Honeycomb Cottonwood Eco House

Jana Hamada, Maryam Ahmed, Shahd Abd-elmaboud, Haneen Hussien

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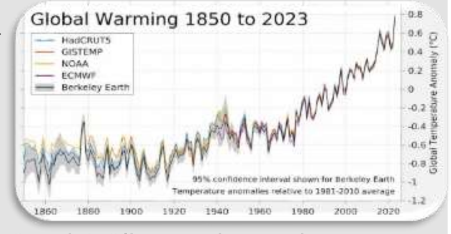
Abstract

The considerable inflation of climate change due to population growth and pollution of affordable resources has become significant impediments to socioeconomic development in Egypt. Even though traditional homes might not be as architecturally pleasing or historically significant as sustainable homes, they might still have issues with efficiency, security, and technologies. In Egypt, in order to meet this challenge, a cottonwood hexagonal smart home is the perfect solution to obtain more environmentally friendly features and a comfortable experience. Cottonwood was chosen due to its excellent insulation, which helps maintain temperature, reduces the need for cooling systems, and lessens air pollution from burning. Furthermore, choosing a hexagonal shape is due to its large surface area, which distributes the temperature. The building depends on renewable solar energy source to reduce climate change effects. in addition to the usage of the MQ7 (carbon monoxide sensor) to detect the danger of carbon monoxide that comes from the heater that led to death and get rid of the gas automatically, and the and the DHT-11 sensor for measuring the temperature and humidity due to its accuracy. After testing the prototype three times and analyzing the data, it was found that after observation and collection of data, the cottonwood hexagonal-shaped smart home reached the design requirements, which decreased the interior temperature by 5 degrees compared to the outside of the home while monitoring humidity and monoxide gas. Thus, the building proved its efficiency to diminish temperature and, furthermore, its durability.

Introduction

Egypt faces major challenges that lead to the deterioration of its development. The project for this semester seeks to address important issues in order to positively impact Egypt's eleven major grand challenges. It also seeks to contribute to Egypt's sustainable development goals by aligning with national strategies for social progress and economic growth, especially recycling garbage, improving the scientific and technological environment for all, reducing and adapting to the effects of climate change, and increasing the industrial and agricultural bases of Egypt. Drawing inspiration from Zaha Hadid's honeycomb building in Riyadh has showcased remarkable architectural innovation, even though the high cost of the materials and the fact that it's non-eco-friendly make a horrible impact on the environment. The ZCB building in Hong Kong is a sustainable building that relies on solar energy as a permanent source and produces zero carbon emissions. Despite that, the material used in this building is non-degradable. On the other hand, the Philippines Bahay Kubo is a low-cost building built from bamboo, which is a natural material friendly for the environment. The weakness of this building is that it is a primitive house that isn't appealing to live in. All of these houses don't depend on smart technology. Consequently, the chosen solution is a smart honeycomb building from cottonwood instead of burning it, which produces greenhouse gases and increases climate change. The eco-friendly building depends on solar energy as its main electricity source and a combination of different sensors, such as a CO sensor to detect monoxide leakage from a gas heater and a humidity sensor. The chosen solution achieved the following design requirements: decreasing temperature by three degrees from the outer environment; detecting monoxide leakage from gas heaters by CO sensor to avoid frequent accidents due to CO leakage, which cause chocking by open the window by servo motor; and using a using a DHT sensor to measure humidity and turn on the fan if humidity increases . The solution will achieve the required designs since cottonwood, a natural material, has a lower thermal conductivity than concrete. Solar energy is a quick type of energy, and for the structure, honeycomb is marked by its light size and durability, and for its large surface area, it could distribute heat. The total volume of the building will be 0.121 m3.



Graph1:Climate change impacts

Materials

materials	Rechargeable battery	Servo motor	Co sensor	Cotton wood	Solar cell	Esp 8266	fan	total
image								
cost	60	60	30	wasted	250	200	50	660

Methods

1- first cotton wood was grinded into tiny pieces and was mixed with urea-formaldehyde glue.

Fig1:Grind cottonwood

2- After that the mixture was put in a hydraulic press to make boards of cotton wood.

3- Then the boards were sliced into 20*50*2 cm rectangular prisms and the house was Shaped with glue.

