بسم الله الرحمن الرحيم

تقرير عن مؤتمر مجلس الإسكان العالمي السابع والثلاثين
الذي عقد في إسبانيا للفترة من ٢٦-٢٩ تشرين أول ٢٠١٠
الذي حضره الأستاذ الدكتور مقداد الجوادي والقي فيه بحثان وترأس فيه جلسة في محور التصميم من أجل الاستدامة و إعادة الاعمار

أعلنت الجمعية الدولية لعلوم الإسكان -IAHS- التي مقرها في ساحل ميامي - فلوريدا - الولايات المتحدة الأميركية في نهاية عام ٢٠٠٩ أنها ستعقد مؤتمر مجلس الإسكان العالمي السابع والثلاثين في تشرين الأول سنة ٢٠١٠ في إسبانيا بالتعاون مع جامعة كانتبريا في مدينة سانت آنـدير في شمال إسبانيا للفترة من ٢٦-٢٩ تشرين أول ٢٠١٠ وأرسلت الملخصات نهاية آذار ٢٠١٠ وارسلت البحوث وأعلن عن قبول ٣١٤ بحثا منها في شهر أيلول ٢٠١٠ كان للدكتور مقداد حيدر الجوادي بحثان فيها

<u>البحث الأول:</u>
Model of House Design Responsive to Hot Dry Climate
نموذج لتصميم إسكاني مستجيب للمناخ الحار الجاف
والمرفق نسخة منه

<u>والبحث الثاني :</u>
Domes and Their Impact on Thermal Environment Inside Buildings
القباب و أثرها على البيئة الحرارية داخل الأبنية
المرفق نسخة منه وهو بحث شارك فيه مع الدكتور مقداد الجوادي المهندس المعماري المدرس جمال عبد الواحد السوداني من المعهد الفني التقني

<u>شملت البحوث المقدمة عشرة محاور</u>
١- المواد وطرق البناء
٢- التصميم من أجل ألاستدامة و إعادة الاعمار
٣- السمات الثقافية والاجتماعية لمشاريع الإسكان
٤- إستراتيجيات تحقيق الراحة والصحة والأمان في التصاميم
٥- التصاميم الإسكانية
٦- إستراتيجيات التصميم و التخطيط الحضري
٧- الاقتصاد و إستراتيجيات التمويل
٨- الإدارة والصيانة
٩- تكنولوجيا البناء والإنشاء والخدمات وأساليب تغليف الواجهات
١٠- أمراض ألأبنية و إعادة التأهيل

وقد دعم المؤتمر من عدد من المنظمات المحلية والدولية وفي أدناه شارات الجهات الداعمة

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ولقد شارك في المؤتمر خمس و ثلاثون دولة وكانت الجلسات صباحية ومسائية وقد كان قد أرسلت رئاسة المؤتمر إلى الدكتور مقداد الجوادي رسالة بتاريخ ٢-٩-٢٠١٠ تطلب فيها من الجوادي الموافقة على رئاسة إحدى جلسات المؤتمر وكانت

الجلسة هي الجلسة الثانية في يوم ٢٧-١٠-٢٠١٠ في محور التصميم من أجل الاستدامة و إعادة الاعمار والتي القي فيها عشرة بحوث

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عقد المؤتمر في مدينة سانت آندير شمال اسبانيا وهي مدينة ساحلية في منتهى الجمال في قاعة المؤتمرات للموقع الملكي لي ماكدالينا حيث كانت الجلسات معقودة في خمس قاعات

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١- تم في الجلسة الأولى في القاعة الأولى افتتاح البحوث ببحث الدكتور مقداد الجوادي الموسوم: Model of House Design Responsive to Hot Dry Climate
وقد نال إعجابا ونقاشا وبعد المؤتمر اتصلت بالدكتور مقداد الجوادي المجلة الأميركية للهندسة المدنية والمعمارية (Journal of Civil Engineering and Architecture) طالبة موافقته على نشر البحث في مجلتها وعارضة عليه ان يكون في لجنة تحرير المجلة او لجنة تقويم البحوث (كما في الرسالة أدناه)

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From Knowledge to Wisdom

Journal of Civil Engineering and Architecture, USA

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This is **Journal of Civil Engineering and Architecture**(ISSN1934-7359), a professional journal published across the United States by David Publishing Company, Chicago, IL, USA. We have learned your paper ***MODEL OF HOUSE DESIGN RESPONSIVE TO HOT-DRY CLIMATE*** in **37th IAHS World Congress on Housing "DESIGN, TECHNOLOGY, REFURBISHMENT AND MANAGEMENT OF BUILDINGS".**
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٢- تم في الجلسة المسائية ليوم ٢٨-١٠-٢٠١٠ إلقاء البحث الثاني الموسوم
Domes and Their Impact on Thermal Environment Inside Buildings
وقد حضر في إلقاء البحث الثاني البروفسور اوكتاي يورال رئيس الجمعية الدولية لعلوم الاسكان حيث تم إلقاء البحث شفويا وليس قراءة مما جعل رئيس الجمعية الدولية أن يشيد بالبحث وبمستواه معتبرا إياه نموذجا لمستوى البحوث التي تم اختيارها للالقاء في المؤتمر كما ورحب بمشاركة الدكتور الجوادي (عضو الجمعية الدولية لعلوم الإسكان) بعد غياب عن نشاط الجمعية منذ أكثر من عشرين عاما

٣-تِرأس الأستاذ الدكتور مقداد الجوادي الجلسة الثانية في يوم ٢٧-١٠-٢٠١٠ في محور التصميم من أجل الاستدامة و إعادة الاعمار والتي القي فيها عشرة بحوث

__الشهادات التقديرية للمؤتمر__
منح الأستاذ الدكتور مقداد الجوادي شهادتين تقديرية عن البحوث التي قدمها في المؤتمر والمرفق صور لها في أدناه

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The Organization of the **37º IAHS World Congress on Housing Science**, co-organized by the International Association for Housing Science (IAHS), Florida International University, USA, and the University of Cantabria (UC), Spain, which took place in Santander, Spain, 26-29 October 2010.**CERTIFIES THAT** the Paper:

"MODEL OF HOUSE DESIGN RESPONSIVE TO HOT-DRY CLIMATE"

by:

Miqdad Haidar Al-Jawadi

Was presented and included in the Congress documentation

Oktay Ural

Prof. Oktay Ural
President of the International Association for Housing Science (IAHS)

Prof. Luis Villegas
Full Professor, University of Cantabria
Director of the 37º IAHS World Congress on Housing

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"DOMES AND THEIR IMPACT ON THERMAL ENVIRONMENT INSIDE BUILDINGS"

by:

Miqdad Haidar Al-Jawadi; Jamal AbdulWahid Al-Sudany

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<u>وقائع المؤتمر</u>

نرفق لكم ضمن هذا القرص بحوث المؤتمر متمنيا أن تقوم وزارة التعليم العالي والبحث العلمي العراقية باستنساخ هذا القرص وتوزيعه على مكتبات الجامعات التي فيها أقسام معمارية ومدنية

الأستاذ الدكتور مقداد حيدر الجوادي
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البحـــــــث ألاول

Model of House Design responsive to Hot-Dry Climate

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Dept. of Architecture-University of Technology
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Key words: climatic Design, sustainable design, courtyards, wind catchers

ABSTRACT

The presented model here represents one of a series of our applied research, aimed at providing easy and very simple design formulation to be a model for architects to illustrate to them the possibility of linking results of applied research with aesthetic and occupation human needs if adopted in large housing projects to be harmonious with our climate and environment.

