Design and Implementation of the Proposed Two-Storey Multi-Purpose Green Building at Brgy. Bagong Pook, Malvar Batangas

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***Abstract*—The office of Barangay Bagong Pook in Malvar, Batangas seeks to design and construct a multi-purpose green building. This will be a two-storey structure with green innovations. The Green Design of the structure must be studied comprehensively to ensure its almost 100 percent efficiency. The Green Design 's main purpose is to be environmentally responsible and resource-efficient, taking advantage of renewable resources. To be able to adhere to the green engineering design of the project, the proponents must research on the most effective and efficient designs for each. The design project must identify the most fitting system for the situation without risking the design and safety of the people. In this project design, the group of Civil Engineering students attempted to design the green building which is intended for different purposes such as a venue for activities, a place for public and private meetings, and a building that can also serve as an evacuation center. The construction of this proposed project design has an estimated cost of Php 2,848,567.69 and can be completed in 162 days.**

Keywords*—*Efficient, effective design, green building, Green Design, multi-purpose, renewable resources, safety

INTRODUCTION

Design and implementation of building begins with an idea and culminates into a structure that may serve its occupants for several decades, even centuries. It is a very complicated, significant, and rewarding process. Buildings are assembled outdoors on all types of sites and are subject to all kinds of weather. Additionally, even a smallest-sized building must satisfy many performance criteria and legal constraints, requires an immense variety of materials, and involves a large network of design and production firms.

The ideal of green building would be a building project that would preserve most of the natural environment around the project site, while still being able to construct a building that is going to serve a purpose. The construction and operation will promote a healthy environment for all involved, and it will not disrupt the land, water, and energy resources in and around the building. Most people believe that they are able to reduce their carbon footprint and actually lend a helping hand to the environment when they choose green building. You can go green in a variety of different ways, but builders and construction workers must do their part as well. Green buildings are designed in such a way to reduce overall impact on environment and human health.

In the Philippines, a multi-purpose hall is the center of considerable activity that has facilities for indoor events, meetings, conferences, performances, and other activities. Eye-catching interior design and the ambiance are the common criteria to achieve a multi-purpose hall. It also serves as evacuation center during typhoons and other calamities especially in a country that is very prone to disasters.

Malvar is a second-class municipality situated in the northeastern part of Batangas. This town is in the 3rd Congressional District of the province. It is composed of 15 barangays and among those is Brgy. Bagong Pook. It is located in the eastern part of Barangay San Pioquinto, the east side of the municipality of Malvar, in the south, the city of Lipa, and in the west, Barangays Poblacion, Luta Norte, and San Fernando. The barangay nearby is at least three kilometers from the municipality of Malvar. The classification of the barangay is rural and the total land area is 239,9830 hectares. It has a population of 2,238 in the 2017 census and total of 504 households.

The proposed multi-purpose hall would be a much-needed addition to the Brgy. Bagong Pook landscape. With its growing population, the barangay needs to construct a venue where it will serve as the center for gatherings. At present, there is no space within the barangay

where residents can convene for assemblies, celebrations, trainings, and other activities. With the construction of the proposed multi-purpose hall, it will surely be a venue which will be used by barangay stakeholders for its social functions and gathering like assemblies, workshops, meetings, entertainments, and many others. It will provide a conducive atmosphere where the constituents and community leaders can convene to discuss important issues related to community development. Furthermore, it will enhance the social interaction among residents in order to improve and transform the living conditions of the community and provide the community a ready evacuation center during calamities.

For the proponents, the construction of the proposed multi-purpose building will be a great project and will help the residents of Brgy. Bagong Pook.

Conceptual framework

The documents involved are the site development plan, architectural and structural drawings, soil profile, loadings, codes used, structural members, and material specification. Structural members consist of footing, columns, beams, floor slabs, walls, staircase, and roofing.

The procedure used for the design analysis are AutoCAD, STAAD.Pro v8i and STAAD RCDC to have the structural and architectural plan. For the project schedule, the proponents used MindView, and for the material and labor estimates, the proponents used MS Excel.

The output is the structural and architectural design of a two-storey multi-purpose green building at Barangay Bagong Pook, Malvar, Batangas, together with the scheduling and the bills of materials.

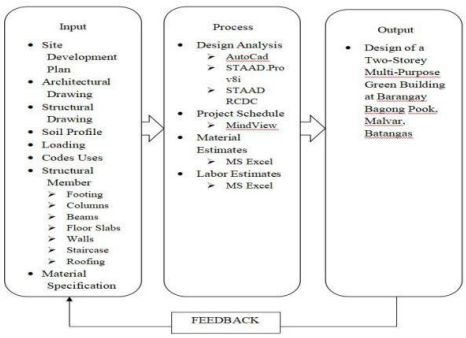

Figure 1. Research paradigm

Objectives of the study

The design project aims to make the structural design of the two-storey multi-purpose green building located at Barangay Bagong Pook, Malvar, Batangas.

