Structural Design of a Two-Story Commercial Building using Building Research Establishment Environmental Assessment Method (BREEAM)

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Abstract

Urban living and modernization with little assessment of environmental and future risks have been root causes of a global negative phenomena that evidently affect not only the lives of the living but mostly the main support of our whole being – nature. But as small steps of ignorance lead to a giant leap of destruction, so do small steps of awareness and action lead to a giant leap of restoration. Given the opportunity to conduct research within the locality of Calamba City, Laguna, and upon careful deliberation and keen analyzation, a team comprising of three women from Lyceum of the Philippines University – Laguna (LPU-L) produced a solution: a two-story sustainable building promoting green and quality living through passing the Building Research Establishment Environmental Assessment Method (BREEAM) Criteria of New Construction. Its design also goes beyond passing the code standards but as well as utilizing local green resources heard and unheard of and conducting various analyzation through software analyses namely CSi. A total difference of 901,569 PHP has been computed from the assessment of both the ordinary and the BREEAM project costs denoting that a project of common construction can only be 3% away from being stable, safe, and sustainable.

Keywords: environment, restoration, BREEAM, stable, safe, sustainable

I. INTRODUCTION

161 constructions – these are but the total number of certified sustainable structures ever recorded among the 40,369 of the year 2018 by the Philippine Statistics Authority (PSA) on their special report [1]. This shows that common building construction has been increasing progressively and in a much faster rate than that of sustainable ones.

On 2015, as the Philippines hit a rating of 1.3 million Filipino families (8.2 million individuals) lack income to afford basic services with 18.2 percent of Filipinos having no certain job labels [2], 3.3 million Filipino families have no access to clean and renewable water resources [3], a distribution of one public doctor to 33,000 Filipinos have been reported by the Department of Health indicating the lack of health services and only a total number 1,157 public libraries are built on different provinces, cities and municipalities within the country generating the lack of resources for rights to public knowledge [4], the researchers from Lyceum of the Philippines University – Laguna (LPU-L) has designed a commercial building called Skywalker.

Being green and being sustainable have been known to be in synonymous to one another although the difference lies on the structure's long-term performance. Green refers to the activities that provide a more efficient use of resources and minimize the harmful impact on the environment when compared to similar products while sustainability refers to activities that allow a specific problem to be solved without having diverse implications in the future. Sustainability is all about being green while green does not necessarily make something sustainable.

World statistics show that countries like Singapore and China are leading as per number of sustainable constructions with a combination of their original sustainability strategies like Green Mark and the "Three Star" Systems [5], respectively, reflecting that no matter how small or how big the area of land a country has, the act to fight pollution and increasing dilemmas of urbanization has been an ongoing investment of time and commitment that paid off for the betterment and well-being of their people.

Building Research Establishment Environmental Assessment Method (BREEAM) is a leading international sustainability rating scheme being adapted by various countries

certifying over 530,000 buildings across the building life cycle and has contributed to the strong focus on sustainability in building design, construction, and use. BREEAM is a trusted and tested effort in ensuring best environmental practice to be incorporated in the planning, design, construction and operation of buildings and the wider built environment [6].

With the aid of BREEAM International New Construction, Skywalker strives to go beyond ordinary building construction measures to achieve sustainability construction the country needs most. BREEAM is parallel to the ten Philippines Strategy for Sustainable Development (PSSD) [7] in resolving and reconciling the diverse issues arising from the country's development efforts though BREEAM is more than an in-depth study and analysis of the structure's design but as well as an assurance of the long-term effectivity in the behavioral characteristics of a building's performance.

The purpose of the structural design and analysis, Skywalker, after passing the BREEAM criteria is to soar as a three-in-one facility center (office, spaces reserved for the livelihood of the community, a library, and a cultural hall for public activities) with its implication that modernization, design and innovation does not have to cost the environment, its people and the structure's performance thus trying to prove that such practices should be mandatory in today's age and time.

Conceptual Framework

Figure 1 illustrates the Input-Process-Output (IPO) format practiced by the project. The procedure starts from the data and information gathering (input) from the reference codes and standards set by the country and the BRE to the BREEAM environmental sections that are deemed crucial in considering the project's design for the accumulation of points.

In designing the structure (process), the aid of software advancements and tools is beneficial to sustain and analyze the construction from generating the floor plans leading to the fundamental behavior of the structure upon the application of loads.

As for the design outcome produced from both the input and the process (output), the plans must be revised as often as necessary before the preparation for the presentation. The design must be rendered among the five positive BREEAM rating benchmarks (pass, good, very good, excellent, and outstanding) thus complying with the codes and standards necessary for the sustainability and serviceability of the structure.

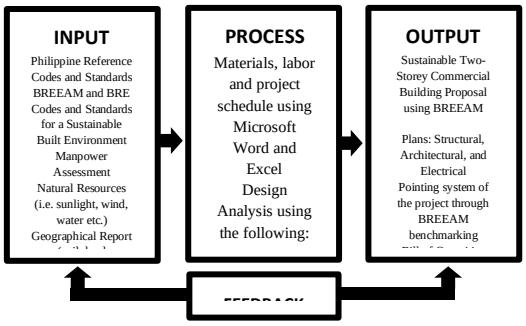

Figure 1. Research Paradigm

Objectives of the Study

The commercial building, in general, supports to develop the locality's condition correlated with health and innovation, and to maximize the efficiency of the area's production and education to the environmental optimization and advantages by applying scientific approaches to the locale's natural resources. Though it is inevitable to produce numerous objectives to be considered for this proposal specifically, the design programs seek answers to develop a safe two-story vertical commercial structure based upon the updated National Structural Code of the Philippines (NSCP), National Building Code of the Philippines (NBCP), and other reference codes applicable in the country set for the following parameters: Footings; Columns; Beams and Girders; and Slabs; design a two-storey commercial building considering the BREEAM certification assessment requirements namely: Management; Health and Well-being; Energy; Water; Transportation Materials; Land use and ecology; and Pollution; analyze the structural integrity of the structure through the use computer-aided programs; and assess the

structural design of the building in terms of: Project Schedule; and Project Cost.

II. METHODOLOGY

Research Design

In recent years, there has been a growing and evident interest in innovation as well as technology that's why people involve these two areas by making an exceptional result. Developmental research was used by the researchers in doing the study as a research method for the design of a commercial building. This type of research design involves production of knowledge with the ideal purpose of improving the processes of instructional design, development, and evaluation. Research defines as the formal, systematic application of the scientific method to the study problem and one result of its application is the creation of knowledge. For this reason, developmental research produces knowledge which is usually generated by applied research that lends itself to the immediate solution of practical problems.

Developmental research allows the researchers to apply any tool to meet the requirements. Descriptive survey methods may adopt in process studies. This design is a systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products, or devices, to installing new processes, systems, and services, or to improving substantially those already produced or installed.

