VERTICAL EXTENSION OF BALIUAG UNIVERSITY TUMANA CAMPUS BUILDING WITH APPLICATION OF ENERGY EFFICIENT DESIGN

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Abstract

The study entitled, "Vertical Extension of Baliuag University Tumana Campus Building with Application of Energy Efficient Design" aims to provide a sustainable energy source on the renovated building by using solar panels. The purpose of the study is to determine the strength and capability of the existing building and to provide a design for the renovation. The design is based on the National Structural Code of the Philippines (NSCP) 2010. The building design may result to a higher possibility of being efficient and economical in using energy which is highly recommended for buildings.

Keywords: Building renovation; Solar powered building; Structural design; Energy Efficient Building

Nowadays, the Philippines have been suffering from different dilemmas and one of it is energy crisis. Many people in the Philippines must deal with rolling blackouts and power outages. This is also a problem of the government of the country. The money intended for foreign trade and other bigger problems would go straight to trying to keep the supply of electricity enough for the whole country. This is a problem that needs a good solution. ("The Philippines' Electrical Problem," n.d.)

The use of renewable energy is a good solution. It is collected from renewable resources such as sunlight, wind, rain and geothermal heat. Since the Philippines is mostly affected by climate change phenomenon, El Niño as a natural occurrence is now being worsened by climate change. Due to this phenomenon, hydropower is lessened. According to Steven Rood

(2015), hydropower is reduced due to the seasonal dry spell, and a major gas production facility supplying power plants will shut down, so that electricity reserves will be running lower – low enough that a random "tripping" or shutdown of a power plant on the grid might cause widespread outages.

Solar has become one of the fastest growing renewable energy sources. It provides an excellent solution to the issue of our diminishing finite sources. It also provides energy "security" because it is harvested from our most abundant resources, the sun. For this reason, solar energy will be a viable option for power as long as the sun exists. (Murray and Smith, 2014). A mere 0.01% of the available sunlight would be sufficient to meet the world's energy needs, even on cloudy days. (Energy Crisis in the Philippines, 2015).

Solar energy is a resource that is not only sustainable for power consumption, it is indefinitely renewable. The systems developed based on solar energy generally do not require a lot of maintenance. You only need to keep them relatively clean, so cleaning them a couple of times per year will do the job. It is a quiet producer of energy. It reduces electricity bills. It helps our environment to minimize carbon dioxide emission because it causes no pollution. It is appropriate in the Philippines because it is a tropical country where the sun shines almost 100%. There are disadvantages in using solar panels. Solar energy can only be harnessed when it is daytime and sunny. It is expensive. Its batteries are large, heavy and need storage space. They also need replacing from time to time. Its stations can be built but they do not match the power output of similar sized conventional power stations. Large area for solar panels is needed to capture sun's energy. The power generated is also reduced during times of cloud cover.

Installation of solar panels may be expensive but it can be an investment for the future. It may help us save money and have a better and healthy environment. Nowadays, homeowners have ventured in the installation of solar panels to partially supply electricity for lighting and cooling resulting in reduced electric bills sourced from grid.

Review of Related Literature

A renovation of building (also called remodelling) is the process of improving a broken, damaged, or outdated structure. When designing a sustainable renovation, according to Lisa Gelfand and Chris Duncan (2012), the best way to define a design problem is to narrow the definition of both the problem and the solution to measurable quantities. This means that the final design must take into consideration priorities for parts to be renovated and compromise for areas that maybe left untouched to meet the goal of a high performance building that maintain its sustainability. Also, coherence between parts that are renovated and parts appear to be untouched must be visible in the final result and blends well to provide enhancement as dictated by the goal set for an integrated design.

They further discussed that as the scope of remodelling grows, the benefits of a holistic understanding of the building also grow. One advantage that existing buildings have is that they do exist, with the potential to observe and measure actual performance such as actual energy and water use as well as the subjective experience of people using the building. Utility bills are an obvious first source of energy use data, but must be analysed carefully so that utility rate structures that vary by season and time of day do not mislead the designer. To identify the most important improvements to make, benchmarking the building, or a comparison of actual performance indicators with expected values could help. (Lisa Gelfand and Chris Duncan, 2012).

- Analyze the site, climates and building user needs.
- Analyze modem building regulations and their implications in the existing building.
- Model the actual and designed building performance.
- Integrate the building design strategies.

A vertical extension according to James Douglas (2006), can often offer the most discrete and economical way of increasing the capacity of an existing building. They are often formed either in the roof space or basement. Most vertical extensions are upward because there is nearly always free space to

expand in that direction. In contrast, downward vertical extensions are limited because of the physical restrictions imposed by the substructure and soil conditions.

By developing building parts such as roof with solar panels, according to Deo Prasad and Mark Snow, Building - Integrated Photovoltaic (BiPV) involves combining solar photovoltaic electricity technologies with those of building construction.

Taking into consideration the cost of installation, the number of solar panels to be installed must be considered. According to AMECO, the main variables that go into determining how many solar panels are needed for a building are its geographical location, average electricity consumption, and roof space. It can also be estimated based on the building's square footage. As a example, Los Angeles Department of Water and Power (LADWP) calculates this type of average at 2 watts for every square foot. So, a 2,000 square foot home would be allowed a solar array of 4,000 watts. Depending on the type of panel that is chosen, a system of this size would be anywhere from 12-18 solar panels.

It is clear that the integration of PV into the built environment offers considerable scope for energy—demand offsets and reduction of greenhouse gas (GHG) emissions.

The introduction of integrated renewable energy makes the holistic approach even more important. Also, it allows buildings to be not only consumers, but also suppliers of energy and in respect to the building within which this renewable source is installed, the possibility of energy self - sufficiency and carbon neutrality. For pioneers of solar energy in buildings, zero emissions - meaning that, over the life of the building, carbon dioxide produced by its construction and occupation is balanced by the savings in carbon dioxide made possible by the supply of renewable energy - has been the Holy Grail. (Prasad, 2005)

Significance of the Study

This study can provide many benefits for the following:

Environment

The growth and development of communities has a large impact of the natural surroundings. To minimize the building's total environmental impact, converting it into an energy efficient building can be a great solution.

The main idea behind this is to use renewable energy by means of solar panel to provide the energy needed for the said building that may also help in the preservation of natural environment.

