Submission Category: Building Integration

Date: 12 November 2012

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Summary Narrative

The newly proposed Reading Elementary School is a challenging design project. The specific requirements of a typical elementary school, in conjunction with the unique economic conditions and demographic of the Reading area, necessitate unique design decisions and innovative solutions. Nexus began the design process by considering a number of goals that would be desired both by the building owner and the design professional. These goals needed to benefit both parties financially, but they also needed to promote functionality and aesthetic quality. Nexus developed goals for the owner that included cost effectiveness, safety and security, and lifecycle and maintenance costs. Adjacent to these goals, Nexus developed goals for the design team that focused on integration of the different disciplines, a philosophy of "reduce, recover, reuse," and utilization of the school itself as a tool for learning.

Once the design goals were established, Nexus began analyzing the given architectural plans in order to identify potential problems and begin considering solutions. In order to achieve this, a set of categories was created to define the purpose of different spaces in the school. Nexus determined that the three major portions of the building included community involvement, administration space, and the educational environment. Concentrating on each of these spaces individually reduced the scope of each building portion and helped Nexus to provide better solutions for each space.

Nexus evaluated the given floor plan, and one of the first decisions was to move the location of the main entrance and incorporate the south façade of the building as the new front façade. This decision was heavily driven by the need for an environment that provided security and comfort for the students coming to the school each day. Turning the building inward on the block and creating a campus feel with the existing school district building helped to provide this comfort and security. Another difficult challenge to explore was the addition of a pool to the building. The pool needed to be placed in a location that was accessible for the community, but still fit into the given program of the school. Nexus made the pool a viable option for the school district by moving the building's location on the site and placing the pool next to the gymnasium and multipurpose space that will also be utilized by the community.

The Reading Elementary school contains a number of other examples of innovative design solutions for each of the integrated disciplines working on the building. The design processes and decisions made by each discipline are explained and justified by the following portions of this narrative. The goals set forth by Nexus were created in order to provide a building that satisfies the needs of students, teachers, and community members, and Nexus feels that the proposed design will successfully achieve and exceed these objectives.

Project Goals / Requirements

Prior to delving into the design of Reading School District's new elementary school Nexus defined owner, team and discipline goals. The owner goals included cost benefit, safety, security, lifecycle, durability, sustainability, accessibility, functionality and flexibility. These goals were then lumped into three broad categories. The first category encompassed how cost effective the design was. Designing to a strict budget and getting every dollar to go as far as possible was very important. The second category was safety and security. Safety and security were both woven into the fabric of the design to ensure that students could learn and interact in a safe environment. The final category was lifecycle and maintenance. It was important to the Reading School District that they get a building that would not be a strain on their budget in the coming years, but rather serve as an example of how to be environmentally conscious while still saving money. These owner goals were distinctly laid out in the prompt and became the main considerations for Nexus' design.

Nexus took the initiative and created three team goals to help guide team decisions. The first team goal was integration. Nexus believes that the team is better than the sum of its parts, but in order to achieve this higher purpose individual designs must be informed and work hand in hand with one another. The second team goal was reduce, recover, reuse. This goal served as a reminder to the team to continue to think outside the box in order to be as efficient and sustainable as possible. The final team goal was to create a learning tool. Simply building a safe and aesthetically pleasing building was not enough; the new elementary school had to actually function to teach students and enhance their ability to learn.

Each discipline also came up with their own set of goals that were more specific and measurable. The construction management discipline aimed to reduce total building cost to less than $200 per square foot, maintain a schedule of less than 15 months and produce a design that is both constructible as well as functional. The mechanical engineering discipline's goals were to reduce the building loads, recover waste heat, and reuse any waste heat that could not be recovered. The structural engineering discipline aimed to produce the most efficient structural system as possible as well as working with all of the other disciplines to provide a structural system that works in conjunction with all the other disciplines.
The lighting/electrical engineering discipline's goals were to create a lighting scheme that is adaptable and functional.

Narrative Description of Systems / Solutions

Reading

Reading School District is one of the least affluent school districts in Pennsylvania. The state average for dollars allocated to each student is $14,535, whereas Reading only allocates $12,989 per student. The vast majority (84%) of Reading's educational revenue comes from state and federal revenue. Only 12% of the district's educational revenue comes from local taxes. Reading's economic situation had a major impact on the projected cost budget for the project and ultimately Nexus' design.

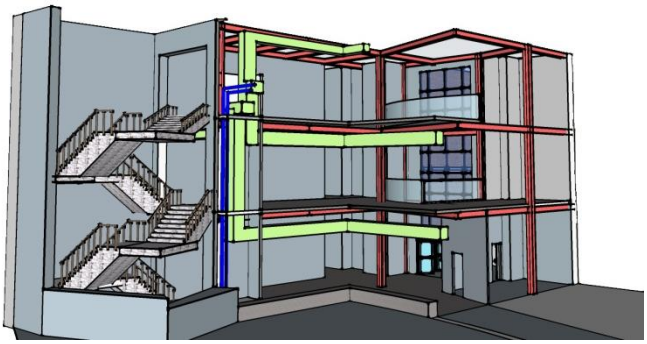
Reading School District's students consistently underperform in comparison to their fellow Pennsylvania students. This may be a product of the fact that they are not allocated the same resources as their counterparts. The environment in which they learn may also have an impact on how they perform. Nexus strove to design a cost effective building which encourages students to come to school and creates an environment which is conducive to learning.

Nexus began by breaking the building into three sections based on their function: experience, community and education. These spaces are elaborated on below.

Experience

The exterior of the building was designed with modularization in mind. The windows in all of the classrooms are the same to help decrease cost and to increase schedule gains. The ICF exterior bearing walls come in 4'x2' blocks that are stacked and make up the vast majority of the façade. The remainder of the façade is an aluminum cladding which is hung from curtain walls.

The cantilever over the entrance helps to welcome students into the building. It also serves the purpose of blocking direct sun from entering into the lower levels of the atrium space. The atrium does allow diffuse sunlight into the core of the building and further into the corridors. This allows for fewer luminaries to be necessary as well as potential energy savings.



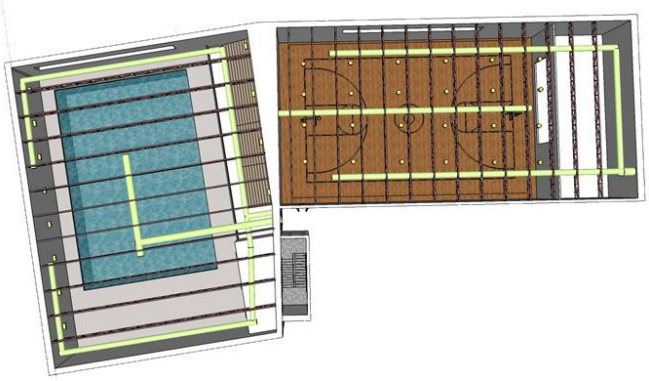
This is the only secure point of entry into the building during school hours. All visitors must come in through the double doors and then turn left and check in at the front desk. This helps to keep unwanted guests from getting close to students. There is also an entrance to the community side of the building that is accessible to the public during off hours to prevent visitors from entering the classroom wing.

The lobby serves as the knuckle to the building because it is where both the structure and the mechanical system split. There is a chase that runs vertically next to the main staircase to allow the duct, ethylene-glycol loop to access all three floors of the building. The ducts then run through the hallway below the structural grid.

The atrium also has alcoves on the second and third floors that allow students to congregate. These alcoves can be used as a reading nook or allow teachers to get their students out of the classroom and into a new more open space. These spaces are well lit thanks to the hanging pendants and the daylight that filters in through the curtain wall.

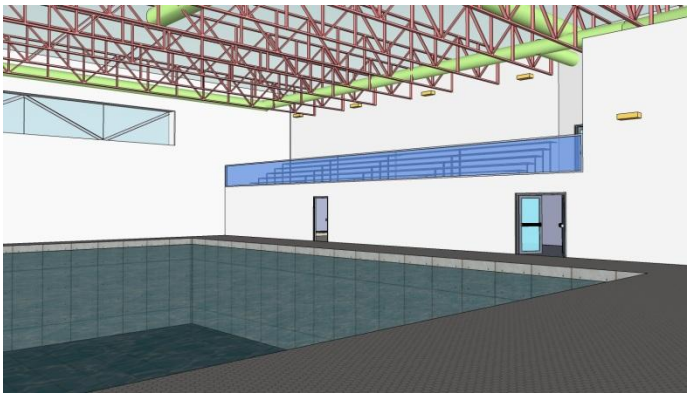
Community

The gymnasium provides a direct link to the community. This elementary school is being funded primarily through public means, so having a public space within the building that could be used by the community was an important feature that Nexus wanted to include. The gymnasium is actually a multi-purpose



space that also functions as the school's cafeteria and auditorium. There is an operable partition which can divide the gymnasium to further facilitate multi-purpose activities.

Because the community determined there may be a need for a shelter, the feasibility of letting the gym double as a shelter was investigated and it was determined that it could be done with little added cost to the project. The gym structure was designed according to the FEMA guidelines. The only major additions that had to be done to the structural system in order to qualify the gym as a shelter was add the slab to the roof and added size to the roof joists. The gymnasium will feature an acoustic deck ceiling to cut down on the reverberation time.



The pool is another community feature that can be used year-round. The pool is six lanes which will be used primarily for recreational purposes. There is a mezzanine level for spectators to view the swimming events. There is one large window on the north size of the pool enclosure. This will provide daylighting while not allowing direct glare. The lighting fixtures in this space are all wall-mounted. This will allow for ease of maintenance because no bulbs will need to be changed over the water surface. The trusses in this space are similar to in the gymnasium, however they are 5' deep and spaced 8.5' apart. This will allow adequate space for the mechanical ducts to be run directly through the trusses. The conditioned air will be supplied along the perimeter to keep continuous airflow over the window to prevent condensation. This will also prevent drafts from directly hitting the swimmers in the pool, as this could be uncomfortable. As per ASHRAE, the pool water will be heated to 80°F and the air temperature will be conditioned to be approximately 82°F. Another major concern for all disciplines are the chlorine vapors that will evaporate off of the pool water. These vapors are corrosive and can damage the building materials and are also harmful to health. These vapors will have to be captured and exhausted.

