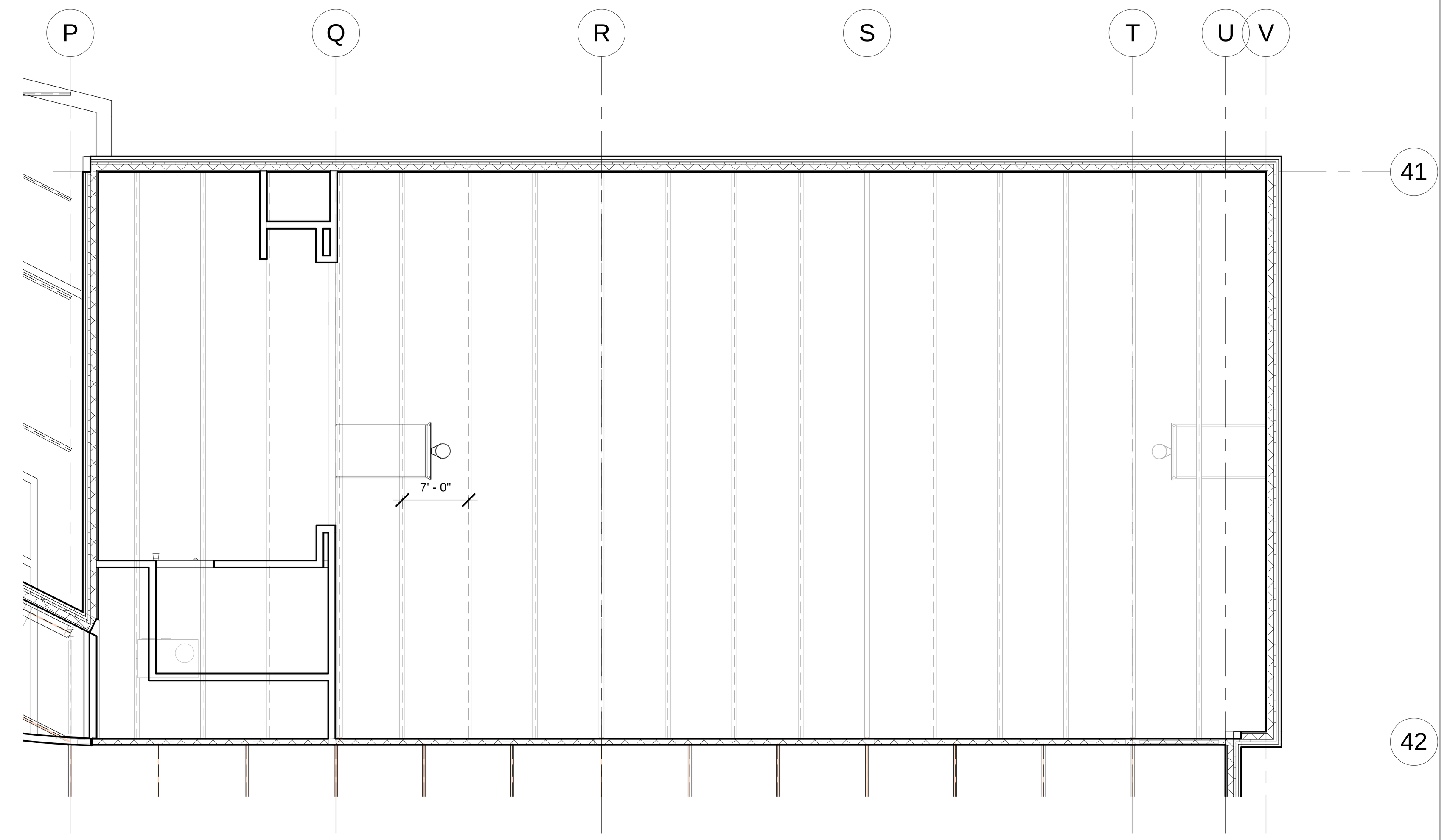
Elementary School Isometrics

Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

I103

Scale



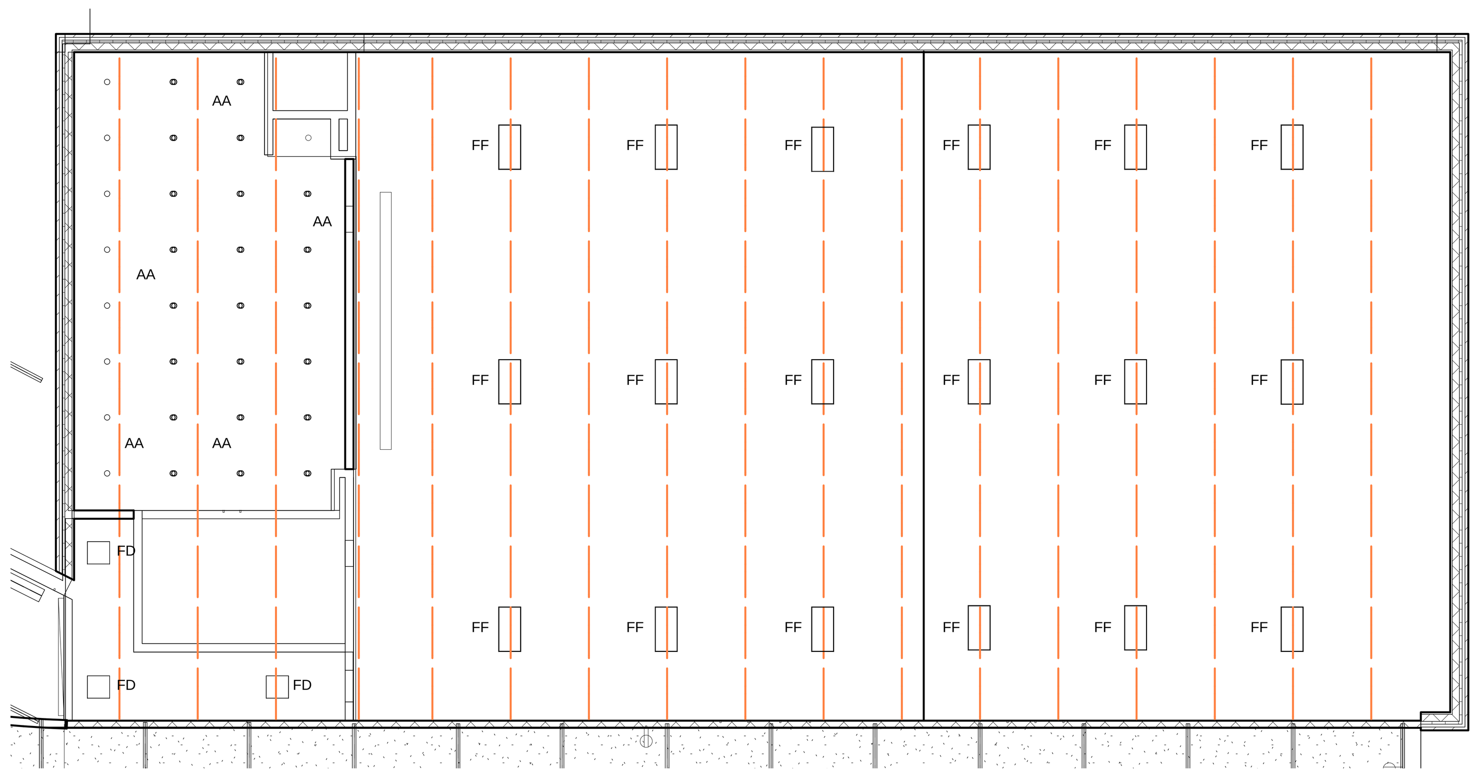


1 MULTI-PURPOSE ROOM STRUCTURAL PLAN
1" = 10'-0"

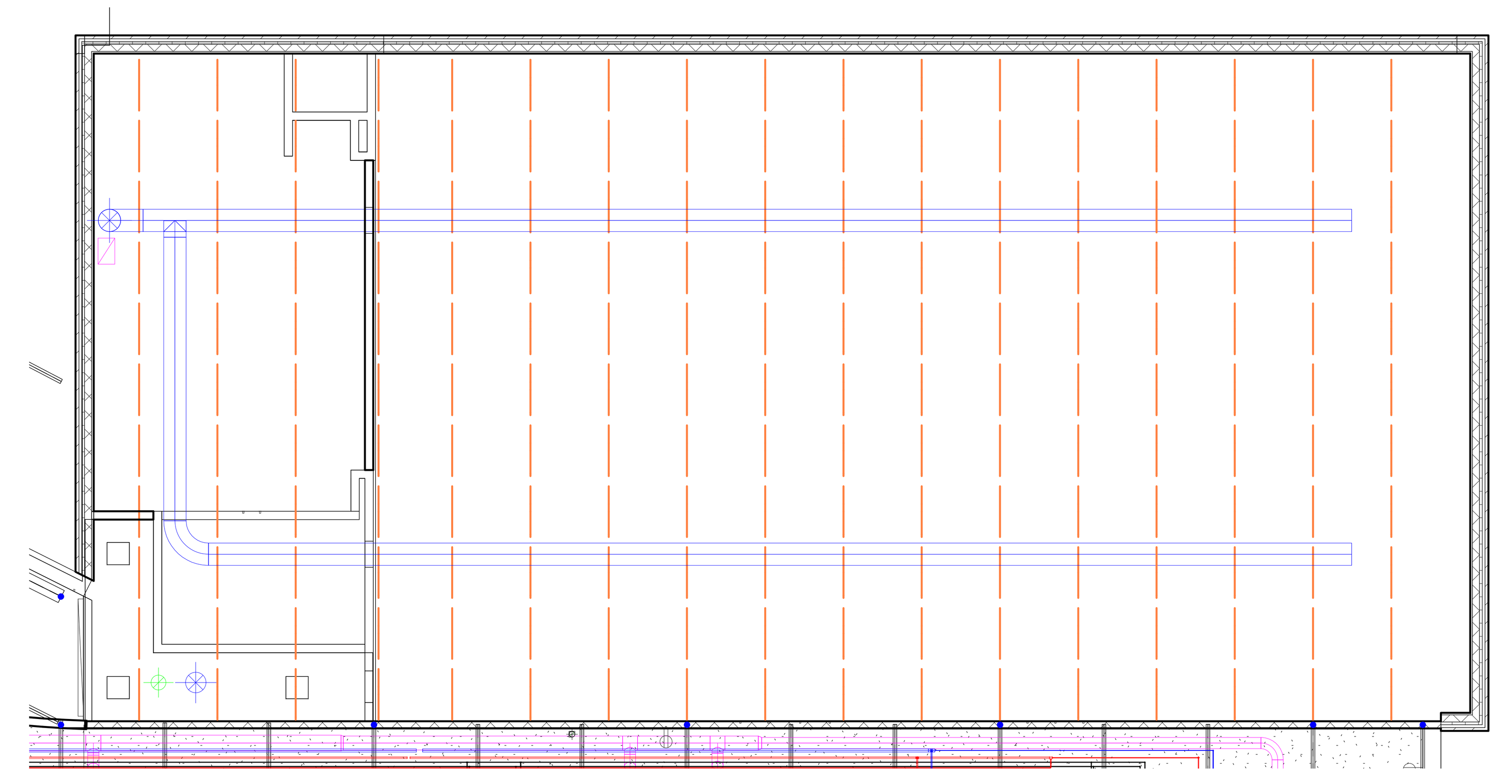
GENERAL NOTES
A. Multipurpose room to act as gym, cafeteria and auditorium for students during school and community after hours

