An analysis of sustainable design integration: design/build of the Jewell Golf Clubhouse/Community Center

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An analysis of sustainable design integration: design/build of the Jewell Golf Clubhouse/Community Center

by

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A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of
MASTER OF ARCHITECTURE

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Program of Study Committee:
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Signatures have been redacted for privacy
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I. INTRODUCTION

Project Background

In the fall of 2003, I joined four other graduate architecture students in search of a way to gain practical experience during our last year of graduate school. Rather than producing a conventional thesis where the final product is written, we agreed that it would be more beneficial for us to design a building and have the built structure be our final product. The project would allow us the rare opportunity to take the architectural methodology that we had been taught and apply it to a realistic setting. Furthermore, we could use the project as a tool to investigate design and building issues that were of interest to us.

We began by investigating different avenues for our involvement in a built structure. The team was lead by our major professor, Bruce Bassler. With his guidance, we partnered with students from Iowa Central Community College’s Building Trades program, led by Bill McAnally. The collaboration gave us the opportunity to learn from an established building instructor while providing his students more exposure to the design aspects of a project. The town of Jewell, Iowa was selected as the location of our project because of its relative proximity to both schools. The Jewell Golf and Country Club was considering building a new clubhouse/community center, and our desire for a design-build project met their needs.

The goals of the project can be compared to the goals of many university design build projects as described by author Jason Pearson. The project set out to accomplish three specific things:

1) To deliver design and building services to a group who would most likely not otherwise have been able to afford it or something of this scale. The country club could have afforded to repair their old building
or construct a smaller building, but the building we helped them achieve gave them a much better chance for sustainability and growth in the future.

2) To educate the community about the value of design.\(^1\) We accomplished this through articles in the local paper intended to keep the public mindful of our progress and introduce them to innovative techniques they might not be familiar with. Often a member of the community would stop at the site, and we took the time to explain what we were doing and answer any questions they had.

3) To develop ourselves as designers and architects by learning from the services we are providing throughout the project. This is what Pearson describes as “service learning” or “project based education,” which “encourages students to assume public leadership as a part of their educational curriculum by applying theoretical approaches discussed in the classroom to actual projects in the real world.”\(^2\)

Similar to other design build programs, the client provided a budget for materials, and we were responsible for site analysis, project design, production of drawings, material procurement, fabrication, and scheduling.\(^3\) A majority of the design build projects that Pearson describes are smaller projects such as single family homes, building additions, and park pavilions. Our project is unique in the fact that it dealt with a much larger scale. Due to the size of the clubhouse and the expected use, there were more factors to account for. Additional responsibilities included budgeting and coordinating with the HVAC subcontractor, equipment providers, electrical subcontractor, lighting representatives, and utility company. Simultaneously, a major portion of our

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time was spent communicating with the client board, who acted as the voice for the 240 members of the country club.

The clubhouse was designed to accommodate the needs of the country club and act as a gathering spot for community functions. The building contains a kitchen with walk-in-cooler, bar/dining room, event/community space, manager’s office, bathrooms, storage, and mechanical space. The design and construction services were provided at a minimal administrative cost to the owner by students from Iowa State University and Iowa Central Community College.

The project never established the conventional procedure of schematic design, design development, and construction documents. Instead, we focused on completing as much of the design as possible before the start of construction, and then keeping the design ahead of the construction once it began. The schedule can be separated into three phases: pre-design, primary design, and secondary design. In the pre-design phase we began gathering ideas and having discussions with the Country Club Board. Designing was essentially split into two phases with the divider being the start of construction. In the first phase, which I refer to as primary design, decisions were made in a conventional fashion. Regular charrettes and group discussions took place, and there was more time to analyze every issue. The secondary design phase took place in coordination with construction on the site. Design decisions were made at a much faster pace, and once an adequate solution was found, minimal time was given to alternatives.

The group of five graduate students included JaDee Goehring, Ryan Kranz, Meredith White, Beau Fey, and I. We collaborated on a majority of the design, but each of us also had parts of the project that we took responsibility for. JaDee focused her attention on the material palette, which included comparing cost, contacting suppliers, and ordering materials. Ryan produced most of our CAD drawings and also worked through the structural analysis and framing details. Meredith wrote some of the newspaper articles,
communicated with the roof supplier, and worked with the landscaping team. Beau developed a few of the CAD drawings, wrote newspaper articles, and constructed physical models. My specific responsibilities were preparing presentation materials, working with the utility company, and communicating and coordinating with the plumbing, electrical, and mechanical subcontractors.

Sustainable Design

My interest in sustainability began while doing research for the design of an elementary school studio project. It was the first time I had focused on sustainable design strategies and their effect on the built environment. Among other things, I was amazed about the correlation between exposure to natural light and the learning curve of children. The research sparked my interest on the topic of sustainability and I began reading books and taking classes on the subject. My study has led me to this definition of sustainable building:

"Sustainable building is the design and construction of buildings using methods and materials that are resource efficient and that will not compromise the health of the environment or the associated health and well-being of the building’s occupants, construction workers, the general public, or future generations."

This is an accurate description of the scope designers and builders strive to achieve with sustainability, but it is rare to find cases where every sustainable ideal is realized. At the minimum, we must assure the health of building occupants and builders. We should pursue sustainable ideas to the best capacity of the project, and implement those which can feasibly be used to

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make an impact. Although beneficial, this task is not easy, and balancing the “trade-offs intrinsic to a sustainable design” can be a challenging process.