This model won a prize of the Iraqi Energy Consultative Committee in a competition for the best environmental design, and in retrospect evaluation after implementation, thermal, economical, and utilization measurements were performed on the model 20 years after its construction. The results were in agreement with initial design expectations, to verify the success of the bases on which the model was designed.

The design style for this model was applied on a 2-storey house, construction area 380 m^2, land plot area 288 m^2, with eastern frontage. The house consists of 5 bed-rooms, reception, living area, office, kitchen, store-room, 4 bathrooms, and interior garden, proved that:

1- The internal temperatures for most days of the year were within thermal comfort limits for dry-hot climate areas;

2- During summer days, use of low-load air-conditioning appliances is sufficient to bring the house temperature to thermal comfort limits;

3- Day-time, since sunrise, the house enjoyed good natural lighting for most rooms;

4- With the introduction of more advanced wind catchers than traditional ones, the design provided natural air circulation, to cool people and building day- and night-time during temperate months, and provided cooling for the night, and early hours of the morning during summer-time;

5- The design facilitated interior space (garden) of temperate temperature during summer and winter, where summer temperature was nearly 13 degrees less than for the outer garden;

6- Electrical power consumption for lighting, heating and cooling about 7500 Kilo-Watt for one year.

Introduction

Great number of architects talks about traditional buildings and how they provided environment suitable for people daily needs in all aspects, including thermal ones. They declared their views to utilize the heritage vocabulary features in present buildings. The performance of the majority in current designs does not meet users needs, the reason, for what we believe in, is that these features in their old formulation were efficient within man's comfort limits, when fans, conditioners and electricity were not available.

For our conviction, the knowledge of the scientific basics of features enables us to develop these vocabularies, and utilize them in our current designs so as to affect current architecture to become thermally responsive.

From the start of the 70's, we have drawn a research plan to lead us connectively to indicators and bases that help architects in designing environment – responding buildings accordance with man's current comfort levels. After more than 15 years of connected research and studies, a house model was designed and built on 288m^2 plot, on which thermal measurements were performed. The results were submitted to a competition organized by the Iraqi Energy Consulting Committee. The design won the competition as the best environmental design in 1992, and was shown three times on Iraq Television during "Science for All" program. During the use of the house, several thermal and usage measurements were performed, and number of houses were designed on the its scientific bases.
After 20 years of the success of experimental experience, new scientific measurement were made, which verified the sound scientific efficiency of the designs used model.

General Description
1-A house built on 288m^2 plot of pant of dimension (12m × 24m) .(Fig. 1)
2- Ground floor area is 180m^2, and 180m^2 for first floor. Both floors include 5 bedrooms, visitors' room, living room, office, a large kitchen and several bathrooms. The house is designed closed to the outside with small windows on the façade while large windows are open onto a courtyard of area about 20m^2, and has two wind catchers, the area of each is about 3m^2. The house has, an outside garden and garage of about 60m^2 (Fig. 2&3),
3- 25cm thick walls were built with Thermostone blocks, whose thermal insulation is 0.2W/mk^o (twice the insulation of ordinary building material), and used structurally as bearing walls.
4- The roofs were built of reinforced concrete 15cm in thickness, covered with waterproofing material layer: 5cm polystyrene, 10cm river sand, and 4cm concrete tiles, (U-value 0.364W/m^{2}k^0)[1].

Broad line Environmental Vocabulary of Designs
1- Benefiting from the concept of adjacent in heritage houses, construction was adopted in our model to be on the outer perimeter of the land plot, to be adjacent to the neighboring ones, which will shield the outer walls from exposure to solar energy and outer hot air. on this basis the house wall will be considered as if it is an inner wall within the unit compound and the houses group as if it is one house, one shields the other from three directions. Thermal conduction along the houses' ground floors will result in thermal equilibrium [2].
2-Use of courtyard, 75% of its ground is laid by porous bricks making the floor a cold pool. Since the courtyard in to vertical section contains protrusions (Fig 3) the walls will be shadowed summer time. The incident sun rays on balcony tiles, which shadow the ground floor of the space will force the hot air above the pathways move within the area between the first floor and the air above making the temperature at the near side of the floor inside to remain at low temperature.
3-The courtyard walls in all directions are elevated to ceiling level (fig.3) which makes air motion within the courtyard weak. The courtyard then maintains low temperature day time, when wind catchers and windows are kept closed.
4-The use of creeping plants and low –condensed indoor plants (fig.4), effectively shadowed the walls from sun rays, keeping walls temperature near the plant's temperature, which lower than that of human body. The adoption of low concentration planting reduces the relative humidity below 40%, resulting in comfortable state. (No water fountains were used to elevate the relative humidity).
5-Adoption of large wind catchers above the house ceiling connected to rooms overlooking the inner garden or connected to windows over looking the outer garden results in bringing air of lower dust and heat percentage than coming from the road, whose temperature is higher due to its contact with black roads of high heat storage and heat – storing outer walls, with the air – borne dust raised by cars, especially in dry hot weather, where streets are force of rising dust. The air coming from large wind catchers means that the high pressure of the incoming air column from the wind catchers will cause air motion that will yield a feeling of an effective

temperature lower than that of true reading of the thermometer [3]. Also if its path on exit is through windows overlooking the outer garden, it will force the outer hot air in the street out of the house.

6-Adoption of Sun breaker made of bricks (fig. 5) as part of the architectural facade of the building has shading efficiency greater than 80% summer time and shading efficiency 30% winter time, this will result in low summer thermal load, and raise natural heating winter time.

7-Placing the windows at the inner edges of the walls thickness to raise their thermal performance [4] and air – capture efficiency, whenever air pressure is positive on the windows and increase evacuation when the window serves negative pressure.

8-Use of insulating building materials, with Time lag between 17 to 12 hours (Thermo-stone Walls) [1], which helps in effecting night – time air cooling of air coming from wind catchers. The cooling is for inner building shell when heat reaches it after 12 hours.