CONSTRUCTION MANAGEMENT
A. Clash Detection done prior to installation
B. Skylights proposed as Add–Alternate to increase natural lighting
C. CMU walls to be placed by hand and perform as shear wall
D. Roof joists to be erected with crawler crane

STRUCTURAL NOTES
A.10" fully grouted reinforced masonry walls
B.32" K–series roof joists @ 7' o.c. span 60' and anchored to steel bearing plates in masonry walls
C.Joists fabricated with oversized slotted holes in top chord to allow for onsite adjustement
D.5.5" composite metal deck with 3.5" topping, insulated to prevent joist movement due to temperature changes



2 MULTI-PURPOSE ROOM LIGHTING/ELECTRICAL PLAN
1" = 10'-0"



3 MULTI-PURPOSE ROOM MECHANICAL PLAN
1" = 10'-0"

LIGHING/ELECTRICAL NOTES
A. GYMNASIUM LIGHT FIXTURES ARE MOUNTED, ON TRUSSES, 24' AFF.
B. RECESSED LED CAN LIGHTS USED FOR GENERAL STAGE LIGHTING.
C. TRACK MOUNTED THATER LIGHTING WILL BE SPECIFIED AND INSTALLED FOR THEATRICAL PERFORMANCES.
D. DUE TO THE DIVIDER, BOTH HALVES OF THE MULTI–PURPOSE ROOM WILL BE CONTROL BY SEPARATE SETS OF SCENE CONTROLS WITH THE SAME SCENES

MECHANICAL NOTES
A.A 18"x26" low return will be utilized in the multi–purpose to allow for better mixing due to high elevation ofsupply ducts.
B.(2) 24" SA ducts supply 6718 CFM
C.Fabric Duct will be installed to allow for better air distribution

Autodesk® Revit®

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

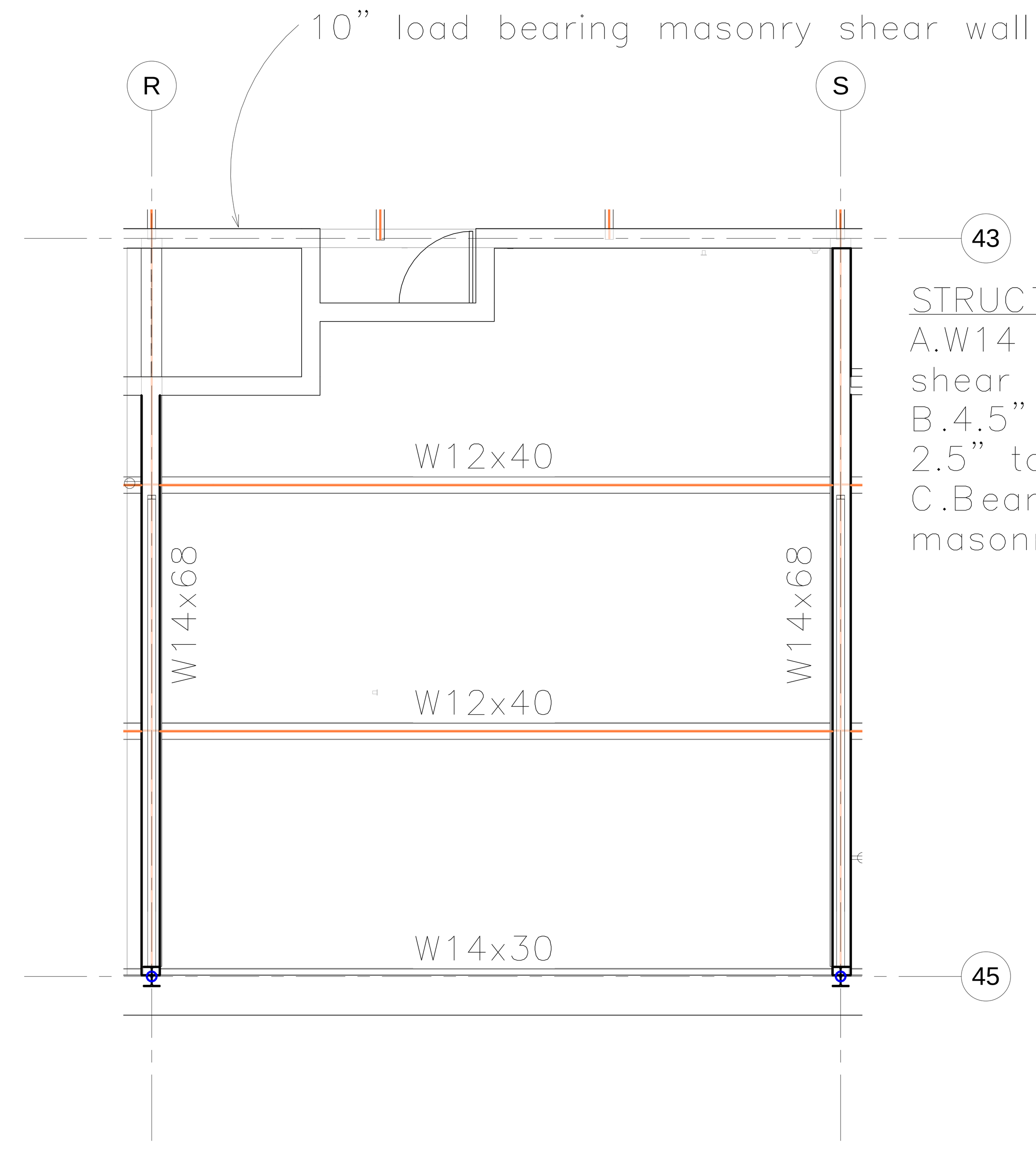
Integrated Multi-Purpose Plans

Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

I104

Scale 1" = 10'-0"

2/20/2013 3:48:36 PM

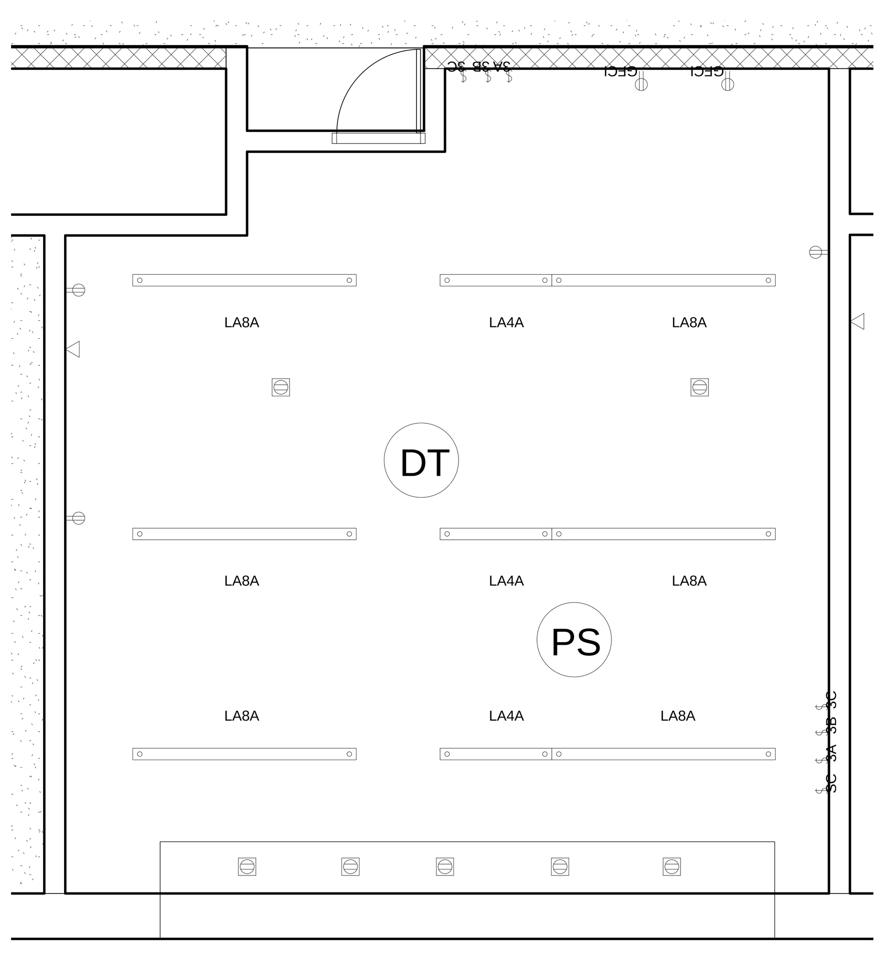


① TYPICAL CLASSROOM STRUCTURAL PLAN
1/4" = 1'-0"

