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Irrigation System for a Farming Facility

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Abstract: *This endeavor aims to introduce a reinforced concrete rectangular water tank and a corresponding distribution system at the Provincial Integrated Agricultural Demonstration Farm and Training Center, situated in Barangay Ipil, Surigao City. The objective of this study is to address the challenges faced by workers in cultivating crops due to the inadequacies of the farm's existing water infrastructure. By leveraging engineering principles, established guidelines, and computer software tools, the design of an efficient water system will be meticulously executed to ensure a reliable water supply for crop cultivation. The research has thoroughly identified the crops currently cultivated on the farm, along with their respective areas. An assessment of the water source has been conducted to mitigate potential contamination risks to the crops. Rigorous water analysis has been performed, confirming that the proposed tank design is fully capable of meeting the water requirements of the crops. The design of both the water tank and distribution system, guided by comprehensive analysis, has been tailored to ensure operational efficiency and system stability. Consequently, it can be confidently concluded that once implemented, the project's designed infrastructure will effectively fulfill its intended purpose.*

Keywords: Irrigation, System, Farming, Facilities

I. INTRODUCTION

In the realm of crop agriculture, water stands as a pivotal climatic determinant, exerting a profound influence on the growth and maturation of plants. Its presence or absence bears a direct impact on the outcome of harvest, ranging from bountiful yields to disappointing reductions or even complete crop failures. The task of maintaining a consistent water supply for agricultural endeavors can often transform into a daunting financial challenge, primarily due to the substantial volumes of water required to sustain the vitality of crops. Farmers tend to rely extensively on the onset of rainy seasons as a crucial element for fostering robust crop growth and ensuring a successful harvest by the season's end. However, when precipitation proves elusive for an extended period, crops can be subjected to perilous outcomes, either withering away due to inadequate hydration or experiencing a significant decline in their overall health and condition [1].

In light of these considerations, the implementation of a water tank presents a practical solution. Such a tank facilitates the collection and storage of water, serving as a reservoir for later irrigation of crops. This setup proves especially advantageous for farms, whether small or extensive in scale, as it liberates farmers from the constraints of solely relying on the rainy season to engage in agricultural activities [2].This water storage unit can be strategically linked to a dependable water source dedicated to agricultural purposes, such as a nearby dam or river. Given the indispensable nature of water for all agricultural endeavors, effective management of its distribution becomes paramount. Agricultural irrigation systems emerge as pivotal tools, fulfilling the critical function of supplying the precise amount of water at the optimal juncture in the growth cycle of crops [3].In contemporary agricultural landscapes, there's a discernible shift from traditional open channels to the increasingly prevalent deployment of pipeline irrigation systems. These systems exemplify a more rational and efficient approach to water resource management, resulting in enhanced utilization of this precious resource [4, 5].

The Provincial Integrated Agricultural Demonstration Farm and Training Center in Barangay Ipil, Surigao City is currently grappling with the challenge of insufficient water pressure due to its existing water distribution system [6]. This agricultural establishment encompasses a land area of 3.22 hectares, out of which 1.85 hectares are allocated for cultivation, while the remainder is designated for veterinary activities. Notably, both the veterinary and planting sections rely on a singular water tank positioned within the veterinary area. This arrangement occasionally leads to

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issues in the planting area, resulting in inadequate water supply for crop irrigation. Consequently, this situation hampers the farmers' efficiency in watering and maintaining the crops [7].To address this challenge, the study proposes a viable solution: the incorporation of a purpose-designed reinforced concrete water tank in the planting area. Such an addition would prove immensely beneficial for the workers and the overall distribution system. The efficacy of this system is particularly enhanced when an elevated water tank is integrated into the distribution network. This elevation ensures uniform and adequate pressure across the farm's expanse, facilitating optimal hydration of plants with the requisite amount of water tailored to their specific needs [8].This proposed water distribution system is particularly well-suited for row crops and tree crops that are cultivated in close proximity on the farm. By leveraging the calculated flow rate of the water source, which amounts to 0.0002 m^3/s, it becomes evident that the water tank's design and the distribution system must be meticulously planned to possess the necessary capacity to effectively meet the water demands of the entire agricultural operation [9].

