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Improving The Thermal Comfort Of The Structures By Applying The Sustainable Engineering Requirements

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Abstract

As a result of the ozone hole, which caused climatic changes in places near the equator, one of these areas is Baghdad's capital, and as a result of the absence of agricultural fields, the emergence caused climate changes. Baghdad climate is hot and dry, with a long time, summers that are hot and short, cold winters. Iraq's weather is impacted by its position among Arabian desert's tropical dryness and the Persian Gulf's tropical humidity, According to the United Nations, Iraq is the fifth-most susceptible country to warming temperatures. According to Berkeley, temperatures have risen by 1.8 degrees Celsius (3.2 degrees Fahrenheit) during the last thirty years. Earth, much above the world average, with summer temperatures often reaching 50 degrees Celsius (122 degrees Fahrenheit), (Washington journal post). Modern thermal comfort theories recommend that a restricted temperature difference be evenly maintained throughout all architectural styles, regions, and people. This strategy treats structure inhabitants for heating purposes, resulting in thermal comfort criteria that necessitate power climate management measures. This frequently results in a high need for air conditioning. Initial investigation and new Technology, HVAC (Heating, Ventilation, and Climate Control) advanced facilities are contesting conventional assumptions of thermal comfort criteria on the basis that they ignore main social and environmental comfort elements. In this paper the researcher took the effect of the modification in the design on the thermal comfort by several engineering solutions for reducing the total main radiant temperature (TMRT(, Potential air temperature (PAT), and the developing of the relative humidity (RH) with the wind speed (WS) Which are playing a significant role on improving the urban heat island (UHI) The research mainly aims to analyze the effect of urban green spaces on the urban heat island as a common strategy for improving the thermal comfort.
It is worth noting that changes in the urban design of built buildings, whether under construction or before design (green or sustainable building) have a significant impact on the energy used for air conditioning the building, as it reduces the energy used for cooling in the summer and heating in the winter, and thus reduces energy costs.by applying the sustainable requirements led to reduce in yearly cooling loads by (24.97%), resulting in a quarter decrease in energy loss. As a result, this research is an attempt to provide a clear notion to the designer about the benefits of the smart exterior technology implementation and to promote its adoption, (Dr.Ibrahim j.Al –Yousif).

Keywords: Urban Heat Island (UHI), Thermal Comfort, Total Mean Radiant Temperature (TMRT), PPTENTAIL Air Temperature (PAT), Relative Humidity (RH).

1. INTRODUCTION

One of the biggest and most important concepts developed in the twentieth century was sustainability, which had an important role in the engineering fields. Sustainable practices aim to safeguard financial stability while maintaining the long-term value of the environment, and they offer a framework to integrate rules with future growth. (Maysoon.M.et al., 2014), During the last few years, the community began alerting to the fact that the construction industry is no longer isolated from environmental threats that threaten the world. These sectors consume the most dangerous environmental resources, including soil, resources, and water, as well as energy. Contrary to popular belief, the construction industry is a highly complex industry which generates large amounts of noise population and construction. Researchers have recently exhibited an increased interest in the major issues of energy and water waste in building due to its continuing use throughout the structure's life. Throughout the design and execution stages, a new notion has been developed in the minds of the sophisticated industrial countries in the globe that were not familiar with

previously؛ Sustainability, green buildings, and sustainable construction are all the same thing. These terms reflect a growing interest in aspects of urban economic development that are concerned with environmental protection, reducing energy consumption, making the best use of natural resources, and relying more on renewable energy sources. Previous research have reported on sustainability in construction in general, but there is no professional study on the crucial role of sustainability in the building sector to prevent negative environmental effects. The balance of economic, social, and environmental objectives in the present and future was a fundamental topic in early Sustainable Development research, and it is becoming increasingly important for a range of organisational and geographical demands. As a result, the environment has become a prominent concern on global, regional, and national education policy agendas in recent years (Ali-Toudert F, 2005). The purpose of sustainable engineering is to create new solutions to fulfil human needs while minimising negative environmental consequences. This approach acknowledges that natural resources are limited and that the earth's ecosystems have a finite carrying capacity. Engineers use sustainable practises to reduce waste, pollution, and energy consumption while increasing efficiency, durability, and social equality.

