



Improving Sustainability Concept in Developing Countries

How To Activate Courtyard in Buildings of Gridiron Planning Pattern to Be of Sustainable Thermal Comfort

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Abstract

Courtyard is a basic element in our traditional buildings. Thermal comfort is very important in courtyard, and without that people cannot use courtyard. In traditional buildings the problem of thermal comfort is solved according to the mechanism of the global planning of the tissue. Thermal comfort is the core of the process and one major issue of sustainability. The mechanism of making courtyard of thermal comfort in modern building of grid iron planning pattern is the research problem. Experiential methodology with theoretical analysis depended to reach that, courtyard can be activated and be of thermal comfort depending on many indicators of type of penetration, staggering position, enclosure and orientation as findings.

Key words: Courtyard, tradition, sustainability, Thermal comfort, hot dry zone

1. Introduction

The reduction of energy consumption through the world of sustainability is very important in many studies. Architecture is one of that fields in many attempts to be sustainable. In our traditional architecture of Arab region, courtyard helps the mechanism of environment according to many values, depending on the global town planning, form of alleys, the figuration of buildings, buildings sections, using of basements, and the existence of shifts, call (Badgairs). Many of these elements had been absent according to the modern life style and the challenges of technology, so the performance of courtyard as environmental system had been reduced.

The research concentrates on the activation of courtyard in modern architectural buildings in order to, response to the new life of town planning, buildings figurations, and modern streets planning, as a research problem, in order to make courtyards environmental active in hot dry regions. Acceptable thermal comfort can be gotten through courtyard depending on natural resources to preserve energy, according to many design values such as enclosure ratio, penetration, grain, and staggering as a research hypothesis.

Experimental work will be discussed through a sample of courtyard in modern building of grid iron planning pattern, by using environmental instruments to measure the activity of courtyard and the effect of its values to reduce energy and get thermal comfort in many months of a year, by adapting the natural resources of temperature, air movement (ventilation) and humidity as basic elements of the process.



1-1 Research problem

The research problem appears through the mechanism of courtyard ,as traditional elements to be active in modern architectural buildings .

1-2 Research methodology

An analytical approach assists with experimental work will be depended , through the basic elements of thermal comfort (temperature , humidity , and air movement)to measure Thermal performance, according to many samples of courtyard in modern buildings .

2. Conceptual frame work

Conceptual research framework extends through theoretical approach ,concentrates on many indicators and values related with the research problem, in order to build theoretical base.

2-1 Courtyard in the traditional buildings

(Charles , Correa , 1983), mentioned that courtyard is a pattern , that is to across a desert and enter a house around it and a pleasure beyond mere photogenic image making at. But is in understanding and using the past must never forget our new life conditions and the actual reality. We all have to see the past and its work. It is most vital. Architecture is an agent of change to invent tomorrow with new creation ,as the finest function. [1]. Moraes , K. & Guney,A, 2008, referred that precedents shapes are the reflection of the use of terminology , and introduced two accounts , the first refers to what is the transferred form into a target design, and how to use and adaptation of precedents in architectural design . On the other hand, how precedents are ideologically recollected in a modern technique of defamiliarizations which pays it. How architects and designers recollect their precedents in new one. [2] . According to (C, Gallo, M . Sala , A.M.M.Sayish, 1998) a traditional courtyard was surrounded by high narrow rooms , having large unglazed windows facing the courtyard. It is completely opened to sky, and some of them partially covered with overhangs and arches. They were of different size, depending on the climate and geography[3] . Osama , 2008, referred that Natural ventilation is used in hot dry zones , especially in Arab regions of Iraq and Arabia Saudi and the Arabia peninsula.[4]

2-1 -1 Courtyard mechanism to be as temperature organizing in tradition Architecture

Systematic mechanism governed the traditional urban tissue. Many researchers wrote about courtyard and its function. The research will concentrate its environmental effect on the building as a whole and the court yard spaces. (A.M.M.Sayish, 1998), mentioned that, courtyards are of different size, and shape , according to geographical zone and type of climate. In hot humid regions , they are large in order to provide good ventilation , but in hot ,dry and dust region they will be small in order to have protection against hot and undesirable wind.[4]

Sahir al-kaissi,1983 mentioned that courtyard in the traditional architecture is the basic element that governs the relation between building and its surroundings. The most important relation is with the alley , as environmental control and its formation according to its width and surrounding buildings , which always of two stories . The environmental mechanism has been affected by that duality according to positive and negative



values of the degree of sun exposing and air movement by pressure change. the relation also has been affected by many major elements , found in traditional architecture like (Badgair) and basement.[5]

Courtyard refers to private realm in the figuration of architecture and the global formation of the tissue of the tradition of the city. There is an important relation between the private realm and the public realm. According to(Fery, 1999), public realm refers to the city , which (Rob krier)called (Res publica) including all public monuments , halls , memorial and public works , the feature of the city , the urban components [6] ,according that there is separation and integration between the units components and the whole system , between the private realm and the public realm in the traditional city . Courtyard is a component in the unit figuration which affects the unit and the global system of the urban tissue.

