Minimization of energy consumption based on Vernacular Design Strategies

Shahrbanoo Djalilian and Mansoreh Tahbaz
Architectural Institute, Shahid Beheshty University, Tehran, Iran

ABSTRACT: How can apply traditional rural buildings design to minimize hydrocarbon energy consumption? This research based on following studies:
1- Traditional methods have been employed to design energy compatible rural building.
2- Local climatic condition studies.
To reach a pragmatic solution. First we have chosen two different Iranian province (hot arid, humid and moderate) and studied climatic condition, building specification and design criteria. Then we have examined compatibility of minimization of energy consumption to traditional design method. In conclusion we will introduce some design method, to minimize hydrocarbon energy in rural areas.

Conference Topic: Traditional solutions in sustainable perspective
Keywords: climatic, classification, Iran, vernacular, comfort, shade, ventilation, evaporation, wind, rural, region, questionnaire, database, design strategies,

INTRODUCTION

The theme in the current research is to find rural housing design principles and practices with regard to energy efficiency matters. For this, two hypotheses are introduced:
1- Observation of vernacular design strategies; which include, in most cases, some basic innovations already developed and used by local residents. This has been made possible by means of studying climatic conditions and rural vernacular architecture;
2- Following the studies, it was then feasible to derive housing design guidelines with regard to minimum energy consumption.

Studied in this research are two totally unlike climatic regions of Iran: one is the coastal flats, north part of Alborz Mountains, overlooking of Caspian Sea -- with humid and moderate climate -- and the other is the desert plains, overlooking Iran Central Plateau, south of Alborz Mountains -- with hot arid climate.

The fundamental job lay in the investigation and analysis of vernacular architecture of each region which also concerned geographic, climatic and cultural qualities of that area. Therefore, geographic/climatic classifications were made in the first step, and cultural influences were studied at a later phase in conjunction with architectural analyses.

2. CLASSIFICATION USING METEOROLOGICAL OFFICIAL DATA

Studies started based on meteorological tables were present by local weather stations. In order to analyze climatic conditions and weather fluctuation in an architectural-based context, The Building Bioclimatic Chart [1] was used to assess indoor air quality, and The Penwarden Chart [2] was used to plot outdoor conditions. Also The Wind Chill Factor Chart [3] and equivalent temperature[4] was used as an indicator of sensing air flows at different temperatures and it was used to determine temperatures at which the wind causes sense of a lower temperature than what the thermometer indicates The methodology includes the assessment of critical climatic conditions in each region (hottest and coolest times of summer and winter), comparing data between these regions, classification and finally, drawing differences and similarities. The critical limits thus obtained from the stated charts are as follows:

2.1 THE BUILDING BIOCLIMATIC CHART
1- In contrast with times when thermal comfort of the indoor space is achieved solely by solar heat gain and the time lag caused by thickness of walls and ceilings, the limit at which the use of a heating device becomes necessary is 12˚ C.
2- The limit at which there is no more need of receiving solar radiation is 21˚ C. In fact, it should rather be stopped from entering into the building.
3- The limit at which shading solar radiations no longer suffices for cooling is 26˚ C. Other cooling methods that are varied based on different climatic conditions -- such as natural ventilation, evaporative space cooling and time lag of massive construction -- shall be taken into consideration.

2.2 PENWARDEN CHART
1- The upper limit of comfort while in shade or exposed to breeze is 21˚ C.
2. The upper limit at which shading or airflow in the outdoor space no longer maintains comfort requirements is 25°C. Other methods such as evaporative cooling by means of pools and fountains, or planting trees and green zones can help.

2.3 WIND CHILL FACTOR CHART

1- The limit at which a wind blow produces a chilling sense is 12°C, meaning that lower than 12°C, a wind at the speed of 5 m/s can be quite chilly.

2- The limit at which a breeze at speeds of 1.5-3 m/s creates a chill factor is 4.4°C. This causes us to sense a lower temperature than thermometer's indicator.