STRUCTURAL NOTES
A.W14 beams and W12 girders with shear tab connections
B.4.5" composite acoustical deck with 2.5" topping
C.Beams anchored to reinforced masonry walls with steel anchor plates

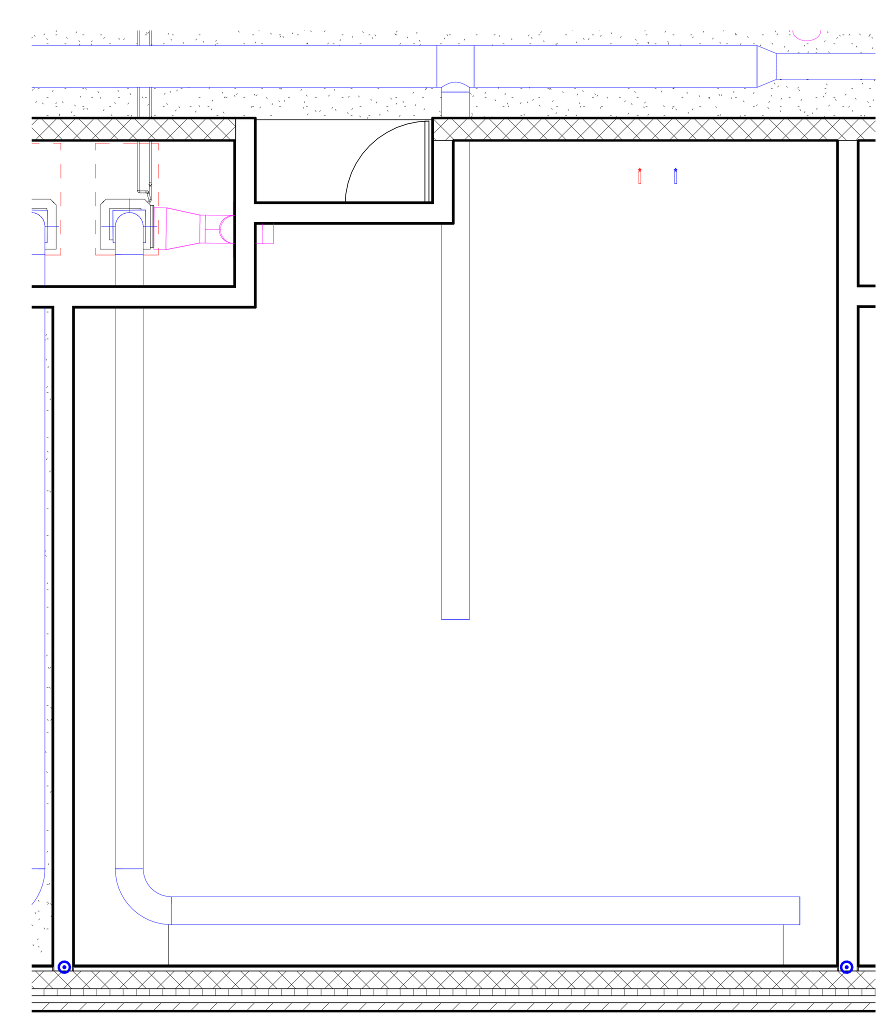
GENERAL NOTES
A. Low Emittance double pane argon filled windows
B. Precast insulated architectural panels with punched openings for window installation
C. Light shelves on south facing classrooms

CONSTRUCTION MANAGEMENT
A. Classrooms will have exposed ceilings to minimize material and labor costs while providing a functional architectural appeal
B. Duct, lighting and electrical hangers will be installed prior to concrete floor placement to minimize rework
C. Clash detection done prior to installation



② TYPICAL CLASSROOM LIGHTING/ELECTRICAL PLAN
1/4" = 1'-0"

LIGHING/ELECTRICAL NOTES
A. LINEAR PENDANT FIXTURES SUSPENDED AT 8' AFF.
B. THE TWO ROWS OF FIXTURES CLOSEST TO THE WINDOW ARE CONTROLLED BY A PHOTOSENSOR.
C. ALL CLASSROOMS ARE CONNECTED TO THE WATTSTOPPER DIGITAL LIGHTING MANAGEMENT SYSTEM.
D. EACH CLASSROOM INCORPORATES A WATTSTOPPER DUAL TECHNOLOGY OCCUPANCY SENSOR.
E. ALL OVERHEAD CABINETS IN BACK OF CLASSROOMS (NOT SHOWN) ARE EQUIPPED WITH UNDERCABINET LED FIXTURES OF THE APPROPRIATE LENGTH.
F. EACH UNDERCABINET FIXTURE HAS ITS OWN SINGLE POLE SWITCH.
G. EVER CLASSROOM INCORPORATES A SCENE CONTROL SWITCH AND SWITCHES TO CONTROL EACH ZONE. FOR A DETAILED SWITCHING AND ZONING DIAGRAM, REFER TO APPENDIX K.



③ TYPICAL CLASSROOM MECHANICAL PLAN
1/4" = 1'-0"

MECHANICAL NOTES
A.Ventilation and Terminal Unit Split
B.12" Rd. Heat Pump SA 988CFM
C.12" Rd. Ventilation SA 537CFM
D.12" Rd. Heat Pump RA 691CFM
E.12" Rd. Ventilation RA 296CFM
F.1/2" CW and HW lines are supplied to classroom sink
G.3/4" CWS to Heat Pump from Bore Field
H.3/4" CWR to Bore Field from Heat Pump