(Mohammad Taleghani, 2011) determined that the three primary concepts for structural sustainability are sources the field of economics construction life cycle, and human design. These principles may be expressed as follows:

a. Energy and water-saving: this concept comprises energy savings by designing environmental circumstances according to the construction guidance, wall thickness, sufficient preparation for the work site, and the utilization of natural energy throughout the form and its resources.

b. Building life cycle: Each structure goes through three phases during its lifetime, as shown by the period beforehand constructing, which involves the preparation and the provision of supplies and supplies, the erection phase, which corresponds with the initial phase and consists of the non-use of natural resources throughout execution, and the stage after completing the building, that offers reuse of the building and facilities**.**

c. Human Design: Entails conserving all ecosystems via topographical assignment, design of cities, and construction planning by utilizing the drawings of neighboring buildings to decrease energy and water requirements and promote human comfort through health maintenance.

For a long time, a lack of renewable energy has been a health issue. Over the last several years, there has been concern about the use of natural resources during construction execution, which has resulted in waste of land, pure water, wood, iron, and other non-renewable resources such as petrol, gas,...etc, which could give rise to a lack of these supplies in the future. Sustainability is defined as the appropriate use of resources such as land, sunlight, and circulation to limit the consumption of nonrenewable energy (Prutha Platelet et al., 2009).

Based on the IPCC assessment, major worldwide pollution decreases of at least 50% below 1990 levels are necessary up to 2050, with additionally global emissions declines after 2050 needed to establish a low-carbon society by the end of the 21th century. It's the only way to keep the temperature rise to two degrees Celsius, which is regarded to be the highest level that humans can bear without suffering catastrophic consequences.

(Ratti. C et al., 2003), defined environment as a collection of environmental circumstances across time. Several vocabularies are used based on the size of the part of the world under discussion. At the person or restricted location level, we use the phrases macroclimate for a large area, meso climate for an average-sized region, regional climate, and ecosystem for a small region.

Local climate trends are frequently connected with surface areas ranging from just a few square meters to a few kilometers. It can refer to a hillside, a canyon, or a portion of a constructed time, for instance, and is characterized by significant variations in temperature, moisture content, wind, daylight because of the unique characteristics of the landscape, urban shape, position, resource nature, proximity to water, appearance or lack of vegetative cover, and so on (Setaih. K et al., 2013).

1.1 Thermal Comfort

Thermal comfort (the research's topic) is an important component of human pleasure. It is up to the designers to make this a reality. The human body constantly generates heat through metabolism, and maintaining thermal comfort involves balancing heat gain and heat loss. Several factors affect how individuals perceive and experience thermal comfort. Whichever of the subsequent sustainable construction goals intended to give the best level of thermal comfort for the institution's inhabitants yet using the least quantity of energy to try to cool in summer and heat in the winter? And, understanding the type of objects within the structure

and the character of its consumers from the bottom up is crucial when developing the correct heat medium for any property or any interior space. Gender, as well as the type of activity performed in the architectural areas Humans are affected by the environment in a number of ways. Thermal comfort constitutes one of the physical factors that influence an individual's general health and the sense of repair without relief. Thermal temperature develops as a result of a mix of surrounding conditions and sloughing, as the surrounding environment can remain heat-free. And was given. 37 degrees Celsius Sensation and no surplus wetness at a comparable rate of production while keeping the air temperature constant at 35 degrees Celsius, In the moment, the linguistic meanings varied while possessing the same content, and they were in disagreement. It is a state of mind in which a person is at ease and pleased with his or her current circumstances. Any average person who lives in it lacks thermal relaxing if the temperature increases or decreases over defined limits, i.e. he is not at peace in high temperatures and additionally not comfortable in extremely cold temperatures. The body's ability to maintain a balance among its own heat and the temperature of its surroundings (Fanger, P.,1988).

1.2 Factors that influence thermal comfort

1.2.1 The potential air temperature

It is a term employed in meteorological to represent the temperature of an object of atmosphere if it was raised internally (as opposed to adding or removing heat) to a standard pressure level, commonly 1000 hPa (hector pascals) or 1000 mb (milli bars).

The theoretical temperature is useful since it enables an analysis of mass of air at various pressure settings. It offers an indicator of the "heat capacity" of the air packet that is not affected by variations in pressure or volume. The real ambient temperature (estimated in Celsius degrees or Kelvin) and the actual pressure level where you are calculating the potential temperature are required for determining the potential temperature. The potential temperature may be calculated using the following formula:

$$\theta = T * (P_0 / P) \wedge (R / C_p)$$

In which P0 is the normal pressure stage (e.g., 1000 hPa), P is the pressure stage that it is desired to determine the possibility of temperature, R is the particular gas unchanged for dried air (around 287 J/(kg.K)), and Cp is the specific heat capacity at steady pressure for evaporate air (around 1005 J/(kg.K)). Using this method, you may calculate the potential temperature at a particular level of pressure and learn about the thermal properties of the air parcel , (George Reeves et al ., 2001).