Solar panel does not require other sources of fuel such as natural gas, coal and oil which are known to be non-renewable. It is a pollution-free power source that can help reduce climate change. It is a clean and safe energy source that can help lessen climate change as it produces no carbon emissions.

Baliuag University

The use of solar panels to generate energy provides many benefits, which include reductions in the costs associated with generating electricity. Solar panels operate for free since sunlight is available at no cost. The Baliuag University can adopt the output of this study to accommodate the growing number of student enrollee. The building can house the CEDE Department, its classrooms and laboratories.

Students and Professors

Also, the physical characteristics of learning environments can affect learners emotionally, with important cognitive and behavioural consequences. Creating more spaces to study will allow the students to feel comfortable, safe and engaged.

Scope and Delimitation

This study covers the renovation of Baliuag University Tumana Campus building, to become energy efficient, including its structural design. It would also include the electrical distribution layout of the solar panels to the appliances such as lights and ceiling fans. Electrical layout for air-conditioning units and power layout is also included. The estimated cost of the renovation and solar panel installation is also included.

Problem Statement

This research specifically aims to answer the following questions:

1. What is the proposed design for the renovation of the building to become energy efficient?
2. What procedure is to be done to determine the strength of the existing beams and columns to support the additional floor?
3. What is the design needed for the electrical layout of the solar panels?
4. What loads are to be supported by the solar panels?
5. What is the estimated cost of the renovation and the solar panel installation?

Methods

Basic Assumptions

The project was subjected on the assumption of renovating the BU Tumana Campus building with application of energy efficient design for its power source. The researchers considered that designing it into a two-storey building and installing solar panels may lead to high cost of renovation. Therefore, every aspect that can affect strength and cost was taken into consideration.

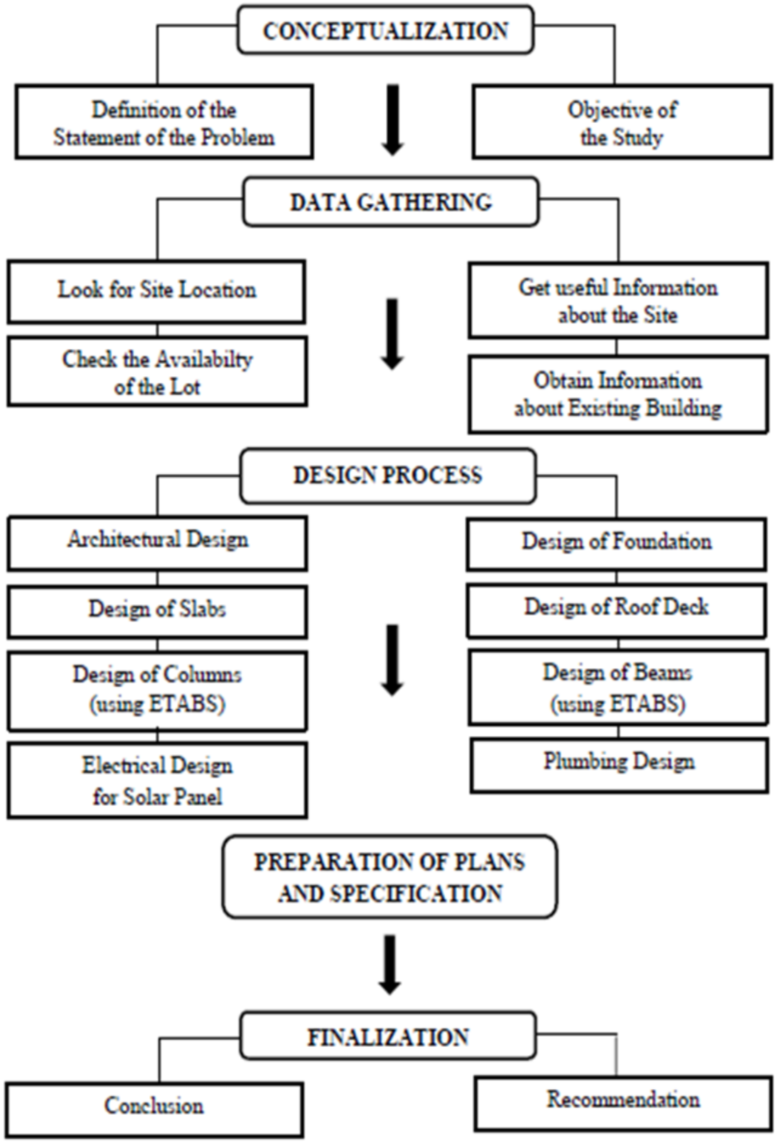

Figure 1: Conceptual Framework

Figure 1 shows the conceptual framework used by the researchers. It all started with the conceptualization of the study.

Then, it follows the data gathering and the design process itself. The researchers prepared the plans and specifications needed to aid the finalization of the study.

The major concern of this study was to design a plan for the renovation of Baliuag University Tumana Campus building with application of energy efficient design. Appropriate engineering principles and computations were applied to the new design in consideration of the following factors: safety, efficiency and cost. The design used in the new building plan was based on the standards and restrictions as stated in the National Structural Code of the Philippines (NSCP).

The lot area of the building was determined by measuring its length and width using engineering tape since it was rectangular in shape. The researchers have decided to make a two storey building to maximize the space. Existing building is to be retained. Excavation on the critical existing foundation was done to determine its dimensions. The strength of the existing beams, columns and foundations were computed to determine whether they are safe to support the additional floor.

In order to support the additional floor, new columns were added in front and in the back of the building. Columns on the ground floor and second floor were spaced at 4.5 m from center to center. In order to support the additional floor, beams were placed above the existing beam of the first floor slab.

Ultimate Strength Design (USD) Method was used to design the slabs. Based on the given dimensions, thickness of slabs and reinforcements were computed. The computations on beams and columns were done using ETABS. For the design of foundation, Ultimate Strength Design (USD) Method was also used.

Monocrystalline type of solar panel was used to generate energy for lights and the ceiling fans. The number of solar panels was based on the electrical consumption of the building. For the installation of solar panel, charge controller was connected to it in order to control the energy that was collected from the sunlight. Then, deep cycle batteries were needed for the storage of energy. Lastly, inverters were present because motored appliances require alternating current (AC) and it converts direct current (DC) to alternating current (AC).

