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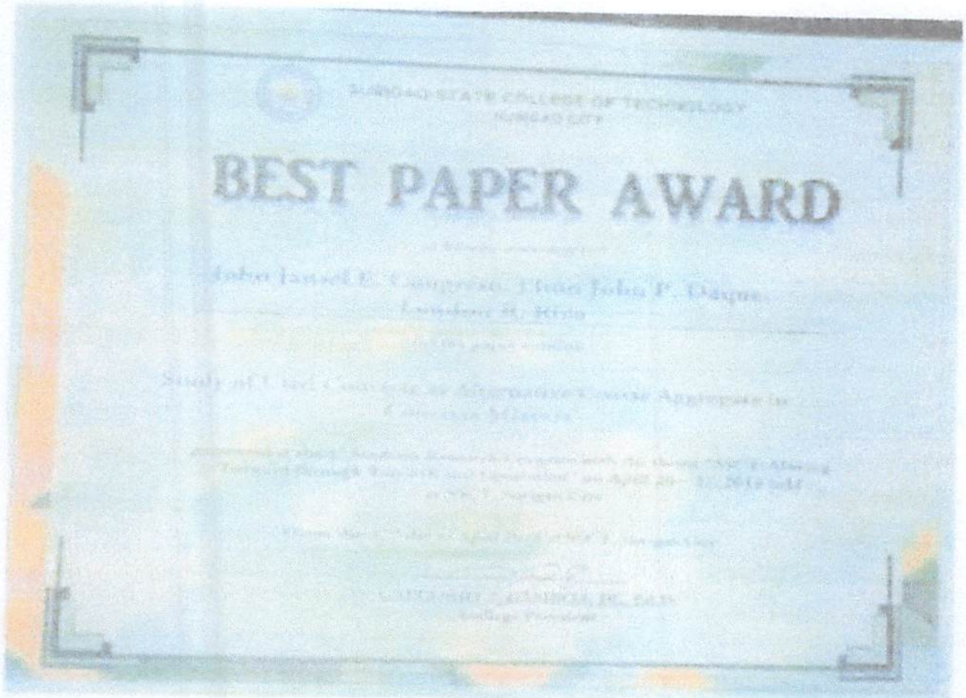
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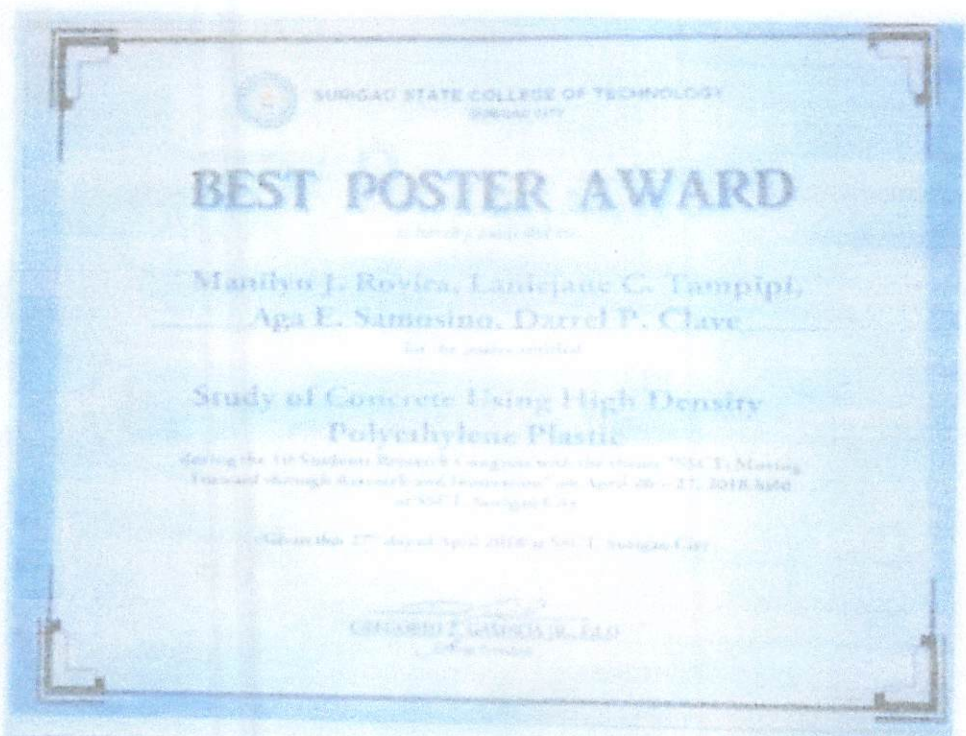
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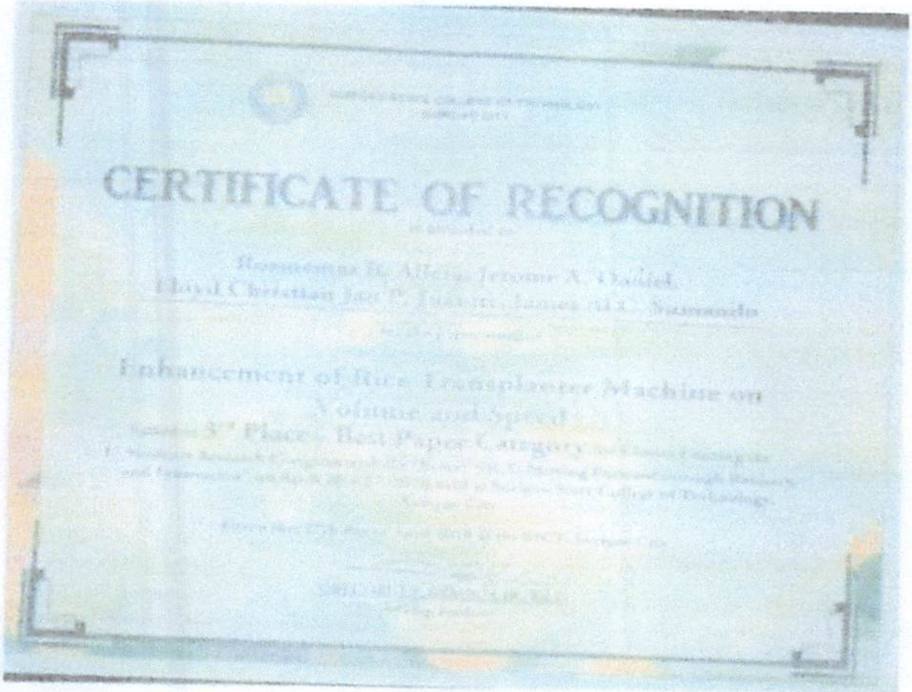

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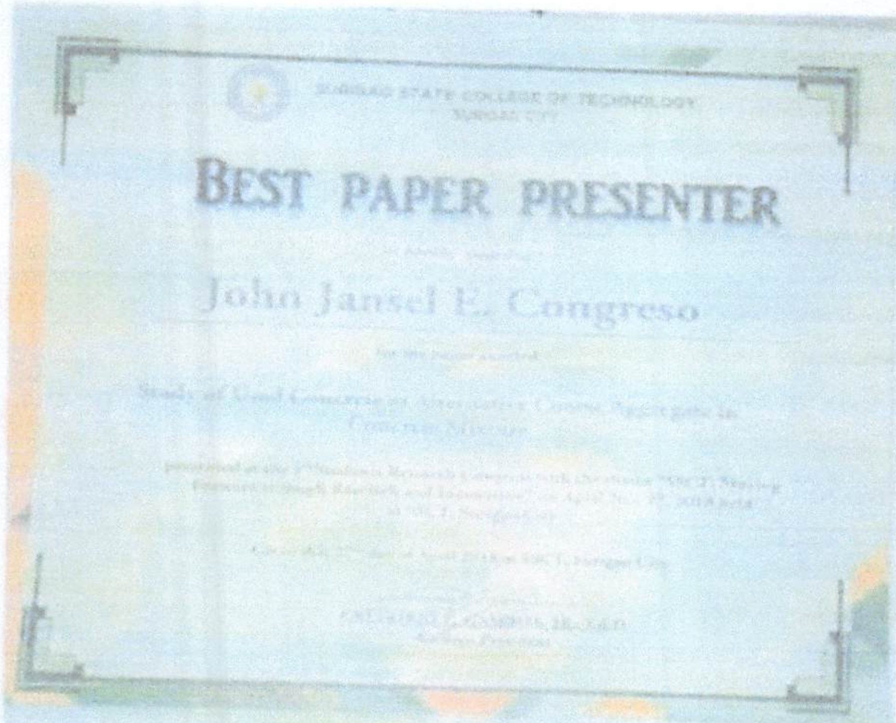

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BEST PAPER PRESENTER

John Jansel E. Congreso

ANALYSIS OF VOID SPACE IN CONCRETE: A CASE STUDY IN SSCT BUILDING

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Abstract: The purpose of this study is to detect the void space in a concrete using the impulse radar, in which this study is located at SSCT building, with the advancement in GPR technology, especially the increase in frequency of commercially available GPR antennae and better data processing software, GPR can now be used for subsurface condition assessment in materials consisting of thin layers[1]. On the other hand, a ground coupled 1.5 GHz antenna was found to offer higher penetration capability, which is crucial for testing thick decks[2]. There are about five developing stages in this study which are, research design, project design, project development, project setting, and data collection procedure[3]. This study is to locate and analyse the void space in concrete providing more relevant and accurate data by simulating raw data collection[4]. GPR offers more penetrating power and so can detect concrete defects or deteriorations at greater depths[5]. As the result of this study the GPR technology has an accurate and sensitive sensor that could cause difficulties during the experiment but by using an accurate algorithm it could be possible to identify the void space[6].

Keywords: Radar system, Ground Penetrating Radar (GPR), Void Space

1. INTRODUCTION

The inspection and analysis of ageing infrastructure assets or those newly installed rely on reliable quantitative data to make informed decisions concerning condition and integrity. Concrete, and other human-made composites (such as asphalt), are widely used as construction materials. As a non-destructive method, GPR can be used to scan these penetrable materials before cutting or coring, or other non-destructive testing.

GPR can see into a structure to provide accurate information showing orientation and depth to subsurface features and objects, an advantage over the more traditional manual and visual inspection methodologies. The information provided by GPR is routinely used to help priorities repair or rehabilitation works according to their importance.

Ground-penetrating radar (GPR) technology has been commercially available since the early 1970s. From the start, operators noticed that the radar image generated around damaged concrete showed increased signal attenuation, sometimes distorted bar reflections, and even direct evidence of delamination cracks.

The development of high frequency antennas, the ability to digitize the collected data, and powerful analysis and imaging software have aided tremendously in the interpretation of test results. In spite of the steady improvement in technology, the main use of high frequency GPR is to locate embedded objects. However, GPR's potential for the condition assessment of concrete structures has been recognized for at least 30 years.

This paper will examine the GPR as a tool for detecting defects in concrete, identify the common numerical method of condition analysis as the main obstacle, and propose an alternative methodology for computer-assisted visual analysis of GPR images capable of producing more accurate deterioration maps of concrete structures.

