

## **Modeling Architecture Compatible with Climate for Tabriz City in Iran**

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**ABSTRACT**— In contemporary era, climatic approaches are considered in architecture designing. The objective of present research is architecture modeling compatible with climate for Tabriz in Iran based on 4 models Olgyay, Givoni, Evans and effective temperature. Determining suitable direction of building and suitable size and depth of sunshades will help decreasing pollution and environment's saving for using environmental potentials in saving energy consumption. Research methodology of this survey is based on architecture modeling compatible with climate in four models mentioned above. The result of this research show that thermal comfort is just 24% in Tabriz and offering climatic solutions in designing is necessary. Use of heating devices in nights of November till May is necessary. Building should be built in East-West direction. Size of windows is medium and it will be assigned maximum 20 to 40% of wall's area. For preventing from fast transferring outside coldness, walls will be considered with heavy materials with delay time of 8 hours or more. Suitable direction of building in Tabriz according to maximum use of radiant energy of sun in winter and direction of dominant wind (East to west and eastern north to western south) and summer desirable wind (western south to eastern north and eastern north to western south) is 50 west. Size of sunshade of southern wall is 25cm according to climate of this city. Resultant findings of this research can use for codifying architecture compatible with climate in Tabriz.

**KEYWORDS:** architecture compatible with climate, climatic modeling, Tabriz city, climatic comfort limitations.

### **Introduction**

In natural history, general rule is that just types and forms can continue their life which can adapt itself with environment (Kasmaee; 2004:Page116). Since human created, he tried to build a shelter for resolving his own needs. In this way, for achieving his aims, he followed plans that were based on climate (Shaterian; 2009 Ghobadian; 2005). With occurring industrial revolution and technology appearing and usage possibility of Fossil fuels and mechanical systems, there were some disorders in climate designation and native buildings and then overusing of fossil fuel causes spreading greenhouses gases and warming earth that would have irreparable damages to human environment. So knowing human's comfort area related to climatic materials (like weather grade, sun's radiation, damp and wind) and determining suitable direction for building related to these materials will help environment and preventing from its pollution. Building's part assigned more than one third of Iranian consuming energy. In this way architecture compatible with climate will be a suitable solution for attaining to comfort conditions with using of natural materials inside of building. (Razjooyan; 2009) Attention to way of building's interaction with climate is as important points in process of architecture designing. (Okeil A 2010, Albatici, Passerini, 2011) On the other hand making warmth comfort and climate for improving and satisfying spatial users lead to considering actions of architecture space (Valerie, Guedi, 2009). Using of suitable weather conditions will result in improving energy in buildings. (Ekaterina, Nikolai, Vera, 2015). In fact nowadays they would pay attention to climate comfort seriously (F.El-Gohary, Fahmy, El-Bardisy, 2016).

### **Importance and necessity of research**

Climate importance: according to increasing importance of global warmth crisis and thinning Ozone Layer, architecture compatible with climate suitable solution climate for achieving to comfort conditions that using of heating and cooling mechanical devices and energy consuming and finally decreasing pollutions will be followed. Economic importance: because of expensive and limitation of fossil fuels, attention to climatic designing for decreasing fuel usage in buildings is necessary.

The importance of architecture designing: native architects of this land recognized human's comfort conditions related to climatic materials as well and will be used maximum. Looking at present architecture of our country show that because of following western styles will be ignored most of climatic designing basis and supplying comfort's condition inside the building without using mechanical devices is impossible. So duty of each architect in present world is using of past experiences and with analysis of these factors some suitable solutions will be used in energy saving and using of available and free savings.

### **Research objective:**

Offering solutions for architecture designing compatible with climate of Tabriz in Iran

**Research Question**

What are architecture designing solutions compatible with climate in Tabriz?