Specifically, it aims to: design the complete structural and architectural design of the two-storey multi-purpose green building in Barangay Bagong Pook, Malvar, Batangas with emphasis on the design of the footings, columns, beams, floor slabs, walls, staircase, and roofing; design the structure based on the Philippine Green Building Code (PGBC); and estimate the materials, labor, and other costs to be incurred in the completion of the design project.

METHODOLOGY

The research method used by the proponents is a developmental method of research. The proposal is a progressive research that develops from time to time. Developmental research is particularly important in the field of instructional technology.

One of the tools that the proponents used was an interview with the person who leads the community so a specific problem encountered by the community will be determined. The interview guide was designed by the proponents themselves and checked by the Research Adviser.

Other tools that the proponents used were the AutoCAD, STAAD.Pro v8i and STAAD RCDC softwares, MindView software, and MS Excel. The AutoCAD was used to identify the perspective of the design project. It also has the provision to create detailed design layouts and can also identify the type of materials that would be used. The STAAD.Pro v8i was used to determine the method of designing structure easily, it does not involve any manual calculation and it is suitable for almost all types of materials for designing. Furthermore, STAAD RCDC software determines the bending moment diagram for every beam and column of the structure which is usually done manually. It is also used to identify the type of load bearing capacity of the structure. On the other hand, the MindView software is the tool for scheduling and for creating the Gantt Chart. Lastly, MS Excel was used for some calculations in the design structure and for the materials and labor estimates.

In the process of the project study, the proponents were guided by the structural provisions and regulations stated in National Structural Code of the Philippines (NSCP) 2015 and National Building Code of the Philippines (NBCP) 2015. It includes all the conditions for designing and construction of footing, column, beam, and slabs.

In this project design, the proponents used the Green Building Code as their innovative approach. They proposed a projected benefit of applying GREEN in a conventional building construction (Table 1).

Table 1. Cost-benefit analysis of applying GREEN in the project

Conventional	Proposed	Cost	Benefit
Consumption of electricity from the main supplier(Batangas II Electric Cooperative)	Installation of 7 Solar Panel	Php 178,000.00	Traditional electricity is sourced from fossil fuels such as coal and natural gas. When fossil fuels are burned to produce electricity, they emit harmful gases that are the primary cause of air pollution and global warming.
Consumption of water from the main supplier (Lipa Water District)	Rainwater harvesting	Php 38,247.50	It will reduce water bills, provide an alternative supply during water restrictions.Rainwater harvesting also decreases stormwater runoff, thereby helping to reduce local flooding and scouring of creeks.
The size of the opening shall be equal to at least ten percent (10%) of the floor area	42.45% opening of the floor area (Windows and doors)	N/A	Free cooling , fresh air , and bright light

Design constraints

Economic constraints

Taking in consideration the economic constraints, materials to be used in construction and operation of the building will be chosen to attain the lowest possible cost that will not compromise the quality and stability of the structure.

Social constraints

The construction of the proposed project could not proceed without the involvement of the people. People's opposition may arise during the construction of the project.

Environmental constraints

The environmental constraints of the proposed project include restricting factors concerning noise control, air protection, tree preservation, excavation, traffic and so on.

Health and safety constraints

These constraints include factors concerning the health and safety of the people involved in the entire construction and functional stage of the project. To prevent the occurrence of accidents, safety measures must be strictly implemented before, during, and after the construction of the proposed project.

RESULTS AND DISCUSSION

Architectural design

Codes

Section 104: General building requirements

All buildings or structures, as well as accessory facilities thereto shall conform in all respect to the principles of safe construction and must be suited to the purpose for which they are designed.

Section 401: Types of construction

For purposes of this Code, all buildings proposed for construction shall be classified or identified according to the types. Type V buildings shall be fire-resistive. The structural elements shall be of steel, iron, concrete, or masonry construction. Walls, ceilings, and permanent partitions shall be of incombustible fire-resistive construction.

Section 805. Ceiling heights

Habitable rooms provided with artificial ventilation have ceiling heights not less than 2.40 meters measured from the floor to the ceiling, provided that for buildings of more than one-storey, the minimum ceiling height of the first storey shall be 2.70 meters and that for the second storey shall be 2.40 meters.

Structural design

Dead loads

The dead load material, ceiling, and the wall, were computed based on the Section 204.2 of the NSCP 2015 while the floor was computed based on the Section 204.3. The total imposed dead load is 4.86kPa.

Table 2. Dead loads considered

Dead Load Material	Load (kPa)
Slab weight (115 thk slab)	2.76
Wall	1.1
Floor (ceramic)	1
Total	**4.86 kPa**

Live loads

The live load was based on the Table 205-1 of the NSCP 2015, since the structure is categorized as an assembly area where it has lobbies and platforms with movable seats, the given uniform load is 4.8kPa. The total imposed live load is 4.8kPa.