Autodesk Revit

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

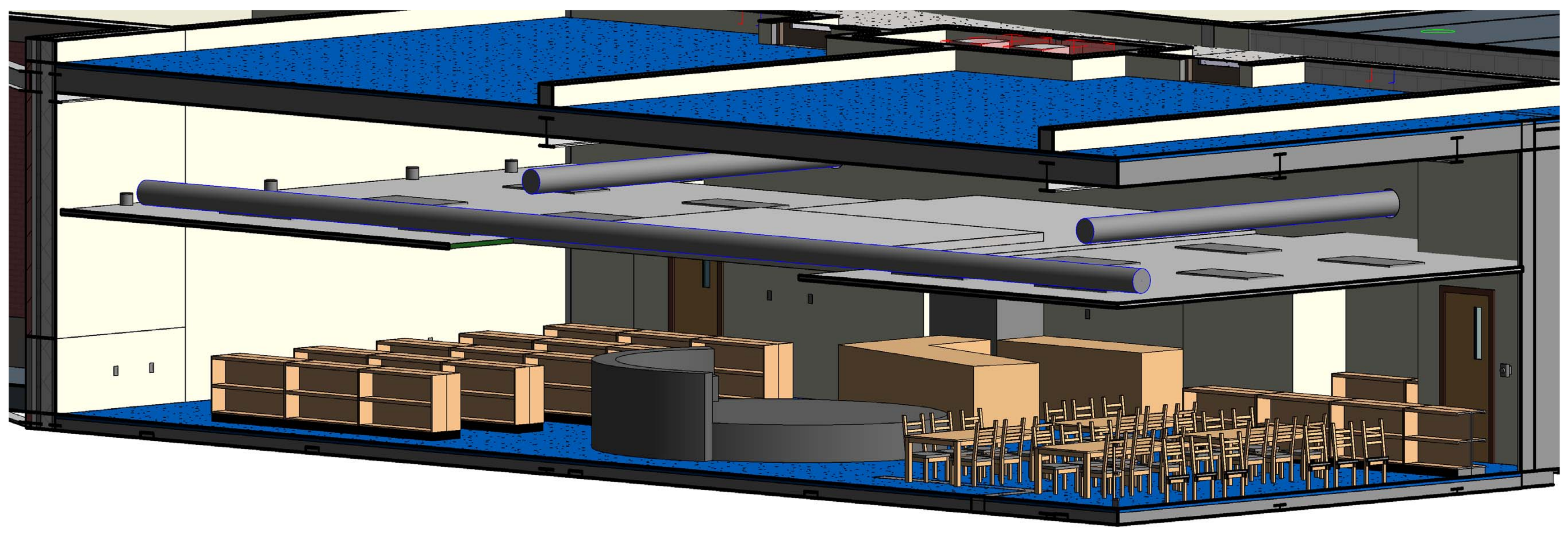
Integrated Classroom Plan

Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

I105

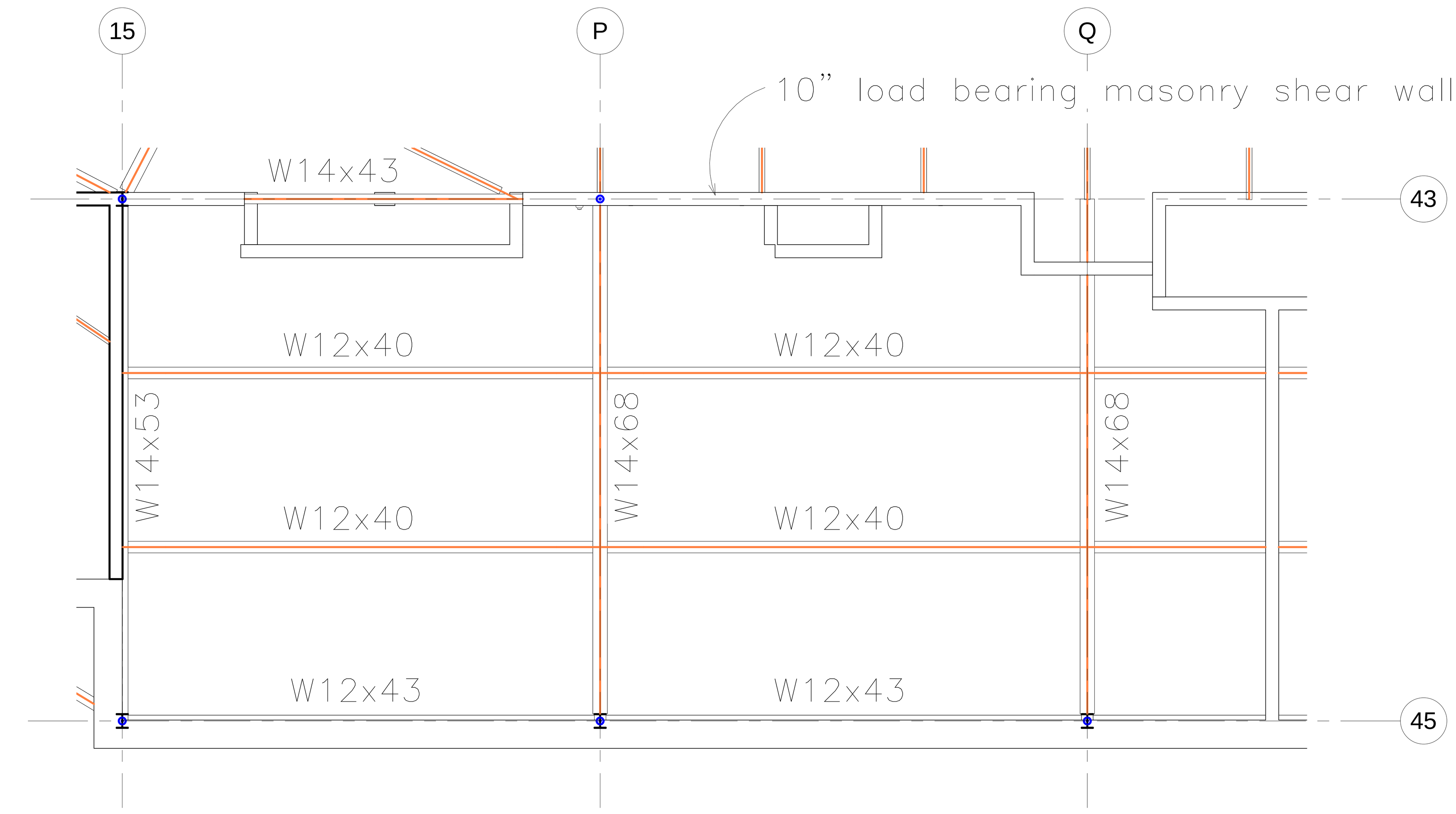
Scale 1/4" = 1'-0"

2/20/2013 3:52:49 PM



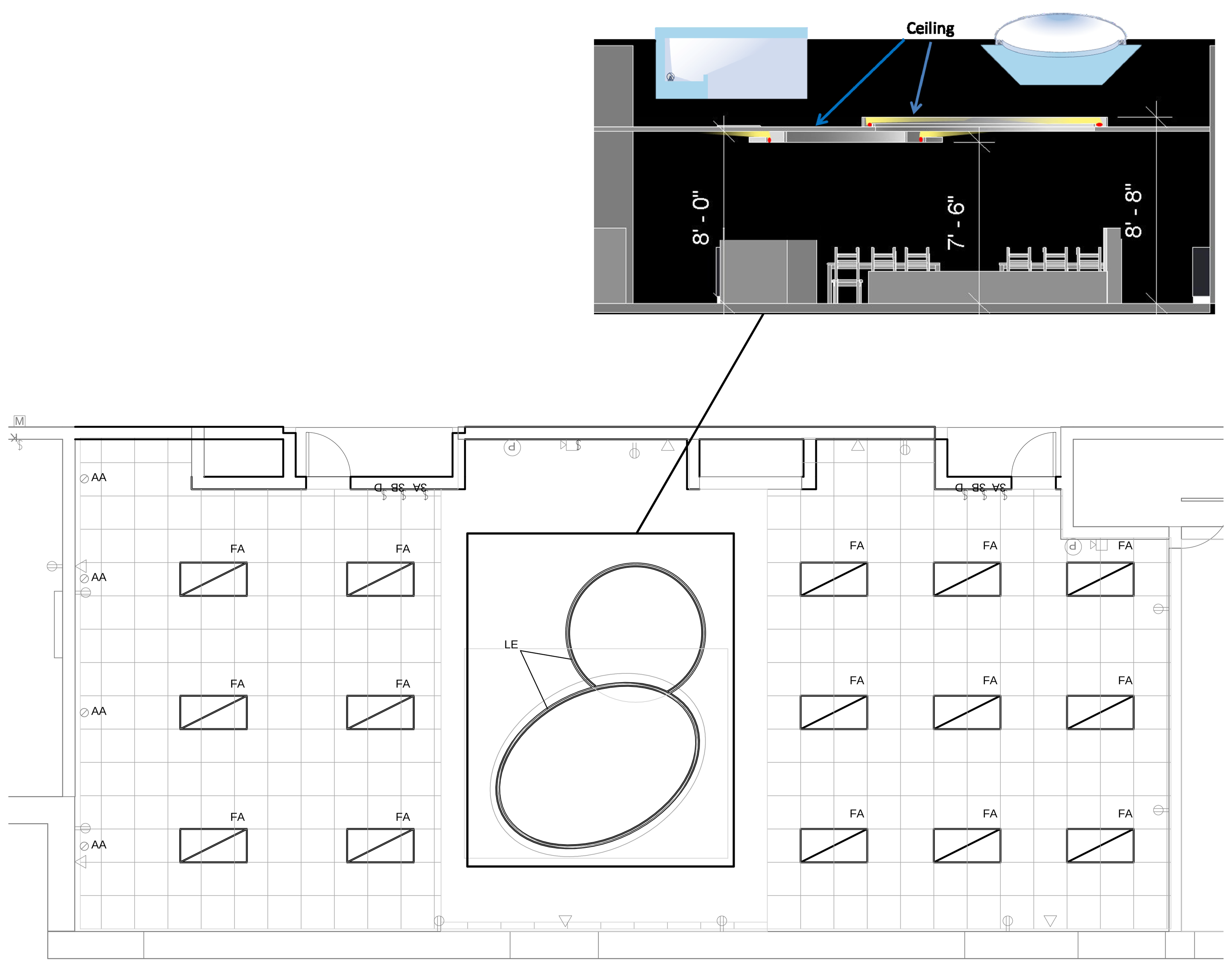
GENERAL NOTES
A. 80 student library

CONSTRUCTION MANAGEMENT
A. Clash Detection performed to minimize rework
B. Drop ceiling provides noise reduction



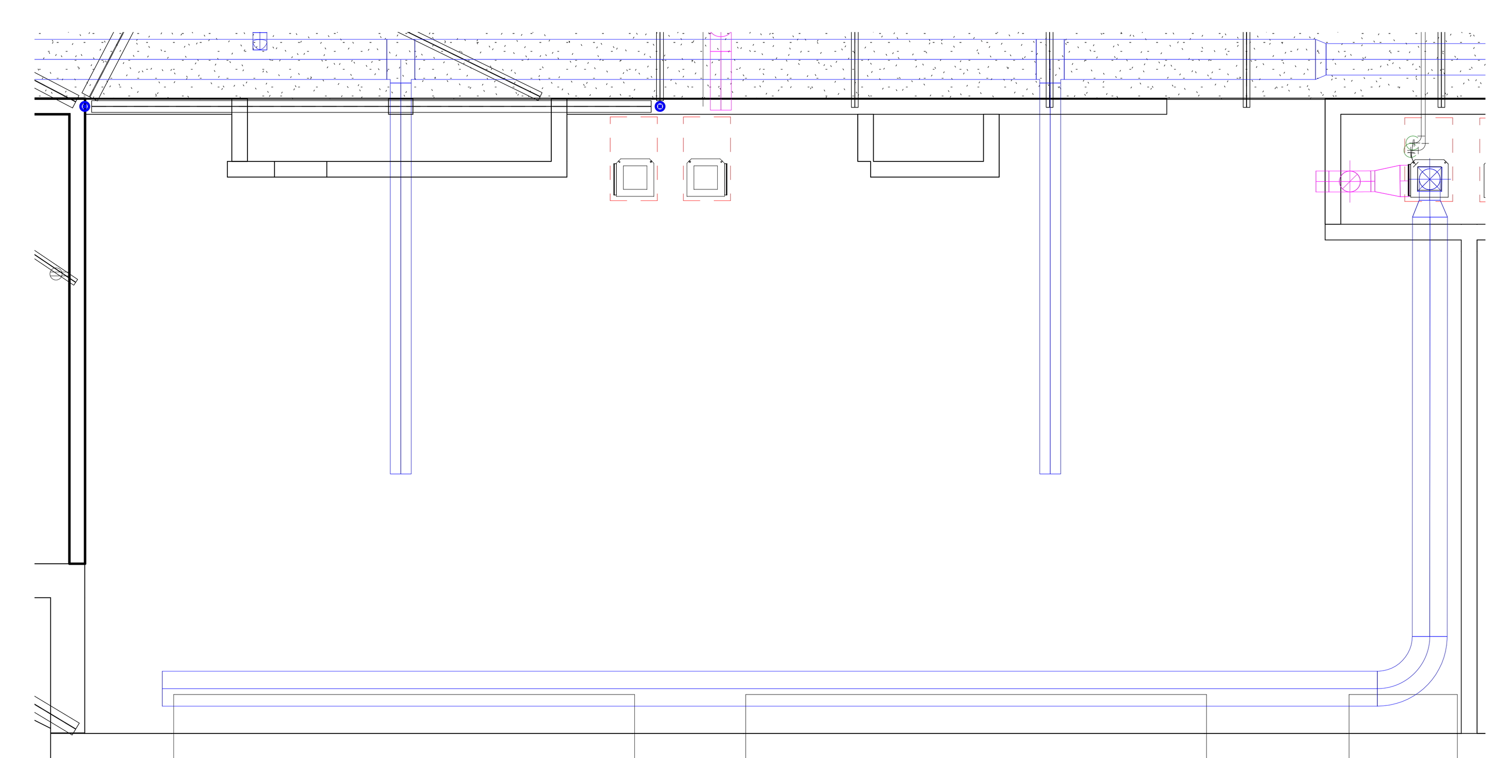
1 LIBRARY STRUCTURAL PLAN
3/16" = 1'-0"

STRUCTURAL NOTES
A.W14 beams and W12 girders with shear tab connections
B.4.5" composite acoustical deck with 2.5" topping
C.Beams anchored to reinforced masonry walls with steel anchor plates



2 LIBRARY LIGHTING/ELECTRICAL PLAN
3/16" = 1'-0"

LIGHING/ELECTRICAL NOTES
A. 2'x2' TILE CEILING DROPPED AT 8' AFF.
B. GYPSUM WALLBOARD USED TO CREATE COVE LIGHTING IN
CENTER OF LIBRARY. SECTION OF COVE CAN BE SEEN ABOVE.
C. LED COVE LIGHTING FIXTURES.
D. 2'X4' RECESSED SINGLE 28WT8 FIXTURES.



