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Green Buildings: The Future of Sustainable Living

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Abstract: The objective of this research project was fulfilled through creation of a contemporary home, that of which undeniably projects modernization due to key LEED (leadership in energy and environmental design) features. Design of this project was carefully supervised by the civil engineering department at California State University, Northridge. The design incorporates a 3-story single-family home with a steel infrastructure. These design properties had a positive impact in LEED specific adjustments which assisted with the overall increase in sustainability. The six civil engineering senior students were able to successfully create a cost analysis and compare the benefits of a LEED incorporated design as opposed to a standard residential home. The difference between the two is evident as the highly sustainable building resulted in a 7.6% increase in overall cost. However, as the savings in energy progress over a 9-year period, the home will inevitably reduce the overall cost to the owner. This research project aided in allowing this diverse team of students to be exposed to real life scenarios, with incorporation of their knowledge acquired from the past 4 years. The diversity and teamwork of this group allowed for equal opportunities of innovation and leadership. Skills such as proper communication and critical thinking will significantly impact them as they progress in their careers as civil engineers.

Key words: LEED, green building, sustainability, energy savings, diversity.

1. Introduction

An engineer must consider many things when designing a new project. Aspects such cost and environmental impact are all things one must consider when calculating the total serviceability of a building. However, civil engineers do not simply build houses, they create a long-term and comfortable building based on the surrounding infrastructure. All designs presented herein were built up to code and with careful consideration of the ethics of engineering which is, "Creating safe, resilient, and sustainable infrastructure."

Studies show that although the environmental impact increases with the construction of green buildings, the design intent of the proposed structure results in more long-term benefits [1]. Because when we look at the functionality of a structure throughout its life cycle, it can be seen that the preliminary cost increase is minimal when it comes to overall impact. Research conducted by Raj and Nabeen [2] supports the idea that by achieving an integrated design and focusing on the importance of value for money, the trade-offs between time, quality and price can be mitigated [3].

Fang et al. [4] showed in their research that buildings worldwide are responsible for 33% of all energy related carbon dioxide emissions. The purpose of this study was to achieve a design that not only cuts down on the amount of energy consumed, but also provides a luxurious and cost effective alternative to the conventional home. The solution is "Green Buildings". Green buildings are buildings that not only reduce negative impacts on the environment, but oftentimes offer many positive impacts throughout their construction and operation as well; and the world is already aware. As collaborative innovation continues to strive, so does the need and popularity of these designs, studies show [5]. This, in turn, shows that the pros of constructing a green building outweigh the cons, but where to begin?

There are many criteria that a design must follow with the intent of achieving high sustainability. Construction in the U.S. can greatly become more

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energy efficient with the help and guidance of the LEED (leadership in energy and environmental design) rating system. Created by the USGBC (US Green Building Council), this rating system provides a certification ranking to better measure just how sustainably efficient a building really is. It also gives a brief insight into what a typical green building consists of. It is shown by Freed [6] in his research that many everyday living components such as poor lighting and materials with volatile components greatly contribute to reduced quality of the indoor environment. Adding LEED fixtures to the design can prevent this reduction and provide a healthier, more comfortable living space.

This study also touches on the educational impact that this research study has given the scholars. Through hard work, leadership and dedication were they able to achieve this coordinative task for a sustainable future. Collaborative teamwork is essential and can be seen within the evidence of this project. Together we can all continue to innovate the world in beautiful and healthy ways.

