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Sustainability in School Architecture: Learning from Tradition and Modernity

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Sustainability in School Architecture:
Learning from tradition and modernity.

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Table of Contents

Abstract 3

Introduction 4

Hypothesis 6

Methodology 6

Results and Discussion 7

Location Study. 7

Site Design 9

Roof System 16

Wall System. 20

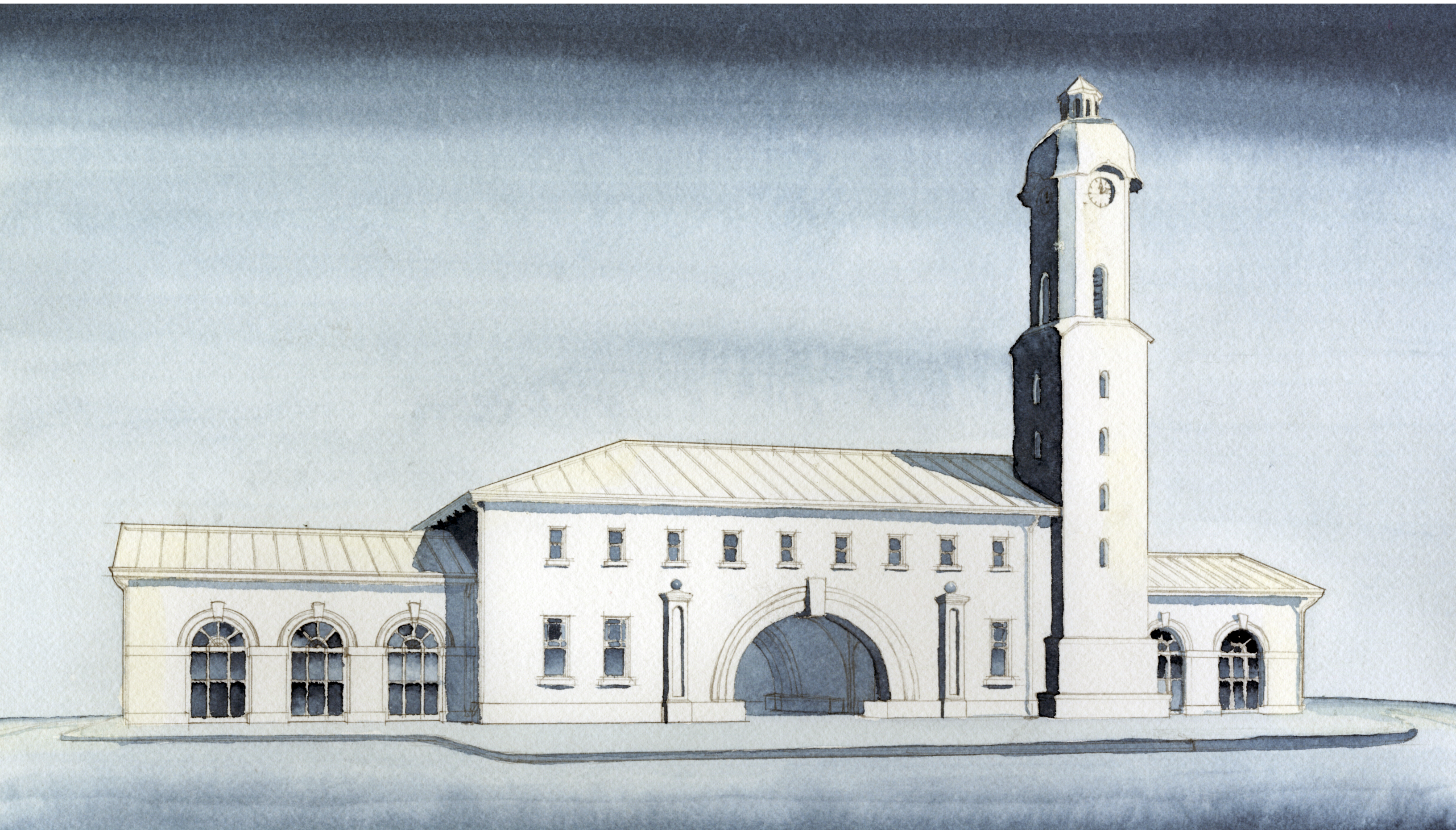
Conclusion 23

Bibliography 24

Acknowledgements 25

Abstract

The terms "sustainability," "sustainable," or "green" are often used to define products or processes that ironically result in limited or negative environmental benefits. Today, our contemporary building construction industry tends to solve environmental performance issues with technological solutions that in some instances have become superficial "green" practices. At times, they lead to counterproductive outcomes and tend to disregard environmental lessons and processes used in the historical building traditions. The best traditional architecture responds to local environmental issues using the generational lessons from the past and present. The goal of this thesis is to identify how the best sustainable building practices found in tradition and modernity can inform the design of a Seventh-day Adventist school in Florida. A school was designed based on the literary review. A computer model was then built of the new design to see how it compared to a LEED certified school.



Introduction

The terms "sustainability," "sustainable," or "green" are often used to define products or processes that ironically result in limited or negative environmental benefits. Stephen Mouzon[1] defines sustainability as "keeping things going in a healthy way, long into an uncertain future; because if it doesn't last, it's not sustainable." Today, our contemporary building construction industry tends to solve environmental performance issues with technological solutions that in some instances have become superficial "green" practices. At times, they lead to counterproductive outcomes that significantly reduce the lifespan of the building. Moreover, common practice tends to disregard environmental lessons and processes used in the historical building tradition.

The best traditional architecture responds to local environmental issues using the generational lessons from the past and present. Contrary to popular belief, traditional architecture evolves as time passes, keeping the best sustainable practices and discarding the ones that do not work. On the other hand, modern common practice tends to rely heavily on the current technological advances without keeping in mind the lessons from tradition. Traditional architecture has proven to be valuable because:

- Traditionally, buildings were constructed using the knowledge passed down through generations in response to climate, using strategies that originate in natural systems rather than relying on mechanical systems and high-tech products.
- These buildings show remarkable reparability. Traditional buildings rely on construction performed on site that is based on humans not automated machines building the entire edifice; therefore, maintenance can be performed on the building without the dependence on a "professional" and his specialized machinery.
- Positive association has been found in terms of likeability, cultural affinity and people's desire to maintain traditional buildings. It is hence desirable, that such positive attributes of traditional buildings be incorporated in future developments of built form.

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[1] *The Original Green*, pp. 15.

- Traditional buildings take advantage of their location. By using the locally available knowledge of building, materials and methods of construction, traditional buildings maximize their efficiency in the areas of skill, materials and methods.

