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ORIGINAL ARTICLE

Evaluation of Climatic Comfort inside and Outside the Buildings-A Case Study of Dezful in Iran

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ABSTRACT
Thermal comfort range for the area under investigation for a twenty year period (1991-2010) was undertaken using data from Dezful synoptic station. This involved experimental bio-climatic method consisting of effective temperature and Mahoni's building bio-climatic parameters including radiation, sunshine hours, temperature and wind speed were applied. Results show that the most comfortable climate is during April-November. It was found that the intensively-spaced buildings with a predominantly northern-southern facing are suitable. Design modification, particularly on type and dimensions of windows can improves the conditions. Results highlight the significance of using bricks for inner walls, outer skins and roofs, rendering efficient heat exchange and insulation. This allows a delay periods over 8 hours ensuring sound ambient and comfort.
Keywords: Climatic comfort, conditions, Dezful, effective temperature, Mahoni.

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INTRODUCTION

Today, urban development, urbanization and importance of climatic conditions in designing the settlements at urban, suburban and rural regions has made rigorous planning that bears the climatic considerations in ensuring sufficient comfort for the occupants very crucial. Given the importance of climatic conditions in emergence of particular life-style for the urban dwellers, regardless of whether they follow open or closed-space way of living, the climatic conditions can have different effects on these two ways of life [1]. This can materialize with four climatic variables that play a significant role in determining the scale and nature of human comfort in open space. These include temperature, wind, humidity and radiation.

The term comfort is used here to refer to a temperature regime which at least meets the quality of life-style sought by at least 80 percent of the dwellers. In other words, it refers to circumstances by which the people feel bio-comfort without feeling either the extreme cold or warm temperatures. [2]. under such conditions, the physiological organisms in human body have the in-build natural system to maintain a pre-determined thermal balance while regulating the energy regime in the body. There are four factors temperature, humidity, wind and radiation that they have important role in climatic viewpoint in terms of human comfort. Among these, the temperature and humidity have more influence than other two on bio-comfort [3].Temperature and wind can be considered as more influential factors than other two in establishing and ensuring human comfort. And as such, the comfort in closed environments can be established by opting for an appropriate building orientation as a means of minimizing or mitigating the adverse effects of temperature, wind and other climatic variables. This necessitates the incorporation of crucial climatic factors such as the radiation, temperature, precipitation, relative humidity, mean maximum monthly temperature and mean minimum monthly temperature. This should also be in conjunction with the use of effective climatic factors that influences human comforts inside and outside

the building complexes.
Various research investigations have been undertaken in this respect, the results of which have shown the crucial importance of climatic conditions on urban planning, architectural design styles and construction practices for residential centers in general and thermal comfort inside and outside the building complexes [4,5,6,7,8].The importance of bio-climatic conditions for town and urban planning is manifested on other research studies which consider the influence of climatic design for promoting and improving the human comfort inside and outside the building complexes [9]. The effects of micro-climatic conditions on urban and municipal planning in general and their influences on urban design elements in particular, have been studied in Bangladesh [10]. Their study focused on trends in climatic change under those conditions and point out the need for incorporating the climatic elements into consideration in urban planning as a means of achieving optimum environment for bio-comfort of the residences. Others have also investigated similar parameters and specially focusing on comfort assessment criteria, the effects of air flow on human comfort and methods of regulating and conditions with construction components and landscaping architecture, motion and behavioral comfort of architectural building features of complexes. They also investigated the effects of wind on various forms and shapes of building and concluded that landscaping architecture, the orientation of building complexes and wind direction can make a significant influence on bio-climatic comfort of the residents [11, 12]. In another research investigation [13], the effect of climatic condition elements on human comfort in designing the outdoor and indoor residential complexes at Serein using and method were studied. Their results showed that based on the Givoni and Mahoni methods, the night temperature of indoor spaces throughout the year is relatively cold while it is comfortably right during warm periods. Their findings show the major challenge faced by the town dwellers during cold periods which necessitates the provision of special measures like air-conditioning appurtenances in the building complexes. Such measures in their view ,makes it possible for the residents to bear the cold climatic conditions of the region while during the warmer seasons the natural ambient in the city is quite suitable for the modern urban life. The importance of climatic conditions such as the radiation and wind speed and direction on the way in which the building in Gorgan region should be oriented has been investigated by [14]. These researchers founded that the most appropriate building direction in this region for optimizing energy consumption and operational economy in these residential complexes is selection of a predominantly southern to south-western facing complexes. The dwellings having such design features will not only meet the economic and the bio-comfort demanded by the modern life style but can also make them more sustainable. Based on the aforementioned criteria, the paper aims to define the bio-climatic comfort zone and the detrimental fundamental architectural features of the Dezful municipality and city planning parameters.