2. Architectural Features

Our building is located in the United States, in sunny Southern California. For this project, the student research team was tasked with designing a residential,

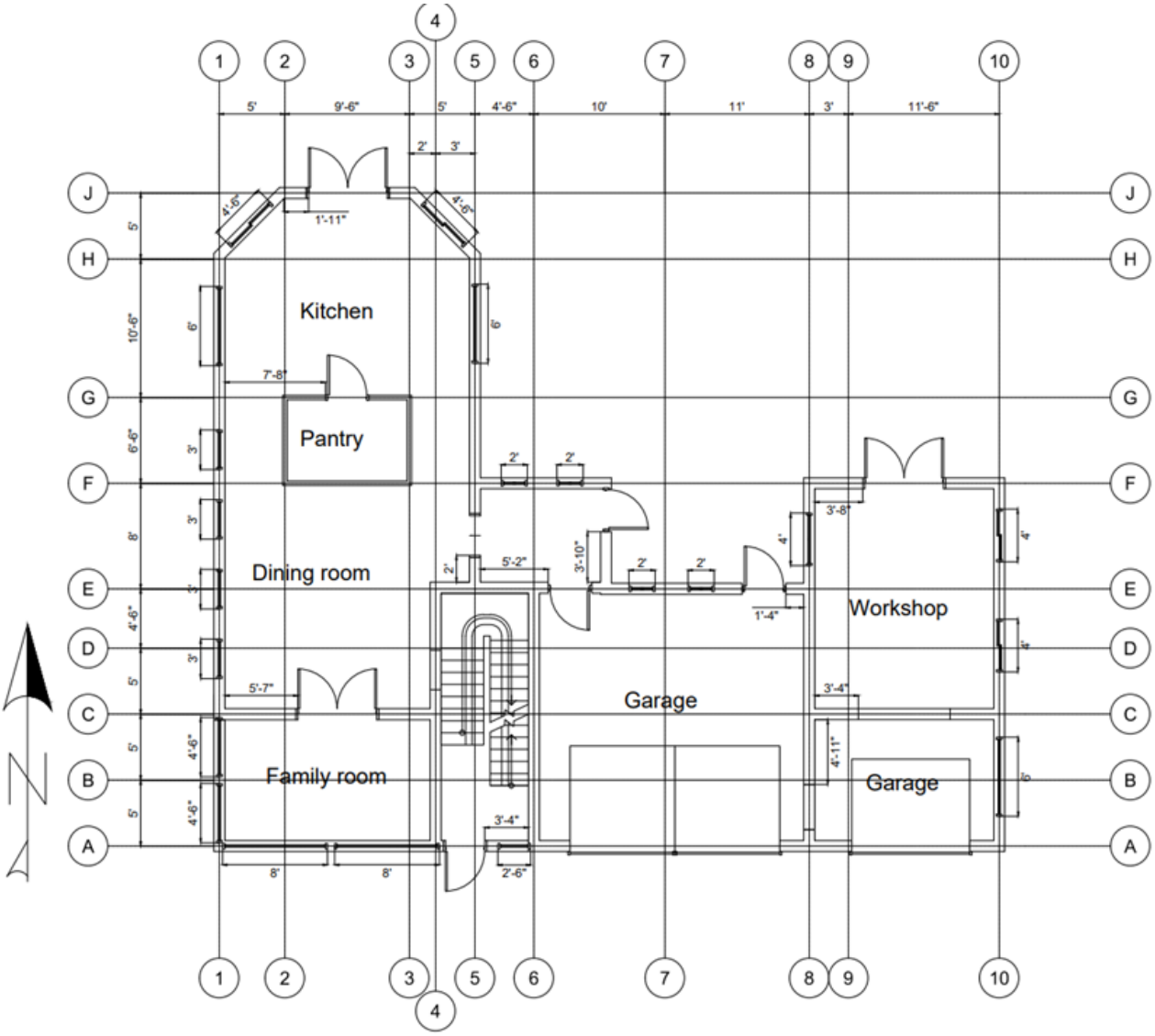

Fig. 1 Architectural plan.

Table 1 Summary of results from structural design.