Results and Discussion

The results obtained attempted to achieve the objectives of the study based on theoretical design. The results of the designing phase of the study are as follows:

Building Description

Total Floor Area – 615.7785 m^2

Number of Rooms:

- Laboratory Room – 1
- Office – 1
- Storage Room – 1
- Comfort Room – 2
- Classroom – 6
- Faculty Room – 1

Materials Used

Table 1. Materials Used and its Properties

Type	E (GPa)	Unit Weight (kN/m^3)	Design Strengths (MPa)
Concrete	200	23.544	fc'=20.7
Grade33 Steel	200	76.9729	Fy=227

Table 1 shows the materials used and its properties with the specific parameters written on the first row.

Loads Used

Total Load = 1.2DL + 1.6LL

Table 2. Live Load and Dead Load

Live Load	
School Classroom	1.9 kPa
Hallway/Exit Facilities	4.8 kPa
Live Load Allowance	0.055 kPa
Dead Load	
Mechanical Duct Allowance	0.2 kPa
Electrical Allowance	0.15 kPa
Live Load Allowance	0.055 kPa

Table 2 illustrates the live load and dead load.

BU Tumana Campus Building Design

- Design of Slab

Table 3. Schedule of slab

FIRST FLOOR

	T	SHORT DIRECTION						LONG DIRECTION					
		CONT. EDGE		MIDSPAN		DISCONT. EDGE		CONT. EDGE		MIDSPAN		DISCONT. EDGE	
		Ø	S	Ø	S	Ø	S	Ø	S	Ø	S	Ø	S
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
S1	150	20	200	20	390	20	450	16	270	16	430	16	450
S2	140	20	240	20	370	20	450	25	450	25	450	25	450
S3	140	16	130	16	210	16	450	16	260	16	410	16	450
S4	90	16	400	16	450	16	450	16	320	16	450	16	450
S5	90	16	200	16	250	16	450	16	250	16	450	16	450
S6	90	16	200	16	300	16	450	16	300	16	450	16	450
S7	90	16	200	16	300	16	450	16	300	16	450	16	450

SECOND FLOOR

	T	SHORT DIRECTION						LONG DIRECTION					
		CONT. EDGE		MIDSPAN		DISCONT. EDGE		CONT. EDGE		MIDSPAN		DISCONT. EDGE	
		Ø	S	Ø	S	Ø	S	Ø	S	Ø	S	Ø	S
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
S1	150	16	250	16	350	16	450	16	300	16	380	16	450
S2	140	20	240	20	370	20	450	25	450	25	450	25	450
S3	90	16	450	16	450	16	450	20	450	20	450	20	450
S4	140	16	140	20	450	20	450	16	300	20	450	20	450
S5	90	16	200	16	250	16	450	16	250	16	450	16	450

ROOF SLAB

	T	SHORT DIRECTION						LONG DIRECTION					
		CONT. EDGE		MIDSPAN		DISCONT. EDGE		CONT. EDGE		MIDSPAN		DISCONT. EDGE	
		Ø	S	Ø	S	Ø	S	Ø	S	Ø	S	Ø	S
	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
S1	100			20	450	20	450	12	110	12	250	12	450

- Design of Beam

Table 4. Schedule of Beam

Beam ID	Span No.	Span Length (Lc)	Section Size	
			Width	Depth
5CB1	1	4.980m	250mm	300mm
3CB4	1	2.750m	300mm	400mm
	1	2.830m	300mm	400mm
	2	2.150m	300mm	400mm
	3	4.980m	300mm	400mm
	4	9.680m	300mm	400mm
3CB6	5-7	4.500m	300mm	400mm
	8	9.000m	300mm	400mm
	9	10.380m	300mm	400mm
	1	4.980m	300mm	400mm
	2-3	4.980m	300mm	400mm
	4-10	4.100m	300mm	400mm

Table 4. Continuation

Beam ID	Span No.	Span Length (Lc)	Section Size	
			Width	Depth
3CB7	11	5.480m	300mm	400mm
	1	4.980m	300mm	400mm
	2	1.992m	300mm	400mm
	3	2.988m	300mm	400mm
	4	4.980m	300mm	400mm
	5-11	4.100m	300mm	400mm
3CB8	12	5.480m	300mm	400mm
2CB2	1	2.750m	300mm	400mm
	1-2	4.980m	300mm	400mm
	3	7.180m	300mm	400mm
	4	2.500m	300mm	400mm
2CB4	5-7	4.500m	300mm	400mm
	8	9.000m	300mm	400mm
	9	10.380m	300mm	400mm
	1-3	4.980m	300mm	400mm
	4-10	4.100m	300mm	400mm
2CB5	11	5.480m	300mm	400mm
	1-3	4.980m	300mm	400mm
	4-10	4.100m	300mm	400mm
2CB6	11	5.480m	300mm	400mm
2CB10	1	10.700m	300mm	400mm

Beam ID	Span No.	Longitudinal Bars						
		A	B	C	D	F	G	H
5CB1	1	3-20 (1,332)	2-20	3-20 (1,434)	2-20	6-16 (614)		
3CB4	1	3-16 (528)		3-16 (528)		5-20 (1,259)		
	1	4-20 (2,115)	3-20			7-20 (2.073)		
	2			3-20 (1,122)	1-20	5-20 (1,307)		5-20 (2,958
	3			5-20 (2,751)	4-20	6-16 (638)		1-20 (1,375)
	4			5-20 (2,552)	4-20	6-20 (1,821)		
3CB6	5			3-20 (861)		6-16 (585)		1-20 (1,479)
	6			3-20 (970)	1-20	6-16 (537)		
	7			3-20 (932)		6-16 (601)		
	8			3-20 (816)		6-16 (818)		
	9	3-16 (0)		3-20 1,537)	2-20	6-16 (0)		