1.1 Related Literature

Using Ground Penetrating Radar Methods to Investigate Reinforced Concrete Structures. In this paper, an overview of the existing literature within the subject area of ground penetrating radar (GPR) methods for the investigation of reinforced concrete structures is reported. Six major application areas had been identified where experimental, numerical and theoretical research on GPR has been developed. The review demonstrates that the applications of GPR to reinforced concrete structures are continuously growing. It was also observed that research in some application areas has been mostly or exclusively carried out at the laboratory scale and, similarly, some application areas have been investigated on real-life structures only.

Automatic De-lamination Detection of Concrete Bridge-Decks Using Impact Signals. An AIDD system is described in this paper. In this system, the traffic noise was eliminated by a physical barrier, as well as a modified ICA algorithm. The MFCCs of the filtered signals were extracted, and the most effective ones were selected as features. The mutual in- formation between the MFCCs and the condition of the concrete from which the signal was calculated was used to select the most effective features. The selected features were used to detect the de-lamination and to train a classifier for future use.

An automatic impact based de-lamination detection system for concrete bridge-decks. Even though sounding methods are simple, fast and inexpensive for detecting de-lamination in concrete bridge decks, their performance can be undermined by traffic noise in adjacent lanes and the subjectivity of the operator. To improve the performance of traditional sounding methods, this study addressed the two factors that reduce their performance and an automatic impact- based de-lamination detection (AIDD) system consisting of hard- ware and software components was developed.

Laboratory validation of corrosion induced delamination in concrete by ground penetrating radar. From this laboratory experiment, it is concluded that the peak amplitude of the reflected signal from the rebar is an effective indicator for corrosion assessment when the defects are not visible on the concrete surface. The presence of surface crack and its development are highly associated with the change in amplitude. Further studies on the effect of varying the samples moisture content to the reflected signals are worthwhile, in order to evaluate the feasibility of applying GPR in corrosion assessment in RC structures in the field, where moisture content varies among different field structures.

Condition assessment of concrete structures using a new analysis method. Ground penetrating radar computer-assisted visual interpretation. GPR (radar) is an efficient tool for condition assessment of concrete. It is especially sensitive to the increase in conductivity caused by reinforcing bar corrosion, while delamination cracks and moisture, have little influence on the attenuation of radar data. The main issue is how to extract this information from the data. In the past, the widespread acceptance of numerical amplitude analysis as the only method of data processing has led to mediocre results.

Amplitude analysis ignores most of the information contained in radar images and leads to errors. GPR

The presented case study well illustrate possibilities of the GPR technique in interpretation of complex pavement structures and possible mechanisms of cracking process. In this work, a prototype of an impulse RADAR sensor is developed and studied. Based on the concept of ground penetrating RADAR (GPR).

1.2 Theoretical Framework

Theory 1. Attenuation

Concrete is classified as a dielectric material and can behave either as an insulator or conductor of electromagnetic waves. From the fundamental theory for electromagnetic wave propagation it can be shown for conductive dielectric materials that:

$$\alpha = \omega[\frac{\mu\varepsilon'}{2}(\sqrt{1+\tan^2\delta - 1}) \quad [1]$$

where: a = attenuation coefficient OJ = 2m - angular frequency Theory 2. Wave Velocity

In most practical applications, geological and building materials are classified as low loss materials (tano« \) at radar frequencies and therefore the general equation for wave velocity is often simplified to:

$$v = \frac{c}{\sqrt{\varepsilon_r}} \quad [2]$$

Which is independent of frequency and conductivity. Theory 3.Vertical Resolution

The vertical resolution is a measure of the ability to recognize individual closely spaced reflectors, or to distinguish two signals in the time domain. For a reflected pulse represented by a simple wavelet, the maximum resolution possible is between one quarter and one eighth of the dominant wavelength of pulse. For the present analysis it was assumed one quarter as usually adopted in GPR practical applications. The wavelength can be calculated in general by equation:

$$\lambda = \frac{v}{f} \quad [3]$$

Where v = wave velocity f = frequency Theory

4.Clutter Reduction

Clutter in GPR systems refers to the radar signals returned from material heterogeneity. In the case of concrete it would be mainly the energy scattered by the larger aggregates. To minimize the clutter effect, the dominant signal wavelength should be much larger than the characteristic dimension of the heterogeneity in the host environment. However for concrete, since it is an artificial material obtained by the mixture of other known materials, there is some control over their size. For this reason, this analysis was carried out assuming only five times the characteristic dimension of the heterogeneity.

$$f < \frac{60}{d'\sqrt{\varepsilon_r}} \quad [4]$$

d' represents the characteristic dimension of the heterogeneity. Theory 5. Horizontal Resolution There are two main controls on the horizontal resolution of a reflection survey, one being intrinsic to the physical process of reflection and the other being determined by the transducer spacing in the case of bistatic mode operation. Since GPR applied on structures usually involves using transducers which act as transmitter and receiver simultaneously, the bi-static mode was not considered in this study

1.3 Conceptual Framework

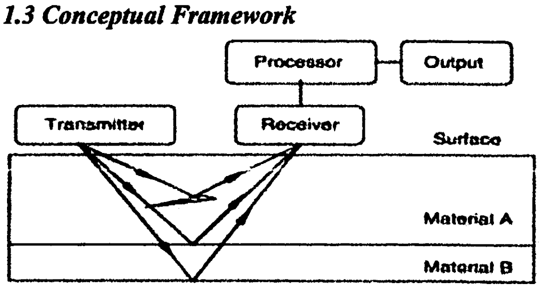


Figure 1. ***Principle of testing with the GPR system.(Dong, Y.Ansari, F, 2011)***

Ground penetrating radar (GPR) operates by transmitting electromagnetic waves (in the range of 10 ~ 10 00 Hz) into the probed material and receiving the reflected pulses as they encounter discontinuities. The discontinuity could be a boundary or interface between materials with different dielectrics or it could be a subsurface object such as de-bond or delamination.

The amplitudes of the received echoes and the corresponding arrival times can then be used to determine the nature and location of the discontinuity.

Compared to other non-destructive techniques such as infrared thermographs, ultrasonic or microwave, GPR offers more penetrating power and so can detect concrete defects or deteriorations at greater depths.

1.4 Objectives

This study is to locate and analyse the void space in concrete providing more relevant and accurate data by simulating raw data collection.

The specific objectives are:

1. To document the system design.
2. To identify void space in concrete.
3. To apply impulse radar to detect the void space in concrete.
4. To analyse data base on radar gram results.

2. METHODS

2.1 Research Design

With the advancement in GPR technology, especially the increase in frequency of commercially available GPR antennae and better data processing software, GPR can now be used for subsurface condition assessment in materials consisting of thin layers. Careful analysis of GPR waveforms can potentially help detect subsurface de-bond sand delaminations within the deck. Compared to other nondestructive techniques such as infrared thermography, ultrasonic or microwave, GPR offers more penetrating power and so can detect concrete defects or deteriorations at greater depths. Results from the literature review show that the lower frequency GPR antenna (1 GHz) cannot detect shallow defects such as de-bonding in FRP wrapped members, but a phase higher frequency antenna (2 GHz) can detect those defects (Jackson *et al.*, 2000). On the other hand, a ground coupled 1.5 GHz antenna was found to offer higher penetration capability, which is crucial for testing thick decks (Halabe *et al.*, 2006).

2.2 Project Design

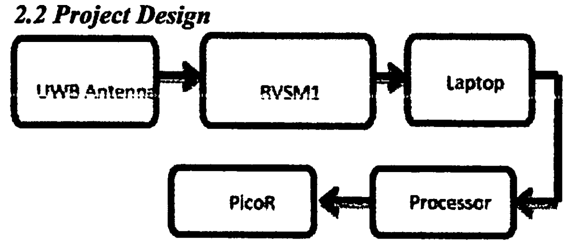


Figure 2: ***Block diagram of the proposed project***

An impulse radar-based system working with a series of discrete sinusoidal pulses within a specified broad-frequency band and a signal repetition rate. Using PicoR-2k evaluation kit for UWB short-range radar development allows to reveal the possibilities of technologies of generation, emission, reception and processing of impulse UWB signals. It is used to develop portable short-range radar systems, including GPR (ground penetrating radar), inspection of building structures (search for reinforcement, irregularities in the structure of the material, determination of any concrete de-lamination).

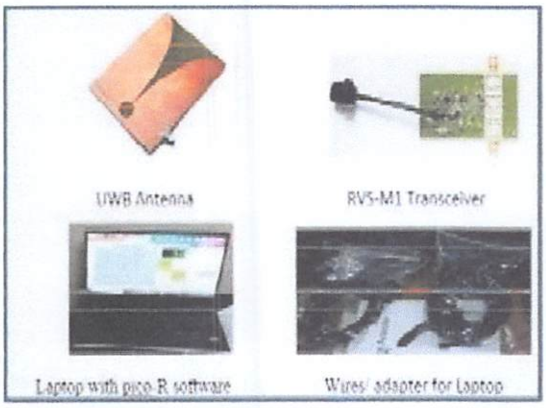


Figure 3. ***System Component***

2.3 Project Development

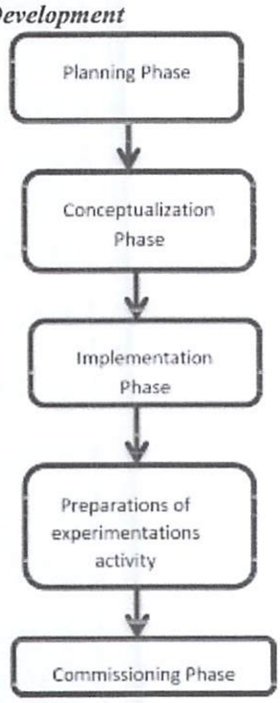


Figure 4. ***Development process of the study***

Planning Phase- The planning will be done with the team for right acquisition of electromagnetic wave radar which can be modified and upgrade. Materials on the fabrication of the antenna are also considered base on local market availability.

Conceptualization Phase - Designing of structural, mechanical, and architectural components. The design is simulated and rendered in the computer for optimization.

Implementation Phase - Antenna simulation using CST software, fabrication of antenna, signal processing design based on raw data extracted from the electromagnetic radar and GUI design will be implemented in MATLAB.

Preparation of experimental activity - A concrete slab will be prepared where it will be exposed to 28 days curing, a DC current injected on three rebar to expedite the corrosion while submerging to NaCI solution to simulate corrosion. Observation of infrared thermograph will be observed and the electromagnetic radar wave behavioural analysis.

Commissioning Phase - Performance testing to the detection of de-lamination in building structure. Refinement and adjustment based on actual problems encounter during the actual scenario of assessment.

2.4 Project Implementation

To accomplish this study, the prototype model of an experimental cart made with ½ inches diameter PVC pipe has been designed and constructed. The cart is pushed and pulled through a flat surface or railing to provide smoothness and avoid shaking of the antenna. The experiment was to detect void space in concrete. Two types of concrete was experimented, with void space and without void space. The scanning trial of each area is tested by pushing and pulling the impulse radar. The scanning trial was conducted in three areas. First area of scanning is conducted at SSCT main campus building, selecting two specific area where there is void space, and without void space, marking it of white tape with the dimension 100x100 cm and 20 cm thickness. The same as in the second area, conducted at Brgy. Cayutan Surigao City basketball court, selecting specific area to be test with void space and without void space, marking with the dimension 100x100 cm and 10 cm thickness. The experiment was done using the impulse radar 1GHz antenna.