3 LIBRARY MECHANICAL PLAN
3/16" = 1'-0"

MECHANICAL NOTES
A.(2) 12" Rd. Ventilation SA 476 CFM
B.20" Rd. Heat Pump SA 2412CFM
C.3/4" CWS to Heat Pump from Bore Field
D.3/4" CWR to Bore Field from Heat Pump

Autodesk Revit

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

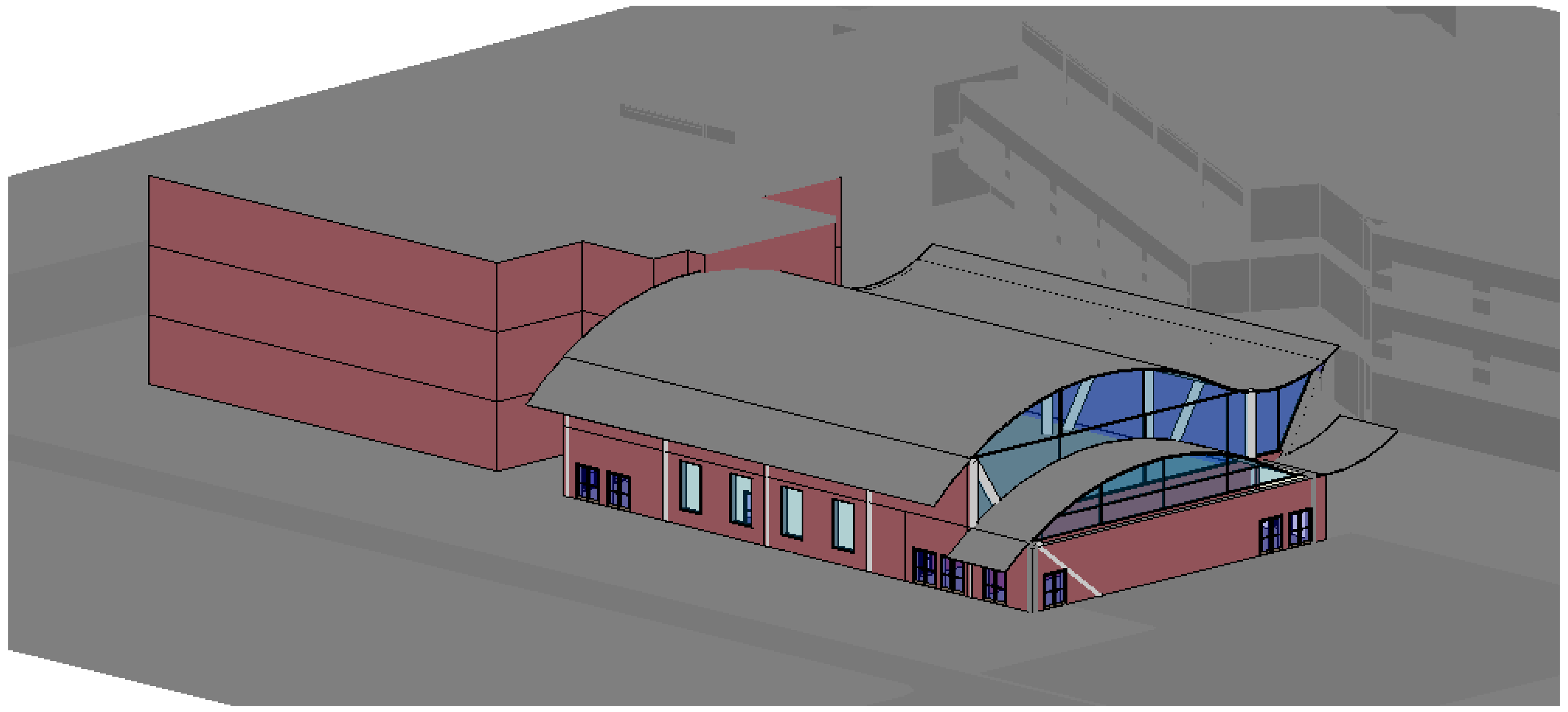
Integrated Library Plan

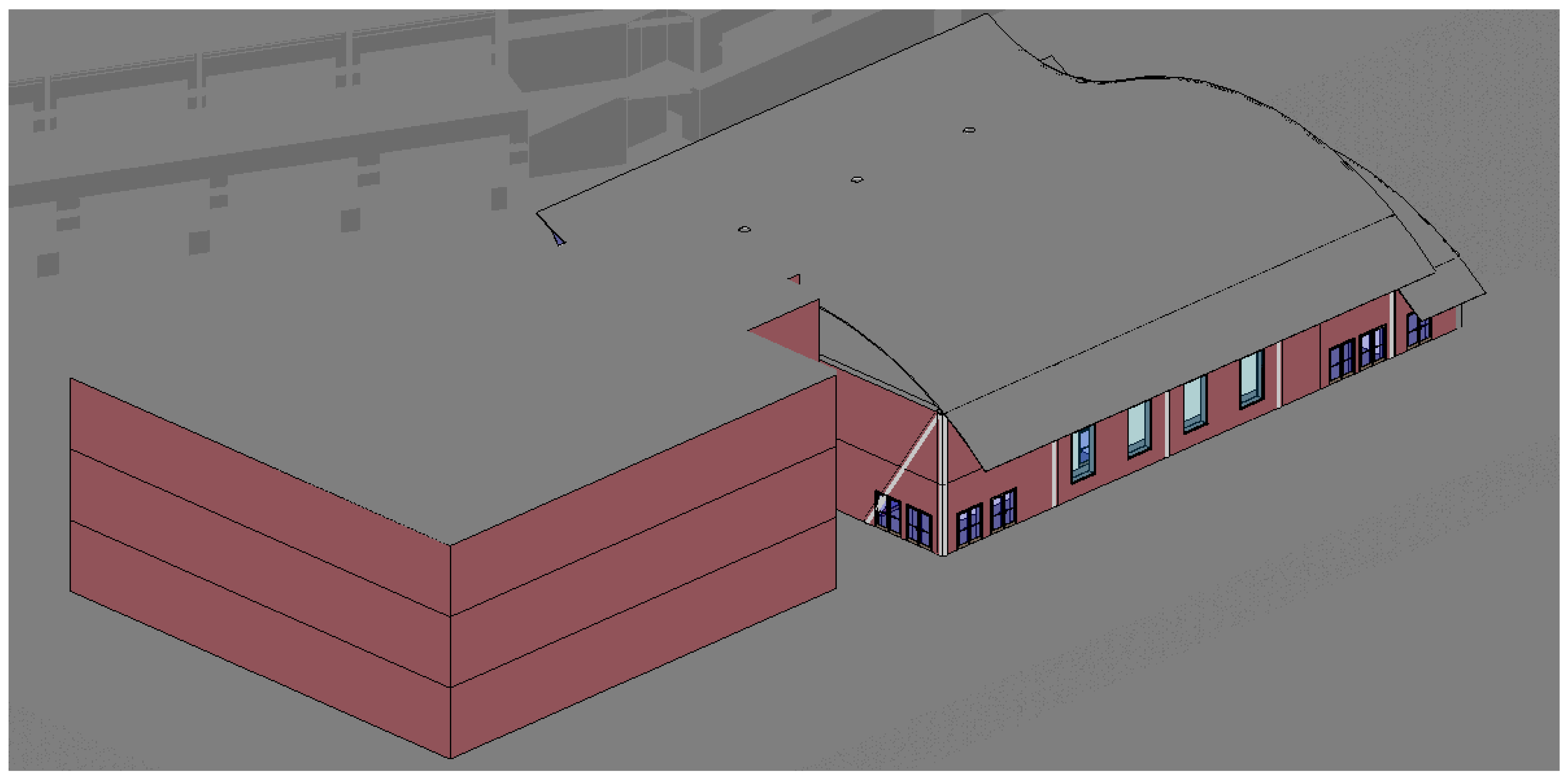
Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