In order to simplify things, I looked at a set of specific criteria used by the Rocky Mountain Institute, a leader in sustainable design innovation. They published “A Primer on Sustainable Building” which I have used as the basis for a lot of my research. The institute focuses on eight criteria when designing a sustainable building:

1. Make appropriate use of the land
2. Use water, energy, lumber, and other resources efficiently
3. Enhance human health
4. Strengthen local economies and communities
5. Conserve plants, animals, endangered species, and natural habitat
6. Protect agricultural, cultural, and archeological resources
7. Be nice to live in
8. Be economical to build and generate

All of the concepts deal with conservation over consumption and being cognitive of the people affected by the architecture. It is important to keep in mind that pursuing these criteria does not always mean applying an innovative solution. One of the things I learned in this process was that many sustainable solutions include ideas and processes that have been considered common practice for a long time.

The US Green Building Council (USGBC) has developed the LEED (Leadership in Energy and Environmental Design) certification to “distinguish buildings that demonstrate a commitment to sustainability.” Their certification process requires detailed documentation and calculations.

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associated with the sustainable design features in order to satisfy the submittal requirements.\(^8\) Unfortunately, the time frame, budget, and conditions of our project ruled out any pursuit of LEED certification.

The advantages of producing a sustainable building have been widely documented, and this thesis is not intended to be another paper on the benefits of sustainable design. A number of books and articles have been written on that subject. For someone who is applying these issues to a real situation, there is no way to know the most accurate way to approach things. Moreover, with sustainability gaining popularity and “green washing” becoming more prevalent, it is hard to decipher whose opinion is the correct one.\(^9\) I never planned on deciding who is right, and this thesis is not intended to be a comprehensive study of sustainable design.

Objective

The objective of this thesis is to analyze the sustainable challenges and features in our building. The conclusions will bring to light areas where we were successful and lacking in an attempt to gain knowledge for future projects. Like many architectural talents, the learning curve for sustainable design involves a lot of realistic practice. The primer recommends approaching the subject in increments. By taking progressive steps we can effectively learn from each project, then take on a little more, do better the next time, and “steadily expand the scope and depth of our design integration.”\(^10\) This thesis is my way of reflecting upon what I learned in the project.

Ultimately, this thesis answers two general questions: (1) What sustainable techniques or features did we integrate successfully? (2) What can


we learn from the sustainable attempts of the project? I will use the criteria mentioned previously as a basis for describing the effect of sustainable elements. The reasoning behind our exclusion of certain sustainable features will be discussed. Comparisons will be made to sustainable challenges of other university design build programs, in order to further learn from the process. Finally, I will provide suggestions for future projects by describing the lessons I learned in the process.

Although we were continually making decisions to improve the work, to organize my thesis I present the ideas in the order in which we first started to focus on them. I’m writing this thesis while the building is still under construction, therefore some decisions are still left to be made and concepts may change.
II. PRE-DESIGN

Initial Steps

From the start of the project, sustainable design never held first priority. This was due in part to the complexity of the project and our lack of experience with the process. We were optimistic about the idea of using sustainable features but had no expectations. The team was confident in our knowledge of the basics of sustainable design, however we knew integrating those ideas into a real project would be complicated. Nevertheless, we were committed to producing a high performance building, and we were teamed up with a contractor who had a reputation for high quality and energy efficient construction. At the minimum, the project would serve as a good introduction to the practical aspects of sustainability.

An analysis of the client revealed some unique concerns that would dictate sustainable decisions later in the process. The first topic dealt with the ease of maintenance. Special consideration was given to the location of mechanical units and other utility equipment. We placed them in accessible spaces to elevate future repair problems. Since the country club only has one full time supervisor, we needed to make sure the up-keep wasn’t more than one person could handle. This pertained to cleaning and caring for anything in the clubhouse; and we had to design the features of the building accordingly. Similar to the maintenance were the durability concerns. With the club’s minimal budget they needed the products and materials to last. In some instances this can dispel innovative solutions, because a true test is not available to prove the long term effects of the product. This is one of the risks normally taken on university design build projects. A product may seem very innovative and appropriate at the time of installation, but its sustainable qualities are unknown. With the constraints of our project we didn’t have the
luxury to take as many risks. A conscious effort was made to use a proven durable product in every application.

At the beginning of the process, it was important for us to establish communication with all of the participants of the project. This is an important step when a design team is pursuing sustainable features in a building. Collaboration “helps ensure that systems work as they are intended to, rather than just as they are designed to.” 11 We identified the mechanical, plumbing, and electrical contractors; and met with each to discuss our objectives for the project. We also talked throughout the project with a mechanical and structural engineer.

Major Challenges

After early discussions with our team and the county club board, it became apparent that there were five major challenges that would affect sustainable design; the budget, time constraints, building scale, usage, and our inexperience. These would test us throughout the entire project.

Satisfying the budget has been the greatest challenge since the outset of the project. The board set the budget at $250,000, which after doing some initial space and number crunching brought us to a meager $50 a square foot. The tight budget limited the sustainable freedoms we had. There are many sustainable ideas that are low-cost solutions, but unconventional techniques usually take more money and time. 12 Furthermore, “budgets usually limit choices to the most common materials and building systems.” 13 Thus we had to learn ways to effectively and efficiently use the pieces we could afford. The

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budget also forced us to prioritize elements of the building, in order to
determine the most feasible impacts we could attain.