The third experiment was conducted using two specimens of concrete block and concrete block with void space. One specimen is purely concrete block with a size 10x100x100cm, another specimen with glass bottle mixed in the concrete block with the size of 10x100x100 cm. The movement of the cart is perfectly perpendicular to position of the buried glass bottle.

2.5 Project Setting

Figure 5. ***Location of the Case Study (Google Maps)***

Surigao State College of Technology (SSCT) is located at Magallanes Street, Surigao City, 8400 Surigao Del Norte. It was built in the year 1960's, an earthquake of magnitude 6.7 hit Surigao City in the night of February 10, 2017, Friday. The school was badly hit by the earth quake which is a perfect location for studying any de-lamination in the concrete structure of the buildings.

2.5 Instruments

In this study, the following components are used as an instrument for the fulfilment of this experimental study:

1. PicoR software
2. Computer/ laptop
3. Transmitting and 1GHz receiving antennas
4. Push cart
5. Measuring tape
6. Marking tape

2.6 Data Collection Procedure

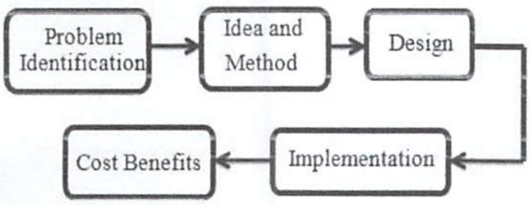


Figure 5. ***Quantitative and qualitative data collection***

Problem Identification - Understanding the behavior based on the signal processing representation from the simulated delaminated reinforced concrete, crack, voids, or moisture content. Antenna consideration and program adjustments will be explored until evidence of the target of interest will be distinguished and proven. **Idea and Method** - The GPR is used to image the subsurface, it may use on a host of different penetrable materials to detect and map features or objects within, GPR is the idea way to investigate the subsurface for a wide range of applications, deploying GPR in the field is easy, and sites can be scanned rapidly, which also makes it an economical choice, With the advancement in GPR technology, especially the increase in frequency of commercially available GPR antennae and better data processing software, GPR can now be used for subsurface condition assessment in materials consisting of thin layers.

Design - The traditional electromagnetic wave radar sensor which has separate monitor, data acquisition unit, long transmission and power cables, backup battery, rf amplifier, transmit/receive antenna and cart with manual picoR.

Cost Benefits - The cost benefit analysis well be computed based on commercially available electromagnetic wave radar and develop portable electromagnetic wave radar. Market analysis is also presented to this report where there will be a survey to the construction firm companies and building owner for future commercialization.

3. RESULTS AND DISCUSSIONS

3.1 Documentation of the system design

Figure 6. ***Preparation and making concrete slab***

Figure 6 shows the preparation and making of two concrete slab one with void and one without void space for experimentation, mixing 3 sacks of gravel and 3 sacks of sand with 1 sack of cement to form two concrete block with the size of 6x100x100 cm.

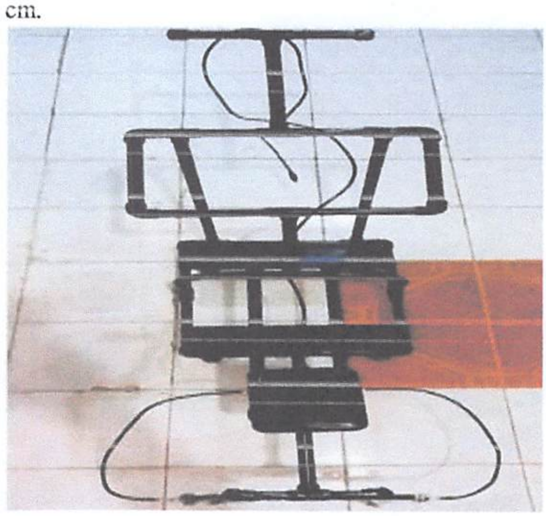


Figure 7. ***Top view of system design*** Figure shows the top view of the cart for the picoR system.

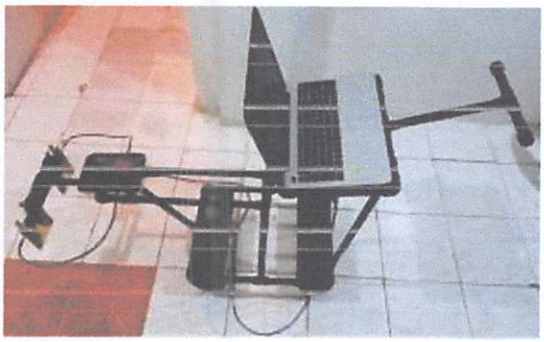
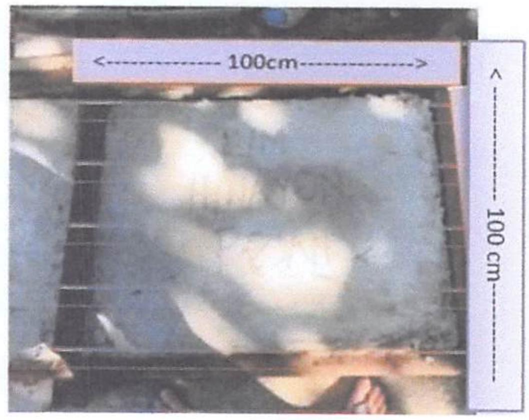
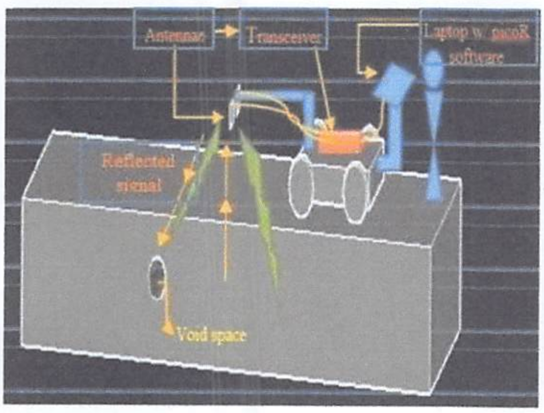


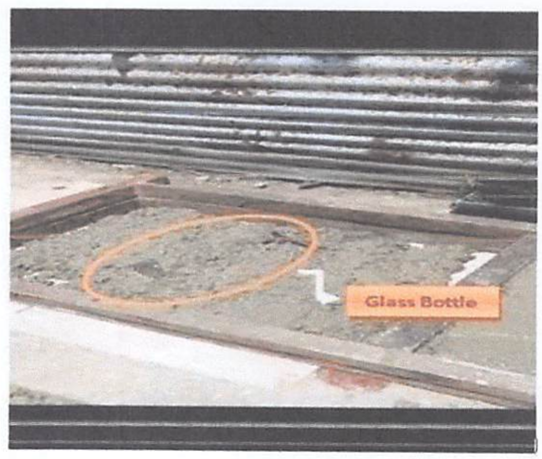
Figure 8. ***Right side view of system design***

Figure 8 shows the right side view of the system



design where the installed picoR





system. **Figure 10.** ***Concrete Slab without Void Space***

Figure 9. ***Test Principle of the GPR system***

Figure 9 shows the scanning principle of the Ground Penetrating Radar(GPR) forward and backward movements.

3.2 Simulated Space Void Using Concrete with Space Void Inside

Experiment was conducted using two specimens of concrete block and concrete block with void space to examine the impulse radar capability in detecting the void space. One specimen using purely concrete block with a size 6x100x100cm as shown in the Figure 10. Another specimen with glass bottle mixed in the concrete block with the size of 6x100x100 cm as shown in the Figure 11.

Figure 11. ***Preparation of void space***

Figure 12. ***Concrete Slab with Void Space***

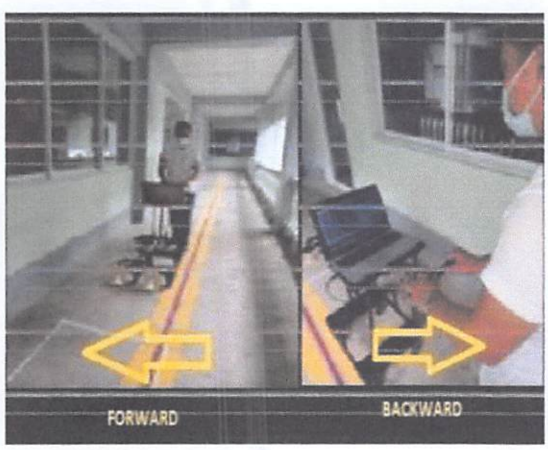


Figure 13. ***Scanning***

The figure above shows the one backward and one forward scanning of specimen using the Develop Impulse Radar at SSCT building main campus.

Figure 14. ***Simulation result with void space***

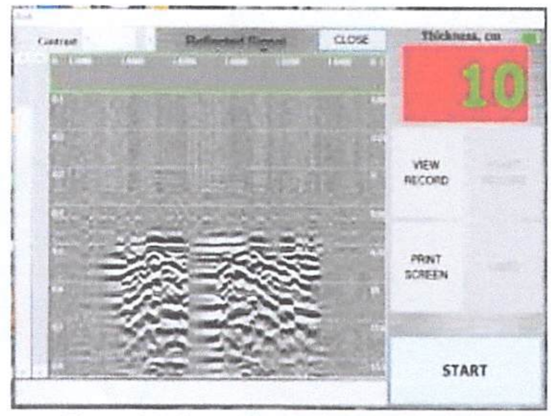


Figure 15 shows the analysis of the behavior of the develop impulse radar using the radar-gram for concrete slab without void space.

3.3Actual Testing

3.3.1 SSCT Main Campus

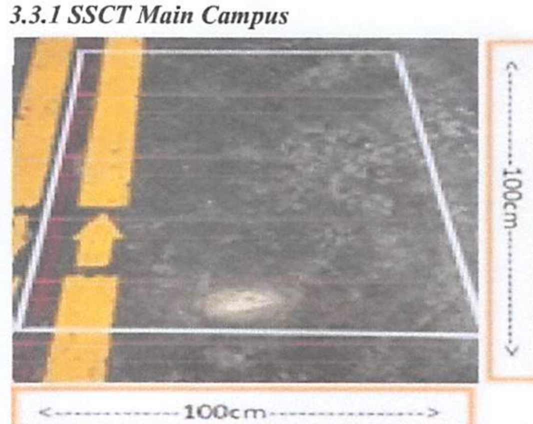


Figure 16. ***Specimen without void space at SSCT***

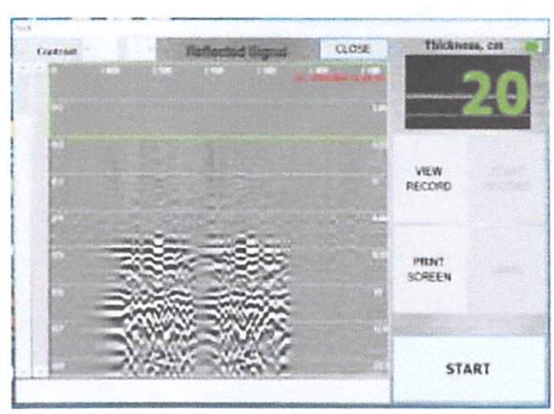


Figure 17. ***Simulation result without void space***

Figure 16 and 17 shows the application and

The figure above shows the analysis of the simulation using a radar-gram of developed behaviour of the develop impulse radar using the Impulse Radar of a specimen without void space at radar-gram for concrete slab with void space.   SSCT Main campus.

