ENHANCING ENERGY EFFICIENCY THROUGH PASSIVE DESIGN PRINCIPLES IN HOT-HUMID CLIMATE, NORTH CYPRUS

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Abstract: **The dormitory is meant for students and its most important function is to provide a substitute home during studies and good possibilities to study. The purpose of these rules is to create an open, pleasant and secure atmosphere and a peaceful living environment in the dormitory.**

The amount of energy required to run these environment is excessively high, Buildings that promote good studies activities can be achieved through passive design. In achieving this, the architectural profession has a leading role to play in adopting passive design principles which are environmentally friendly and cost effective. This research explores passive design principles in enhancing energy efficiency in a hot-humid climate **of North Cyprus. This will achieved by carrying out an evaluative case study research. The case study will be purposively select from E.M.U Famagusta North Cyprus. Instruments of data collection used are: visual survey and application of energy efficient architectural checklist. The research results obtained shows that more passive design principles such as: use of atrium, use of cavity walls and use of soft landscape need to be employed and properly maximized in design of university dormitory. The following are some recommendations: Institute of Architect and Architect Registration Council should organize more symposiums where issues on energy efficiency and passive design will be discussed with the focus of educating practicing architects on recent researches and innovations on these issues.**

Keywords: **Dormitory, Energy, Energy Efficiency, Passive Design, hot-humid climate.**

1. INTRODUCTION

One of the vital functions of building is protecting the occupants from hot and adverse weather. The primary goal of building design is to construct a comfortable and energy-efficiency internal environment. Buildings are regarded worldwide as one of life's essential needs and a necessity for man's existence Agboola, (2004). Observations by Akinola, (2015) in an environmental study showed that most buildings use more active energy for both thermal and visual comfort, thereby demonstrating that these buildings are not in fact passive Akinpade, (2012). explains that, in every individual's life, environments play a major role whether a student, teacher, employer or employee. The effectiveness of the institutional building project depends directly on the degree of user satisfaction, as users would expect indoor environmental conditions that can accommodate computer-intensive activities as well as paper-based tasks successfully.

The dormitory is meant for students and its most important function is to provide a substitute home during studies and good possibilities to study. The purpose of these rules is to create an opens, pleasant and secure atmosphere and a peaceful living environment in the dormitory. In most universities dormitory and other public buildings, heating and cooling of buildings today accounts for high energy consumption Adamson & Aberg, (1993).

Passive design is a term that describes an age-old concept: Designing structures that take advantage of the weather, the sun's free energy and the natural environment. Passive architecture maximizes the natural climate benefit of indoor living space heating and cooling Stewart, (2009).

Passive design involves a wide range of approaches that optimize the natural environment resulting in energy efficiency buildings design and lowers energy consumption per unit of output, thereby increasing energy conservation. Passive design involves a wide range of approaches that optimize the natural environment, resulting in energy-efficient building design and reducing energy consumption per unit of output, thus increasing energy conservation.

This theory emphasizes architectural design strategies that reduce energy consumption by incorporating conservative energy efficient architectural features such as sufficient fenestration rates, an intensive building envelope, thermal mass and increased daylight design Sanford and Stamas, (2008).

Heating and cooling of buildings account today for high energy consumption in most university dormitory, malls, offices, hotels, and other public buildings. Adamson & Aberg, (1993).Life cycle analyzes have shown that most of the energy in a building is used in operating energy or in the post occupancy period of the life of a building Australian Association of Cement and Concrete, (1994).

The International Hotel and Restaurant Association (2005) also establishes that buildings directly account for more than 50 percent of total energy consumption in many countries, especially in the industrialized world, and even more when one includes what it costs to manufacture the building materials.

This paper aim to explore passive design principles in enhancing energy efficiency in a hot-humid climate for university dormitory, the aim is going to achieve though the following objectives; study the concept of passive design principles that can enhance energy efficiency, identify the passive design principles applicable to hot-humid climate that can enhance energy savings, To identify the passive design principles and the architectural design requirements applicable in university dormitory design. This research seeks to answer the following questions; what passive design principles can be employed to enhance energy efficiency hot-humid climate? What is the possible percentage of energy savings achieved by adopting passive design principles? What are the passive design principles and the architectural design requirements applicable in university dormitory design? And will also focuses on passive design principles applicable in a hot-humid climate of Cyprus which enhances energy efficiency in a university dormitory thereby boosting the comfort of students and conserving energy.