The pool is being treated as an add-alternate. The pool falls under special construction, which accounts for approximately 12% of the current cost of the building. If we do not build the pool, these funds can be allocated to other

Cost Breakdown w/ Pool

		Cost/SF	% of Cost	Cost
Division 1	General Requirements	$ 11.73	6%	$ 1,050,000
Division 2	Existing Conditions	$ 5.86	3%	$ 525,000
Division 3	Concrete	$ 31.28	16%	$ 2,800,000
Division 4	Masonry	$ 15.64	8%	$ 1,400,000
Division 5	Metals	$ 15.64	8%	$ 1,400,000
Division 6	Wood, Plastics, and Composites	$ 1.95	1%	$ 175,000
Division 7	Thermal and Moisture Protection	$ 7.82	4%	$ 700,000
Division 8	Openings	$ 11.73	6%	$ 1,050,000
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Division 11	Equipment	$ 1.95	1%	$ 175,000
Division 12	Furnishings	$ 3.91	2%	$ 350,000
Division 13	Special Construction	$ 1.95	1%	$ 175,000
	Pool	$ 27.93	-	$ 2,500,000
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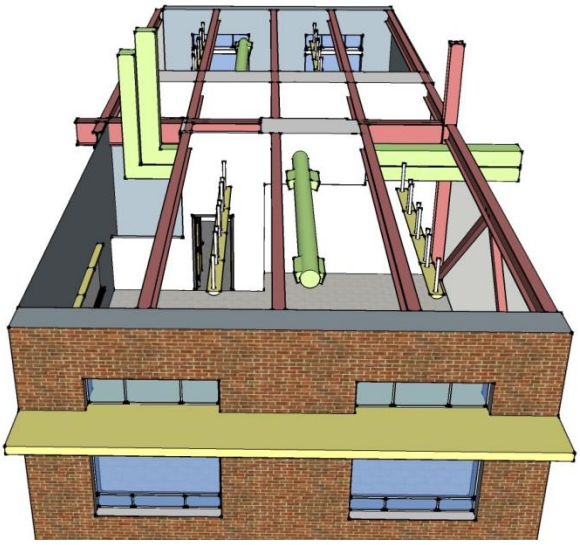
		Cost / SF $ 223.41	**Total**	$ 20,000,000

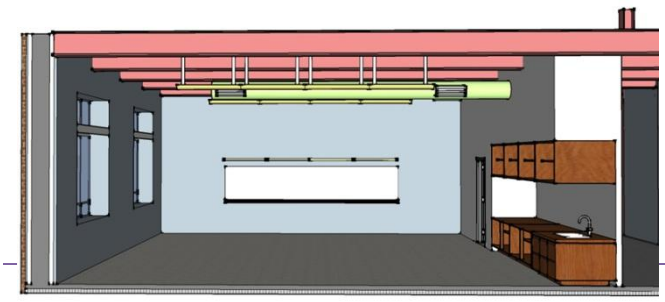
needs of the school or simply lower the overall cost of the building. If the pool is not built, the building will remain in its moved position due to the modified parking and the internal campus. The place where the pool would have gone will remain grass.

Education

The education area of the building serves as the primary function of the facility. As a new elementary school, Nexus spent the most amount of time on the design and integration of the classrooms. As a result, the classroom area is most developed thus far. To begin, the layout of the classrooms largely remain as originally designed. The general floor plan was deemed the most functional and flexible design. Thus, the building system selection came from the design goals to enhance these spaces. In regards to the classroom, the owner desired it to be a space that meets the goals of lifecycle and cost benefit. To meet these goals, Nexus defined the goals of integration, flexibility, and learning tool.



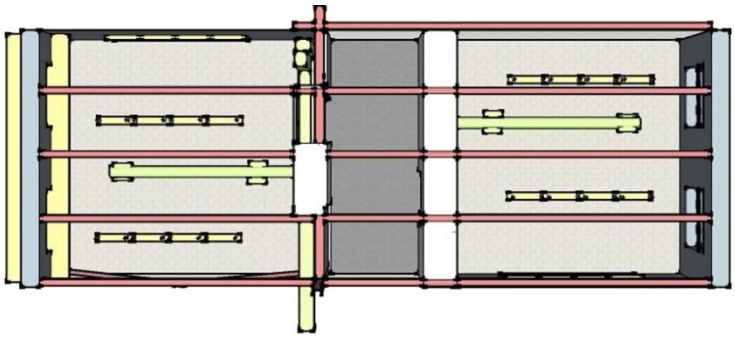
After altering the structural grid to only have one column line, the mechanical and lighting system were selected. Nexus collaborated through several design iterations to come to the idea of a bulkhead above the counter space on the corridor wall of the classrooms. Although the structural bay size grew and the beam depths became larger, the mechanical ducts still fit in the newly designed bulkhead. As seen in the image below, the upper level cabinets still fit with proper clearance above the counter level cabinets. The structural system also incorporates two bays of lateral bracing in the classroom spaces (as seen in the image above). Due to the fact that this lateral bracing is only in two bays, classrooms may still be combined to create one large classroom. This however, would necessitate knocking down a metal stud and gypsum wallboard partition wall. Yet, this is easier than removing a concrete masonry unit infill wall.



The mechanical supply and return duct run in the bulkhead as previously explained. There is one branch with a few diffusers that runs through the middle of the classroom, evenly conditioning the

space keeping the students in a comfortable environment. Next, the lighting scheme involves two major items – electric light and daylighting. The electric light is supplied by two rows of pendant lights as seen in the image below. These luminaires supply both direct and indirect lighting. In addition, there are indirect wall-mounted luminaires above the board to illuminate the front of the classroom. Lastly, there are task lights mounted to the bottom of the upper cabinets.

In regards to daylighting, there are façade-mounted overhangs (louvers) above each of the two windows in each classroom. These work in conjunction with the light shelves on the interior wall. Since these two items work together, they help eliminate glare on the whiteboard, thus improving the quality of the learning environment.



Finish materials were selected to enrich the structural, mechanical, and lighting systems. The interior walls will all be gypsum wallboard. This adds minimal acoustic treatment but does provide a smooth finished surface. The gypsum wallboard will most likely be high-impact rated so that students do not damage it. The corridor walls will have two layers of gypsum wallboard on each side to meet fire rating requirements. Next, the floor will be covered with carpet tiles. These are both maintenance friendly as only one tile needs to be replaced at a time, and provide the supplementary acoustic treatment. Lastly, the casework is still being developed to increase its movability.

From the above descriptions, one can recognize the integration of the building systems in the classroom spaces. Furthermore, it is important to note how the classroom will be used a as a learning tool. By having painted mechanical duct and structural steel members, the students will easily be able to identify different building components. Although they may not necessarily have a class on building materials, they will inherently learn to recognize the different colors they see and what those colors represent.

Safety

Prior to creating a learning environment, safety had to be established. Reading is near the top of the list in terms of crime in Pennsylvania, so Nexus focused heavily on the

importance of maintaining the safety and security of the students. In order to maintain the secure feel Nexus turned the educational campus in on itself to shelter the students. This inward turn created a large group congregation space on the inside of the campus. This area allows students to congregate away from the main roads and the dangers of the community. The theme of safety was carried into the building by maintaining one secure entrance. The one entrance ensures that no unwanted visitors enter the school, which is crucial at an elementary school. Nexus also promoted safety by creating a more open atmosphere with high ceilings and easy access to all parts of the building.

Flexibility

One of the goals of the owner was flexibility. Gypsum wall board on metal stud allows the owner to more easily change the layout of classrooms and other spaces. There is minimal lateral cross bracing so it would be conceivable to take down a wall and make a classroom twice as large. In order to create a more open feel the two column line structure that was proposed was modified to a single column line. This reduces the floor space occupied by vertical columns and adds to the flexibility of the design. The open ceiling plane also allows for the mechanical or lighting layouts to be changed much more easily. Excluding a drop ceiling also allows for future telecommunication or electrical to be run to accommodate new technology. The gym also serves as a multipurpose space that acts as a gymnasium, cafeteria and auditorium. The dividing partition is operable and can be used to split the gym in half to further facilitate unique uses of the space.

Lifecycle

The overhangs / lightshelves are also an important part of another one of Nexus' goals - the reduction of lifecycle costs. Reducing direct light from entering the classrooms helps create a better learning environment and reduces the amount of solar heat gain. Reducing solar gain helps to cut down on the use of the mechanical system and ultimately reduces the energy consumption of the building saving Reading School District's money. In the case of the lobby the opposite approach is used, and glazing is used to allow light into the atrium space. This helps to illuminate the lobby and hallways and reduces the need for luminaires in these spaces. This is a savings of both upfront costs and lifecycle costs.

Rationale for System Selections and Solutions

Structure

The Elementary School project for the Reading School District requires a structural system that meets client goals and meets requirements presented by site conditions and by the conditions of the project. The client goals and the project team goals were considered in making each decision. These goals include, building and site security, low life-cycle cost, energy and environmental concousness, a felixble building layout, intergration across all disiplines, and to produce a good learning environment.

The project structural team was able to produce a structure that is not only efficient, but also helps the team and other disciplines reach their goals. By using innovative materials, such as Insulated Concrete Forms, we were able to produce an innovative structural design. Also, by using good engineering practices, a very efficient structure was produced. This is evident by the reduction of the number of columns by using long spans in our building and in turn reducing the number of piles for our foundation.

Mechanical

In designing a mechanical system for the Reading Elementary School many socioeconomic, constructability, and feasibility factors were taken into consideration. Our preliminary calculations presented us with a 70,000 cfm and 190 ton load requirement for the building. As such, it was determined that an Ethylene-Glycol recovery system be implemented to design the most cost effective system in terms of upfront and lifecycle costs. The recovery system manufactured by Konvekta was used in the determining the efficiency and cost analysis of this system as it was found to be the most energy efficient and sustainable in comparison with the products of other manufacturers. The system too will be a 100% outdoor air system to allow for high maximized ventilation rates and an overall improved internal environment. Because the building functioning as a nexus for education of students and giving back to the community it was clear that the system design must provide a valuable product to the owner in terms of its cost effectiveness, efficiency, and flexibility.

In initiating the design sequence for the mechanical system a conceptual mass energy model calculated using project Vasari. The model generated very basic annual energy use values based off a typical elementary school schedule. It too provided a thorough analysis of wind conditions on site and solar radiation conditions on each façade of the building. From this preliminary energy model a Trane Trace700 energy model was created as the design moved into more developed and advanced stages of mechanics. These outputs were used to develop both the static and dynamic considerations of the building's mechanics.

Lighting / Electrical

The design of the lighting and daylighting system of the Reading Elementary School takes several things into account, including functionality and ease of use. These are the two most important factors with respect to lighting because they are necessary for the school to perform to its best ability. The main focus up until now has been on three core spaces: a classroom, the gym/pool, and the lobby.

Functionality for a school is paramount in its ability to operate correctly. Therefore, it is imperative for each system, lighting/daylighting included, to perform to the best of it ability. The lighting system has striven to create an atmosphere that is conducive to learning and has a welcoming environment. The space also needs to be user-friendly for the teacher, visitors, and students. The building needs to be able to be whatever the occupant needs it to be.

Construction Management

The construction management portion of this project encompasses the three design engineering disciplines. The construction managers were tasked with ensuring an integrated building design that addressed the delivery method, project planning, budget, and schedule. This integration began by developing a BIM Execution Plan, which helped define team dynamics. The BIM Execution Plan is frequently referred to for information exchanges, milestone deadlines, and collaboration procedures amongst team members.

The site logistics plans developed for construction show how the various trades will be able to easily flow on site from one task to another. By breaking the building up into three sections, contractors will be able to properly divide their work crews to address concerns when

they arise. The final site plan shows how the building was repositioned to the center of the northern half of the site to accommodate space for the pool.

The project budget is usually the first item defined during the feasibility study and programming phase. As discussed below, based on the amount of money spent on each Reading School District student annually, the district would likely only allocate $13.7 million dollars to the construction of a new school. However, this number becomes unreasonably low when one recognizes that with an 89,500 square foot building, that equates to only $153 per square foot. Thus, Nexus proposes to increase the cost per square foot to $195 and the total cost to $17.5 million. This increased cost is of value to the owner based on greater life cycle savings and the longevity of the facility itself. The project schedule is discussed in depth in the succeeding pages. The new school will be built in 15 months. This fast track project must start immediately following the end of the school year and continue throughout the following school year, and finally end before the subsequent academic year commences.