The goal of this thesis was to identify how the best sustainable building practices found in tradition and modernity can inform the design of a Seventh-day Adventist (SdA) school in Florida. By learning from both tradition and modernity, a better way to design and build can be identified to pave a way for others to follow. To begin, a literary review was performed of traditional and modern sustainable building practices. Then, a school was designed using the best practices. Next, a computer model was created to analyze the design at different seasons of the year using Building Information Modeling (BIM) software. Finally, the school design was compared to a current Leadership in Energy and Environmental Design (LEED) certified building using the data obtained from the computer model. At last, this report compiles the findings.

Currently, Architects Engineers and Construction (AEC) professionals use software to simulate data of costs and technological equipment used in energy production. Autodesk, a maker of Building Information Modeling (BIM) software, defines it as an, "Intelligent model–based process that provides insight for creating and managing building and infrastructure projects faster, more economically, and with less environmental impact." Moreover, LEED is a rating system developed by the United States Green Building Council (USGBC) and used in the U.S. as a tool to measure and quantify the environmental performance of buildings.

The school design was based on the senior project of the course ARCH 441-2 Foreground Building Studio. The hypothetical scenario is as follows:

- Project Name: CREATION SdA Educational Campus
- Customer: Seventh-Day Adventist (SdA) church
- Site Location: Celebration, Florida
- Program Requirements: One daycare facility and K-12 campus for 400 Students
- Site Square footage: 348,450 sq ft.

The LEED certified building that was used to compare the school design is called the Learning Gate Community School (LGCS). It is located in Lutz, Florida and is 70 miles away from the project site. This project was chosen because:

- *The school is a LEED certified building.*

  The LGCS achieved a Platinum LEED certification.

- *Availability of published data.*
  The LGCS is featured in the USGBC website as one of the examples of LEED certified buildings and has information on the project, site, architect and owner.
- *Same building type.*
  With similar building types, both being schools, a useful comparison can more easily be made regarding their shape, size, use and location. Since the LGCS is significantly smaller than the SdA school, there will be some differences due to the size of the project.
- *The school is within 150 miles from the project site.*
  The distance between SdA project and the LGCS site matters because they will experience the same weather.

Since the project is large in scale, this thesis will focus in three specific areas of the design:

1. Site design.
2. Roof system.
3. Wall system.

Hypothesis

The environmental performance of modern and future buildings can be significantly enhanced using the timeless knowledge found in tradition along with modern practices and innovations.

Methodology

The research will involve the following stages:

A. A detailed literature review of responses to environmental issues found in historical traditional buildings that outlines:
   a. Best practices.
   b. Significant data.
   c. Arguments for/against.

B. A detailed literature review of responses to environmental issues found in common modern buildings that outlines:
   a. Best practices.
   b. Significant data.
   c. Arguments for/against.

C. Interviews with professionals and researchers in the construction and sustainability disciplines.
D. Testing of the hypothesis.
   a. First, to design a school (Celebration SdA Campus) based on the best traditional and contemporary practices available today.
   b. Second, analyze the school design using BIM software.
   c. Finally, compare the design to a contemporary project that has been LEED certified.

Results and Discussion

LOCATION STUDY.

The project's site is located in the center of Florida. It is a region in the U.S. that experiences brief cool winter periods. The summers, on the other hand, are very long, hot and humid; therefore, the region is identified as a cooling zone – meaning that there are more hot days during the year than cold and the main challenge for the designer is to cool the building down to a comfortable level. Humidity arises from the mixture of high temperature and a high water table (between 3-4' below grade[2]) that decreases the outdoor comfort level. The main danger of the presence of high humidity comes from the development of mold and mildew either to the exterior of the envelope[3], easily treated, or within the envelope itself, usually requires replacement of components. However, much of the region benefits from its proximity to the coast and the reliable sea breezes that have been proven to be the strongest during the day, weaker at night, and nonexistent in the morning. (Lechner)

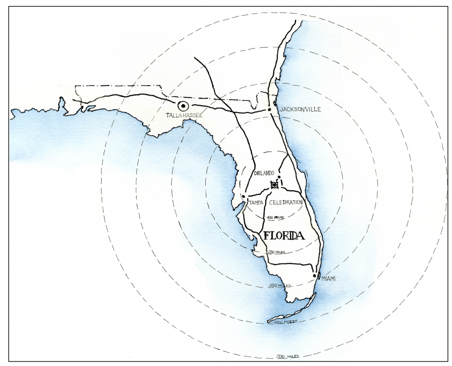


Figure 1: Regional Map

To take advantage of the abundant sun energy of this region, a solar study was conducted to identify the sun's path, angle, and position throughout the year. In

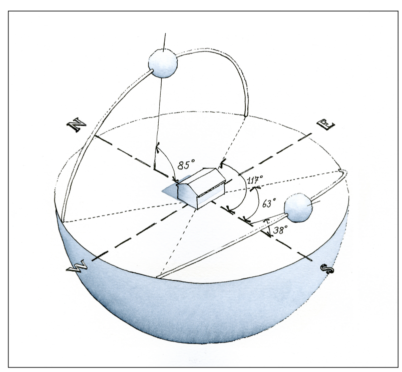


Figure 2: Sky Dome Study

[2] Information gathered from the Soil's report performed by Nodarse.

[3] The building envelope is the layer of a building that separates the exterior from the interior.

figure 2, the upper sun path represents summer solstice. At the peak of the season, the angle of the sun will reach 85º, which is almost perpendicular to the ground. On the other hand, the lower sun path represents the winter solstice. At its climax the sun's angle will be 38º. With this information, shadow studies can be performed to determine how much sunlight will be lost/gained in specific areas of the project as the result of the building form. In addition, the critical lengths and locations of shading devices and spaces can be determined and the design adjusted depending on the desired efficiency target.

Another key weather factor is hurricane season, occurring from June 1 to November 30. The Florida Building Code advises that buildings in this region be designed to withstand 140mph winds, but requires buildings to be designed to withstand 120mph winds. Although hurricane season only lasts for a few months, it brings significantly high precipitation levels averaging 60in per year.[4]

As mentioned earlier, the site's water table is high. The data obtained from the site's survey company, Nodarse, shows that the average yearly water table level is 4'(below grade) for the region. However, when the survey was performed, the level was measured at 3' (below grade). With the water table being this high, special attention needs to be placed when designing the foundation to counter capillary action. Capillary action is the process in which water travels vertically in a fine porous material. To counter this effect, a layer of gravel (4" to 6" minimum) is placed directly above the excavated area.