1.2.2 Total Mean Radiant Temperature (TMRT)

is the sum of all irradiance doses to which a live body is exposed - governs unique thermal comfort, On the median, radiant heat Although the interaction of radiant and turbulence thermal profits or losses has a considerable influence on the human equilibrium condition in outdoor situations, TMRT is the most important climatic factor influencing human energy expenditures throughout sunny weather in summer. Raymond output may also be used to calculate TMRT. "Trying to Calculate the Total Mean Radiant Heat in Urban Infrastructure - Assessment of Heating Index", The mean radiant temperature (TMRT) is one of the most important factors impacting human thermal comfort in an urban environment (Lindberg et al., 2014).

The periodic warming of a fake boundaries in which the radiation heat transfer from the majority of the human body's unit matches that of an actual irregular barrier is referred to as TMRT. ISO stands for the World Organization for Standardizations. It is the average temperature of the human body's radiation surrounds as its entirety. In compared to recirculation or the process of e solar energy flow accounts for a large fraction of body heat transfer (Folk G.et al., 1974). because it is closely related to both the environment and pedestrian action (Whyte.W,1980).

As a consequence, modelling convective heat transfer in both live beings and their environment is a realistic concern. We will be able to predict and manage the effects of heat in relation to the expanding urban heat island effect (UHI) and increasingly severe weather events once TMRT is defined in a real-world urban setting. TMRT varies both chronologically and spatially in cities as urban buildings react to sunlight by collecting, reflecting, or creating radiation at various wavelengths (Jianxiang, 2014).

Exterior shading affects the temperature outside and human interior thermal comfort, influencing space utilization (Tzu, 2012). It was established that if a place is slightly more shaded throughout the spring, summer and autumn, human thermal comfort increases. Because a sparsely shaded condition can give rise to more solar rays in the winter, someone's thermal condition is greater when the location is less protected (Hwang et al., 2011).
The mean radiant temperature (TMRT), which summarizes both short-term and long-wave energy fluxes (including direct and reflecting) that every person is exposed to, is one of the most critical environmental elements impacting human energy equilibrium and living conditions (Sofia, 2007).

1.2.3 Relative Humidity (RH)

The temperature, humidity, and wind speed of the room all influence thermal comfort. Other factors that impact your comfort include your level and habits, clothing, your gender, your age, and overall health. Thermal radiation (hot surfaces) and thermal radiation loss (cool surfaces) both influence heat transport. The environment's moisture content (RH) is an indication of its water contents in proportion to the feasible saturated level. Warmer air may retain more humidity. When absorption reaches 100%, the dew point is the temperature at which air water collapses. Since temperature affects the humidity ratio, (George Reeves et al ., 2001).
The relative humidity is calculated using the following formula:

$$RH = (e / e_s) * 100\%$$

Where, RH is the relative humidity (expressed as a percentage), e is the actual vapor pressure, and e_s is the saturation vapor pressure at the given temperature As chilly air from outside heats up, humidity levels decrease. Fridge cooling systems usually remove humidity from the air as they cool. The process of e conditioner introduce water into the air. Moisture levels are stated as a percentage of the quantity of moisture particles that are expected to be present in the atmosphere to the maximum number that can be kept until precipitation occurs. It is usually expressed as a percentage.

1.2.4 Wind velocity

Wind is the movement of air masses caused by differences in atmospheric pressures caused by topography and water, involving air temperature fluctuations that can occur on basic (between various locations) or minor proportions (riverfront, lakefront zone, lowlands, and so on). In the first case, we're discussing global winds, but in the second, we're discussing localized winds. Three characteristics characterize air: speed, place of blowing, and consistency.

The impact of geography on localized storms is substantial and quantitative. The air configuration varies as a result of two factors on the ground with challenges: topography layer density and height. Wind is detected by meteorological sensors situated in specified geographical areas. Changing the surroundings influences the velocity, especially in relation to the elevation in the given site (Federico M. Butera, 2014).

1.3 Improving Thermal Comfort

Enhancing thermal comfort in structures entails taking into account a variety of elements that influence the atmosphere inside. Particular solutions for improving thermal comfort in structures include as follows:

a. Insulation: Appropriate exterior wall insulating reduces heat transmission via walls, roofs and floors. This comprises materials that insulate like fiberglass, foam, or cellulose, which serve to reduce the gain of heat in the summer and heat loss in the winter.

b. Efficient windows: Putting low-emissivity (low-E) treatments and multiple layers of glass on windows that are energy-efficient can assist limit heat transmission and manage solar heat absorption. Such windows can help improve efficiency and reduce draughts.

c. Shading: External shading devices like awnings, overhangs, or louvers can block direct sunlight from entering the building, reducing heat gain. Internal shading options such as blinds or curtains can also be used to control sunlight and glare.