This research endeavor holds the potential to offer significant assistance to the agricultural enterprise, addressing a persistent issue faced by farmers involving inadequate water supply and its effective distribution. By implementing the proposed solutions, the farm stands to notably alleviate the challenges surrounding water scarcity and streamline the process of irrigating the crops [10].

The introduction of a reinforced concrete water tank also promises multifaceted advantages for the farm. Notably, its durability and longevity are of paramount importance, factors that resonate especially well in the farm's context. The farm's geographical location in a mountainous region exposes it to the risk of bushfires, and the tank's robust construction ensures its resilience in such adverse conditions. Moreover, the tank's inherent durability aligns with the agricultural operation's longevity requirements, while its cost-effectiveness serves as an additional merit that enhances its feasibility and utility [11].

II. METHODS

Figure 1 below depicted above outlines the study's sequential progression. It offers a visual representation of the tasks undertaken by the researchers from project initiation to its conclusion. The problem statement phase initiates with preliminary site visits to the farm. During these visits, researchers ascertain the root issue, which in this case is the inadequate water supply for the crops due to the farm's existing water distribution system. Subsequently, the process involves collecting pertinent data essential for shaping the project's design. Following data collection, the gathered information is subjected to comprehensive analysis employing both hydraulic and structural principles aligned with established engineering criteria. This analytical phase acts as a pivotal stepping stone, facilitating the derivation of the final output: the meticulously crafted design for the water tank and the accompanying distribution system.

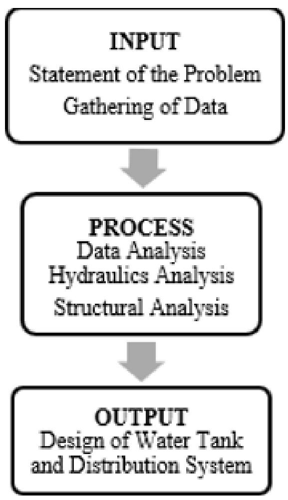

Figure 1. Flowchart of the Study

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2.1 Project Design

In this study, a developmental research design is employed, distinct from a simple instructional development approach. Developmental research design is characterized by its systematic investigation into the creation, refinement, and assessment of processes that must adhere to predetermined effectiveness criteria. This concept is visually represented in Figure 2.

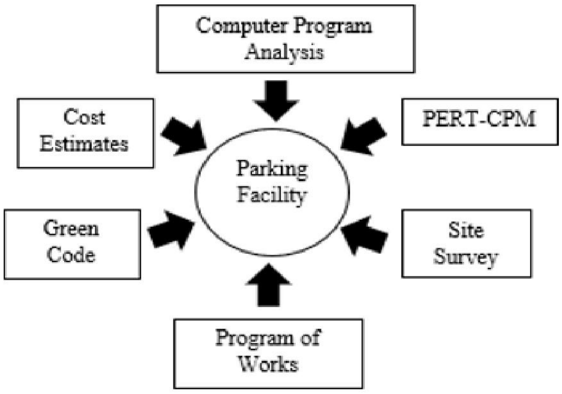

Figure 2. Project Design Chart

The diagram provided above illustrates the developmental design process of the project. The developmental design, serving as a guiding framework, steers the study's trajectory. The collected data will be harnessed for conducting hydraulic analysis, which in turn aims to unveil pressure contours and flow patterns within the system. This analysis also plays a crucial role in determining flow rates, head losses in pipes, and pressures at critical junctures under varying water demand scenarios. This insight equips the study to ascertain the system's capacity to meet its intended demand effectively.

Within the realm of water distribution, it's imperative to maintain water quality throughout the distribution pipes and ensure a sustained supply with adequate pressure head. The network comprises reservoirs and pipe intersections, a configuration thoroughly investigated within this study. The design of pipe layouts involves the careful selection and combination of pipes of differing dimensions, materials, valves, and outlets. These elements collectively aim to deliver water with the desired quality, quantity, and pressure.