Table 1: Annual Design Conditions

Threshold	Cooling		Heating	
	Dry Bulb (ºF)	Wet Bulb (ºF)	Dry Bulb (ºF)	Wet Bulb (ºF)
0.1%	93.2	74.5	35.2	34.7
0.2%	92.5	74.6	37.8	35.4
0.4%	92.1	74.7	39.4	35.7
0.5%	91.9	75.1	39.9	35.7
1%	91.0	75.6	41.9	39.5
2%	90.0	75.3	44.4	42.3
2.5%	89.4	75.4	45.5	43.0
5%	88.0	75.1	49.5	46.5

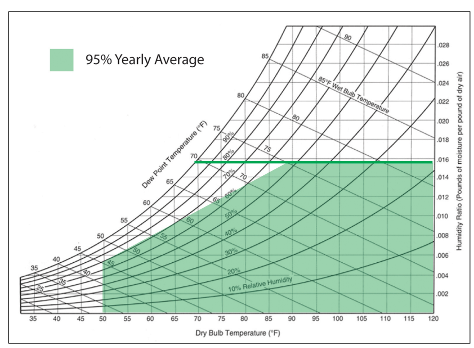


Figure 3: Dew Point Study

Due to the high levels of heat and humidity, it is imperative to study the dew-point for the site. The data for this study was taken from the Green Building Studio (BIM Software) analysis performed on March 26, 2012. According to Florida

[4] Data according to climate region 14 in *Heating, Cooling, Lighting.*

International University, building temperature should be set at 75ºF. Figure 3 shows the most extreme temperature situations (plotted from table 1). The dew point is around 70ºF. This means that if the temperature of the building is maintained around 75ºF, condensation will not occur.

The value of the dew point analysis is that it shows at what interior temperatures water particles will form. If an interior temperature can be established, it will reduce the possibility of condensation. As a result, there will be a reduction in the probability of mold, mildew, interior humidity, and water damage to the roof, wall and floor systems. By being aware of the moisture levels, proper action can be taken to protect building assemblies from moisture.

Thermal control in the envelope is also important. A study done by the Florida Solar Energy Center[5] points out that the most important factors to achieve actual zero energy consumption in homes are a tight envelope and high insulating values for the walls and roof. The study looks at two methods of construction, the Zero Energy Homes (ZEH) and the Passivhaus. Although both methods incorporate high insulating values and tight envelopes, each achieve their outcomes in different ways. The ZEH relies heavily on new technologies and photovoltaic systems. On the other hand, the Passivhaus looks to passive methods, i.e. thicker walls, tall ceilings, etc. Either way, these superinsulated examples typically have roofs rated at R60, walls rated at R30 and floors rated at R20. (Parker)

Site Design

The site's layout, planting, and building form are part of the design. Site design is the first and critical step in determining the outcome of a building; in our case, a sustainable building. The site's layout deals with the orientation, organization, and intermediate distance between parts. The planting design can include managing the existing vegetation and proposing new landscaping, both of which will have an effect on the biodiversity of the site. Finally, the building's form and orientation will determine how it will be affected by external weather factors.

Sustainable practices found in literature.

Layout

1. *Long axis of buildings should be from east to west.(traditional)*

Orienting the building's long axis east to west will take advantage of the sun's

[5] *Very Low Energy Homes in the United States: Perspectives on Performance from Measured Data* by Danny S. Parker.

path and create opportunities to place most of the windows facing south. This allows natural lighting to be used efficiently. This is an ancient traditional practice that was used to capture the sun's energy during the day for heating and lighting.

2. *Site and orient the buildings to capture the prevailing winds.(traditional)*
   The arrangement of buildings may significantly reduce the amount circulation throughout the site. If buildings are properly arranged, good air circulation can occur, leading to increased thermal comfort of outside spaces. Evidence of this practice is evident in ancient writings such as from Vitruvius,[6] where he advises the layout of streets to capture prevailing winds.
3. *Have neighboring buildings shade each other.(traditional)*
   When buildings are close to each other (narrow alleys), depending on the season and building height, they will shade each other. This has an effect that reduces the temperature on the ground and when breezes pass through adds to the comfort level of pedestrians. Evidence of this practice is visible in medieval urbanism, where buildings are separated by narrow alleys.

Planting

4. *Preserve the natural site elements as much as possible.(modern)*
   By preserving and zoning areas that will not be touched during construction, allows for native plants and animals to survive and maintain their way of life. This practice has gained popularity in recent years to help conserve natives species.
5. *Incorporate native plants as much as possible.(traditional)*
   Using native plants in the site allows for biodiversity to occur and have a higher level of assurance that will survive without the additional expense of irrigation systems. Moreover, native plants minimizes the need for fertilizers and pesticides and increases water conservation. The use of native plants was prevalent before potable water became available. After it became available, the use of other plants (that require more water) became possible becoming a problem that requires exponential amounts of water.
6. *Provide open space to serve as habitat and promote natural biodiversity. (modern)*
   Providing open space with the landscaping will promote higher biodiversity, because birds, insects and animals will have ample space to survive. Since our

[6] *Ten books on architecture*, written in around 20 BC.

current building culture has encroached into undeveloped land, this practice aims to restore some of that land back, and is being promoted through LEED credits.

7. *Use Trees that have high canopies. (traditional)*
   Because of high humidity levels, high canopy trees are preferred. The high branches shade the ground and as air moves through it, the thermal comfort is increased.
8. *Use plants for shading. (traditional)*
   In certain occasions, it is economically feasible to plant a tree to provide shade rather than to make an entire addition to the building. Since trees in Florida do not loose their leaves during the winter months, using trees as shading devices may reduce the cost on the overall project.

Building.

9. *Use the building to shade itself. (traditional)*
   Courtyards, loggias, colonnades, and balconies are examples of the building shading itself. They are spaces within the building that are shaded, thus reducing the outside temperature and creating comfortable outdoor areas that promote people to be outdoors.

Implementation of sustainable practices.

1. The placement of the buildings follows the east to west axis. Although some buildings are oriented north/south, they are either responding to the main roadway or are part the four courtyard design.
2. The buildings are separated by narrow 14' wide alleys, that channel and allow air to circulate through the courtyards.
3. Since buildings are very close to each other, their shadow reduces the temperature of the wall and ground.
4. The majority of the native plants located near the boundary (where most of the older trees are located) were kept and in the central courtyard, the three older oak trees were used as part of the landscaping.
5. The four courtyards use native high canopied trees (Stoppers, *Eugenia spp.*) that may reach a height of 30 feet, tolerate high levels of salt in the water, do not require irrigation, and promote wildlife diversity.
6. The shaded playing space will be lined with Gumbo Limbo (*Bursera* simaruba) trees that promote biodiversity in birds as well as insects, specially migrating butterflies.