d. Natural ventilation: Organic ventilation mechanisms in structures enable the inhalation of new air and the evacuation of stagnant air. This may be accomplished by arranging doors, vents, or movable sunroof to improve air flow and offer cooling in moderate weather.

e. Mechanical ventilation: In buildings where natural ventilation is not feasible or insufficient, mechanical ventilation systems can be installed. These systems ensure a continuous supply of fresh air while also providing the opportunity to control indoor air temperature and humidity.

f. Efficient HVAC systems: The presence of heat, airflow, and climate control (HVAC) systems are critical to preserving thermal comfort. Using energy-efficient HVAC systems, such as those with variable speed fans or inverter technology, may give more accurate temperature control while also reducing energy use.

h. Occupant control: Giving people control over their local surroundings improves comfort. Variable temperature controls, such as heaters or fan speed controls, allow occupants to customize the environment to their liking.

i. Lighting design: Appropriate illumination layout may lower the amount of heat produced by lighting fixtures, reducing the need for extra cooling. Lighting solutions that use less energy, such as LED lights, produce less heat and add to overall thermal comfort..

1.4 ENVI- Met 5.0.3

The ENVI- Met 5.0.3 Atmospheric Visualization and Data System for Urban environments is an application or model designed to improve thermal comfort micro size ecological models in urban environments. It is a software application designed to simulate urban climates, outside thermal comfort, and airflow dynamics. It enables extremely fine research and modelling of how environmental parameters such as moisture, humidity, temperature, wind, and solar radiation fluctuate inside cities and metropolitan regions. ENVI-met is frequently utilized by academics, developers, designers, and ecological consultants to examine the ecological effect of architectural decisions, green buildings, and environmental protection initiatives. It may aid in comprehending and optimizing elements such as building location, green space transportation, and material selection in order to promote outdoor comfort, minimize heat island impacts, and improve general sustainability in cities. To build 3D simulations and visualize how things look inside urban settings, the programmer integrates climate data, urban mathematics, vegetative knowledge, and other characteristics. It aids in assessing the efficacy of various urban design initiatives in fostering sustainable and livable urban settings.

2. METHODOLOGY

2.1 Study Area

A Place near of a governmental multi store building (printing house) in Baghdad city is selected for the study as shown in Figure 1. This place was selected since it is an essential the spot with large modern printing equipment to create various printing manufacturing such as newspapers, magazines, and booklets in various cutoff sizes, particularly as it is a government agency that gave it a special importance to print private papers such as colleges and schools exams copybooks and exam questions as well as government secret documents due to its privacy even though many commercial products are being that Many land surface temperatures can be found in the chosen location. that the chosen area has many land surface temperature (LST) principles, that affect the thermal comfort of the constructions and people walking around the buildings; additionally, there is no green cover, such as trees or plants, which contributes to better thermal comfort or provides some shade in summer conditions.

Figure 1. Selected Building (Printing House Al Sabah Newspaper).

2.2 Preparation of The Model For Simulation

It is utilized in the development of the model by ENVI-met 5.0.3 software to give actual imagination for the simulation process to offer excellent results after the modification by the ENVI-met program. One of the ENVI-met program's features is the ability to find the location of the selected area and automatically provide the latitude and longitude of this area, which provided accurate results for air temperature, wind speed, relative humidity, and total mean radiant temperature. Reality information should be entered like the nature of the main road which is paved by asphalt and the interior road's materials which

is paved by concrete, the nature of the building walls and roofing materials in addition to determine the true north for the building which is important to give the actual building orientation to the sunlight or thermal radiation, these functions must enter accurately before designing the model carefully to give accurate and satisfying results to improve the thermal comfort for the environment and the human using this building or walk around it as shown in Figure 2.

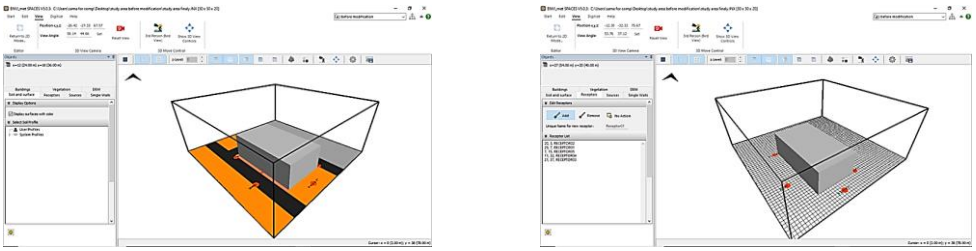

Figure 2. Designing Model by ENVI -met 5.0.3

The date of the hottest day in Iraq, which is July 30th, 2015 in which Baghdad experienced the warmest weather ever and recorded 123.8 degrees Fahrenheit equal to 50 degrees centigrade at 03:00 pm, should be determined to produce correct results in the simulation [Washington post journal].