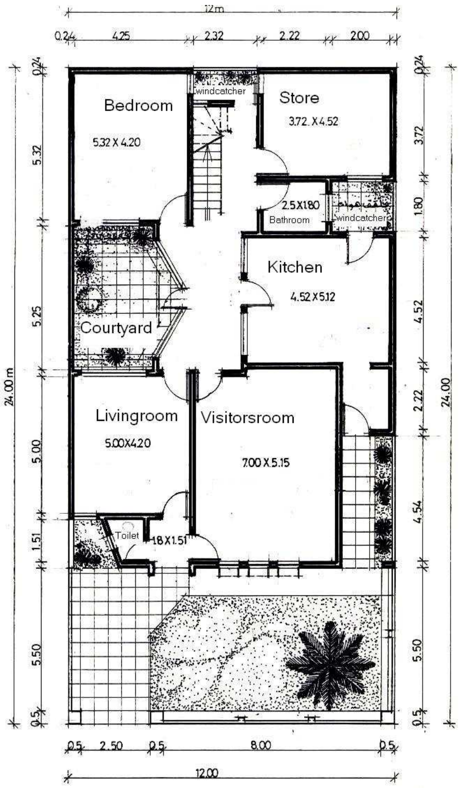


Fig-1 Façade of the model design – Baghdad - Iraq

Fig-2 ground floor plan

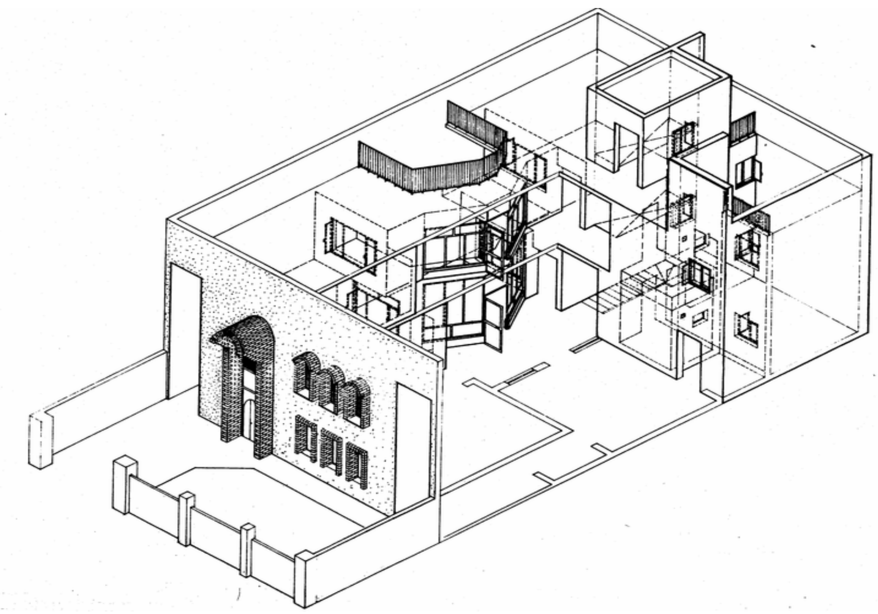
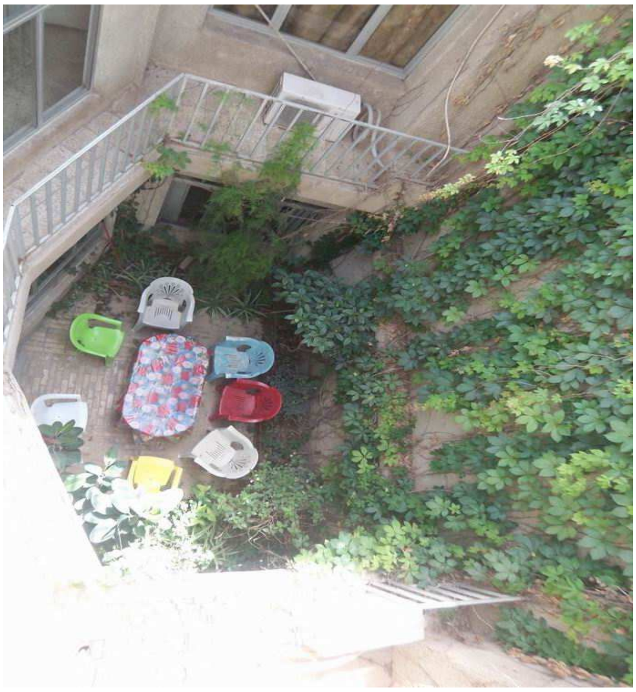


Fig -3 Isometric of the Model Design

9-Use of small external windows, at 10% of floor area or 24% of the outer wall area shadowed by sun and rain protection projections as to the windows overlooking the inner garden, and glazed areas shadowed by sun and rain protection projection, which represent 87% to 55% of vertical walls.
10-Good winter sun was provided for rooms overlooking the exterior via vertical windows enabling sun rays entry to 15m inside the house (Fig 6). As to summer, the sun rays enter to less than 1m inside, and for short periods. The winter sun was made to reach the west – facing rooms on ground floor and overloading the courtyard by the property of reflecting sun rays from 10mm glass in the first – floor. Although this Sunning is not sufficient it provides the inhabitant with feeling of warmth, and the pleasure of enjoying the sight of winter sun. The percentage of rays entering was 20% of its original energy.

Visual Aspects
Normally it is said that environment – compliant buildings are poor aesthetically. On this basis, attention to visual vocabulary of the model was given, including optical illusion in enlarging the



space
Fig -4 creeping plants shading courtyard walls Fig -5 fine Asparagus plants

area and feeling of openness. The inner spaces were to be connected with the inner garden by large windows, effecting illumination of inner of about 1:15 of the illumination of inner garden. Such percentage gives the observer feeling of visual comfort, with no stress to connect the inner space with garden as if it is one part of it (fig.7). Therefore, whenever one enters a space of spaces overlooking inner garden adds the garden area to that of the room, giving the feeling that the building area is much bigger than the true area. However, if we use big windows in the spaces overlooking the exterior, it would give smallness to these rooms, because they create optical rebound for the eye as a result of quantity if intense light coming from the outer space, which causes a feeling of withdrawing the wall containing the window to the inside which causes a feeling of shortening the length of room (since the outside rays even in the winter is greater 100 times that of illumination of room illumination) [5].

Fig -6 winter sun patch in visitors room

Fig -7 Sun breaker made of bricks

Fig-8: Optical illusion in enlarging the space area and feeling of openness.

