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Grain Effect on Climate Organizing of Courtyard in Hot Dry Regions

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Abstract :- **Climate adaptation is one of the important issues of sustainability. The reduction of energy is a great matter that took place in the world. Thermal comfort is a main factor effect human inner & outer spaces. The research concentrated on temperature reduction & thermal comfort through courtyards as an important element in buildings design , through referring to the property of grain , which affect the configuration of courtyards in order to gain thermal comfort , and how to make balance between temperature , air movement and humidity.**

Through analyzing three types of buildings of different courtyards , by using environmental instruments , according to experimental methodology , the research reach to the important elements , co figurate courtyards and affect temperature , air movement and humidity , as important elements of comfortable temperature in many times in summer. The edge between mass and space of the courtyards had affected, as a relation between these duality in order to reach acceptable comfortable zone in hot dry regions in outer spaces and inner spaces, to get thermal comfort, as indicator of energy reduction.

The research aim & purpose: The research aimed to determine the degree of grain effects on courtyards to be active in climate changes to be of comfort heat in hot dry regions .

The research method: experiential methodology depended to reach the findings & results.

The research arrived that grain effects on thermal comfort & climate changes of courtyards through many indicators of solid \ void ,(penetration), elements position, elements shapes and orientation as findings.

key words (Courtyard , Grain, Climate &Thermal comfort)

I. INTRODUCTION

Many endeavors took place in order to reduce energy consumption through the world of sustainability. In our traditional life styles in Arab region, court yards help the mechanism of environment according to many values, depending to the global town planning, form of alleys, the figuration of buildings, buildings sections, using of basements, and the existence of shifts, calls (Badgairs). Many of these elements had been absent according to the modern life style and the challenges of technology, so the performance of court yard as environmental system had been reduced.

The research concentrates on the mechanism of courtyard to be active , responding to the new life styles , through modern town planning , buildings figurations , and modern streets planning , as a research problem , in order to make court yards environmental active , as one of element of climatic adaptation in hot dry regions. Acceptable thermal comfort can be got through courtyards grain by using natural energy as an aspect of sustainability, as a research hypothesis.

Experimental work will be discussed through Three samples of courtyards buildings , according to environmental instruments depends to measure the activity of courtyards and the effect of grain on energy reduction of court yards , by adapting the natural resources of temperature , air movement(ventilation) and humidity as basic elements of the process to gain thermal comfort .

A. *Research problem*

The research concentrates on the mechanism of courtyard to be active, responding to the new life styles, through modern town planning, buildings figurations, and modern streets planning. The research problem is, how to activate courtyards to be of thermal comfort, in buildings of grid iron planning pattern in hot dry region.

B. Research methodology

According to experimental work many indicators play in the role of the study through: 1. Thermal performance, to measure temperature according to various courtyards, 2.Ventilation performance, according to air movement in various courtyards, 3. Humidity performance, according to the effect of plants and water on the process.

II. CONCEPTUAL FRAME WORK

Conceptual research frame work extends through theoretical approach concentrates on many conceptions and values relate with the research problem, in order to build theoretical base.

A. court yard as traditional pattern

Moraes , K. & Guney,A[6], referred that precedents shapes the reflection of the use of terminology , and introduces 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 pays it. How architects and

designers recollect their precede tents in new one [6]. According to Charles Correa [4] courtyard is a pattern , that to across a desert and enter a house around it and a pleasure beyond mere photogenic image making at. But in understanding and using this 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. [4]. According to C, Gallo et al, [3] that 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. They were large in hot humid region to provide good ventilation, on the other hand they were small in hot – arid region to get protection against hot and dust [3]). Osama , 2008)[12] referred that Natural ventilation used in hot dry zones , especially in Arab regions of Iraq and Arabia Saudi and the Arabia peninsula.[12]

A.A. courtyard as a temperature organizing

Systematic mechanism, governed the traditional urban tissue. Many researchers write about courtyard and its function. The research will concentrate about its environmental effect on the building as a whole and the courtyard spaces.

Al-kaissi,[1] mentioned that courtyard in 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.[1].