Data Gathering Procedure

Figure 2 illustrates that the researchers started by brainstorming and evaluating ideas by giving insights about the study that they wanted to do. They specified first the requirements needed to bring the design the proposal in completion. The researchers analyzed whether the design satisfies the 3S namely: serviceability, strength, and stability. If the answer is "no", they need to redesign the proposal and if the answer is "yes", then they can proceed to search for related studies necessary in supporting their study. The researchers need to improve the design based on the articles, journals, reports, and books collected to analyze if the proposal follow the guidelines in achieving the BREEAM certification, if the answer is "no", then they need to go back in improving the design then if the answer is "yes", they can proceed to propose the project.

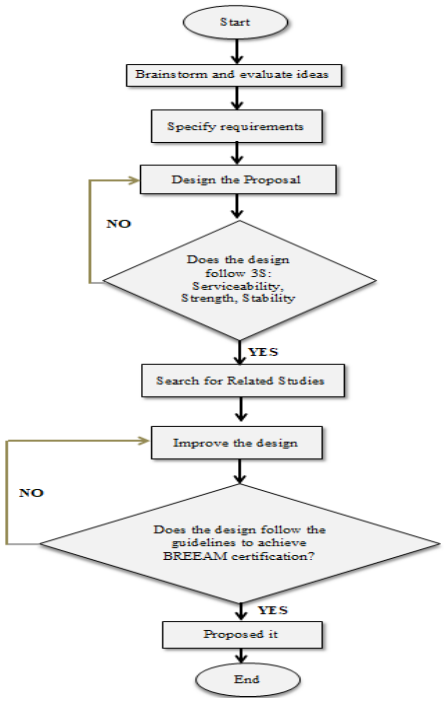

Figure 2. Flowchart of Designing a Three-Story Cultural Facility Center sing BREEAM

Design Standards

Upon the process of designing the structure, revised and updated standards from various reference codes namely the National Building Code of the Philippines (NBCP 2015), National Structural Code of the Philippines (NSCP 2015), Fire Code of the Philippines, etc. have been used as the basis to provide the minimum requirements necessary for the completion of the project. These codes are used to satisfy the serviceability, stability, and strength as well as the design and the quality of the materials to be used.

Design Constraints

As for the design of the project, inevitable limitations are defined by the following realistic constraints which are observed and known through site inspection, survey, social profile and current economic state and the availability of the resources.

Economic Constraint

Generally, economic constraint is one of the largest limiting factors in every design project. Since the researchers aims to construct a BREEAM certified building, where the budget would be coming from is a constraint.

Design Analysis

The following subsection caters the analysis of the area on which the structure will be built and its soil properties, structural behavior, and design.

Table 1. Initial Design Assessment

INITIAL DESIGN ASSESSMENT	
LOCATION SELECTION	With the help of the government office, they have given a free lot to use and analyze together with its soil sample which is summarized on the previous table. For this proposed project, *Skywalker*, they have allotted a 17,374.00 m^2 lot, specifically the open lot beside Waltermart Calamba located at Sampaguita St. Miramonte Subdivision, Pansol Calamba City 4027.
NUMBER OF FLOORS ASSESSMENT	For economical use, the simpler the design, the better. But with simplicity makes a building less interesting thereby decreasing the number of people wanting to acquire the structure especially if the proposed structure is rentable for commercial use. To eliminate the use of elevators, a two-story project has been decided doing it mostly in a horizontal projection rather than vertical to also eliminate possible settlement. No constraint for the initial sizing of the building is assessed since the land acquired by the structure versus the total land allotted is only approximately 12.59%.
STRUCTURAL MEMBERS	The structural members are designed to withstand earthquake forces as per code making it a ***Special Moment-Resisting System***.

Table 2. Cost-Benefit Analysis

Conventional	Proposed	Cost	Benefits
USE OF 6LPF WATER CLOSET AND 4LPF URINAL	INSTALLATION OF 3LPF WATER CLOSET AND WATERLESS URINALS FOR MALE RESTROOM	₱ 357,809.94	DECREASE OF WATER CONSUMPTION BY 50%
USE OF ELECTRICAL LIGHTS IN HALLWAY	INSTALLATION OF SKYLIGHTS	₱ 21,646.46	DECREASE IN CONSUMPTION OF ELECTRICAL POWER UP TO 74%
USE OF NORMAL AIR CONDITITIONING UNIT	INSTALLING AN AIR CONDITIONING UNIT THAT SAVES ENERGY	₱ 517,470.00	DECREASE IN CONSUMPTION OF ELECTRICAL POWER UP TO 26% AND SAVE UP TO 12% OF THE ORIGINAL TOTAL COST OF USING ORDINARY ACU
INSTALLING ORDINARY TYPE OF DOORS	INSTALLATION EFCO-DOOR & TIMBER	₱ 206,607.60	PROVIDE AN ALTERNATIVE MATERIAL FOR ORDINARY TYPE OF DOORS WHICH CONFORMS WITH HEALTH, SAFETY, AND ENVIRONENTAL PROTECTION
PLYWOOD ORDINARY	PLASFORM FORMWORK PANELS	₱ 1,193,173.48	DECREASE UP TO 74% OF THE TOTAL COST OF USING PLYWOOD AS A CONVENTIONAL FORMWORK
PLANTS USED FOR AESTHETIC VALUE	SPECIFIC PLANTS THAT REQUIRES LESS MAINTENANCE	₱ 11,250.00	DECREASE IN INSTALLATION OF PLANTS BY 30% AND CAN SAVE WATER COSUMPTION UP TO 71% PER YEAR

III. RESULTS AND DISCUSSIONS

Complying with the Local and International Standards for the Design and Loads

Table 3. Building Footprint

BUILDING FOOTPRINT	
NAME OF PROJECT	SKYWALKER (Commercial Building)

NUMBER OF PHYSICAL FLOORS	Two (2) comprising of the following: **(a) Ground Floor (Slab-on-grade)** - Elevation: 600 mm from the N.G.L. **(b) Roof Slab** -Elevation: 4650 mm (F.F.L.) from the Ground Floor
AREAS	**Ground Floor**: 2188.70 m^2 (Garden Exclusive) **Roof Slab**: 1959.20 m^2 (Garden Inclusive)
LOADS CARRIED BY THE ROOF SLAB	There are five loads considered acting on the proposed structure: ***Frame Loads:*** **(a) Dead Loads and Superimposed Dead Loads** - Self-weight (ETABS generated) - Masonry using 150 mm CHB Walls with 2 faces: **CONCRETE MASONRY UNITS** Hollow Concrete Masonry Units Unplastered. Add 0.24 kPa for each face plastered

Grout Spacing	Wythe thickness (mm) 100	150	200
16.5-kN/m³ Density of Unit			
No grout	1.05	1.15	1.48
800	1.40	1.53	2.01
600	1.50	1.63	2.20
400	1.79	1.92	2.54
Full	2.50	2.63	3.59
19.6-kN/m³ Density of Unit			
No grout	1.24	1.34	1.72
800	1.59	1.72	2.25
600	1.69	1.87	2.44
400	1.98	2.11	2.82
Full	2.69	2.82	3.88
21.2-kN/m³ Density of Unit			
No grout	1.39	1.44	1.87
800	1.74	1.82	2.39
600	1.83	1.96	2.59
400	2.13	2.2	2.92
Full	2.84	2.97	3.97

