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ORIGINAL ARTICLE

Construction design zoning of the territory of Iran and climatic modeling of civil buildings space

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Abstract Considering the natural and climatic characteristics of different regions of Iran coupled with modern construction techniques and materials make it possible to make design decisions to create comfortable conditions for its residents. It is stated that improvement of a microclimate in houses in many respects depends on the choice of construction methods. In order to improve the microclimate for the basic areas, the Iran typological requirements and recommendations on improvement of a microclimate of residential environment are defined in the present study for both houses and city multi-storey build-up areas. On the basis of the typological requirements, experience of historical traditions, modern tendencies, and preservation of environment, construction methods for the four allocated design-building zones are developed. Using the recommended construction methods, town-planning principles of designing houses and principles of microclimate formation, which is determined by their space-planning and architectural-constructive decisions, were formulated. Effective design of civil buildings was developed on the basis of quantitative and qualitative characteristics of the environment, environmental factors affecting the climate, climate-ecological modeling of space, layout of the climate, and environmental zonings of territory of Iran. Among the construction design zones (CDZ) determined by certain relationship of climatic conditions and the available local construction materials; four CDZs are singled out considering the well-established designs and the existing design-construction base. The results of the research form a basis for general scientific, methodological, architectural, and planning principles of designing residential and public buildings. Moreover, some recommendations on developing of Iranian modern architecture of civil buildings with regard to national, Islamic, and cultural traditions are provided.

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1. Introduction

The Iranian civil architecture is an important part of entire Islamic cultural heritage. Its development is inherent in the very traditions and sequence of historical development, similar to other Muslim world countries: intensive urban development (mid-20th century); development of the traditional style

(70s–80s); appeal to the national architectural heritage and traditions (mid-80s of 20th century).

Concerning the Iranian architecture, there is a tendency toward the study and making full use of the types historically generated for planning structures of civil buildings of traditional architectural forms and architectural details in modern architectural construction practice. This tendency was particularly developed since 90s of 20th century, and the use of national traditions in modern civil building grows and develops constantly. The experience of the Iranian national culture and traditions of architecture throughout a centuries-old history of development of civil buildings left a legacy of many wonderful examples that reflect the views of the society in dealing with the issue of design and architecture. The analyzed architectural analogues and references have formed the information base of research and became the basis for comparative scientific analysis (Moradchelleh, 2008).

Problems of traditional structural morphology, existing structures and materials in the architecture, dependency on climatic and seismological conditions, the wind mode, and other objective factors are especially relevant as ever.

2. Features of a construction base

Lessening the adverse climatic features is achieved by the centuries-old practice of construction materials, natural (stones, wood, cane, clay, lime, and sand) and artificial materials (tubular and integral brick, glass), to create a comfortable environment. It is notable that even today, in a combination with rolled metal and monolithic reinforced concrete, the traditional construction materials perform the functions of bearing and protecting designs.

The range of traditional materials used in construction of civil buildings is based upon the local availability, and used as follows: (a) natural stone (granite, a shell rock) available in abundance and of high quality, served as a bearing and decorative material of which ornaments of various kinds were made; (b) marble from domestic quarries and from other countries was often used as furniture or mosaic for decoration of interiors and exteriors of religious buildings; (c) wood (pine) served as skeletons of walls, span covers of halls and domes; (d) in the form of gypsum, stucco as a decoration material for columns, vaults, and domes.

The common material for walls of houses that were constructed in recent years was adobe (grizzle) brick – "hesht", with the size of $10 \times 20 \times 35$ (40) cm, made from yellow clay of a particular viscosity. The foundation was made as a massive monolithic basis – a mixture of clay, lime, gravel, and water. In seismically active areas, the design was reinforced by a wooden skeleton.

Wooden window frames in the walls facing "hyatt" had a variety of shapes; rectangular, arched, or wing (lancet). Stone arches were constructive elements for doors and window apertures, and an ornament of façades and interiors. The use of glass as well as decoration of houses with multi-colored stained-glass windows has a long tradition in Iran (since XII century). Small various forms of windows facing the lanes are often equipped with metal or stone lattices. Sometimes separate glazing in two layers in cold regions is used.

Among span covers, flat beamed, vaulted or domical shapes were common. Boards were placed on round or rectangular wooden in section beams. Below they were lined with planks on the wrought iron nails, and on top were plastered with thick mud brick mixture – clay and straw. Roofs were paved with

Table 1 Zoning construction base of Iran.

No.	Type of construction industry	Construction design zone			
		Northern CDZ 1	North-western CDZ 2	South-eastern CDZ 3	Southern CDZ 4
1	Brick industry	Provincial centers	Provincial centers	Provincial centers	Provincial centers
2	Glass industry		Tehran, Qazvin	Esfahan, Yazd	
3	Cables and wires	Amol, Provincial centers	Tehran, Shakhrod, Provincial centers	Provincial centers	Provincial centers
4	Construction machinery and equipment	Rasht	Arak, Tabriz	Shiraz	Ahvaz
5	Woodwork and lumber	Gonbad-Kavus	Tehran	Behshaher	
6	Marble slabs and items		Sanandaj, Mashhad	Esfahan, Zahedan	
7	Gypsum and gypsum items			Semnan	
8	Ceramic roof tile	Sari	Hamadan	Behshaher	
9	Reinforced concrete items	Provincial centers	Tehran, Tabriz Provincial centers	Esfahan, Provincial centers	Provincial centers
10	Steel rebars and rolled metal		Qazvin	Esfahan, Nishabor, Miyane	Ahvaz
11	Cement industry	Neka, Minodash	Tehran, Qazvin, Mashhad, Shahrod	Sofiyan, Bedjnord	Provincial centers
12	Electric materials and equipment	Gonbad-Kavus	Tehran	Esfahan, Shiraz	Provincial centers
13	Rolled aluminum and aluminum products		Arak		
14	Thermal insulation materials and items	Provincial centers	Tehran, Mashhad, Provincial centers	Esfahan, provincial centers	Provincial centers
15	Brick and ceramic siding	Rasht	Mashhad	Esfahan, Yazd	
16	Varnish and paint materials	Rasht	Tehran, Qazvin, Karadj	Shiraz	
17	Roofing and moisture proofing materials	Provincial centers	Tehran, Gazvin, Tabriz	Esfahan, provincial centers	Provincial centers

ceramics, basalt plates, or porous clay whenever possible. There was another version of the span cover with two layers of beams and diagonal tension braces in the middle. The vaults were spread with small ogive made from bricks – "hesht", which were replaced with burnt bricks in the later period.