Structural element	Design results
Beams	W8×10, W10×12, W12×14, W12×16, W14×22
Columns	W10×33
Foundation	Square footings, 3 pile group

single-family structure. Specifications of the project were kept according to engineering code ASCE 7-22 and ASCE 7-16. The end result of the home will include the following: 5 bedrooms, 3 full bathrooms, 1 kitchen, 1 dining room, 1 laundry room, 1 sunroom, 1 loft, 1workshop and a 3-car garage. The building will be constructed atop a hill to not only give a breathtaking view to those that reside, but a few eco-friendly solutions as well.

A visual representation of the typical floor plan of the building is provided in Fig. 1. The remaining floors contain minor modifications and adjustments such as an open ceiling on the second floor for added daylight and ventilation.

3. Structural Design

With this in consideration, steel was chosen as the main material for the building's structure due to its longer service life. While the common material used in residential construction in California is wood, and using wood for construction may have kept us on a lower budget; in the long term, steel is a better option for our design language. The added fire hazard and decay ratio of wood that comes with wooden construction as opposed to steel also lowers the sustainable standard that this project intends to follow. The specifications of the residual finish also require a more flexible structure in order to support things such as large windows for proper sunlight and ventilation control. Solar panels and rainwater recovery systems will also be put in place for added sustainability.

The team has gone through many iterations from a vacant lot to this three-storey house. Many setbacks were faced and overcame thus achieving this modern mansion design. Students have always followed quality and sustainability goals to design this LEED Silver standard house. A summary of the results from structural design of the building is presented in Table 1.

4. Design for Sustainability and LEED Design

Due to the overwhelming evidence stating that LEED buildings save significant amounts of energy and money, a high certification was striven. High certification ensures lower costs on average with data recording over 71.1% of energy saved due to green buildings when compared to industrial [7]. The purpose of this design will be to provide a sustainably efficient multi-family living space capable of offering the look and comfort of a million dollar California home. Given the following specifications, this design will achieve a Silver LEED certification from eco-friendly additives. A few of the most notable improvements are shown in Fig. 2.

5. Cost Analysis

An accurate estimate was able to be found, with the help of RSMeans, for the overall construction of the proposed project. This analysis was able to include costs accumulated from all aspects of the build ranging from the materials needed for structural integrity to furniture and other living accommodations. The cost, however, does not include any LEED specific enhancements added to the design with the goal of making it more environmentally sustainable. If we were to adjust the cost to include these adjustments, the project would see a 7.6% increase in overall cost. The great thing about being sustainable is that the added features will save the owner thousands of dollars in aspects such as energy savings throughout the lifespan of this home. Based on the findings from cost analysis, in 8.5 years time, the project will have accumulated