According to,(Fery , 1999) ,towns and cities in the past developed incrementally without master plan and with very good results , when in 1950s and the 1960s grand – scale master plans developing things dramatically. [6]

2-1-2 The Act of activation in modern buildings of courtyard Pattern & Grains effect

Grain always refers to the relation between mass and space. According to (Ashihara, 1978), space and mass are of equipotentiality in their common relation , but when space penetrates mass , positive and negative values appear according to enclosing force between them [7]. (Alkaissi , 1983) , referred that the relation between the physical forms and their space appears according to equipotentiality of surface between mass and space . When the plane is smooth the relation between them weak and is of neutral condition. Any change in the surface form, which separates them will cause a type of grain, of energy creation. The values appear according to the gorgeous and recessed of the mass . According to (Alkaissi , 1983, p) the gorgeous elements be of positive value , and of negative space. [5] . Grain and the negative spaces will appear in the interfacing of figure and ground (figure / ground).

(Schulz , 1971) , mentioned that negative space is as a join , according to the degree of transparency and penetration between outer and inner space with transit zone will be appear. [8]. Grain in Islamic architecture according to (Ardalan , 1974)that are many elements appeared , specially the arch , is one of the basic element of inner court yard space. Arches always figurate receded elements of the walls, as morphological type. Arches create continuous connection of space according to the process of transition and expansion , in order to bond the mass to the receded elements in a physical volumes [9].

(Besim hakim , 1988), mentioned that history of comprehensive system in Islamic societies is included in Arabia peninsula , which controlled regulated construction ,activities and changes within the built environment. The process of change and growth traditional system with associated values continued to the 1940s, and gradually was adopted to modernism , which it affected the built environment according to the factor of change .[10].

Table 1. declares major urban form variables of grid iron city (The researcher)

Major variables	Patterns
Planning & design organizational (grid iron)	Wide streets with hierarchy
Combination of buildings	Detached buildings with recesses , courtyard absence
Structural elements	Modern patterns
Integrated variables	Outdoor looking ,appearance

2-1-3 Courtyard Indicators

One of basic courtyards indicator is enclosure. The values of grain appear according to enclosure condition, and the relation between space and envelope. (Ashihara,1978), referred, that spatial order will be created centripetally by giving some degree of an enclosed feeling to each components areas of the exterior space. To this end it is necessary to pay attention to the shape , quality and location walls. [7]. So scale is very important in determining the degree of enclosure in courtyard, according to the relation between height and horizontal dimensions of the space.

(Ashihara ,1978), referred that quite a large H/D ratio and the floor is relatively rough. The exterior space is smaller with H/D ratio equaling 1:2, 1:3 [7]. In this direction scale , and proportion are important values appear in court yard figuration determining its character and ability of negative or positive values. Hierarchy is another value of inner enclosed space with exterior space. Ashihara , mentioned , that exterior space consists of one space , two spaces or a number of complex spaces , and it's possible to conceive a hierarchical order in spaces [7] .this property refers to penetration , through the relations between inner space of courtyard and exterior space. Grain always refers to the relation between space and its surrounding surfaces as enclosure character. The properties of the relation is the finest , if there is equipotentiality between space and surrounding planes , which figure the court yard form . the relation be grain if there is penetration between them . There is entire penetration when there is entire communication between inner courtyard space and exterior . There is partial penetration , when there is recession or session of the courtyard form as protrusions.