Table 4. Continuation

Beam ID	Span No.	L1 (m)	L2 (m)	Stirrups Zone A	Stirrups Zone B	Typical Elevations
3CB6	7-8			3-10 @150mm Type A (0.6)	22-10 @150mm Type A (0.6)	3S
	9		2.595	3-10 @150mm Type A (0.0)	57-10 @150mm Type A (0.0)	3S
	1	1.245		3-10 @125mm Type A (0.9)	27-10 @150mm Type A (0.8)	3S
	2-3		1.245	3-10 @150mm Type A (0.7)	27-10 @150mm Type A (0.6)	3S
	4-10		1.025	3-10 @150mm Type A (0.6)	22-10 @150mm Type A (0.6)	3S
3CB7	11	1.370	1.370	3-10 @150mm Type A (0.9)	30-10 @150mm Type A (0.6)	3S
	1	1.245		3-10 @150mm Type A (1.8)	49-10 @75mm Type A (1.3)	3S
	2		0.498	3-10 @150mm Type A (0.6)	9-10 @150mm Type A (0.6)	3S
	3			3-10 @150mm Type A (0.6)	15-10 @150mm Type A (0.6)	3S
	4		1.245	3-10 @150mm Type A (0.6)	27-10 @150mm Type A (0.6)	3S
	5-11		1.025	3-10 @150mm Type A (0.6)	22-10 @150mm Type A (0.6)	3S
	12	1.370	1.370	3-10 @150mm Type A (0.9)	30-10 @150mm Type A (0.6)	3S
2CB2	1			3-10 @150mm Type A (0.9)	12-10 @150mm Type A (0.6)	3S
	1-2			3-10 @150mm Type A (0.0)	27-10 @150mm Type A (0.0)	3S
	3			3-10 @150mm Type A (0.7)	39-10 @150mm Type A (0.0)	3S
	4		0.625	3-10 @75mm Type A (1.5)	15-10 @150mm Type A (1.1)	3S
2CB4	5		1.125	4-10 @100mm Type A (1.1)	22-10 @150mm Type A (0.6)	3S
	6		1.125	3-10 @125mm Type A (1.1)	22-10 @150mm Type A (0.6)	3S
	7		1.125	3-10 @125mm Type A (1.0)	22-10 @150mm Type A (0.6)	3S
	8		2.250	5-10 @75mm Type A (1.4)	69-10 @100mm Type A (1.1)	3S
	9		2.595	3-10 @150mm Type A (0.0)	57-10 @150mm Type A (0.0)	3S
	1			3-10 @150mm Type A (0.0)	27-10 @150mm Type A (0.0)	3S
	2		1.245	3-10 @150mm Type A (0.8)	27-10 @150mm Type A (0.6)	3S

Table 4. Continuation

Beam ID	Span No.	Longitudinal Bars A	B	C	D	F	G	H
2CB4	3			5-20 (2,788)	4-20	6-16 (1,137)		2-20 (1,557)
	4			5-20 (2,836)	5-20	5-20 (1,290)		1-20 (1,696)
	5			5-20 (2,920)	5-20	4-20 (1,219)		2-20 (1,611)
2CB5	6			5-20 (2,908)	5-20	4-20 (1,245)		2-20 (1,635)
	7			5-20 (2,924)	5-20	4-20 (1,240)		2-20 (1,638)
	8			5-20 (2,930)	5-20	4-20 (1,257)		2-20 (1,651)
	9			5-20 (2,947)	5-20	5-20 (1,266)		1-20 (1,655)
	10			5-20 (2,927)	5-20	6-16 (0)		1-20 (1,464)
	11	3-16 (0)		3-16 (0)		6-16 (0)		
	1	3-16(0)			4-20	6-16 (0)		
	2			5-20 (2,727	4-20	6-16 (826)		1-20 (1,363)
	3			4-20 (2,498)	4-20	6-16 (915)		2-20 (1,557)
	4			4-20 (2,441)	4-20	6-16 (925)		2-20 (1,573)
	5			4-20 (2,457)	4-20	6-16 (947)		2-20 (1,770)
2CB6	6			5-20 (2,539)	4-20	6-16 (898)		2-20 (1,632)
	7			4-20 (2,437)	4-20	6-16 (866)		2-20 (1,693)
	8			4-20 (2,398)	4-20	6-16 (888)		2-20 (1,794)
	9			4-20 (2,445)	4-20	6-16 (896)		2-20 (1,797)
	10			5-20 (2,525)	4-20	6-16 (935)		2-20 (1,832)
	11	5-20(2,753)	4-20	5-20 (2,702)	4-20	6-16 (1,395)	2-20 (2,195)	2-20 (1,781)
2CB10	1	3-16(11)		3-16 (0)		6-16 (0)	3-20 (1,886)	

Beam ID	Span No.	L1 (m)	L2 (m)	Stirrups Zone A	Stirrups Zone B	Typical Elevations
5CB1	1	1.245	1.245	3-10 @100mm Type A (0.5)	40-10 @100mm Type A (0.5)	1S
3CB4	1			3-10 @150mm Type A (0.6)	12-10 @150mm Type A (0.6)	1S
	1	0.707		5-10 @75mm Type A (1.6)	24-10 @75mm Type A (1.5)	3S
	2		0.538	3-10 @125mm Type B (2.1)	14-10 @100mm Type **B** (2.2)	3S
	3		1.245	3-10 @150mm Type A (0.8)	27-10 @150mm Type A (0.6)	3S
	4		2.420	3-10 @150mm Type A (0.9)	54-10 @150mm Type A (0.6)	3S
3CB6	5-6		1.125	3-10 @150mm Type A (0.6)	22-10 @150mm Type A (0.6)	3S