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 [5], public realm refers to the city , which (Rob krier)called (Res publica) which includes all public monuments , halls , memorial and public works , the feature of the city , the urban components [5],.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 affects the unit and the global system of the urban tissue.

According to, Fery [5] ,towns and cities in the past developed incrementally and without master plan with very good results , when in 1950s and the 1960s grand – scale master plans were developed things went dramatically. [5]

A.B. what is grain?

Always grain refers to the relation between mass and space. According to (Ashihara, 1978)[8], space and mass are of equipotential in their common relation , but when space penetrates mass , positive and negative values appears , according to enclosing force between them [8]. Alkaissi [1] , referred that the relation between the physical forms and their space appear according to equipotentiality of surface between mass and space . When the plane be smooth the relation between them weak and be of neutral condition. Any change in the surface form, which separate 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 [1] the gorgeous elements be of positive value , and of negative space. [1] . Grain and the negative spaces will appear in the interfacing of figure and ground (figure / ground).

Schulz [7] , mentioned that negative space be as join , according to the degree of transparency and penetration between outer and inner space with transit zone will be appear. [7]. Grain in Islamic architecture according to Ardalan [2]that are many elements appeared , specially the arch , which be 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. [2]

A.C. Grain indicators

One of basic grain indicator is enclosure. The values of grain appear according to enclosure condition, and the relation between space and envelope. Ashihara [8] 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. [8]. So scale is very important in determine the degree of enclosure in court yard, according to the relation between height and horizontal dimensions of the space.

Ashihara [8], referred that quite a large H/D ratio and the floor is relatively rough. The exterior space be smaller with H/D ratio equaling 1:2, 1:3 [8]. 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 [8] mentioned , that exterior space consists of one space , two spaces or a number of complex spaces , and it's possible to conceive of a hierarchical order in spaces .[8] .this property refers to penetration , through the relations between inner space of court yard and exterior space. Grain always refers to the relation between space and its surrounding surfaces as enclosure character. The properties of the relation be finest , if there is equipotential between space and surrounding planes , which figurate the courtyard 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 1. declare grains indicators & values (Researcher)

Grain 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)

B. Thermal comfort

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]. Always thermal comfort 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 , [9] thermal comfort can be determine by four factors in outer space including : temperature. Air movement, humidity and vapor pressure which relates with air movement , and water quantity in it.

B.A. Hot dry zone

Coach [3] 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 another climates of hot dry climates. In the regions with this type of climate an attempt is normally made to take advantage of the great temperature variation during the day-night cycle. Our study concentrates on hot dry region. Dry climate classified into two parts: the dry arid climate and the dry semiarid climate. The dry arid is 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. [10]. 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 48c. [11]

B.B. Courtyard climatic mechanism in traditional buildings:

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 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.

Sayigh , marafia [3], referred that traditional courtyard was surrounded by high narrow rooms. There was many unglazed openings, facing the courtyard. 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 , 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 [3] , referred to(Talibs model, 1984) according to the courtyard cycle which 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 court yard 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 courtyard ,and inner spaces of rooms become warmer After sunset the air temperature and courtyard begins to descend into courtyard as a complete cycle.

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

- Night operation: when there is no blowing of the wind, and the badgair tower performs as a cheminey , 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 pulled down through the badgair tower. When there is no wind blowing both air circulation, cooler air is delivered to inside building. Wind performance and badgair shape as element through height, cross section and orientation will affect the process [3] .

III. EXPERIMENTAL WORK.

Many research samples had been chosen in order to evaluate the hypothesis, depending on experiential methodology. The researcher select three buildings samples, containing court yard in their design. The buildings are of grid iron planning. The samples situation are in Babylon province. The province is of hot dry climate and lies between latitudes 32-29 N and longitudes 44-26 E. [11]. All samples situation are in Hilla , the center of Babylon province.