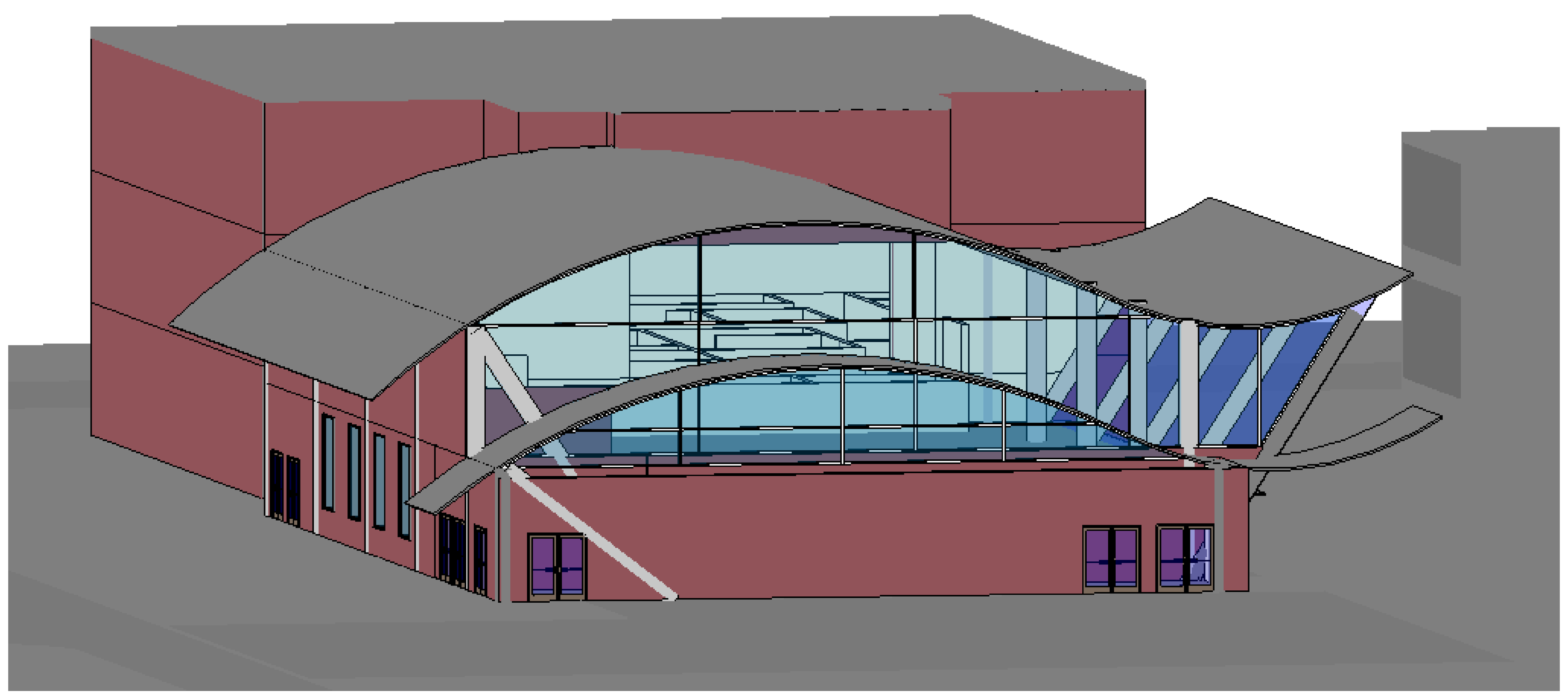
I106

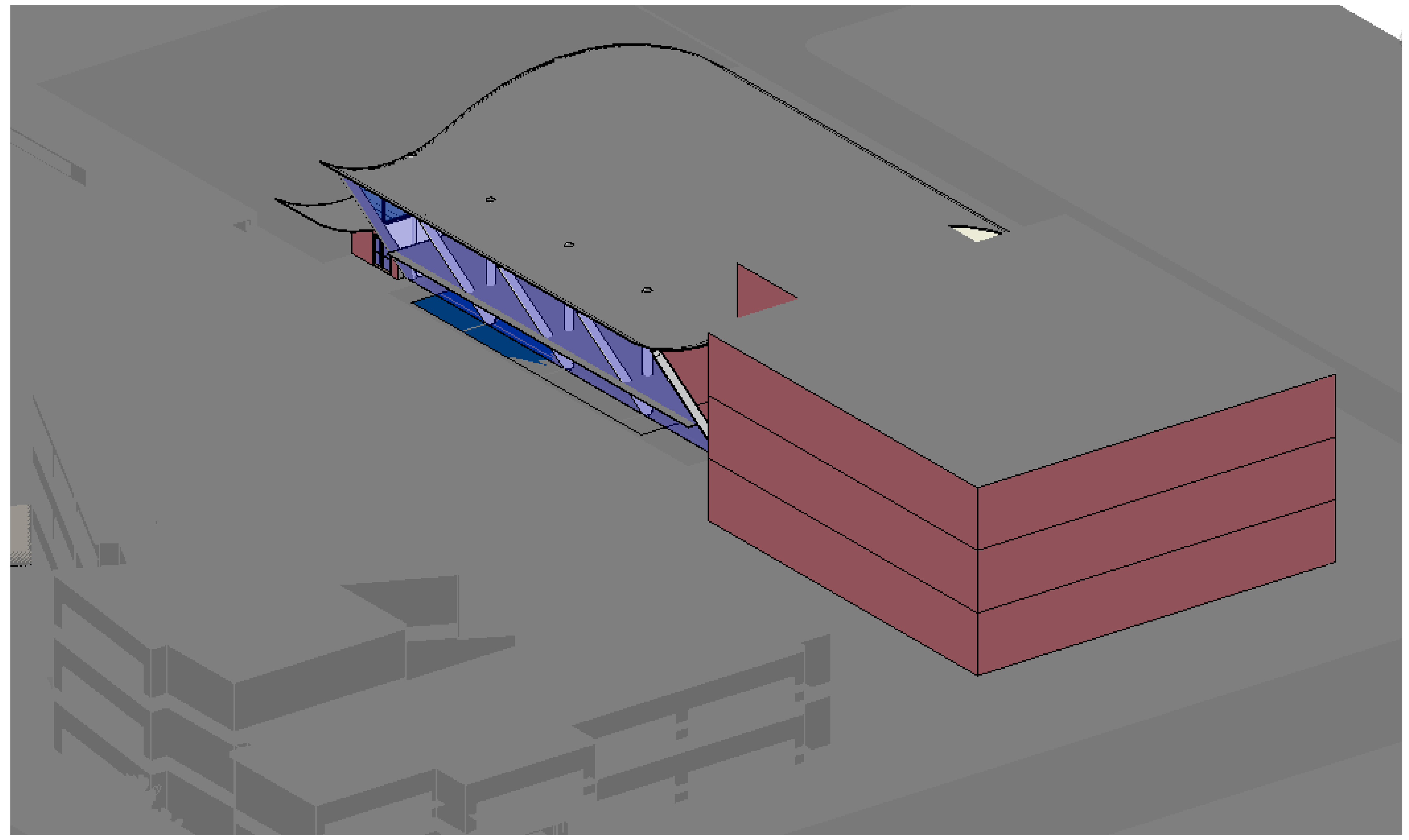
Scale 3/16" = 1'-0"