Table 2. declare basic values & secondary values (Researcher)

Indicators	Main values	Secondary values
Enclosure	scale	H/D
	proportion	
Penetration	Hierarchy	Entire connection(inner & exterior)
		Partial connection
Space & mass relation	Positive & negative values	Equipotential
		Protrusions, staggering (vertical & horizontal)

2-2 Thermal comfort

Thermal comfort according to (ASHRAE55-74 standard), Is condition of mind that expresses satisfaction with thermal environment . it is a comfort zone of climatic condition , which majority of people would not feel discomfort in it. In the past few decades, there have been several attempts to develop a systematic methodology for adapting the design of a building to human requirements and climatic conditions. Such attempts include the development of the building bioclimatic[3]. thermal comfort always refers to satisfy with climate, in order to gain micro system .Thermal comfort differs from out and in space. Each situation is of special indicators that affect to gain thermal comfort. Macpherson , classified six factors for inner spaces including, temperature, air movement, humidity, radiant temperature, metabolic rate and clothing levels [3].Many other studies concentrate on major factors in out space to be of thermal comfort. According to (Shahin , 1989,) thermal comfort can be determined by four factors in outer space including : temperature. Air movement, humidity and vapor pressure relate with air movement , and water quantity in it[3]. Thermal comfort according to Olgyays bioclimatic chart is : temperature

20-30 °C, humidity 20%-60% , and air movement speed 0.1 m/s-1m/s [4], That is for indoor interior buildings , and can adapt for exterior spaces .

2-2-1 Hot dry zone

(Coach , 1998) classify five types of climates; (cold climates , dry warm climates, wet warm climates , windy climates , complex climates)and each of these climates is of many characters[3]. Although there is an other climates of hot dry climates in the regions with this type of climate attempt is normally made to take advantage of the great temperature variation during the day-night cycle. Our study concentrates hot dry region. Dry climate classified into two parts: the dry arid climate and the dry semiarid climate. The dry arid of a climate is almost 12% of the land surface. Dry climate is spread a long from 20-35 north and south of the continental regions of the mid-latitudes[12]. (Iraq lies between latitudes 29-39 N and longitudes 39-49 E , and small area lies west of 39. Most of Iraqi climate is hot arid with subtropical influences. The summer temperature is of average about 40 °C, for most of the country and some time exceeds 48 °C [13]

2-2-2 Sustainability & Courtyard in traditional buildings:

Sustainability always refers to the optimizing usage of natural resources . The meaning of energy reduction is one of sustainability goals . thermal comfort and sustainability mean the smart dealing with natural recourses to be acceptable for people . Islam as religion has deep respect and consideration of natural environment [14] . The strength of vernacular architecture is that it blends buildings into various settings so that there is a natural harmony between climate, architecture and people. In countries such as, Iraq there have been evolved buildings which not only demonstrate this harmony and unity between people and their environment. There are many elements affect the process of thermal comfort in courtyards: 1.courtyard, 2. walls, 3.badgair.

(Besim Hakim , 1986) mentioned in his Arab Islamic studies about traditional urban structure fabric, that there are three variables governing the urban form of the Islamic city according to :

Organizational , planning and design variables according to streets and paths relates with the global physical frame , the local various accommodation relations and buildings type.

Combination of buildings and the organizational elements.

Primary buildings elements , their values of materials and technique[15]

(Besim Hakim , 1989) , also described , that organizational , planning and design variables, relates with many elements like :

Street system.

Elements above the streets

The combination of buildings relates with:

Courtyards building

Courtyards elements. [16]

(Sayigh , Marafia , 1998), referred that traditional courtyard was surrounded by high narrow rooms. There was many unglazed openings, facing the court yard. There was also some time partially arcades. Courtyards were of various sizes, according to the geographical location and the type of the climate. The mechanism of the courtyard of many ,are as below :

- Cool air of night kept for many hours from the hot wind.
- Rooms draw day light and cool air from court yard.

- Ventilation enhances during the operation.
- Comfortable outdoor space provided.

(Sayigh , Marafia) , referred to(Talibs model, 1984) according to the courtyard cycle which are described during 24h through three phases. In the 1st phase cool night air descends into courtyard and into surrounding rooms, and cool will keep to the afternoon . Courtyard loses heat by radiation to night sky. During the 2nd phase of midday, the sun strokes courtyard directly. Some cool air begins to rise and also leak out of the surrounding rooms. In that mood the courtyard acts as a chimney. Massive walls prevent external heat to penetrate and the penetration is delayed . it depends on time lag of the wall, which all of that shape a phase . in the last phase especially in the afternoon court yard ,and inner spaces of rooms become warmer After sunset the air temperature and courtyard begins to descend into court yard as a complete cycle.