Table 4. Continuation

Beam ID	Span No.	Longitudinal Bars						
		A	B	C	D	F	G	H
3CB6	1	3-20 (1,401)	2-20			6-16 (1,014)		
	2			4-20 (2,383)	4-20	6-16 (767)		
	3			3-20 (1,880)	3-20	6-16 (790)		
	4			3-20 (1,472)	2-20	6-16 (528)		
	5			3-20 (1,266)	2-20	6-16 (528)		
3CB7	6			3-20 (1,319)	2-20	6-16 (528)		
	7			3-20 (1,309)	2-20	6-16 (528)		
	8			3-20 (1,353)	2-20	6-16 (528)		
	9			3-20 (1,351)	2-20	6-16 (528)		
	10			3-20 (1,350)	2-20	6-16 (546)		
	11	4-20 (2,031)	3-20	3-20 (1,802)	3-20	6-16 (1,115)		
	1	4-20 (2,299)	4-20			7-20 (2,068)		
	2			4-20 (2,456)	4-20	6-16 (528)		1-20 (1,228)
	3			3-16 (528)		6-16 (528)		
	4			3-20 (1,186)	1-20	6-16 (528)		
	5			3-20 (1,052)	1-20	6-16 (528)		
3CB8	6			3-20 (988)	1-20	6-16 (528)		
	7			3-20 (1,002)	1-20	6-16 (528)		
	8			3-20 (1,011)	1-20	6-16 (528)		
	9			3-20 (1,052)	1-20	6-16 (528)		
	10			3-20 (1,081)	1-20	6-16 (528)		
	11			3-20 (1,180)	1-21	6-16 (528)		
	12	3-20 (949)	1-20	3-20 (1,403)	2-20	6-16 (921)		
2CB2	1	3-16 (528)		3-16 (528)		6-20 (1,608)		
	1	3-16 (0)				6-16 (0)		
	2			3-16 (0)		6-16 (0)		
	3			3-16 (0)		6-16 (1,158)		
	4			3-20 (823)		6-20 (1,873)		3-20 (2,670)
2CB4	5			3-20 (1,151)	1-20	6-16 (929)		
	6			4-20 (2,283)	4-20	6-16 (938)		
	7			3-20 (1,128)	1-20	6-16 (1,019)		
	8			4-20 (1,946)	3-20	5-20 (1,345)		
	9	3-16 (0)		5-20 (2,683)	4-20	6-16 (0)		1-20 (1,342)
	1	3-16 (0)				6-16 (0)		
	2			4-20 (2,142)	3-20	6-16 (895)		1-20 (1,338)

Table 4. Continuation

Beam ID	Span No.	L1 (m)	L2 (m)	Stirrups		Typical Elevations
				Zone A	Zone B	
2CB4	3		1.245	4-10 @100mm Type A (1.1)	32-10 @125mm Type A (1.0)	3S
	4-9		1.025	4-10 @100mm Type A (1.2)	26-10 @125mm Type A (1.0)	3S
	10		1.025	3-10 @150mm Type A (0.0)	22-10 @150mm Type A (0.0)	3S
	11-1			3-10 @150mm Type A (0.0)	30-10 @150mm Type A (0.0)	3S
	2		1.245	3-10 @ 150mm Type A (0.8)	27-10 @ 150mm Type A (0.7)	3S
	3		1.245	3-10 @ 150mm Type A (0.9)	27-10 @ 150mm Type A (0.8)	3S
	4		1.025	3-10 @ 150mm Type A (0.8)	22-10 @ 150mm Type A (0.8)	3S
	5-6		1.025	3-10 @ 150mm Type A (0.9)	22-10 @ 150mm Type A (0.8)	3S
2CB6	7-8		1.025	3-10 @ 150mm Type A (0.8)	22-10 @ 150mm Type A (0.8)	3S
	9		1.025	3-10 @ 150mm Type A (0.9)	22-10 @ 150mm Type A (0.9)	3S
	10		1.025	4-10 @ 100mm Type A (1.1)	32-10 @ 100mm Type A (1.1)	3S
	11	1.370	1.370	5-10 @ 75mm Type A (1.4)	43-10 @ 100mm Type A (1.2)	3S
2CB10	1	2.675		3-10 @ 150mm Type A (0.8)	60-10 @ 150mm Type A (0.0)	1S

- Design of Column

Table 5. Schedule of Column

COLUMN ID	SECTION	REINFORCEMENT	
		MAIN REINFORCING BARS	LATERAL TIES
CC1	400mm x 400mm	12-25mmØ	10mmØ@100mm
CC2	400mm x 400mm	12-25mmØ	10mmØ@100mm
CC3	400mm x 400mm	12-28mmØ (base) 12-16mmØ (storey 2)	10mmØ@100mm
CC4	400mm x 400mm	12-32mmØ	10mmØ@100mm

Table 5. Continuation

COLUMN ID	SECTION	REINFORCEMENT	
		MAIN REINFORCING BARS	LATERAL TIES
CC7	400mm x 400mm	12-25mmØ (base) 12-16mmØ (storey 2)	10mmØ@100mm
CC8	400mm x 400mm	12-25mmØ (base) 12-16mmØ (storey 2)	10mmØ@100mm
CC9	400mm x 400mm	12-25mmØ	10mmØ@100mm
CC10	400mm x 400mm	12-25mmØ	10mmØ@100mm
CC11	400mm x 400mm	12-25mmØ	10mmØ@100mm
CC12	400mm x 400mm	12-25mmØ	10mmØ@100mm
CC13	400mm x 400mm	12-28mmØ	10mmØ@100mm
CC14	400mm x 400mm	12-16mmØ	10mmØ@100mm

- Design of Foundation

Table 6. Schedule of Foundation

SQUARE FOOTING

FOOTING	Pu	L	w	D	# of bars
F1	1182.1958kN	2.9m	2.9m	500mm	16-25mm Ø
F4	507.7131kN	1.9m	1.9m	500mm	11-25mm Ø

RECTANGULAR FOOTING

FOOTING	Pu	L	w	D	# of bars longitudinal	# of bars transverse
F2	1336.1451kN	4.4m	2.2m	650mm	32-25mm Ø	11-25mm Ø
F3	1549.1494kN	3.9m	2.8m	575mm	25-25mm Ø	6-25mmØ

- Design of Stair

SPAN = 2.6m
RISER = 18cm
THREADS = 20cm
AREA = 201.1 mm^2
USE 16mmø BARS SPACE BY 110 mm O.C.
USE 10 mmø TEMP. BARS SPACE BY 260 mm O.C.

Material and Budget Estimation

- Concrete Works

Table 7. Budget Estimation

	QUANTITY	Class B 1:2 1/2:5		Total Material Cost
		UNIT	Material Unit Cost	
SLAB				
Cement	2461	Bags	215	529115
Sand	136.7	cu. M	1271	173745.7
Gravel	273.4	cu. M	1000	273400
BEAM				
Cement	674	Bags	215	144910
Sand	37.4	cu. M	1271	47535.4
Gravel	74.8	cu. M	1000	74800
COLUMN				
Cement	223	Bags	215	47945
Sand	14.86	cu. M	1271	18887.06
FOOTING				
Cement:	152	Bags	215	32680
Sand:	10.07	cu. M	1271	12798.97
Gravel:	20.13	cu. M	1000	20130
Total Material Cost (Pesos)				1405677.13