2. LITERATURE REVIEW

2.1 The Concept of Energy Efficiency

Encarta dictionary defines efficiency as achieving effectiveness without any wasted energy. Energy efficiency is a cost-effective way to achieve an environmentally friendly model that will save money and combat greenhouse gas emissions. Community Research and Development Centre CREDC (2009) emphasize that Energy efficiency has become an urgent and vital aspect of sustainable design, which is now a global demand. Janssen (2004) asserts that an improvement in Energy efficiency is known as any action taken by a supplier or consumer of energy products that reduces energy consumption per unit of production without reducing the level of service delivered.

2.1.1 Energy Efficient Buildings

United Nations (1991) defines energy efficient buildings as buildings that have minimum levels of energy inputs. Well-designed power efficient buildings provide the best human comfort condition while reducing energy costs. According to the Development and Land Use Policy Manual for Australia (DLUPM) (2000), the aim of energy-efficient buildings is to boost occupant comfort and reduce energy consumption (electricity, natural gas, etc.) for heating, cooling and lighting. Chowdhury (2006) assert that increased energy efficiency in buildings can provide financial benefits through reduced electricity bills and have a role in reducing total societal energy use.

2.2 Thermal Comfort and Energy Efficiency

Thermal comfort is a subjective sensation. It is that state of mind that expresses satisfaction with the thermal environment. Alternatively, it is that state of mind that does not express dissatisfaction with the thermal environment (Ogunsote, 1991). It is similar to situations where people can sleep soundly and function easily, and where the body's thermo-regulatory mechanisms demand a minimum. The American Society of Heating Refrigeration and Air-Conditioning Engineers

(ASHRAE), (2009) defines thermal comfort as the state of mind that expresses satisfaction with the surrounding environment. Factors such as temperature, ventilation, humidity and radiant energy affect thermal comfort, and for humans the comfort zone is within a very narrow range of conditions. Exterior climate conditions alter the acceptable interior conditions. Energy efficiency is achieved when occupant comfort is maintained through limited reliance on mechanical space conditioning.

The following parameters are factors that enhance energy efficiency and promote thermalcomfort of occupants in a building:

A) Window size.

b) Window orientation.

c) Shading device.

2.3 Passive Design

Passive design is one of the oldest and most active methods for energy conservation. This goes literally back to the man in the cave. Cave dwellings in the northern hemisphere frequently had openings to the south so that the sun could heat the rock inside during the day and then release the heat into the cave at night Shearer, (2010). The theory remains the same, but it has been made much more efficient by modern technology and building materials. Passive design includes a wide range of strategies that maximize the flow of energy from natural climate to building design, construction and management. The principle remains the same, but it has been made much more effective by modern technology and building materials. Passive architecture involves a wide range of techniques that optimize the flow of energy from natural environment to building design, construction and management. Passive design doesn't move the solar energy; it uses it right where it's collected Shearer, (2010). This means that the collection spots must be strategically placed in the first place so that they perform some needed function inside the building. For example, if a building has a lot of windows that regularly get a lot of sunshine, the interior will be naturally heated by the sun; this is an example of solar energy being collected and passively used. The system can be improved by a wide variety of apps, from window positioning to building orientation in addition to flowers for landscaping. For example, making use of landscape lights that are powered by the sun is one of the most common examples of passive design. The key to designing a passive design building is to best take advantage of the local climate Shearer, (2010).

Elements to be considered include window placement and glazing type, thermal insulation, thermal mass, and shading a building designed with passive design can save enormous amounts of money over the building's life. Solar cooling systems are used for building cooling and ventilation. The first concern in solar cooling is how to avoid cooling loads. If excessive heating can be minimized, then the problem of providing sufficient cooling will be half solved. Cooling loads are due to sunshine through windows or on the outside of walls or roofs, hot air entering the building or heat conducted from hot outside air to the inside. Natural cooling systems are a passive cooling system that depends solely on natural means for the cooling of buildings.