Courtyard is of great effect in arid region, which of diurnal temperature variation[3]. Badgair is also basic element of the operation during two dualities:

- Night operation: when there is no blowing of the wind, and the badgair tower performs as a chimney , Through the day the badgair wall have been heated , and the heated air is exhausted through the tower . The circulation of air through the wall will cool the structure and the badgair walls also.
- Day operation: when there is no wind blowing during the day, the badgair act as chimney, cold walls and air will be pulled down through the badgair tower. When there is no wind blowing both air circulation, cooler air is delivered inside the building. Wind performance and badgair shape as element through height, cross section and orientation will affect the process [3] .

3. Application:

There is two research samples which had been chosen in order to evaluate the hypothesis design values of enclosure ratio, penetration ,grain ,and staggering , depending on experiential methodology. The researcher select building samples, containing courtyard in its design. The buildings are of grid iron planning. That samples situated in Babylon province. The province is of hot dry climate and lies between latitudes 32-29 N and longitudes 44-26 E [13]. The sample is in Hilla , the center of Babylon province.

3-1 Experimental work sample

The samples had been selected in our research, as shown in Table (2)

Table 3. declares selected samples data,(Researcher)

Sample no.	Building type	Planning pattern	Stories no.	Orientation	Courtyard ratio
C1	Public (office building)	Grid iron	3 stories with rear tower	East	1/1
C2	residential	Grid iron	2 stories	west	1/1

The research depended on many instruments(PCE – A420 for wind force & PCE-EM882 Environment meter for temperature and humidity) in order to measure the basic elements of thermal comfort. the positions and results of the experiments , shown below in fig (1A.B. 2A.B. 3A.B) and tables (3,A,B,C,D- 4,A,B,C,D – 5,A,B,C,D) . All measurements took place in the beginning of October. The selection of that month , had been

depended , for it is a time of natural thermal comfort must be founded , and far a way from mechanical energy usage, in order to reduce energy consumption.

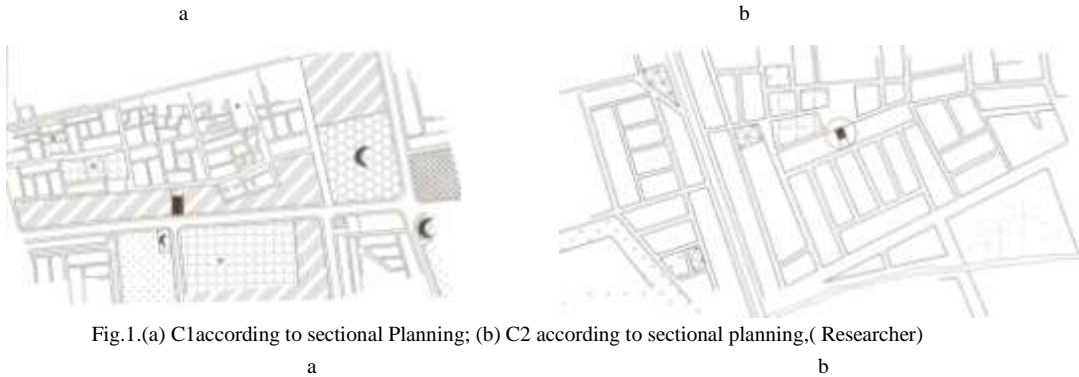


Fig.1.(a) C1 according to sectional Planning; (b) C2 according to sectional planning,(Researcher)

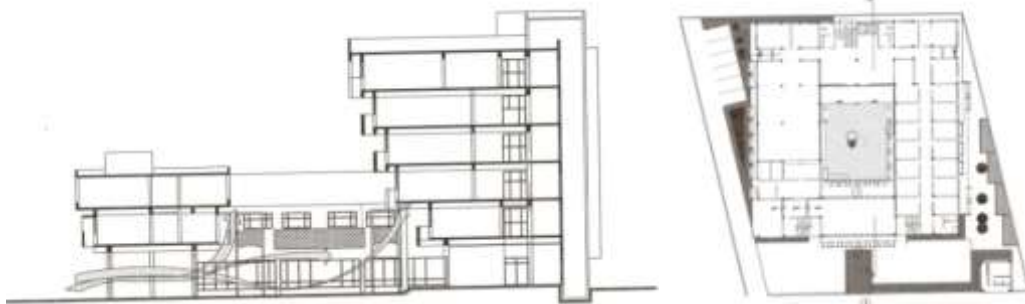


Fig.2.(a) C1 section A-A; (b) C1 ground floor plan,(Researcher)