Look-ahead

At this point in the design process, the various disciplines have effectively managed to work together to avoid major clashes and enhance one another's designs. From now until February 22, 2013, the individual disciplines will be fine-tuning their deliverables while consistently interacting with each other. This will continue the integration of the building system at a more detailed level and augment Nexus' project. We understand that there are less than 15 weeks until Friday, February 22, 2013. The following lists Nexus team deliverables yet to be produced and those things to be refined. Also included is a timeline of milestones up to the final submission deadline.

Nov. 12 – week 1 (presentation 11/12)
Dec. 10 – week 5 (report draft 12/14)
Jan. 7 – week 9 (presentation 1/9)
Jan. 21 – week 11 (presentation 1/23)
Feb. 4 – week 13 (presentation 2/6)
Feb. 18 – week 15 (final submission 2/22)

nexus:
-modeling – building completeness, material selections, rendering capabilities
-supporting documentation and drawings – codes, zoning, and other legal requirements; specification standards

structure:

- ETABS model
- RAM model
- detailing structure
- detailing connections of the steel beams to the concrete bearing wall
- detailing the reinforcing in the concrete walls for compression and for lateral shear

mechanical:

- working with HVAC manufacturers
- system investigations - energy storage
- investigate ways of altering the configuration of the air handlers and exhaust components
- investigate opportunities for more advanced energy savings; update energy models

lighting / electrical:

- light the offices, hallways, clinic, and exterior
- investigate and determine the appropriate electrical system

- update energy models to determine energy savings

construction management:

- detailed estimate – structure, façade, MEP, finishes
- first cost versus life cycle analyses
- detailed schedule – update structural components; more in-depth MEP and finishing sequences; risk analysis
- site logistics / 4D – more detailed including equipment simulations; clash detection
- constructability – systems integration; crane and concrete pump sizing; hoist functionality
- LEED analysis – LEED checklist; sustainability challenges; cost benefit analysis

Cost Breakdown

		Cost/SF	% of Cost	Cost
Division 1	General Requirements	$ 11.73	6%	$ 1,050,000
Division 2	Existing Conditions	$ 5.86	3%	$ 525,000
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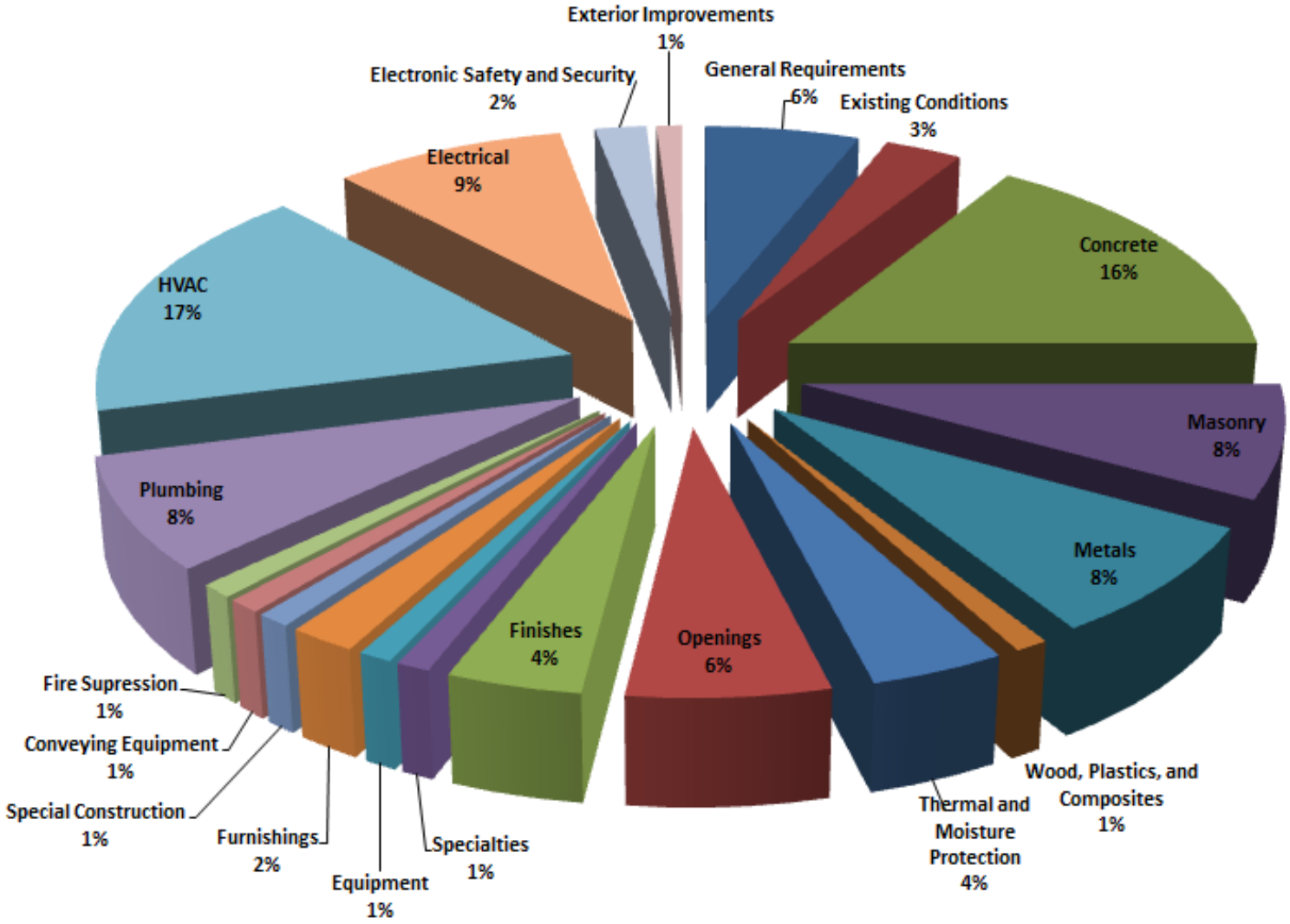
	Cost / SF	**$ 195.48**	**Total**	**$ 17,500,000**

Cost Breakdown



Cost Breakdown w/ Pool

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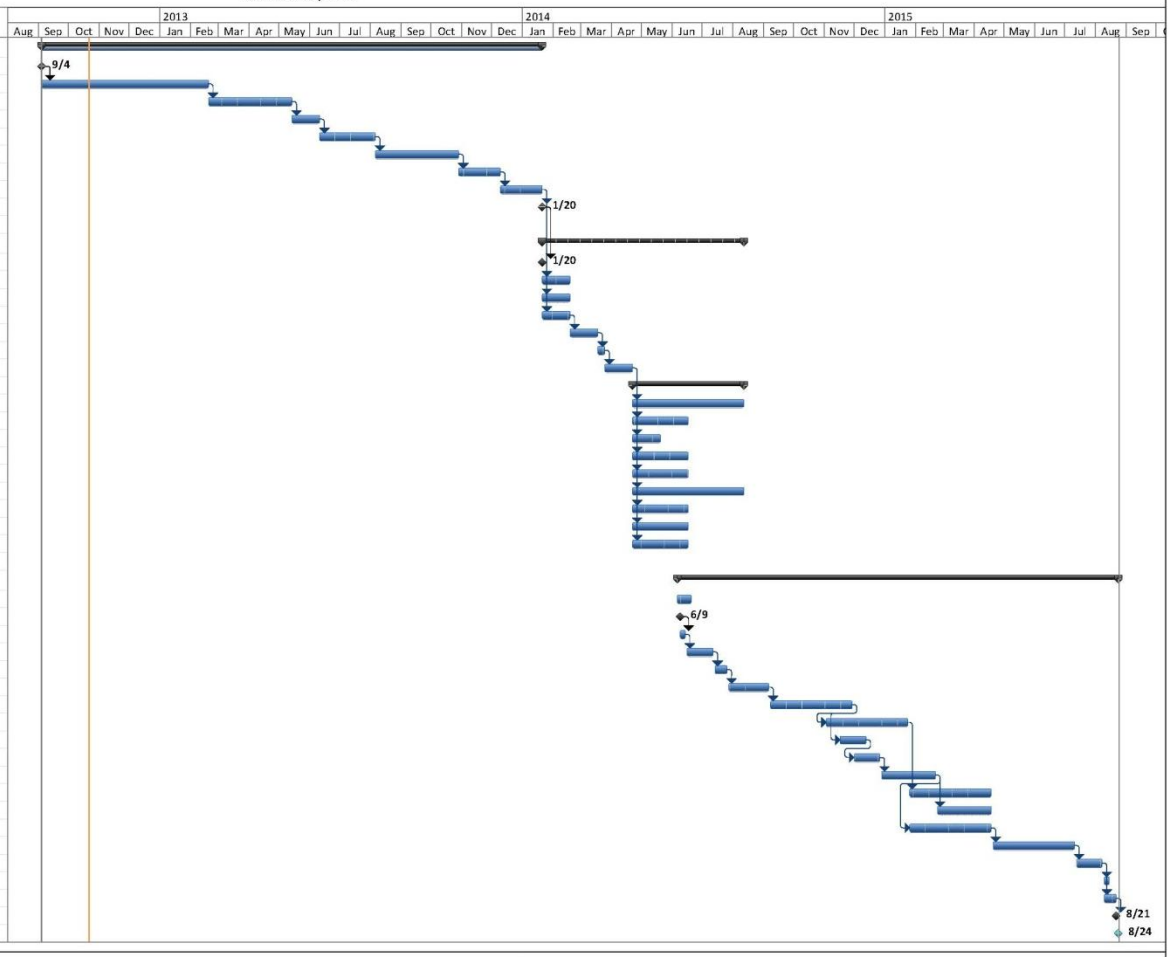
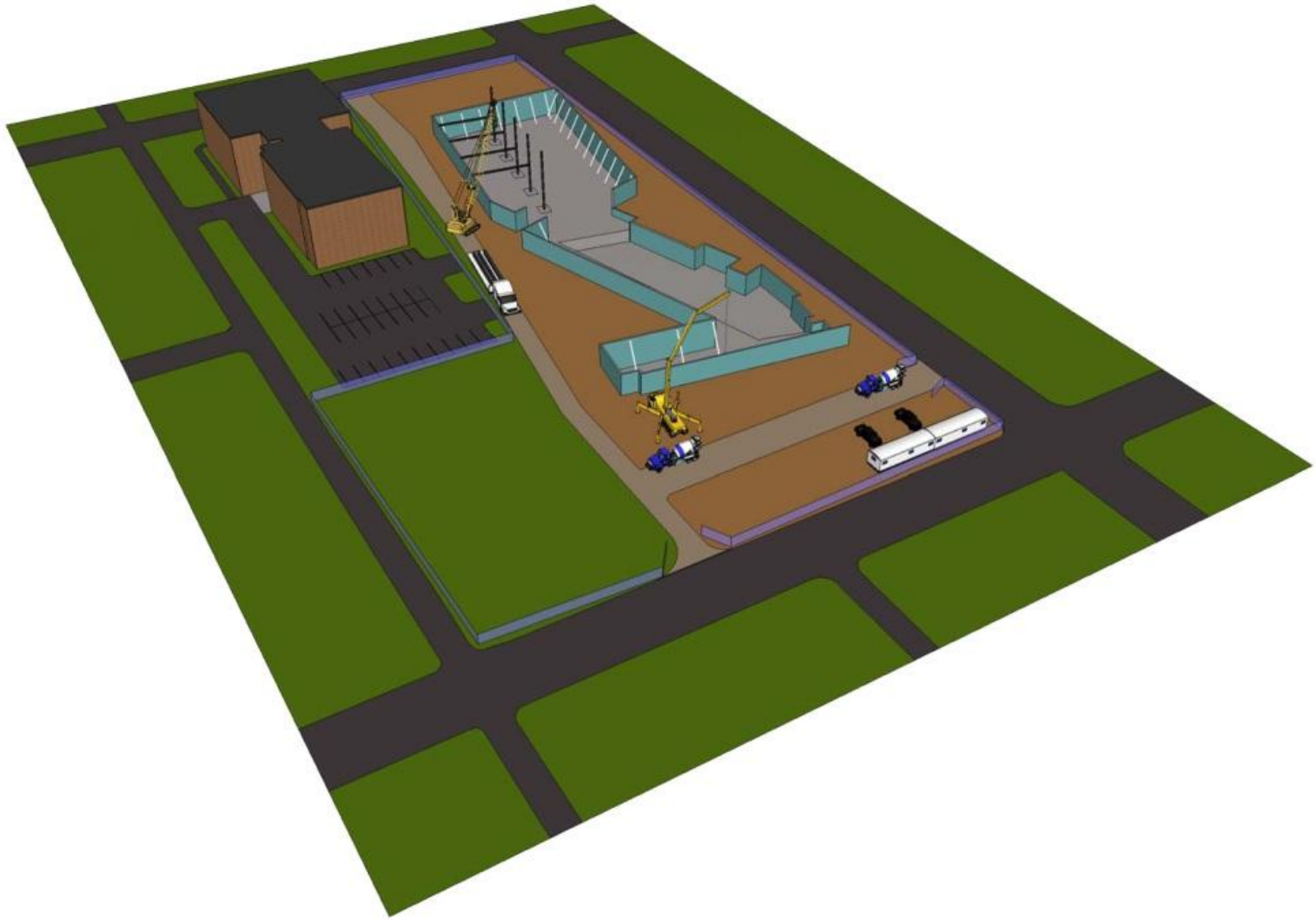
	Cost / SF	**$ 223.41**	**Total**	**$ 20,000,000**