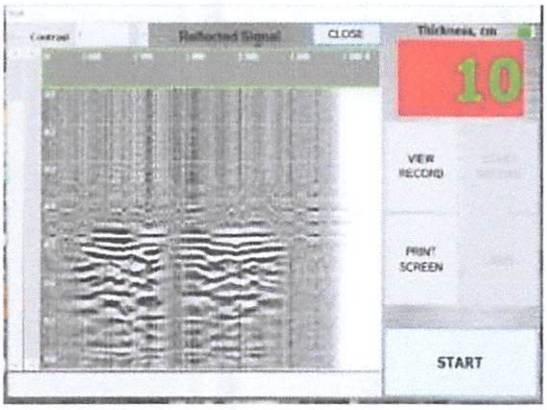


Figure 15. ***Simulation result without void space***

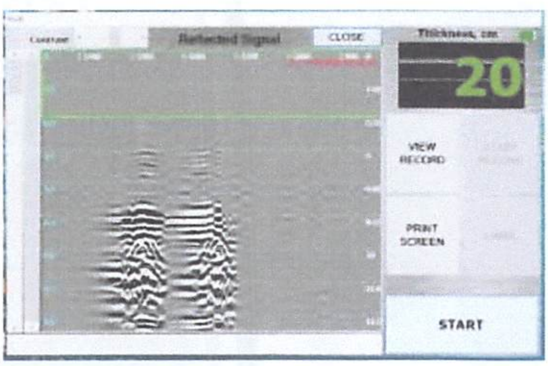


Figure 19. ***Simulation result with void space***

Figure 18 and 19 shows the application and simulation using a radar-gram of developed Impulse Radar of a specimen with void space at SSCT Main campus.

3.3.2 Basketball Court at Brgy. Cayutan, Surigao City

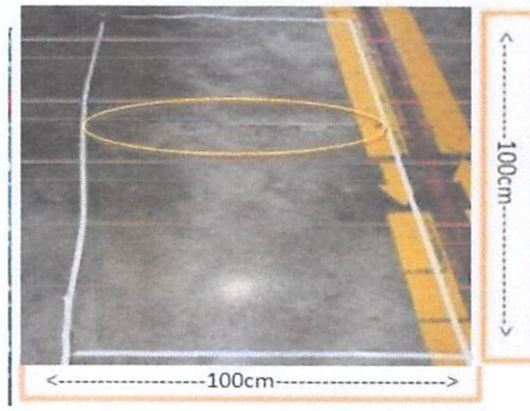


Figure 18. ***Specimen with void space at SSCT***

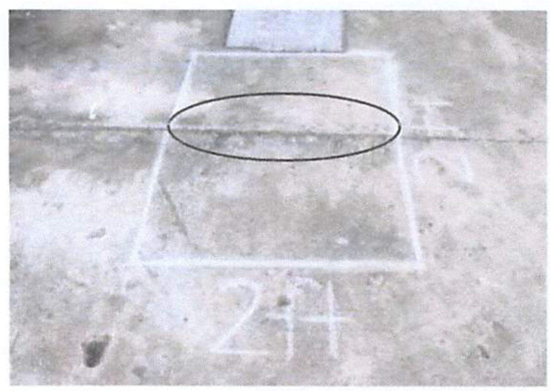
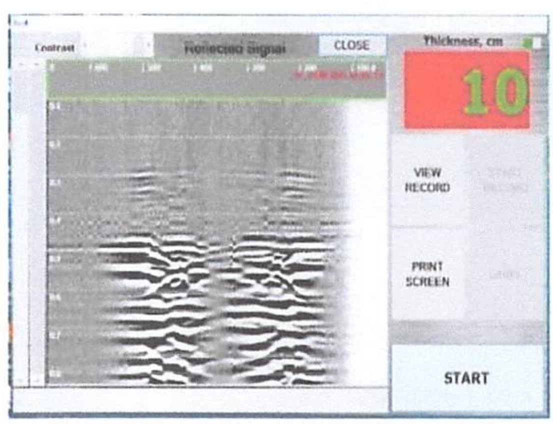


Figure 22. ***Specimen with void space at Basketball court***



simulation using a radar-gram of developed

Figure 20. ***Specimen without void space at Basketball***

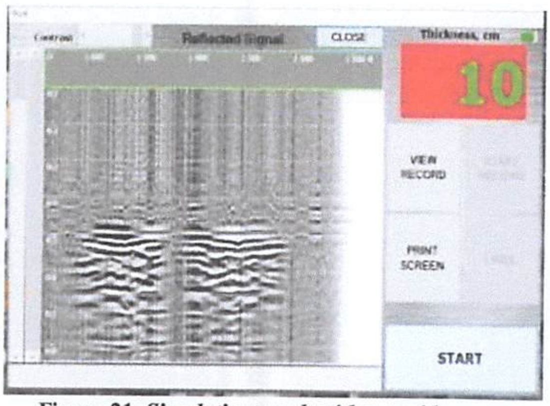


Figure 21. ***Simulation result without void space***

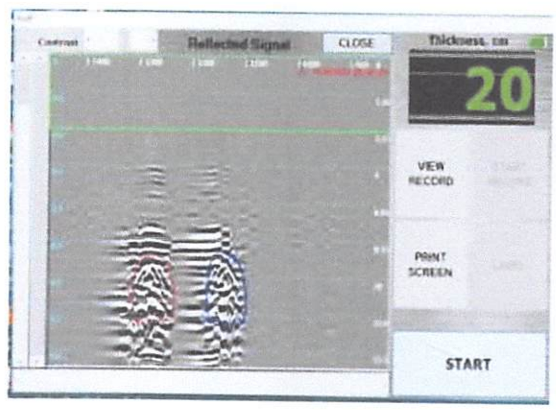
Figure 20 and 21 shows the application and simulation using a radar -gram of developed Impulse Radar of a specimen without void space at the basketball court of Brgy. Cayutan.

Figure 23. ***Simulation result with void space***

Figure 22 and 23 shows the application and

Impulse Radar of a specimen with void space at the

basketball court of Brgy. Cayutan Surigao city. ***court***



3.4 Radar-gram Interpretation Analysis

The data is signifying the result of the applied impulse radar; it identifies the forward and backward movement of impulse radar.

Figure 24. ***Test result in SSCT Without void Space***

Base on the screen reflected signal you can see the blue circle on the screen is indicated as forward movement of the radar and the red one is backward, as a result you can see a pyramidal waveform signal that signifies the detection of void space on the concrete. The thickness of the concrete is 20cm and the antenna module is placed at a height of about 0.5m. It has the same data movement in forward and backward movement.

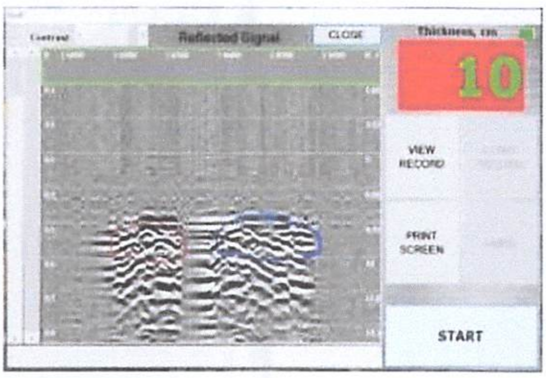
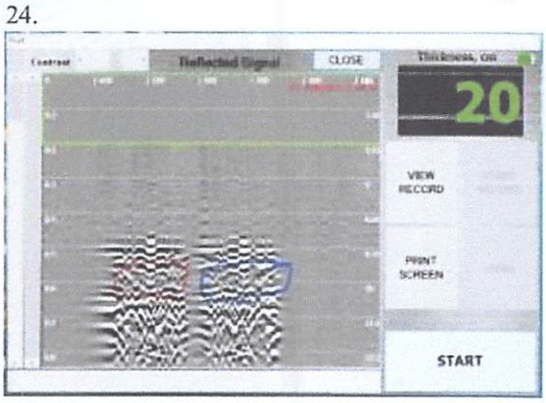


Figure 25. ***Test result in SSCT With void Space***

Base on the screen reflected signal you can see the blue circle on the screen is indicated as forward movement of the radar and the red one is backward, there is no pyramidal waveform that signifies that the picoR did not detect any void space in t he concrete. The forward and backward movement of the radar does not have the same result like in figure 24.



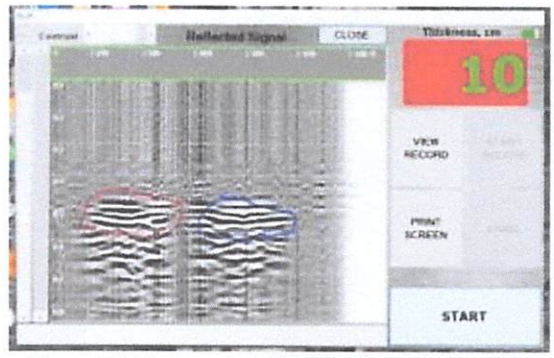


Figure 27. ***Test result in Basketball Court with Void Space***

The above data shows the inconsistent movement of the reflected signal which indicates the void space, the inconsistent is due to an invalid void space by moving the picoR forward and backward.