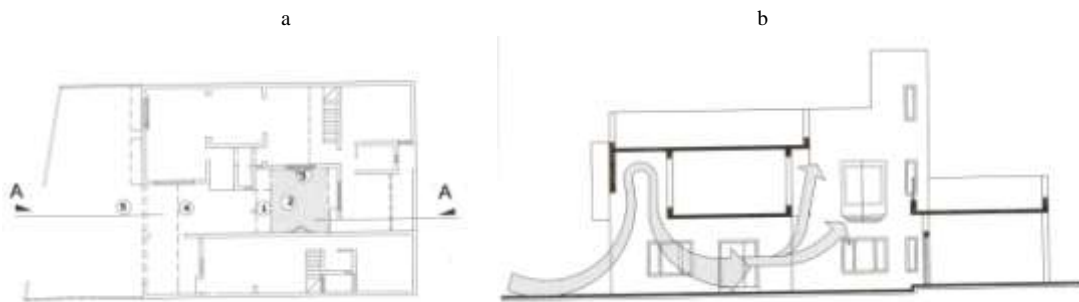


Fig.3. (a)C2 section A-A; (b) Ground floor plan,(Researcher)

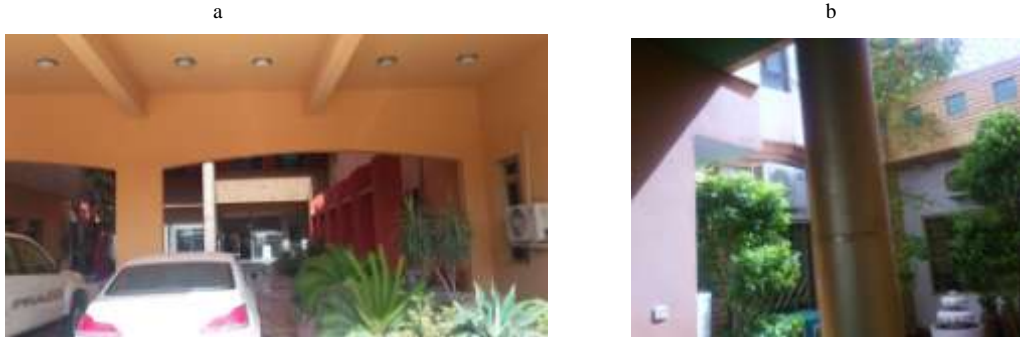


Fig.4.(a) C2 courtyard inner space; (b) C2 Courtyard inner space Researcher

3-1-1 C1: Public buildings Courtyard (middle Euphrates electrical building) data

Table 4-A declaring the data at 9 A.M

Situation point	Temperature	Air movement	humidity	Notes
1	33.1	1.3	29	All data at 9 a.m 17-9-2014
2	33.1	0.3	29.2	
3	32.4	0	31.9	
4	34.5	1.1	27.1	
5	36.5	1.1	25.4	

Table 4-B declaring the data at 12 mid of day

Situation point	Temperature	Air movement	humidity	Notes
1	37.3	1.7	23.7	All data at 12 mid day17-9-2014
2	36.5	0.9	25.7	
3	37.5	0	30.4	
4	37.5	1.6	22.9	
5	39.8	1.2	21.4	

Table 4-C declaring the data at 15 P.M

Situation point	Temperature	Air movement	humidity	Notes
1	36.4	1.5	28.2	All data at 15 p.m 17-9-2014
2	34.1	0.2	29.8	
3	33.1	0	31.6	
4	36.8	1.	27.3	
5	40.6	1.8	26.3	

Table 4-D declaring the data at 18 P.M Table 4-C declaring the data at 15 P.M

Situation point(P)	Temperature	Air movement	humidity	Notes
1	33.1	1.3	29	All data at 18 p.m 17-9-2014
2	34.1	0.3	29	
3	32.4	0	29.9	
4	34.5	1.1	27.1	
5	36.	1.1	25.	

3-1-2 C2: House courtyard data

Table 5-A declaring the data at 9 A.M

Situation point(P)	Temperature	Air movement	humidity	Notes
1	28.3	1.6	28.2	All data at 9 mid day13-9-2014
2	28.5	1.2	22.5	
3	28.7	0.1	28.2	
4	28.9	0.2	28.5	
5	30	1.6	29	

Table 5-B declaring the data at 12 mid of day

Situation point(P)	Temperature	Air movement	humidity	Notes
1	37.5	1.6	22.5	All data at 12 mid day13-9-2014
2	37	1.1	22.3	
3	37.3	0.1	22.3	
4	38	1.3	23.1	
5	41.5	3.9	23.2	