The floor was of clay or adobe basis. On the laid stones covered with fine gravel, a thick layer of clay was placed to protect premises from penetration of moisture from the ground. In apartment houses and smart rooms atop of them, ceramic or stone tiles were placed. The floor laid atop of wooden beam spans was of timber flooring.

In Iran, over the past decades, the metallurgical, petrochemical, machine-building, aluminum industries rapidly developed on the basis of oil and gas deposits, coal, iron and nonferrous metal mines. Zoning of the main components of construction base in Iran is provided in Table 1.

Modern civil engineering of Iran is now less dependent on local materials and regional construction base, but more on the import of any required materials, products and equipment of the construction industry, attracting professionals from abroad or vice versa, and the available own base. Active trade in this field with its neighbors (Turkey, Russia, and China), and adopting advanced construction technology of countries such as Germany, Britain, Italy, and Japan has strengthened the domestic construction industry.

The choice of materials should be based on the requirements for constructions with regard to the materials operating conditions such as strength, durability, fire resistance, and seismic stability. If constructions meet the above-mentioned requirements, the choice should be made upon technical and economic feasibility considering the specific conditions of construction, as well as the aesthetic properties of the materials.

Prefabricated reinforced concrete structures are very common in Iran due to the industrial realization and local availability of required cheap construction components. These structures are used in large-panel and volumetric-block multi-storey residential buildings (columns, frames, beams, plates, vaults, wall panels, as well as trays, and vineyard racks); frame-panel civic buildings (span elements, coverings, staircases, foundations, and skeletons of multi-storey buildings); sacral constructions (structure beams and frames span up to 18 m, truss spans 18–24 m, plates of spans covers, columns of up to 16 m in height, shells, foundation blocks, and piles).

Monolithic reinforced concrete structures are recommended to be used in the construction of large modern dwellings and public buildings erected in the sliding or resettable formwork, regardless of the construction site location.

The prefabricated monolithic reinforced concrete structures virtually do not require a formwork (modular parts of the structure play the role of the formwork), and are distinguished by simplicity and low metal content of joints, by virtue of the availability of a necessary base. Such structures are commonly found in the Northern and North-western regions of Iran. Considering the high mechanical characteristics and certain "elegance", steel structures are used in main constructions at big span flights and heights of civil buildings and constructions, as well as at high loadings, namely, truss structures with building spans of 30 m and more, columns over 14.5 m, crossbars with step of columns more than 12 m, and light mesh structures (rod, spatial) with a grid of columns not less than 18 m × 18 m. It is recommended to expand the use of lightweight lattice and profiled structures and aluminum alloys resistant to corrosion. This property makes these elements desirable to use them in remote mountainous areas of North-western Iran, as well as in

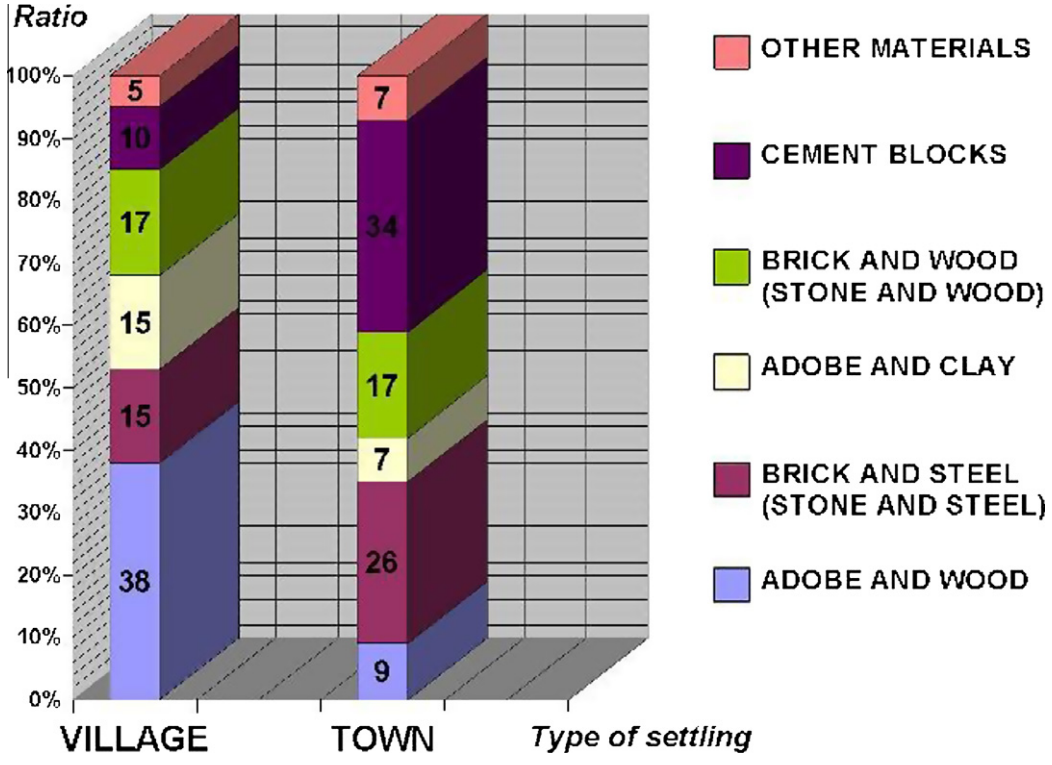

Figure 1 Traditional construction materials in Iranian dwelling.

earthquake-prone areas and in structures to which heavy aesthetic demands are imposed.