Subsequently, the project proceeds to the structural analysis stage. This phase assesses the water tank's structural design, evaluating its capacity to withstand external and internal stresses, as well as anticipated forces. The analysis computes the load borne by the water tank's structure and forecasts its performance under these loads. Additionally, reinforced concrete design is integrated to counteract tensile stresses, particularly within specific concrete areas that could lead to undesirable cracking or structural failure. Reinforced concrete may also be pre-stressed to enhance the structure's behavior under operational loads.

2.2 Project Setting

The project site is situated in Barangay Ipil, Surigao City. This location encompasses an agricultural expanse spanning 1.85 hectares and is specifically situated within the Provincial Integrated Agricultural Demonstration Farm. The delineation of the agricultural zone is marked by the yellow line, whereas the proposed tank placement is indicated by the red line. The precise Global Positioning System (GPS) coordinates for the tank's placement are recorded as 9°47'59.51" N latitude and 125°26'41.24" E longitude. Notably, the nearest active Surigao fault trace relative to the water tank's location is approximately 2.1 kilometers, as identified through the Phivolcs fault finder tool.

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Figure 3. Location of the Project

2.3 Instruments

Within the context of this project study, the principal instruments employed encompass the subsequent tools:

- Drafting software: This category of software applications serves designers and engineers in generating both two-dimensional and three-dimensional models of physical components.
- Microsoft Office suite: This collection encompasses a variety of office-oriented applications designed for creating documents, presentations, spreadsheets, and datasheets, facilitating diverse documentation needs.
- Global Positioning System (GPS): Comprising approximately 30 strategically spaced satellites orbiting the Earth, this system empowers individuals equipped with ground receivers to accurately determine their precise geographic coordinates, aiding in location pinpointing.

2.4 Ethical Considerations

During the project study, the researchers took care to adhere to legal and environmental guidelines. Additionally, they emphasized the human factor as a central ethical concern. This entailed an evaluation of how the project design affects human intervention, underscoring its impact on individuals as a pivotal ethical consideration.

III. RESULTS AND DISCUSSION

3.1 Crop Varieties at the Demonstration Farm

The Provincial Integrated Agricultural Demonstration Farm and Training Center boasts a diverse array of cultivated crops. The subsequent table provides an inventory of the crops currently grown on the premises, along with the corresponding land area dedicated to each.

TABLE 1: CROPS IN THE FARM

Crops	Area (m^2)
Pechay	217.593
Cabbage	263.52
Corn	1,372.63
Eggplant	254.76
Tomatoes	149.18
Okra	171.67
Ampalaya	248.843
Banana	2,609.12
Pineapple	818.64
C hilli Pepper	188.65
Onion Leaves	150.69
Lemon Grass	71.84
Aloe Vera	95.99

3.2 Analysis of Water Source

The water required to fulfill the project's needs is sourced from a stream, characterized as a narrow and consistent-flowing river with a discharge rate of 0.0002 m^3/s. The following illustration depicts the water source observed during the survey.

Figure 4. Source of Water

Crops	CWR (mm/day)	FIR (lps/ha)	FWR (lps/ha)	DWR (lps/ha)
Pechay	4.7686	0.4629	0.661	0.8266
Cabbage	4.22	0.4847	0.6923	0.202
Corn	2.308	-0.085	-0.121	-0.151
Eggplant	3.28	0.3758	0.5368	0.0671
Tomatoes	5.894	0.6784	0.9691	1.2115
Okra	4.701	0.5403	0.7719	0.965
Ampalaya	64.15	7.421	10.607	13.253
Banana	8.456	0.9749	1.3927	1.7409
Pineapple	3.025	0.3463	0.4948	0.6185
Chilli Pepper	2.138	0.2437	0.3481	0.4351
Onion Leaves	2.211	2.2521	0.3601	0.4502
Lemon Grass	2.1375	0.2436	0.3480	0.4350
Aloe Vera	2.95	0.3376	0.4824	0.603