2.3.1 Advantages of Passive Design

Tahmina, (2009), provides the following as the advantages of passive design:

(i) Cost Savings

(ii) Energy Efficiency

(iii) Aesthetics

(iv). Enhance Comfort

2.4 Passive Design Principles for Enhancing Energy Efficiency

Passive design principles have proven to be extremely effective and can greatly contribute in decreasing the cooling load of buildings. Tahmina, (2009) assert that there are principles classified into planning aspects and building envelope that help to guide the passive design process in order to achieve energy efficiency in a design. These are:

Planning Aspects:

I. Building form,

II. Building orientation,

III. Spatial organization,

IV. Landscape

Building Envelope:

I. Building material,

II. Natural ventilation,

III. Day-lighting.

2.5 Climate

Climate is a statistical composite of weather conditions of a particular place viewed over a very long period of time e.g. 30-40 years (Dean, 2004). The word climate comes from aGreek word "klima", which means the „slope" of the earth in respect to the sun. The climate of a location is affected by its latitude, terrain, and altitude, as well as nearby water bodies and their currents. The following are the elements of climate: temperature, pressure, cloud, sunshine, rainfall, wind and humidity. Micro-climate is found in a more limited space like a room, a street, town or small landscape while macro-climate is that of a much larger space such as over a country , a continent or on oceans.

2.5.1 Designing with Climate

The entire world can be classified into five main climatic zones according to Koppens climatic classification (2009) as: Tropical Zone, Dry Zone, Moderate Zone, and Continental Polar Zone. Through the ages, climate has always been a vital determinant of architecture and building. The art of building and the quality of the architecture of a place have always reflected the people's adaptation to local materials and methods of their economic, social and cultural needs, which are affordable to their economic capacity. Hence, the need to design with climate has always been a major consideration in architecture. Vitruvius, (1960) in his ten books on Architecture drew attention to the importance of climate in architecture and town planning. It is therefore important to analyze the climatic scenario of an area in order to understand the typical thermal behavior of buildings in such an environment. Knowledge on the thermal behavior of the building envelope is crucial to control the amount of heat movement in a building space. Zain, (2007) factors that influence thermal comfort in humans include outdoor air temperature, relative humidity and airflow. Various strategies also need to be adopted to facilitate air flow because it has been observed by Zain, (2007) that if there is no air flow, occurrence of thermal comfort is only 44% occurrences in temperatures below 28.69 °c but an air flow of 0.7 m/s can improve the occurrence of thermal comfort to 100%.

2.5.2 Cyprus Climatic Zone

Climatic zones are defined for a better understanding of the workings of the global climatic system Markus and Morris (2008). Cyprus has a hot-humid climate Mediterranean and semi-arid type (in the north-eastern part of island) with very mild winters (on the coast) and warm to hot summers. Snow is possible only in the TROODOS MOUNTAIN in the central part of the island. Rain occurs mainly in winter, with summer being generally dry. TROODOS MOUNTAIN

2.6 University Dormitory

Accommodation is one of the most essential necessities of life and inconceivable to relinquish Yildirim, (2010). In higher education management also students' accommodation is a considerable matter in many countries of the world Nimako, (2013). Academic productivity extremely depends on facilities and services for the students, especially housing Akinyode, (2014).

Improving the quality of education in a college requires a proper environment to support the growth of student learning. Student dormitory is an excellent place for students to study and develop. Thus, providing high quality dormitory services and understanding the needs of students are important issues that colleges ought to focus on them Liu, (2013).

The physical environment helps students develop their intellectual abilities and gain social cohesion and be responsible citizens Najib et al., (2011); Hassanain, (2008). Places used by students are there, that happen their academic life Yildirim, (2010). Therefore, studies on students also encompass residence. Entrance to university is not just attending in classes, living in dorms have many opportunities for growth of students along with other interests Blimling, (1993).