Wooden bearing and protecting structures are used in forest areas in the Northern Iran. It is recommended to improve the domestic wood industry for prefabricated, pre-engineered, and laminated structures, production of which is still less developed. Such structures are appropriate for the construction of one- and two-storey residential and public buildings and worship places.

Stone structures are recommended as supporting and retaining walls, pillars, fences, and non-bearing partitions. Stone and reinforced wall structures are appropriate to be employed in the mining areas of natural sawn stone (pumice, limestone-coquina), especially in the North (The Caspian Sea) and South (the Gulf of Oman and the Persian Gulf). Artificial stone materials – brick, cinder (breeze) blocks and ceramic blocks as well as modern materials and structures – carcass, girders, light domes and vaults, facade panels, and new decorative materials have found widespread uses across the country.

The approximate ratio of traditional constructional materials typically used for Iranian apartment houses is displayed in Fig. 1 (Kasmai, 1980; Ghobadian, 1998).

3. Construction design zoning

Analysis of the six basic climatic-environmental zones (CEZ) in Iran has provided the opportunity to choose four construction design zones (CDZ), Northern, North-western (central), South-eastern, and Southern CDZs (Fig. 2), in accordance with the peculiarities of the local climate (geoclimate and movement of air masses), seismic activity of the Earth,

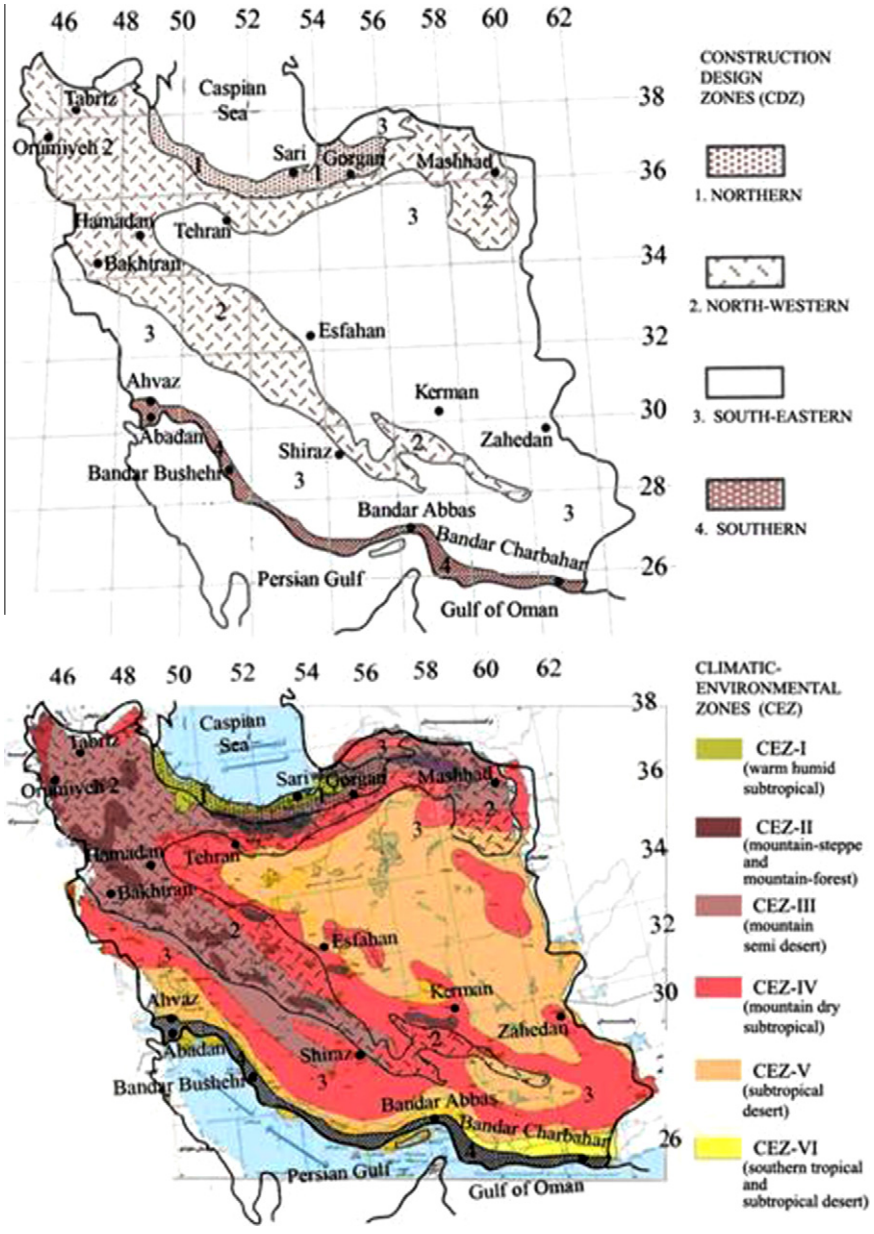

Figure 2 Main construction design zones and their connection with climatic-environmental zones.

presence of a particular design and construction base, and well-established traditions.

Northern construction design zone (N CDZ) coincides with the first climatic-environmental zone (CEZ-I) of a warm humid subtropical climate of the Southern coast of the Caspian Sea. The ethnographic and historical centers of Northern CDZ are the towns of Qazvin, Gorgan, and Rasht.

The North-western construction design zone (NW CDZ) includes two climatic-environmental zones; the second zone (CEZ-II): a mountain-steppe and mountain-forest climate of the Western Iran and Kopet Dag, and the third zone (CEZ-III): a mountain semi-desert climate of Northern and Eastern Iran. The ethnographic and historical centers of the zone are the towns of Tehran, Orumiyeh, Bakhtaran, Tabriz, Mashhad, and Hamadan.