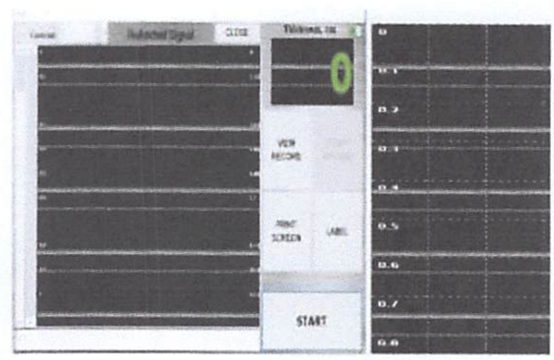
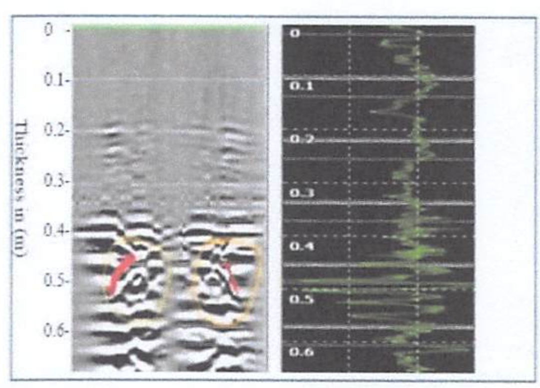


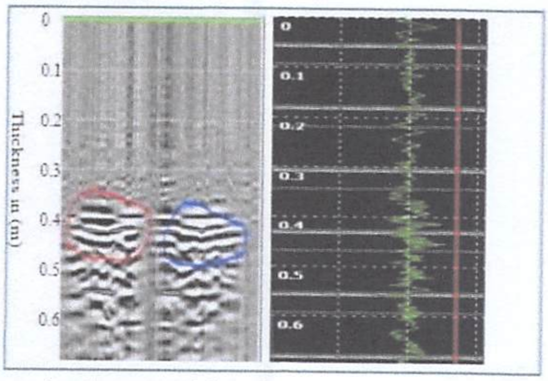
Figure 28. ***PicoR Software GUI***

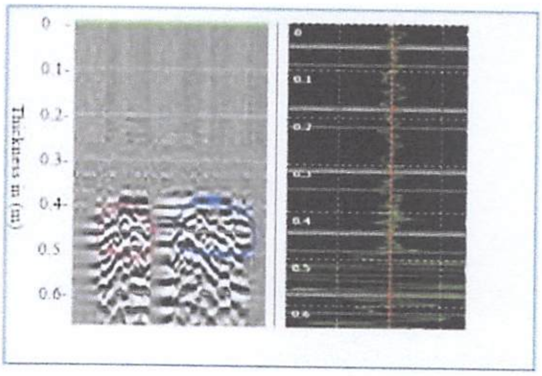
Figure 28 shows the graphical user interface (GUI) of the software used to gather and record data. This type of program is also called radar gram.



3.5 Location of Void Space in the Radargram Result

Figure 26. ***Test result in Basketball Court Without void Space*** Figure 20 is the location is at basketball court, to find another the glass of battle is buried with a thickness of 10 cm concrete slab.



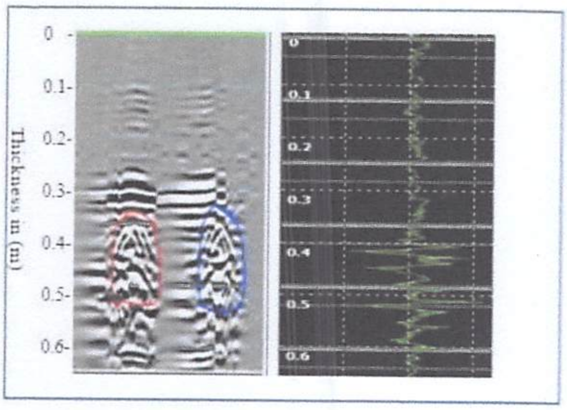


result, the second location that also has void space, as the data shows, the forward and backward movement is always consistent through the data result.

Figure 29. ***Concrete Slab Testing With Void Space*** The data above shows a red mark indicates that void space was detected in the concrete slab where

Figure 32. ***Basketball Court Result with Void Space*** The figure above shows the location of void

Figure 30. ***Concrete Slab Testing Without Void Space*** space of the concrete 10 cm thickness detected in Base on the radar gram result in the figure the basketball court as indicated in the sine wave on shown above, it shows that there is no void space the right part of the figure. detected in a solid concrete slab.



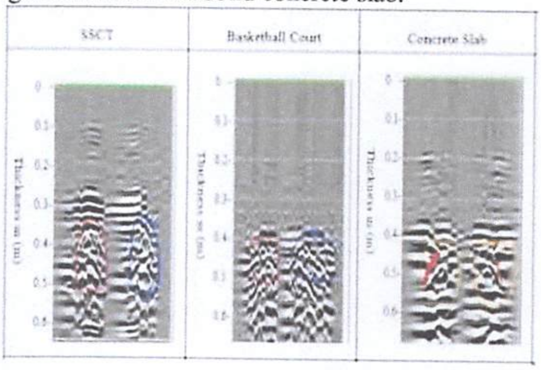


Figure 33. ***Data Collection of the radar-gram with void space***

Figure 31. ***SSCT building Testing with Void Space*** The figure above shows the comparison of data The figure above shows the location of the 20 results in the radar-gram in different area location cm thick

concrete with void space detected in the during experiment which has void space detected. SSCT building as indicated in the sine wave on the The gathered data are conducted in SSCT main right part of the figure. campus building, Brgy. Cayutan basketball court,

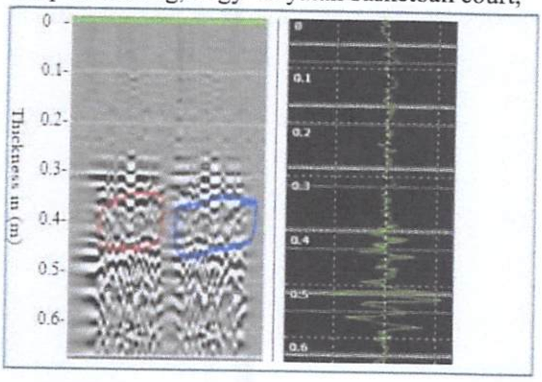
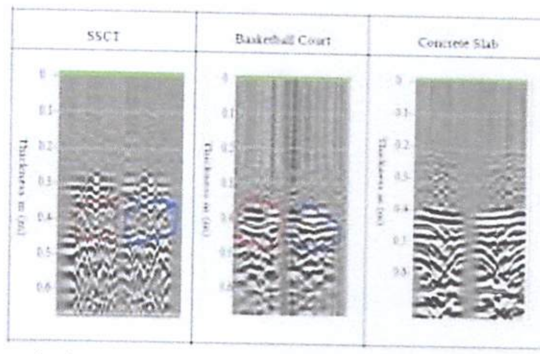


Figure 31. ***SSCT Building Testing Without Void***



and the experimented concrete slab with buried glass battle as void space.

Space

Figure 34. ***Data Collection of the radar-gram***

The figure above shows the test result in radar ***without void space*** gram indicating that there is no void space detected.

The figure above shows the comparison of data results in the radar-gram in different location without void space conducted in SSCT main campus building, Brgy. Cayutan basketball court, and the experimented concrete slab without void space.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The documentation of the system design is proper with all its eco-friendly materials, also the picoR is easy to assemble in the cart. Both transmitting and receiving antennas are easy to attach to its transceiver module. The user interface of the software is easy to operate. The experiment are conducted in different areas to gather and analyse data since this study is just only an experimental. To identify void space in the concrete by selecting specific areas in SSCT building, basketball court in brgy. Cayutan Surigao City, and making concrete slab for the experiment that has void space and without void space with measurements of length, width, and thickness. As the result of this study, the GPR technology has an accurate and sensitive sensor. It is a very high standard for detection, it can see into a structure to provide accurate information showing orientation and depth to subsurface features and objects. During simulation, data readings from the impulse radar is detected easily in moving the cart with forward and backward smooth motion in the selected areas of the study.

The result of the experiment shows that the pyramidal curve data in the radar-gram indicated as void space in the concrete. Compared to the data that has no void space which has no pyramidal curve in the radar-gram result. Data processing and interpretations have been applied relatively successfully an advantage over the more traditional manual and visual inspection methodologies, in detection of void space it also have a prevention to present that the concrete has less strength and need an improvement to be more preventable. The impulse radar will be an accurate technology to be used to determine the strength of a concrete.

Recommendations

Base on the findings and conclusions presented, the following recommendations are suggested.

1. It must not have a person near at the antenna because it will cause an interruption to a reflected signal.
2. This GPR is applicable for dry area only, since there is an interrupted signal through dye electric.
3. The cart should not cause vibration to the picoR because it could cause signal interruptions.

5. ACKNOWLEDGEMENTS

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged.
However, the group would like to express their deep appreciation and indebtedness particularly to our coauthor: Engr. Vrian Jay V. YLaya for his endless support, kind and understanding spirit during our case presentation. Also, the dean Engr. Robert R Bacarro, for extending his effort and giving time to enhance our thinking on making a very detailed and concise research study. To all relatives, friends and others who in one way or another shared their support, either morally, financially and physically, thank you. Above all to the great almighty the author of knowledge and wisdom, for his countless love. We thank you.

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WIND POWER DATA LOGGER USING WEIBULL AND RAYLEIGH ANALYSIS

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Abstract: The data loggers used to automate the process of gathering data for wind speed assessment, by using wind power data logger powered by Linux based raspberry pi 4 and anemometer to measure wind speed and stored the data to the system with some features GUI that show the graphs for the wind speed through an LCD. The study used Weibull and Rayleigh distribution analysis for the data. There are about five stages in developing this research project, which are the analysis phase, design phase, development phase, implementation phase, and communication phase. The study shows that the build device Linux-based raspberry pi 4 data logger can give accurate readings for wind speed. the device data-log the wind speed on the island of Masapelid barangay pateñio and gathered the data through a CSV file. the project analyzes the data using the Weibull and Rayleigh distribution method and concludes that wind power generation in the area is possible compared to the Philippine wind power classification.

Keywords: Renewable, datalogger, Wind, raspberry pi, SBC, Weibull, Rayleigh, GUI, graph

1. INTRODUCTION

Wind power system is used in rural areas where frequent power outage is common. Wind power energy is applicable for off-grid and on-grid system which gives energy between the grid and wind power. The system switches between wind and power grid if one of the power sources is interrupted [1]. Single board computer is one of the most powerful small computers that capable of making programming ideas from scratch. Raspberry pi is a Linux-based single-board computer used by technical app developers used for data processing and graphical visualization, it contributes more flexibly and can be work better with microcontrollers[2]. Most microcontrollers are used in data logging applications like data logging for solar PV and can used also for wind[3]. Data logging systems are also used for online and wireless platforms like IoT and other wireless connectivity like 3G, Bluetooth, Modems through online and wireless real-time monitoring. Home solar system monitoring is used in web and mobile-based to monitor small solar systems [4]. One of the most commonly used data logging is a microcontroller based on Arduino because of its cost-effective data logging performance along with the use of sensors, like reading voltage, current, and power, with Arduino cheap data logging feasible for recording data for low-cost design[5].

The project helps assess the feasibility of wind power generation by gathering data about wind performance to give a more efficient and effective future implementation of renewable power generation.

As the grid line is continuously providing energy for consumer, there are some issues in the areas with a power outage or brownouts, Implementing off-grid wind power and implementing on and off-grid system however it is weather dependent[6][7], and the system is not sure if it is possible to implement the system in the area.

The project proposed a datalogger for wind speed to conduct an assessment ensuring effectiveness for future implementation of a wind power system. By using SBC or Single Board Computer, visual graphics like graphs and data allow monitoring capabilities for offline mode. Raspberry pi and sensor configuration is the best combination for computing and processing where GUI is displayed and the data from the sensor communicate with GPIO of the SBC, This project can work offline and XGA (1024x768) resolution LCD the graphs and outputs a RAW file CSV.

Based on the observation of the area the wind is consistent. the researchers caught interest in this project because it fits properly in the field of electrical engineering and this giving idea of what is possible improvement about this project to enhance the feasibility of wind renewable power generation.

