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Structural Investigation and Analysis of Housing in Terms of Energy in Ardebil City

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ABSTRACT

Across the world, buildings consume 40% of energy, 16% of potable water and 25% of jungles wood. Urban housing has a considerable share of energy consumption. Energy shortage and environmental crises warnings- dissemination of 50% of carbon dioxide by buildings- and need for sustainable development have made Iranian government to revise energy consumption and section 19 of national building regulations is dedicated to energy consumption in buildings.

The present paper investigates dimensions of the present status of Ardebil City housing and analyzes these dimensions with respect to energy. Finally, some solutions are recommended and an appropriate model is proposed for buildings in Ardebil City.

KEYWORDS: building, energy, housing, Ardebil

INTRODUCTION

Man has always tried to get prepared against climatic disasters (factors and elements) and reach comfort. This comfort which involves heating, cooling, moisture and illumination aspects is usually satisfied by architecture solutions and strategies using construction material (Towers, 2005). Compression, location and standard form of our houses and buildings play important role in determination of energy demand (ministry of housing and urbanization, National building regulations preparation office, 2009). Successful regulation of life, exercising buildings regulations and use of sustainability standards is now a basic duty.

Future buildings are expected to observe four rules in relation to energy (Towers, 2005):

-first, energy saving: energy consumption in buildings should be diminished. Urban housing consumes energy reserves. However, some basic innovations have been made in order to access higher levels of insulation, use of sunlight energy and improvement of ventilation efficiency. These innovations can save energy via consumption reduction.

-the second rule is development of energy production via renewable resources. Although this is an important subject and is concerned with governments' policies, this can be implemented using new technologies and equipment of energy production in houses or groups of houses.

-the third rule is water management and methods of water recovery in buildings.

-the fourth rule is protection of resources which are being ruined and protection of environment which involves selection of appropriate materials for buildings and it also involves better design for improvement of health and environmental distribution.

New solutions can have advantages for reduction of energy waste, meet new buildings demands and improve environmental health. The present paper investigates relationships among structure, environment and energy consumption in Ardebil urban housing. It introduces and reports climatic-geographical characteristics, structural texture-construct and different aspects of energy consumption. In the end, we recommend a solution (solar inactive building plan) for desirable model. Different factors are important in optimum design and plot section and determination of access routes of housing units (Toudert, 2005). These factors are classified in two groups:

Socio-economic and cultural factors, environmental factors.

Socio-economic and cultural factors include people's customs and beliefs, municipality regulations, economic power and so on.

Environmental factors are divided in two groups, the first group includes natural and man-made status of plot like topography, slope, land material and so on. The second group is climatic conditions of the region like sunlight radiation angle, heat, intensity and direction of wind, precipitation and so on (Lamberts, 2003).

In the present research, optimum direction is determined only from climatic dimension and is concluded in the following four pivots:

Ardebil climatic indices in relation to design

Optimal building direction, optimal passages direction and structural-architectural dimensions

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Ardebil Geographical situation

Ardebil City has an eastern longitude of 48 degrees and 39 minutes- 47 degrees and 48 minutes and northern latitude of 38 degrees and 33 minutes-37 degrees and 56 minutes and is the center of Ardebil province in north-west of Iran. Arasbaran, Qeisirdagh, AqonDagh, QizilGoul, Bozgoush and other mountains in Ardebil province have all made the climate of this region very cold. During different seasons, Ardebil province is influenced by three climates (Siberian climate, moderate climate and northern air flux). The impacts of the mentioned climates on Ardebil weather are as follows: (Design and Exploration Engineering Company. 2005, summary of report of comprehensive city plan on present condition)

- cold and semi-humid, in western, southern and central parts of province
- cold and humid, in foothill parts of province
- moderate and semi-dry, in northern parts of the province

Ardebil city climate is moderate and cold.