The South-eastern construction design zone (SE CDZ) is characterized by hot arid climate and includes two climatic-environmental zones; the fourth zone (CEZ-IV): mountain dry subtropical climate of Southern Iran and the fifth zone (CEZ-V): a climate of subtropical deserts (with sub-districts). The main towns of Shiraz, Kerman, Zahedan, Esfahan, and Birjand are the basic ethnographic and historical centers of the zone.

Southern construction design zone (S CDZ) characterized by hot humid climate, coincides with the sixth climatic-environmental zone (CEZ-VI), the climate of southern tropical and subtropical deserts of the Persian Gulf and the Gulf of Oman (with sub-districts). Ethnographic and historical centers of the zone are the towns of Bushehr, Bandar-e-Abbas, Ahvaz, and Abadan (Kasmai, 1980; Alijani, 2002; Ganjnameh, 1996; Kasmai and Ahmadinezhad, 2003; Riyazi, 1977).

These four construction design zones (CDZ) are considered in more detail with specification of the specific features and architectural building traditions in each of the zones and the

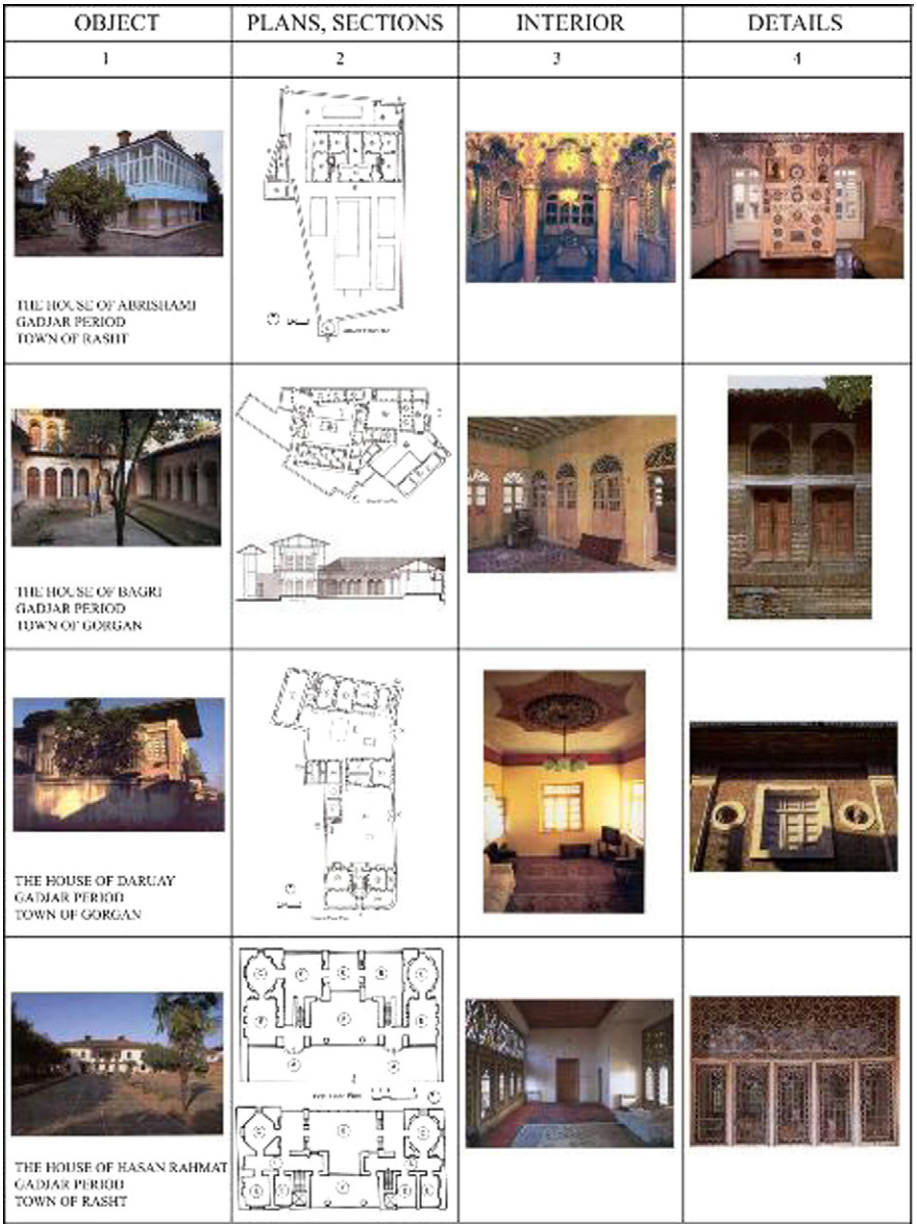

Figure 3 Typical traditions in architecture of Iranian dwelling for warm humid climate (Ganjnameh, 1996, 1998).

relevant requirements of future-oriented design and construction.

3.1. The Northern construction design zone

The construction in Northern construction design zone (N CDZ) with hot summer weather is characterized by a gallery-type single/family dwelling, which is based on techniques that provide cross-ventilation and aeration (to lower the temperature and humidity). This is achieved by arrangement of broad galleries, terraces, buried summer rooms, and the related planning of a house (Moradchelleh, 2008; Shaterian, 1999).

In traditional national architecture of a region, residential buildings (houses) stand apart on high especial plinths, with orientation of the main dwelling spaces to the East and the West. In the location and planning of houses, the available relief and an opportunity of visual perception of the sea from each house are taken into account. This zone is justified by the use of separately located sparse manor and blocked build-up area (Fig. 3).

Two types of rarefied building formation are offered (Brent and Brolin, 2007; Zomorshidi, 1994):

– A dotted manor building, sparse staggered and manor building rarefied, and group staggered types of building, which provide broad guidance and taking into account the prevailing wind direction (West, Northwest), as well as day time and night breezes. Recommended sparse and staggered buildings (be sure to patios) provide aeration of manor buildings and the area, as well as disclosure of the main façade of the sea and visual perception of a seascape.