After assessment of critical climatic limits according to the building climatic chart, a Building Identification Index was composed for each of the stations.

3. CLASSIFICATION USING VERNACULAR PROPERTIES

This method was used to gather data on rural localities where meteorological tables were not available. It can be used, nevertheless, in conjunction with the existing meteorological data so as to broaden microclimate descriptions. The data for this purpose was collected from another research carried out several years in advance [5].

The questionnaires included information on:

- Questionnaire a: Natural properties (observation)
- Questionnaire b: Climatic properties (interview)
  1. Humidity
  2. Rainfall
  3. Frost
  4. Sky Condition
  5. Winds
- Questionnaire c: Lifestyles in accordance with climate
  1. Behavior, clothing, food, etc. (interview)
  2. Housing efficiency (interview)
  3. Building Condition (observation)
- Questionnaire d: Wild Plants and Crops
  1. Wild Plants (bushes and trees) (observation + interview)
  2. Agricultural crops and cultivation conditions
  3. Agricultural calendar of bushes and trees.
- Questionnaire e: Animals
  1. Insects
  2. Birds (domestic and non-domestic)
  3. Mammals (domestic and non-domestic)
  4. Other.

Also employing a database previously developed [5], we gathered information on:
- Table a: Inanimate substances of the natural environment (General Information, geographic location, topography, land cover, sky conditions)
- Table b: Properties of Wild Plants (Trees and shrubs)
- Table c: Properties of Agricultural Crops (Trees and shrubs)
- Table d: Growth Stages In Plants (Trees and shrubs)
- Table e: Animals (domestic and non-domestic)

After the analysis of local data, they were converted into climatic charts and statistics which then supplemented the previous meteorological tables (Appendix 1).

4. EXPLORING VERNACULAR ARCHITECTURE DESIGN STRATEGIES

The next stage comprised investigation and evaluation of climate control clues and strategies already used in vernacular architecture of the given regions, primarily aimed at reducing heating and cooling loads [6]. These studies indicate the major obstacles present and the way out. Following categories were considered:

a. General Specifications of Buildings
b. Relation between mass and space
c. Shape of urban texture and neighborhoods
d. Specifications of open, semi-open, and closed spaces
e. Openings and windows

The results were then compared to the previously drawn conclusions on climatic status, thus assessing the suitability of the strategies for that particular climate.

4.1 STRATEGIES OF CLIMATE CONTROL: DESERT REGION (Appendix2)

Unfavorable winds demand for more dense textures, smaller courtyards, and more twined passageways to prevent wind from forcing into the building blocks. Houses in this region are of courtyard (atrium house) type. Often the summer and winter living areas sit at opposite wings in a building, or the winter living area sits on a lower floor while the summer living area – consisting of a more densely windowed room and terrace (open space for sleep) at the side or in the front – sits on the upper floor.

In parts where groundwater is abundant due to geographic location, houses are placed inside farming/agricultural lands. They are built on a basic modular system roofed by barrel vaults. Sometimes one module or a half is used as the transition space between the courtyard and the interior; comprising a single or double-loaded semi-open hall called Talar or Soffeh (porch). Garden houses possess summer Soffehs with ample natural ventilation.

Houses are built mainly one story high and roofed by barrel vaults.

The transition spaces between the courtyard and the interior is by means of corridors or Soffehs and Talars.

Night use of the open spaces (e.g. on rooftops) are indeed very common because of the air's dryness and evaporative cooling of the building mass. Small number of yearly rainfalls provides for flat roofs. In areas where roofs are vaulted, a flat layer at the top is built by vaulthing through wider arcs above the existing ones. This in turn provides for double-layered roofs and better insulation.

Using cool and humid cellars is typical during overheated summer days. In some cases, cooling of
the courtyard space is done by letting cool air from the cellar flow out to the exterior through hatches.

To maintain proper airflow inside the house, vents are built into the ceilings so that cool air from the courtyard replaces the warm air accumulated under the vaults in rooms and kitchen.