A. experimental work samples

There are three samples have been selected in our research, as shown in Table (2)

TABLE 2. *declares selected samples data,(Researcher)*

C NO..	**Building type**	**patter n**	**Stories**	**Orientatio n**	**Rati o**
C1	Public office building	Grid iron	3 stories with rear tower	East	1/1
C2	Public office building	Grid iron	2 stories	East	1/1
C3	Residence	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 on 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 away from mechanical energy usage, in order to reduce energy consumption.

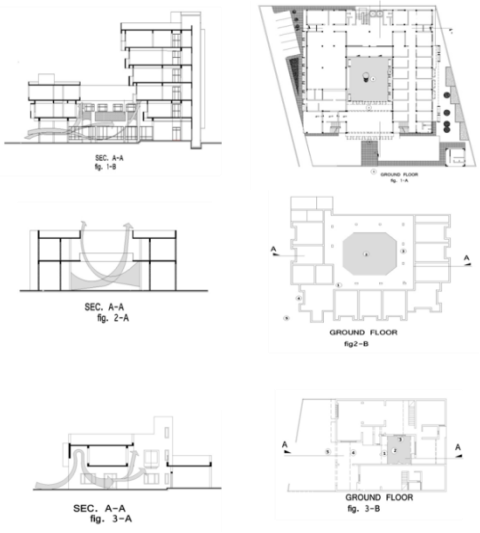


Fig.1.A,1.B,2.A,2.B,3.A,3.B. *Samples Ground Plans and Sections*

A.A. Public buildings Courtyard (middle Euphrates electrical building)

TABLE 3.A. *declaring the data at 9 A.M*

Situation point	Temperature	Wind speed	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 3.B. *declaring the data at 12 mid of day*

Situation point	Temperature	Wind speed	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 3-C declaring the data at 15 P.M

Situation point	Temperature	Wind speed	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 3-D declaring the data at 18 P.M

Situation point(P)	Temperature	Wind speed	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.	

A.B. Public buildings Courtyard (Entail management & religious affairs building)

TABLE 4.A. *declaring the data at 9 A.M*

Situation point(P)	Temperature	Wind speed	Humidity	Notes
1	32.6	0	29.3	All data at 9 a.m 17-9-2014
2	33.7	0	24.2	
3	38.5	0	15.1	
4	38	0.5	24	
5	35.3	1.9	28.5	

TABLE 4-B *declaring the data at 12 mid of day*

Situation point(P)	Temperature	Wind speed	Humidity	Notes
1	38.6	0.1	16	All data at 12 mid day17-9-2014
2	39.7	0	19.1	
3	38.5	0	15.1	
4	40.1	1.8	8.2	
5	41	2.4	8.4	

TABLE *4-C declaring the data at 15 PM.*

Situation point(P)	Temperature	Wind speed	Humidity	Notes
1	38.2	0	14	All data at 15 p.m 17-9-2014
2	39.8	0	18.5	
3	38.3	0.1	14	
4	41.1	1.4	7	
5	41	1.8	7.8	

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

Situation point(P)	Temperature	Wind speed	Humidity	Notes
1	35.6	0	29.3	All data at 9 p.m 17-9-2014
2	35.7	0	24.2	
3	36.5	0	15.1	
4	37	0.5	24	
5	35.3	1.9	28.5	

A.C. House courtyard

TABLE *5-A declaring the data at 9 A.M*

Situation point(P)	Temperature	Wind speed	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	Wind speed	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	Wind speed	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	Wind speed	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

B. discussions

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

B.A.Graph 1.(A,B,C,D,E) declare temperature through selected hours day in different positions(P1,P2,P3,P4,P5) of courtyard spaces of samples (C1 , C2, C3), according to :

B.A.A. Analyzing temperature in P1:

-about 4.5 ºC in penetration edge (P1)between penetrated courtyard space and entirely closed court yard space at (9 clock) morning.

-about 1.1 ºC between penetrated courtyard space with staggering in section in ratio to the other , that non stager exist. the gap is 2 C to the entirely closed space (C2) according to the enclosure ration of H/D, in the mid of day .