	Computation (Excel): **MASONRY** CHB | VALUE | UNIT | OUTPUT | UNIT UNIT LOAD FOR WALL | 2.63 | KPA UNIT LOAD FOR PLASTER | 0.24 | KPA | 3.11 | KN/M THICKNESS | 0.15 | M FACES | 2 **(b) Live Loads (Reducible, Non-Reducible, Roof)** -Stairs Computation (Excel): **STAIRS** NO. | LL | UNIT | LENGTH | UNIT | OUTCOME | UNIT 1 | 4.8 | KPA | 0.8 | M | 17.024754 | KN/M 2 | | | 6.293648 | M ***Shell Loads:*** **(a) Dead Loads and Superimposed Dead Loads** -Self-weight (ETABS generated) -Roof Slab Load Code Referral: Total Superimposed Dead Load= 2.52 kPa (Inclusive of the toppings/finished, ceiling utilities, and water proofing) -Planter's Box Formula: **OTHER LOADING CONSIDERATIONS** PLANTER'S BOX/ TREE PITS (SDL=kPa) = (UNIT WEIGHT OF SOIL)*(DEPTH) OVERHEAD WATER TANKS (LL=kN) = (UNIT WEIGHT OF WATER)*(BASE AREA) ESCALATOR (LL = kN) = [23.54]*0.4*(WIDTH)*(SLANT LENGTH)*1/2 PARTITION LOADING (SDL = kN/M) = (23.54)*(THICKNESS)*(CLEAR HEIGHT) Computation (Excel): **PLANTER'S BOX** UNIT WEIGHT OF SOIL | UNIT | DEPTH | UNIT | OUTCOME | UNIT 18 | kN/m^3 | 0.5 | M | 9 | kPa **(b) Live Load (Reducible, Non-Reducible, Roof)** Since the designed function of the proposed slab is for assembly of crowd garnering a Live

Load value of 4.8 kPa, therefore according to the National Structural Code of the Philippines, Chapter II Section 205.5:

"*… may be reduced on any member supporting more than* $15\ m^2$*, including flat slabs,* ***except for floors in places of public assembly and for live loads greater than 4.8 kPa****…"*

LOAD COMBINATIONS

SERIES 100: LFRD Design Load Combination

LOAD COMBINATION
SERIES 100: LFRD DESIGN LOAD COMBINATION
101 1.4(DL + SDL)
102 1.2(DL + SDL) + 1.6(LL_R + LL_NR) + 0.5LL_ROOF
103 1.2(DL + SDL) + 1.6LL_ROOF + 0.5LL_R + 1.0LL_NR
104 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQx + 0.3EQy
105 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQx - 0.3EQy
106 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQx + 0.3EQy
107 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQx - 0.3EQy
108 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQy + 0.3EQx
109 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQy - 0.3EQx
110 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQy + 0.3EQx
111 1.42(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQy - 0.3EQx
112 0.68(DL + SDL) + 1.0EQx + 0.3EQy
113 0.68(DL + SDL) + 1.0EQx - 0.3EQy
114 0.68(DL + SDL) - 1.0EQx + 0.3EQy
115 0.68(DL + SDL) - 1.0EQx - 0.3EQy
116 0.68(DL + SDL) + 1.0EQy + 0.3EQx
117 0.68(DL + SDL) + 1.0EQy - 0.3EQx
118 0.68(DL + SDL) - 1.0EQy + 0.3EQx
119 0.68(DL + SDL) - 1.0EQy - 0.3EQx

SERIES 200: Seismic Drift Check Load Combinations

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201 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQx + 0.3EQy
202 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQx - 0.3EQy
203 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQx + 0.3EQy
204 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQx - 0.3EQy
205 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQy + 0.3EQx
206 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQy - 0.3EQx
207 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQy + 0.3EQx
208 1.2(DL + SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQy - 0.3EQx
209 0.9(DL + SDL) + 1.0EQx + 0.3EQy
210 0.9(DL + SDL) + 1.0EQx - 0.3EQy
211 0.9(DL + SDL) - 1.0EQx + 0.3EQy
212 0.9(DL + SDL) - 1.0EQx - 0.3EQy
213 0.9(DL + SDL) + 1.0EQy + 0.3EQx
214 0.9(DL + SDL) + 1.0EQy - 0.3EQx
215 0.9(DL + SDL) - 1.0EQy + 0.3EQx
216 0.9(DL + SDL) - 1.0EQy - 0.3EQx

SERIES 300: Wind Drift Check Load Combination

SERIES 300: WIND DRIFT CHECK LOAD COMBINATION
301 1.2(DL+SDL) + 1.6(LL_R) + 0.5WL + X
302 1.2(DL+SDL) + 1.6(LL_R) + 0.5WL - X
303 1.2(DL+SDL) + 1.6(LL_R) + 0.5WL + Y
304 1.2(DL+SDL) + 1.6(LL_R) + 0.5WL - Y
305 1.2(DL+SDL) + 0.5(LL_R) + 0.5WL + X
306 1.2(DL+SDL) + 0.5(LL_R) + 0.5WL - X
307 1.2(DL+SDL) + 0.5(LL_R) + 0.5WL + Y
308 1.2(DL+SDL) + 0.5(LL_R) + 0.5WL - Y
309 0.9(DL+SDL) + 1.0WL + X
310 0.9(DL+SDL) + 1.0WL - X
311 0.9(DL+SDL) + 1.0WL + Y
312 0.9(DL+SDL) + 1.0WL - Y
313 1.0(DL+SDL) + 0.5(LL_R+LL_NR+LL_ROOF) + WL +X
314 1.0(DL+SDL) + 0.5(LL_R+LL_NR+LL_ROOF) + WL - X
315 1.0(DL+SDL) + 0.5(LL_R+LL_NR+LL_ROOF) + WL + Y
316 1.0(DL+SDL) + 0.5(LL_R+LL_NR+LL_ROOF) + WL - Y

SERIES 400: Service Load Combination – For Footing Design

SERIES 400: SERVICE LOAD COMBINATION - FOR FOOTING DESIGN
401 1.0(DL + SDL) + 1.0(LL_R + LL_NR + LL_ROOF)
402 1.0(DL + SDL) + 0.75(LL_R + LL_NR + LL_ROOF) + 0.535EQx
403 1.0(DL + SDL) + 0.75(LL_R + LL_NR + LL_ROOF) - 0.535EQx
404 1.0(DL + SDL) + 0.75(LL_R + LL_NR + LL_ROOF) + 0.535EQy
405 1.0(DL + SDL) + 0.75(LL_R + LL_NR + LL_ROOF) - 0.535EQy
406 0.6(DL + SDL) + 0.7EQx
407 0.6(DL + SDL) - 0.7EQx
408 0.6(DL + SDL) + 0.7EQy
409 0.6(DL + SDL) - 0.7EQy
410 1.0(DL + SDL) + 1.0(LL_R + LL_NR + LL_ROOF) + 0.7IEQx
411 1.0(DL + SDL) + 1.0(LL_R + LL_NR + LL_ROOF) - 0.7IEQx
412 1.0(DL + SDL) + 1.0(LL_R + LL_NR + LL_ROOF) + 0.7IEQy
413 1.0(DL + SDL) + 1.0(LL_R + LL_NR + LL_ROOF) - 0.7IEQy