- Formworks

	Quantity	Unit	Unit Cost	Material Cost
1st floor				
COLUMN				
Bd. Ft. Of frame required:	1,246.14	bd. Ft.		
Total no. Of lumber 2"x3"x8':	468	pcs	240	112320
No. Of plywood 1/4":	42	sheets	455	19110
#2 1/2 CW nails:	9.7	kg	148	1435.6
#1 finishing nails:	4	kg	148	592
BEAM AND GIRDER				
Bd. Ft. Of frame required:	3,472	bd. Ft.		
Total no. Of lumber 2"x3"x8':	868	pcs	240	208320
No. Of plywood 1/4":	124	sheets	455	56420
#2 1/2 CW nails:	28.6	kg	148	4232.8
#1 finishing nails:	11.8	kg	148	1746.4
2nd floor				
COLUMN				
Bd. Ft. Of frame required:	1,246.14	bd. Ft.		
Total no. Of lumber 2"x2"x8':	468	pcs	120	56160
No. Of plywood 1/4":	42	sheets	455	19110
#2 1/2 CW nails:	9.7	kg	148	1435.6
#1 finishing nails:	4	kg	148	592
BEAM AND GIRDER				
Bd. Ft. Of frame required:	3,472	bd. Ft.		
Total no. Of lumber 2"x3"x8':	868	pcs	240	208320
No. Of plywood 1/4":	124	sheets	455	56420
#2 1/2 CW nails:	28.6	kg	148	4232.8
#1 finishing nails:	11.8	kg	148	1746.4
Roof deck				
COLUMN				
1m height x 24				

Continuation

	Quantity	Unit	Unit Cost	Material Cost
Bd. Ft. Of frame required:	1068.12	bd. Ft.		
Total no. Of lumber 2"x2"x8':	401	pcs	120	48120
No. Of plywood 1/4":	36	sheets	455	16380
#2 1/2 CW nails:	8.3	kg	148	1228.4
#1 finishing nails:	4	kg	148	592
COLUMN				
2.5m height x 4				
Bd. Ft. Of frame required:	178.02	bd. Ft.		
Total no. Of lumber 2"x2"x8':	67	pcs	120	8040
No. Of plywood 1/4":	6	sheets	455	2730
#2 1/2 CW nails:	1.4	kg	148	207.2
#1 finishing nails:	0.6	kg	148	88.8
Total Material Cost (Peso)			829580	

- Masonry

		Quantity	unit	unit cost	material cost
Total no. Of CHB 10 x 20 x 40		7419	pcs	12	89028
Class B	Cement	603	bags	215	129645
Mortar	Sand	49.85	cu.m	1271	63359.35
Plastering					
	Cement	228	bags	215	49020
	Sand	18.99	cu.m.	1271	24136.29
Rebars					
Vertical reinforcement	10mm diam Spaced @ 80cm				
Horizontal reinforcement	10mm diam Spaced @ 60cm				
Vertical reinf. 12mm diam x 6m long		159	pcs	196.07	31175.13
Total Material Cost (Peso)				428127	

- Painting Works

Surface area			Gallons of paint	Unit Cost	Material Cost
exterior walls - acrylic semi-gloss					
892.96 sq.m.			45	2000	90000
Interior walls - acrylic gloss latex paint					
941.87 sq.m.			48	2200	105600
		surface area			
Ceiling/slab	1	607.68 sq.m.	25	1900	47500
	2	697.68 sq.m.	25	1900	47500
	3	62.89 sq.m.	3	1900	5700
Total Material Cost (Peso)				296300	

- Structural Steel

Bar Diameter		Quantity	Unit	Unit Cost	Material Cost
25mm	9m long	154.32	kg	693.64	107042.5248
	6m long	1481.48	kg	462.36	684977.0928
20mm	6m long	2004.94	kg	295.92	593301.8448
16mm	9m long	197.53	kg	284.04	56106.4212
	6m long	1239	pcs	348.42	431692.38
12mm	7.5m long	26.67	kg	133.2	3552.444
10mm	9m long	117.28	kg	110.88	13004.0064
	7.5m long	22.83	kg	92.4	2109.492
	6m long	1276	pcs	136.01	173548.76
#16 G.I.wire		241.82	kg	48	11607.36
Total Material Cost (Peso)		2076942.326			

- Architectural Works

Tiles	Quantity	Unit	Unit Cost	Material Cost
Floor finishes				
Tiles 60x60cm	1,704	pcs	119	202776
Cement mortar	48	bags	215	10320
White cement filler	279	kg	350	97650
Tile adhesive	62	bags	300	18600
CR floor finishes				
20x20cm unglazed floor tiles	1024	pcs	12.4	12697.6
Cement mortar	4	bags	215	860
White cement filler	19	kg	70	1330
Tile adhesive	5	bags	300	1500
CR wall finishes				
10x20cm glazed wall tiles	6,201	pcs	23.25	144173.25
Cement mortar	10	bags	215	2150
White cement filler	57	kg	70	3990
Tile adhesive	13	bags	300	3900
Doors & Windows				
Doors	25	Set	2000	50000
Windows	10.76	sq.ft.	325.33	3500.5508
Total Material Cost (Peso)			553447.401	

- Miscellaneous Work

Finishing Hardwares	Unit	Qty.	Unit Cost	Material Cost
Door knobs	Set	35	1059.75	37091.25
Door closer	Sets	35	1300	45500
Stopper	Sets	35	372	13020
Total Material Cost (Peso)				95611.25

- Earthworks

	Unit	Quantity	Price	Material Cost
Clearing	sq. meter	447.54	250	111 885
Layout	sq. meter	447.54	50	22 377
Excavation	sq. meter	413.76	1250	517 200
Hauling of Debris	sq. meter	30	250	7 500
Total Material Cost (Peso)				658 962

Electrical and Solar Panels				
	Qty.	Unit	Unit Cost	Material Cost
Ceiling Fan	17	pcs	2400	40800
LED Bulb	20	pcs	399	7980
LED Tube	68	pcs	250	17000
200AH Battery	5	pcs	11400	57000
Charge Controller	1	pc	1000	1000
Monocrystalline Solar Panel	15	units	8990	134850
Circuit Breaker	25	pcs	380	9500
Wire	305	m	18	5490
Switch	20	sets	150	3000
Conduit	60	pcs	80	4800
PVC Clamp	100	pcs	5	500
PVC Elbow	100	pcs	20	500
PVC Cement	10	pcs	75	750
Junction Box	15	pcs	25	375
Electrical Tape	30	pcs	30	900
Cable Tie	3	sets	25	75
Outlet	51	sets	55	2805
ACU	13	pcs	24450	317850
Total Material Cost				605175