Table 5-C declaring the data at 15 P.M

Situation point(P)	Temperature	Air movement	humidity	Notes
1	34	2.8	21	All data at 15 p.m 17-9-2014
2	34.9	2.4	20.8	
3	34.8	1	20.8	
4	37	1.1	21.6	
5	39.5	0.8	22	

Table 5-D declaring the data at 18 P.M

Situation point(P)	Temperature	Air movement	humidity	Notes
1	33.3	0.3	27.6	All data at 18 p.m 17-9-2014
2	33.7	0.1	27.8	
3	33.7	0.1	27.6	
4	34.1	0.1	27.6	
5	35.5	1.1	27.6	

All points situation as below:

- P1 - in penetration space
- P2 – middle of courtyard
- P3 – horizontal or vertical elements grain
- P4 – in the edge of building (edge of building and outer space)
- P5 – exterior space

3-2- Discussions

The analyzing of the research depends on three alternatives (temperature , wind force and humidity), as below:

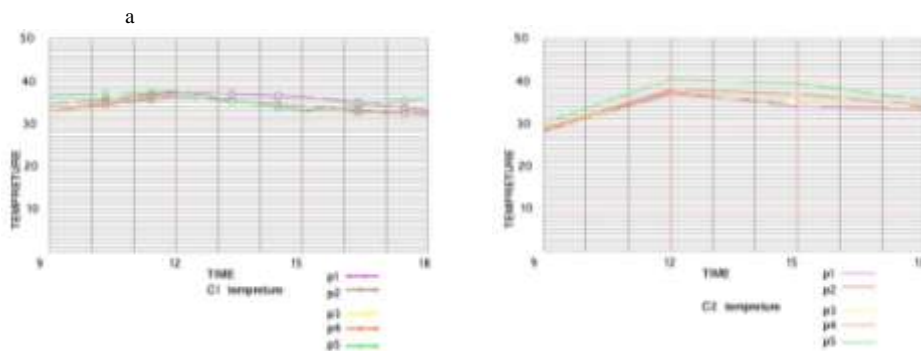
3-2-1 – Graph 1.(A,B) declare temperature through selected hours day in different positions(P1,P2,P3,P4,P5) of courtyard spaces of samples (C1 , C2), according to :

A- Analyzing temperature at 9 clock: in sample (C1)there was 3.4 c° difference between outer space (p5), and the center of courtyard space according to enclosure ratio (H/D), and all the other points was less than outer space .in the sample (C2) in all courtyard points extended 1.1 c° -1.5 c° , according to enclosure ration (H/D).

B- Analyzing temperature at 12 clock: temperature in center courtyard of (C1)was of 3.3 c° less than outer space according to the activation of air movement by staggering , grain and penetration . temperate in (C2) 4.5 c° in center of courtyard less than outer space (p5) , according to the same mentioned reasons.

C- Analyzing temperature at 15 clock: temperature in center courtyard of (C1)was of 6.5 c° less than outer space according to the activation of air movement by staggering , grain and penetration .the temperature in other points of courtyard (p1, p3,p4) extended 4.6 c° -5.5 c° less than outer space according to grain , penetration and staggering. temperature in (C2) was 4.6 c° in center of courtyard(p2) less than (p5)

E- Analyzing temperature at 18 clock: the temperature in (C1) was about 1.8 c° -2.2 c° less than outer space according to the equality of pressure between in and out space in that time. Temperature in (C2) was 1.8 c° in center of courtyard less than outer space according to the mentioned reasons.



Graph 1.(a,b) declare temperature through selected hours day,(Researcher)

3-2-2 – Graph 2.(A,B) declare air movement through selected hours day in different positions(P1,P2,P3,P4,P5) of courtyard spaces of samples (C1 , C2,) , according to :

A - Analyzing air movement (ventilation) at 9 clock:

-According to P1 for C1, C2 there was about (1.2-1.6 m/s) for C1,C2 , in (P2) there was about (0.3-2 m/s) for C1,C2 ,in (P3) it was less in C1 and be active in C2 , according to the effect of vertical and horizontal elements , and in (P 4) there was air movement in C1, C2 between(0.1 -0.4 m/s) ,according to the orientation

B - Analyzing wind force (ventilation) at 12 clock:

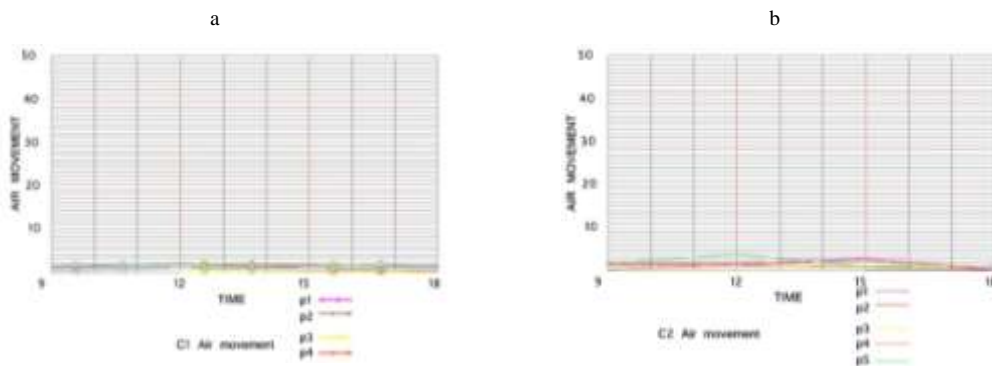
-According to P1 for C1, C2 there is about (1.2-1.6 m/s) ,for C1,C2 in (P2) there was about (0.3-2 m/s) for C1,C2 ,in (P3) it was less in C1 and be active in C2 , according to the effect of vertical and horizontal elements , and in (P 4) there was air movement in C1, C2 between(0.1 -0.4 m/s) for all times according to the orientation

C - Analyzing air movement (ventilation) at 15 clock:

- in (P2) it was less in C1 and be active in C2 , to be about (.22 m/s)in C1 and 2.4 m/s, according to the effect of enclosure and orientation.

D - Analyzing air movement (ventilation) at 18 clock:

- in (P 2) there is air movement in C1, C2 between(0.1 -0.3 m/s). air movement was 1.3 m/s in p1 and 1.1 m/s in p4 , according to orientation , penetration and staggering .



Graph 2.(a,b) declare air movement through selected hours day,(Researcher)

3-2-3- Graph 3.(A,B), declare humidity through selected hours day in different positions (P1,P2,P3,P4,P5) of courtyard spaces of samples (C1,C2), according to:

A - Analyzing humidity at 9 clock:

-in all points of courtyard for c1 extended 27.1% - 29 % , and in c2 extended 27.1% -29.9 %

B- Analyzing humidity at 12 clock:

-in all points of courtyard for c1 extended 22.9% - 23.7 % , and in c2 extended 22.5% -28.2 %

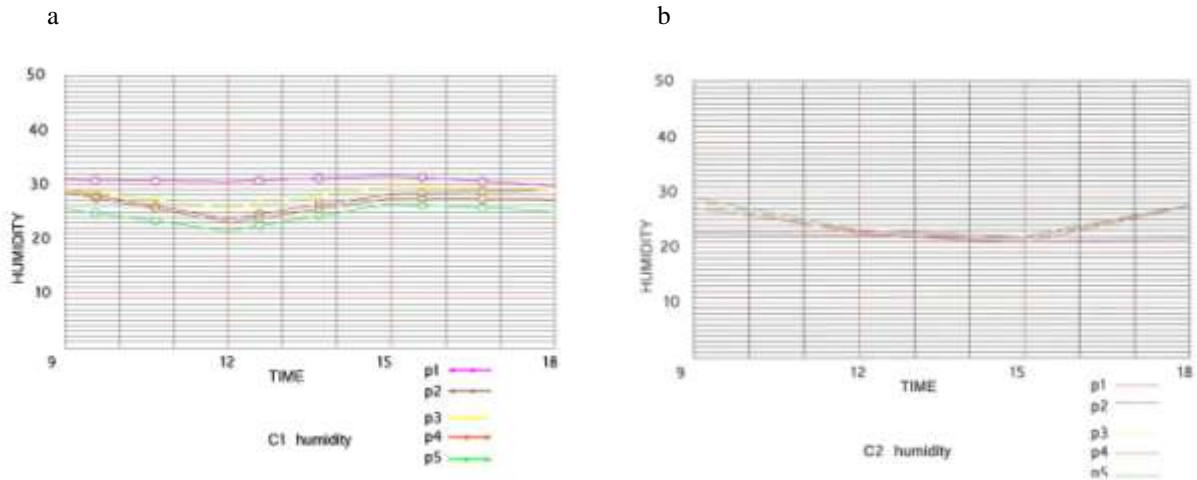
C - Analyzing humidity at 15 clock:

- in all points of courtyard for c1 extended 27.3% - 31.6 % , and in c2 extended 22.3% -23.1 %

D- Analyzing humidity at 18 clock:

-in all points of courtyard for c1 extended 27.1% - 29 % , and in c2 extended 20.8% -21.7 %

All the deference in spaces and humidity according to penetration, orientation , plants , fountains and water .