SERIES 500: Ultimate Load Combination – For Footing Design

SERIES 500: ULTIMATE LOAD COMBINATION - FOR FOOTING DESIGN
501 1.4(DL+SDL)
502 1.2(DL+SDL) + 1.6(LL_R+LL_NR) + 0.5LL_ROOF
503 1.2(DL+SDL) + 1.6LL_ROOF + 0.5LL_R + 1.0LL_NR
504 1.2(DL+SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0 EQx
505 1.2(DL+SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQx
506 1.2(DL+SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR + 1.0EQy
507 1.2(DL+SDL) + 0.5LL_R + 0.5LL_ROOF + 1.0LL_NR - 1.0EQy
508 0.9(DL+SDL) + 1.0EQx
509 0.9(DL+SDL) - 1.0EQx
510 0.9(DL+SDL) + 1.0EQy
511 0.9(DL+SDL) - 1.0EQy

IRREGULARTIES

There are two main types of irregularities as per ***National Structural Code of the Philippines (NSCP 2015) Chapter 2***:

(a) Vertical Irregularities
-There is no analyzed vertical irregularity found on the proposed structure eliminating the need to use Response Spectrum Analysis (RSA).

(b) Horizontal Irregularities
-One subcategory of horizontal irregularities was found present on the proposed structure:

	b.1. Nonparallel systems irregularity ***Solution:*** Using 100x + 30y in Modal Analysis

BREEAM New Construction

Table 4. Summary of BREEAM Achievements for Health and Well-being

Hea 01 Visual Comfort	Designing of windows based on the distance from the workplace with equivalent percentage.	1	1.60%	-
Hea 02 Indoor Air Quality	Complying with the Philippine Green Building Code Minimum Ventilation rates in Breathing Zones	1		-
Hea 03 Safe Containment in Laboratories	-	-		-
Hea 04 Thermal Comfort	-	-		-
Hea 05 Acoustic Performance	-	-		-
Hea 06 Security	-	-		-
Hea 07 Safe and Healthy Surrounding	Design of safe cycle paths, safe footpaths, pedestrian drop-offs that should have direct access to the footpaths, and the outside space.	2		-

Table 5. Summary of BREEAM Achievements for Transportation

Tra 01 Transport Assessment and Travel Plan	To reward awareness of existing local transport and identify improvements to make it more sustainable.	2	11.50%	
Tra 02 Sustainable Transport Measures	To maximize the potential for local public, private and active transport through provision of sustainable transport measures appropriate to the site.	10		₱12,700.00

Table 6. Summary of BREEAM Achievements for Management

ACHIEVED BREEAM CRITERIA	CONSIDERED PARAMETERS	EQUIVALENT CREDIT SCORE	EQUIVALENT PERCENTAGE OF CREDIT	COST
Man 01 Project Brief and Design	-	0	0.52%	-
Man 02 Life Cycle Cost and Service Life Planning	-	0		-
Man 03 Responsible Construction Practices	Assigning an individual in monitoring and recording data of energy and water consumption from construction phase.	1		-
Man 04 Commissioning and Handover	-	0		-
Man 05 Aftercare	-	0		-

Table 7. Summary of BREEAM Achievements for Materials

Mat 01 Environmental Impacts from Construction Products - Building Life Cycle Assessment (LCA)	-	-	0%	-
Mat 02 Environmental Impacts from Construction Products - Environmental Product Declarations (EPD)	-	-		-
Mat 03 Responsible Sourcing of Construction Products	-	-		-
Mat 04 Insulation	-	-		-
Mat 05 Designing for Durability and Resilience	-	-		-
Mat 06 Material Efficiency	-	-		-

Table 8. Summary of BREEAM Achievements for Water

Wat 01 Water Consumption	Comply with the Wat 01 calculator provided by BREEAM	4	6.22%	-
Wat 02 Water Monitoring	Placing of water meter, sub-water meter for monitoring of the building's water consumption.	1		
Wat 03 Water Leak Detection	Installing of leak detection system and flow control devices.	2		₱36,006.44
Wat 04 Water Efficient Equipment	Installing of waterless urinals for male restroom and water closets with 3 liters per flush	1		₱323,984.52

Table 9. Summary of BREEAM Achievements for Energy

Ene 01 Reduction of Energy Use and Carbon Emissions	Achieving full credit for Ene 02	2	2.71%	-
Ene 02 Energy Monitoring	Monitoring of energy through energy meter for every room of tenancy areas	2		-
Ene 03 External Lighting	-	-		-
Ene 04 Low Carbon Design	-	-		-
Ene 05 Energy Efficient Cold Storage	-	-		-
Ene 06 Energy Efficient Transportation Systems	-	-		-
Ene 07 Energy Efficient Laboratory Systems	-	-		-
Ene 08 Energy Efficient Equipment	To encourage installation of energy efficient equipment to ensure optimum performance and energy savings in operation.	2		

Table 10. Summary of BREEAM achievements for Waste Management

Wst 01 Construction Waste Management	-	-	2.55%	-
Wst 02 Use of Recycled and Sustainably Sourced Aggregates	Importing of recycled aggregates for construction from off-site locations.	1		-
Wst 03 Operational Waste	Purchasing of recyclable and non recyclable labeled trash bins that will be placed in accessible areas in the building.	1		-
Wst 04 Speculative Finishes (Offices Only)	Avoid finishing of ceilling and placing of carpets to tenanted rooms to avoid waste	1		-
Wst 05 Adaptation to Climate Change	-	-		-
Wst 06 Design for Disassembly and Adaptability	Recommendations based on the study that aim to enable and facilitate disassembly and functional adaptation.	1		-

Table 11. Summary of BREEAM Achievements for Land Use and Ecology

LE 01 Site Selection	Investigation for contaminated land and implementation of the prevention.	1	1.15%	-
LE 02 Ecological Risk and Opportunities	-	-		-
LE 03 Managing Impacts on Ecology	-	-		-
LE 04 Ecological Change and Enhancement	-	-		-
LE 05 Long Term Ecological Management and Maintenance	-	-		-

Table 12. Summary of BREEAM Achievements for Pollution

Pol 01 Impact of Refrigerants	-	-	3.75%	-
Pol 02 Local Air Quality	Prevention of usage of combustion system in supplying for heating and hot water. It shoud be powered by electricity only	2		-
Pol 03 Flood and Surface Water Management	Assessing flood hazards in the Municipality of Calamba, Laguna	1		-
Pol 04 Reduction of Night Time Light Pollution	Safety or security lighting is provided and will be used in limited hours	1		-
Pol 05 Reduction of Noise Pollution	To reduce the likelihood of noise arising from fixed installations on the new development affecting nearby noise-sensitive buildings.	1		-
Inn 01 Innovation	-	-	0%	-

Table 13. Tally of Points and Percentage

TOTAL		**41**	**30.00%**	**372690.96**

Structural Integrity

Using computer-aided programs namely ETABS and SAFE and with the design's passing of the code standards and BREEAM criteria, the building has undergone simulations for both earthquake and wind for the superstructure.