4- two hexagonal prisms were shaped from rectangular prisms

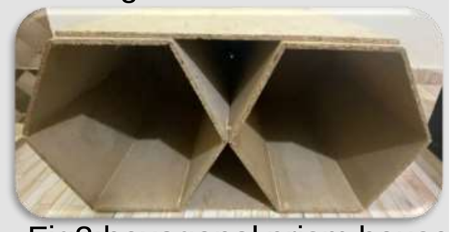


Fig2:hexagonal prism house

5- solar cell was used to generate electricity putting above the building.

6- After constructing the house: plenty of sensors were used connected to Esp 8266: co sensor was connected to pin A0, DHT sensor was connected to pin D3, and two motors: servo motor was connected to pin D1, and a fan connected to pin D2.

7- connected sensors to remote XY application to display readings and graphs

8- send notification if co increased above 10% or humidity increased above 40%.

Test plan:

First trial:

1- the cottonwood was grinded into large pieces, so It Did not hold together well, so it failed.

Fig3:DHT sensor connected to ESP

Fig4: co sensor connected to ESP

Second trial:

1- measuring temperature outside and inside the house by temperature sensor after 2 minutes.

2-after that, detecting the change of CO gas exiting from smoke minutes and detecting the change again after opening the window during 1m.

3- furthermore, detecting of humidity level increasing due to water vapor inside the house and after turning on the fan during 1minutes.

Third trial:

After increasing time to get more accurate sensors reading:

1- repeating detection of temperature after 4m.

2- detecting CO leakage again after 2m.

3- finally, detecting the change of humidity after 3m.

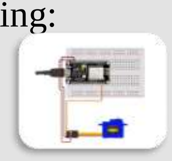


Fig5:DHT circuit Diagram

Fig6: IDE reading

Results

time	0m	1m	1m30s	1m43s	2m	4m
reading	28℃	27℃	26℃	25℃	24℃	23℃
comment	Outside the house	Inside the house	_____	_____	_____	The least inside T

Table1: Temperature measurement

Time	0m	1m	2m 30s	3m
Reading	98%	85%	70%	64%
comment	Fan turned off	Fan turned on	______	Least reading

Table2: Humidity Reading

Time	0m	30s	1m	2m
Reading	18.28%	11.83%	7.82%	5.87%
comment	Close window	Open window	______	Least reading

Table3: CO Reading

Analysis

Egypt faces challenges of climate change due to rapid industrialization and urbanization. Despite agricultural and industrial potential, gaps in technology adoption hinder progress. Rising pollution levels in the environment urgently require technological interventions for ecosystem protection and human health. The main challenges to be solved are climate change and technology improvement. The required solution to address these challenges is to construct a sustainable green house from natural materials such as cottonwood and was painted with natural organic paint to insult water and humidity as studied in **CH.2.10** and connect it with plenty of sensors, including a CO sensor and a humidity sensor. The prototype meets design requirements, which are detection of monoxide leakage from the gas heater and opening the window by a servo motor to reduce the gas. Also maintain a lower temperature than outside, as cottonwood has a lower thermal conductivity than other building materials. And measure the humidity with a humidity sensor and decrease it by opening a fan for ventilation.

The building depends on solar cell, which is renewable sources of energy. With efficiency measure depends on ME.2.05:

Efficiency of solar cell=$\frac{\boldsymbol{panel\ power\ in\ (kw)}}{\boldsymbol{panel\ length \times panel\ width\ in\ (m)}} \times \mathbf{100}$

Length= 0.224m, width=0.134m, max power= 0.003 kw

So efficiency= $\frac{\mathbf{0.003}}{\mathbf{0.224 \times 0.134}} = \mathbf{10\%}$

And with potential difference= 9 volt. Which make it appropriate for turn on sensors and actuators in the building.

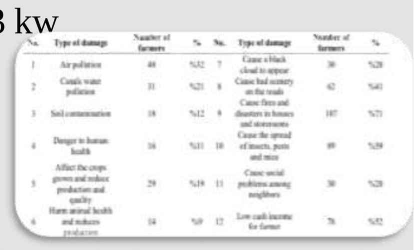


Table4:Agriculture waste pollution

The design of prototype is hexagonal shape comes from honeycomb design which

Is lighter and durable it characterized by its large surface which distribute the heat as found in **PH.2.14**.