The biggest concern with the budget may be the way it was defined.
When considering sustainable solutions, the initial cost of materials, land,
design, and labor can not make up the entire budget. If that is the case, the
cost of construction will be the only focus and “many sustainable principles will
go unused.”14 However, if the long term repercussions of using a sustainable
solution are included in the budget then it becomes much more valuable. The
effects of sustainable design can best be seen in the operating costs and
expected maintenance needs of the building. One way of estimating the long
term expense is through a life cycle analysis. “If life cycle costs are considered
then anything that reduces the cost of maintaining the building over its useful
life should be given due consideration” in the budget.15 With this considered,
one can make a much better argument for a sustainable solution over a non-
sustainable one.

One of our ways to reduce the budget was providing labor support to the
utility contractors. If we save the contractor’s installation time, then that
savings can be reflected in their fee. It was helpful that all of the contractors
acknowledged that this was an educational process, and they were willing to
let us help and learn.

Another major challenge was the time constraint of the project. The
project started in the fall of 2004 and the construction needed to be complete
by May 1st of 2005, the start of the golf season. Even though attention was paid
to sustainability at the beginning, with the fast pace of the project it became
apparent that it could not be the main focus. A greater sense of responsibility
was given to completing the project successfully, which unfortunately in most

university design build projects “means that we finish on time and under budget.”\textsuperscript{16}

A compressed schedule allows less time for research and analysis of alternative solutions. This is a common constraint of many design build classes, especially in the early years of programs. Scott Wing, the director of the Penn State design build program, explains that, “We sometimes believed we all would learn more by slowing down, working more deliberately, and debating the merits of varied design approaches, but our ethical decision to ensure the completion of the house drove a construction schedule that conflicted with our ethics of teaching.”\textsuperscript{17} The struggle to satisfy the client’s schedule while also presenting alternatives to the client was evident through the whole process.

The tight schedule also puts a strain on design production. We were constantly asking ourselves “How can we build that, and more importantly, can we build it in time?” At the start of construction, design documents were not complete, and many details were still unresolved. Fortunately, we could count on our construction contractor to help us solve many of the issues in the field, but it limited the opportunities to investigate innovative alternatives.

The building’s large scale added another level of adversity. In other design build programs as well as past projects at Iowa State the scale of the project is much smaller. A smaller project allows for more experimentation, because it involves a smaller application of the ideas. Evidence of this can be seen in the Rural Studio projects.\textsuperscript{18} The studio prides itself on using innovative techniques, but admits that most projects are “small and simple in plan.” When later faced with a larger project, “the building’s large size prohibited the expressive architecture that made their previous projects so distinctive.”\textsuperscript{19} The

larger project they were involved with was a 1700 square foot house compared to the 5000 square feet that our clubhouse was projected to be. The scale definitely made it hard for us to progress from the basics of sustainable design.

In correlation with the scale, another challenge was dealing with the changing occupancy conditions of the building. The golf dining space accommodates most of the regular customers and golf events. The number of people that can fit in the dining space is 46, but additional space is available in the event/community room. All of the golf events and activities take place between the beginning of May and the end of September. The event/community space was intended to be a profitable space for the country club. The club expected to have receptions or gatherings in the space, and fill it to close to capacity around ten times a year. The random influx of people resulted in aspects of the building becoming much more complex than a common building of this size. Not to mention the fact that the extended future use of the building was unknown, and the occupancy use could easily change ten years down the road.

Figure 1. Building Plan
All of the challenges of the project were directly affected by the inexperience of our group. Our normal studio projects never emphasized budgeting, dealing with clients and contractors, or scheduling, so those three particular topics were quite new to us. Even subjects we were familiar with required increased attention when applied to a real project. In particular with sustainable design, having the knowledge and having the know-how to implement the knowledge, can be two totally different things. Designers frequently run into this problem. They realize their social responsibility to protect the environment and conserve resources, but there is a greater sense of responsibility to complete the project on time and on budget. Gaining the understanding and confidence to implement sustainable techniques can take many years of experience. Sustainable consultants are often used to achieve certain goals. In our case, there was no money for sustainable design consultants, and combined with our inexperience, we did not know what scope we could attain. We settled on accomplishing as much as we could with the resources and realities we had.

Existing Conditions

The old clubhouse was an old farmhouse with many additions. It was very inefficient and it was definitely showing its age. The board considered just repairing the dilapidated roof and foundation, but that would have cost around $40,000 and only been a temporary fix. With the age and condition of the clubhouse the thought of renovation was unreasonable. However, there was an opportunity to salvage some parts of the old building. The board had a sale of everything in the building that was still usable including the windows.
and deck. Other pieces like the retaining wall bricks and plantings were salvaged to be reused around the new building.

The Site

The new clubhouse occupies the same location as the old building on the southwest side of the golf course. By using the old location, we prevented the unnecessary disturbance of new land. Furthermore, we were able to take advantage of the sewer and water infrastructure that was already in place. To gain efficiency, we updated the electrical and gas service to the building.

Before we began designing, we mapped out boundaries around the building in order to preserve the existing green space and efficiently use the land (Figure 2). Visitors approach the site from the driveway on the southeast corner, and park in the gravel parking lot on the south side of the building. On the north side of the building sits the 9th hole green, and on the east side is the 5th hole tee off box. The west side contains space for carts and a majority of the circulation to the start of the course.