Reading Area School District
New Elementary School

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



Steel Erection and Concrete Pour Site Layout



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COMPOSITE GIRDER DESIGN SPREADSHEET

*Add 1 kip to each point load for beam self weight

P_D	P_L	P_U	Concrete strength	Deck and Slab DL
28.448	10.08	51.266	4 ksi	56 psf

Span	Spacing	b'
28 ft	40.00 ft	42 in

b_{Eff}		V_U	M_U
84 in.	interior	51.3 kips	478.5 kip-ft
42 in.	exterior		

I_{min} (From $\Delta_{LL\ Allowable}$)	$\Delta_{LL\ Allowable}$
504.53 in^4	0.93 in.

Q_n	a (assumed)	y_2
21 kips	2 in.	5 in.

Pick Section From Steel Manual

W	24	x	68

I (Non-Composite)	ϕM_P
1830 in^4	664 kip-ft

I	$\sum Q_n$	ϕM_n
2970 in^4	251 kips	916 kip-ft

# of studs	Economy
24	2144

Δ Checks

$\Delta_{TL\ Allowable}$	I_{min} (From $\Delta_{TL\ Allowable}$)	$LL_{Construction}$
1.4 in.	1286	20 psf

$P_{Unshored}$	$M_{unshored}$
43.53 kips	406 kip-ft

$\Delta_{wet\ concrete}$	I_{minWC} (From $\Delta_{TL\ Allowable}$)
1.2951074	1693

Check Self-Weight	a
OK	0.88 in.

Camber
1.25 in

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EXTERIOR BEARING WALL DESIGN SPREADSHEET

	Pu
1st Floor	47.2
2nd Floor	41.2
3rd Floor	41.2
Roof	17.6
Total	147.2
x2	294.4

$\phi P_n=0.55\phi f_c'A_g[1-(kl_c/32h)^2]$

Empirical Design Method

Wall Dimensions

0.50	x	7	504
			(A_g)