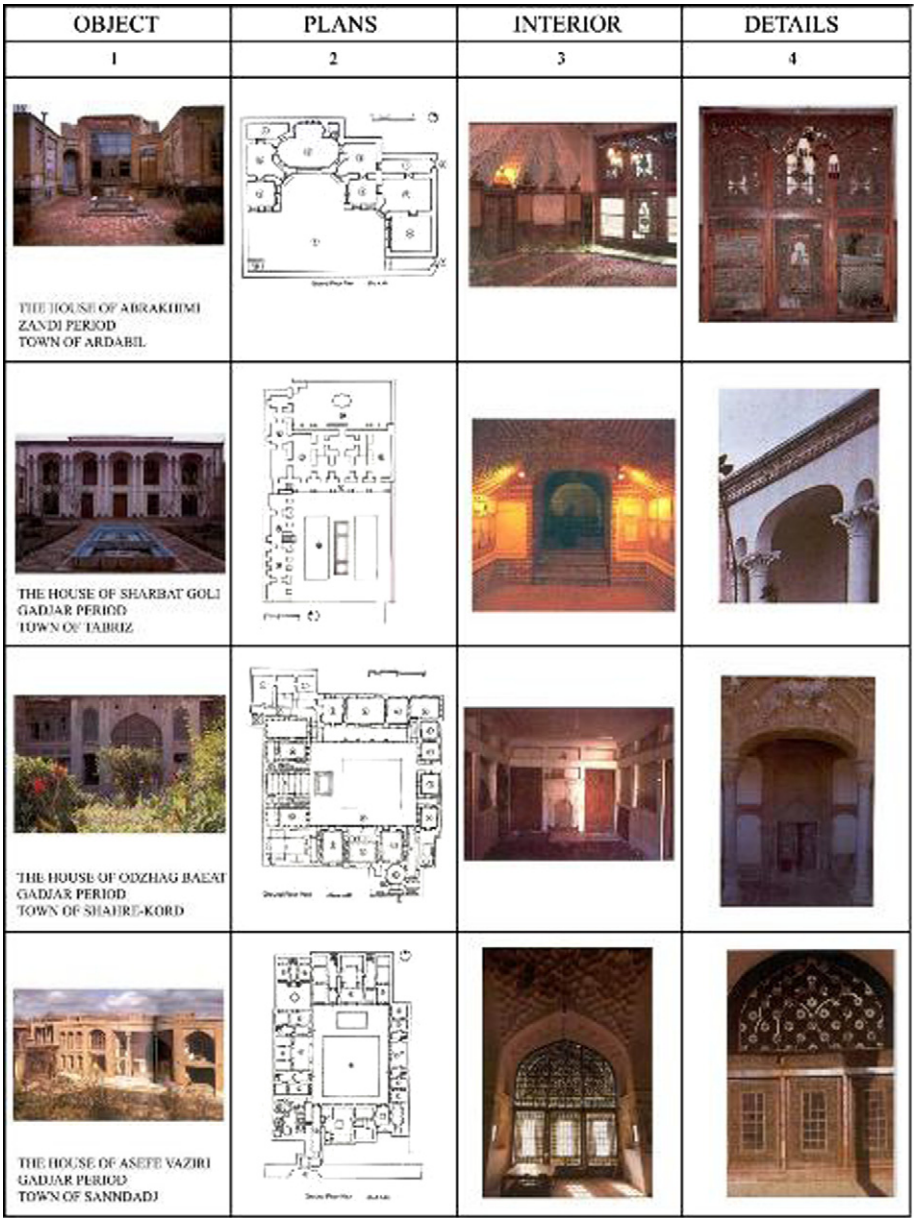

Figure 4 Typical traditions in architecture of Iranian dwelling for cold climate (Ganjnameh, 1996, 1998).

Thus, it is appropriate to arrange transport links parallel with the buildings at the sea coast; at a 300–400 m distance from the coast, to provide a protection-indented space.

– The linear blocked type of manor buildings, with linear ledges and concave front of building, and MDU. The front side of build-up area is chosen with regard to the nature of the contours of the coast (its relief) and the provision of local recreation areas. To reduce heat loss at night and daytime, overheating of premises, blocking, and use of various types of buildings, fan-shaped, staggered, jagged, sparse, and linear shapes is suggested.

Such techniques are recommended to ensure viewing of the sea, aeration of a build-up area in front of the facades. It is desirable to have parking lots inside the building areas and, footpaths perpendicular to the edge of the coast and along the direction of breezes.

In civil buildings of the Northern CDZ, especially in the coastal zone, the linear form of the plan, the big planes, the high number of window openings, and wide color palette of fronts are dominated. In designing buildings of ayvan type with patios, galleries, and arcades, Basilica dome types, as separately standing buildings with free planning, and around the periphery, dotted ring multifunctional complexes are welcomed.

3.2. The North-western construction design zone

There are inherent variations in temperature (day and night, summer and winter) with a clear continental climate in the North-western construction design zone (NW CDZ). The zone includes two climatic zones with a cold climate; the first zone: the mountain-steppe and mountain-forest climate, and the second zone: the mountain semi-desert climate. The zone has the highest population density [15].