Advanced Design Vocabulary Implemented in the Design

Wind catchers

Wind catchers in heritage architecture are air passages in the residence walls whose horizontal cross – section is not greater than 20cm × 100cm, ending in an opening inside the rooms, for which the mason gives his best to beatify it. The air duct cross section area does not exceed, at best, 0.2m^2, whose majority were around 0.1m^2. Due to the narrow opening, the mason around cannot plane and polish its inner walls, consequently it become a haven for ants and insects, and the wandering of rats between houses in view of its darkness. The majority of house wall are damp due to the influence of ground water, which cools the passing air through the wind catchers slightly as a result of evaporation (this what the author has experienced in 1950). The quantity of air delivered was very small, for which it was finally closed after the author's father bought an electric fan.

The principle of air exchange is considered the best hygienic treatments, and the principle of obtaining air motion is considered an important principle that signals the person of temperature reduction despite higher than comfort limits [6] , what is called "Effective Temperature", which varies in feeling with velocity increase of air passing over the living bodies. On this basis, our under standing made us think of the importance of adopting natural ventilation, and the development of this vocabulary. We have innovated a new type wind catchers whose cross – section area is not less than 2m^2, two sides of which are 3 meters higher than house roof, which face the common Baghdad air.

This wind catchers opens on rooms overlooking the inner garden or outer garden, which cause the air to impinge on the two high walls to drop into the wind catchers. Also; its impact on the

two high walls causes negative pressure behind the walls, that is above the inner garden which increase the speed of air motion inside the rooms as a result of difference in height in the air column inside the wind catchers and inner garden, which is lower by 3 meters, and due to the development low pressure above the garden as a result of its impact on the wind catchers wall. (Fig9)

The speed of the air coming through the windows overlooking the wind catchers, whose area is $0.5m^2$, increases the speed of air flow inside the spaces to the extent that a person sleeping in a bedroom is compelled to place cover on the body. No air cooling equipment were used during the last 20 years in the main bedroom, but were forced to install air – cooling equipment during the last three years because of the dusty climate occurring in Iraq during the last 3 years as a result of gross rain shortage which prevented us from using the wind catchers on some days.

The Courtyard

The inner courtyard or past inner garden used to be passage, about which room doors and their inner walls overlooked it.

The hot and cold, rain and dust whenever they occur used to affect the rooms overlooking and individuals moving about inside house. When European architecture was transported, that was publicized by architects graduated from European countries, people departed from the inner – courtyard – based designs completely.

Our convention that inner courtyard is a delight to the eye and sound social connection, we have developed the courtyard to as to be used as isolated of climatic changer, a beautiful vision connector, family gathering site, and an air – exchange center.

We know the provision of clean natural air replacing of the fumigation of inner spaces, even on lower sunning, which people like to reduce during the summer in dry hot climates.

Then development then came by glazing one of the main walls overlooking the interior to the level of ceiling to retain the feeling of openness and visual comfort (fig.10). It is of importance to mention here, it is not permitted to cover the courtyard with glass ceiling, because it becomes a thermal store and causing lower air motion, thus stopping the function of wind catchers.

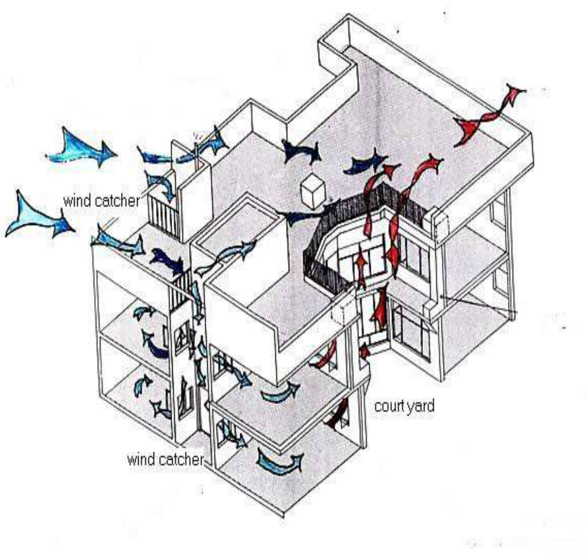


Fig -9 Air distribution by using wind catchers   Fig -10 glazing one wall overlooking the interior

Thermal Measurements

In order to integrate the design from thermal point of view, several treatments were adopted, such as by contact with adjacent houses, use of Thermostone walls, ceiling isolations, use of wind catchers to cool rooms and inner shell of the house at night, adoption of the principle of inner courtyard stepped in its vertical section, use of porous materials for flooring, adoption of creeping plants in the inner courtyard and non – dense plants, and use of sun protectors on the

outer openings. Consequently, this resulted in temperature inside it, as indicated in the August data (where August is considered in Iraq as the highest temperatures), as seen in Table (1). Fig (11) indicates near or within human-comfort limits for hot dry places, which changes sensibly to an effective temperature (lower temperatures when motion of incoming air from wind catchers occurs or even use ceiling fans). In August 2008 thermal measurements showed that monthly average, maximum, minimum and range are almost similar to those taken in August 1988.

Table 1: showing average Air Temperature during August 1988 for different spaces outside and inside the house, knowing that one (250 Watt) evaporative air cooler were used in each floor

Space	Roof	External Garden	Courtyard	Bedroom Ground floor	Visitors room	Living room	Bedroom First Floor	Office first floor
Temperature Max. C°	43.0	43.0	30.5	28 .0	28.0	28.0	30.5	31.0
Temperature Min. C°	30.0	30.0	27.0	22.0	22.0	22.0	25.0	25.0