$\rho_{min\ vert}$	$\rho_{min\ horiz}$	s	k
0.0015	0.0025	12	1

h	l_c	f_c'
12	504	4

$\phi P_{n,max}=0.80\phi[0.85f_c'(A_g-A_{st})+f_yA_{st}]$

Compression Members

A_{st}	A_g	f_y	f_c'
14	504	60	4

ϕ	$\phi P_{n,Max}$
0.85	1704.08

$V_c=2\lambda f_c'^{1/2}hd$

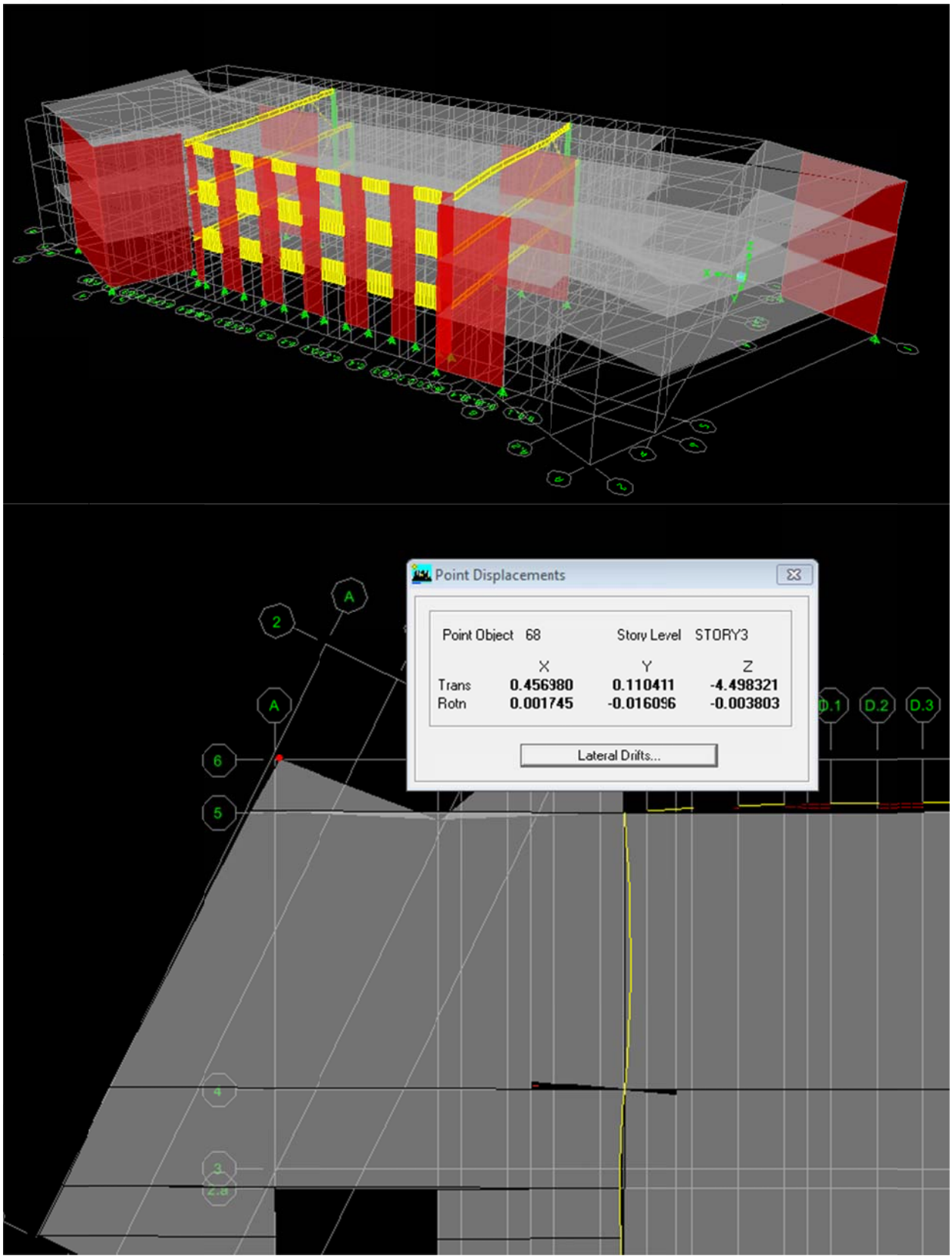
Shear in Walls

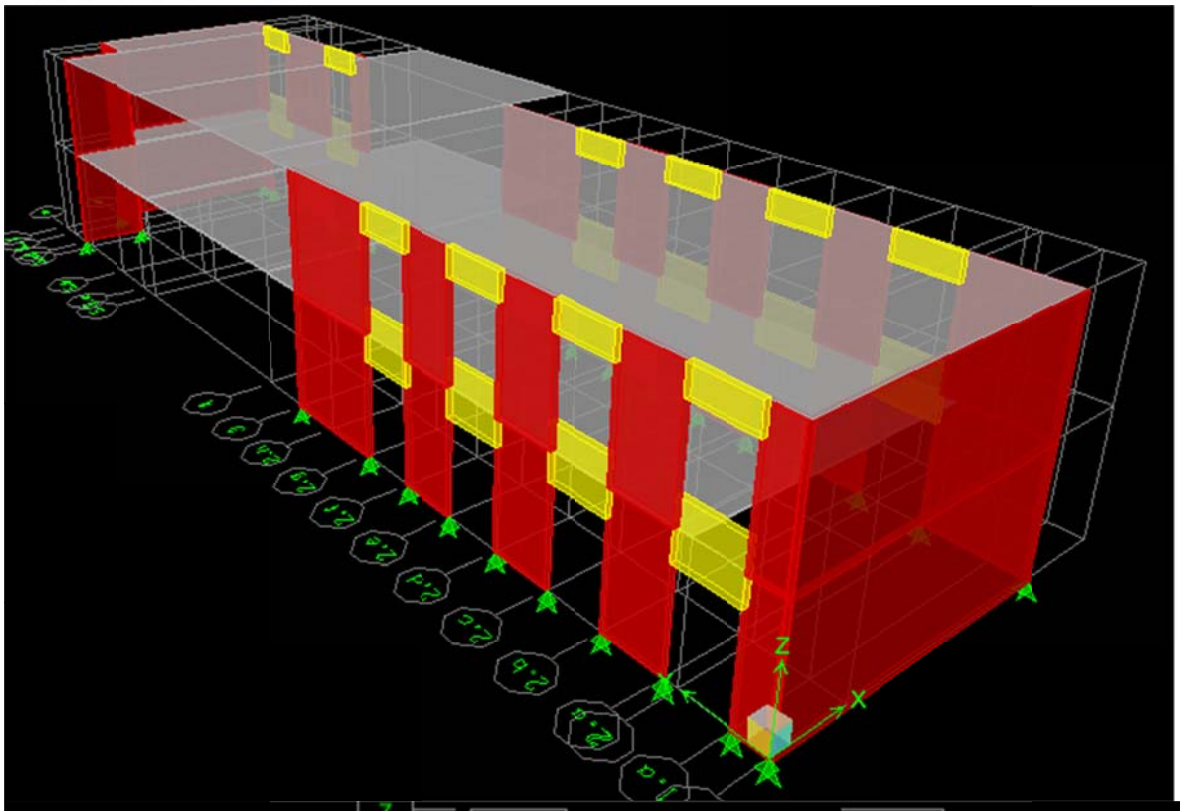
$V_s=A_vf_yd/s$

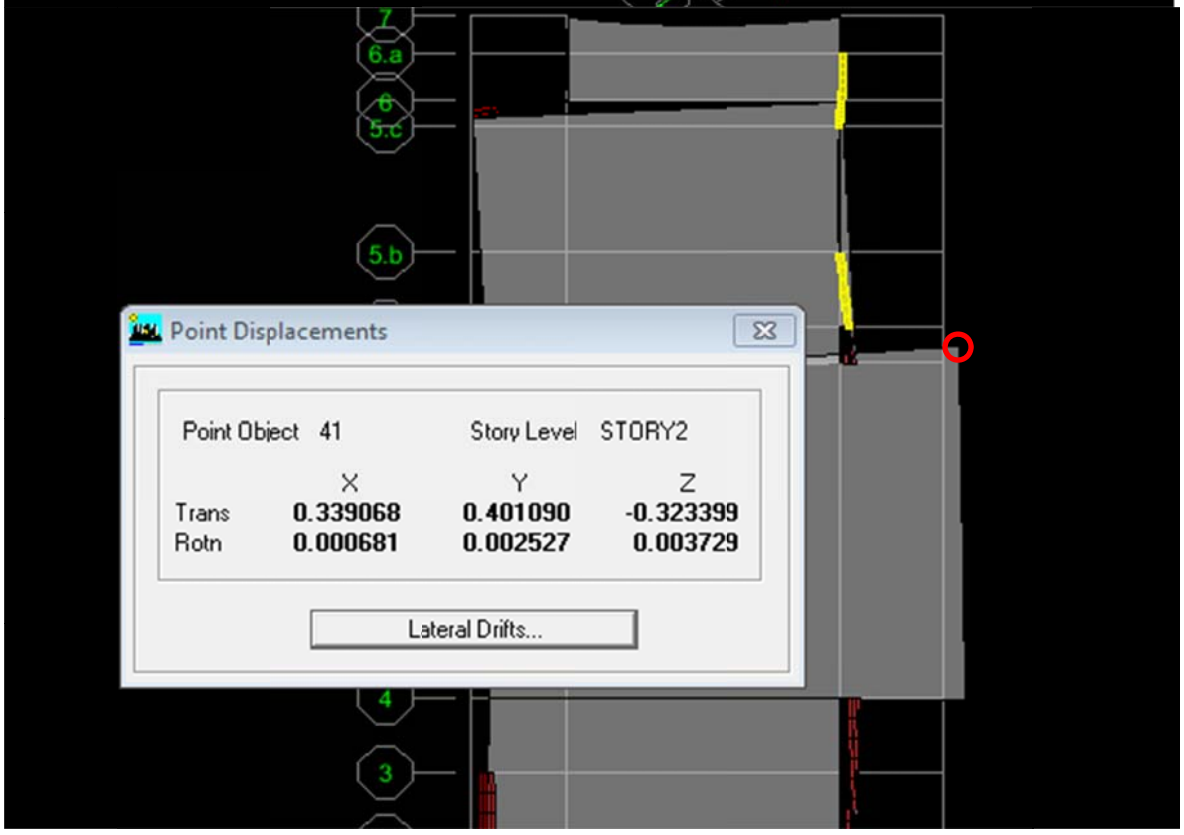
λ	f_c'	h	d	ϕ
1	4000	6.00	67.2	0.75

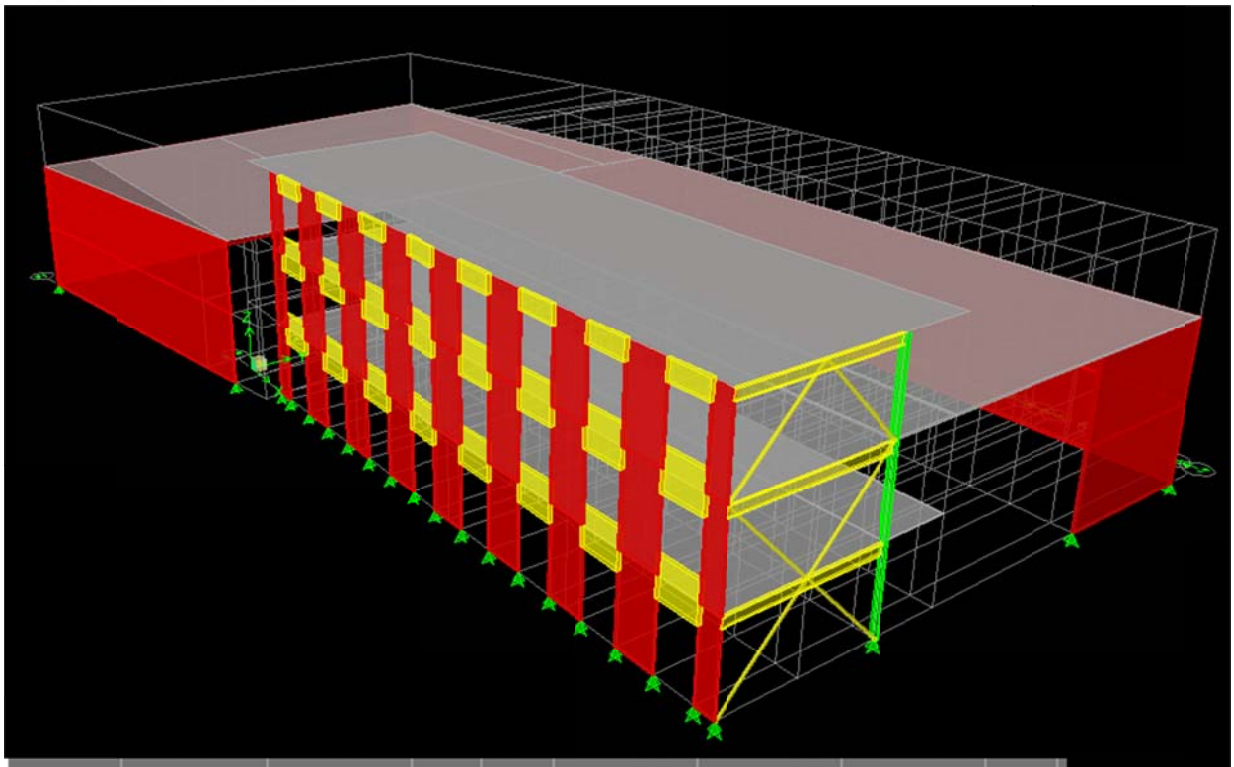
V_c	V_s	s	A_v	bar#
51.00121	49.28	18	0.22	3

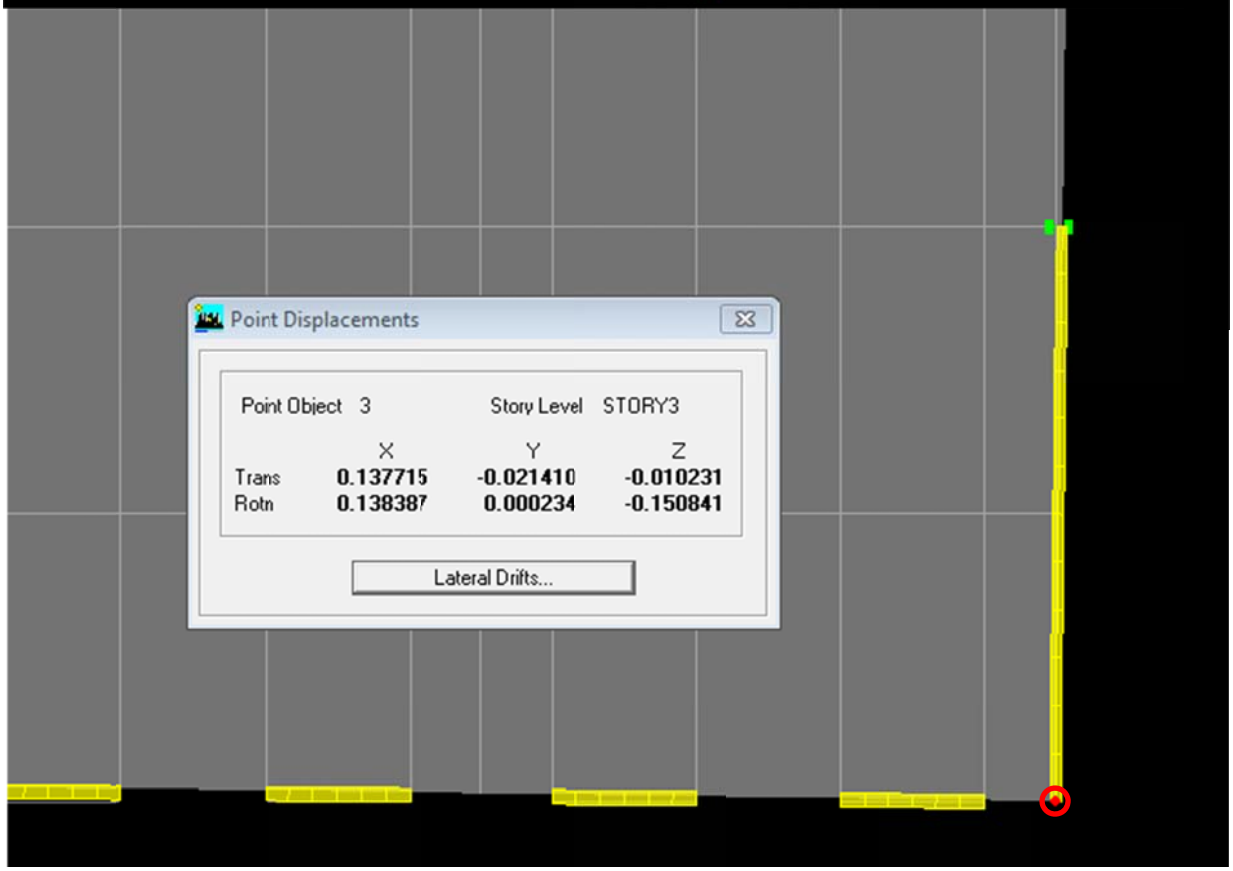
ϕV_n
75.21091


Point Displacements
Point Object 68
Story Level STORY3
X
Y
Z
Trans
0.456980
0.110411
-4.498321
Rotn
0.001745
-0.016096
-0.003803
Lateral Drifts...
A
2
A
6
5
D.1
D.2
D.3