Plumbing	
	Material Cost
Plumbing Works	50000

Summary Material Cost	Php6 999 821.781
Labor Cost (45% of material cost)	Php3 149 919.801
SUMMARY COST	Php10 149 741.58

Solar Panel

- Total Power Wattage @ 85% Inverter Efficiency: WT = 3358.8 W
- Total Current A = 15.267 A
- Required Amp - Hrs Of Battery @ 48 Hrs Load Operation: (Use 80% Battery Efficiency) AH = 916.04AH (use 1000 AH)
- Total No. of Required 200ah Batteries (Connected In Parallel To Add Up Ah) Total No. = 5 UNITS
- Required Wattage of Panel For 8 Hrs Charging/ Day @ 50% Demand Factor WP = 3000W
- Required No. Of 200 W Solar Panel: No of Panels = 15

Return of Investment (Solar Panel)

Table 8. Return of Investment

Estimated cost of solar panel installation	Average monthly bill amount	Return of Investment
Php269 483	Php14 471.396	19 months

- Design Layout

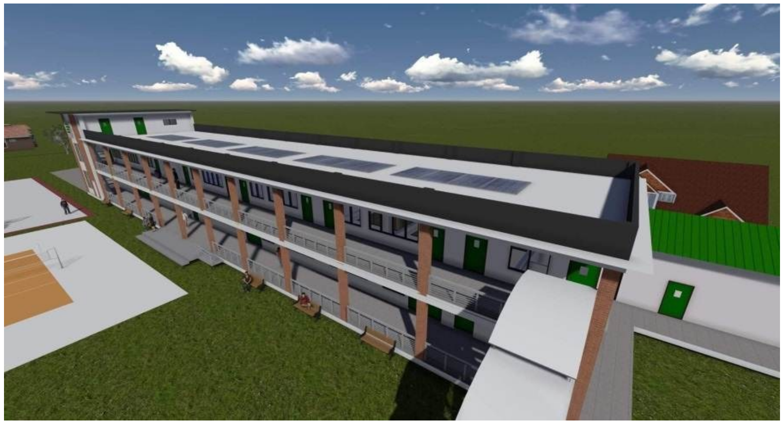

Figure 10. Perspective View 1

Figure 11. Perspective View 2

Figures 10 and 11 shows the perspective views of the vertical extension of the Tumana Campus of Baliuag University

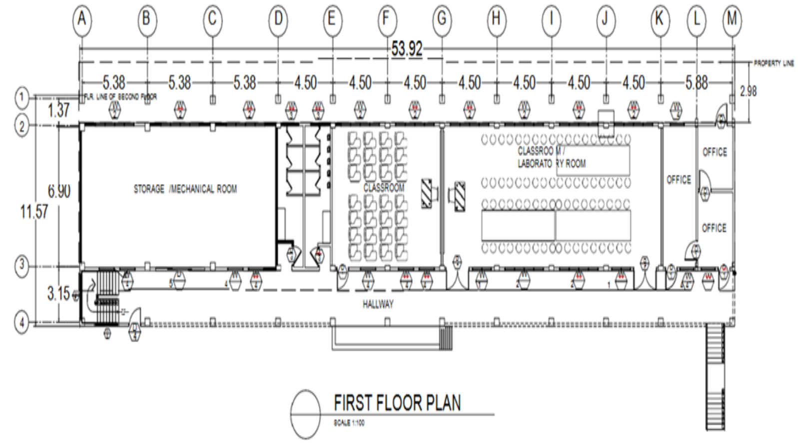

Figure 12. First Floor Plan

Figure 12 illustrates the first floor plan.

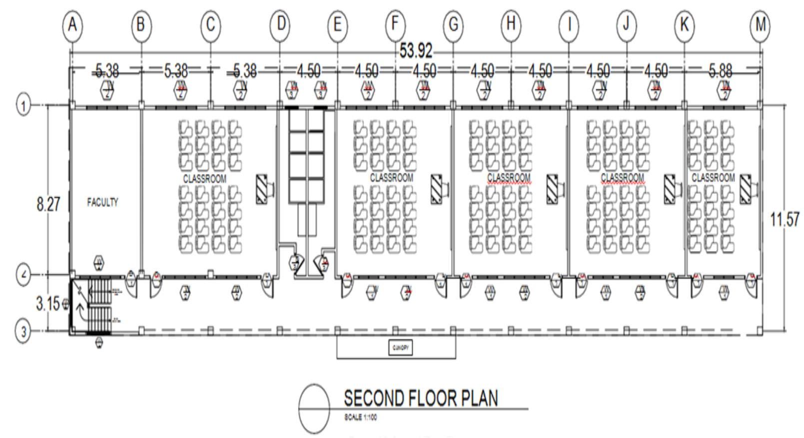

Figure 13. Second Floor Plan

Figure 13 shows the second floor plan.

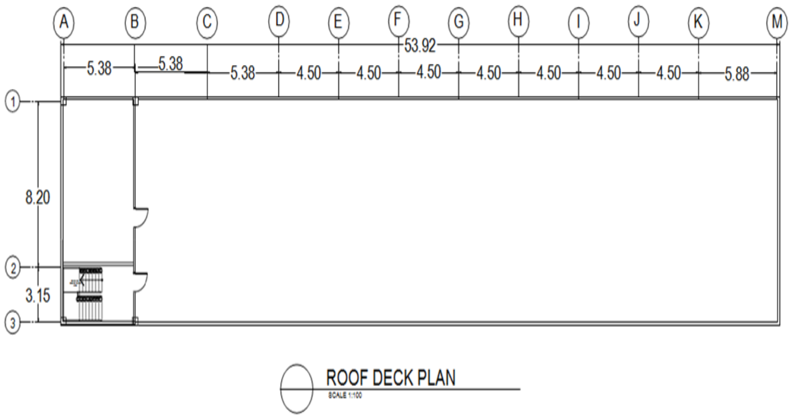

Figure 14. Roof Deck Plan

Figure 14 shows the roof deck plan of the vertical extension of the Tumana Campus of Baliuag University.