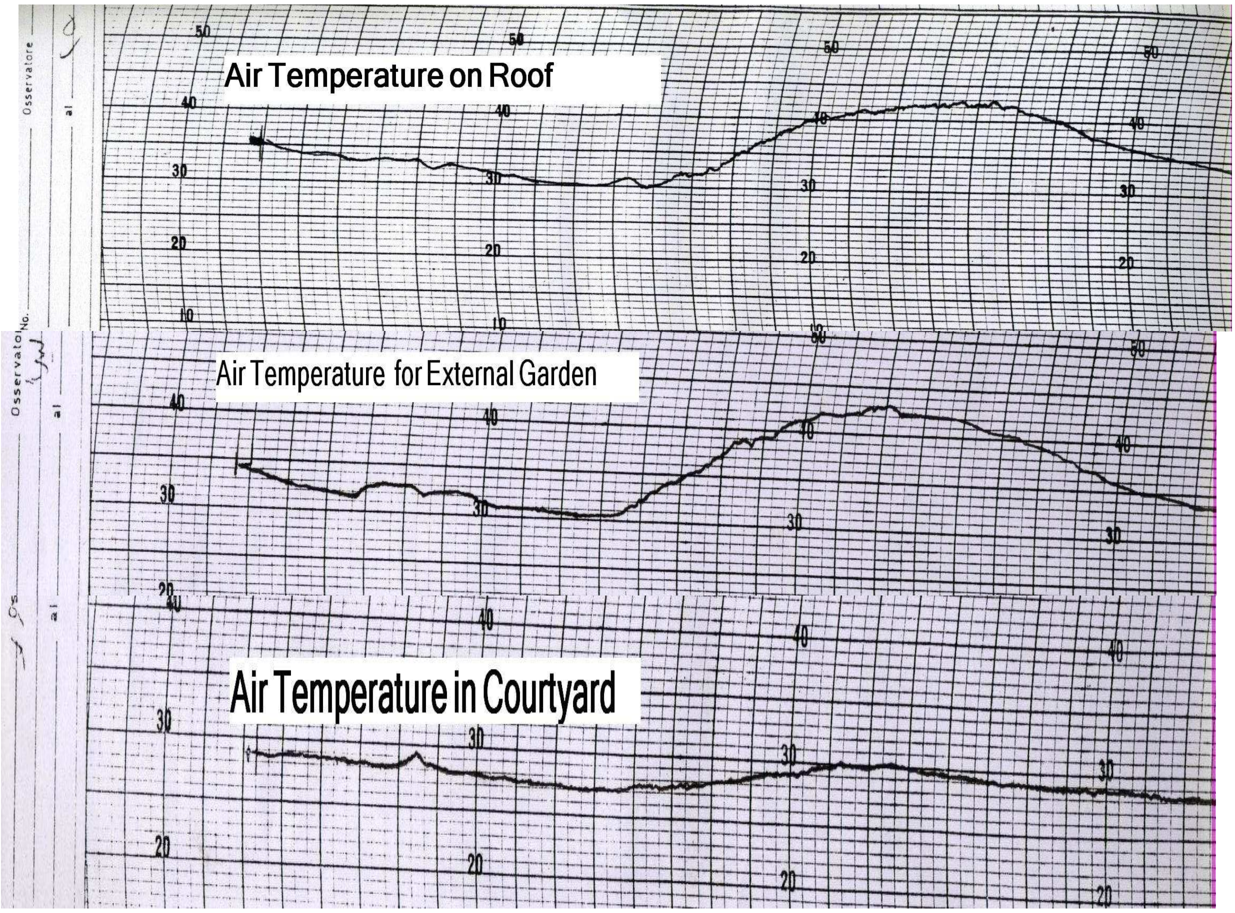


Fig- 11 Comparison between courtyard air temperature and ambient air temperature on 27th of August

This in its entirety proved how sound the design is in being responsive to climate. The other thing proving that the design model is responsive to the climate is the electricity bills for the two years (**from 17-7-1988 to 21-6-1990**) amounted to 15000 KW (Fig12), which means the building was not dependent in its cooling and heating on high electric power.
What can prove the success of realizing thermally-comfortable buildings by using of developed heritage vocabulary as in our model and the adoption of corrective treatments, is in the excellent growth of indoor plants in the inner garden (Fig.4&5), especially the fine Asparagus, the height of which reached 7 meters. It is conclude from the aforementioned, it is possible to adopt and utilize developed heritage vocabulary, the adoption of natural treatments, and utilizing visual environmental vocabulary to realize climate – responsive and beautiful designs

Fig-12showing from electricity bill the amount of electricity (from 17-7-1988 to 21-6-1990) 15000KW

Conclusions

Attached houses and inward looking design strategy provide protection from high summer solar energy, and work together with the use of thermal insulation block walls (Thermostone) in lowering air temperature and decreasing the daily temperature oscillation inside house spaces. The use of large and improved wind catchers in conjunction with courtyard reduces the need for reliance on air cooling and air moving-equipments day and night for long periods of the year, and achieving the benefit of cooling buildings' inner skin and human body during moderate summer nights. Moreover, wind catchers help in achieving excellent natural ventilation, keeping air in the building fresh and make living conditions inside healthier, even in the occurrence of lack of insulation.

The integrated gathering of climatic and architectural design vocabulary and the use of plants, with the use of some improved heritage vocabulary could assist designers in reducing dependency on polluted energy and make the house nearly self dependent on creating comfortable environment,

Openness of rooms with moderate lighting intensity inner garden has a great psychological effect on increasing room sizes visually, feeling of openness, and providing relaxing and comfortable place for family.

References

[1] the Iraqi Energy Consulting Committee," Thermal Insulation Hand book, Baghdad, Iraq, 2002

[2] Markus,T. & Morris,E. "Building Climate And Energy", Pitman Publishing Limited, London, 1980

[3] Boutet, Terry "Controlling Air Movements" McGraw-Hill Book, USA, 1987

[4] Al-Jawadi, Miqdad, et al,
The Effect of Window Position Inside Wall Thickness on Direct Sunlight Control in Building for ad –IraqHot Regions in Iraq" Journal of Universities Arab Union, Vol.8, No. 2, 2001 Baghd

[5] Carterette, Edward, & Friedman, Morton "Perception of Space & Motion" Academic Press, New York, 1995

[6] Shaban, A.C. & Al-Jawadi, Miqdad. "Analysis of Climate of Iraq and Its Impact on Buildings" Building Research Centre, Baghdad, Iraq, 1973.

البحـــــــث ألثــــــاني

Domes and their Impact on Thermal Environment inside Buildings

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ABSTRACT

Research and scientific studies over more than thirty years have concentrated on the subject of less dependency on polluting power, realizing thermal comfort inside buildings, and inviting declaration for dependence on natural solutions and benefiting from previous experiences.

The impetus to the rising attention is the drive to adopt the domed roofs, which were previously used by pioneers in buildings as one of several environmental solutions for warm regions. These declarations raised questions, which could not find easy solutions. The questions included:

a- Doesn't the use of dome increases roof surface area for increased thermal exchange?

b-Doesn't the use of dome means the increase the inner space volume, which requires more air-conditioning appliances?

c-Dose Part of the dome, exposure to direct solar energy, and the occurrence of differences in temperature will result in air movement around the dome, driving the heat further, consequently being better than flat roofs?.

d-Which of the two techniques is better in realizing thermal comfort and cost-effectiveness, regarding power expenses?

This paper is aimed at disclosing the dome's thermal performance and to provide answers to the questions raised about it. It is also intended to concentrate on the dome's thermal behavior by adopting mathematical technique supported by experimental measurements on single domed building and identical flat-roof building.

Mathematically, the computer energy simulation package (Ecotect), special for thermal performance evaluation of buildings was used. The results were compared with experimental results on single domed building and identical flat-roof building, tabulated, and diagrams.

The final results arrived at the dome-system works to lower temperature by about (2 – 6) ^{o}C on average, and aids in reaching thermal balance summertime. In winter, however, thermal losses from dome-roof are greater than those from flat-roof.

Introduction

Domed roofs were used at the start of their appearance as means of obtaining roofs for wide spaces, and whose advantages emerged in past erase when no air conditioner, coolers, ceiling fans, and even electric powers was not available. It is useful pushing hot air during summer, generate by man and cooking utensils, away from human motion level, the heavy cold air near the room's floor, and remains close to peoples motion and seating, while the hot at the higher regions of spaces constrained to domed part.