3. RESULTS AND DISCUSSION

3.1. Results Before Modifying The Model

Potential air temperature (PAT) :

Maximum (pat) = 47.43 ºC
Minimum (pat) = 43.89 ºC

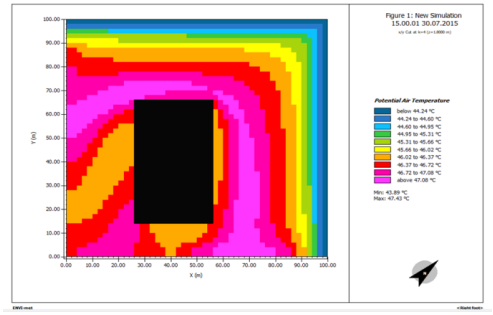

Figure 3: Results for PAT

Mean Radiant Temperature (TMRT):

Maximum (TMRT) = 77.04 ºC
Minimum (TMRT) = 58.74 ºC

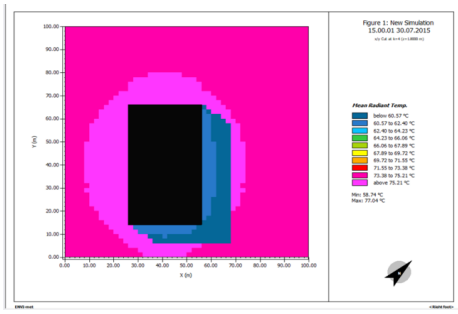

Figure 4: Results for TMRT

Wind Velocity :

Maximum wind velocity = 3.13 m\s
Minimum wind velocity = 0.03 m\s

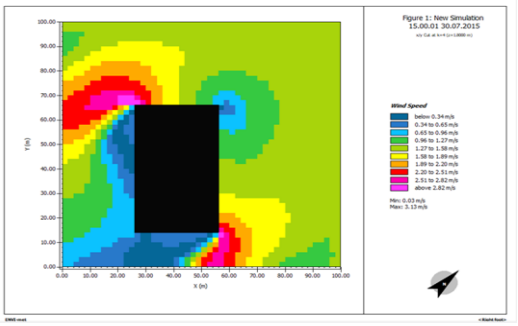

Figure 5: Results for wind velocity

Relative Humidity (RH) :

Maximum (RH) = 24.89 %
Minimum (RH) = 20.31%

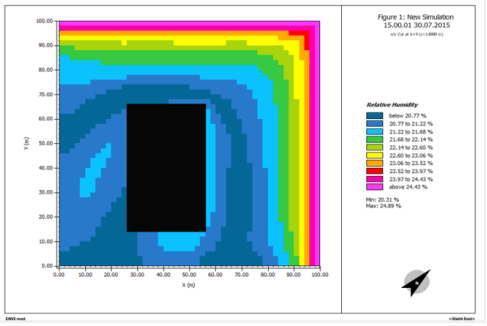

Figure 6: Results for relative Humidity

3.2. Modification of The Model

Achieving thermal comfort for the structure by lowering the mean radiant temperature (TMRT), potential air temperature, and relative humidity levels will occur in numerous ways:

1. Planting thickly trees that provide lots of shade; one of these trees that has recently expanded in Iraq is the Melia Azedarach tree; it costs between five and six dollars, depending on its size. It is planted for adornment and shade because it tolerates dryness, is perennial, densely shaded, and appealing (Figure 7).

2. Using thermal insulators Thermal insulators prevent heat transfer through walls, ceilings, and floors in a structure. The materials and forms of insulators are diverse, and they are often combined into rolls. The ability of a material to resist heat flow determines its thermal insulating capability. The researcher utilized a The best choice is to use (Isogam) which is made in the form of rolls (aluminum rolls with bituminous felt inside) with a width of 1 m * 10 m in length and 4 mm thick, consisting of aluminum and tar as shown in the Figure 8.

3. Asphalt pavements absorb and retain more heat than rough surfaces. As a result, typical asphalt pavements emit high temperatures into the atmosphere, contributing to the urban heat island (UHI) phenomenon. To reduce the impact of UHI, different cool asphalt solutions, including as the delivery of chemicals and substances, protective coatings, and multilayer design, have been used, Figure 9.

4. Using of the decorative brick road (red stones) in the interior roads of the building instead of the concrete roads which absorb the sunlight less than the concrete as shown in Figure 10.