4.2 STRATEGIES OF CLIMATE CONTROL: FLAT PLAINS (Appendix3)

Buildings in this region normally are single structures and have at least two open sides because of the high humidity in air and soil. In other words, they are surrounded by patios and open exterior space. Multiple openings are built into the buildings' windward and leeward faces.

Houses are commonly one story dwellings set on posts and/or portico space with no basement. Frequently, they are configured into a line of rooms flanked at sides by Ivan s. To prevent damage caused by severe wind-driven rains, a roof overhang extends beyond the walls and covers the Ivan area, thus providing an umbrella-wise protection. Overhangs in the windward sides are usually extended to ground level.

Roofed verandas define a key use of the open space especially during periods of rain. However, where climatic conditions permit, they may well be used as the main living area all year through.

Two-story houses found in some areas are built for the advantage of better cross ventilation in the upper level. This second story is therefore used as the summer living area. Consisting of a room and a roofed hall called Talar that is open at three sides, the lower story however, embraces the winter living area because of its reduced exposure to wind, consequently less thermal transfer with the outside.

Walls are mainly of brick or mud-brick, and roofing of wood laths, tiles, metal sheets or chaff of rice applied on gable roofs that have proven to be well-suited to that climate.

5. DESIGN PRINCIPLES

In the end, combining scientific findings with meteorological data and vernacular strategies, regional climatic design guidelines have been developed [6].

These principles provide keys to:
- shape of urban texture and neighborhoods
- general building specifications
- relation between mass and space
- characteristics of open
- semi-open and closed space
- building envelope
- material
- construction technology

5.1 DESIGN PRINCIPLES: DESERT REGION (Appendix4)

In order to decrease heat loss to the least possible, buildings should be grouped into massive low-rise blocks. Curved roofs (barrel vaults, domes, etc.) are preferred due to providing shaded areas on the rooftop.

Constraining some proportions of the house into the earth would provide a great deal of comfort since the underground temperature of the earth is lower than on its surface on hot days, and higher on cold days -- thus making cellars cooler than other rooms during summer, and warmer during winter.

Courtyards shall be well-shaded; therefore, they must either be surrounded by high walls or be located lower than ground level.

Designers shall bear in mind the prediction and preparation of open living spaces such as the rooftop and terrace for some seasonal activities. In areas where roofs are vaulted, the can be topped by a flat layer to allow for these activities. Moreover, it would double-layer the roof thus provides better thermal insulation.

5.2 DESIGN PRINCIPLES: FLAT PLAINS (Appendix5)

It is recommended for any closed area to have at least two sides of outdoor exposure. Naturally, this would mean single-layered buildings with an in-line plan configuration that occupy a rectangular slab plan; either built at the side, around or inside yard(s). These slabs can be placed on top of each other, both because it would result in the same lot coverage, and that at raised level, rooms would benefit better ventilation.

It is best to have the building elevated on posts so as to avoid the impacts of wet earth due to the low depth of ground waters. Furthermore, this would help get better ventilation because of increased exposure to winds. Also portico and such spaces allow for the flow of air underneath the floor slab.

Intense rainfalls demand for fast draining systems with sufficient gutters and downspouts. Gabled roofs with proper slopes are advised. Since rain most often falls in the cold seasons and is driven by prevailing winds from west, it is best to have one sloping side of the roof face west to achieve a faster drain and, if elongated enough, provide shelter for the west façade.

Use of semi-open spaces is particularly common throughout the year because of outdoor convenient climatic conditions. These areas offer well-ventilated spaces also well-protected against rain and sun simultaneously. These areas are frequently located at one, two, three, or four sides of the building and in front of enclosed areas.

CONCLUSION

Following procedures, will guide architecture, to design optimum hydrocarbon energy saved building:
- consideration and classification of climatic condition
- studies of microclimate in different areas
- field studies and consider vernacular design strategies

REFERENCES

[6] Tahbaz, Sh. And Djalilian, Sh., Architecture and Climatic Condition Adjustment, Shahid Beheshty University, it is under publishing