The part contains small opening to allow hot – air passage in the summer, and collects all the smoked resulting, from burning wood and coal, used for cooking and heating. The smoke is gathered within the domed part with no random motion within the space of the flat ceiling.

Advocated of heritage architecture revival exchanged a great deal of talk about the importance of adopting and utilizing heritage vocabulary, including the domed and introducing them as architecture features in current designs. This is so without taking into consideration the change

in the limits of current human thermal comfort, who is uses air – cooling equipment which change summer and winter to spring atmosphere, and simulated in its performance the thermal comfort limits of the current individual.
In the light of considering the importance of using domes in architecture, as a climatic tool a symposium was organized in Baghdad in the late 80's but could not give a convincing scientific answer about domed roofs from the thermal point of view.
After the provision of the scientific facilities in designing computer programs, which may be used in simulation different construction aspects.
In addition to that a provision of two buildings in Baghdad, similar in design, the first the domed space in the guest room exactly, the other, its dome had been removed completely, but in its place, a flat roof was its replacement which triggered our interest to undertake this work that gives a clear picture regarding the performance of domes summer and winter times, which would provide benefit to those working in architecture.

Thermal Comfort and Design Treatments

Man's body adopts itself to its surroundings in many aspects including thermal aspect.
People before the availability of electricity and fans were handling hot weather in a nature manner.
They were innovating solutions to get near thermal comfort of their bodies, and when electricity and fan were made available, the individual got very near to thermal comfort limits. But, once the evaporation coolers appeared, the feeling of users concerning the old thermal comfort limits changed, and started narrowing these limits. Until air – conditioners appeared, where acceptable thermal comfort limits became very distant from comfort limits, interacting with prior to the days of electricity, thus climatic treatments and design vocabulary that were considered a climatic solution in our heritage architecture to approach the thermal comfort limits before the advent of electricity, became imperative to revise its natural content and analyze it again on scientific bases which should realize thermal comfort limits for the current individual, and take what can be transported, and modify what needs modification to benefit from our fore fathers to suit this era's needs especially for the dry hot regions, as most of Iraq regions.

Properties of dry hot climate (Baghdad City)

The majority of parts of Iraq have dry hot climate, represented by Iraq's capitol (Baghdad located 33.3° longitude north and 44.4° longitude characterized by clear skies, where the annual brightness hours is 3224 hours, distributed as 12.3 hours summer time brightness, with a daily average of solar radiation intensity of 7.3KW/m^2 which reaches midday in summer (July) to 950W/m^2, and approximately 500W/m^2 midday in January. [1}
From the analysis of climate of Iraq [2] (Baghdad) it is found the average hot and temperate period is about 8 months, and the average cold months is 4 month. The designer has to take this into consideration, innovating and using new technical means in construction and make use of heritage solution to be developed so that the designed buildings are simulate for such climate, with least use of artificial means that are atmosphere polluting.

Architectural Treatments

Architects interested in providing thermal comfort to housing users attempt to innovate new methods or use models or transfer heritage features of buildings. The transfer may not be successful unless scientific bases of surrounding environment are studied successfully for that items or model. Among those are the domed roofs.
The ongoing talk about domed roofs attracted the attention and curiosity of those interested in architecture; a symposium in the late 80's was organized to discuss the positive aspects of using

domes, but the symposium couldn't provide the answer to the various questions raised, since most of the research was descriptive, romantic, and heritage reminiscent.

Queries about Domed Roofs

Quires approached among architects about the environmental – climatic effects of domes, many aired their views about undertaking real research to reply to the following queries:
1-Won't the use of domed roofs increase surface area of the roof, which will increase thermal exchange.
2-Won't the use of domed – roofs increase the volume of the inner space, which will need extra air conditioning equipment.
3-Will the exposure of part of the dome to direct solar energy and occurrence of the temperature difference in dome surface will initiate air motion around the dome, pulling the heat away, butter than flat roofs.
4-Which of the two methods is better generally from incident solar energy, provision of thermal comfort, and expenses saving on energy.
To answer these queries, researchers found that exact calculation must be made and design an efficient computer program capable of giving numerical answer that will guide architect to sufficient answer to their queries, by considering the computer program as the reference of reliable result.
By chance, we found two identically – designed housed belonging to a government publishing agency, where the guest room had dome – shaped roof. The domed roof was removed in one of the houses and replace by flat – roof (Fig.1&2).
The establishment agreed to our request to performed thermal measurements, installing thermal sensors stuck to the dome and flat roof, for the sake of our work during summer and winter, and comparing the result obtained from the computed program to be used with other dome shapes to suggest comprehensive advice (Fig.3)

Fig (1) Showing The flat slab in second house used in case study
See measuring wind speed by hot wire anemometer

Fig (2) Showing The dome in The house used in case study

Computer Program

In order to perform calculations to distinguish between the domed – roof and flat surface, it was necessary to design a computer program to calculate solar energy on current and arch shapes to obtain the total energy incident on these shapes and integrated the total according to solar radiation incident angle on the domed surfaces [3].
The program is provided by the averages or simultaneous hour measurement of the required day with hour measurement of temperature of the external air at that day to determine the total quantity of heat the dome will allow to transfer into the inner space according to building materials used in dome construction, and compare it with the energy transported by the flat roof whose area is equal to dome – base area.

At a later stage, a trial version of the program Ecotect [4] was used to compare the experimental results performed on domed and flat roofs of two similar houses in their ground layout guest room, one with flat roof and other with domed roof. The benefit of the program was to know the difference in temperature occurring in the experimental measurement for the dome model, and the computer results to benefit from the program in difference that occur in temperature when different dome models are studied.

Experimental Measurements

Five Thermal sensors were stuck in the location shown in fig.3 inside the dome roof and flat roof, with another sensor installed in Stephenson screen outside the house, measurements were taken for number of cold and hot days during January and July (thermal measurements were re-taken a year after using infrared thermometer for comparison Fig (4). The comparison showed slight difference) .