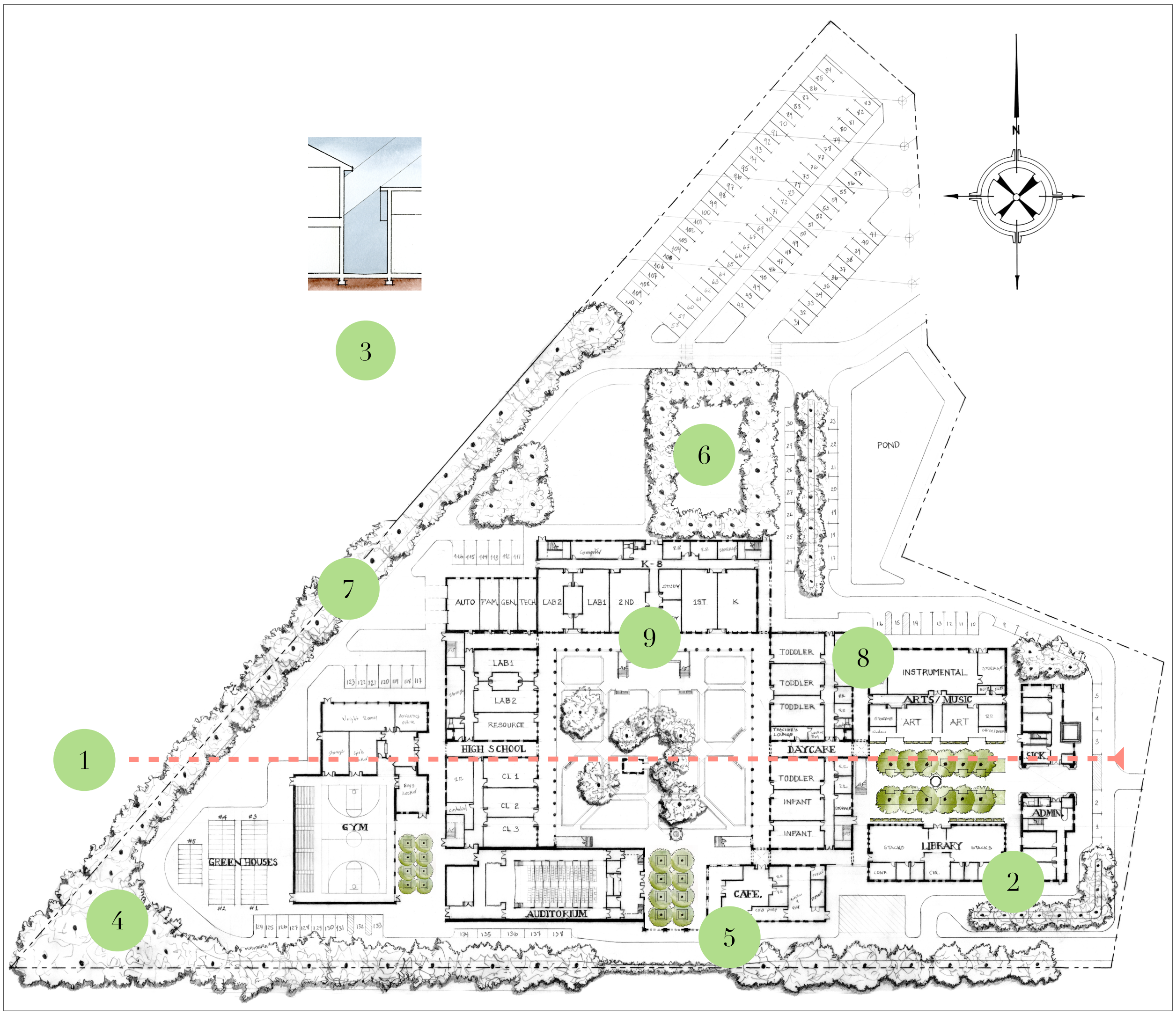


Figure 4: Proposed Site Pan

7. Yellow Pines are to be planted along the property line to provide the first line of protection against highway pollution (noise, trash, etc.). Stoppers and Gumbo Limbo trees also have high canopies where people can move underneath them.
8. The four courtyards use trees to provide shade. Figure 5 shows the amount of shadow that can be expected from winter solstice to summer solstice. The amount of shadow will depend on the tree's height and the canopy's width. At the base, seating areas can be provided that serve as benches and retaining walls for the tree's roots. Instead of building a structure, planted trees are used to create occupiable space, thus reducing the

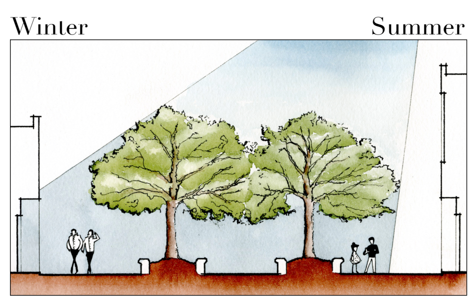


Figure 5: Courtyard Study

price on the project.

9. The educational facility has a two floor colonnade that wraps around the interior of the classrooms. This colonnade provides protection from the sun during the summer months and allows the sun to warm up the area during the winter months. Four courtyards, lined with trees, protect pedestrians from the sun and allow air to circulate underneath their canopy.

What results can be drawn from the BIM model?

Using Vasari[7], a wind simulation can be performed utilizing the wind data of the region. Figure 6, shows a yearly wind diagram of the town of Celebration, which shows that strongest winds come from the Atlantic coast due East-NNE, and from the Gulf coast are the West-WNW. This information will be used in the wind simulation to see the effects of the wind on the geometry of the buildings. Once the simulations are complete, decisions can be made on the placement of trees or a change in the geometry of the building to respond to the wind effect.

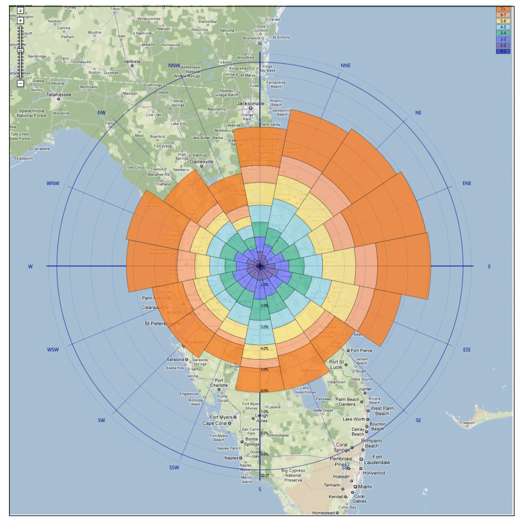
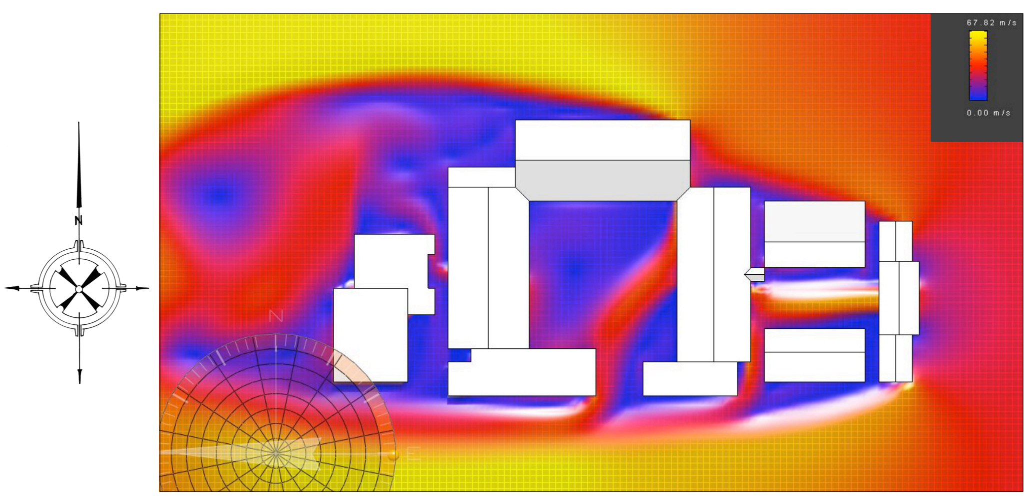