Area and Discussion

Dezful township has two district (Markazi and Sardasht), its total area is approximately 4700 km^2 and is located in northern Khuzestan province between 32^0 24/ N and 48^0 24/ E. It is bounded by Lorestan province from north, Masjed Soleiman and Shushtar from east, Susa and Shushtar from south and Andimeshk from west.

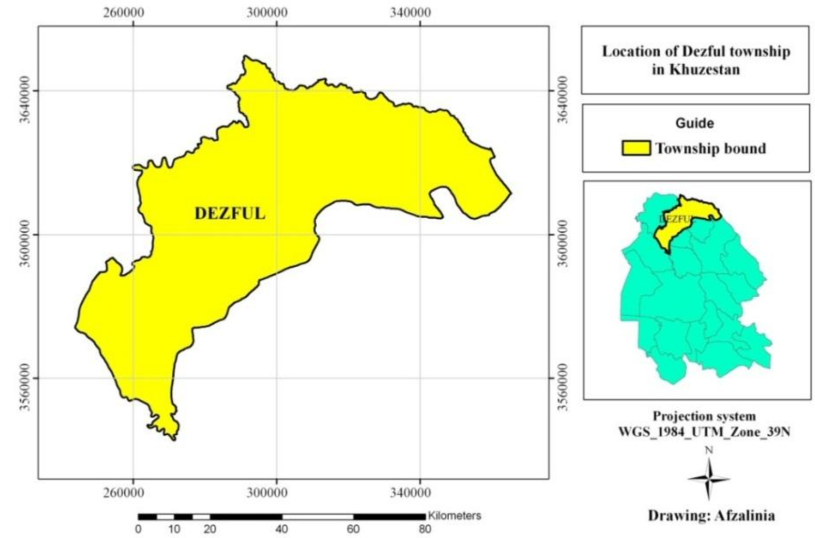

Fig 1. Location of Dezful Township in Khuzestan province

MATERIAL AND METHODS

The methodology involved using descriptive analysis for evaluating the climatic comfort inside and outside the buildings. The data were collected from the synoptic station in Dezful for a twenty years period between (1991-2010). In this study factors related to climate such as mean temperature, relative humidity, precipitation, wind speed and direction, and the sunshine hours were used for this purpose. The Mahoni index for the building bioclimatic factors for the buildings in Dezful was also used. The method involved estimating the comfort range for the days and nights based on average annual temperature, and monthly humidity range. Subsequently the temperature for the days and nights of each month were determined by comparing mean maximum monthly temperatures with comfort range at days with the average minimum monthly comfort range at nights. Given the air temperature condition for each month and the registered data indices for the year were determined. These were used as the basis upon which to determine the temperature condition of the synoptic station, comfort or otherwise for various months in respect of human comfort and dryness or humidity states for each month. The effective temperature indices were also used to assess the human bio-climatic index.

RESULTS AND DISCUSSION

The aim of assessing the human bio-climatic of a region is to determine the effects of climatic elements over human physiology in free environment. The effective temperature index was used for the analysis of the heat condition of the building complexes in the city. The index included calm air temperature and saturated air which makes it possible to have the same effect without radiation. One of the methods for determining effective temperature and comfort coefficient is by applying the equation as follows:

$ET=T-0.4(T-10).(1-RH/100)$ [1]

ET: Effective temperature T (c°): Temperature RH: Relative humidity (%)

The classification order of comfort coefficients are shown in table 1.