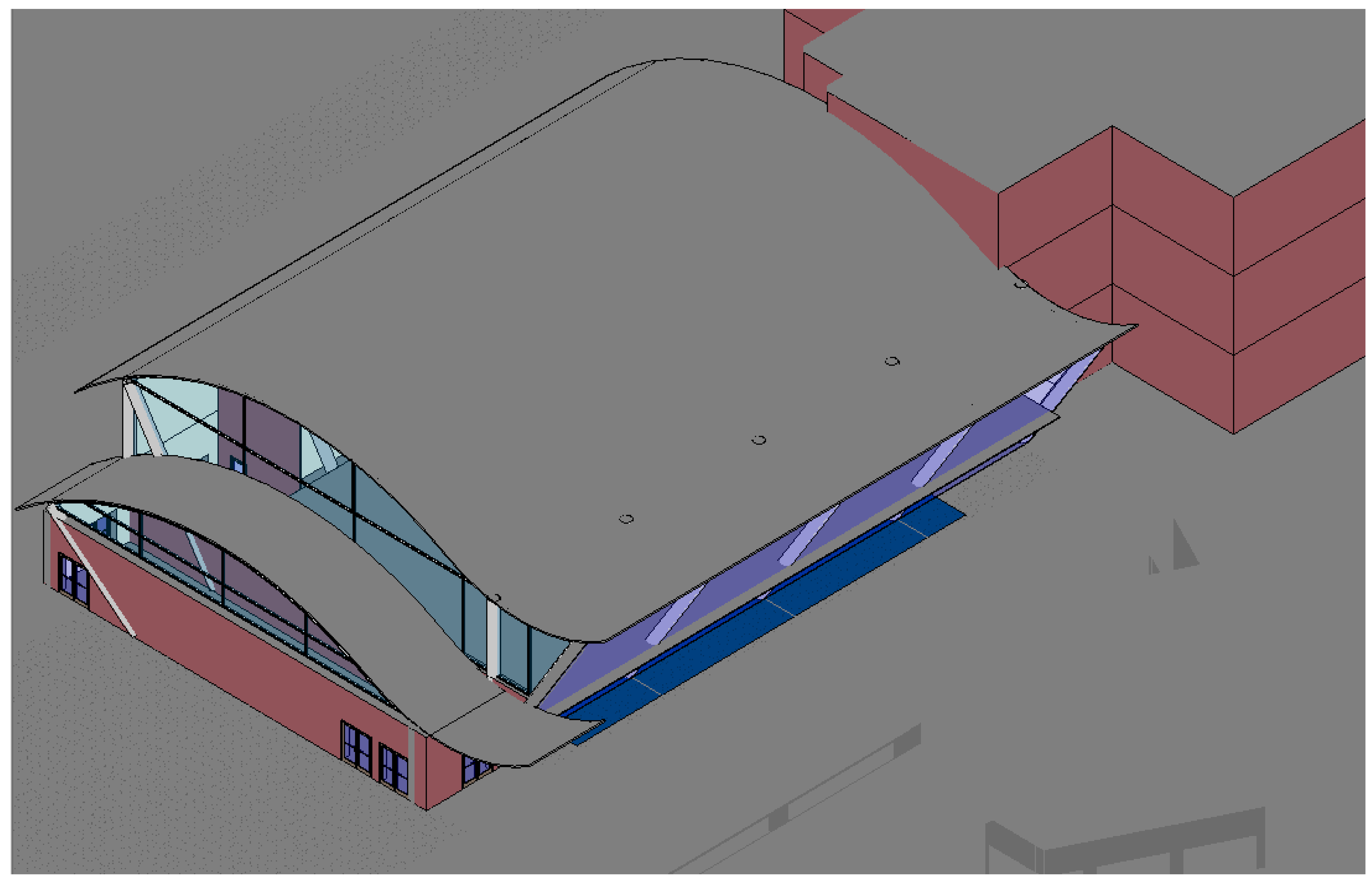
2/20/2013 3:52:54 PM











Autodesk® Revit®

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

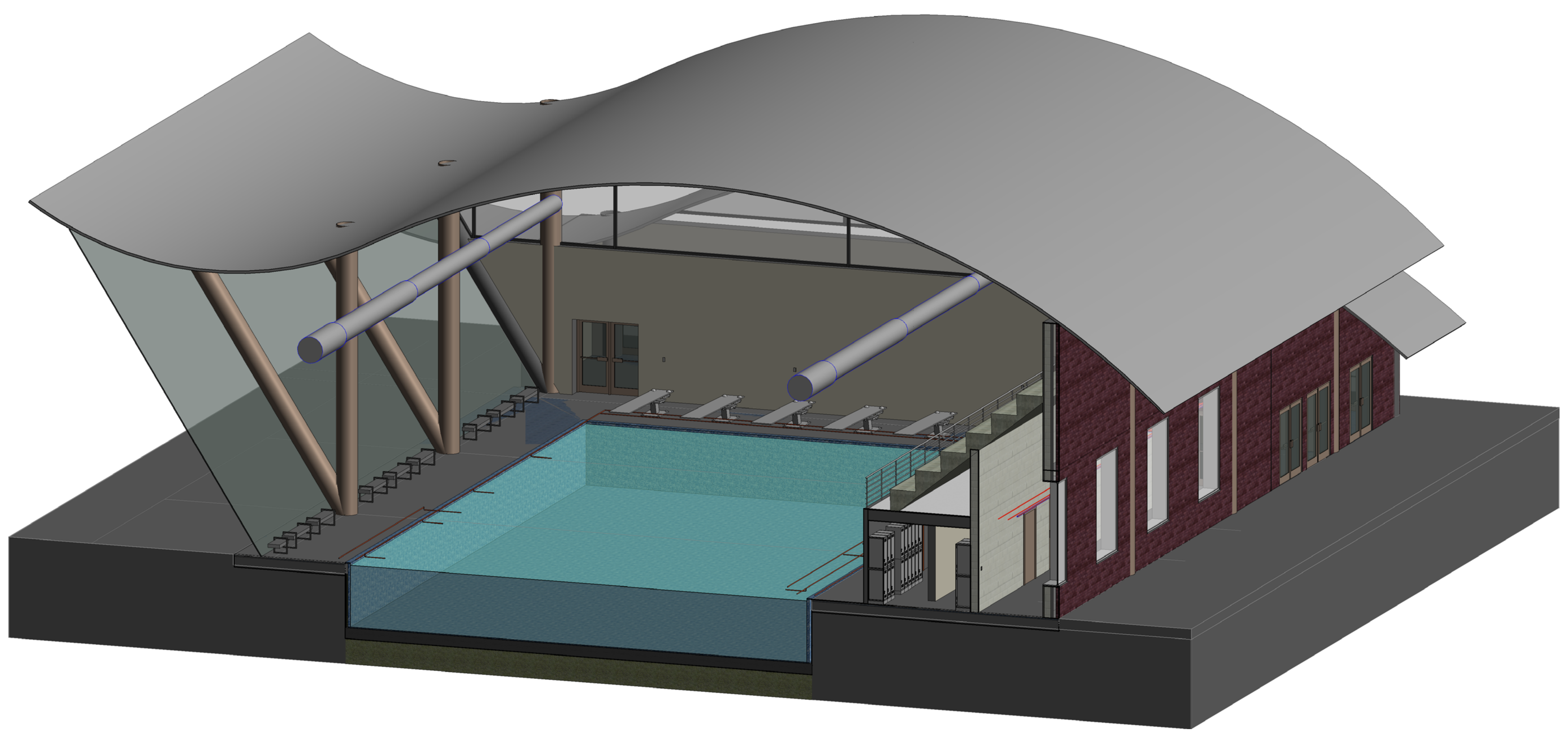
Phase 2 Isometrics

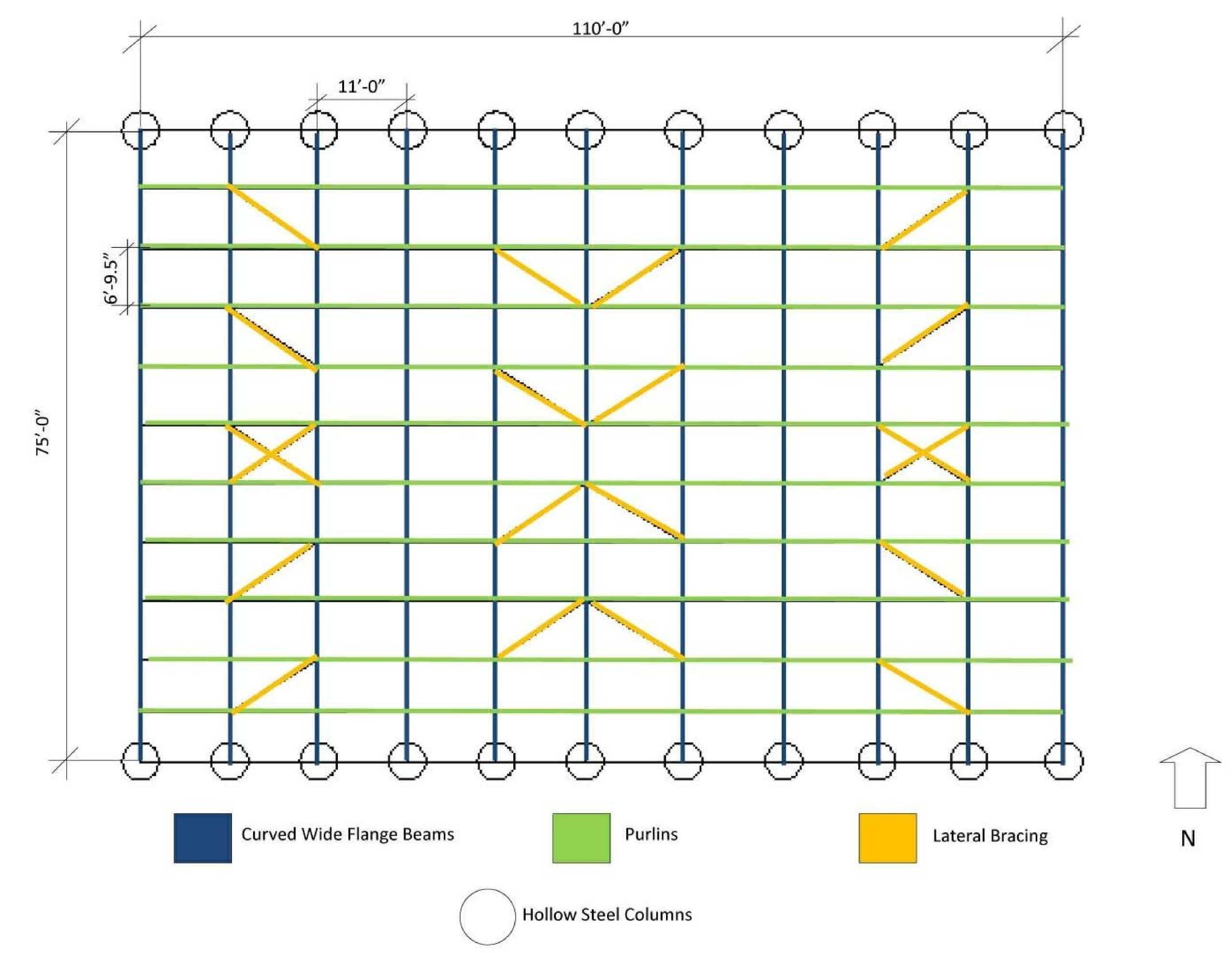
Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