Figure 6: Wind Rose Diagram

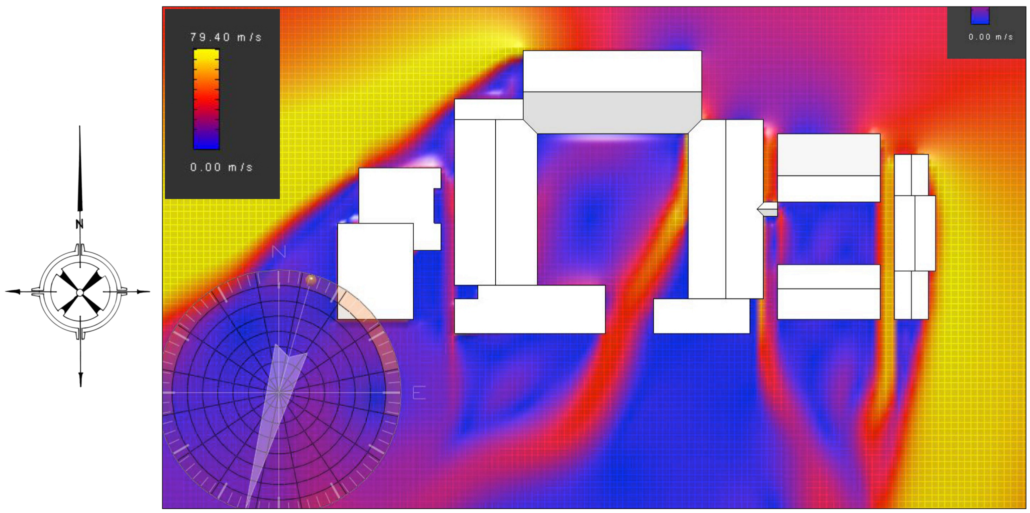
Simulation 1, shows that as air passes from east to west, the most extreme air velocities are on the north and south of the arrangement. Air is able to circulate through the school's main entrance, and the main courtyard does have air circulation.



Simulation 1: Wind from East to West

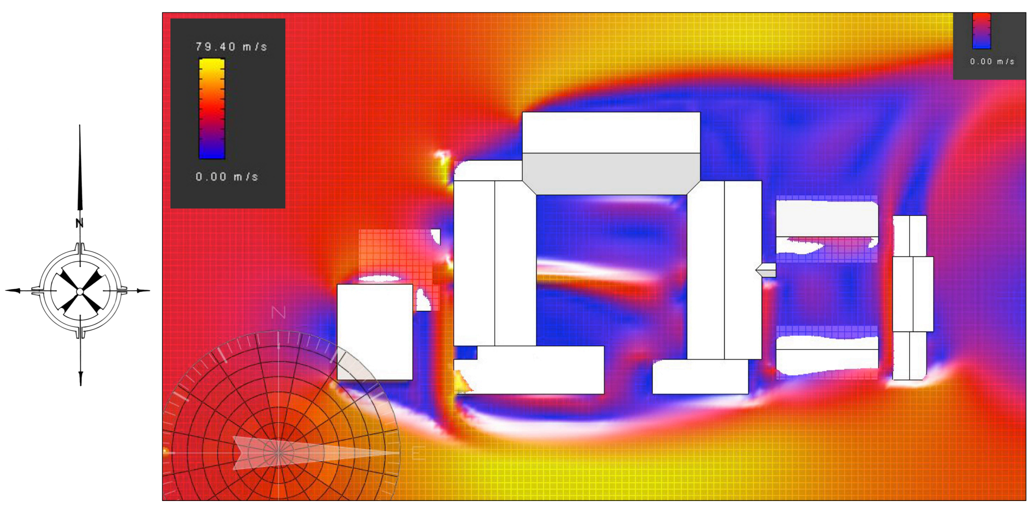
[7] Vasari v.2.5, Autodesk Program.

Simulation 2, shows that the highest air velocities will be found on the east and north-west. As air moves through the buildings the narrow alleys channel the air through the complex.



Simulation 2: Wind from North-North-East to South-South-West

Simulation 3, shows that as air moves from west to east, most of the air gets divided to the north and south. The remaining air is channeled into the main courtyard. The alleys are shown to direct the airflow through them not allowing the air to remain in one place.



Simulation 3: Wind from West to East

How does it compare to the LEED project?

Figure 7: Aerial Photo of Learning Gate Community School

The Learning Gate Community School (LGCS) is broken down into tree parallel buildings going from east to west. It is connected by covered elevated walkways and the construction of the project was done with minimal disturbance to the site.

The similarities are as follows:

1. *Buildings face south. (traditional)*
2. *Buildings are connected by narrow walkways. (traditional)*
3. *Most of the native vegetation was not disturbed. (modern)*

The differences are as follows:

1. *All buildings are elevated. (traditional)*

   This practice has been used in cooling regions to allow the air to flow underneath the building.
2. *The covered areas use glass to shade. (modern)*

   This practice is only possible in modern time with the development of glass coatings that prevent solar radiation to occur.
3. *The buildings are narrow and their longest side face east/west. (traditional)*

What results can be drawn from the comparison?

Although the LGCS is smaller than the SdA school, the main concepts of sustainability are still present in both designs. While the main difference between the two buildings lies in that the LGCS is raised off the ground and the SdA school is not, the cost of raising the building would not have justified the end result. This is a direct example that the building's size affects major approaches to construction. Since the LGCS buildings are small enough, they are able to raise them off the ground, allowing for passive ventilation to occur. Another difference that has to be pointed out is the use of glass to cover a walkway instead of using plants or a colonnade. While glass may be able to reflect the sun's radiation and perform as it is supposed to, the amount of embodied energy that it takes to manufacture the glass and its protective layers is significantly higher than if traditional building methods were used to shade the elevated walkways. The site seems to be arranged to allow for good air ventilation. Moreover, since the longest side of the building runs from east to west, the LGCS is able to capture the prevailing winds of the region. The courtyards are important on the SdA and LGCS because they create pleasant outdoor spaces where people are able to occupy and are drawn to them due to their comfort level.

ROOF SYSTEM

The roof is what protects the building from the weather, wind, storms, etc. For the roof to endure the elements of nature, careful thought must be placed on the design, structure, and materials.

Sustainable practices found in literature.