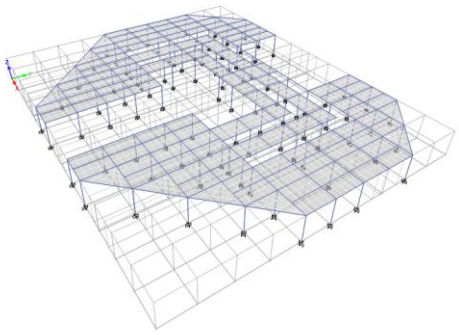


Figure 3. ETABS Framing Plan

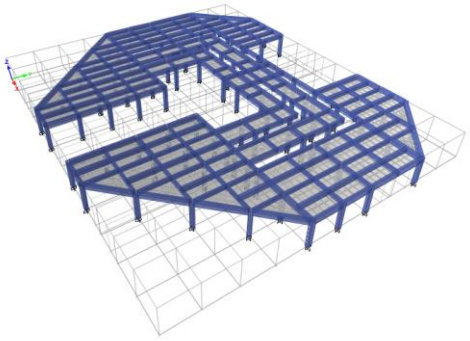
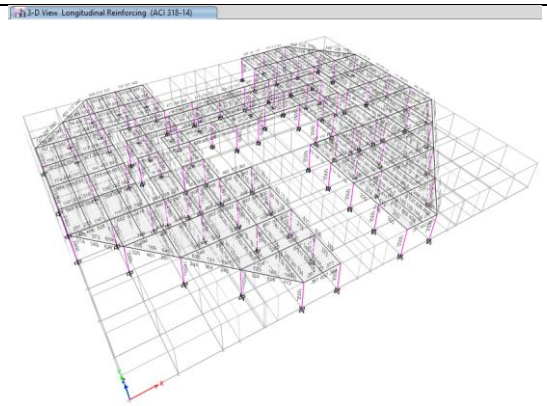


Figure 4. ETABS 3D Framing Plan

Table 14. Earthquake Assessment Results

EARTHQUAKE SIMULATION	
Objective: to ensure the structural integrity of the proposed structure under seismic forces.	
Description	**Outcome**
Static Base Shear	Manual Calculation and Program Calculated Value are the same.
Displacement	Passed
Story Drifts	Passed
Conclusion:	

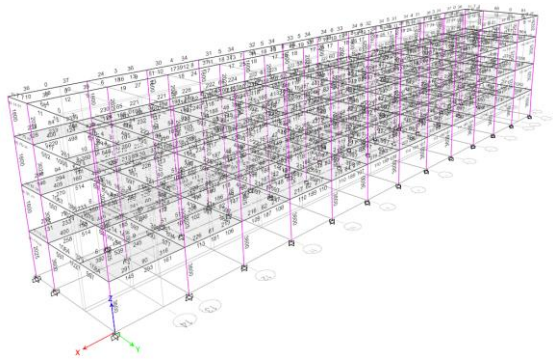


Magenta-colored system defines the passing of a reinforced concrete structure thus rendering the economical outcome that could be generated.

The proposed two-story commercial structure *passed* the analysis under seismic conditions.

Table 15. Wind Assessment Results

WIND SIMULATION	
Objective: to ensure the structural integrity of the proposed structure under wind forces	
Description	**Outcome**
Displacement	Passed
Story Drifts	Passed
Conclusion:	



Magenta-colored system defines the passing of a reinforced concrete structure thus rendering the economical outcome that could be generated.

The proposed two-story commercial structure passed the analysis under seismic conditions.

Table 16. Comparative Assessment of earthquake and Wind for Foundation Use

ASSESSMENT OF BOTH THE EARTHQUAKE AND WIND SIMULATIONS					
Objective: to distinguish which of the two forces has the higher value of displacement to be used for the analyzation of foundations.					
Earth quake	*MAXIMUM ACTUAL DISPLACEMENT, Δs*	4.38	**Wind**	*MAXIMUM ACTUAL DISPLACEMENT, Δs*	0.16
	MAXIMUM ACTUAL DRIFT, ΔM	0.00		*MAXIMUM ACUAL DRIFT, ΔM*	0.00
Conclusion	Since the value of displacement given by seismic loads are higher than that of the wind, its value governs since it deflects the building by ***23.2%*** compared to ***0.862%*** effect of the wind. Therefore, foundation analysis due to earthquake forces shall be used.				

Foundation:

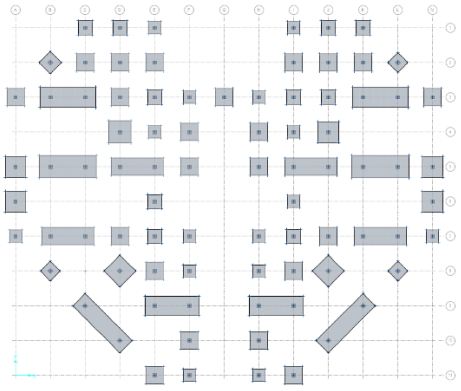


Figure 5. Foundation Layout

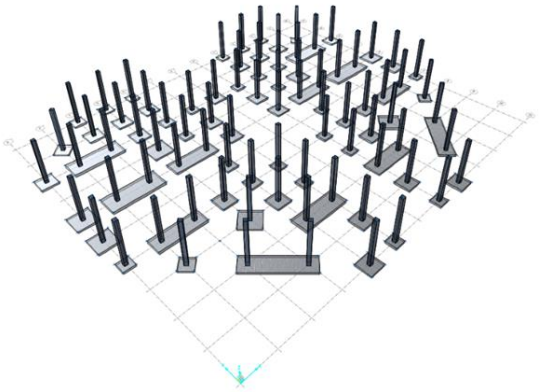
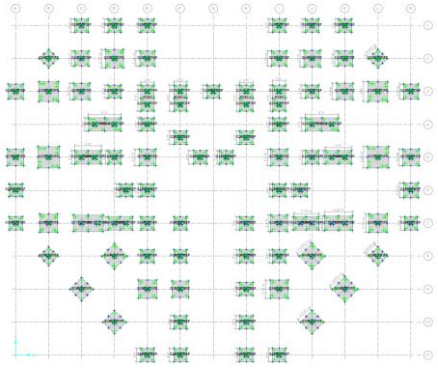


Figure 6. Foundation 3D Layout

Table 17. Foundation Analysis Results

FOUNDATION	
Objective: to ensure the structural integrity of the foundation to be used for the proposed structure	
Description	**Outcome**
Soil Pressure	Footing Sizes Passed
Punching or Two-Way Shear	Thickness Passed
Conclusion:  The proposed design for foundation thereby *passed* the assessment.	