I107

Scale

2/20/2013 3:33:50 PM





GENERAL NOTES

A. 6 lane (50'x90') indoor pool

B. Stadium style seating above locker rooms

CONSTRUCTION MANAGEMENT

A. Concrete pool basin

B. Structure supported by Rammed Aggregate Pier foundation

C. Same precast panels installed as school

D. Non-Slip floors on pool deck

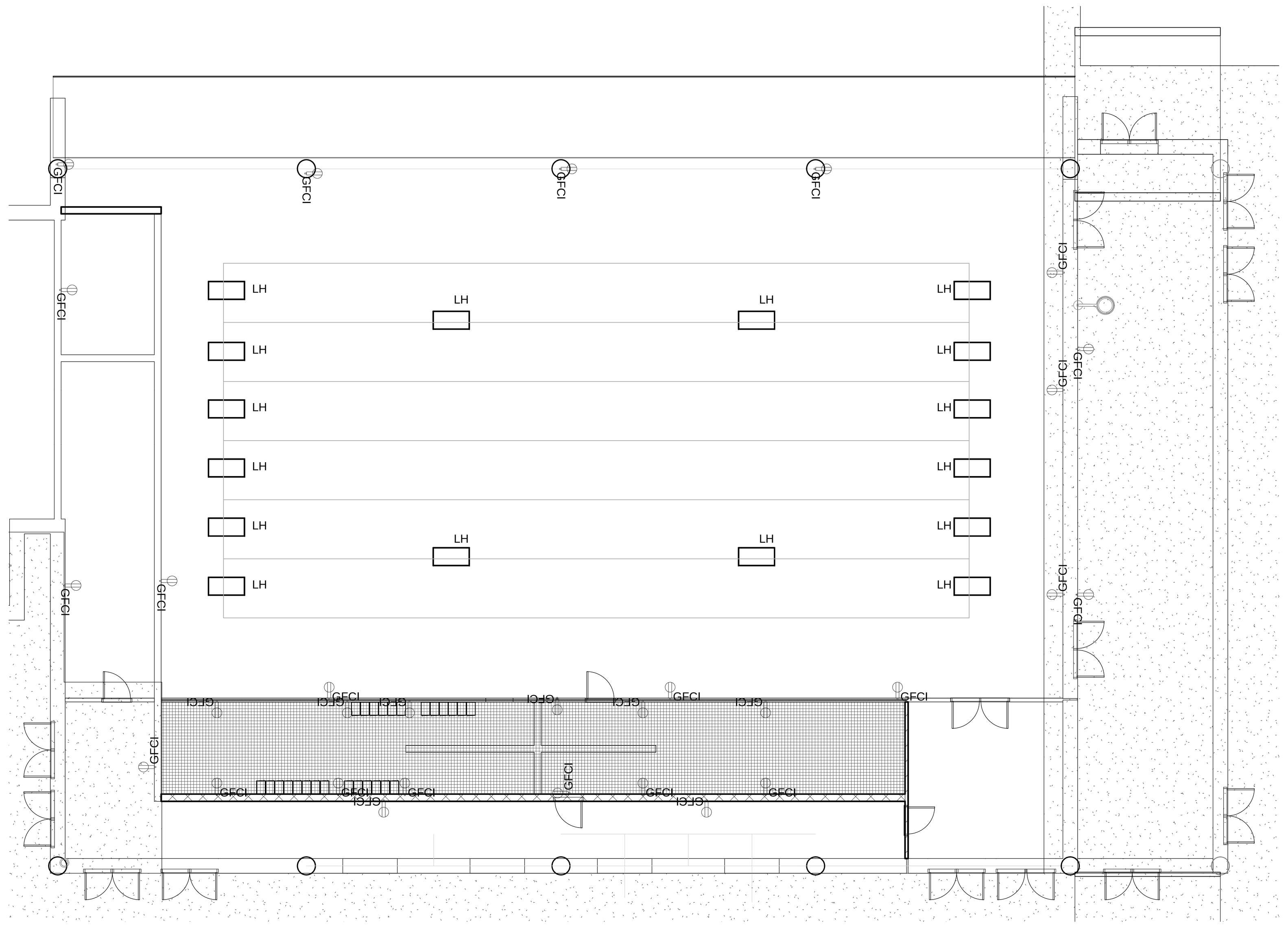
STRUCTURAL NOTES

A.Prefabricated insulated metal deck roof panels

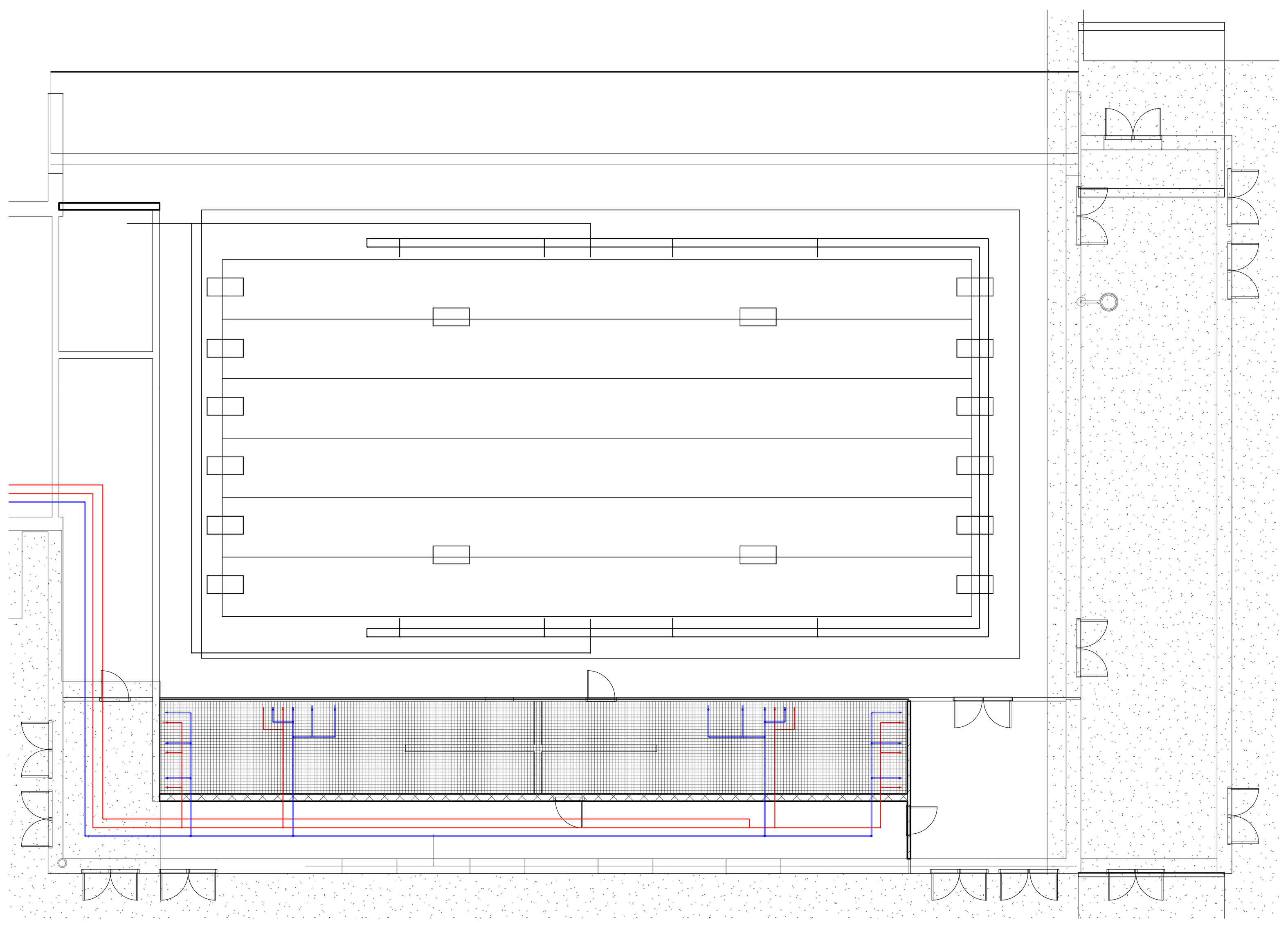
B.Panels supported by W21 rolled girders and W12 purlins that span 75' across natatorium

C.Vertical and slanted hollow steel columns

D.Cast in place concrete stadium style seating supported by interiorload bearing masonry walls



1 NATATORIUM LIGHTING/ELECTRICAL PLAN
1" = 10'-0"



2 NATATORIUM MECHANICAL PLAN
1" = 10'-0"

LIGHING/ELECTRICAL NOTES

A. WATERTIGHT FIXTURES SUSPENDED AT 22' ABOVE POOL DECK.

B. FIXTURES WILL BE CONTROLLED FROM A SWITCH INSIDE A CONTROL ROOM.

MECHANICAL NOTES

A.(2) 30" Rd. RA Ducts

B.(2) 30" Rd. SA Ducts

C.Lockers are supplied with domestic cold water, hot water and hot water recirculation lines.

D.Pool Plumbing ties into the AHU for water heating

Autodesk® Revit®

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

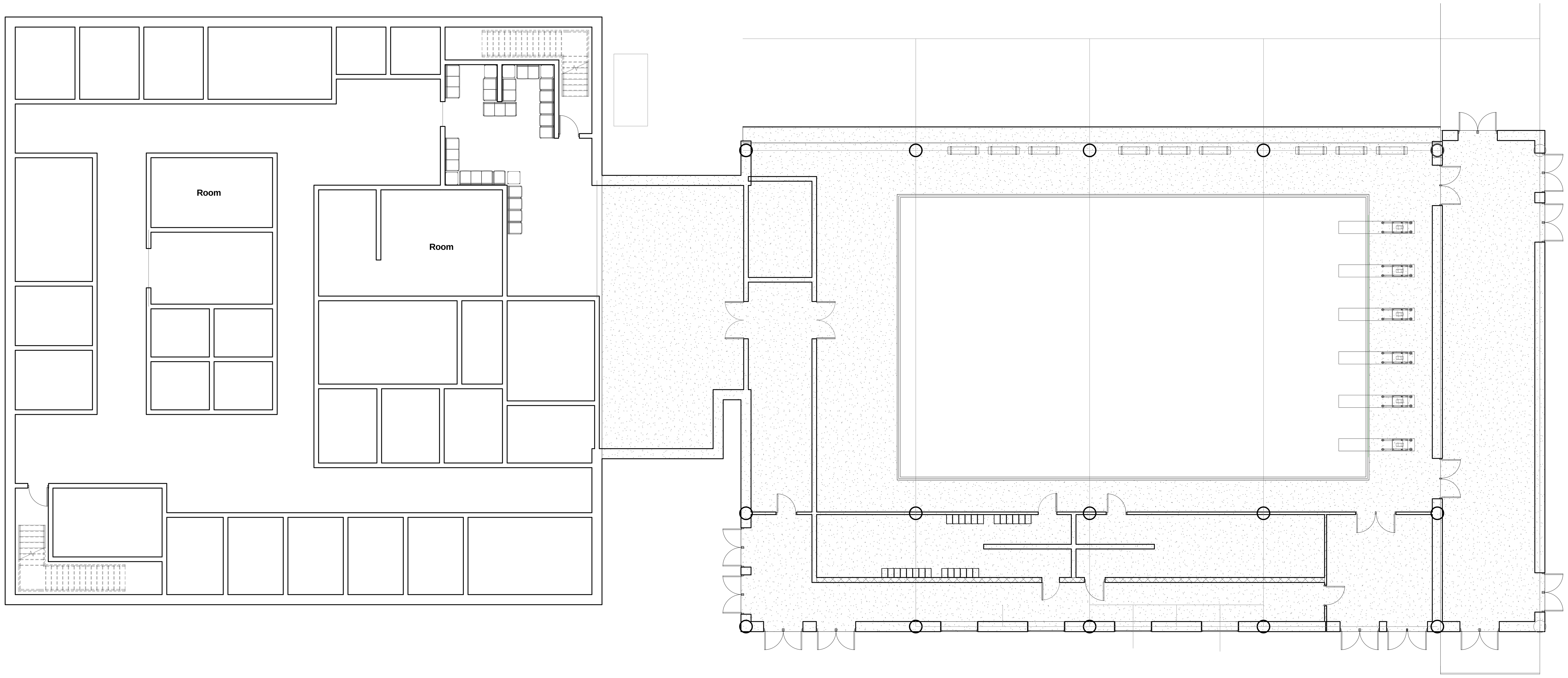
Integrated Natatorium Plan

Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

I108

Scale	1" = 10'-0"

2/20/2013 3:53:04 PM



1 for sheets
1/8" = 1'-0"

Autodesk® Revit®

www.autodesk.com/revit

No.	Description	Date

AEI Team #04-2013

Reading Elementary School

Phase 2 Architectural Plans

Project Number	04-2013
Date	22 February 2013
Drawn By	Author
Checked By	Checker

I109

Scale	1/8" = 1'-0"

2/20/2013 3:53:13 PM