Figure 5. Water Requirements

Water is an indispensable factor in the growth and development of agricultural crops. As a critical component of plant physiology, water sustains numerous essential processes, such as photosynthesis, nutrient uptake, and temperature

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regulation. Understanding the precise water needs of different crops is paramount for achieving optimal yields and maintaining agricultural sustainability. Crop water requirement refers to the volume of water necessary for sustaining healthy plant growth throughout various stages of their life cycle. It takes into account factors such as climate conditions, soil type, crop type, and growth stage. Accurate estimation of crop water requirement not only ensures efficient water usage but also aids in resource planning, irrigation management, and overall agricultural productivity. This comprehensive exploration of crop water requirement delves into the key considerations, methodologies, and factors that influence how much water different crops need. By understanding and managing crop water requirements effectively, farmers and agricultural stakeholders can strike a balance between water conservation and ensuring successful crop production.

Hydraulic analysis is an essential prerequisite for any project involving the implementation of works in a river. The design study can be carried out by applying the basic theory of hydraulics.

With the capacity of the tank, the dimension of the tank can be determined using below formula:

2160 m3 (0.20) = 432 m3

Volume of tank = (9 x 8 x 6) m

Designed Volume of Tank = 9m x 8m x 6m

Actual capacity is greater than required capacity in order to have enough allowance. After that, the discharge of the tank can be determined using flow rate calculation.

Q = A x V

where, A – area

V – volume (0.0585 m/s)

which states that when flow is constant, as velocity increases, the flow area decreases and vice versa.

Q = (9) (8) (0.0585) Q = 4.212 m3/s

Then, diameter of the pipe from the reservoir to the tank will follow. The units in the simulation are in English System. Diameter is computed using Hazen-Williams Formula,

HL = 10.67 (L) (Q)1.85

C1.85 D4.87

where,

HL – head loss

L – length of pipe in m

D – diameter of pipe in m

Q – discharge in cubic meter per second

C – Hazen's Coefficient (with constant of 130)

137 = 10.67 (1358.45) (4.212)1.85

1301.85 D4.87

D = 0.218 m say 220 mm

The design of the project is shown in the following figures. Figure 6 below is the plan view of the water tank.