1.1 Related Literature

In Faya-Largeau, Chad the analysis for wind speed and wind energy potential used the Weibull distribution methods to achieve cost-effective wind turbine in the Saharan zone[8][9]. Just like an assessment for the data is a must to have a reference for comparison whether the system is effective or not, just like in PANGAN-AN island, a case study conducted an assessment of renewable energy systems for rural electrification provide the best possible option to improve energy access because of some locations are lacking electricity. However, it claims that there are several factors of implementing the system including technology, economics, and the community[10].

Wind speed power production and wind speed relationship define a power curve where it shows the illustration of power output curves through mph or m/s versus the power in kW[11]. Wind characteristics are the basis to determine wind energy source suitable in a particular area[12]. Weibull distribution is the best method to determine if the area is suitable for Wind and also Solar global irradiance from the sun and estimate the annual energy power generation of a PV plant[8][13].

Dataloggers are used in monitoring PV solar to measure and record data like temperature, voltage, current, humidity, and irradiance that can be accessed through an internet website or via mobile phone. This allows the users to communicate with the datalogger online and monitor the data. Arduino-based are commonly used in data logger design for an affordable cost and display the data readings through digital LCD and stored in SD card[14].

Smart data logger used in meteorological parameters, a weather station that collects wind speed, temperature, PV generation output data that allow monitoring by the user through online, it claims that the smart logger effectiveness, the system claims to be an accurate, robust and precise and minimal cost[15].

In another work, the automatic weather station was designed for real-time weather monitoring where data is transmitted through wireless communication, uploaded data via FTP and stored to the web server and allows user to monitor the data with an android device, It claims that the system is flexible in the parameter of weather real-time monitoring and functional user interface design[16].

The rationale of the project is having wind speed for data reading using SBC such as raspberry pi 4B as the main processing and running Linux-based system that can work offline and can provide graphical visual graph output displayed through XGA LCD and give raw data CSV.

1.2 Theoretical Framework

Converting anemometer data from analog to digital is needed to be able to communicate between the sensor and the computer. Anemometer has a power supply needed to be able to operate and also a range of voltage from minimum to maximum wind speed.

Base on the datasheet for the anemometer wind speed calculation there is a voltage minimum of about 0.77V and a maximum voltage of 2V for the anemometer speed ranging from 0 m/s to 32.4 m/s.

$$V_S = \Delta V/d \qquad (1)$$

$$W_s = V_s * S_{max} \qquad (2)$$

By using the formula (1) where V_S is the Voltage speed correspond to the change of Voltage ΔV divided to the distance unit in meter. Then we can calculate now for the windspeed W_s (2) by multiplying the Voltage speed V_s and maximum Speed S_{max}.

In wind power generation, the wind speed that starts to generate power is 6.7 mph or equivalent to 3 m/s, the nominal or rated wind speed for turbines is 26 mph to 30 mph or 12 m/s to 13m/s. This is the rate for large-scale wind turbines if the wind speed exceeds 55mph or 25 m/s the turbine cut out the speed to avoid damage[11].

Wind turbines work by converting the kinetic energy in the wind first into rotational kinetic energy in the turbine and then to electrical energy that can be supplied. The energy available for conversion mainly depends on the wind speed and the swept area of the turbine.

$$P_{avail} = \frac{1}{2} \rho A v^3 C_p \quad ; \quad A = \pi^2 \qquad (3)$$

Where:
ρ = Air density
V= Wind speed
C_p = Power Coefficient

Based on the formula given the power can be calculated [17].

1.3 Conceptual Framework

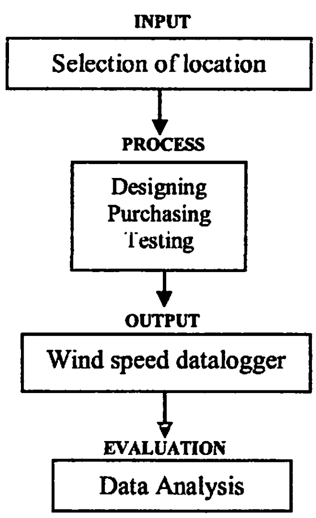

Figure 1. IPO of the study

Figure 1 starts with the input wherein the researchers determine the location where the project should be tested to gathered data. After that, the researchers proceed to the process stage, where designing purchasing, and testing takes place. This stage is challenging because this is where trials and errors are mostly present. Making the goal output to build a datalogger for wind. Evaluating the data for data analysis.

1.4 Objectives

This study aims to build a datalogger for wind speed to assess and collect data for the feasibility of wind power generation.

The specific objectives are:

1. Build wind speed data logger using Linux-based GUI.
2. Data-log the area for 1 week.
3. Make an analysis of the data.

2. METHODS

2.1 Research design

The cross-sectional research design used the project revising already existed technology and apply a variety of methods that rely on previous research with uniqueness. We also test our project and apply theory in the actual test.

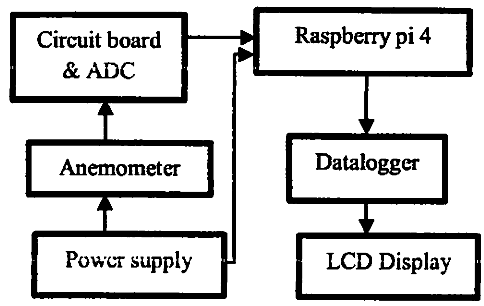

Figure 2. The Block Diagram of the Proposed Project

The block diagram Figure 2 measures the wind speed with the use of an anemometer for sensing where it connected to the circuit through I2C for conversion from an analog signal to digital to be able to be processed with a Raspberry Pi 4 connected to the PSU(power supply unit) or charge adapter to power the Raspberry Pi 4 which is 5 volts 3amps then all the data readings displayed in our 7 inch LCD visualizing graphs next is to our datalogger which is still in the raspberry pi command to output raw data.

2.3 Project Development

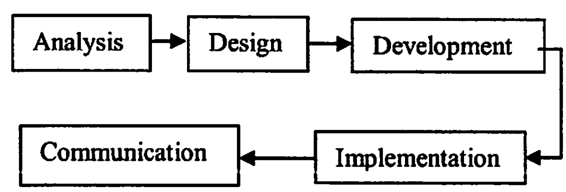

Figure 3. Development Process of the Study

The analysis phase where the materials of our project availability should be feasible and the chosen technology use has been researched and studied thoroughly to use on the project to achieve expected results.

Design phase at this stage we design a block diagram about how our project works and then later convert it to a schematic diagram.

Development phase where all the requirements needed in our project are arranged such as schedule, materials and tools, and instructions of our project.

Implementation phase where the instructions of our project are identifying how the project is made until it is completed.

Communication phase where the final output of our project is present and research journal for validation from the research panel.

2.4 Project Implementation

Check for the availability of the components local or online find all the requirements to the project and make the budget computation of the cost.

Purchase the required components check for the price inflation to have good deals of purchasing and check for sales of the components to have discounts.

Build the project based on the planned design and ask for recommendations from experts about the project to ensure the project's effectiveness.

Location selection and ask permission to the local residence importantly in the barangay leader officials of the pick location to ensure the accessibility of the area.

Securing the device to avoid damage and checking for the stability of the mechanism or sensors in the project to ensure that the project builds sturdiness.

Making daily reports for the data gathered in the device to monitor the process and troubleshoot for data reading interruptions.

Observe surroundings for possible natural accident causes harm of the device and apply cleanliness to the environment.

2.5 Project Setting

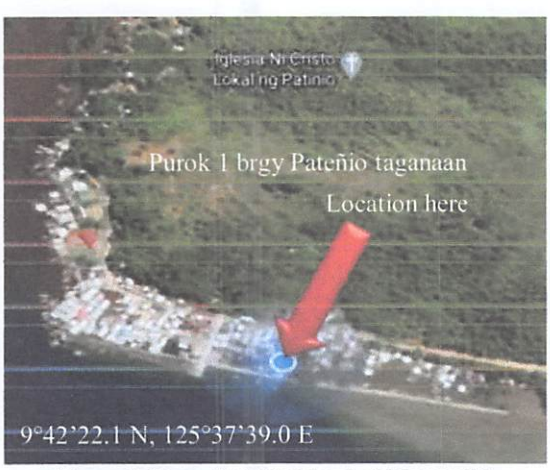

Figure 4. Brgy, Pateñio Island of Masapelid

The place is located on the island of Masapelid, Barangay Patiño, Municipality of Tagana-an. image of the island on Google Maps is as presented. This place is situated at approximately 9°42'22.1 N, 125°37'39.0 E. This island is facing the Pacific, making them the first to face the storms and typhoons if ever there is one. Barangay Patiño is just one of the places the distribution of grid lines is difficult, due to the geography of the island, the line of electricity is sometimes being interrupted and causes blackout for days, and also during storms and typhoons. This project will help for the assessment of the possible implementation of wind power generation.

2.6 Participants of the Study

The participants are the group of people or individuals that the researchers plan to become part of conducting the study.

Table 1. Profile of the participants

Participants	F(n=33)	% of involvement
Electrical Engineer	2	6.1%
Electronics Engineer	2	6.1%
Surneco	3	9.1%
Safety Offices	1	3%
Household holder	25	75.76%
Total:	33	

Table 1 shows the participants of the study. These include 2 Electrical engineers for the electrical privileges and an Electronics Engineer who will evaluate the difficulty and electronic advice of the installations of the project. 3 representatives of surneco assessing and evaluating the performance of the system and 25 household holders. Convenience Sampling, which is a type of non-probability or non-random sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the study.

2.7 Instruments

The materials used by the researchers for developing the wind sensor data logger.

Anemometer the instrument used for reading wind speed data and provide data to the raspberry pi.

2.8 Research Ethics

Ethics applied in this project study are as follows:

1. Honesty, for honest scientific communication, honest report data results from methods and procedures.
2. Objectivity, for they strive to avoid bias in experimental design, data analysis, data interpretation, peer review, and other aspects of research where objectivity is expected or required.
3. Intellectual property, for the honoring of patents, copyrights, and other forms of intellectual property.
4. Openness, for the sharing of data results, ideas, tools, and resources and to be open for criticism.

2.9 Data Collection Procedure

Quantitative Data Collection

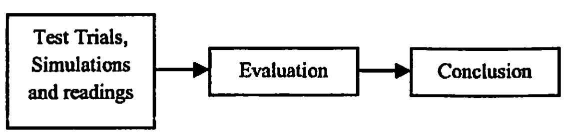

Figure 5. Quantitative data collection

Quantitative data are based on the project readings with the use of instruments conducting a test to gather results of the project, after that we evaluate the gathered data in the test readings of the instrument then construct a conclusion.

2.10 Statistical Tools

Weibull Distribution method

Different probability distributions have been used for describing and analyzing wind data. Among all distribution functions, Rayleigh and Weibull probability distributions are the most accurate and adequate ones in analyzing wind. To use the Weibull probability distribution, it is necessary to calculate two parameters, the shape parameter (k) and the scale parameter (c). there are several methods to estimate Weibull parameters such as the graphical, the moment, the standard deviation, the maximum likelihood, the energy pattern factor, and the power density method. According to the Standard deviation method, the Weibull parameters (c and k) were calculated using the following equations [18]:

$$k=\left(\frac{\sigma}{V_{avg}}\right)^{-1.086} \quad (1 \le k \le 10) \quad (4)$$

$$c=\frac{V_{avg}}{\Gamma\left(1+\frac{1}{k}\right)} \quad (5)$$

where V_{avg} is the average wind speed (m/s), σ is the standard deviation of the wind speed data and Γ is the gamma function.