2.7 Architectural Design Requirements for University Dormitory

Some of the requirements are:

- Accessible laundry facilities should be provided on the basis of 1 washing machine and dryer to every 75 students. Facilities may be split across buildings or in a separate building and should ideally be located adjacent to entrances.
- A single wheelchair accessible staff and visitor WC should be provided in each building close to the principle entrance.
- Cleaner's cupboards are to be provided on each floor. Each should be approximately 3m2 and provide a 'Belfast' sink, hot and cold water and shelving.
- Commons rooms are required to suit the building layout to meet the maximum Cat 6 cable length of 90m from patch panel to RJ45 outlet. However, provision should not be less than one per alternate floor.
- Secure and covered bin stores are to be provided externally for general waste and recycling. The facility can be shared between buildings if considered appropriate by the University.
- Covered secure cycle storage is to be provided at each residential building or group of buildings.
- Lifts should be provided as necessary to ensure all rooms are accessible to ambulant disabled. Car size should provide a minimum capacity of 8 persons and be equipped with CCTV, alarm and voice connection.

3. METHODOLOGY

The research will employ quantitative research (CASE STUDY) relevant to passive design and how such cases have enhanced energy efficiency. Cases were properly documented and data obtained from cases were assessed and analyzed using energy efficient architectural features.

Variables that apply to energy efficient design as they relate to the Cyprus hot-humid Climate and how they enhance energy efficiency in university dormitory are analyzed. The following are such variables:

a) Building envelope

b) Landscape design

c) Building form

d) Natural Ventilation

e) Day-Lighting

f) Building orientation

3.1FINDINGS AND DISCUSSIONS

3.1.1 CASE STUDY: DAU3 EMU CYPRUS

DAU 2 EMU Cyprus Located at the center of the campus where you can reach any facility at ease.

Dormitory Features:

- On-campus accommodation
- Female/Male Blocks
- WC in corridors
- WC/Shower in corridors
- TV Hall
- Student kitchen
- Student capacity: 48
- Number of rooms: 24

Room specialties:

- Standard double room: 12 m2
- Standard double corner room: 10 m
- Cable Internet
- Split-unitary air-condition

Standard double room: 12m2

- Bed-study unit
- Wardrobe
- Chair
- Refrigerator
- Air-conditioner
- Door
- Window
- Bed-side table
- Bookshelf

Corner Double Room: 10m2

- Bunk bed
- Wardrobe
- Chair
- Refrigerator
- Air-conditioner
- Door
- Window
- Bed-side table
- Bookshelf
- Des

Plate 1: Approach view walkway of DAU3 EMU (Source: Researcher's Field Survey, November, 2019)

Plate 2: Natural lighting augmented by use of artificial lighting in DAU3 EMU (Source: Researcher's Field Survey, November, 2019).

3.1.1.1SPATIAL ORGANISATION

The block has two floors. There are 4 corridors on the ground floor with 2 standard and one corner room in each one of them. Students residing in the same corridor share two WCs, two washbasins and a bath-shower. Furthermore, 48 students share the common kitchen and the TV lounge. There is satellite broadcasting in the TV room. Each room has a spacious area furnished with desks, a wardrobe, and bookshelves for two to live comfortably. The dormitory is made up of two floors of retail (eateries, boutiques, entertainment and services) with corporate office spaces

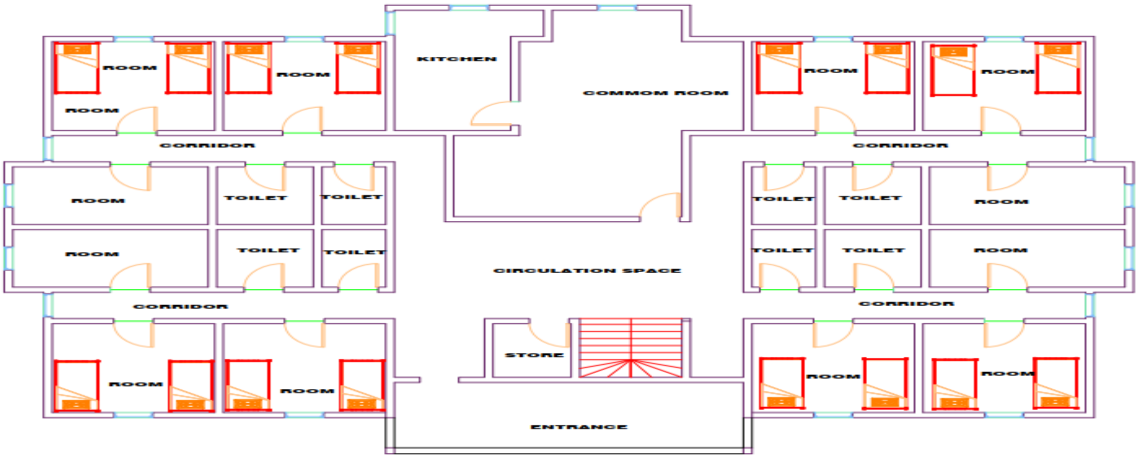

Fig 4.2: Spatial Organization Dau3 EMU (Source Researcher's Field Survey, November, 2019).