Table 1. The resulting comfort coefficient order derived from the above relation

Effective temperature	-20 to -10	-10 to 1.67	1.67 to 15.5	15.5 to 17.8	17.8 to 22.2	22.2 to 25.6	25.6 to 27.5	27.5 to 30
Comfort index	very cold	cold	very cool	cool with comfort	comfort	Warm with comfort	Very warm	Sultry

Table 2. The results of comfort coefficients order for different months in Dezful

Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Effective temperature	12.34	12.62	15.65	19.67	23.03	23.25	28.83	30.19	26.15	24.62	19.87	14.35
Average of Effective temperature	Very cool	Very cool	Cool with comfort	Comfort	Warm with comfort	Warm with comfort	Sultry	Sultry	Very warm	Warm with comfort	comfort	Very cool

Assessing the bio-climatic conditions of buildings

Regardless of the heat-generating elements or heating system appurtenances, the inner building's air temperature is subjected to climatic conditions. The effects of climatic conditions on air temperature of the buildings depend on the construction type, construction size and the features of its outer walls. The Mahoni criteria were used to investigate the human comfort conditions in the building and the effect of climatic conditions on determining the building characteristics.

Mahani index

Using Mahoni index the effect of climatic conditions on formation of the building design and structural features based on architectural components using four table groups were evaluated. As can be observed from table 2(first group of Mahoni), the climatic condition of three months in the year (March, April and November) and the nights on other three months (May, September and October) have desirable climatic conditions, and on days and nights of three months (January, February and December) and night on March, April and November the climatic condition is observed to be cold. Other months are considered to be relatively warm.

Table3. Mahoni group table1

Name of location	Dezful
Latitude	48/23
Longitude	32/27
Height of sea level	143 m

Table 4: Mahoni index.

Months and Factors	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
The average monthly maximum temperature	17.68	18.03	23.58	28.94	35.51	38.75	45.65	45.51	40.34	36.65	28.41	20.93
The average monthly minimum temperature	7.57	8.02	9.89	14.78	19.15	24.06	27.57	29.67	23.09	24.21	33.15	10.05
The average monthly temperature fluctuations	11.10	11.10	13.69	14.16	14.69	18.08	15.75	15.84	17.25	15.41	13.08	10.88

Table 5. The Mahoni group humidity index

Months and Factors	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
The average monthly maximum temperature	90	88	80	76	61	47	46	53	58	68	83	91
The average monthly minimum temperature	58	46	38	32	17	9	8	13	14	18	31	51
Average	74	67	59	54	38	28	27	33	36	43	56	71
Humidity group	4	3	3	3	2	1	1	2	2	2	3	4

	Humidity group
1	Relative humidity less than 30%
2	30 to 50%
3	50to 70%
4	More than 70%

The highest temperature	45.65
The lowest temperature	7.57
The total annual rainfall	307.33

Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Rainfall mm	57.95	46.31	40.23	35.38	18.76	1.85	0	0	0	4. 4	24.16	75.29

Months	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Prevailing winds	9.5 E	10.25 E	11.15 E	13.7 SE	12.6 SE	10.15 SE	9.25 W	7.5 W	8.3 W	8.7 W	11.05 W	12.05 W
Secondary winds	W	W	W	W	W	W	SE	SE	SE	NS	NS	NS

Table 6: Tables 2 of Mahoni group

	Average annual temp>20 ⁰C		Temp between 15⁰-20⁰		Temp < 15⁰C	
Humidity group	Day	Night	Day	Night	Day	Night
1	26-34	17-25	23-32	14-23	21-30	12-21
2	25-31	17-24	22-30	14-22	20-27	12-20
3	23-29	17-23	21-28	14-21	19-26	12-19
4	22-27	17-21	20-25	14-20	18-24	12-18