Table 3. Imposed live load

Live Load	Uniform Load (kPa)	Concentrated Load (kPa)
Assembly areas	4.8	0
Total	**4.8 kPa**	**0 kPa**

Seismic loads

The seismic load location of the project is in

Batangas that represent Seismic 4, the seismic load Z is 0.04.

Table 4. Seismic Consideration

Seismic Load	
Z	0.4
I	1
RWx	8.5
RWz	8.5
STYP	4
NA	1.2
NV	1.2
CT	0.0731

Factored loads

As defined in NSCP 2015 Section 203.3.1, where the load and resistance factor is used, structures and all portions thereof shall resist the most critical effects from the following combinations of factored loads:

1. U = 1.2D + 1.6L Where:
2. U = 1.2D + 0.5L + 1.6Wx D=Dead Load
3. U = 1.2D + 0.5L + 1.6Wz L=Live Load
4. U = 1.2D + 0.5L + 1.6Ex W=Wind Load
5. U = 1.2D + 0.5L + 1.6Ez E = Earthquake Load

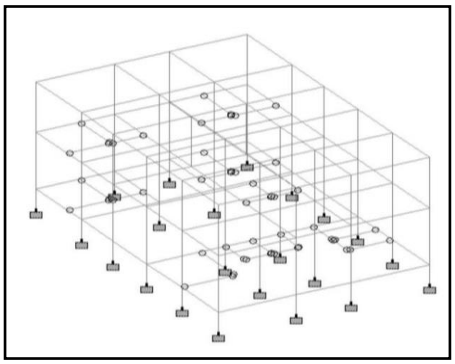

Figure 2. STAAD framing plan

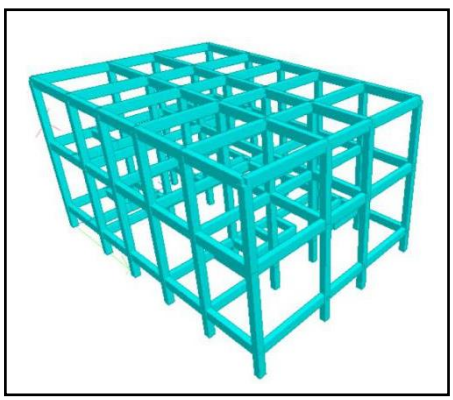

Figure 3. STAAD 3D framing plan

Philippine Green Building Code

The Green Building Code seeks to improve the efficiency of building performance through a framework of acceptable set of standards that will enhance sound environmental and resource management that will counter the harmful gases responsible for the adverse effects of climate change, throughout the building's life cycle. The Green Building Code is a set of regulations setting minimum standards for compliance and not intended to rate buildings.

CONCLUSION

The purpose of this design project is to create a structural design of a two-storey building that will satisfy the needs of the beneficiary of having a multi-purpose building that will be mainly be used as an activity and evacuation center. The building is incorporated with Green Designs that answer the difficulties and problems of pollution due to constant construction in our country.

The proponents were able to come up with the structural design of the project using STAAD that includes the design of the footing, column, beams, slabs, and walls.

This project guarantees the efficiency of imposing the Green Design in the proposed project. The Green Design's main purpose is to be environmentally responsible and resource efficient, to reduce the overall impact of the built environment on human health and the natural environment, and to take advantage of renewable resources. The design of the project comprises of the minimum requirements as stated in the NSCP 2015, the NBCP 2010, and in the Philippines Green Building Code. The structure is designed to be structurally safe and eco-friendly. It was innovated with the use of the rainwater harvesting and the green roofing with the use of solar panels. These innovations address important environmental issues and support green, sustainable growth. The building incorporated with Green Design will improve the quality of living and at the same time, reduces energy and water consumption which will cut off the costs of daily expenditures of future occupants.

In the continuous growth of the construction industry in the world, with this, people should start thinking how to save nature. Implementing Green Design would be a great help to protect the environment.

RECOMMENDATION

The researchers recommend that further study should be done to improve the design of the rainwater harvesting facility, quality of treated water for drinking, and domestic use and cost efficiency of rainwater harvesting facility.

Further studies should be done to consider more innovative applications of Green Engineering for effective ventilation system and natural lighting system of the building to improve the conservation of energy of the structure and to have more extensive analysis on the exact cost saved by Green Engineering applications. If the government would be able to finance the project, the researchers recommend for greener engineering concepts. Conducting new studies incorporating new eco-friendly materials are highly recommended.

Finally, further studies should be done for a new proposal of constructing another structure with Green Engineering applications beside the project in order to maximize the lot area. The construction of another eco-structure would help people to become aware of global warming, and at the same time, would eliminate environmental problems.

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