![Figure 2. Existing Site](image-url)
III. PRIMARY DESIGN

Space Configuration

One of the first major decisions dealing with sustainability was the number of floors in the building. The board felt strongly about building a two story clubhouse, where the golf dining room and the event/community space were on separate floors. Our design team questioned whether a two story building was the best choice. We conducted a building comparison of the two story versus one story options, and a comparison chart was presented to the board (Appendix). The chart highlights the inefficiencies of the two story plan. A multistory building needed separate men’s and women’s bathrooms on each floor as well as kitchen space on both floors. The doubling up of spaces creates an unnecessary waste of resources. In order to provide an entrance at the lower floor it would require a great deal of earth grading and site work. In our attempt to minimize the disruption of the land, the two story plan began to look unreasonable. We also felt that a lower story event/community space would have an awkward feel that went against the inviting experience the clubhouse was trying to provide. Since half of the lower level would be below grade, the view and daylight in the space would be dramatically reduced. This would reduce the attractiveness of the room and an occupant’s comfort in the space. On the other hand, a one story plan allowed us to open the floor plan during big events and provide more room for occupants. Ultimately, the board agreed with our analysis and we proceeded with a one story plan.

Another sustainable idea explored at the beginning was optimizing the building size. The notion of “designing just enough” and being “as big as it needs to be, no bigger” was critical in our pursuit. Obviously, “bigger buildings require more land, more lumber and more energy,” and those were resources
that we could not waste.\footnote{Barnett, Dianna, and William Browning. *A Primer on Sustainable Building*. Snowmass: Rocky Mountain Institute, 1998. pg. 41.} We accomplished this by performing a space analysis and creating spaces that were multifunctional. One of the best examples of this is the relationship between the golf dining room and the event/community space, the two gathering spaces in the building. We knew the largest events would only occur a few times a year, and therefore designing a room to accommodate the largest crowd was unreasonable. Instead, we convinced the board that during the biggest events it would be more efficient to use the whole building. The building’s space relationship allows the gathering spaces to be used separately or as one collective room. A wall containing a series of doors divides the two spaces. In order to sustain these spaces in both conditions we created a central core of supporting spaces, otherwise known as “the cube” (Figure 3). These spaces included the kitchen, bathroom, bar, and circulation; and they were shared by both the golf dining room and the event/community space.

![Figure 3. The support spaces](image-url)
We calculated occupancy loads to find the optimal size of each room. The event/community and golf dining rooms were designed to hold 140 and 46 people, respectively. The bathrooms were required to have three lavatories each to accommodate the occupancy load. We worked through several kitchen plans in order to find an adequate amount of space for all equipment they might acquire in the future. Finally, to further tighten the square footage we took advantage of unused attic space to house mechanical units and additional storage.

We paid special attention to providing an ADA accessible building. We wanted to not only accommodate everyone but make all users feel comfortable. Consideration was given to many facets of the building including circulation paths both inside and outside the building, window heights, and a minimum of three feet for door widths. The bathroom was also designed to be completely ADA accessible.

The design was approached as a way of planning for the future use and expansion of the building. A building that is flexible to future change has a much better chance of sustainability. We knew from the beginning of the project that every element of the building could not be obtained within the initial budget. However, accommodating the building for future changes allows for much easier expansion. One example of this is framing in the location of future windows. By framing in space for a window without actually placing a window in that spot, we allowed for easier installation of a window in the future. The patio is another good example. A certain amount of money was allocated to the patio, and the board was concerned that the size of the patio we proposed was too small. There was no way of really knowing an appropriate size for the space until after its use was observed. By designing the patio in such a way that it allows easy expansion in the future, we provided a solution that accommodated the board's concerns. Another example was the design of the kitchen. Commercial kitchen equipment is very expensive and at this stage the club could not afford all of the equipment they wanted. By providing
enough space, we satisfied their future desires. In essence, we provided the first phase of the new building, but we kept in mind future phases.

Windows

One of the first conflicts we ran into was the placement of the windows. Due to the budget, we knew there was a limited amount of windows we could afford. The majority of the golf course was on the north side of the building, and we wanted to accentuate those views. However, the natural tendency is to place a majority of the windows on the south side of the building to take advantage of sunlight. Normally “orienting the building to capture expansive views or to achieve privacy and security should be done in concert with siting for solar access,” but in our case this was not feasible. We had to decide what would give us the best overall building even if it was not the most sustainable choice. We decided that south facing glass was a lower priority, because the building’s greatest occupancy was during the summer golf months. During this season the building would be in a “cooling mode,” and additional heat from the south windows would act as a deterrent. As a result a minimal number of windows were placed on the south side of the building. This also encouraged patrons to take advantage of the patios we provided in order to get sun. During the winter, there was a similar but less consistent condition. The occupancy in the winter was expected to be large groups in a conference or reception setting. In that case, the occupancy load would provide much of the heat in the space and additional heat from sunlight would not be necessary. The only case that didn’t satisfy our argument was a small meeting during the winter, and that was a sacrifice we decided we had to accept.

This does not play down the fact that we still wanted to introduce natural daylight into building. Large windows were placed on the north and east sides as well as glass doors on all sides of the building (Figure 4). All of the windows are double paned, low-emissivity, and argon filled for maximum energy performance. Most of the windows are four feet wide and were placed high enough to allow diffused glare-free daylight to flood back through the rooms. A row of clerestory windows were also included to introduce more light into the bar space. Daylighting provides the building with a good quality light that increases the comfort of the people in the room. Furthermore, “daylit buildings use substantially less energy while providing a welcome connection to the outdoors.”