Figure 7: Melia Azedarach (Orwa et al.2009)

Figure 8: Isogam single aluminum layer (William C. Turner, 2011)

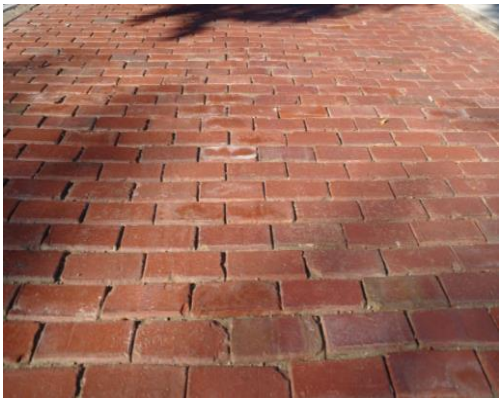

Figure 9: Red stone (brick road) (Wienerberger, 2009)

Figure 10: Red Coated Asphalt (P.E. Phelan et al., 2017)

3.3. Results for Model After Modification :

Mentioned modifications were applied to the model to develop the thermal comfort. The model after modifications is presented in Figure 11.

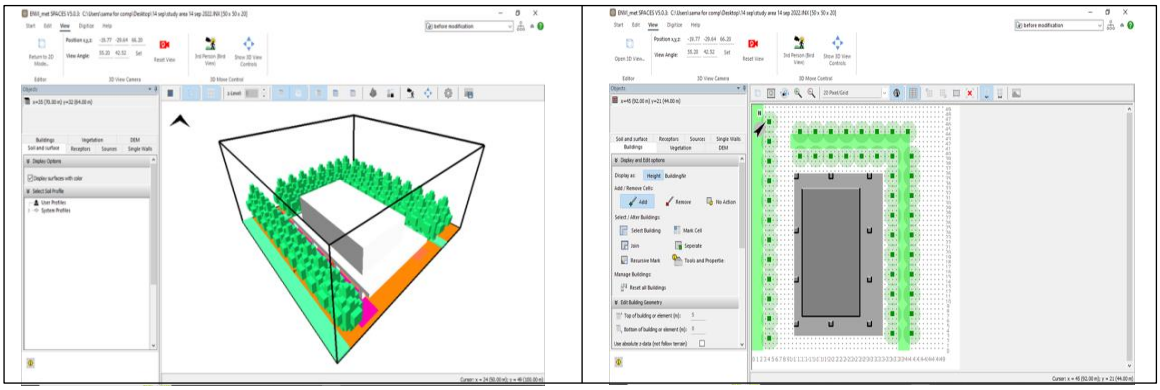

Figure 11: Model after modification

Potential air temperature (PAT) :

Maximum (pat) = 47.43 ºC
Minimum (pat) = 43.89 ºC

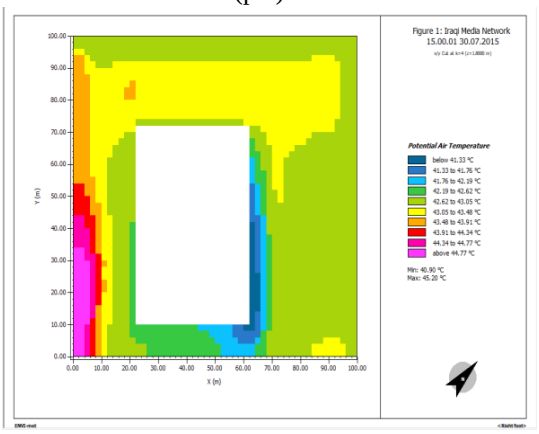

Figure 12: PAT

Mean Radiant Temperature (TMRT):

Maximum (TMRT) = 77.04 ºC
Minimum (TMRT) = 58.74 ºC

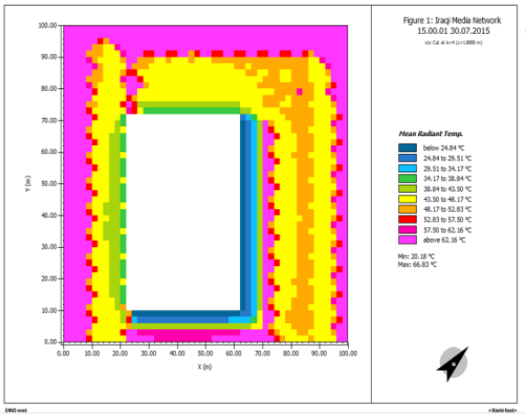

Figure 13: TMRT

Wind Velocity :