3.1.2 ASSESSMENT OF APPLICATION OF ENERGY EFFICIENT

ARCHITECTURAL FEATURES CHECK-LIST

The following energy efficient architectural features check-list is used in the assessment of DAU 2 EMU Cyprus and the full assessment is shown in Table 3.1:

Building envelope

(ii) Natural lighting

(iii) Natural ventilation

(IV) Landscape design

(v) Building orientation

(VI)Building form

S/N	VARIABLES	CHECKLIST	LEVEL OF APPLICATION			
			ABSENT	**LOW**	**AVERAGE**	**HIGH**
1	**Building Envelope**	Suitability of the materials to the climate			✓	
		Use of external insulation		✓		
		Use of light colours				✓
2	**Natural Lighting**	Wall to window ration (40%)			✓	
		Use of specially transparent glass			✓	
3	**Natural Ventilation**	Use of operable windows			✓	
4	**Landscape Design**	Use of soft landscape			✓	
		Use of hard landscape		✓		
5	**Building Orientation**	Sun Orientation (East -West)			✓	
		Wind Orientation (South-West – North-East)			✓	
6	**Building Form**	Large building surface area		✓		

(Source: Researcher's Field Survey, November, 2019).

4. CONCLUSION

In a world where there is increasing concern over climate change using passive design principles to enhance energy efficiency is ideal for a university dormitory because it is cost effective and environmentally friendly. Using mechanical means should however be optimized in terms of design, operation and control to enhance energy efficiency. For the hot-humid climate like Cyprus, energy efficiency is achieved with open forms having large surfaces with the principal axis lying along north-south direction, increasing window openings, efficient landscape design, use of shading devices, optimal day lighting use of roof garden which reduces energy cost by 25% (National Resource Defense Council, 2012), application of Sun light tube and atria to enhance interior day lighting thereby reducing energy cost by 10% (Evolve Energy System, 2004), use of insulated cavity walls to reduce total heating and cooling by 30% (Sustainable Energy Authority, 2002), good landscape design which serves as an effective means of protecting the building from unwanted solar gains and redirecting the wind flow to enter the building for natural ventilation thereby reducing cooling cost and heating cost to as much as 25% (Nyuk and Yu, 2005). From the cases studied in DAU1 EMU Cyprus, it is apparent that much still need to be done in applying the concept of passive design principles in enhancing energy efficiency in university dormitory. I strongly recommend to both the Institute of Architect and Architect Registration Council to organize more symposiums where issues on energy efficiency and passive design will be discussed. . Thereby educating the practicing architects on recent researches and innovations on these issues since the architectural profession has a leading role to play in adopting passive design principles.

REFRENCES

[1] Adamson and Aberg, O. (1993). *"Design for Climatization; Houses in Warm-HumidAreas"*. Building Issues 1993:1LCHS, Lund.

[2] Agboola, T. (2005) "Housing state" in Readings in Urban and Regional Planning; Agboola Tunde (ed). Pp 187- 256.

[3] Akinola, S. R. (2015) The Pattern of Housing Quality in Osogbo, Osun State, Nigeria, Ife Journal of Environmental Design and Management, Vol. 1, Nos. 1 and 2, pp. 109 – 120. Anantharajan, T. (1983) Evaluation of Residential Development through Users' Rating and Rating of Environmental Attributes. Proceedings of IAHS Congress of Housing, Miami, Florida.

[4] Akinyode, B.F. (2014). Students' Satisfaction and Perception on Rented Apartments in Nigeria: Experiment of lautech Students. International Journal of Business and Social Research, 4(7): 58- 70.