Mean wind power density

By using the Weibull probability density function. the density of power of the wind (by unit surface) can be obtained by using the following equation[19][20]:

$$WPD = P(V) = \frac{P(V)}{A} = \frac{1}{2}\rho\varsigma^{3}C_p \quad (6)$$

Where ρ is the density of air and A is the swept area of the rotor. C_p is the power coefficient. The actual amount would be less since all available energy is not extractable[21].

The two significant parameters of k and c are closely related to the mean value of the wind speed v_m as[22]:

$$v_m = \varsigma\Gamma\left(1+\frac{1}{k}\right) \quad (7)$$

As the scale and shape parameters have been calculated, two meaningful wind speeds for wind energy estimation, the most probable wind speed and the wind speed carrying maximum energy can be obtained. The most probable wind speed denotes the most frequent wind speed for a given probability and the wind speed carrying maximum energy represents the wind speed that carries the maximum amount of energy and is expressed as follows[22]:

$$v_{MP} = \varsigma\left(\frac{\kappa-1}{\kappa}\right)^{\frac{1}{\kappa}} \quad (8)$$

$$v_{Max\,E} = \varsigma\left(\frac{\kappa+2}{\kappa}\right)^{\frac{1}{\kappa}} \quad (9)$$

Rayleigh distribution is a simplified case of the Weibull Distribution where the dimensionless shape factor of the distribution is fixed ($k = 2$)[18].

Mean refers to the mean or average that is used to derive the central tendency of the data in question, "the mean can be characterized as a socialist, a fulcrum, a solution to the least-squares criterion, a set of ideal coordinates of the origin in n-dimensional space" [19].

Standard Deviation is a statistic that describes the amount of variation in a measured process characteristic or a measure that is used to quantify the amount of variation or dispersion of a set of data values. "Specifically, it computes how much an individual measurement should be expected to deviate from the mean on average" [20].

3. RESULTS AND DISCUSSIONS

3.1 Wind speed data logger

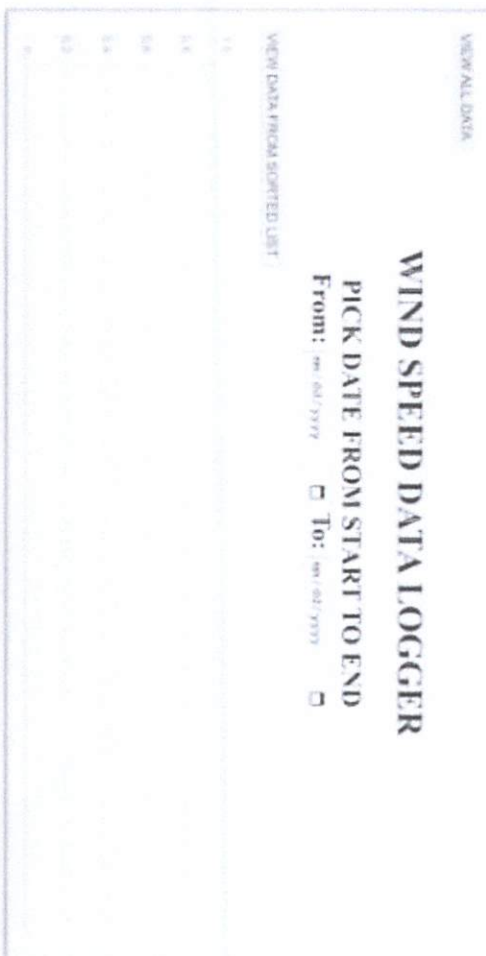

Figure 6. User interface

The system user interface with graph shown in the figure 6 for the actual wind speed where the user can view all data or pick a date to gather the data given the time and date. The data from the database compile and display the graph for wind speed.

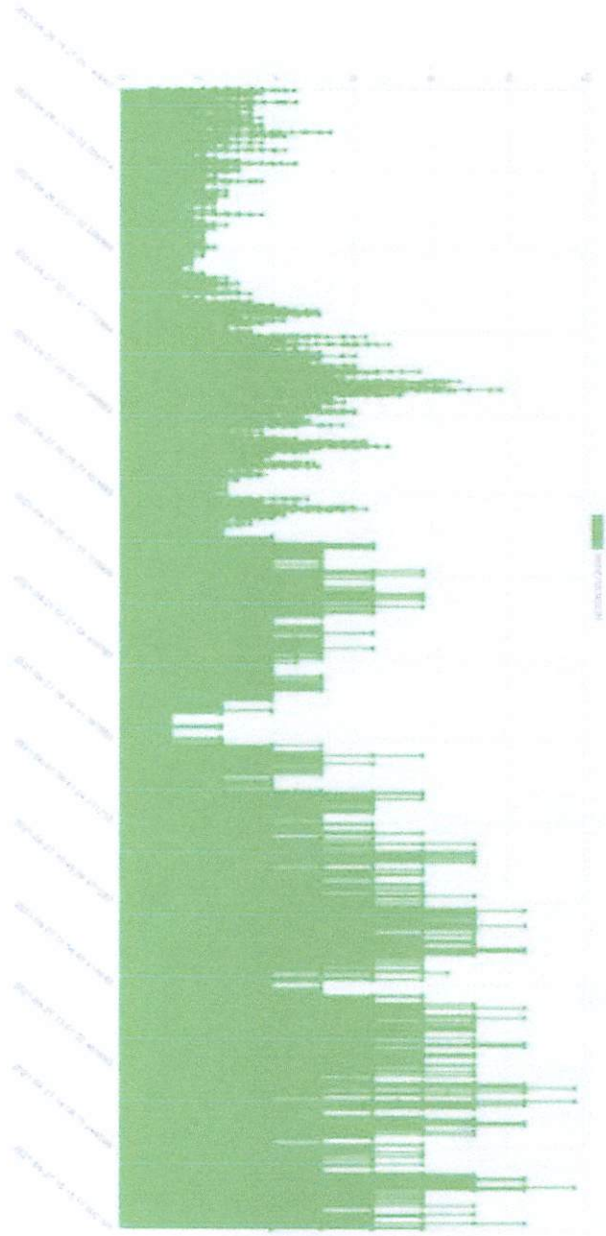

Figure 7. GUI wind speed graph

Figure 7 shows the wind speed graph where the x-axis is the date and time and the y-axis is the wind speed in meter per second.

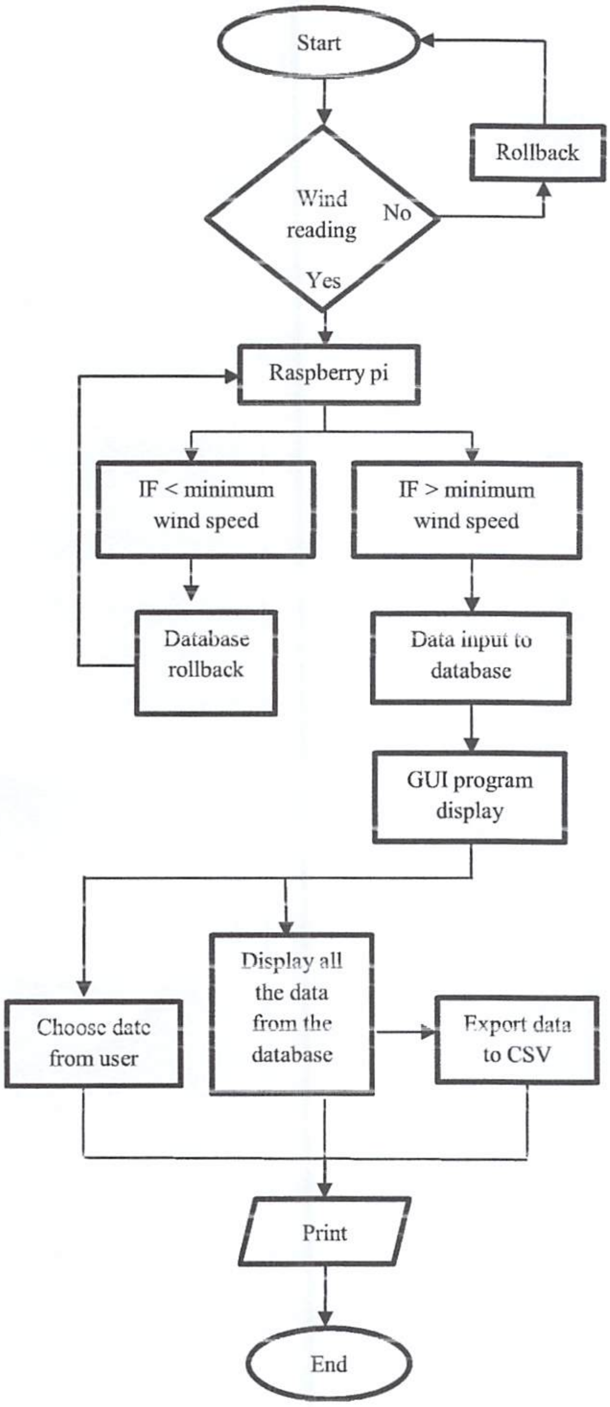

Figure 8. Flowchart

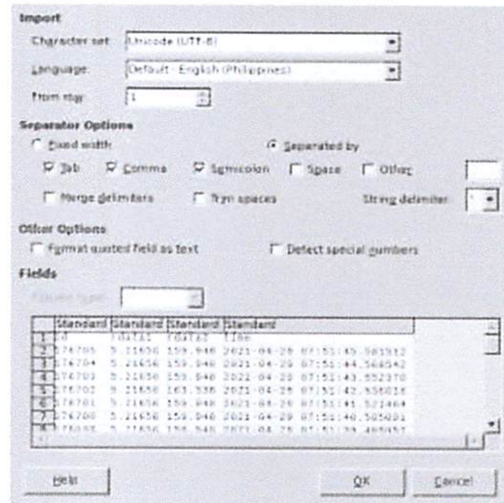

Figure 9. CSV file

The graph for the data recorded for wind speed is shown in the figure 7 The green graph of the data can be export through the CSV or an excel type for the data figure 9 file to compile all the recorded wind speed to be able to manage and monitor the data. As the graphical presentation viewed above the time interval for the reading of the data is every second.