**Research methodology**

Research methodology of this research is analytical survey. In this research at first we got climatic characteristics of this area with conveying 30 years meteorology statistics in Tabriz (1959-2010). In this survey, some climatic parameters are used like radiation, temperature, raining, relative damp, steam pressure, average monthly maximum temperature, and average monthly minimum temperature... according to analysis climatic factors, weather main characteristics of this city is achieved. Then by use of weather characteristics and climatic materials, the limitations of thermal comfort is conveyed by use of Olgyay, Givoni, Mahoney, Evans and effective temperature and the best condition of thermal comfort is achieved for different seasons. Then by considering effective parameters of wind, radiation angel and condition of sun will present some directions in a way of best posture of buildings, sizes of windows, conveying the condition of sunshades and depth determining and their suitable size.

**Study area**

Tabriz is center of eastern Azarbaijan province, in 620 Km western north of Tehran and almost in geographical center of eastern Azarbaijan province is stated on the vast plain in 50 Km of eastern Orumieh Lake and a branch of Talkheh Rood (Aji Chai) by the name of Mehran Roud will pass among city. In table 1 data of Tabriz is brought. (Heidari; 2010: page 38) Table- Tabriz geographical data

Height from sea	Geographical width	Geographical length
1364 m	38.13°	46.28°

Reference: Heidari; 2010; Page 39

**Table1-** Meteorology statistics of Tabriz during years 1959-2010

	January	February	March	April	May	June	July	August	September	October	November	December
<b>Maximum average temperature</b>	2.5	4.46	8.99	13.24	19.33	27.14	33.24	33.65	30.65	24.59	16.31	10.39
<b>Minimum average temperature</b>	-4.36	-5.4	-0.6	3.46	9.19	14.52	19.6	20.23	16.96	10.96	3.9	-1.14
<b>Average temperature</b>	-1.24	-0.75	3.98	8.20	14.17	21.3	26.27	26.74	25.69	17.57	9.79	4.28
<b>Maximum damp</b>	82.94	85.36	80.74	74.94	77.77	73.24	51.07	40	54.2	63.45	69.67	72.63
<b>Minimum damp</b>	55.13	48.98	43	34.39	36.57	15.98	17.09	16.44	20.73	23.26	34	39.73
<b>Average damp</b>	69.93	67.86	62.44	54.42	56.71	44	33.64	30.26	36.85	43.25	52.5	57.26
<b>Monthly raining</b>	15	16.92	42.18	38.65	69.70	17.94	4.2	2.01	14.2	9.79	16.45	11.73
<b>Sunny hours</b>	128.38	161.355	166.03	205.44	225.1	319.64	359.71	345.04	328.29	248.21	215.08	175.32
<b>Glacial days numbers</b>	26	25.5	17	3.88	0	0	0	0	0	0	4.6	18.78
<b>Dominant wind direction</b>	NE	NE	NE	SW	SW	SW	NE	NE	NE	E	E	E

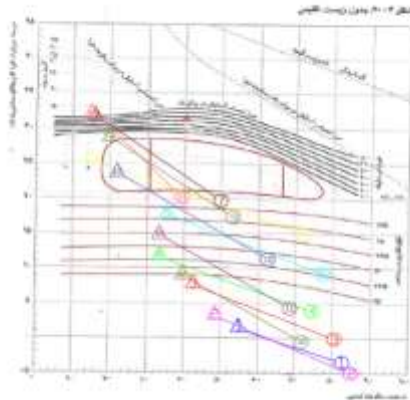
Reference: meteorology organization of eastern Azarbaijan province

**Thermal comfort**

Thermal comfort of human will be said to the condition that a human is in thermal comfort condition mentally and intellectual (Watson; 2005, page 29) in other words thermal comfort s said to the condition that human’s body doesn’t need heat loss and even absorbing it. The most important effective factors on human comfort’s feelings are as below: 1- temperature 2- weather damping 3- environment radiation temperature 4- weather flow 5- activity rating 6- cloth. Among these 6 factors, four parameters are related to environmental factors and the other two factors are individual characteristics. The other factors are such as age, sex, environment color and climate conditions which has no more effect on thermal comfort feelings (Watson; Kasmaee; 2004. Fiabelo; 2001)