The view was deemed one of the most important qualities, because it sold the clubs major asset, the course. The large windows on the north side of the building frame a gorgeous view of the course. Window mullions were carefully aligned to provide an unobstructed view for both

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seated and standing patrons. The north windows also offered an indoor-outdoor space relationship by bringing the course into the building. These factors added to the comfortable feel we hoped to produce in the space.

![Figure 5. North Elevation](image)

In order to introduce natural ventilation, we included a number of operable windows. Five operable awning windows were placed on the north wall of the golf dining room. A window placed parallel to them on the south side of the building is also operable to encourage cross ventilation through the building. Natural ventilation helps to reduce some of the cooling load and provide healthier indoor air quality. Operable windows also increase the level of comfort by adding the sounds and smells of the outdoors.

**Mechanical Issues**

Deciding on a mechanical system is a major step when striving for a sustainable building. The mechanical units constitute “a majority of a building’s energy use.” Therefore, it is essential to limit their impact on the building. Many sustainable experts agree that “slashing the power consumption

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of the built environment is what reaps the most benefits environmentally.”

As a result, more attention was placed on the mechanical system than any other part of the building. Many discussions occurred with the board and the final result acted as a turning point for our project.

The first step we performed was calculating accurate heating and cooling loads for the building. This in itself is important because contractors “routinely install larger systems than necessary” to simplify the process. Due to the number of people expected in the building and the warm weather during the months of heavy use; the cooling load stood out as the dominant load in the building. Even during the winter, the crowd at a larger event would provide more than enough heat, and cooling might still be needed. Some heating units would be needed for the smaller winter events. Once we came to an agreement on the needed loads, we looked at different systems we could use in the building.

The country club board was very adamant about using a geothermal system, because they had heard good things from friends who owned them. Although, at this point, I think that most of the members of the board were under the assumption that a geothermal system for the clubhouse would be equivalent to a geothermal system in a home of the same size. They would learn later that this was not the case. Our group was also optimistic about using geothermal, but we were a little more realistic about the up front costs. We asked the mechanical contractor to investigate both a geothermal system and a more traditional option. When the comparison came back, the cost of either system shocked us a little bit. Using a geothermal system seemed unlikely with its price tag reaching over 45% of our total budget. There was also a conflict over the location of the bored vertical loops or horizontal trenches that would supplement the system. In addition, the mechanical contractor explained to us that a geothermal system produces the most savings.

during the heating cycle. Since the majority of our mechanical load was used for cooling, geothermal might not be the best option. However, convincing the board that it wasn’t the best option would prove to be one of our biggest struggles. As I mentioned before, they had trouble grasping the notion that a system designed for a 5000 square foot house is not the same as that of a 5000 square foot clubhouse; especially a clubhouse that is designed to host events of 150 people. We did our best to persuade the board that our mechanical contractor was looking out for their best interests. After several attempts with varied success, the board sought out the services of another mechanical contractor. The second contractor was personally closer to the board members and he had a little more experience with geothermal systems. Convinced that the new contractor would provide a lower fee, the board allowed him to complete his own load calculations and cost analysis. Only after their new contractor came back with a budget essentially higher than our original contractor did the board decide that we were providing the best service. This proved to be a major turning point in the design of the building, and from then on I felt like the board began to trust us more.

Ultimately, we decided on utilizing a more conventional mechanical system containing high efficiency gas furnaces and air conditioners. The furnaces have a relatively high efficiency rating of 92.1, and the air conditioning units have a seasonal energy efficiency ratio of 13 Btu/watt, which is also good. The original design contained six units, but after a re-evaluation of the usage and square footage of the building, we were able to further optimize the system and eliminate one of the cooling units. The five remaining units were separated into three heating and cooling systems and two cooling only systems, which allowed us to satisfy the overriding cooling loads without wasting extra heating equipment. The event room was equipped with a 5 ton heating and cooling unit and a 5 ton cooling only unit. An additional 2.5 tons of capacity was also utilized from another 4 ton unit to accommodate the space. The rest of that 4 ton unit provided heating and cooling to the entry way and
bathrooms. The golf dining space was accommodated with one 4 ton cooling only system and one 4 ton heating and cooling system that also fed the manager’s office. In the kitchen a compensating hood is utilized to capture heat and grease vapors and replace them with fresh air. We would have liked to size all of the mechanical units smaller in anticipation of natural ventilation techniques but we had to guard against expansion in the future.

We also investigated using a more efficient in floor radiant system to supply the heating and cooling. Similar to the geothermal option, it was much more expensive and the benefits didn’t comply as well with the building’s usage. For instance, a radiant system is not as beneficial when the major load is cooling. Instead we went with a more tradition central forced air system.
using round duct work. Using a more traditional system also made it easier for us to help the mechanical contractor, and lower the installation cost of the system.

Tailoring the mechanical system to the buildings specific needs added to the efficiency of the system. Using the five different systems allowed us to control different zones of the building and accommodate a couple different scenarios. Each system could be shut off or adjusted to provide the optimal amount of heating or cooling needed for a particular use. This would ultimately keep the operating costs down. In order to function effectively, it was essential that we inform the clubhouse manager on the extent of the system and the different ways it could be used. At the same time, we wanted to stress the use of the operable windows to provide ventilation and lessen the reliance on the mechanical system.