Table 7:.The air temperature condition in Mahoni Index

Months and Factors	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Average monthly maximum	17.68	18.03	23.58	27.73	35.51	38.75	45.65	45.51	40.34	36.65	28.41	20.02
The upper comfort limit(day)	27	29	29	29	31	31	31	31	31	29	29	27
The lower comfort limit (day)	22	23	23	23	25	25	25	25	25	23	23	23
Average Monthly minimum	7.57	8.02	9.89	13.66	19.15	24.06	27.57	29.67	23.09	21.24	15.33	9.67
The upper comfort limit(night)	21	23	23	23	24	24	24	24	24	23	23	21
The lower comfort limit(night)	17	17	17	17	17	17	17	17	17	17	17	17
Air temperature condition(day)	Cold	Cold	Suitable	Suitable	Warm	Warm	Warm	Warm	Warm	Warm	Suitable	Cold
Air temperature condition(night)	Cold	Cold	Cold	Cold	Suitable	Warm	Warm	Warm	Suitable	Suitable	Cold	Cold

Table8. The dryness or humidity indices in each month

s Month and Indices	Jan	Feb	Apr	Dec	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
Humidity H1													0
H2													0
H3													0
Dryness A1		*	*	*	*	*	*	*	*	*	*		10
A2					*	*	*	*	*	*			6
A3	*	*										*	3

The next stage the number of months which have been identified based on index such as dryness and humidity are analyzed in the propose tables of construction details as follows:

Table 9. Mahoni's preliminary proposals

Study area		**indices Heat condition**					
Mahoni's architectural preliminary proposals		A3	A2	A1	H3	H2	H1
		3	5	10	0	0	0
Settlement style							
• 1-Length of the building along the east - west	1			0-10			
		5-12					
2-Intensive architecture incorporating yard	2	0-4		11,12			
Intervening spaces between buildings							
3-Collection of wide and open for yard	3						11,12
4-As above-Conditioned to avoid of cold and warm wind	4						2-10

• 5-The collection of intensive	5						0,10
Circulation inside a building							
6-Single arches for air flow	6						3-12
				0-5			1,2
7-Serial arches and air flow forecast	7			6-12			
						2-12	0
• 8-Secific air flow not required	8					0,1	
The windows							
9-Larg windows 40 to 80%	9			0			
10-Very small windows10 to 20%	10			0,1			
• 11-Average windows20 to 40%	11			All other conditions			
The walls							
12-Light walls-short delay periods	12			0-2			
13-Heavy walls-internal and external	13			3-12			
The roofs							
14-Light roofs-thermal insulation	14			0-5			
• 15-Heavy roofs- a delay periods over 8 hours	15			6-12			
Night sleep outdoors							
• 16- Required space for night sleep	16		2-12				
Protection against the rain							
17-Necessary protection against the rain	17				3-12		

Table10.proposed Mahoni architectural details

Thermal condition indices								
Station name		A3	A2	A1	H3	H2	H1	
Dezful		3	5	10	0	0	0	
Orit size, light penetration, window								
Northern and southern walls area :40 to 80%	1				0	0,1		
Average: wall space 25 to 40 %	2				1-12			
						2-5		
Small: wall space 15 to 25%	3					6-10		
					0-3			
Very small: wall space 10 to 25%	4							
						11,12		
Average: wall area 25 to 40%	5				4-12			
Aperture location								
Wind –facing north – south walls with human height								3-12
	6				0-5			1-2
Fix in the inner walls as above	7				6-12			
							2-12	0
Aperture protection								
Requires protection from direct sun radiation	8		0-2					
Requires protection from rain	9					2-12		
Walls and floors								
Light, low heat capacity	10				0-2			
HHeavy- a delay period over 8 hours	11				3-12			
The roofs								
Light, reflecting and double glazing surfaces	12				0-2			10-12
Light-proper insulation	13				3-12			
					0-5			
Heavy- a delay period over 8 hours	14				6-12			
External space								
• Outdoor sleeping area	15			1-2				
Adequate provisions for draining runoffs	16					1-12		

Mahoni method analysis

Having determined the temperature range over the seasonal periods at the synoptic station, and specifying the human comfort and discomfort in respect of climatic conditions at the structural complexes under study, the dryness or humidity of each month were determined and the results are illustrated in table 4.