In city area and especially in foothill areas of Ardebil, when autumn starts and cold air mass arrive from cold areas of northern semi-sphere, weather temperature drops rapidly ad this temperature reduction trend continues until late January and when February begins, cold intensity decreases and temperature rises gradually. When autumn starts and northern high-pressure masses come to lower latitudes, precipitation is facilitated. First, precipitation is high and in December, January and February, monthly precipitation decreases and when weather starts warming from March to late May, precipitation increases and precipitation decreases from June to September in which precipitation is low all over Iran. due to neighborhood to Caspian Sea and presence of humidity resources, mountainous areas and snowy mountains along with rainy air mass has caused reduction in moisture even in warmest months of a year. Wind direction in January and February is south-western in Ardebil. In March and spring and summer and beginning of October, eastern wind is dominant (Design and Exploration engineering company, 2005).

Buildings structures in Ardebil City

The following points must be regarded when investigating structure of urban buildings:

- materials used in buildings
- structure of houses
- quality of buildings in terms of being new, usable, repaired or being distressed
- quality of wellbeing facilities like Gas, electricity, water and so on.

Quality of structure of houses in Ardebil

One of the important indices in structure of houses in Ardebil City is quality of structure and type of materials. City buildings are average in terms of structure quality. It can be said that during the past few years, quality of structure of buildings has increased.

Table 1: statistics of construction and materials of residential houses in Ardebil in different years

year	sum	Iron-brick, stone-brick	percentage
1998	1140	702	1.97
1995	1244	740	2.08
1994	1227	736	2.07
1993	1267	733	2.17
1992-1995	1461	941	2.64
1991	2479	1712	4.81
1989-1986	13980	10008	28.15
1976- 1986	20318	14676	41.28
1965-1976	6578	4010	11.27
1966	4107	976	Not mentioned
	1003	277	0.77
	54804	35551	

Reference: Iranian Center for Statistics, 2001, people and housing census

Table 2: statistics of houses in Ardebil in terms of Structure

percentage	number	Structure and materials
65	35551	***Iron-brick, stone-brick***
17	9311	**Brick-wood, stone-wood**
11	5880	Metal structure
1.5	851	Adobe, wood
1	623	concrete
1	614	Cement block
0.3	184	Fully wood
0	45	Adobe and mud
0	26	full brick or brick-stone
0	101	other
0	42	Unknown (material)
3	1576	Unknown (structure)

Reference: center for Iranian statistics, 2001, People and Housing Census

Overall structure of residential buildings in different city areas

In 1996, according to Nationwide People and Housing Census statistics, 77% of residential buildings in Ardebil City were built out of strong materials (brick and iron or stone and iron and metal skeleton), 18% of buildings were built out of short-lived materials (brick and wood or stone and wood and cement block and full brick or stone and brick) and 2% of buildings were built out of weak materials (adobe and wood or fully wood) and the remaining buildings are not mentioned in statistics. In 1996, 35551 buildings (65%) were built out of brick and iron or stone and iron and 9311 buildings (17%) were built out of brick and wood or stone and wood (total buildings: 54804 buildings). Furthermore, 5880 buildings (11%) had metal structure and 623 buildings (1%) had concrete structure. The remainder (3.3%) lay in groups like fully wooden, adobe and wood, adobe and other and not mentioned. Due to climatic conditions and cold weather of Ardebil City, materials like brick and stone which have high thermal capacity are used in buildings. According to 1996 statistics, 77% of buildings in Ardebil have materials like stone-brick and iron-iron structure. This figure shows an increase in comparison with previous statistics. 18% of structures of city buildings have been made up of short-lived materials like stone-wood, cement block and wood. Further, 2% of houses have wood and adobe as material. The remaining 3% are not mentioned. Structures of most ordinary houses in Ardebil are made out of brick-iron or stone-iron materials. Statistics show that most these houses have been built in 1967-1976. Most buildings built in 1987-1990 and 1976-1985 have brick-iron or stone-iron structures; i.e. 65% of Ardebil houses have such structures.

Field study samples

Ardebil City buildings have been classified in three categories in field studies:

- newly-built houses, distressed houses, old houses and newly-built houses

Newly-built houses are mainly located in southern areas of the city and towns New Savalan, Karshenasan, Azadi and Hafiz. Houses which have concrete structures and are located in south-western and south-eastern areas of the city have been built on a pre-designed plan. These buildings constitute 2236 Hectares (38%) of total city area.

