Designing a Tensegrity Form of an Outdoor Hydroponic System Utilizing Bamboo (*Bambusoideae*) and Abaca Fiber (*Musa textilis*)

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ABSTRACT

The **Coronavirus Disease 2019 (COVID-19) pandemic** has caused problems regarding **unemployment and lack of food.** With this, Filipinos turned to **indoor and outdoor gardening** as an alternative source of income and food. However, one of the problems faced by home gardeners is **space insufficiency**. This research aims to find a solution to this problem by designing an **outdoor tensegrity hydroponic system** and to construct its **model** using **Bamboo (*Bambusoideae*) and Abaca Fiber (*Musa textilis*)**. The research followed a system called the **ADDIE Model** to execute its methodology. The **dimensions** of the tensegrity hydroponic system design was planned during the **Analysis phase. Freehand sketches** of proposed designs were created during the **Design phase**. The three chosen proposed designs were rendered using **Sketch-up** in the **Develop phase.** The best design was picked by comparing the three proposed designs in **FreeCAD.** The chosen design was constructed in the **Implementation phase** and was evaluated during the **Evaluation phase**. The chosen design, **table-top design**, had the **highest pascals (Pa)** under a **Generic Wood stressor** in the **Von Mises Stress test.** The structure maintained its **balance** and withstood **a load of three liters of greywater**.

Keywords: tensegrity; hydroponic system; COVID-19; bamboo; abaca

INTRODUCTION

The **COVID-19** is an ongoing crisis that caused a **halt in the cycle** within the labor market and economic activities. Filipinos turned to **indoor and outdoor gardening** as an alternative source of income and food. It became an option for farmers to also sell their harvests through **e-commerce.** An **efficient solution** to space insufficiency is to use **hydroponic systems** that can occupy **small spaces** in many types of residential areas (Grady, 2020). Designing an outdoor hydroponic system while incorporating **tensegrity** creates a more **space efficient, lightweight, and decorative garden** that maximizes space-utilization, food production, and consumption.

OBJECTIVES

1. **Design** a space-efficient and stable tensegrity hydroponic system for outdoor gardening.
2. **Prove** that the tensegrity structure is an appropriate alternative structure for the hydroponic system by subjecting it to the Von Mises Stress and load capacity test.
3. **Demonstrate** that using indigenous materials such as bamboo and abaca fiber are suitable substitute materials for the standard hydroponic systems.

METHODOLOGY - ADDIE MODEL

ANALYZE
Needs Analysis Method
Aesthetics and Ergonomics

DESIGN
Ideation Process
Rapid Sketching Analysis

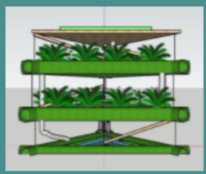
DEVELOP
Design Modelling - Sketchup
Design Experimentation - FreeCAD

IMPLEMENT
Hard Model Construction

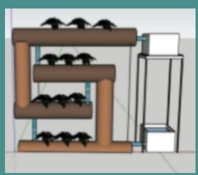
EVALUATE
Balance, Space Efficiency, and Load Capacity Evaluation

Three Chosen Designs Modeled in SketchUp:

Table-top

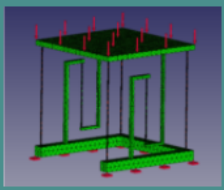


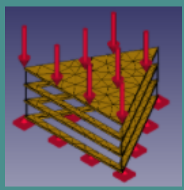
Triangular Design

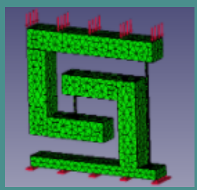


S-Design

Three Chosen Designs Modeled in FreeCAD:







RESULTS AND DISCUSSIONS

Table 1. Theoretical Results on Load Capacity Gathered from FreeCAD.

	Table-top Design	S Design	Triangular Design
Average Load Capacity with Generic Wood Stressor (Density: 700.00 kg/m^3)	1125.04 Pa	81.41 Pa	363.09 Pa

Through the Finite Element Method (FEM) in FreeCAD, the **load capacity** of the three final designs were calculated. The results in FreeCAD were merely **theoretical** and only served as a basis for identifying which design is the **most durable or most deformed.** The **Von Mises Stress** was used to find out if the chosen material will **yield** or fracture (Simscale, n.d.). **Table-top design** was the least to experience deformation and was able to maintain its structure when under the **Generic Wood stressor**. This could be due to the **table-like** appearance of the design; supporting abaca strings at four corners were able to **prevent deformity**. When the Von Mises Stress from Generic Wood was applied, **table-top design** had the highest average load capacity of **1125.04 pascals (Pa)** as shown in Table 1. **Higher pascals** (Pa) means that the structure can **hold higher pressure or stress.** As a result, **table-top design** was chosen for modelling.

Before modifications.

After modifications.

Sunlight Exposure.

CONCLUSION

The COVID-19 pandemic limited the sources for food and income. Individuals turned to **home gardening** however **lack of space** was a problem identified. A **space-efficient and stable** model of an outdoor tensegrity hydroponic system was designed in **Sketchup** and tested in **FreeCAD**. The process followed the **ADDIE model** which began with **rapid sketching** that was further narrowed to the **final design** until it was **constructed** and **evaluated.** Results from the **Von Mises Stress** and **load capacity test** proved that the table-top design incorporated with tensegrity is an **alternative structure** for a hydroponic system. The constructed table-top model used **bamboo and abaca fiber** and proved its durability under stress and compression.