Estimating methods of thermal comfort limitation of human in Tabriz

1. Chart of Olgyay climatic biology

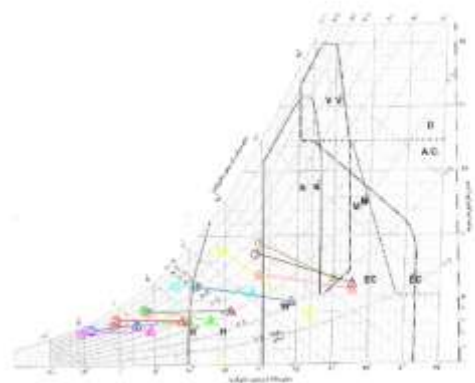


**Figure 1-** Continental biological table

Triangles show the comfort condition of days and circles show the comfort condition of nights. Numbers show respectively number 1, Dey (Jan.) month and number 12 is Azar (December). By writing statistics of average temperature and monthly average damping of Tabriz according to (Table 3) in Olgyay chart will be achieved (based on maximum average temperature and minimum damp of days' comfort condition and based on minimum average temperature and maximum damping comfort condition in nights are conveyed):

1. People of Tabriz in fresh air are in comfort just in days of June, September and October.
2. In days of March, April, November and December will achieve to comfort level in front of sun.
3. In days of July and August with air flow or damping environment will achieve to comfort.
4. In nights of all months of year we should use heating devices.
5. Nights of July, February, March and December should be mechanically warm and this need a closed environment.

2. Chart of biological-climatic Giuni structure



**Figure 2-** Biological-climatic structure chart of Tabriz

Results of Giuni climate al-biological chart for Tabriz:

- 1- The weather of building in point of comfort in Tabriz in days of April, May and September will be desirable.
- 2- In days of July and August in buildings with thick walls and insulating roofs the comfort condition will be suitable.
3. In days of March and November the weather of outside is cold but inside of building is warmer than out and there is no need of heating source and use of suitable materials will supply building's warmth.
4. During December to March comfort sense in building is possible just by use of heating devices.
5. It is necessary to use heater in nights of September to May.

6. In nights of June to September by use of 8 hours heating delay of walls can prepare comfort conditions.

3. Evans index

Evans for determining comfort area, the relation of weather's dry temperature will be determined by relative humidity (in four groups 0-30%, 30-50%, 50-70%, 70-100%, air flow, inappreciable (0.1 m/s) to appreciable (1 m/s); activity (rest or domestic light workings); clothing (summer style clothes and winter style clothes inside of home).

**Table 2-** Comfort area of Tabriz with Evans index

December	November	October	September	August	Jul	June	May	April	March	Feb.	Jan		
28.5	28.5	29.5	29.5	29.5	29.5	29.5	28.5	28.5	28.5	28.5	27.5	Scale A	Day Comfort area
30.5	30	32.5	32.5	32.5	32.5	32.5	32.5	30.5	30.5	30.5	29.5		
22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5		
28	28	30	30	30	30	30	28	28	28	28	27.5		
18	18	18	18	18	18	18	18	18	18	18	18	Scale C	
22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5		
25.5	25.5	26	26	26.5	26	25.5	25.5	25.5	25.5	25.5	25.5	Scale A	Night comfort area
28	28	28.5	28.5	29	28.5	28	28	28	28	28	28		
20	20	20	20	20	20	20	20	20	20	20	20	Scale B	
25.5	25.5	26	26	26.5	26	25.5	25.5	25.5	25.5	25.5	25.5		
16	16	16	16	16	16	16	16	16	16	16	16	Scale C	
20	20	20	20	20	20	20	20	20	20	20	20		