Old houses are located in central neighborhoods like Pirzargar, Haftan, Ghasemiyeh, Bazar, Tova, Hoseiniyeh, Hoseinali, Zeinabiyyeh and other central neighborhoods. These constitute 3239 Hectares (55%) of total city area.

Further, suburban buildings which have rural structures and have been added to city area as a result of city development have mainly short-lived materials (brick-wood). These houses constitute 26% of city area. In central parts of the city (old areas), materials and structure of most buildings are made out of brick-iron or stone-iron. These houses occupy 46% of total area.

Old houses constitute 7% of city total area and are spread in neighborhoods like Kheir Abad, Yousef Abad, Niyar and Bahar Abad. As it can be seen in table 3, according to 1996 statistics, 48365 houses (88%) have water subscription, 39345 houses (71.7%) have gas subscription (total houses: 54804). Furthermore, 92% of houses which have been built in 1991-1996 have electricity subscription. In 2005, there were 110719 electricity subscribers and 89274 subscribers (80.6%) were residential subscribers. At this very year, total electricity consumption in Ardebil City in one month was equal to 48.5 million KWPH. According to Ardebil Gas Company data, all areas of the city was supplied with gas and gas network map is also present. The number of residential subscribers of Gas Company was 85200 and total gas consumption of the city was equal to 23325000 cubic meters in one month. However, there is no plan for development of gas pipeline network in future and this seems to be necessary for Ardebil Gas Company.

Concerning urban installations, it must be noted that considering climatic conditions and cold weather of Ardebil, gas supply is a must for the city. 57% of buildings which have been built in 1991-1996 have pipeline gas subscription and this figure indicates some kind of progress.

Table 3: ordinary residential buildings in terms of facilities in 1996

Not mentioned	1996	*Sum*	*Facilities*
1003	1140	54804	***Resident in rural and urban areas***
979	968	53368	***Minimum electricity***
372	196	22388	***Minimum telephone***
889	845	48365	***Minimum pipelined water***
731	399	39345	***Minimum pipelined gas***
32	11	720	***Minimum cooler***
8	13	500	***Minimum central heat device***
4	6	263	***Minimum central cooling and heating system***
652	784	39013	***Minimum kitchen***
489	518	28173	***Minimum bath***
989	1128	54451	***Minimum toilet***
880	792	47845	***Minimum electricity and pipelined water***
362	179	21919	***Minimum pipelined water, electricity and gas***

447	501	26311	***Minimum kitchen and bath***
0	0	22	***All above facilities***
0	1	3	***None of the above facilities***
6	3	74	***Not mentioned***

An analysis of city water data reveals the following conclusions:

In 1996, domestic water consumption constitutes 57.15% of total water consumption in the city. This figure increased to 57.30% in 2001 and 57.50% in 2011. According to predictions, domestic water consumption share increases to 57.70% of total city water consumption. Per capita water consumption in Ardebil experienced a 9.25% increase from 138.89 liters per day in 1996 to 151.73 liters in 2011. Predictions show that over a 25-year period (1996-2021), daily water consumption of every person in Ardebil city will experience an increase about 14.5% which is equal to 20.12 liters (from 138.89 liters in 1996 to 159.01 liters in 2021). Estimations show that over this period, about 16.70% of water supply has been wasted.

Table 4: per capita water consumption in a day (liters)

Total per capita (liters per day) in all applications	Water waste (liters per day) in all applications	Per capita domestic consumption(liters per day)	Population	Design year
243.00	40.50	138.89	401121	1996
250.62	41.77	143.59	490375	2001
263.80	43.97	151.73	695063	2011
275.60	45.93	159.01	943210	1400

Reference: Ardebil Province Annual Statistics, 2011

Sewage system

At present, about 20% of urban area has sewage system. On the other hand, because Ardebil drinkable water is supplied by underground reserves and 41 water wells are used to supply water, sewage dumping in the form of injecting in disposal wells will contaminate underground water supplies and adverse impacts of contaminations will be unavoidable in short future (Design and exploration Engineering Company, 2005).