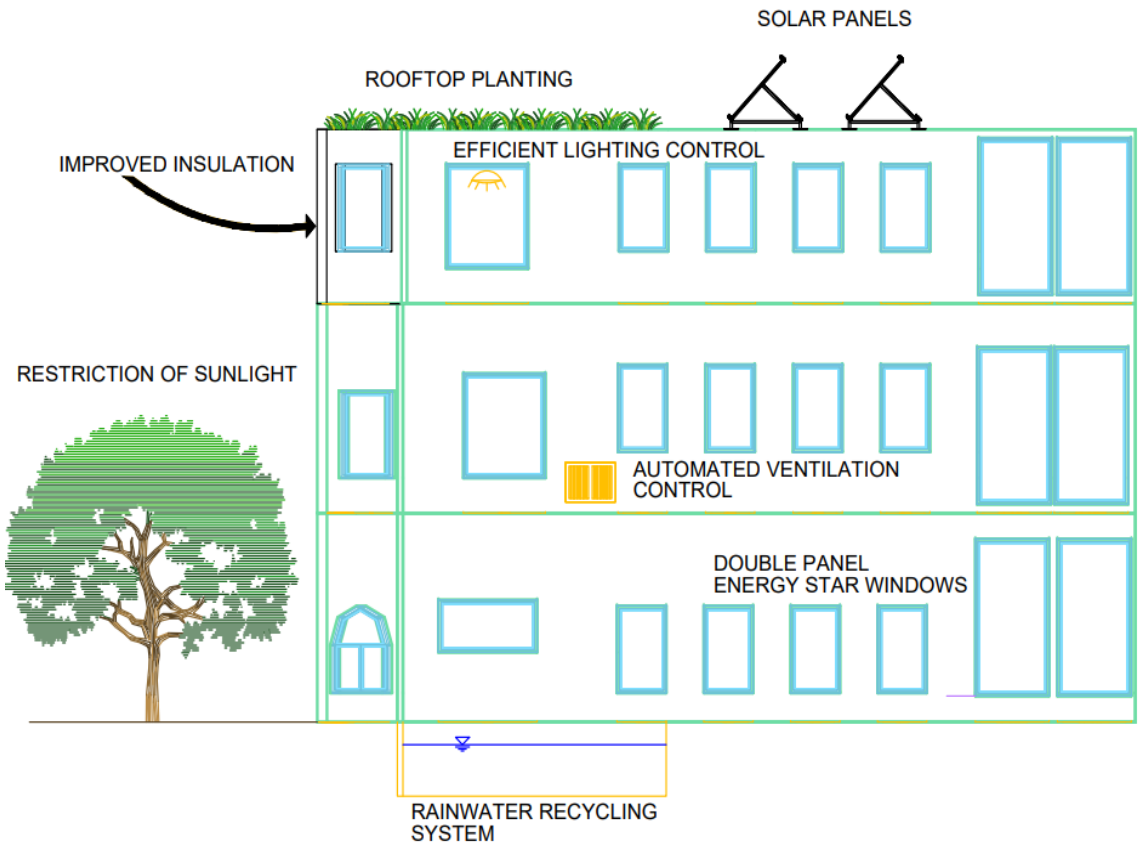

Fig. 2 Features of proposed green building.

enough savings to counteract the added costs of the LEED enhancements and begin to fully contribute to providing profits to the owner.

6. Educational Objectives

The creation of this project is beneficial in the sense that it taught the group key elements of leadership and teamwork by following the student scholar model. Along with the technical knowledge obtained by producing the results, many interpersonal skills were developed. These sets of skills are imperative and will be carried over through every individual's future occupations. By collaborating in an ethnically diverse group, the students were able to integrate all their knowledge which differs greatly in the broad subject of engineering to create a project worth taking pride in. The team of engineers are also diverse in cultures. The team is composed of Hispanic, Middle Eastern, and Chinese backgrounds. Coming together with their diversity, the team was able to incorporate knowledge from engineering studies abroad, computer software and real life experience working on the field. By working with different minded individuals, this led to a creative and unique project which stands out far greater than that which is done by the average team.

On the topic of minority, collaboration with neighboring groups has further affected the progression of research and results. A female member has been very influential in the core design and offered great practice for collaborative learning. By working together to produce exceptional results, not only are students creating a fruitful community, but also allowing the collaboration of any and all members, regardless of gender. Each member was given the chance to speak their mind freely and change anything they wished within the design which inherently gave everyone equal leadership. Equal opinion and

productivity from each student was encouraged in order to enable this leadership as well as be successful innovators in the engineering world. Further expanding on possessing a healthy community, the idea of LEED was studied and incorporated in the design of the green building. This idea further elevates the design and amplifies the distinguished idiosyncratic results of the model in comparison to others.

7. Conclusion

The purpose of this project was to design a 3-story, single-family home while both maintaining high sustainability and reducing overall cost. The research team consisting of six undergraduate civil engineering students was able to design just that, resulting in a silver LEED certification. After adding the LEED features, the cost of the conventional building saw an increase of 7.6%, which can be paid off in 8.5 years on the basis of the cost-analysis results. Overall, this research project was a huge success because soon-to-be engineers were able to connect their teachings from the last four years into real life applications. With the help of the civil engineering professor, Dr. Tadeh Zirakian, at California State University, Northridge, the students were able to provide an innovative perspective and peer into the future of sustainability.

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