In order to calculate the thermal resistance of the flat and doomed roofs, hot wire anemometer where used to measure wind speed in (2 cm.) near the flat and doomed roof surface. Fig (1&5), knowing that average difference between measured wind speed on domed roof is twice of that on flat roof

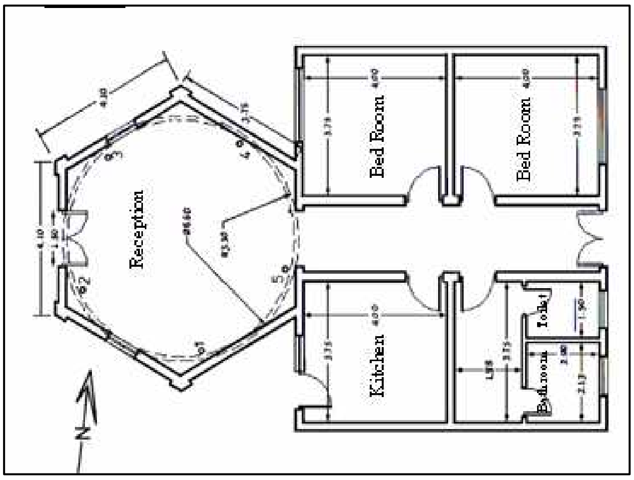


Fig (3) Ground plan for the house used in case study

Fig(4) Thermal measurements using infrared thermometer

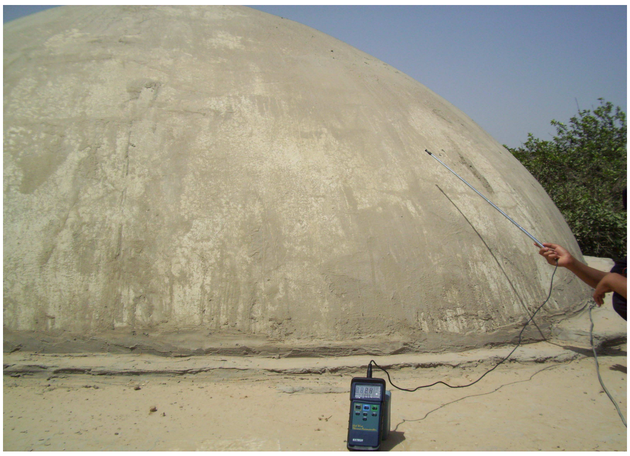
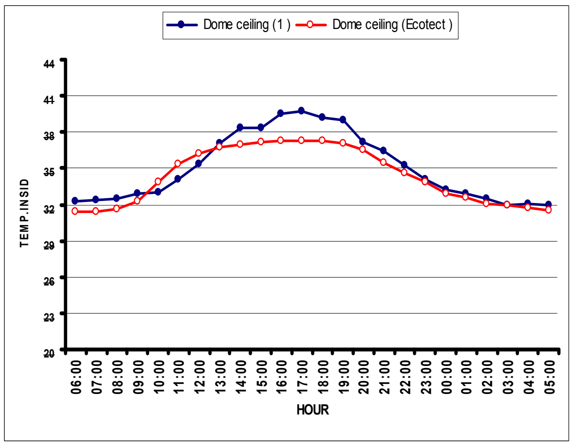


Fig (5) measuring wind speed by hot wire anemometer



Fig(6)The difference between measured temperature and computed temperature (by Ecotect) for domed roof (date 8-7-2006)

Results were compared with the results derived from the trial Ecotec program, and results were about 95% close, which gave us simulate other types of dome by the program to arrive at general recommendations, covering domed – roof of all types (Fig 6) ,

Solar Energy and heat transmission Comparison for Dome Types and Flat Roof

In order to perform sound comparisons, dome – base radius of 6.6m was adopted, since this number is similar to that of the dome on which experimental thermal measurements were made, then from review of heritage buildings, 4 shapes of domes were determined common – types (Fig.7). Studies were performed on these types, whose results are to be adopted to give due recommendations.
The results were found according to the follows:

1-The hourly amount of energy received by each type, as direct solar energy, and scattered radiation energy as a daily average for July and daily average for December for four types of dome roofs and flat roof.

2-The amount of energy and heat transferred according to dome building materials and those of flat roof since the building materials for flat roof, acceptable in Iraq is concrete material, while building material for domes is generally brick.

3-The effect of ventilation openings at the base of the dome on final temperature of dome – roof.

Results

1-Quantity of total solar energy utilized by each type
Result showed that flat – roof receives solar energy less than other types of dome summer and winter (Table-1)

2-Quantity of transported energy according to dome building materials and those of flat – roof.
Since the building materials of domes in Baghdad is brick of thickness 0.24 coated with humidity prevented and protective layer of cement, which gives gross coefficient energy transfer whose value is U_{value} – 1.28W/$m^{2°}$c.
The flat – roof material is concert with preventive on top of which concrete tiles of gross coefficient of energy transfer whose value U_{value} = 1.88W/ $m^{2°}$c.[5].
From this it can be said thermal transfer in dome – roof is better than thermal transfer in flat – roof due to difference of type of building material which may be adopted in domed – roofs, which is difficult to adopt in flat – roofs because thermal loss is worse than flat roof

3-Practical Measurements of Temperature on Inner surface.
The dome – roofs in practical measurements in the specimens containing thermal sensors on roofs gave temperatures lower than temperatures of flat – roofs in summer (Fig.8) and temperature lower in winter which indicates that domes have positive effect in summer in reducing inner temperature and very bad winter due to thermal loss caused by its surface area. We believe the main reason is due to difference in gross coefficient of heat transfer of dome building material and building material of upper flat – roof in conduction.
But what is felt is that air flow outside the dome had an effect of pulling a quantity of accumulated heat on dome wall more than from flat – roof. Unfortunately the tested dome has no opening near its base to help in studying the effect of air ventilation experimentally. Ventilation effect will be studied through computer thermal simulation programs.

4-Effect of Ventilation Opening at the base of dome on final temperature of roof.
By adopting very small opening in the dome – base during summer ensuring two air change per hour for the air gathered within the dome, the gross heat transfer will make the dome system better than flat – roofs for summer thermal performance (Table1).

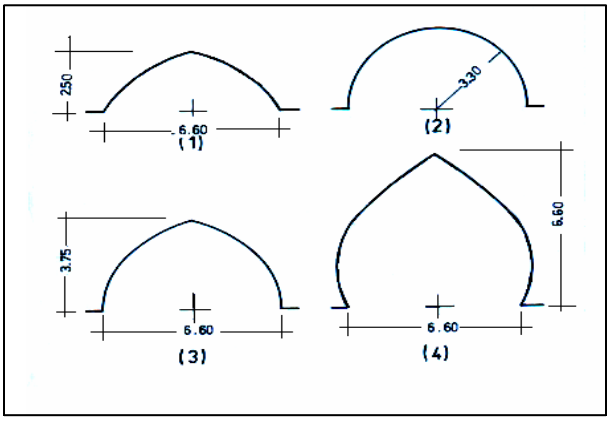


Fig (7) The common type of domes used in Iraq

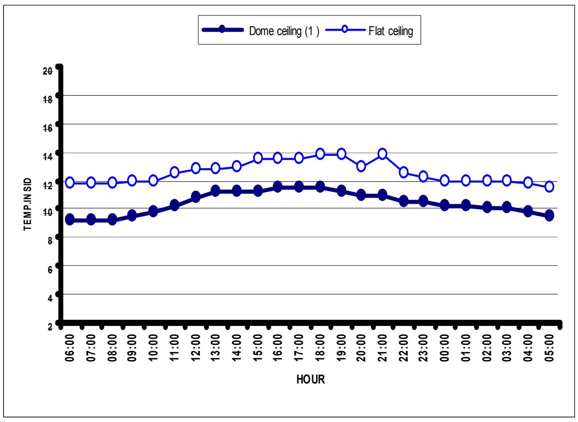


Fig (8) Showing the difference in internal roof temperature for domed and flat roofs (date 7-8-2006)