Maximum wind velocity = 3.13 m\s
Minimum wind velocity = 0.03 m\s

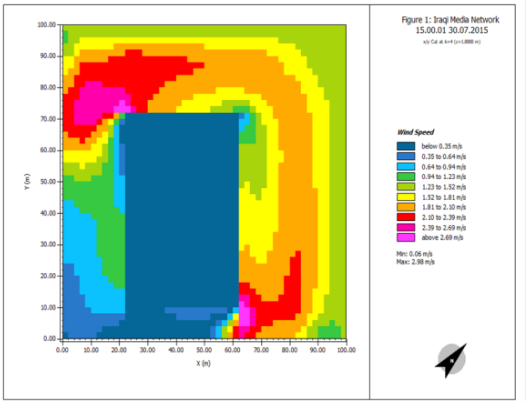

Figure (14): wind velocity

Relative Humidity (RH) :

Maximum (RH) = 24.89 %
Minimum (RH) = 20.31%

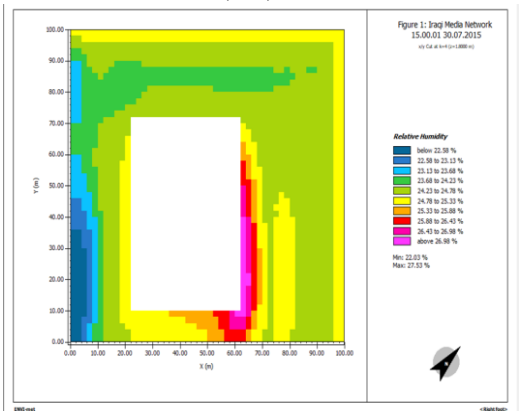

Figure (15): (RH)

4. CONCLUSION

Simulation results of this research show that:

1. The investigation revealed that the academic programed ignored a number of the concepts and principles of sustainability, in addition to failing to examine sustainability-related technology, such as modeling methods and programming that aids in the sustainable design processes.

2. According to the findings, the vendors of customers are disinterested in implementing sustainability ideas and values into the layout of the building projects. Our civilization clearly lacks environmentally knowledge, and we face a number of issues and obstacles, some of being commercial in character.

3. Additionally, there is a societal barrier to prioritizing the power source concerns while looking for an idea.

4. The absence of vegetation cover in the research's location resulted in a warm and hot environment with a low level of relative moisture, which affects the warmth of the building's people inhabitants.

5. The lack of shading in the research region resulted in a rise in the surface of the ground region, that reflected sunlight and affects people going through the structure.

6. The conventional materials utilized for the research region's walls, roofs, and exterior building surfaces collected a large quantity of heat throughout the day and retained it until night.

7. The pavement utilized in the research area's major road (black asphalt) collected heat and reflected sunlight, resulting in massive volumes of (TMRT) and (PAT) impairing thermal comfort.

8. The research area's inner roadways have been coated with cement, which collects solar radiation and produces large levels of (TMRT) and (PAT), decreasing thermal comfort.

5. RECOMMENDATIONS

To get better results in developing thermal comfort the researcher recommended that :

1. The importance of modelling energy efficiency prior to the development process with simulated programs and pathways allows for assessment of the ecological design parameters used in the scope of work.

2. In terms of thermal efficiency, it is preferable to build residences and compact buildings along the east-west axis, since this circumstance boosts the amount of the walls facing north and south, enabling sunlight to penetrate when warming is necessary.

3. Developing thick vegetation surrounding this structure to provide shading and thermal comfort to its occupants. It is preferable to plant dense, persistent trees with plenty of leaves.

4. Sun curtains ought to be made from substances that are unable to retain or store warmth, such as hardwoods, and ought to have layouts so that they do not obscure the sun. The primary function of air movement is to reduce ambient temperature.

5. High-density cement should not be used in the construction of sun blinds or the inner roadways encircling the structure. Given its ability to hold heat throughout daytime and dissipate it at nighttime whenever the ambient temperature decreases than the outside temperature, this form of pavement is termed a heat lake, which impacts the warmth of the residence's inhabitants.

6. Avoid employing asphalt in the inner roadways surround the construction, as well as in pedestrian paths, because it has the ability to take in and reflect temperatures which has a negative impact on thermal comfort.

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Declaration of Competing Interest

There is no conflict of interest in this study.