[5] Blimling, G.S. (1993) New challenges and goals for residential life programs. In Winston Jr, Roger B, Anchors S. (Eds.), Student Housing and Residential Life: A Handbook for Professionals Committed to Student Development Goals. San Francisco: Jossey-Bass, p. 1-20.

[6] Cement and Concrete Association of Australia,(1994). "Energy Efficiency through Passive Solar Design"

[7] Chowdhury, A.A.(2006)."Towards Energy Efficient Building Assets. A Review on SubTropical Climate". Fifteenth Symposium on Improving Building Systems in Hot and Humid Climate.

[8] Community Research and Development Centre CREDC (2009)."Energy efficiency survey in Nigeria"

[9] Dean, K. (2004). "*Climate Change and Global Warming"* A Publication on Social, Political, Economic and Environmental Issues that affect us all.

[10] Development and Land Use Policy Manual for Australia (2000)."Development and Land Use Policy Manual". Energy Efficient Building Design.

[11] Hassanain, M.A. (2007). Post-Occupancy Indoor Environmental Quality Evaluation of Student Housing Facilities. Architectural Engineering and Design Management, 3: 249–256.

[12] International Hotel and Restaurant Association,(2005)."Fostering Innovation To Fight Climate Change". A Public Report of Hotel Energy Solutions project publication

[13] Janssen,R.(2004)."Towards Energy Efficient Buildings in Europe". London: The European Alliance of Companies for Energy Efficiency in Buildings.

[14] Koppen,W.(2009). "Updated World map of the Koppen – Geiger Climate Classification". Hydrology and Earth System Sciences 11, pp. 1633-1644.

[15] Liu, M.S. (2013). Assessing Student Dormitory Service Quality By Integrating Kano Elaborative Mode With Quality Function Deployment Method - A Case Study In A Hospitality College In Southern Taiwan. The International Journal of Organizational Innovation, 5(3): 133-150.

[16] Markus,T.A. and Morris,E.N.(2008).“Building Climate and Energy”. Pitman Publishing Ltd.

[17] Najib, N.U., Yusof, N.A. and Osman, Z. (2011). Measuring Satisfaction with Student Housing Facilities. American Journal of Engineering and Applied Sciences, 4(1): 52-60.

[18] Nyuk,H. and Yu,C. (2009).“*Tropical Urban Heat Islands: Climate Buildings and Greenery”*. London: Taylor & Francis Group.

[19] Nimako, S.G. andBondinuba, F.K. (2013). An empirical evaluation of student accommodation quality in higher education. European Journal of Business and SocialSciences, 1(12): 164–177 .

[20] Ogunsote,O.O.(1991).“*Notes on Computerised Storage of Climatological Data for theArchitect. Climate and Human Settlements - Integrating Climate into UrbanPlanning and Building Design in Africa”.* United Nations Environment Programme (UNEP), Nairobi, Kenya.

[21] Ogunsote,O.O,Prucnal-Ogunsote,B.,Adegbie,M.(2011). “*Optimizing Passive CoolingSystems in Residential Buildings: A case study of Akure, Nigeria”.*

[22] Shearer,D.(2010).“*Concept of passive solar building design and thermal storage”*.

[23] Sanford,M. and Stamas,M.(2008).*“A Building That Creates More Energy Than It Uses”*

[24] Stewart .W.(2009). “Passive Solar Design and Retrofit”

[25] Tahmina, A.(2009).“*Passive Design Features for Energy-Efficient Residential Buildings in Tropical Climates: The context of Dhaka, Banglandesh”* M.Sc. thesis unpublished, Department of Urban Planning and Environment, Division of Environmental Studies Research- fms Kungliga Tekniska Hogskolan.

[26] Yildirim K. and Uzun O. (2010). The Effects of Space Quality of Dormitory Rooms on Functional and Perceptual Performance of Users: ZübeydeHanım Sorority. GU J Sci, 23(4):519-530.

[27] Zain,Z.M.(2007).*“Hot and Humid Climate: Prospect for Thermal Comfort in Residential Building”.* Desalination, 209(1-3): Pg. 261-268.

[28] Vitruvius,M.P.(1960).“*The Ten Books on Architecture”*. New York.