Reference: from writer

**Table 3-** Condition of Tabriz in Evans triples scales

December	November	October	September	August	July	June	May	April	March	Feb	Jan	Heating conditions in scales	
cold	cold	cold	comfort	warm	comfort	cold	cold	cold	cold	cold	cold	A	day
cold	cold	cold	comfort	warm	warm	comfort	cold	cold	cold	cold	cold	B	
cold	cold	comfort	warm	warm	warm	warm	comfort	cold	cold	cold	cold	C	
cold	cold	cold	cold	cold	cold	cold	cold	cold	cold	cold	cold	A	night
cold	cold	cold	comfort	comfort	comfort	cold	cold	cold	cold	cold	cold	B	
cold	cold	cold	comfort	warm	warm	comfort	cold	cold	cold	cold	cold	C	

Reference: from writer

**Table 4-** Weather condition in Tabriz with Evans index

December	November	October	September	August	July	June	May	April	March	Feb	Jan.	Heating conditions in scales
cold	cold	comfort	comfort	warm	warm	comfort **	comfort ***	cold	cold	cold	cold	day
cold	cold	cold	comfort	comfort	comfort	comfort	cold	cold	cold	cold	cold	night

Reference: from writer

**Table 5-** Different conditions of weather and architecture guidelines compatible with them

Architecture guidelines for condition settings of inside weather of building	Temperature frequency during day	Studied condition	Damping average		Temperature average		Weather conditions and situations
			Minimum	Maximum	Minimum	Maximum	
Necessity of air flow	-	Day with comfortable scale A and with warm Scale B	More than 70%	-	-	More than 27°	1- high temperature and relative humidity during day
	10° or less		% 50-70	-	-	More than 27.5°	
Building parts with warming capacity and delay time	-	Warm days	% 0-30	-	-	More than 32.5°	2- high temperature and high frequency during day
	-		% 30-50	-	-	More than 30.5°	
	More than 10°		% 50-70	-	-	More than 29.5°	
Necessity of being mechanical devices for heating and cooling	-	Warm days	% 0-30	-	-	More than 38°	Severe discomfort
	-		% 30-50	-	-	More than 37°	
	More than 10°		% 50-70	-	-	More than 35.5°	
	10° or less		More than 70%	-	-	More than 32°	
Suitable warming condition	More than 10°	Comfort days	% 0-30	-	More than 10°	Less than 32.5°	4- comfort days and nights but with high frequency of heating during day
	More than 10°		% 30-50	-	More than 10°	Less than 30.5°	
	More than 10°		% 50-70	-	More than 10°	Less than 29.5°	
	More than 10°		More than 70%	-	More than 10°	Less than 29°	
Building saving from severe wind and radiation							5- daily comfort
Adequacy of building parts with heat capacity in itself		Fresh	-	-	-	15-18grade	6. low temperature during day
No necessity of thick insulation and adequacy of temporary heating devices		Cool	-	-	-	10-15grade	
Necessity of suitable insulation and permanent heating device		cold	-	-	-	Less than 10°	
Necessity of air flow	-	Cold nights	-	More than 70%	More than 25.5°	-	7. high temperature and high damping during day
	10° or less		-	% 50-70	More than 26°	-	
Building parts with high warm capacity	-	Warm nights	-	% 0-30	More than 27.5°	-	8. high temperature and low damping during night
	-		-	% 30-50	More than 26.5°	-	
	More than 10°		-	% 50-70	More than 26°	-	
Necessity of good insulation with average or high temperature capacity in building		Cold nights	-	-	Less than 10°	-	9. low temperature during night

**Table 6-** Assessment of weather condition during year

December	November	October	September	August	July	June	May	April	March	Feb.	Jan.	Weather condition
												1. high temperature and high damping
				✓	✓							2. high temperature and high frequency of temperature during day
												3. severe discomfort
		✓	✓			✓	✓					4. comfort day and night but high frequency of temperature during day
												5. day's comfort
												6. day's low temperature
✓	✓							✓	✓	✓	✓	7. high temperature and high damping in night
												8. high temperature and low damping in night
✓	✓							✓	✓	✓	✓	9. low temperature in night