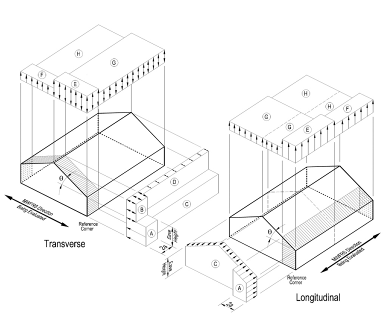
1. *Use proper roof pitch for the region. (traditional)*
   Selection of an adequate roof pitch may help the roof not get blown away by heavy winds during hurricane season. Traditionally, hurricane prone areas have relied on roof pitches of 6/12 through 8/12 because as the air passes over a roof, it pushes down creating a downforce on the roof instead of an uplift.
2. *Use eaves. (traditional)*
   Shedding the water away from the building is the immediate task of the eave. In the region, an eave may be as wide as three feet; any longer and it would need to be engineered to withstand hurricane winds. Other purposes include protecting the walls and pedestrians, and providing shade for the wall.
3. *Ventilate roof. (traditional)*
   Good air circulation within a roof reduces solar heat gain. In open attic spaces, vent areas should be distributed along the perimeter of the roof. The roof's ridge should also have areas where hot air can escape.(Lstiburek and Carmody)
4. *Prevent indoor air leakage. (modern)*
   The connection between the roof and the wall needs to be detailed to minimize, if not eliminate, air leakage from the interior spaces. By reducing the amount of air that escapes the building, it reduces the amount of conditioned air that needs to be replaced.

5. *Use light color roof finish. (traditional)*

   The use of light reflective color finishes are preferred, because they tend to reflect more light than the darker colors thus, reducing heat absorption.

   Implementation of sustainable practices.

Although the Florida Building Code requires one to design for 120mph wind, the SdA school will be designed for 140mph winds, because it will give the structure a greater chance to last longer.



Main Wind Force Resisting System – Method 1 | **h ≤ 60 ft.**

Figure 6-2 (cont'd) | **Design Wind Pressures** | **Walls & Roofs**

Enclosed Buildings

Simplified Design Wind Pressure, p_{s30} (psf) *(Exposure B at h = 30 ft., K_{zt} = 1.0, with I = 1.0)*

Basic Wind Speed (mph)	Roof Angle (degrees)	Load Case	Zones									
			Horizontal Pressures				Vertical Pressures				Overhangs	
			A	B	C	D	E	F	G	H	EOH	GOH
140	0 to 5°	1	31.1	-16.1	20.6	-9.6	-37.3	-21.2	-26.0	-16.4	-52.3	-40.9
	10°	1	35.1	-14.5	23.3	-8.5	-37.3	-22.8	-26.0	-17.5	-52.3	-40.9
	15°	1	39.0	-12.9	26.0	-7.4	-37.3	-24.4	-26.0	-18.6	-52.3	-40.9
	20°	1	43.0	-11.4	28.7	-6.3	-37.3	-26.0	-26.0	-19.7	-52.3	-40.9
	25°	1	39.0	6.3	28.2	6.4	-17.3	-23.6	-12.5	-19.0	-32.3	-27.5
		2 [4]	-------	-------	-------	-------	-6.6	-12.8	-1.8	-8.2	-------	-------
	30 to 45	1	35.0	23.9	27.8	19.1	2.7	-21.2	0.9	-18.2	-12.3	-14.0
		2 [4]	35.0	23.9	27.8	19.1	13.4	-10.5	11.7	-7.5	-12.3	-14.0

Table 2: Design Loads, ASCE 7

1. The educational facility uses a roof pitch of 6/12 (27º), because it is the lowest angle that gets close to a neutral uplift factor (using the ASCE 7 guidelines). Wind factors can be calculated in the search of an efficient roof angle. Table 2 points out that as the angle changes from 25º to 30º-45º the pressure on the roof moves from uplift to downforce.
2. All buildings have 2'-6" eaves on all sides. An eave shadow study was conducted and showed that a 2'-6" worked well for shading and protection from rain. Figure 8 shows that at the most extreme angle during the summer solstice, the eave aids the wall system in reducing the heat absorption. It also provides a shaded path for pedestrians to use.

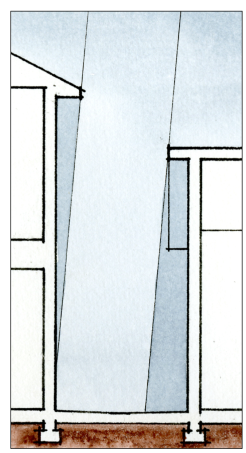


Figure 8: Eave Study

3. The location for the ventilation of the roof can be found at two locations the eaves and the roof's ridge. Since the roof is constructed out of metal, the ridge openings are located at the interlocking layers where the sides meet. Roof vents are also located underneath the eave and are evenly spaced throughout the roof system.

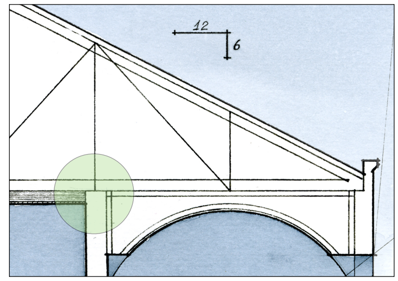
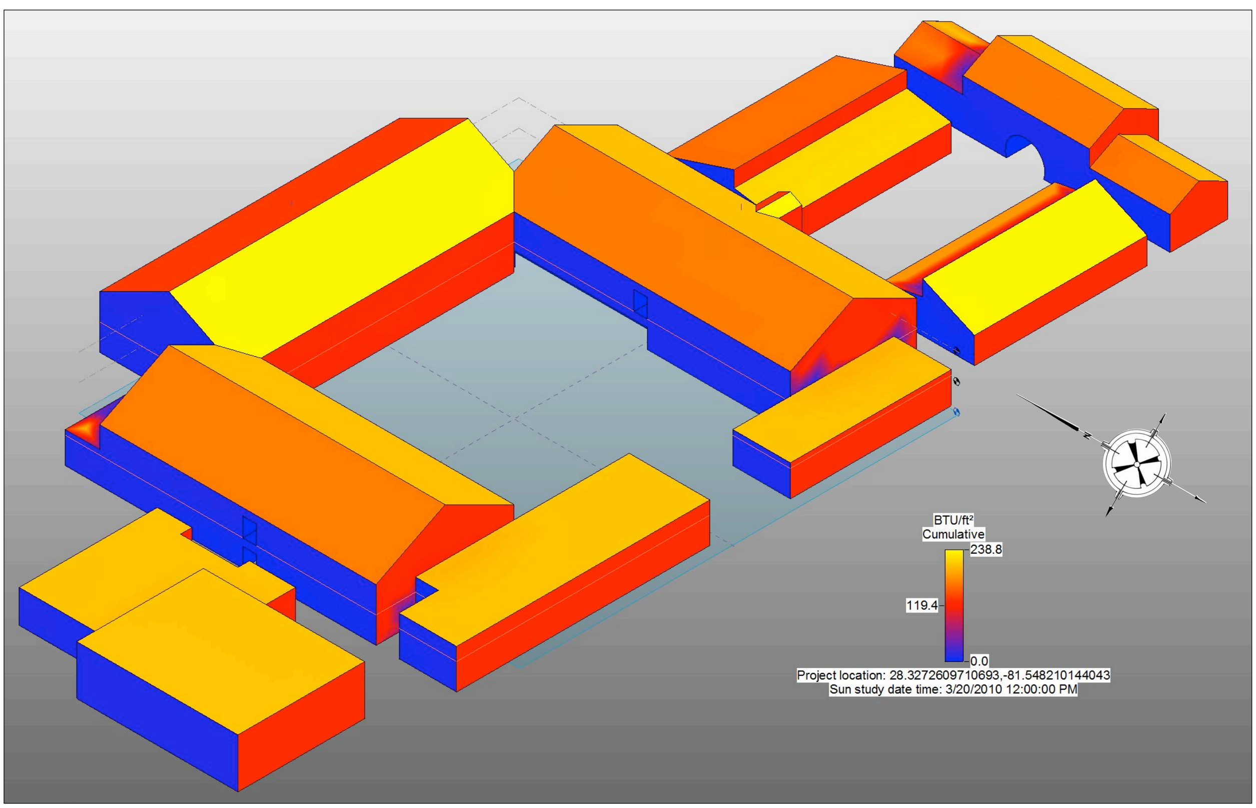