Slab:

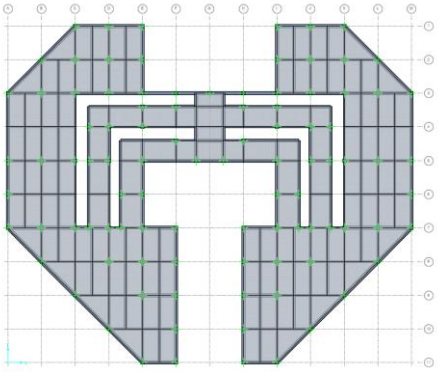


Figure 7. Slab Plan

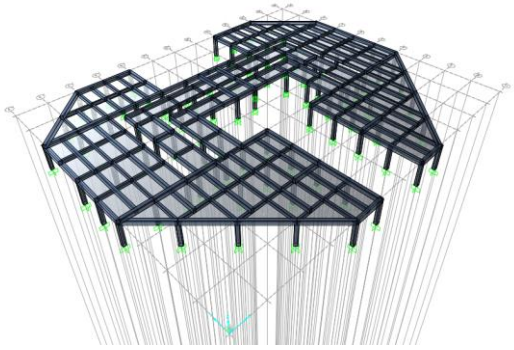
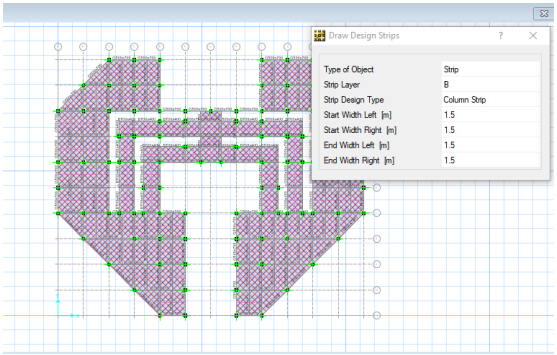


Figure 8. Slab 3D Plan

Table 18. Slab Analysis

SLAB	
Objective: to ensure the structural integrity of the slab to be used for the proposed structure	
Description	**Outcome**
Deflection Limit	Passed
Conclusion:  The proposed design for slab thereby *passed* the assessment.	

Evaluation of Project Cost and Schedule

Table 19. Bill of Quantities for Ordinary Assessment (Pre-construction and Construction Phases)

	BILL OF QUANTITIES ORDINARY ASSESSMENT (EXCLUSION OF THE GARDEN)												
	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COST				TOTAL COST				GRAND TOTAL	
				MATERIAL		LABOR		MATERIAL		LABOR			
A.	PRE-CONSTRUCTION												
I.	SOIL INVESTIGATION		1									30,000	PHP
II.	PLANS, DOCUMENTATION AND FEES	SETS	1									150000	PHP
II.	MOBILIZATION/DEMOBILIZATION	LOT	1									100,000	PHP
III.	OPERATIONS AND MAINTENANCE OF TEMPORARY FACILITIES AND REMARKS (SITE OFFICE, COMFORT ROOMS, WAREHOUSE, REMOTE BARRACKS)	MONTHS											
IV.	TEMPORARY FENCE	LOT	1									75000	PHP
V.	SAFETY AND HEALTH	LOT	1									150000	PHP
VI.	SITE SUPERVISION	LOT	1									40000	PHP
VII.	OPERATIONAL OVERHEAD	LOT	1									25000	PHP
B.	CONSTRUCTION PHASE												
B.I	EARTHWORKS												
I.	CLEARING AND GRUBBING	SQ.M.	2,698			20	PHP			53958.351	PHP	53958.35058	PHP
II.	SURVEY	SQ.M.	2,699			20	PHP			53978.351	PHP	53978.35058	PHP
III.	STRUCTURAL EXCAVATION	CU.M.	3,511			400	PHP			1404400	PHP	1404400	PHP
IV.	BACKFILL AND COMPACTION	CU.M.	694.0831			200	PHP			138816.62	PHP	138816.62	PHP
V.	GRAVEL BEDDING	CU.M.	9.73125	820	PHP	246	PHP	7979.625	PHP	2393.8875	PHP	10373.5125	PHP
B.II	TERMITE CONTROL WORKS												
VII.	SOIL POISONING	SQ.M.	2,210	320	PHP	96	PHP	707200	PHP	212160	PHP	919360	PHP
B.II	CONCRETE WORKS												
I.	REINFORCED CONCRETE												
	R.C. COLUMN FOOTING (ISOLATED AND COMBINED)	CU.M.	148.5047	4730	PHP	1419	PHP	702427.23	PHP	210728.17	PHP	913155.4003	PHP
	R.C. FOR SLAB-ON-GRADE	CU.M.	1313.193122	4730	PHP	1419	PHP	6211403.5	PHP	1863421	PHP	8074824.507	PHP
	R.C. FOR 4500X500X500 MM COLUMN (S.O.G. - ROOF SLA	CU.M.	109.125	4730	PHP	1419	PHP	516161.25	PHP	154848.38	PHP	671009.625	PHP
	R.C. FOR 300X600 MM GIRDER	CU.M.	93.6	4730	PHP	1419	PHP	442728	PHP	132818.4	PHP	575546.4	PHP
	R.C. FOR GIRDER, 500MM X 700MM	CU.M.	144.14848	4730	PHP	1419	PHP	681822.31	PHP	204546.69	PHP	886369.0035	PHP
	R.C. FOR BEAM, 400MM X 700MM	CU.M.	94.78	4730	PHP	1419	PHP	448309.4	PHP	134492.82	PHP	582802.22	PHP
	R.C. FOR ROOF SLAB	CU.M.	1175.468168	4730	PHP	1419	PHP	5559950.2	PHP	1667985.1	PHP	7227935.318	PHP
II.	STEELWORKS	KG	63775.63	32	PHP	9.6	PHP	2040820.2	PHP	612246.05	PHP	2653066.208	PHP
B.III	FORMWORKS												
	PLYWOOD ORDINARY, 1/4"x4'x8' PLYWOOD ORDINARY, 1/2"x4'x8'	SQ. M.	1034.116807	100	PHP			103411.68	PHP	84	PHP	103411.6807	PHP
	USED OIL	GAL	244	40	PHP			9760	PHP		PHP	9760	PHP
	CW NAIL, ASSORTED	KG.	24	60	PHP			1440	PHP		PHP	1524	PHP
B.IV	MASONRY WORKS												
	150 MM THK. CHB WALLS	PC.	3816	15	PHP	156.51	PHP	57240	PHP	597242.16	PHP	654482.16	PHP
B.V	FABRICATED MATERIALS AND HARDWARES	UNIT	103					197540	PHP			197540	PHP
B.VI	FINISHING WORKS	UNIT										32560.5	PHP
BVII.	CARPENTRY WORKS	SQ. M.	615	410.96	PHP	123.29	PHP	252740.4	PHP	75823.35	PHP	328563.75	PHP
BVIII.	PAINTING WORKS												
	WOODEN PAINTING AND METAL PAINTING												
	QUICK DRY ENAMEL, WHITE	GAL	0.5	540	PHP	32.16		270	PHP	32.16	PHP	302.16	PHP
	QUICK DRY ENAMEL, CHOCO BROWN	GAL	1	430	PHP			430	PHP	32.16	PHP	462.16	PHP
	MASONRY PAINTING												
	PERMACOAT LATEX, TULLE WHITE	GAL	50	486	PHP	22.11		24300	PHP	1105.5	PHP	25405.5	PHP
	PERMACOAT LATEX, CHOCOLATE BROWN	GAL	10	430	PHP			4300	PHP	221.1	PHP	4521.1	PHP
BIX.	ELECTRICAL WORKS												
	CONDUITS, BOXES AND FITTING	UNIT										150000	PHP
	CIRCUIT BREAKER 100A 2P	SET	2	650	PHP			1300	PHP	15750	PHP	1300	PHP
	LIGHTING FIXTURES	SET	54	75	PHP			4050	PHP			4050	PHP
	SAFETY SWITCH 30A 2P	SET	2	603.25	PHP			1206.5	PHP			1206.5	PHP
	FIRE ALARM BELL, VIBRATING TYPE	SET	10	2000	PHP			20000	PHP			20000	PHP
	FIRE ALARM STATION, MANUAL SINGLE ACTION	SET	20	2010	PHP			40200	PHP			55950	PHP
	ELECTRICAL TAPE	ROLL	25	37.5	PHP			937.5	PHP			937.5	PHP
	RUBBER TAPE	ROLL	25	100	PHP			2500	PHP			2500	PHP
BX.	PLUMBING WORKS												
	SEWER LINE WORKS	L.S.	1					23700	PHP	7110	PHP	30810	PHP
	SANITARY FIXTURES	L.S.	1					192000	PHP	57600	PHP	249600	PHP
	DOWNSPOUT/STORM DRAINAGE	L.S.	1					5800	PHP	1740	PHP	7540	PHP
	COLD WATERLINE WORKS	L.S.	1					56000	PHP	16800	PHP	72800	PHP
	WATER CLOSET WITH ACCESSORIES, ORDINARY	SET	21	13269.648	PHP			278662.61	PHP			278662.608	PHP
	URINAL, ORDINARY	SET	8	8039.05	PHP			64312.4	PHP			64312.4	PHP
	MIRROR	SQ. FT.	100	100	PHP			10000	PHP			10000	PHP
	FAUCET, LAVATORY	SET	800	1250	PHP			1000000	PHP			1000000	PHP
	WATER PUMP 1 HP	SET	2	9094.73	PHP			18189.46	PHP			18189.46	PHP
BXI.	SANITARY WORKS												
	CATCH BASIN	UNIT	12	1500	PHP			18000	PHP	57600	PHP	75600	PHP
	THREE CHAMBER SEPTIC VAULT	UNIT	1	42878.52	PHP			42878.52	PHP			42878.52	PHP
BXII.	WATERPROOFING												
	WATERPROOFING, CEMTITIOUS	GAL	270	500	PHP			135000	PHP			135000	PHP
	WATERPROOFING, ELASTOMERIC	GAL	125	400	PHP			50000	PHP			50000	PHP
	TOTAL (WITH 10% CONTINGENCY)											31166195.52	PHP
	TOTAL (WITH 12%VAT AND 10% CONTINGENCY)											34,556,144	PHP