Since most energy efficient buildings are tightly sealed, air pollutants can accumulate and eventually reduce the indoor air quality. Thus, it was important for us to deliberately ventilate the spaces using energy recovery ventilators. A ventilator was attached to each of the five mechanical units. The ventilators are used to exhaust particulates and volatile organic compounds in the room while recovering 73% of the temperature difference between the incoming and exhausted air. This promotes a more comfortable atmosphere and reduces the health risks from indoor air pollutants. The country club also wanted to offer the golf dining room as a smoking area and keep the rest of the building smoke free. The energy recovery ventilators were able to accommodate this.

Finally, attention was placed on limiting the noise from all of the systems. "The better mechanical system designs are typically invisible to the users." Three of the units were placed in the upper story attic space above the kitchen and bathrooms. The other two units were placed in two small

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rooms on the south end of the event/community space. The return air vents on those units were specifically designed long enough and with as many elbows as possible, to prevent sound transmittance.

Building Envelope

Product durability was one of the major sustainable features of the building. "A material’s durability, as measured in its life-cycle cost, has profound environmental ramifications. In many cases, the production and disposal of building materials has far worse consequences than the material’s actual use. Extending the usefulness then becomes critical."\(^{29}\) We understood that using non-durable building components, especially in the envelope, would result in high life cycle costs due to maintenance, repair, and premature replacement.\(^{30}\) Since the board had a limited amount of money for upkeep, we searched for products that were proven to last.

We first looked at using wood siding on the exterior walls. However, the maintenance responsibilities associated with treating, painting, and cleaning the wood ruled it out. Furthermore, wood was a lot more expensive than some other options. We decided to use James Hardie fiber cement siding for the building. Hardiplank is made up of a mixture of 10% virgin wood fibers and 90% cement. It is cheaper than traditional wood siding, and Hardiplank does not warp or shrink, is fire resistant, and doesn’t require maintenance after initial staining. On the down side, cement contains a great deal of embodied energy, and the virgin wood fiber has to transport all the way from New Zealand. Nevertheless, we felt the product’s durability and low maintenance was worth the trade off.

We agreed on a smooth Hardiplank lap siding on the exterior of the golf dining and event/community spaces (Figure 7). For the outer surface of “the cube,” we went with a smooth Hardipanel grid system. The grid pattern is an unconventional application of the product. Essentially, we cut each 4’ by 8’ sheet in half to create a 4’ by 4’ grid on that portion of the building. In order to keep the product durable we made sure to work out the joint details of the new application. The exterior walls were also covered with a stucco wrap thermal barrier and half inch Styrofoam insulation, providing an R-value of 22 for the wall system.

![Figure 7. Hardiplank lap siding and Hardipanel vertical siding](http://www.jameshardie.com)

For the roof, we utilized structural insulated panels (SIPs) for certain spaces. SIPs are pre-fabricated panels composed of expanded polystyrene foam sandwiched between two pieces of oriented strand board. They are shipped to the site ready to install. When used in the roof they provide many qualities absent when using conventional wood trusses. The uniform insulation offers continuous superior thermal performance and a lower infiltration rate. Since they are manufactured in a controlled setting the amount of waste can be reduced and recycled. The panel construction allows for long unsupported

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spans which worked well in spaces like the entry and golf dining room. The only downfall was the additional cost, so we had to be selective about where we placed them.

Figure 8. SIPs over the Office

Above the SIPs, we went with a standing seam metal roof, because of its low maintenance, aesthetic characteristics, and long term durability compared to alternatives. The metal also allowed us to obtain the roof slopes that we wanted without having drainage issues. The metal roof has the chance of being recycled in the future.

Figure 9. Metal roof panel

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IV. SECONDARY DESIGN

Interior Elements

Some of the more unique sustainable elements in the building are interior features. These pieces were fabricated by the students, and they included bathroom partitions, window and door trim, base boards, chair rails, divider panels, and lighting fixtures. Most were constructed using Baltic birch plywood, because of its durable quality and lower price. The students found innovative ways to apply this uncommon material and use it to enhance the buildings aesthetic. Furthermore, fabricating these elements in place of traditional solutions is an efficient use of the labor we had. By constructing the pieces in a controlled environment, the students were able to reduce the amount of waste and ensure good quality. The unique pieces were tailored for each space, and they enhance the quality of the rooms.

To supplement the daylit portions of the building, we introduce some energy efficient electrical lighting. We are using fluorescent tube lighting in the event space and compact fluorescent can lighting in the hallway and bathrooms. “Fluorescent lights use a third to a quarter of the electricity of incandescent bulbs” and last ten times longer.\(^3\) The event/community space was intended to house a variety of different uses and users. “Since different people perceive light quality, quantity, and color differently, have different visual abilities, and even have different appetites for light at different times of the day or year, a lighting system must be flexible and adjustable.”\(^4\) The space has a number of different lighting conditions to efficiently use the electric light. The room is split into four banks of lighting, and each part can

be dimmed or shut off to accommodate a particular event. This allows the proper control of light to ensure the efficient use of resources.