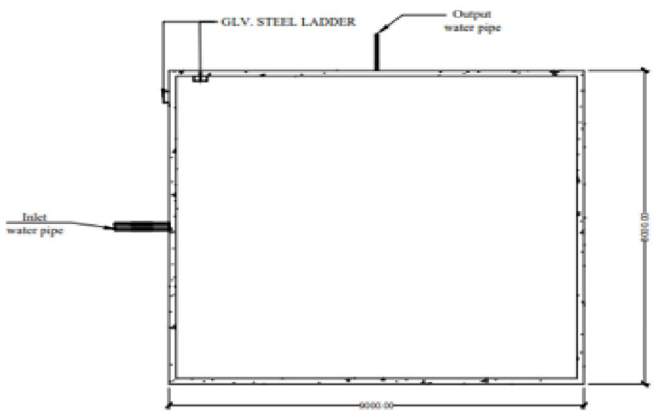

Figure 6: Plan View of the Water Tank

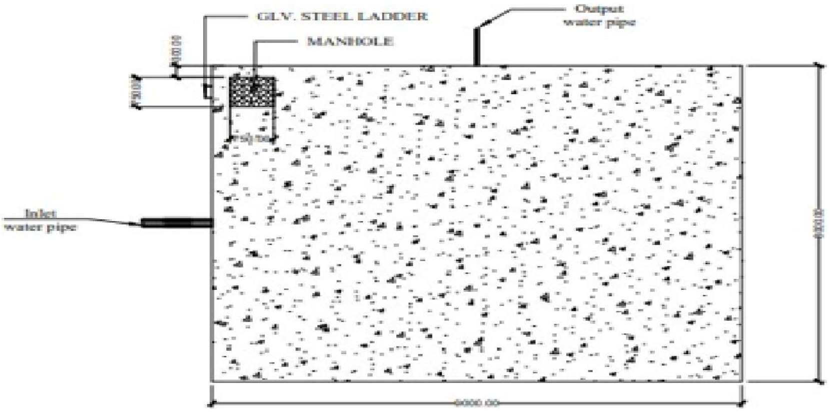

Figure 7: Section View of the Water Tank

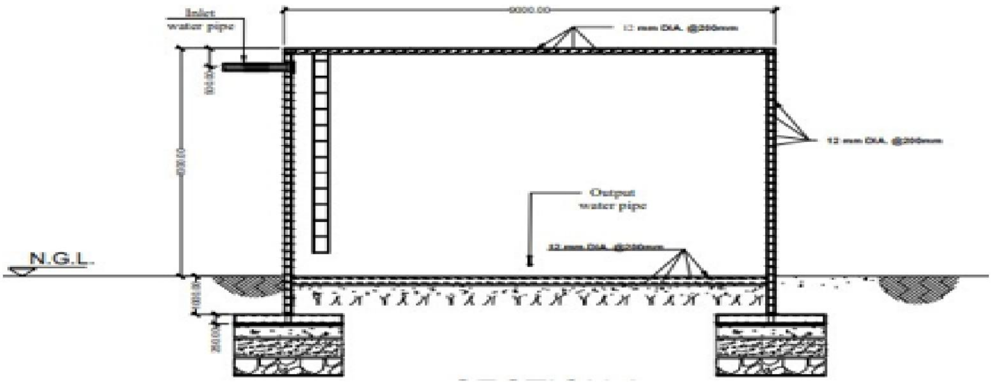

Figure 8: Section View of the Water Tank

In engineering and architectural design, comprehensive visualization is crucial to accurately conceptualize and communicate the form, structure, and details of complex structures. When it comes to designing a water tank, three distinct perspectives are employed: the top view, front view, and side view. Each of these views offers a unique vantage point that aids designers, engineers, and stakeholders in understanding the tank's dimensions, proportions, and features.The top view in Figure 6 provides an overhead representation of the water tank, offering insights into its shape and layout when observed from directly above. This view is particularly useful for assessing the tank's footprint and how it integrates into its surroundings.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The identification of crops on the farm has been established, revealing that the existing water tank falls short in catering to the diverse range of crops present. Given that each crop occupies a considerable area, the inadequacy of the current tank becomes evident, prompting the imperative for designing an additional water tank to accommodate both present and future cultivation needs.

An analysis of the water source has been conducted, revealing subpar water quality as inferred from the results of the water analysis. This makes the water unsuitable for consumption due to its compromised health and acceptability aspects, particularly pertaining to taste, color, and other sensory attributes.

A meticulous evaluation of the farm's water requirement has been undertaken. This analysis serves as a benchmark to determine whether the newly designed water tank can effectively cater to the water demands of the crops. Remarkably, the discharge capacity of the designed tank substantially exceeds the cumulative water requirement of the crops. As a result, the designed rectangular water tank holds the capacity to adequately supply the requisite water for both the current and future crops.

The comprehensive design of the water tank and distribution system has been successfully executed. The analytical assessment confirms that the water system is poised to operate with efficiency once implemented. Moreover, the robustness of the major components of the water system has been evaluated to ensure their resilience against diverse natural challenges and conditions.

4.2 Recommendations

In light of the water source analysis, it is advisable to implement water treatment measures to preempt potential contamination risks. Crops irrigated with tainted water could inadvertently result in contaminated food products, posing a risk of illness upon consumption. The adverse impact of subpar water quality extends to both the crops' overall quality and the well-being of consumers.

It is prudent to propose a water distribution system that employs a pipe layout conducive to minimal water stagnation within the pipelines. This strategic layout is instrumental in averting concerns such as tuberculation and encrustation, which can arise due to prolonged water stagnation.

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