Figure 9: Roof Connection to Wall

4. To prevent the probability of air leakage, the insulation and interior finish will be placed under the roof trusses. At the same time, a flexible sealant will be used in all joints to allow for contraction and expansion of the components while maintaining a tight envelope. Figure 9, shows the roof-to-wall connection and the placement for the insulation.
5. The roof will be constructed out of metal and will have the profile of a five v crimp. The final finish will be light in color to reflect the sun's radiation.

What results can be drawn from the BIM model?

A Vasari simulation was conducted using yearly weather data of the region. Simulation 4, shows that the roof with the highest absorbed temperature (bright yellow) are the ones that face south at an angle. Moreover, these are the roofs that work best for the location of photovoltaic systems (solar panels). The medium temperature (orange) roofs are the ones that face east to west and are flat roofs. Finally, the low temperature (Red) roofs are those the face away from the south.



Simulation 4: Roof Heat Study

How does it compare to the LEED project?

The LGCS was constructed using pre-fabricated modules and shipped to the site. The roof has an insulating value of R-30, which ranks about midrange in comparison to Zero Energy Homes mentioned earlier in this study.

The similarities are as follows:

1. *The construction of the buildings reduces the possibility for air leakage. (modern)*
   The prefabricated panels use connections that reduce air leakage due to tight fittings, flexible sealants, and spray foams.
2. *The roof's finish is white.(traditional)*
   The white roof reflects the majority of heat from the sun.

The differences are as follows:

1. *Minimal eave.(modern)*
   The roof has a minimal roof length design that is a product of a prefabricated structure.
2. *The roof's pitch is 2/12. (modern)*
   Roof pitch is well below the recommended pitch for the region. The design has to compensate in the structure to be able to withstand hurricane winds.

What results can be drawn from the comparison?

The main difference between the two designs is the roof pitch. Using a flat roof does not mean that it is a bad design. It just means that there will be greater stress on the structure during hurricane season that may decrease the life of the building. The lack of an eave in the LGCS means that the walls will be exposed to the elements, increasing their maintenance. In creating sustainable buildings, we are reminded to design them to last. Therefore, using a roof pitch that will reduce the amount of pressure on the structure, and using an eave will help the building last longer. Another factor to keep in mind is the higher cost of glass, used for shading devises, compared to economical natural alternatives such as trees. Using the Vasari simulations as an example, the LGCS roof can be expected to be at a midrange temperature. Nevertheless, using hip roofs (SdA buildings) will balance the temperature, because one side will have significant lower temperatures.

WALL SYSTEM.

The wall system is the vertical protective layer of the building that is in direct contact with the forces of nature. It is supported by the foundation system and supports the roof. A study was conducted on the different wall systems available today. The Autoclaved Aerated Concrete (AAC) construction was chosen, because it accomplishes the structural aspect within one system, as well as the insulation, sound proofing, and fire safety. The critical factors of wall design in the region is how it deals with rain penetration, rain absorption, air movement, and vapor diffusion. Other factors include the type of windows used to ventilate the interior and the exterior finish.

AAC Construction Study.

AAC was first patented in 1924 by a Swedish architect named Johan Axel Eriksson. It is a highly cellular, lightweight material made up of quartzite sand, lime, and water. These ingredients are processed with cement and a rising agent that generates large amounts of pores. AERCON, maker of AAC says, "It is precisely these pores, in addition to the solid structure of calcium silica hydrates, which give AAC its exceptional product properties: fire resistance/non-combustable, superior thermal insulation, excellent acoustical insulation, lightweight, termite and pest resistance, ease of workability and handling, universal application, non-allergenic, and efficient construction." (AERCON 3) When AAC was tested by the Underwriters Laboratories (UL), it received the highest UL fire ratings in the industry. Therefore, the product was categorized as "non-combustable," and neither toxins or gases were emitted when exposed to fire. AAC's thermal performance reduces, if not eliminates, the need for insulation and has low heat transfer rates. The porous structure of AAC reduces significantly the transmission of sound without the need of additional layers of other materials. This is especially helpful when used in schools because classrooms are right next to each other. In addition, the low density of AAC walls work well in humid climates because they will not overheat due to the constant high temperatures

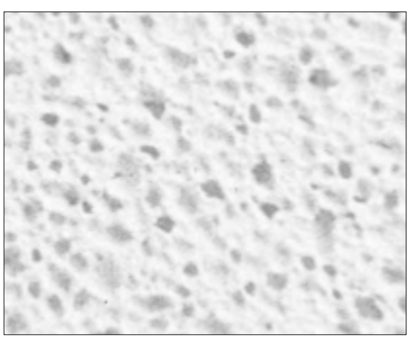


Figure 10: Magnified View of AAC

Sustainable practices found in literature.

1. *Use an exterior treatment that repels water. (traditional)*

   The exterior treatment is the first line of defense against water damage. This layer must be able to endure the region's heavy rain and wind. Depending on the type of construction, the treatment will be in the form of a thin layer (paint), a thick layer (stucco), or inert materials such as marble and stone.

2. *Use adequate insulation.(modern)*

How much insulation is needed? A good principle to begin tackling this question is, "The more insulation the better."[8] Figure 11 shows the recommended insulation (R) values for Florida. When comparing the wall values from the department of energy for walls, R14, to the superinsulated buildings from earlier, R30, a range is established to pick from depending on the desired outcome.