Z
X

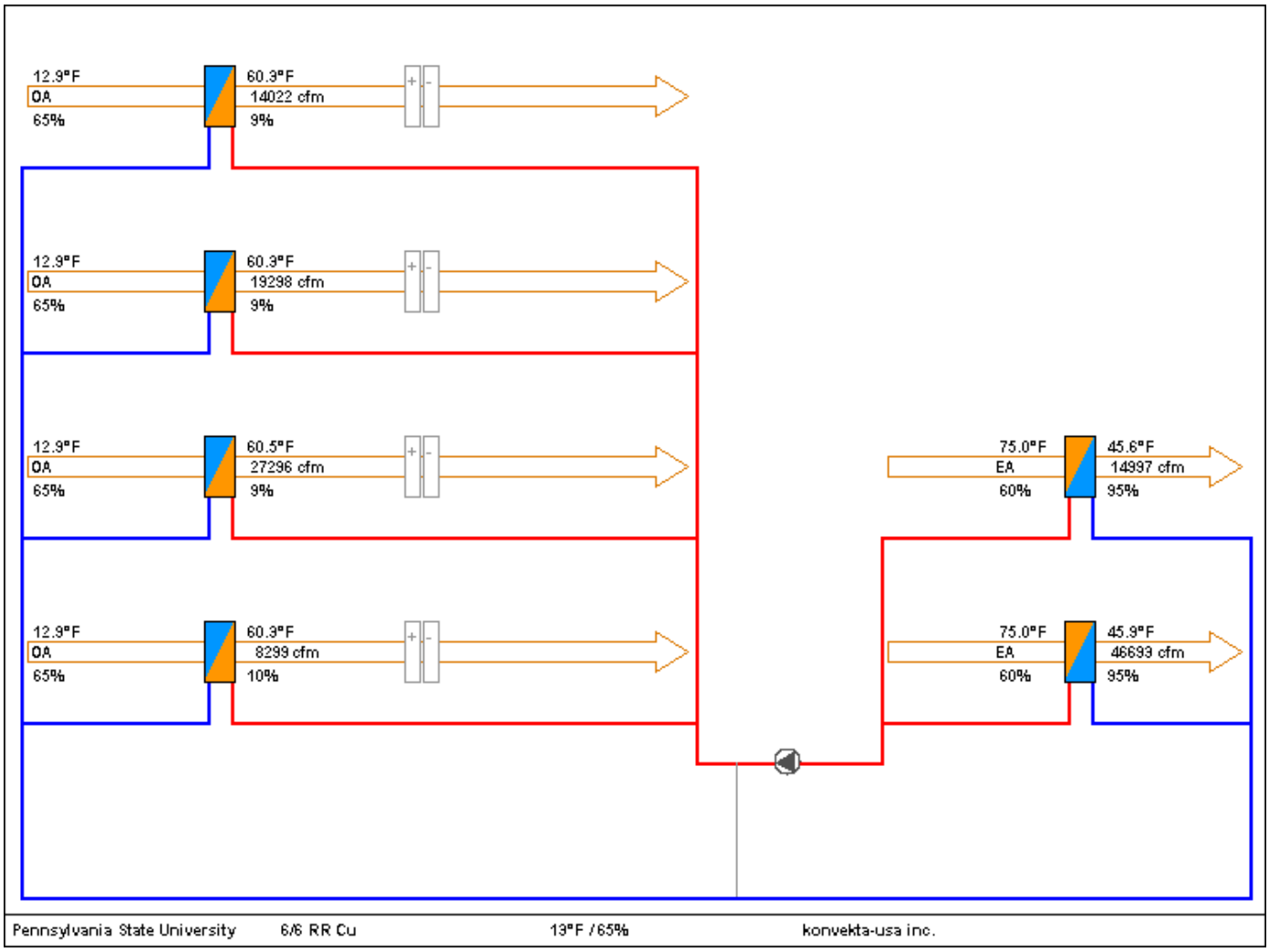

7
6.a
6
5.c
5.b
4
3
Point Displacements
Point Object 41
Story Level STORY2
X
Y
Z
Trans 0.339068 0.401090 -0.323399
Rotn 0.000681 0.002527 0.003729
Lateral Drifts...




Point Displacements
Point Object 3
Story Level STORY3
X
Y
Z
Trans
0.137715
-0.021410
-0.010231
Rotn
0.138387
0.000234
-0.150841
Lateral Drifts...

Date : **8. November 2012**
Site : **Pennsylvania State University**

100% Air Volumes



Economic Summary

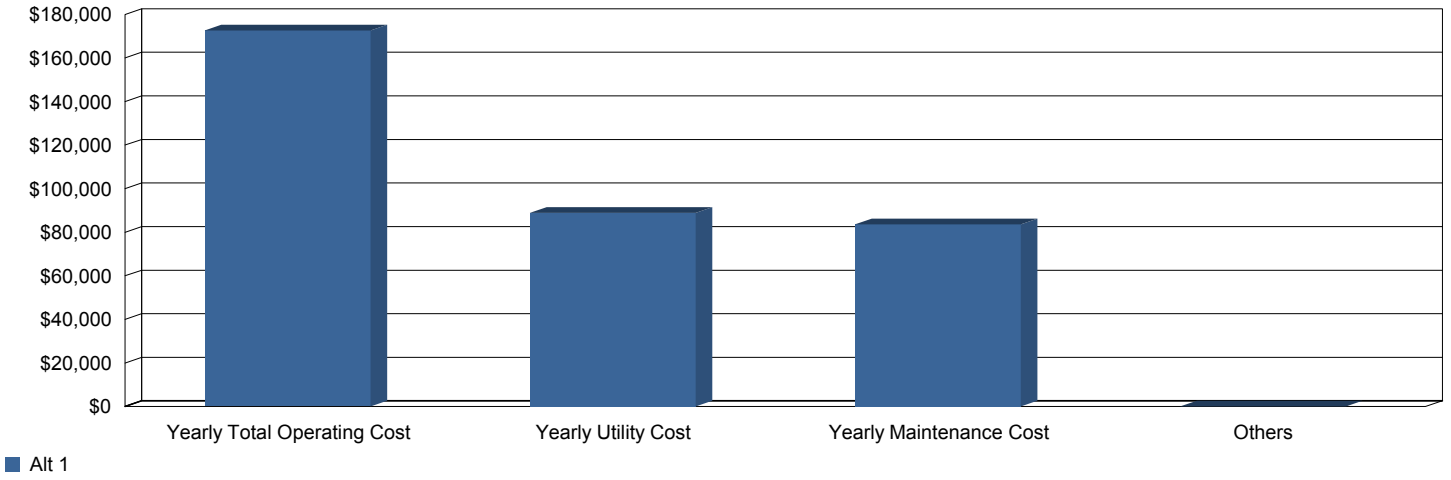
Project Information

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

Economic Comparison of Alternatives

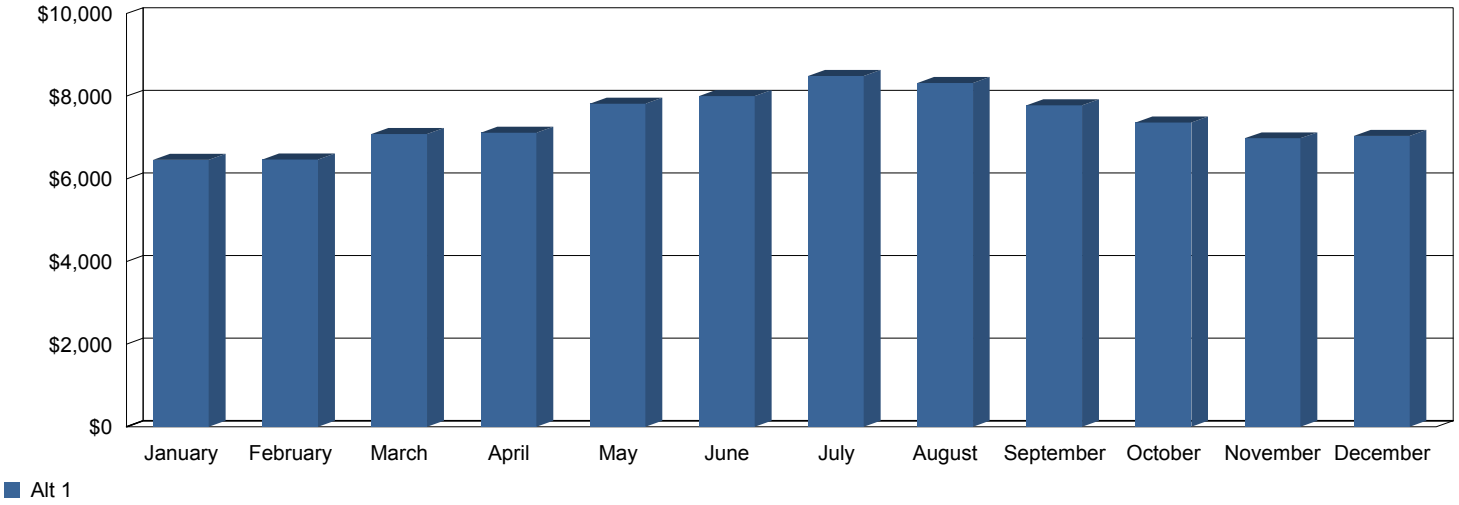
Yearly Savings ($)	First Cost Difference ($)	Cumulative Cash Flow Difference ($)	Simple Payback (yrs.)	Net Present Value ($)	Life Cycle Payback (yrs.)	Internal Rate of Return (%)	Life Cycle Cost

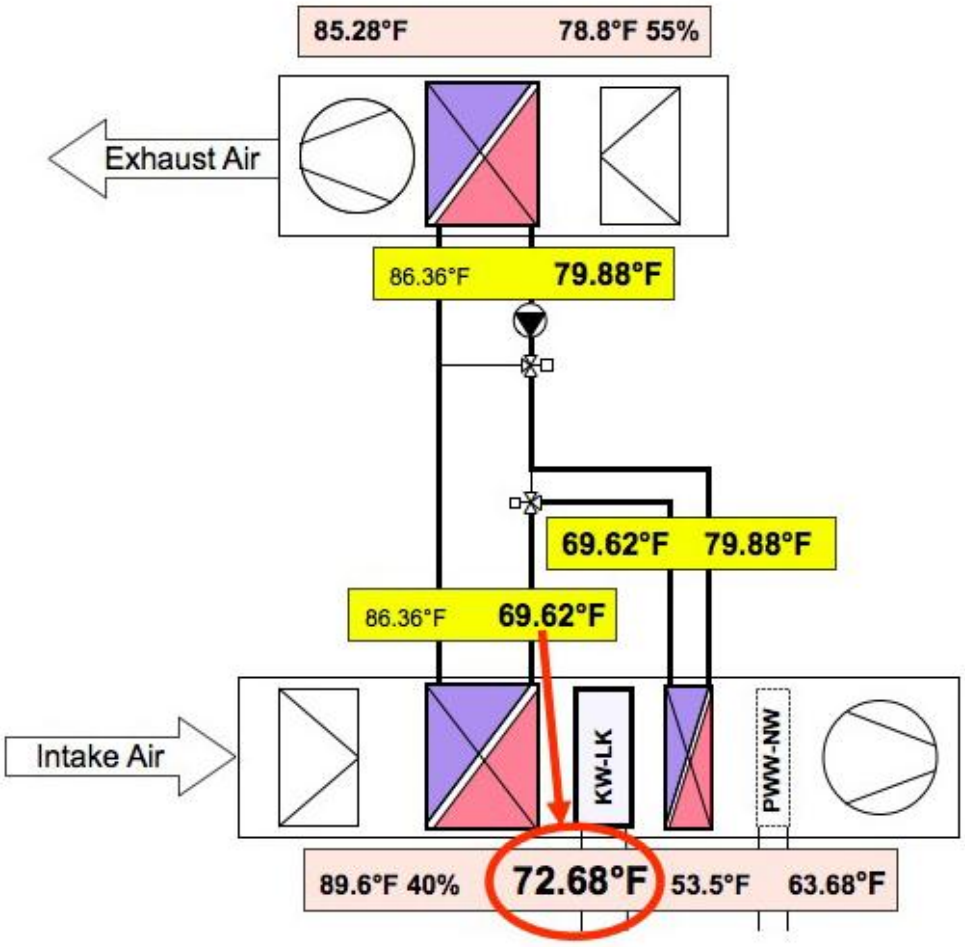
Annual Operating Costs



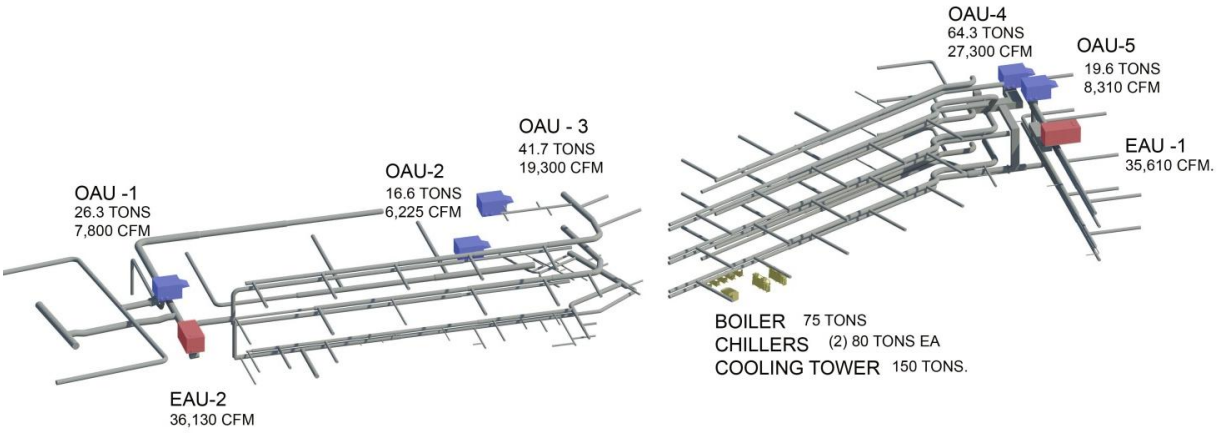
Yearly Total Operating Cost ($)	Yearly Utility Cost ($)	Yearly Maintenance Cost ($)	Plant kWh/ton-hr