3.2 Hardware design

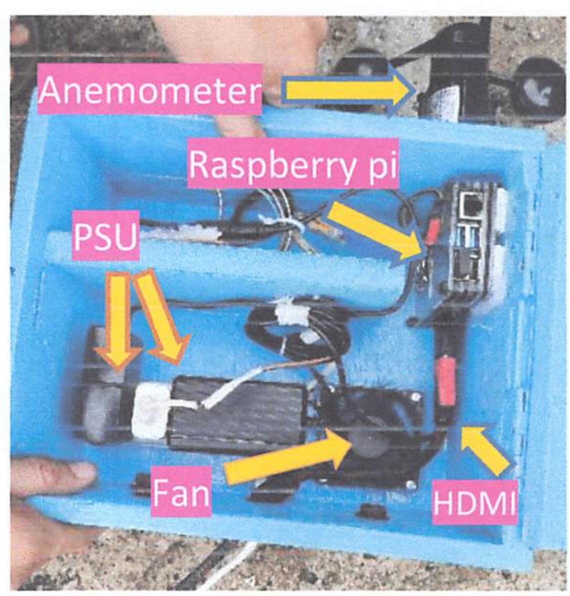

Figure 10. Project interior

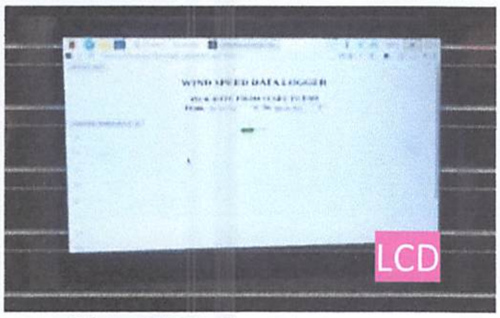

Figure 11. Display output

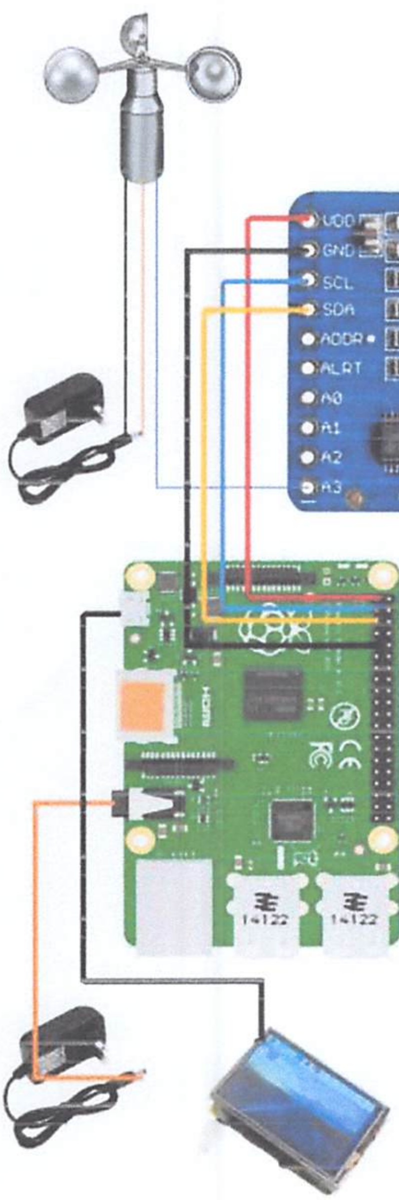

Figure. 12 Component's diagram

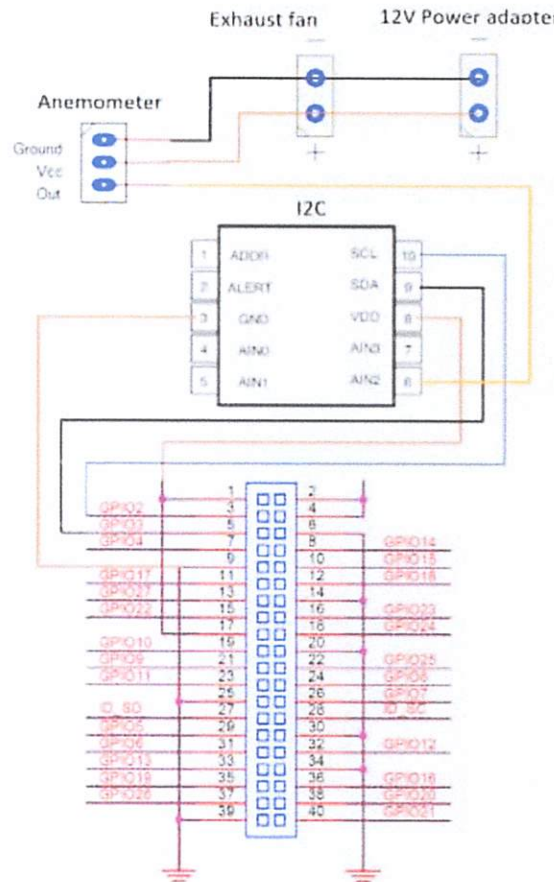

Figure 13. Schematic diagram

3.3 Recorded Datalog

Wind speed characteristics

Average wind speed and maximum wind speed per day for a week are shown in Figure 9. It is measured in m/s. Data shows that mean wind speed ranges 4.03 m/s – 7.07 m/s. Maximum wind speed measures 12.77 m/s, as shown in Table 2.

Table 2. Mean and Maximum wind speed

Days	Mean wind speed	Max wind speed
Day 1	7.07	11.76
Day 2	7.01	12.77
Day 3	4.03	7.91
Day 4	6.62	7.80
Day 5	6.77	8.07
Day 6	6.90	9.46
Day 7	6.83	8.46

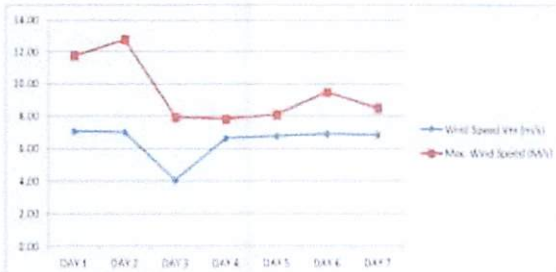

Figure 14. Graph of Mean and Maximum Wind Speed

3.4 Wind power data analysis

Analysis of Weibull and Rayleigh Parameters and densities.

$V_{max\,E}$ or the speed of the maximum energy-carrying wind speed and V_{mp} or the speed of the most probable wind speed are shown in figure 15. The understanding of the V_{mp} and $V_{max\,E}$ leads to the possibility to know if the site is possible for the installation of the wind turbine. Data shows that $V_{max\,E}$ ranges from 6.20 m/s to 11.81 m/s. V_{mp} ranges from 4.50 m/s to 6.10 m/s as shown in Table 3.

Table 3. V_{maxE} and V_{mp}

Days	$V_{max\,E}$	V_{mp}
Day 1	8.62	5.07
Day 2	9.86	5.70
Day 3	8.57	6.10
Day 4	7.42	5.59
Day 5	8.14	5.49
Day 6	8.60	5.51
Day 7	6.20	4.50

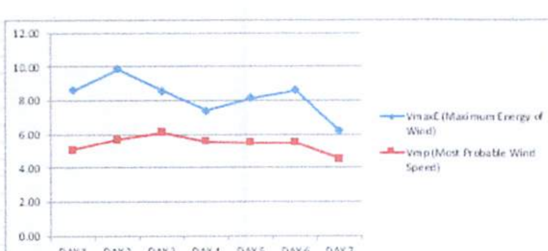

Figure 15. Graph of V_{maxE} and V_{mp}

Table 4. Wind power classification

Class	Resource Potential Utility	Resource Potential Rural	Wind Power Density (W/m^2) @ 30 m	Wind Speed (m/s) @ 30 m
1	Marginal	Moderate	100-200	4.4 – 5.6
2	Moderate	Good	200-300	5.6 – 6.4
3	Good	Excellent	300-400	6.4 – 7.0
4	Excellent	Excellent	400-600	7.0 – 8.0
5	Excellent	Excellent	600-800	8.0 – 8.8
6	Excellent	Excellent	800-1200	8.8 – 10.1

Table 5. Weibull & Rayleigh wind power density

Day	K (shape Factor)	C (scale factor)	WPD Weibull (w/m^2)	WPD Rayleigh (w/m^2)	WPD Actual (w/m^2)
1	1.80	7.52	389.22	435.46	306.38
2	1.85	7.89	432.68	398.13	328.81
3	1.50	6.64	344.72	238.59	302.82
4	2.04	6.55	223.89	228.43	291.19
5	1.43	7.45	243.78	258.60	199.10
6	1.90	7.77	268.74	293.50	211.71
7	2.00	7.71	286.58	286.32	205.37

The wind power classification is shown in Table 4. data source given from "Philippines wind energy Resource Atlas Development" stated that "the wind speed average is not the best indicator of the resource" instead it uses the wind-power-density term expressed in watts per square meter (w/m^2)[12]. It shows the class ranging from 1 to 6 then the class separate to utility and rural resources potential, it shows the table for power wind power density and wind speed, Comparing to the 1-week data collected in the device in table 5 the data show that the wind power density (w/m^2) can be classified between 2 (good) and 3 (excellent) in rural and for utility.

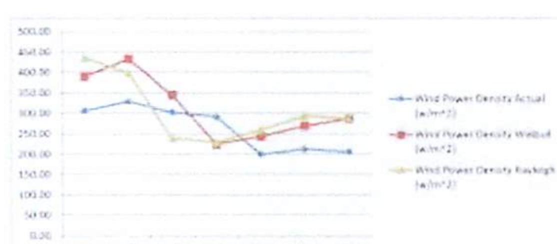

Figure 16. Graph of wind power density Weibull, Rayleigh, and actual

Table 5 presents the daily values of the shape parameter k, the scale parameter c, and the wind power density available on Masapelid Island. The shape and the scale factor were obtained using Eq. 4 and 5, Wind power Densities were obtained using

Eq 6. Thus, the result of the shape factor and scale factor are respectively in the range of 1.43 - 2.04 and 6.64 – 7.89. Equation 5 was used to calculate the wind power density. The wind power density was calculated in Weibull, Rayleigh, and the actual power. The wind power density of Weibull varies from 223.89 w/m^2 – 432.68 w/m^2, wind power density Rayleigh varies from 228.43 w/m^2 – 435.46 w/m^2 and wind power density actual varies from 199.10 w/m^2 – 328.81 w/m^2. Maximum wind power density is recorded on Day 1, obtaining 435.46 w/m^2 by the Rayleigh Distribution method. The minimum wind power is recorded on day 5, obtaining 199.10 w/m^2 as shown in Figure 16.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

GUI based on Linux was build and works properly using python programming language and the device capable of giving accurate readings for wind speed continuously.

Wind data logger device was used to record data for one week and the device was capable of continuous runtime and recorded easily the one-week data in the area.

Data analysis has been make using Rayleigh and Weibull for wind power density provided in the actual data shown in table 2 the value can be classified as good, and excellent compared to the wind power classification provided by the Philippines wind energy Resource Atlas Development, therefore Brgy, Pateño island of maspelid is capable of the system.

Recommendations

Base on the findings and conclusions presented, the following recommendations are suggested.

1. Due to a power outage, the device can be interrupted by recording data, so the researchers recommend adding a power backup or battery to make it standalone to avoid data interruption.
2. the data analysis for the Weibull and rayleigh distribution calculation has been done manually, the researchers recommend including the Weibull and rayleigh distribution methods and formula in the program for more reliable and fast calculation.

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