In order to conserve water resources, attention was paid to the fixtures and appliances placed in the building. The water running to the building accommodates the faucets, toilets, water heater, dishwasher, and ice machine. Most of the faucets will contain aerators to provide only the needed amount of water for their location. The bathroom faucets would more than likely be set lower than the kitchen, because a greater flow is needed for kitchen activities. As far as the toilets and urinals are concerned, the code requires low consumption models. These models use about a third of the water of past versions, and are reasonably efficient. The water heater can be one of the greatest users of energy. Thus, we looked into using an energy efficient model for the building. One unit we looked was an “on demand” water heater, which reduces the annual water heating costs by eliminating the standby losses that occur in a tank water heater. A final decision about the water heater has not been made. The exact type of dishwashing and ice machine units will not be determined until after the project is complete, but water conserving models would be ideal.

Landscaping

One group of students was responsible for developing the exterior spaces around the new building (Figure 10). Walkways were designed on the south and west sides of the building to lead golfers and pedestrians to the two entrances. A rather large patio was provided on the north and east sides of the building as well as a grilling area. Sustainability was not the group’s main motivation, but plenty of their ideas and techniques can be classified as such. The patio acts as an extension of the gathering spaces, and it adds another dimension to events. Personalized donation bricks in the patio give the club another way to
collect money for future improvements to the building. Landscaping was integrated on all sides to soften the edges of the building. Most of the plantings require low maintenance, especially after the first year or two when they become established. All of the original landscaping from the old building was transplanted back into the new landscape, and the old retaining wall bricks were also reused. Due to the new year round use of the building, the group picked new trees, flowers, and shrubs that would provide some foliage during every season.

Figure 10. Landscaping (drawn by Joel Mathis, a student at Iowa State University)

The group had a good relationship with the course’s grounds keeper, and they were able to accommodate his maintenance issues in the design. One of the more sustainable aspects of a landscape is the attention given to watering needs. Water is constantly “applied in the wrong way, at the wrong time, in
the wrong qualities.”35 The grounds keeper was able to install a new irrigation system that would provide an efficient and ideal amount of water for the landscape.

Construction

Sustainable building construction doesn’t require unconventional construction methods or building materials. A well built wood frame house with “good insulation, a tight building envelope, and high performance windows can be as environmentally friendly as a house will all the latest green bells and whistles.”36 We did not intend to investigate many alternative construction techniques, because we wanted to gain an understanding of conventional methods first.

Much of good construction results from paying attention and caring about the little things. Having a contractor that is dedicated to sustainable construction can greatly influence the building’s quality. In this respect, our building contractor Bill McAnally was perfect for the job. Following his lead we were able to learn a great deal about the sustainable construction process. We started the site work by fencing off our area to minimize the impact to the surrounding site. Throughout the project we were careful to stay clear of tree roots and other vegetation. Bill taught us how to efficiently use our resources, minimize job site waste, and take advantage of advanced framing methods. Some of the techniques we utilized include: reusing form work lumber to frame the building, pre-fabricating walls to reduce waste, framing corners with two studs instead of three, and salvaging the small scraps of rigid foam insulation in order to use them to insulate the slab. We were also selective about the lumber we used as stakes and batter boards. We only picked wood that was

not in good enough condition to be used in the building. It is this attention to detail that adds to a sustainable building, and is not regularly seen on most job sites.

One of the first sustainable elements we used in the construction was frost protected shallow foundations. The building code requires that footings be protected against frost heave. Traditionally, foundations are protected from frost by placing the footings below the frost line. “Frost protected shallow foundations provide protection against frost damage without the need for excavating below the frost line.”37 Our footing was only placed approximately 24 inches below grade. The foundation utilizes rigid insulation placed around the outside to direct heat loss from the building toward the foundation (Figure 11). The two inch thick insulation was placed vertically along the outside edge of the foundation as well as horizontally from the footings. The shallow foundation saves us money in material due to the reduction of concrete and steel. It also provides increased energy efficiency and occupant comfort because the slab is insulated from the outside.

![Figure 11. Rigid insulation surrounding the foundation](image)

We took advantage of engineered lumber for some of the sheeting, framing, and structural members in the building. Engineered lumber is made of long thin wood stands bonded together using heat and adhesives. The product has few of the defects that result in waste of traditional lumber. Since the wood is converted directly into strands, the trees used are traditionally fast growing, which conserves resources by reducing the amount of old growth lumber that is harvested. Oriented Strandboard (OSB) is an engineered structural wood panel, and it was used for the sheathing on all of the walls. OSB is more consistent and moisture resistant than alternates generally used. Engineered studs were used to frame the tall north and east walls of the event space. They provide more strength than a traditional stud as well as less chance of warping, twisting, or bowing. Engineered wood I-joists were used instead of solid wood to frame the floor above the kitchen. Laminated Veneer Lumber (LVL) was used for a majority of the beams in the building. LVLs provide more stability, uniformity, and reliable strength than regular solid sawn members. Exposed parallams were used as the structure in the golf dining space. Parallams provide the strength of engineered wood, are ideal for longer spans, and have an aesthetic character we could express (Figure 12).
Placing attention on insulation can dramatically reduce infiltration problems and improve the indoor air quality of the building. The event space ceiling is insulated with blown cellulose insulation, which is made from newspapers. A vapor retarder is also utilized to further insulate the space and help support the blown insulation. Icynene foam is used to insulate the attic above the kitchen. Icynene contains no formaldehyde, emits no harmful emissions, and has superior insulation quality over other insulation products. For the exterior walls, fiberglass batt insulation is placed in between the studs. Advanced framing methods provide optimal spacing between the studs and allow for better application of the insulation and help reduce thermal bridging. The inside of the exterior walls contains the Membrain smart vapor retarder. The vapor retarder allows excess moisture to escape from the wall cavities and is ideal for sites with seasonal fluctuations in temperature. On the exterior, a half inch of extruded foam insulation was placed on the sheathing around the perimeter of the building (Figure 13). Overall, the attention placed on the insulation will produce a very tight and effective building envelope.