- it is about 1.9 Cbetween penetrated space of courtyard which of grain and vertical staggering property and is 5 ºC in courtyard space of non grain at 15 clock.
- it is of 8 ºC , between penetrated space with grain and 3.3 ºC with non grain at 18 clock after noon.

B.A.B. analyzing temperature in P2:

-at 9 clock the difference is 4.5 ºC between penetrated space with staggering in vertical section . and is 5 ºC in non penetrated space.

- at 12 clock the temperature is 1/2 ºC between penetrated with staggering space , and 4 C in non penetrated.
- It is 1 ºC between penetrated with vertical staggering and 5.8 ºC higher in closed courtyard space , at 15 clock after noon.
- it is 1.8 ºC between penetrated space with vertical staggering and penetrated and non staggering . The difference with closed space courtyard is 5.1 ºC, at 18 clock after noon.

B.A.C. analyzing temperature in p3:

-the temperature is 4.1 ºC between penetrated space with grain (vertical & horizontal elements) , and staggering in section , and 10.5 ºC in courtyard space of non grain at 9 clock.

- temperature is of 1/2 ºC between space with grain and non staggering , and 1.1 C for courtyard space of non grain at 12 clock.
- temperature is 1.9 ºC between space of staggering and vertical grain elements , and 5 ºC in non grain courtyard space at 15 clock.
- it is of 8 ºC between penetrated space with grain and 3.3 ºC in non grain at 18 clock , after noon.

B.A.D. analyzing temperature in p4:

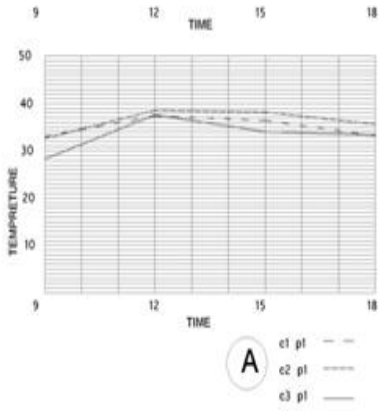
-temperature is 5.6 ºC of penetrated court yard space and 9 C in non penetrated in deference , at 9 clock morning.

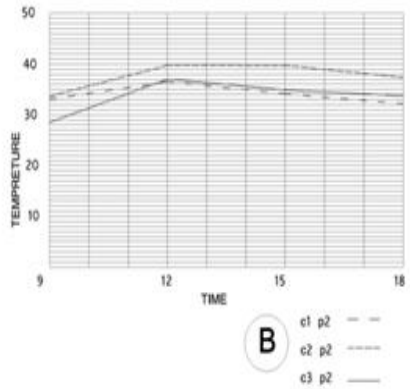
- the temperature is of 0.5 ºC difference between penetrated staggering space and only penetrated one . it is 2.6 ºC in non penetrated one at the mid of day.
- 4 ºC difference between one of penetrated with staggering and the other of no staggering , but the difference is 7.5 ºC with one of no penetration court space at 15 clock after noon.
- 1.5 ºC the difference with the penetrated staggering space and the other only of penetration property, but the difference is 7.5 ºC of non penetration courtyard space at 18 clock .

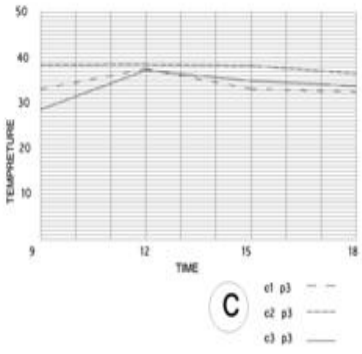
B.A.E. analyzing temperature in p5:

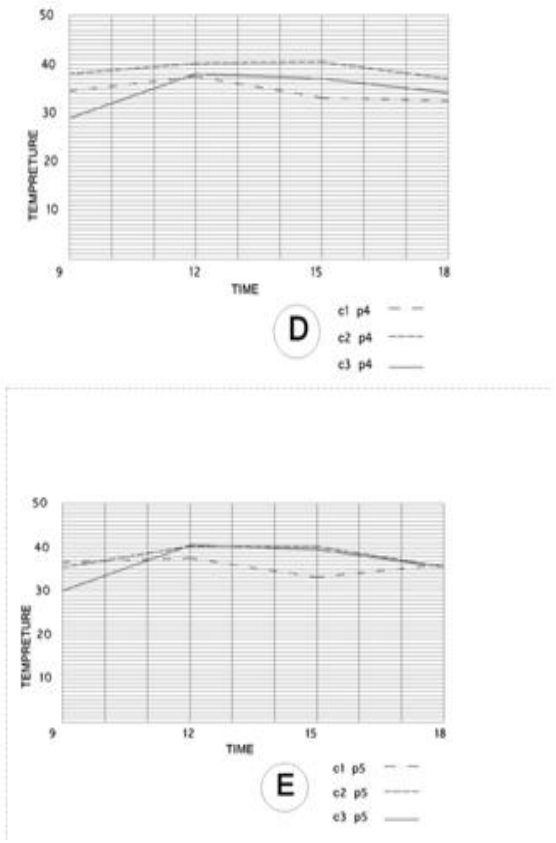
-the temperature difference between c1 and c2 is 0.5 ºC ,and with C3(6.5 ºC) decreasing at 9 clock morning, according to orientation.

- the difference is 2.9 ºC between C1 , C3 decreasing , and 0.5 ºC between C1, C3 in the mid of day.
- it is 6.5 ºC between C1, C3 decreasing , and 0.7 for C2 at 15 clock after noon.
- it is 0.5 ºC between C1, C3 decreasing , and no difference with C2 , at 18 clock.









Graph 1. (A,B,C,D,E) declare temperature through selected hours day

B.B. Graph 2.(A,B,C,D,E) declare wind force through selected hours day in different positions(P1,P2,P3,P4,P5) of courtyard spaces of samples (C1 , C2, C3), according to :

*B.B.*A. Analyzing wind force (ventilation) in P1:

-According to P1 for C1, C2 ,C3 there is less wind force in C2 , and about (1.2-1.6 m/s) for C1,C3 , for 9 , 12,15,18 clock.

*B.B.*B. Analyzing wind force (ventilation) in P2:

- in (P2) there is no air movement in C2, and about (0.3-2 m/s) for C1,C3 at 9, 12, 15, and 18 clock.

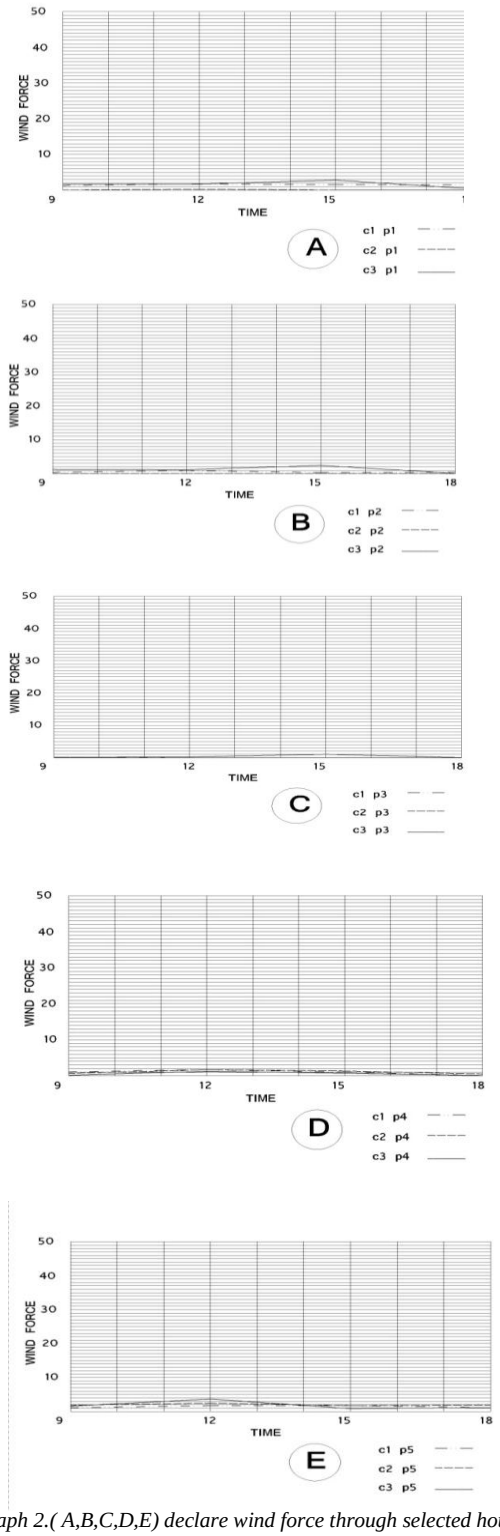
*B.B.*C. Analyzing wind force (ventilation) in P3:

- in (P3) it is less in all types and be active in C3 , to be about (1 m/s) in 15 clock afternoon , according to the effect of vertical and horizontal elements .

*B.B.*D. Analyzing wind force (ventilation) in P4: - in (P 4) there is air movement in C1, C2,C3 between(0.1 -0.4 m/s) for all times according to the orientation.

*B.B.*E. Analyzing wind force (ventilation) in P5:

- in (P5) air movement between (1-2 m/s) for C1,C2,C3 , at all times, and be increasing for C3 at 12 clock , due to orientation.



Graph 2.(A,B,C,D,E) declare wind force through selected hours day

B.C. Graph 3.(A,B,C,D,E), declare humidity through selected hours day in different positions (P1,P2,P3,P4,P5) of courtyard spaces of samples (C1,C2,C3), according to:

*B.C.*A. Analyzing humidity in P1:

-in (P1)is 28% for C1,C2 ,C3 at 9 clock am.

- it is 23.9% for C1 , 16% for C2 , and 22.6% for C3 at 12 clock
- it is 28.4% for C1 , 14% for C2 , and 21% for C3 at 15 clock p.m.
- it is 29% for both C1 , C2 , and 21% for C3 at 18 clock p.m.

*B.C.*B. Analyzing humidity in P2:

-it is 29% for C1 , 22.5% for C2 , and 24.1% for C3 at 9 clock a.m.
- it is 25.6% for C1 , 19.5% for C2 , and 22.2% for C3 at 12 clock.
- it is 29.5 % for C1 , 18.5 % for C2 , and 21% for C3 at 15 clock p.m.
- it is 29% for C1 , 24.3% for C2 , and 27.5% for C3 at 18 clock p.m.

*B.C.*C. Analyzing humidity in P3:

-it is 30.8% for C1 , 15.1% for C2 , and 28.1% for C3 at 9 clock a.m.
- it is 30.1% for C1 , 14% for C2 , and 21% for C3 at 12 clock.
- it is 31.6 % for C1 , 14 % for C2 , and 21% for C3 at 15 clock p.m.
- it is 29.9% for C1 , 25.1% for C6 , and 27.5% for C3 at 18 clock p.m.