ECOTECT Computer Thermal Simulation

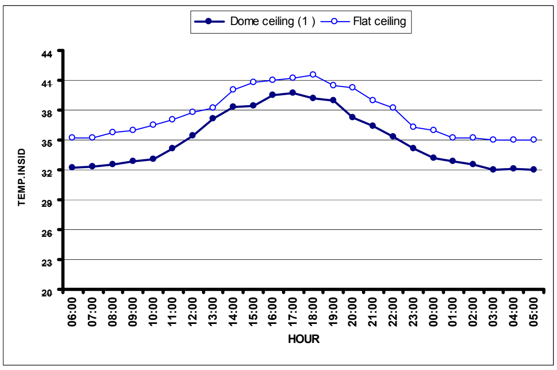
_Results from ECOTECT showed that the 4 types of domes (Fig. 7) are better in Summer Thermal performance than flat roofs (Fig.9), and showed that the shape No. 1 has the best performance than the others, and showed that the third shape is better than No. 2, and the worse is No. 4The final results arrived at the dome-system works to lower temperature by about (2 – 6) ^{o}C on average, and aids in reaching thermal balance summertime. In winter, however, thermal losses from dome-roof are greater than those from flat-roof

Table (1) Amount of Solar Energy(watt)falling on the domed roofs and flat slab during , July &January

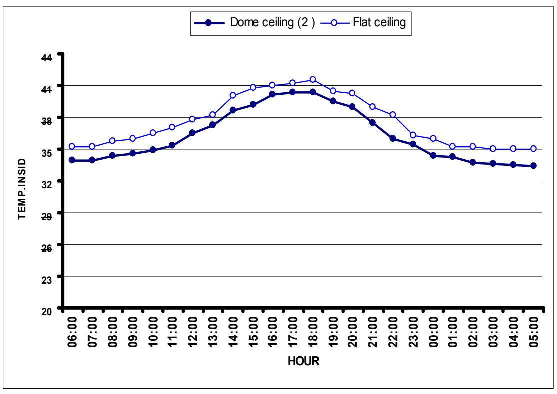
	Sample (1)	Sample (2)	Sample (3)	Sample (4)	flat slab
Summer	273174.72	317514.4	300737.05	465849.59	261062.05
Winter	87178.372	115749.79)	105477.67	186284.77	74367.13

Table(2) The effect of movements on removing heat energy for four dome shapes

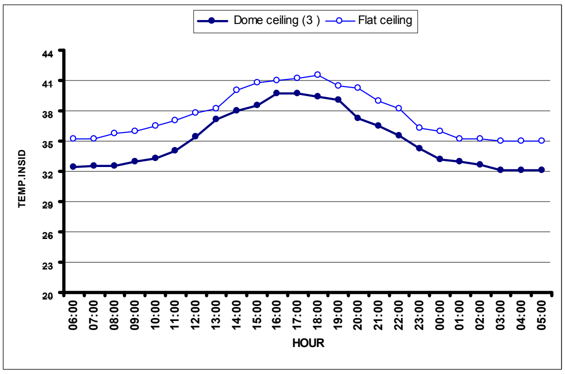
Dome shape	Energy transferred	Energy removed by Ventilation	The net energy transferred
Sample (1)	691.573	210.226	410.347
Sample (2)	913.704	228.753	684.951
Sample (3)	837.605	384.612	452.993
Sample (4)	1227.141	531.790	695.351



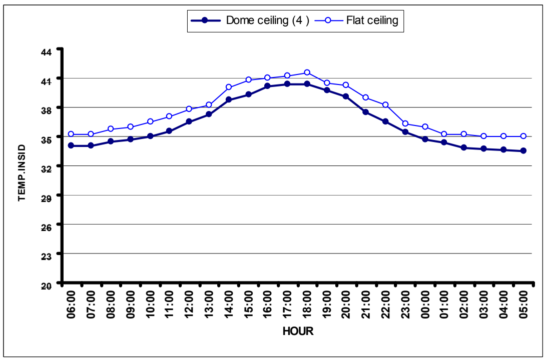
DOME No. 1



DOME No. 2



DOME No. 3



DOME No. 4

Fig (9) Showing the difference in internal roof temperature for domed and flat roofs (date to 7-8-2006)

Conclusions

1. The numerical comparison between dome – roofs and flat – roofs as absolute energy loads, without taking into account air motion and without taking the difference in the building materials of the dome and building of flat – roofs into consideration, make flat – roofs better than dome – roofs.

2- The passage of ambient air imposed on the building around the dome, one part of which protrude above the flat roof level resulted in pulling a quantity of accumulated heat on the dome surface without being exposed to sun radiation. The dome roof became, in all its types, better in summer than flat surface and increased its heat loss in winter.

3- The difference in temperature on dome surface due to difference in quantity of solar radiation incident on dome parts increases the air speed as a result of air pressure difference on the surfaces which increases the pull of heat accumulated on dome surface which increases its efficiency in summer and reduces it in winter.

4- The presence of small ventilation openings at the dome base to ensure two air change per hour for the air accumulated within the dome will increase the efficiency of the dome system as summer thermal performance.

References

[1] Iraqi Solar Energy Center " Unpublished solar energy data" ,Baghdad, 2002

[2] Shaban, A.C. & Al-Jawadi, Miqdad. "Analysis Of Climate Of Iraq and Its Impact on Buildings" Building Research Centre, Baghdad, Iraq, 1973

[3] Markus, T. A., & Morris, E. N., " Buildings, Climate And Energy", Pitman Press, L.T. D., 1980

[4] www.torrents.net/torrent/269050/**Autodesk-Ecotect**-Analys

[5] the Iraqi Energy Consulting Committee," Thermal Insulation Hand book, Baghdad ,Iraq, 2002

[6] Dawud ,Azhar J., " passive Approaches to Solar Architecture design Iraq" ,Thesis submitted for the degree of Master for university of sheffielde,1983.

[7] Halacy, Daniel, "UNDERSTANDING PASSIVE COOLING SYSTEMS", - VITA Publishing, Wilson Boulevard, USA, 1986

[8] Terry, S Boutet, "Controlling Air Movement", McGraw-Hill Book Company, USA 1987