References

1. Adriano Magliocco,. Katia Perini ., (2004). Urban environment and vegetation: comfort and urban heat island mitigation.
2. Ali-Toudert F, (2005). Thermal Comfort in an East-West Oriented Street Canyon in Freiburg (Germany) Under Hot Summer Conditions, Theoretical and Applied Climatology.
3. Baetz, B.W.; Korol, R.M., (2008). Integrating Sustainable Development Concepts into an Engineering and Society Programme", Technology and Society, 1991. ISTAS apos; 91: apos; Preparing for a Sustainable Societyapos; Post Conference Edition. Proceedings of the 1991 International Symposium on.
4. Cenedese, a. & Monti, P., (2003). Interaction between an Inland Urban Heat Island and a Sea-Breeze Flow: A Laboratory Study. Journal of Applied Meteorology, 42(11), pp.1569–1583.
5. Dardel S., (2015). Climate Smart Fortaleza. Thesis for a diploma in Environmental Engineering, Department of Engineering, Faculty of Engineering, Lund University .
6. David V. J. Bell (2016) . Introduction To Sustainable Development.
7. Dhirgham Alobaydi., Mohammed Bakarman.,(2016). The Impact of Urban Form Configuration on the Urban Heat Island: The Case Study of Baghdad, Iraq.
8. Dorer V., Allegrini J., Orehounig K., Moonen P., Upadhyay G., Kämpf J., and Carmeliet J., (2013). Modelling the Urban Microclimate Impact on the Energy Demand of Building and Building Clustres. 13th Conference of International Building Performance Simulation Association, Chambéry, France .
9. Dorer V., Allegrini J., Orehounig K., Moonen P., Upadhyay G., Kämpf J., and Enno Koehan, Devang Patel, Santosh Khonde (2009). Introduction of sustainability to civil and construction engineering students, Lamar University, AC 2009-591.
10. Ethan, Jocie, Kim and Fred ., (2011). Roof Designs: Terms, Types, and Pictures.
11. Fahmy M., and Sharples S., (2009). On the Development of an Urban Passive Thermal Comfort System in Cairo, Egypt, Building and Environment.
12. Fanger, P.,(1988). Assessment of Man's Thermal Comfort in Practice, British Journal of Industrial Medicine 30.
13. Federico M. Butera (2014) . Sustainable Building Design For Tropical Climates Principles and Applications for Eastern Africa .
14. Federico M. Butera, (2014). Nature of vegetation and building morphology characteristics across a city: Influence on shadow patterns and mean radiant temperatures .
15. George Reeves et al ., (2001). ASHRAE handbook.
16. Gwo-Jen Hwang., Hui-Chun Chu., (2011). A concept map approach to developing collaborative Mindtools for context - aware ubiquitous learning.
17. Herbert J., Johnson G., (1998). Arnfield A, Modeling the Thermal Climate in City Canyons. Environmental Modelling and Software 13 .
18. Jianxiang, (2014). Heat transfer in heterogeneous nanostructures can be described by a simple chain model.
19. Johnsson G. and Hunter L., (1995). A numerical Study of Dispersion of Passive Scalars in City Canyons: Boundary-Layer Meteorology 75 .
20. Krystyna Strumio,. (2021). Sustainable City- Green Walls and Roofs as Ecological Solution.
21. Lea & Febiger; ., (1974) .Textbook of environmental physiology. Philadelphia.
22. Lindberg et al., (2014). Role of Built Environment on Factors Affecting Outdoor Thermal Comfort - A Case of T. Nagar, Chennai, India .
23. M Nikolopoulou., M Bruse., (2004). Urban Green Space in Europe.
24. Maysoon.M.et al., (2014). Architecture and sustainability Investigate the relevance of sustainable design solutions in decreasing environmental impacts on the built environment, Al-Azhar Engineering Thirteenth International Conference December 23-25, 2014
25. Mohammad Taleghani, (2011) Sustainability in architectural education: A comparison of Iran and Australia.
26. Nichol J.(1996). High-Resolution Surface Temperature Patterns Related to Urban .
27. Omar H. Kharofa (2018). Methods and means of applying sustainable engineering in buildings\ Muthanna Journal of Engineering and Technology.
28. Panariti A., T., Maliqari A., Tashi P.,(2014). The Impact of Urban Texture in Outdoor Thermal Comfort, International Journal of Science and Research.
29. Prutha Platelet et al., (2009). Use of sustainable green materials in construction of green buildings for sustainable development.

30. Qudama Al-Yasiri., (2021). A short review on passive strategies applied to minimise the building cooling loads in hot locations.
31. Rachel Emas (2015). The Concept of Sustainable Development: Definition and Defining Principles, Florida International University.
32. Saleh, S.A., Ahmed, H.K., et al., (2013). Waterproofing Blog - Iraqi Building Code M. B. A. 501 First Edit., Baghdad, Iraq: Ministry of Planning, Central Organization for Standardization and Quality Control.
33. Setaih. K et al., (2013). Assessment of Outdoor Thermal Comfort in Urban Microclimate in Hot Arid Areas. 13th Conference of International Building Performance Simulation Association, Chambéry, France.