Total Cost (with 10% Contingency): 31,166,195.52 PHP
Total Cost (with 12% VAT and 10% Contingency): 34,556,144.00 PHP

Table 20. Bill of Quantities for BREEAM Assessment

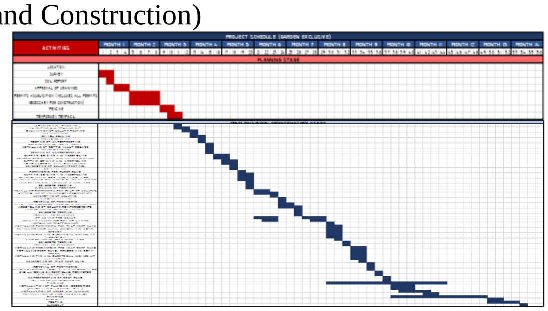
	BILL OF QUANTITIES BREEAM ASSESSMENT (EXCLUSION OF THE GARDEN)												
	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COST				TOTAL COST				GRAND TOTAL	
				MATERIAL		LABOR		MATERIAL		LABOR			
A.	PRE-CONSTRUCTION												
I.	SOIL INVESTIGATION		1									30,000	PHP
II.	PLANS, DOCUMENTATION AND FEES	SETS	1									150000	PHP
II.	MOBILIZATION/DEMOBILIZATION	LOT	1									100,000	PHP
III.	OPERATIONS AND MAINTENANCE OF TEMPORARY FACILITIES AND REMARKS (SITE OFFICE, COMFORT ROOMS, WAREHOUSE, REMOTE BARRACKS)	MONTHS											
IV.	TEMPORARY FENCE	LOT	1									75000	PHP
V.	SAFETY AND HEALTH	LOT	1									150000	PHP
VI.	SITE SUPERVISION	LOT	1									40000	PHP
VII.	OPERATIONAL OVERHEAD	LOT	1									25000	PHP
B.	CONSTRUCTION PHASE												
B.I	EARTHWORKS												
I.	CLEARING AND GRUBBING	SQ.M.	2,698			20	PHP			53958.351	PHP	53958.35058	PHP
II.	SURVEY	SQ.M.	2,699			20	PHP			53978.351	PHP	53978.35058	PHP
III.	STRUCTURAL EXCAVATION	CU.M.	3,511			400	PHP			1404400	PHP	1404400	PHP
IV.	BACKFILL AND COMPACTION	CU.M.	694.0831			200	PHP			138816.62	PHP	138816.62	PHP
V.	GRAVEL BEDDING	CU.M.	9.73125	820	PHP	246	PHP	7979.625	PHP	2393.8875	PHP	10373.5125	PHP
B.II	TERMITE CONTROL WORKS												
VII.	SOIL POISONING	SQ.M.	2,210	320	PHP	96	PHP	707200	PHP	212160	PHP	919360	PHP
B.II	CONCRETE WORKS												
I.	REINFORCED CONCRETE												
	R.C. COLUMN FOOTING (ISOLATED AND COMBINED)	CU.M.	148.5047	4730	PHP	1419	PHP	702427.23	PHP	210728.17	PHP	913155.4003	PHP
	R.C. FOR SLAB-ON-GRADE	CU.M.	1313.193122	4730	PHP	1419	PHP	6211403.5	PHP	1863421	PHP	8074824.507	PHP
	R.C. FOR 4500X500X500 MM COLUMN (S.O.G. - ROOF SLA	CU.M.	109.125	4730	PHP	1419	PHP	516161.25	PHP	154848.38	PHP	671009.625	PHP
	R.C. FOR 300X600 MM GIRDER	CU.M.	93.6	4730	PHP	1419	PHP	442728	PHP	132818.4	PHP	575546.4	PHP
	R.C. FOR GIRDER, 500MM X 700MM	CU.M.	144.14848	4730	PHP	1419	PHP	681822.31	PHP	204546.69	PHP	886369.0035	PHP
	R.C. FOR BEAM, 400MM X 700MM	CU.M.	94.78	4730	PHP	1419	PHP	448309.4	PHP	134492.82	PHP	582802.22	PHP
	R.C. FOR ROOF SLAB	CU.M.	1175.468168	4730	PHP	1419	PHP	5559950.2	PHP	1667985.1	PHP	7227935.318	PHP
II.	STEELWORKS	KG	63775.63	32	PHP	9.6	PHP	2040820.2	PHP	612246.05	PHP	2653066.208	PHP
B.III	FORMWORKS AND SCAFFOLDS												
	ALUMINUM FORMWORKS (PACI FORMWORKS)	SQ. M.	1034.116807	7	PHP			7238.8176	PHP	84	PHP	7238.817646	PHP
	USED OIL	GAL	244	40	PHP			9760	PHP			9844	PHP
B.IV	MASONRY WORKS												
	INSULATING CONCRETE FOAM	SQ. M.	572.4	252.5	PHP	156.51	PHP	144531	PHP	89586.324	PHP	234117.324	PHP
B.V	FABRICATED MATERIALS AND HARDWARES	UNIT	103					268780	PHP			268780	PHP
B.VI	FINISHING WORKS	UNIT										32560.5	PHP
BVII.	CARPENTRY WORKS	SQ. M.	615	410.96	PHP	123.29	PHP	252740.4	PHP	75823.35	PHP	328563.75	PHP
BVIII.	PAINTING WORKS												
	WOODEN PAINTING AND METAL PAINTING												
	QUICK DRY ENAMEL, WHITE	GAL	0.5	540	PHP	32.16		270	PHP	32.16	PHP	302.16	PHP
	MASONRY PAINTING												
	PERMACOAT LATEX, TULLE WHITE	GAL	50	486	PHP	22.11		24300	PHP	1105.5	PHP	25405.5	PHP
BIX.	ELECTRICAL WORKS												
	CONDUITS, BOXES AND FITTING	UNIT										150000	PHP
	CIRCUIT BREAKER 100A 2P	SET	2	650	PHP			1300	PHP	15750	PHP	1300	PHP
	LIGHTING FIXTURES	SET	28	75	PHP			2100	PHP			2100	PHP
	SAFETY SWITCH 30A 2P	SET	1	603.25	PHP			603.25	PHP			603.25	PHP
	FIRE ALARM BELL, VIBRATING TYPE	SET	10	2000	PHP			20000	PHP			20000	PHP
	FIRE ALARM STATION, MANUAL SINGLE ACTION	SET	20	2010	PHP			40200	PHP			55950	PHP
	ELECTRICAL TAPE	ROLL	25	37.5	PHP			937.5	PHP			937.5	PHP
	RUBBER TAPE	ROLL	25	100	PHP			2500	PHP			2500	PHP
BX.	PLUMBING WORKS												
	SEWER LINE WORKS	L.S.	1					23700	PHP	7110	PHP	30810	PHP
	SANITARY FIXTURES	L.S.	1					192000	PHP	57600	PHP	249600	PHP
	DOWNSPOUT/STORM DRAINAGE	L.S.	1					5800	PHP	1740	PHP	7540	PHP
	COLD WATERLINE WORKS	L.S.	1					56000	PHP	16800	PHP	72800	PHP
	WATER CLOSET WITH ACCESSORIES, SUPF	SET	21	11275.14	PHP			236777.94	PHP			236777.94	PHP