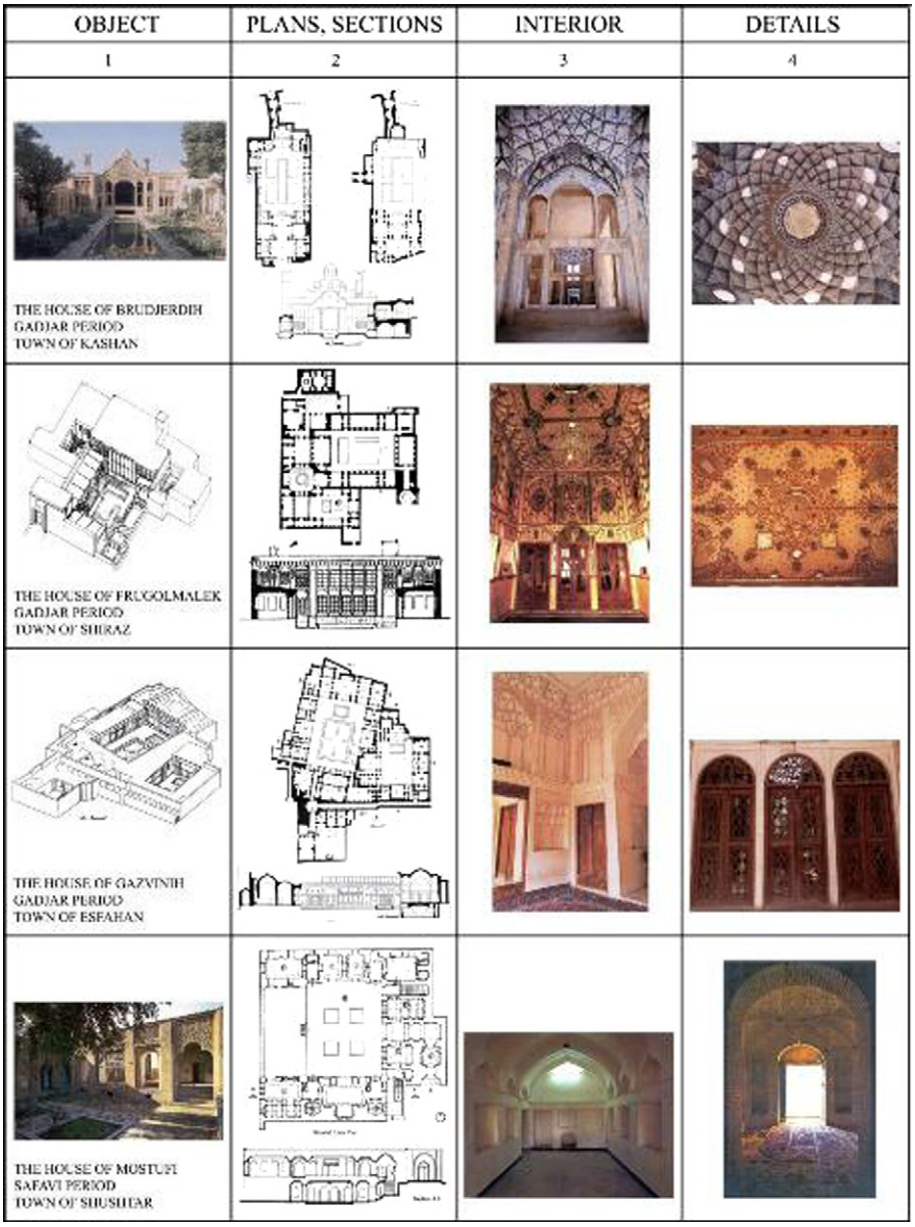

Figure 5 Typical traditions in architecture of Iranian dwelling for hot arid climate (Ganjnameh, 1996, 1998).

In traditional national architecture of the region, saddle and 4-hipped roofs (because of heavy rainfall and the nature of mountain climate) and occasionally flat roofs are prevalent. The predominant orientations of manor buildings are South-east, South, and South-west; and buildings are located on raised plinths (to avoid the freezing of the ground). Residential buildings are often constructed in blocking form to be kept warm. The main types of residential buildings are as follows: sectional, corridor, gallery, manor, blocked, and mixed structures (Fig. 4) Brent and Brolin, 2007; Zomorshidi, 1994.

In mountain areas, terraced and two-tier type houses are widespread. Thus, it is appropriate to construct the manor buildings blocked, and carpet build-up areas. The manor house may have rectangular, dotted, Γ-shaped, or Π-shaped form in plan, and the location of the house had the central priority inside of the garden. In the case of closure and implementation techniques of a carpet building area, homes are formed around the yard or garden, and have a Γ-shaped, Π-shaped and O-shaped (perimeter) forms on the plan. The structure of the building area can include galleries, ayvans, terraces, and loggias. Depending on planning decisions, houses may have the latitudinal and meridian orientation (Moradchelleh, 2008; Shaterian, 1999).

Recommended constructions in mountain areas are manor, sparse, two-rowed, rarefied, terrace with staggered placement of houses, blocked single-strand (carpet-double rowed), and terraced with benches; and in semi-arid areas blocked (to conserve heat), dotted-row terraced houses, Γ-shaped and Π-shaped, and blocked linear buildings.

To improve the microclimate, the following are advisable:

– Building on the South (predominantly) and South-eastern slopes.