THE Dimensions of the building as shown are:

Volume of hexagonal prism=$\frac{3\sqrt{3}}{2}a^2$h (a is the base and h is the height)

a= 0.2m, height=0.5m number of hexagonal prisms=2

So the volume= $\frac{3\sqrt{3}}{2}\mathbf{0.2^2 \times 0.5 \times 2 = 0.104}\boldsymbol{m^3}$

Volume of triangular prism= area of triangle(width $\times$ $hieght \times \frac{1}{2}$)$\times$ $depth$

Width=0.20m, height=0.17m, depth=0.5m, number of triangular prism=2

Volume= $\mathbf{0.2 \times 0.17 \times 0.5}$ **=0.017**$\boldsymbol{m^3}$

The total volume= 0.017+0.104=0.121$\boldsymbol{m^3}$**.**

In MA.2.7 the concept of limits is used to measure the amount of heat absorb by cotton wood and the relation with thickness:

$$\lim_{d \to .012} f(x) = \frac{K A \Delta T}{d}$$

F(x) is heat conductivity, K is thermal conductivity of cottonwood, A is surface area of the building, T change in temperature, d is thickness.

K= 0.2WmK, A= 1.4m^2, $\Delta T = 3$℃, d approaches to 0.012m.

So f(x)=$\frac{\mathbf{0.2 \times 1.4 \times 3}}{\mathbf{0.012}} = \mathbf{70 w/m.k.}$

Cottonwood is better insulator for heat than other constructing material, due to its low thermal conductivity compared to others, and the increasing of thickness of the building.

first trial:

Cottonwood was grinded into large pieces which was inefficient and didn't mix with each other in hydraulic press.

Second trial:

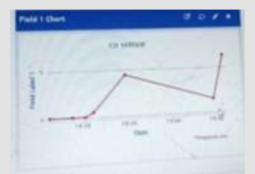
as shown in the opposite graph 1 the amount of monoxide gas variation detected by co sensor during 3minutes. Co started to decrease after opening the door and gas exit. As humidity increases in house fan started to rotate and decrease it as shown in graph 3. the humidity was detected by DHT during 1 minutes and started to decrease after using the fan as shown in graph2.

Graph2:1st co reading

Graph3: 1st humidity reading

In third trial:

The prototype has successfully as shown in graph 3,4 achieved design requirements after detecting co and humidity for 3 minutes for more accuracy. temperature decreased 5℃ than outside.



Graph4: 2nd co reading

Graph5: 2nd humidity reading

Conclusion

The project's purpose is to develop a smart building that can then be utilized to decrease the temperature inside the house compared to outside by not less than 3 degrees Celsius. Based on the data obtained and previous research, the solution design was able to overcome the difficulty of increasing temperature. To address this problem, the decided solution was to build a smart house made of cottonwood in a hexagonal shape and three feedback systems that will be powered by a renewable energy source, which is solar energy. The temperature, humidity, and CO emissions will be monitored by the three feedback systems to ensure that they remain in the ideal range. The outcome results after three trials were able to decrease temperature from 28 degrees Celsius to 23 degrees Celsius, humidity from 98% to 64% after opening the fan, and finally, CO level from 18.28% to 5.87% after opening the window. compared to (Dana, Martin, Monika, and Robert 2014), show that the most common wood in buildings (timbre) has a thermal conductivity of more than 0.17 W/mK compared to cottonwood, which has a thermal conductivity of 0.087 W/mK and decreases temperature 5 degreed than outside. That makes cottonwood best low-cost recommended building material.

Recommendations

In science, there is nothing called complete work; hence We did our best in this project. We got many ideas to improve the project, but we couldn't apply all in the prototype, due to the lack of time and limited capabilities, so we have some recommendations :

1-using of DHT22 sensor to detect temperature and humidity which is more accurate and efficient than DHT 11, due to it is high price we replaced it with a lower price and efficiency sensor which is DHT11sensor.

2-In order to ensure the success of this project, it can be constructed in the real life by the ratio 1:80 so, its volume should be 53248m^3

3- painting cottonwood with varnish which is organic insulator slows down degradable and humidity effects on cottonwood.

4- mix cottonwood with rice straw to rise durability and thermal insulation effect due to low thermal conductivity of rice straw.

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Jana.1322503@stemdakahlia.moe.edu.eg

hanin.1322505@stemdakahlia.moe.edu.eg

maryam.1322514@stemdakahlia.moe.edu.eg

shahd.1322513@stemdakahlia.moe.edu.eg