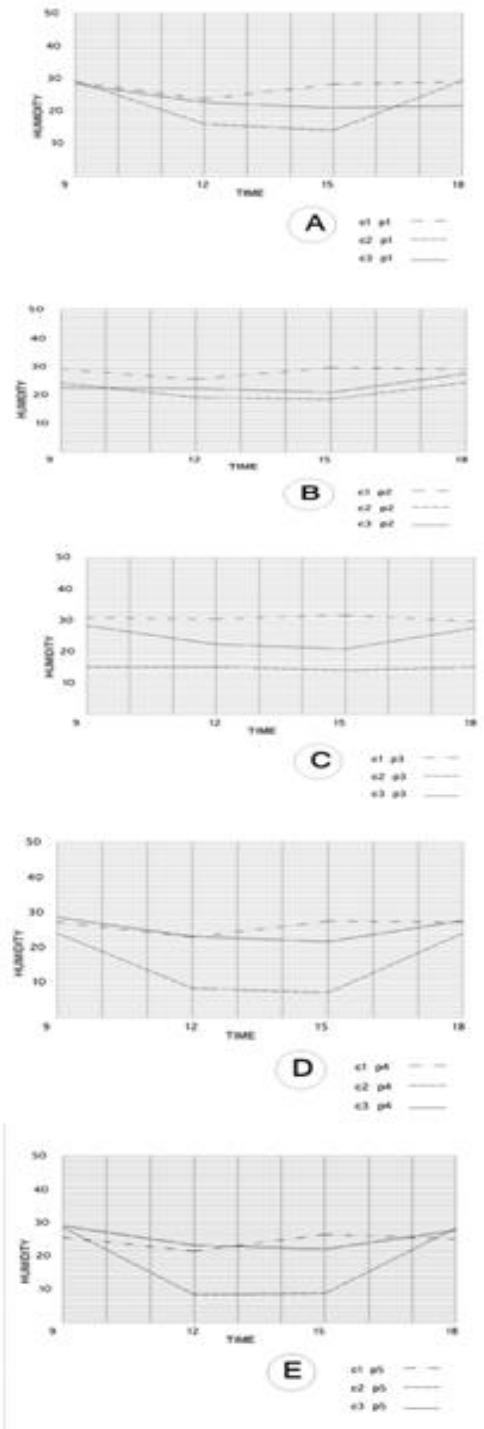
*B.C.*D. Analyzing humidity in P4:

-it is 27.5% for C1 , 24% for C2 , and 28.6% for C3 at 9 clock a.m.
- it is 23% for both C1 , C3 , and 8.2% for C2 at 12 clock.
- it is 27.6 % for C1 , 7 % for C2 , and 21.6% for C3 at 15 clock p.m.
- it is 27.1% for C1 , 27.2% for C3 , and 24% for C2 at 18 clock p.m.

*B.C.*E. Analyzing humidity in P5:

-it is 25.5% for C1 , 28.3% for C2 , and 25.3% for C3 at 9 clock a.m.
- it is 21.5% for both C1 ,23.1for C3 , and 8.2% for C2 at 12 clock.
- it is 26.5% for C1 , 22 % for C3 , and 8.7% for C2 at 15 clock p.m.
- it is 25% for C1 , 27.5% for C3 , and 28.3% for C2 at 18 clock p.m.

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



Graph 3.(A,B,C,D,E), declare humidity through selected hours day

IV. FINDINGS:

- We live in countries of great cultural patterns, giving a feeling of place and identity , and all of them have special mechanism according to spirit of age and global planning requirements.

- All those patterns can be improved to be active for our update life, by modifying them according to our modern requirements of life and culture.
- Courtyard is one of a famous pattern in our heritage. it is the heart pulsing of traditional architecture . it is of special mechanism to be major space with acceptable thermal comfort.
- Courtyard pattern can be improved in modern buildings of grid iron planning pattern to be a space for living , with thermal comfort.
- Grain is a basic effect in the mechanism of courtyard in modern buildings to active with acceptable thermal comfort .
- There are many factors affect the mechanism of courtyard space to be of thermal comfort , according to temperature , air movement , and humidity.
- Grains indicators are affected by , enclosure according to the ratio of H/D , and hierarchy by the relation between inner space and exterior space , and penetration is the basic property of that
- Vertical section of penetrated space, as staggering is the most important in the processes.
- According to an experimental trial for three samples of modern buildings of grid iron planning pattern , the research found that enclosure , hierarchy of spaces between inner and exterior space as penetration property , with (staggering and protrusions) as grain are of most important for getting thermal comfort increasing air velocity, which is one of important element of temperature comfort factors . air velocity increasing and more humidity decrease the temperature in hot dry zone.
- Isolated courtyard space with the exterior space is of comfort temperature at morning because of ratio of (H/D)and be un comfortable in mid of day and afternoon , for there is no air movement . Inner courtyard space with penetration property is of thermal comfort in the morning and of less temperature from the isolated one in mid day and afternoon . inner courtyard space with penetrated property and grain , according to (staggering in vertical section and protrusion) is less temperature from the previous samples (for all day hours), because of increasing of air velocity.

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