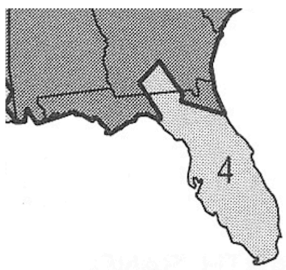


Table 15.6A Recommend Minimum Insulation Levels

	Ceiling		Walls		Floor		Slab Edge†		Basement†	
Zone*	I-P	SI	I-P	SI	I-P	SI	I-P	SI	I-P	SI
1	50	8.7	20	3.5	25	4.3	15	2.6	15	2.6
2	50	8.7	20	3.5	25	4.3	10	1.7	15	2.6
3	50	8.7	20	3.5	25	4.3	10	1.7	10	1.7
4	40	6.9	14	2.4	14	2.4	5	0.9	10	1.7
5	40	6.9	14	2.4	14	2.4	5	0.9	5	0.9
6	40	6.9	14	2.4	12	2.1	5	0.9	5	0.9

Figure 11: Recommendations from the Department of Energy.

3. *Properly detail control joints. (modern)*

Control joints are planned wall separations that allow walls to crack in selected locations. These joints are necessary, because they allow the materials to expand and contract, reducing the possibility of major damage to the structure of the wall.

4. *Use light colors for final wall finish. (traditional)*

The use of light colors will reduce the heat absorption of the wall because it will reflect the light.

5. *Use local materials. (traditional)*

Using local building materials assure that construction is being done with materials that are proven to work in the location.

Implementation of sustainable practices.

1. The exterior treatment used in the wall system is a ½" thick stucco layer. This layer absorbs the water and controls rain penetration as it gradually dries towards the exterior of the wall. To ensure that water penetration does not occur, the stucco layer must be continuous and sealed when needed.
2. The perimeter AAC 12" walls have an insulation value rated at R19. The reason

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[8] Heating, Cooling, Lighting, pp. 470.

behind this high insulation value in AAC is the lack in interconnected porosity. Therefore, capillary action breaks down quickly and moisture cannot continue entering deep into the block.

3. Unless specified otherwise, control joints will be placed every 24' on center. Caulking should be used to protect against the elements. In special areas where caulking does not completely fix the problem, flashing should be used in conjunction with the caulking.
4. The wall's finish will be white, because it has been proven to reflect the most light.
5. The AAC manufacturer is located 20 miles away from the project site. This allows for minimal expense in transportation and local availability of people that know how to work with the product.

How does it compare to the LEED project?

Since the LGCS is built into modules, it has the advantage of fast construction.

The similarities are as follows:

1. *Uses white wall finish. (traditional)*
   As evident from figure 7, the aerial photo shows that the LGCS's wall are painted white.
2. *High wall insulation value. (modern)*
   The insulating values of the LGCS are rated at R21. It is achieved by using 6 studs and spray foam.

The differences are as follows:

1. *The LGCS does not use local materials. (modern)*
   This practice is inherent from the use of pre-fabricated products. They are made somewhere else, and then transported to the site.
2. *Use of building wrap to aid in the control of moisture. (modern)*
   The use of building wrap adds a layer of protection especially at the joints and corners.

What results can be drawn from the comparison?

Since the LGCS relies on pre-fabricated systems, it is bound to require specialized technicians to maintain and repair the modular system. Masonry, on the other hand, is easier to keep up and sustain because of the availability of people to do so. This point may be a great factor on the longevity of the building. If it is harder to maintain, that may lead to a reduction in the lifespan of the structure. Air tightness is another factor that the two buildings differ in their approaches. The LGCS uses building wrap that may weaken as the metal structure expands and contracts. Contrastingly, stucco, fluctuates depending on the weather at a slower rate. Nonetheless, if a repair is needed, it is easier to repair stucco than the building wrap. The windows on the SdA buildings are at pushed in 4" from the exterior. This setback allows for a shadow area in the window that is in shade, reducing the interior heat gain. The window setback is possible because of the AAC Wall thickness. The LGCS walls are not able to use this practice because the walls are not as thick.

Conclusion

When the study first began, it started with the presumption that performance of buildings may be greatly enhanced using the knowledge found in tradition along with modern practices. It is finally the moment to ask the questions, do the findings confirm the hypothesis? Can better buildings be created by using traditional and modern practices? From my findings, I have concluded that using modern and traditional practices do enhance the performance in buildings. Many traditional factor such as narrow alleys, eaves, colors, etc., increase the life, efficiency and comfort of the design. However, modern practices also add to these aspects of the design by creating better insulated walls, increasing the habitat for native species, and contributing to reducing the air leakage from a building. The combination of the two approaches works. While traditional architecture use methods of constructions that have proven to work on the long run, modern materials, methods, and processes can help the design process by introducing advances in technology. If both methods are used in conjunction, a sustainable, long living building can be created.

Bibliography

AERCON. "Technical Manual". Aercon. 1 Jan 2012. <http://www.aerconaac.com/TECHNCAL%20MANUAL/Introduction.pdf>.

Craig, A. Peter. "Vapor Barriers: Nuisance or Necessity?" Hanley-Wood 2004.

Hale, Jonathan. The Old Way of Seeing: How Architecture Lost Its Magic (and How to Get It Back). New York: Houghton Mifflin Company, 1994.

Heap, Jeed. "Learning Gate Community School (Lgcs)." Ed. Jose Quezada2012.

Lechner, Norbert. Heating, Cooling, Lighting : Sustainable Design Methods for Architects. 3rd ed. Hoboken, N.J.: John Wiley & Sons, 2009.

Lstiburek, Joseph W. "The Perfect Wall." The Masonry Edge: 20.

Lstiburek, Joseph W., and John Carmody. Moisture Control Handbook : Principles and Practices for Residential and Small Commercial Buildings. New York: Van Nostrand Reinhold, 1993.

Montoya, Michael. Green Building Fundamentals. New Yersey: Pearson Education, 2011.

Mouzon, Stephen A. The Original Green. Miami: The Guild Foundation Press, 2010.

Mouzon, Stephen A., and Susan M. Henderson. Traditional Construction Patterns. New York: McGraw-Hill, 2004.

Nodarse. Geotechnical Engineering Report. Celebration, 2011.

Parker, Danny S. "Very Low Energy Homes in the United States: Perspectives on Performance from Measured Data." Energy & Buildings. Ed. Florida Solar Energy Center. Cocoa: Florida Solar Energy Center, 2008. Vol. FSEC-RR-302-08.

Studio, Green Building. Weather Data: Autodesk Software, 2012.

USGBC. "Usgbc - Leed Information". 2012. USGBC. 10 January 2012. <http://www.usgbc.org/DisplayPage.aspx?CMSPageID=124>.

Zechmeister, Dan. "Loadbaring Masonry's Bottom Line." Masonry Resource Guide 2008: 10.

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