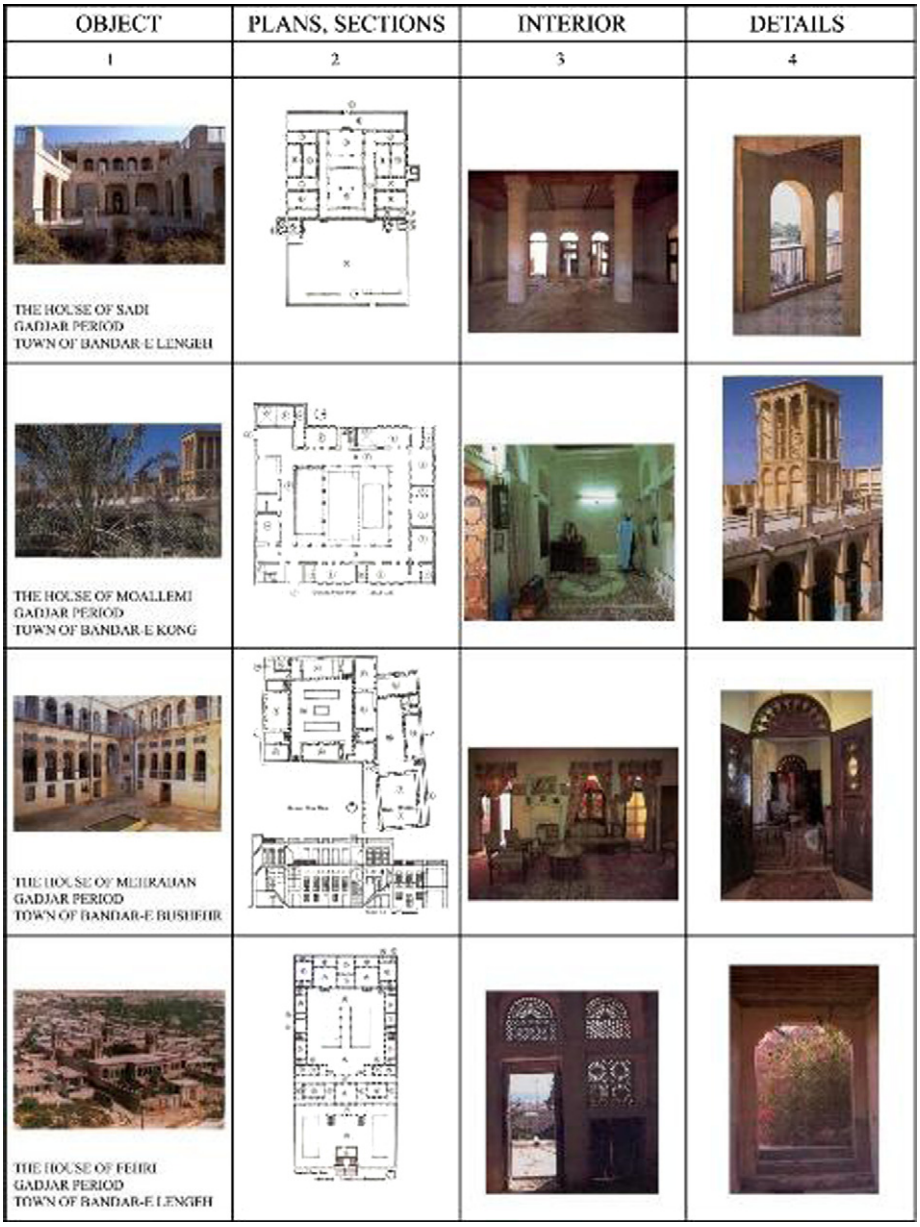

Figure 6 Typical traditions in architecture of Iranian dwelling for hot humid climate (Ganjnameh, 1996, 1998).

– Orientation of premises mainly to the South, South-east, and South-west.
– Arrangement of the roads along construction sites (along slopes), and footpaths on slopes.
– Location of houses and roads at an angle of 450 to each other to protect from winter cold winds.
– Moreover, arrangement of gaps between houses in compact construction areas allow visibility and light exposure.

For public buildings in a cold rainy climate, local building materials with increased strength are used. In such areas, compact, dotted, and ''compressed'' forms of plans, small number of window apertures, and limited open space summer dwellings are prevalent. In the decoration of facades, dark and dull colors, traditional sharp-pointed, arched, and horseshoe arches are used (Moradchelleh, 2008; Shaterian, 1999).

The requirements of building designing in such areas is as follows: protection of the construction from being cooled, using multi-layered exterior walls to avoids thermal insulation, orientation of the living room to the South, protection from the wind (terracing location of buildings in the mountains, and compactness of a planning decision), compact functional connections between spaces within the heated volume, and making use of pitched roofs to remove heavy precipitation rapidly. It is advisable to construct buildings with inner galleries, domical spans and ayvan types (from 1 to 4), patios of a closed type, atriums, and glazed enclosing arcades. Cooperation and erection of multifunctional complexes are desirable.