Therefore, development of sewage system is necessary for Ardebil City.

Collection and dumping of rain water in Ardebil City

Collection and disposal of rain water from rooftops and house yards has some problems which are mainly resulted from the followings:

- earth impermeability; this problem causes formation of still water and can cause contamination and disease in Ardebil City.
- low slope of lands which is less than 1% in some areas.
-shortage in sewers in direction of general, main and sectional slopes
- Absence of a plan for collection and direction of superficial flowsof rain water in many city districts (Design and ExplorationEngineering Company, 2005).

If we prepare a plan and appropriate executive direction for directing rain water from rooftops to sewers, re-use of refined sewage for irrigation of farmlands and urban green areas (water cycle and recovery process) will be possible. On the other hand, spread of pollution and diseases arisen from still water will be prevented.

Analysis

Considering the discussions, climatic indices which must be regarded in designing buildings and main streets are as follows:

Change with cold weather, (6 months day and night, 4 months at nights) and prevention from thermal waste in buildings about 2 months per year.

Application of mechanisms for preventing heat waste:

One-minimization of external surfaces which are prone to cold weather

It is better to build houses in compressed manner so that they have only one main face and are stuck to neighboring buildings in other external surfaces (Sharma, 2003).

Avoiding direct relationship between internal and external spaces is also important. Therefore, medium spaces should be built.

Two: application of materials with high thermal resistance

Due to low temperature variations, we recommend use of materials with high thermal resistance. In other words, use of thermal insulation layers in walls and roofs is important (Singh &Akash, 2006).

Use of UPVC windows or double windows and also use of thermal insulating layers within windows with mobile insulating networks at the back of windows (Boil, 2008).

Three- building plan: building plan is better to be built in western-eastern direction and life spaces should be organized in this plan in a way that most spaces receive winter sunlight. Further, it is important to predict

reflecting surfaces in external design and in front of windows in order to use sunlight energy in cold season in passages.

Predictionof considerations regarding houses and passages design in snowy conditions seems to be necessary.

Acquisition of sunlight energy and also use of appropriate materials can lengthen thermal storage of buildings (Meguro, 2005).

Using sun systems and thermal systems, cold conditions can be reduced and comfort can be reached.

Minimization of shadow conditions especially in passages and avoiding undesirable winds especially in cold months is also important. Buildings should be sealed and direction of cold winds should be in idle face of buildings (Wattson, 1997). In other words, wind direction and main building face should make an angle between zero and 22.5 degrees.

Optimal building direction

Considering radiation issues, cold conditions and also regarding wind direction in Ardebil, a south-eastern degree of 30 receives the most sun energy in cold conditions. Moreover, other climatic considerations are also met in these conditions.

Conclusion

Energy saving is an important element in designing which is used for increasing absorbed sun energy. With this in mind, solar inactive house plan is a good solution for favorable housing model in Ardebil. This plan is good for climatic architecture and can respond to the followings:

Building design should be compatible with climatic conditions as far as possible so that natural conditions are used appropriately. Further, building efficiency in unfavorable climatic conditions should be demonstrated so that energy consumed for heating and cooling is minimized. In other words, consumed energy should reach at a normal level and therefore, comfort conditions are satisfied in architecture space.

In addition to heat save, some positive effects of using natural energy are as follows:

- Determination of direction of building
- Total form and volume of building
- Combination and location of internal spaces
- Determination of skylights position
- Ventilation
- Other features concerning climatic solutions
- Prevention from thermal energy waste in buildings

Because internal heat is very important in designing houses in Ardebil, the following recommendations are proposed:

- Reduction in external surfaces contact with cold weather
- Compression of buildings
- It is important to have only one observable face of buildings and in other sides, the buildings should be connected to each other and the side which is in contact with cold weather should not have any opening (door or window).
- Use of medium space between inside and outside of buildings
- It is better to use high-quality materials in order to regulate internal heat of buildings.
- It is better to use insulators between roofs and walls.
- Use of UPVC windows and glasses
- Use of thermal insulators and insulating windows and similar things

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