Figure 13. Extruded foam insulation on the exterior walls
V. CONCLUSION

The two questions posed at the beginning of the thesis were: What sustainable techniques or features did we integrate successfully? and, What can we learn from the sustainable attempts of the project? The following is a reflection of the ideas described in the thesis.

Evaluating Sustainable Design Integration

We approached the topic of sustainability lightly and that hindered its integration into the project. We also didn’t clearly identify sustainable expectations at the beginning of the project. Instead, we relied heavily on our “sustainable optimism” as a way of integration. As a result, our design concepts dictated the sustainability, rather than the other way around. Our hopefulness could only take us so far. As we became more involved in the complexities of the project, sustainability gradually fell as a priority. This did not make our sustainable design integration any less effective, just underdeveloped.

There are many concepts in the project that we could have pushed further, just as there are more concepts we could have investigated or incorporated. Acknowledging those areas where you need improvement is part of the leaning process. For example, some of the areas we could have improved on include water collection, life cycle analysis, pushing for energy efficient appliances, and aggressively pursuing innovative solutions. However, it is easy to make the argument that we could have done more, because you can always do more.

Fortunately, successful sustainable design is not an “all or nothing” achievement. Judging by the criteria set out in the beginning of the thesis, we
did a fairly good job. We were able to appropriately use the land by redeveloping on the site of the original building. Energy and water efficient concepts were investigated throughout the project, and the health of occupants was enhanced with insulation and ventilation. The spaces we provided are comfortable and pleasant to be in. We strengthened the local community by demonstrating to them the value of design and providing them a place to hold events. Finally, our involvement and careful product selection made it an economical clubhouse to build.

However, we could have done a better job bringing the sustainable pieces together as a whole. Allowing different sustainable elements to rely on one another further adds to the efficiency of a building. For instance, introducing natural ventilation should reduce the cooling load, and thus a smaller mechanical system can be provided. However, this type of integration puts a lot of trust on an anticipated result. Since the future usage of the building was unknown, we stayed on the conservative side.

The project was difficult in the fact that we didn’t have a basis to compare to or evolve from. Therefore, most of our successfully integrated ideas were closer to conventional than innovative. Since we had no template to follow, we were creating the template. Thus, this project should serve as a good basis and the minimum standard for future ISU design build endeavors.

Lessons Learned

For sustainable design to reach its potential, it is important to have a commitment from all parties at the beginning of a project. Many of the vital decisions are made during the early stages of a project, and using sustainability as a criterion for those decisions is crucial. One way to accomplish this is with an initial meeting which lays out the sustainable design expectations. “An intensive, multidisciplinary facilitated meeting can help identify and overcome
many of the barriers of sustainable design.\textsuperscript{38} Furthermore, the meeting establishes sustainability as a priority and sets everyone on the path to a common goal.

Sustainable solutions must be pursued aggressively. Letting sustainable concepts fall into place will not work as well. It takes the personal dedication of both the architect and client in order to realize the possibilities. In our case, the board showed interest when we introduced sustainable ideas such as using geothermal, FFPF, and SIPs panels. However, we lacked the persistence to introduce more.

Finally, I learned that it takes years of experience building upon the lessons of each project in order to gain the knowledge needed to fully integrate sustainable design. This project serves as my first step in a pursuit to produce sustainable buildings.

## VI. APPENDIX

### Jewell Golf and Country Club

#### BUILDING COMPARISONS

<table>
<thead>
<tr>
<th>Features</th>
<th>One Story Building</th>
<th>Two Story Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen</td>
<td>adjacent to all gathering spaces</td>
<td>space needed on upper and lower floors</td>
</tr>
<tr>
<td>Manager's Office</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Men's Bath</td>
<td>X</td>
<td>one on each story required</td>
</tr>
<tr>
<td>Women's Bath</td>
<td>X</td>
<td>one on each story required</td>
</tr>
<tr>
<td>Storage</td>
<td>X</td>
<td>space on each floor needed</td>
</tr>
<tr>
<td>Bar/Register</td>
<td>X</td>
<td>proximity to lower level functions</td>
</tr>
<tr>
<td>Golf Dining Space</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Community/Event Space</td>
<td>can accommodate 200 people less acoustical separation</td>
<td>complete separation from other functions</td>
</tr>
<tr>
<td>Mechanical</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Stairs</td>
<td>not needed</td>
<td>needed for exit accessibility</td>
</tr>
<tr>
<td>Deck/Patio</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Others</td>
<td>responds to circulation paths and site barriers</td>
<td>earth grading issues</td>
</tr>
<tr>
<td></td>
<td>allows for the separation or union of gathering spaces</td>
<td>traffic past the 5th tee box</td>
</tr>
<tr>
<td></td>
<td></td>
<td>decreased natural lighting and views for the lower level reception space</td>
</tr>
<tr>
<td></td>
<td></td>
<td>less site area needed</td>
</tr>
</tbody>
</table>