Monthly Utility Costs

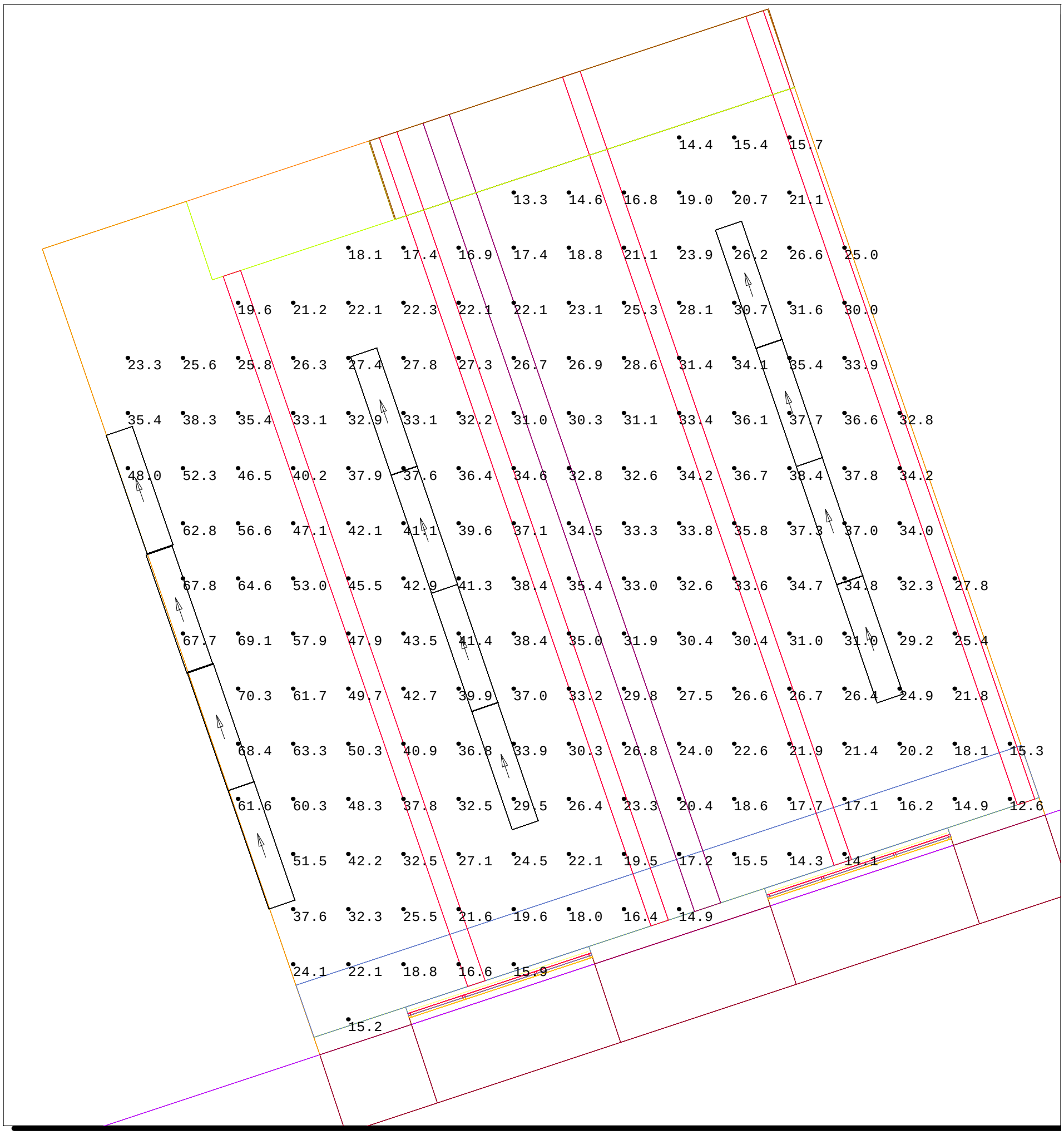




De-humidification Circuit


OAU -1
26.3 TONS
7,800 CFM
OAU-2
16.6 TONS
6,225 CFM
OAU - 3
41.7 TONS
19,300 CFM
EAU-2
36,130 CFM
OAU-4
64.3 TONS
27,300 CFM
OAU-5
19.6 TONS
8,310 CFM
EAU -1
35,610 CFM.
BOILER 75 TONS
CHILLERS (2) 80 TONS EA
COOLING TOWER 150 TONS.

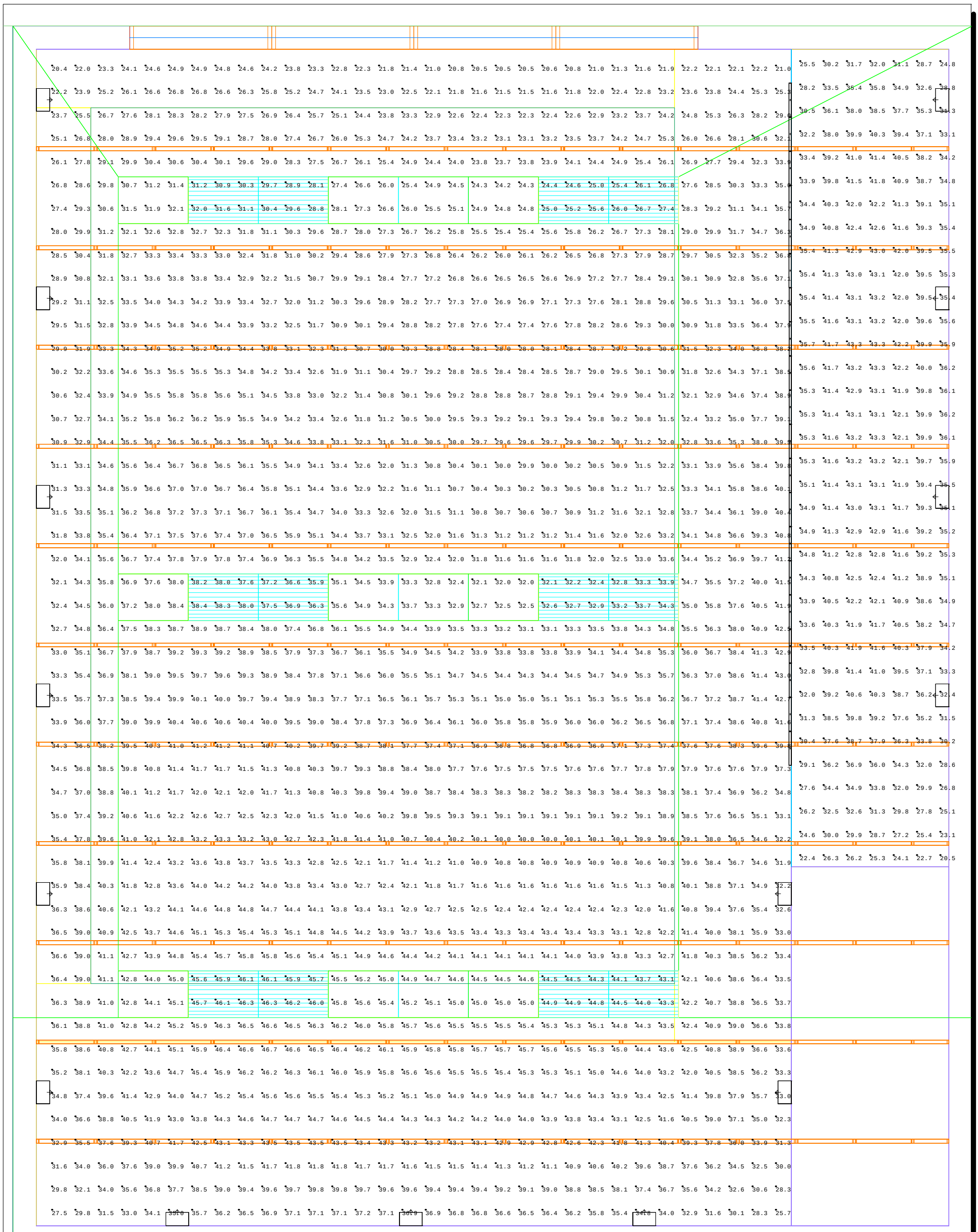
1/16"=1'-0" FIRST FLOOR PLAN



Luminaire Schedule					
Symbol	Qty	Label	Arrangement	Total Lamp Lumens	LLF
	12	SOL-VL-20-80-4-T5-2	SINGLE	5800	0.700

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
CalcPts	Illuminance	Fc	31.81	70.3	12.6	2.52	5.58