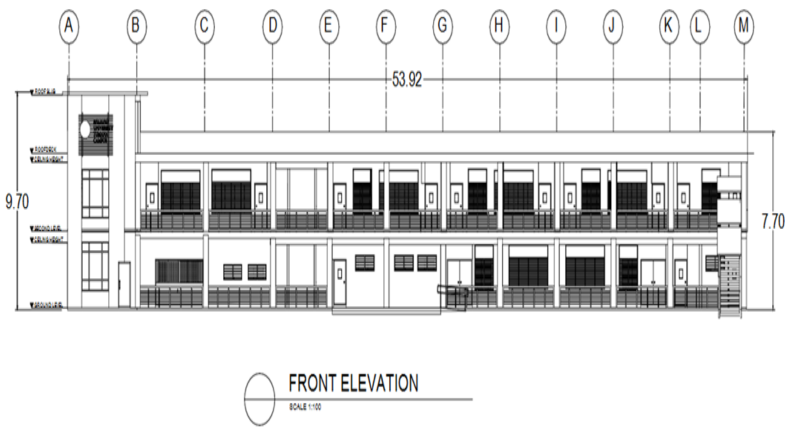

Figure 15. Front Elevation

Figure 15 illustrates the front elevation.

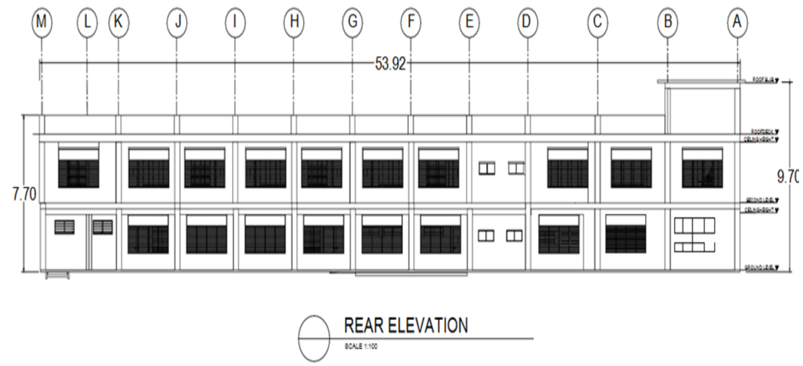

Figure 16. Rear Elevation

Figure 16 shows the rear elevation.

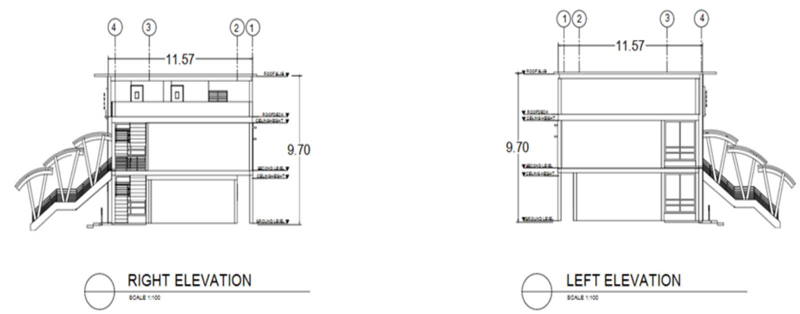

Figure 17. Side Elevation

Figure 17 shows the right side and left side elevation.

Discussion

This study is about the renovation of Baliuag University Tumana Campus Building from a single- storey building to a two-storey building. Installation of solar panels to provide energy for the building enables to minimize the building's total environmental impact and to reduce the costs associated with generating electricity.

The capability of the existing building to carry the load of the additional floor was tested by computing the strength of the existing beams and columns. Based on the computations, it showed that the existing beams and columns cannot support additional loads that will be imposed by the vertical extension.

Ultimate Strength Design (USD) Method was used to design the slabs. Based on the given dimensions, thickness of slab and reinforcement was computed. The computations on beams and columns were done using ETABS. Ultimate Strength Design (USD) Method was used for the design of foundation.

In order to support the additional floor, new columns added in front and in the back of the building. The columns and beams to be added will have the following dimensions 0.4m x 0.4m for column, and 0.3m x 0.4m for beam. Columns on the ground floor and second floor are spaced at 4.5m from center to center. In order to support the additional floor, beams will be placed above the existing beam of the first floor slab.

The computed thickness of slabs on the first floor are 150mm (S1), 140mm (S2, S3) and 90mm (S4, S5, S6, S7); 150mm (S1), 140mm (S2, S4) and 90mm (S3, S5) on the second floor; and 100mm (S1) for the roof slab.

Four types of foundations were analyzed, two square footings (F1, F4) and two rectangular footings (F2, F3). The computed dimensions of foundation are F1 - 2.9m x 2.9m d=500mm, F4 - 1.9m x 1.9m d=500mm, F2 – 2.2m x 4.4m d=650mm, and F3 – 2.8m x 3.9m d=575mm.

Fifteen units of 200W solar panels and five units of 200ah batteries will be needed for the solar panel installation. Based on the computed estimation for the solar panel installation and the average monthly bill for the amount of the electricity consumption in Tumana Campus building, the computed return of investment is 19 months.

The total estimated cost of the renovation and solar panel installation is Php10 149 741.58.

Summary

The population of students in Baliuag University had been growing for years. The purpose of this study is to design a plan for the renovation of Baliuag University Tumana Campus building with application of energy efficient design with an additional floor to serve as classrooms.

The designs and structures of the building were calculated by the researchers based on the National Structural Code of the Philippines (NSCP) to ensure that the building will be safe and comfortable for the students and professors.

The proposed design is a two-storey building with roof deck where the solar panels will be placed. Additional beams and columns were needed to support the additional floor.

Conclusion

Upon completing the design process, analyzing the data gathered, and interpreting the obtained results, the researchers have concluded the following:

- The design of the existing building is not safe to support the additional floor. New columns on appropriate foundation and beams are needed to ensure the strength of the building.
- Installation of solar panels would be of great help for the Baliuag University as it results to a higher possibility of being efficient and economical in its use of energy. It helps in the reduction of costs associated with its consumption of electricity.

Recommendation

The researchers propose the following recommendations for improvements and possible application of the study:

- Provide a more detailed estimation including the comprehensive construction process.
- Design a layout for the solar panel installation that will cover all the electric consumption of the building which will include air conditioner, equipment for teaching aids, etc.

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