As can be observed from the tables, February, March, April ,may, June, July, August, September ,October, November are categorized as the humid group 2 or 3 with a ten degree centigrade temperature variation. For this reason, A1 was used as their dryness index. Because during the night in May, June, July, august and September the weather is warm during which the humidity group is 2, therefore the A2 index was selected for these months. The A3 was used for dryness index of other months.

The factors related to humidity index in the region were not available because of the decreased relative humidity under warm climatic condition of the station. Generally speaking, it seems that the layout of residential and commercial complexes should be designed according to the Mahoni's four-table which have a predominantly intensive texture.

Moreover, results also show the direct effects of solar radiation in such a manner to bear in mind the optimum intervening spaces between the buildings as a means of best utilizing the shading factors. For this purpose, it was found necessary to determine the direction of the buildings and their facial architecture as a means of optimizing the light penetration features in the buildings of the region and ensuring ideal ambient for their residents. Results show the northern-southern facing buildings as the most desirable direction to ensure optimum bio-climatic environment for the residents. In other words, under such circumstances, the most desirable bio-climatic conditions can be achieved by designing the architecture of the building in such a manner to have its long axis having an eastern-western direction. This is likely to make it possible to optimize the direct radiation of the sun for the warm and cold seasons.

One of the ways in which to improve the architectural design of buildings required to optimize the lighting management is to design the facial aspect of such structures to constitute preferably an area ranging between 15 to 25 percentages of the total structural skin. Another consideration is to select heavy construction materials for internal and external walls and roofs in order to ensure an 8 hours delay or time laps between the time of the building being exposed to the direct solar radiation and the time it penetrate inside the structure. Under circumstance, where relevant factors are considered in the design of structural architecture, a desirable and comfortable outdoor environment can be established for the residents to rest and sleep during five months of the year.

CONCLUSIONS

Results of the bio-climatic conditions in Dezful in respects of structural features and climate based on effective temperature index [1] show that bio-climatic comfort in this region is attributed to April and November. This is against the results of Mahoni index suggested by [15], whose study shows four warm months for Dezful. This necessitates special structural design features in such a manner to overcome and mitigate the shear heat generated by direct exposition of the buildings to radiation. For this reason, almost all such structures are equipped with appropriate air-conditioning devices in order to regulate the inside temperature coupled with suitable insulation provisions for effective heat convection purposed. Results therefore show the appropriateness of designing more intensively-spaced structural textures consisting of windows with windows constituting 15 to 25 percentage of total structural skin surface. It was further shown that the most appropriate structural design is to opt for the north-south facing direction.

The major recommendations for improving the bio-climatic quality of the people using the architectural structures in Dezful can be listed as follows:

The architectural features of the building complexes in Dezful should be more space -intensive with plenty of shedding features by plantation of a tick vegetation cover to regulate direct penetration of sun-light inside the structures during particular seasons when the shear heat can be a real challenge. Thus in order to establish a desirable public route system complemented by plantation of ever-green vegetation covers and trees with ample shading to mitigate the effects of direct sun-rays on the building structures.

The most appropriate architecture is incorporating a design that has a south-north facing feature.

Incorporate structural materials that provide sufficiently desirable insulation cover in the structural components as a means of providing bio-comfort for the dwellers.

The painting should preferably be of light type and avoiding the use of dark color construction materials.

Minimize the use of glasses for the windows and outdoors and if possible incorporate double-glazing windows for the doors and windows.

Use the covered pathways around the main municipal centers squires and roundabouts.

Use the canopies as a shade-generating element in the architectural structures of the building complexes to enhance their bio-climatic comfort quality. Enhancing the environmental quality of the surroundings by planting appropriate vegetation cover using ever-green varieties.

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