Reference: from writer

**Results from Evans index:**

1. Necessity of suitable insulation and permanent heating device from (November) to (March)
2. Suitable heating capacity in (April), (June), (September) and (September).
3. Building's parts with heat capacity and delay time in (July) and (August).
4. Effective temperature

According to conducted surveys in Tabriz, main necessity of building in this climate is sun's radiation during cold months of year. According to above-mentioned tables the most confirmed energy is in vertical level 5° in west (vertical line on main face of building, 5° from southern axis to western side will be deviated.) This side according to dominant wind of Tabriz which is east to west and eastern north to western south and comfort wind from western south to eastern north is suitable.

5. Computing size and depth of sunshade

For preventing from entering sun's radiation energy inside of building during warm period of years based on maximum hour of sun's radiation on southern wall (according to table 21 at 12 am.) sunshade for this wall will be designed according to below formula:

$$D = \{h \cos(Z+N)\} / \text{tg}\beta$$

H: height or length of shadow in terms of meters

D: Depth of sunshade in terms of meters angel

N: angel between vertical line on window and south is fact.

Z: Radiation's side

β: angel of radiation

$$D = \{1.2 \cos(180+175)\} / \text{tg} 78 = -0.25 \text{ m} = 25 \text{ cm}$$

For assuring that aforesaid sunshade won't prevent from sun radiation inside of room in winter, we should count depth of sun's influx inside of room and height of shadow which is in result of sunshade's depth in southern window on first day of Dey (Jan.).

$$L = H / \text{tg}\beta$$

Which in it,

L: depth of sun's influx inside of building in matter of meters

H: Height of window's roof from building's floor in matter of meters

β: angel of radiation

$$L = 2.8 / \text{tg} 78 = 0.59 \text{ m}$$

$$h = D \text{tg}\beta / \cos(Z+N) = 0.25 \text{tg} 78 / \cos(180+175) = 1.18 \text{ height of shadow in terms of meters}$$

$$\text{tg}\alpha = 1.18 / 0.25 = 4.72$$

$$L = h / \text{tg}\alpha = 2.8 / 4.72 = 0.59$$

## Conclusion

From collection of aforesaid sections, below conclusions will be intercepted via architecture compatible with climate of Tabriz: doing surveys in Tabriz show that 72% of conditions in cold temperature condition, 24% of condition in thermal comfort condition and just 4% of the year is stated in warm conditions which shows cold condition of the area and should be designing solutions compatible with these condition. In this city only in (June), (September) and (September) is comfortable in fresh air and inside of building by use of suitable heating capacity can get to comfort. In days of (March), (April), (November) will be get to comfort in front of sun but inside of fresh air with air flow or damping environment can get to comfort and inside of buildings with thick walls (suitable warm capacity and delay time) and insulation level is suitable in comfort condition. In Azar (December) to (March) is possible just by use of heating devices and necessity of insulation. Using of heating devices in nights of (October) to (April) is necessary. In nights of (May) to (September) by use of 8 hours heating delay walls can prepare comfort condition. Housing designing solution is compatible with climate in Tabriz City as below: building should be built in western-eastern side. Space between buildings is considered compactly. Average and maximum size of windows 20 to 40% of wall scale is assigned and it's better to put them in northern or southern walls especially when dominant eastern north or western south wind. For preventing from fast transferring out cold, walls with heavy materials with delay time about 8 hours or more will be considered. Roofs will be built by heavy materials and delay time more than 8 hours and a space will be planned for sleeping out during summer cool nights. Suitable side of building in Tabriz according to maximum usage of sun's radiation energy in winter and side of dominant wind (east to west and eastern north to western south) and desirable wind in summer (western south to eastern north and eastern north to western south) is 5° western. Size of southern wall's sunshade is 25 Cm according to climate of this city.

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