	WATERLESS URINAL	SET	8	15129	PHP			121032	PHP			121032	PHP
	MIRROR	SQ. FT.	100	100	PHP			10000	PHP			10000	PHP
	FAUCET, ALTERED NOZZLE	SET	199.12	1250	PHP			248900	PHP			248900	PHP
	WATER PUMP 1 HP	SET	2	9094.73	PHP			18189.46	PHP			18189.46	PHP
BXI.	SANITARY WORKS												
	CATCH BASIN	UNIT	12	1500	PHP			18000	PHP	57600	PHP	75600	PHP
	THREE CHAMBER SEPTIC VAULT	UNIT	1	42878.52	PHP			42878.52	PHP			42878.52	PHP
BXII.	WATERPROOFING												
	WATERPROOFING, CEMTITIOUS	GAL	270	500	PHP			135000	PHP			135000	PHP
	WATERPROOFING, ELASTOMERIC	GAL	125	400	PHP			50000	PHP			50000	PHP
	TOTAL (WITH 10% CONTINGENCY)											31979085.86	PHP
	TOTAL (WITH 12% VAT AND 10% CONTINGENCY)											35467713	PHP

Total Cost (with 10% Contingency): 31,979,085.86 PHP
Total Cost (with 12% VAT and 10% Contingency): 35,467,713.00 PHP

Table 21. Assessment of the Ordinary and BREEAM Costs

PRICE DIFFERENCE	901,569
PERCENTAGE INCREASE	3%

Table 22. Project Schedule (Pre-construction and Construction)



Estimated Time for Project to Finish: Approximately 14 Months (One Year and Two Months)

IV. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The main purpose of this study is to create a safe design of the structural members of a two-story commercial building that is based on the national standards which have been answered on chapter two on the design analysis, to comply with the Building Research Establishment

Environmental Assessment Method for New Construction (BREEAM) certification standard being met on chapter three, and to evaluate the percentage difference with respect to its environmental contribution and the common practice of construction in the country with the use of software analysis and other technical studies which have been met on chapter three on results and discussion.

The proposed commercial building is not only structurally safe it also complied with the BREEAM requirements making this proposed structure a sustainable building. It achieved an overall percentage credit of 30% and according to the BREEAM's benchmark rating, 30% is considered pass. Therefore, the structure is assessed to pass the BREEAM criteria for certification.

Recommendations

As the researchers gathered all the possible results after analyzing the proposed project and formulating a conclusion, the researchers produced the following recommendation:

For future owner or a future licensed civil engineer that will have a client that wants to have a BREEAM Certified building, they must give high priority to the planning phase of the project. There are pre-requisites that must be satisfied under the categories of BREEAM to obtain a rating. Choosing a site for the said structure is important since it may give a great impact on the ratings. Soil exploration and soil investigation of the site location is also needed to be considered to have an economical design of the foundations.

For future researchers, comparison between the conventional and sustainable building is a must to find categories that need to improve. This study focuses on the structural and architectural design aspects, an electrical plan was provided by the researchers, but the proponents recommend seeking advice from an electrical engineer or have a collaboration with an electrical engineering student, thus plumbing and mechanical are not scope of the study.

Finally, it is recommended to implement this project design. This commercial building will help the environment and the future occupants. The study strictly considers the sustainability and renewability resources in the design.

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[1] P. S. A. (PSA), "Construction Statistics From Approved Building Permits: Fourth Quarter 2018," Philippine Statistics Authority (PSA), Philippines, 2019.

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[3] P. S. A. (PSA), "Annual Poverty Indicators Survey," Philippine Statistics Authority, Philippines, 2014.

[4] N. D. Library, "The National Library of the Philippines," National Diet Library, Tokyo, Japan, 2008.