Graph 3.(a,b), declare humidity through selected hours day,(Researcher)

4. Conclusions :

- Courtyard is a thermal organizing pattern in traditional buildings of hot dry, and humid regions , according to the systematic formation mechanism of the global planning of the tissue.
- According to the transformation of the planning pattern from organic to grid iron the mechanism of the courtyard can't be active without modifying the design characteristics of its formation.
- There are three factors affect the mechanism of courtyard to be of thermal comfort (temperature , humidity and air movement) , and through balancing between that three factors , we can get thermal comfort buildings of courtyard in hot dry regions.
- There are many design indicators and values can activate courtyard in buildings of grid iron pattern to be of thermal comfort , including , courtyard enclosure ratio (H/D), penetration (indoor & outdoor space relation), grain, and vertical elements staggering .
- Grain effect appears through the degree of penetration between inner courtyard space and surrounding outer space , relates with the place of penetration and orientation.
- Grain effect , appears also through the relation between mass and space , according to mass engraving, and staggering in vertical section of the mass and space edge.
- Thermal comfort can be reached in courtyard space by increasing air movement , with suitable humidity . the first property can be got through penetration between outer & inner space of courtyard ,and vertical staggering . the second property can be reached by plants , fountains and water in penetration position of courtyard in regions of hot dry regions, and buildings of grid iron planning pattern.
- There is about 5 c° -6 c° difference between out space and courtyard inner space depending on the previous mechanism .
- According to samples analysis temperature extended 28 c° -34 c° , humidity extended 20%-30% , and air movement is between 0.1s/m-1.3m/s . All the results are of thermal comfort for courtyard exterior

spaces. of buildings, which can correspond sustainability ,depending on natural resources and the property of design.

- There is difference in temperature between totally closed courtyard of buildings of grid iron planning pattern, and grained courtyard , due to penetration .
- The reduction of courtyard temperature affects the temperature of rooms surrounding the courtyard , according to the reduction of heat gain , through the walls.

References

1. Correa , Charles , (Architecture and Identity) , The Aga Khan , Award for Architecture , Proceeding of the regional Seminar in series Exploring Architecture in Islamic Cultures , 1983.p.12.
2. Moraes , Zarzar , (Under standing meaningful Environments Architectural precedents and Question of Identity in creative Design) , published by IOS press . Vol.4 , 2008.p.7.
3. C, Gallo, M . Sala , A.M.M.Sayish,(Architecture Comfort and Energy) , Kidlington , Oxford OX5 1GB. UK,1998.p.22-3-11-70-34-35.
4. <http://dr-sama.8m.com/abstract.htm>, (Natural ventilation in traditional courtyard houses in central region of Saudi Arabia) , 2008.
5. Al- kaissi , sahir, (the influence of natural and cultural environment of the fabric of the city) , phd thesis , university of Sheffield , 1983.p.360.
6. Frey, Hilderbrand. "Designing the city towards a more Sustainable urban form" Taylor & Francis e-library.Papers, 2008.p.13-2.
7. Ashihara , Yoshhinobu (Exterior design in architecture), van Nostrand Reinhold company , Newyork , 1978.p.37-78-83-82.
8. Shulz , christain , norberg , (existence space & architecture), jhon wiley & sons , newyork , 1971.p.27.
9. Ardalan , nadar , & bakhliar , laleh , (the sense of unity), the university of Chicago press , chicago , London , 1979.p27.
10. Hakim ,Besim, (Teaching architectural theory abroad: the necessity to contextualize), independent scholar and consultant ,Albuquerque , NM, 1988.p2.
11. Shahin , Bahjet , (architecture & climate in hot dry regions session), college of engineering , Baghdad university , continuous learning , 1989.p2-3.
12. <http://www.mapsofworld.com/referrals/weather/climate/dry.climate.html>.
13. <http://en.wikipedia.org/wiki/Iraq>, - en . wikipedia .org/wiki/Hillah
14. Izzi dien ,(the courtyard of oriented houses in baghdad), journal of beliefs &values No.1, 1997, carfax.p1.
15. Hakim, Besim, ” Arabic – Islamic cities” , kpl limited, London, 1986.p124.
16. Hakim, Besim, “Encyclopedias of architecture: Design, engineering, and construction”, U.S.A., vol3, shonwelly and son, 1989.p.89.