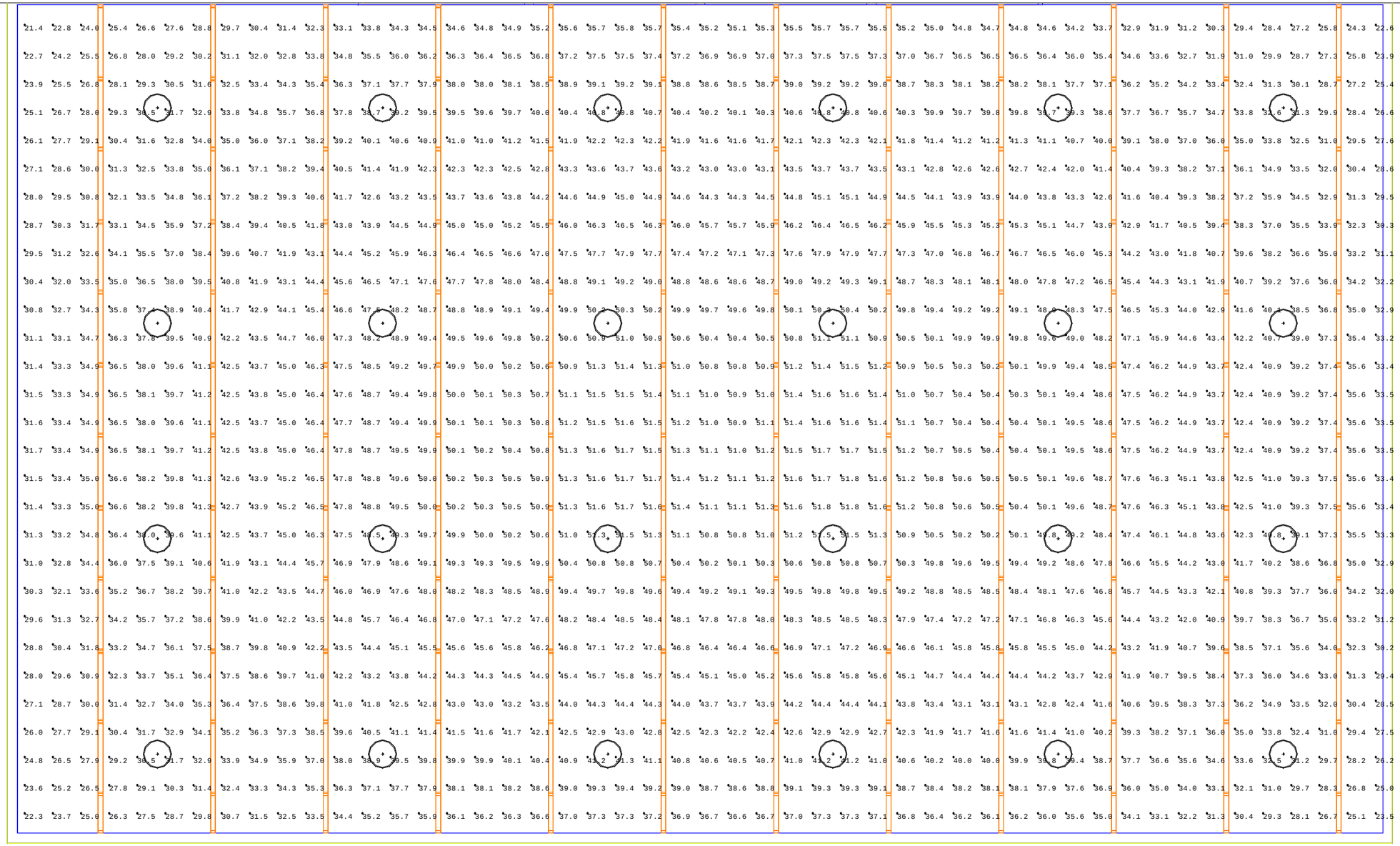
Electric Light Only



Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
CalcPts	Illuminance	Fc	35.55	46.7	20.4	1.74	2.29
CalcPts_1	Illuminance	Fc	37.06	43.3	20.5	1.81	2.11

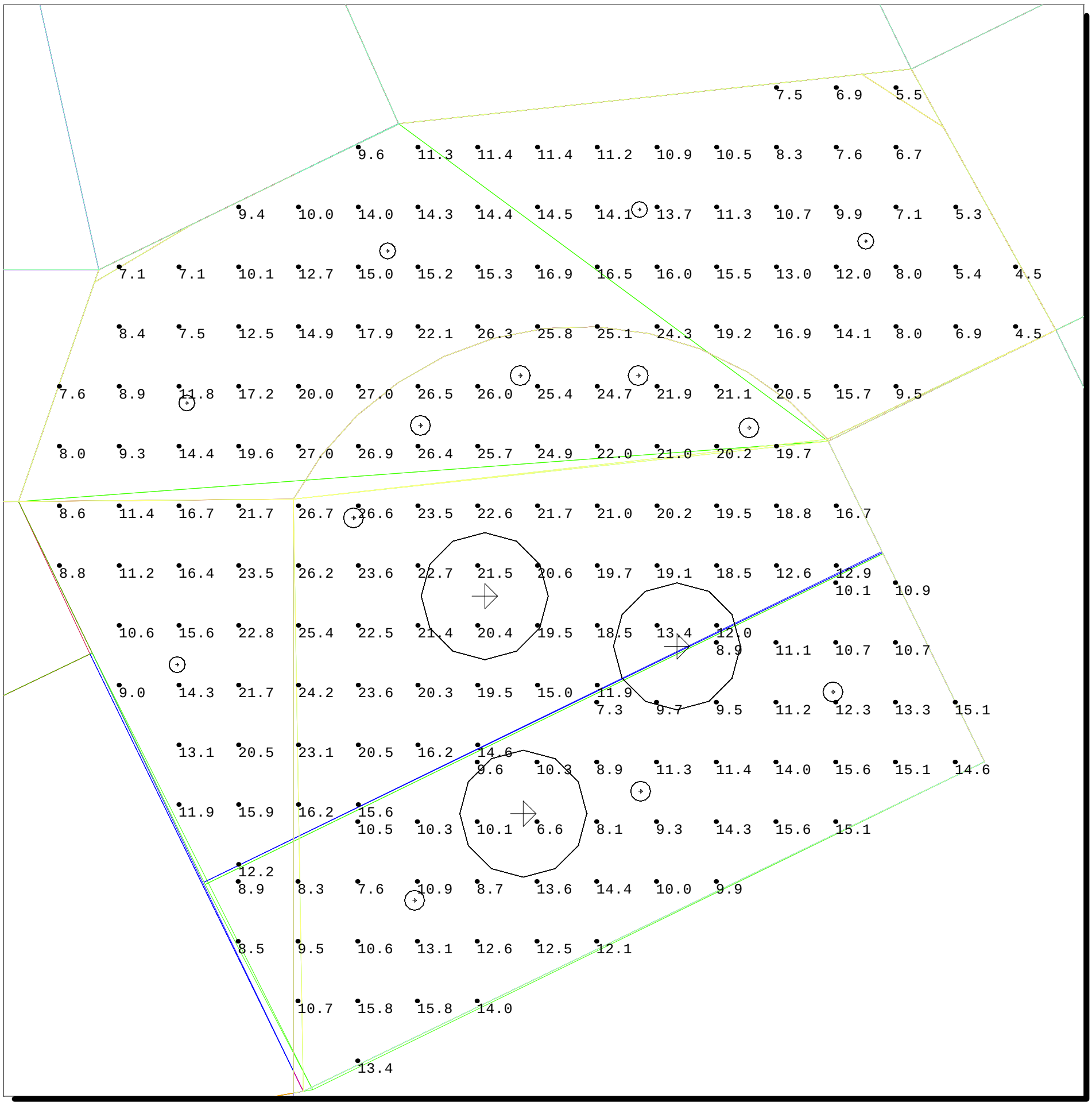
Luminaire Schedule					
Symbol	Qty	Label	Arrangement	Total Lamp Lumens	LLF
	15	M404 2X400W	SINGLE	80000	0.830
	20	M60	SINGLE	1900	0.700

Electric Light Only



Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
CalcPts	Illuminance	Fc	41.18	51.8	21.4	1.92	2.42

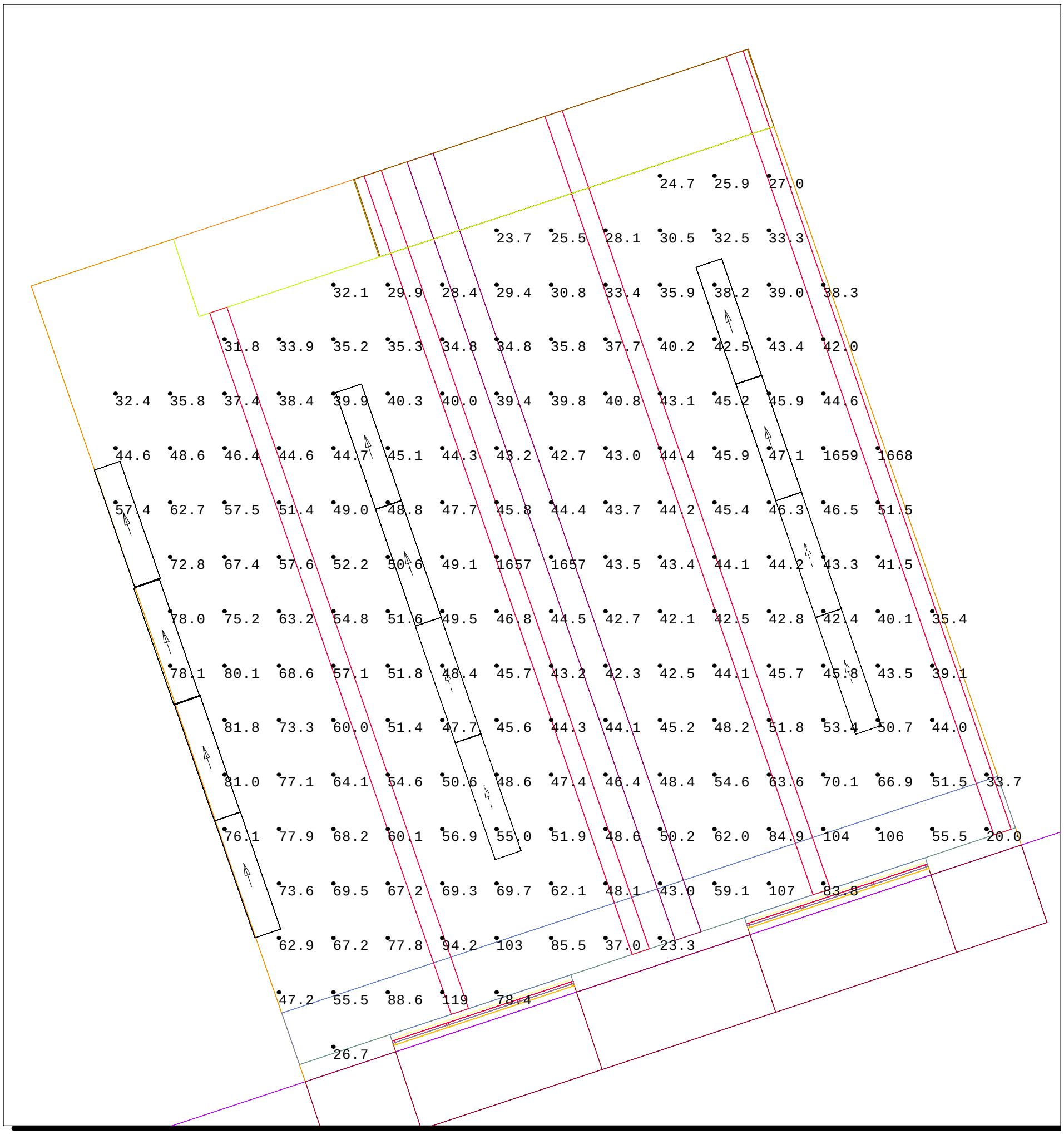
Gym - Electric Light Only



Luminaire Schedule					
Symbol	Qty	Label	Arrangement	Total Lamp Lumens	LLF
⊙	3	B6704_CW	SINGLE	N.A.	0.800
⊙	8	PD8V120-80VC_150PAR38CMH	SINGLE	9100	0.700
⊙	5	PD6V142E-60VC_32TTT	SINGLE	2400	0.700

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
Lobby	Illuminance	Fc	16.11	27.0	4.5	3.58	6.00
Vestibule	Illuminance	Fc	11.39	15.8	6.6	1.73	2.39

Lobby



Luminaire Schedule					
Symbol	Qty	Label	Arrangement	Total Lamp Lumens	LLF
	12	SOL-VL-20-80-4-T5-2	SINGLE	5800	0.700

Calculation Summary							
Label	CalcType	Units	Avg	Max	Min	Avg/Min	Max/Min
CalcPts	Illuminance	Fc	85.10	1668	20.0	4.26	83.41

Daylight and Electric - No Shades December 21