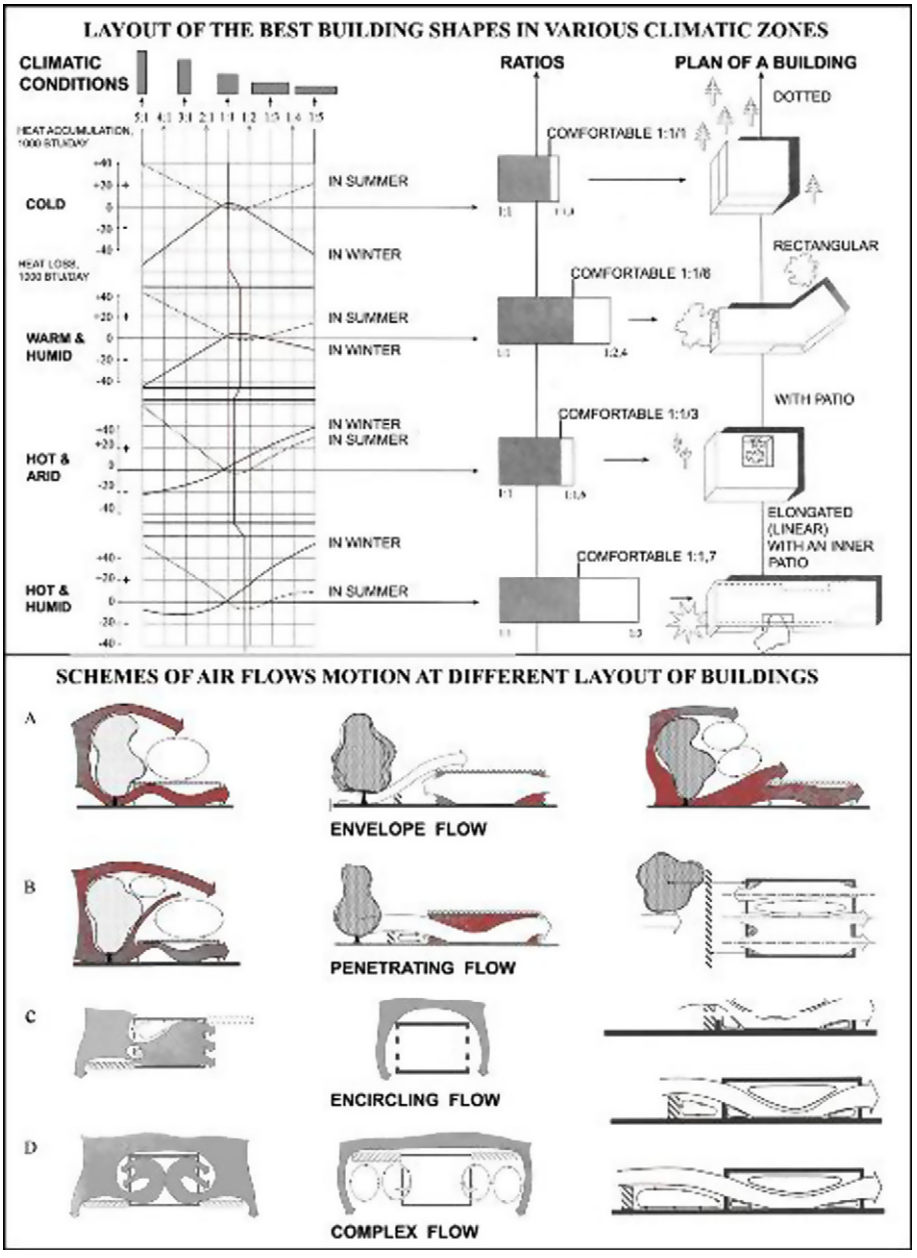

Figure 7 Ways and methods of climate control of buildings in Iran.

3.3. The South-eastern construction design zone

The South-eastern construction design zone (SE CDZ), which occupies a significant area of the country, is sparsely populated due to the adverse climate conditions (the lowest population density in Iran). This vast territory has dry mountain subtropical climate of Southern Iran and subtropical desert climate of the Iranian plateau, with seismic activity reaching 7–8 points magnitude on the Richter scale (Moradchelleh, 2008; Zomorshidi, 1994).

The least urbanized provinces are concentrated in this region. The area's large cities make 2.5% of all cities of the country, while its rural population makes up more than 75% of country's rural population. These areas are industrially underdeveloped, and thus, considering the industrial construction base, the industry of manufacturing construction materials and the network of design organizations are insufficiently advanced. All these lead to more active use of construction base of the adjacent regions of the country (Shaterian, 1999).

In the national residential architecture of the region, flat and domical coverings are prevalent, and especially in hot provinces, the dual two-layer roofs for keeping warm air and heating the rooms at night are used. Moreover, houses are located mainly not on plinths, but on the ground to be protected from the heat. Also, use of all kinds of bhud-geers («wind traps») is very advanced for natural ventilation, and buildings are designed paired and blocked (Fig. 5) Brent and Brolin, 2007; Zomorshidi, 1994. For public buildings in hot and dry climate SE CDZ, materials of high strength are used. Typically, compact (dotted) and perimeter shape of the plan with one, and often two patios, with a large number of window and door apertures (with a focus on the South-west and South), shaded summer rooms, and furnishing the facades with bright colors are used. The arcades are characteristically semi-circular, three-part, Assyrian arches.

In the climatic conditions of South-eastern CDZ with mountain dry subtropical climate and subtropical desert climate, gallery and terrace houses, houses, complexes with patios, from half-open to closed configurations are widespread. Depending on the terrain, it is recommended to form build-up areas, from the Estate of rarefied two-row type to the blocked group or carpet. To improve the microclimate in a build-up area, depending on climatic sub-regions, the followings are suggested (Moradchelleh, 2008; Shaterian, 1999):

- Arrangement of traffic and pedestrian footpaths linkages, courtyards and patios, pools and fountains, the elements of natural ventilation (bhud-geers), and vertical and horizontal shading.
- Planting, watering, shading, and landscaping of areas, parking lots, covered patios, household courtyards, streets, and pedestrian linkages.
- Protection of the buildings from the South-west, South, South-east winds with sand and dust, locating the transport links in the direction of these winds and the arrangement of entrances into the houses on the leeward side.
- Ensuring the aeration of high-density buildings by increased shading, reducing the external walls and coverings of the areas, implementing mutual shading of buildings, streets, and yards.

Table 2 Features of the traditional architecture of Iran in the construction design zones (Ghazbanpor, 2001).

No	Characteristic	Construction design zone			
		Northern CDZ 1	North-western CDZ 2	South-eastern CDZ 3	Southern CDZ 4
1	Climate	Warm humid	Cold	Hot arid	Hot humid
2	Mode of operation	Close, half-open	Close, half-open	Open, half-open, close	Half-open, open, isolated
3	Form of the plan	Extended, linear	Compressed, compact and dotty	Compact, dotty with a patio	Extended, linear with summer dwellings
4	Type of a covering	Slope	Flat, saddle, 2/4-hipped roof	Flat, domical	Flat, domical
5	Orientation to the cardinal	E, S, W, In the sea	S-E, S, S-W	S-E, S	S, S-E, In the sea
6	Foundation of buildings	On plinth	On plinth, On the ground	On the ground	On the ground
7	Square of window openings	Large	Small	Small	Middle
8	Utilization of natural ventilation, airing (bhud-geers)	Middle	Small	Large	Large
9	Composition of buildings	Isolated	Blocked (for heat accumulation)	Blocked (for heat isolation)	Isolated
10	Predominant colors of outer decoration	Arbitrary	Dull colors, dark colors	Bright, light colors	Bright colors
11	Thermal insulation of exterior protective structures	Temperate thermal insulation	High thermal insulation	High thermal insulation, horizontal sun protection	Temperate thermal insulation, horizontal and vertical sun protection
12	Prevention of natural influence	Cold and wind protection	Cold and wind protection	Hot and wind protection	Hot and cold wind protection
13	Correlation of premises	Within heated volume	Within heated volume	Open spaces with transforming protective structures for day and night residence	Open spaces with transforming protective structures for day and night residence

– Design the predominant direction of pedestrian streets mostly from North to South.

Development of active cross-ventilation in courtyards of public buildings is welcomed by blocking and erection of buildings in immediate proximity, and implementing a variety of functions through construction of premises located along the perimeter. In designing civil buildings, the following demands should be met: compact space-planning solution with one – two courtyards (hyatt), increase in volume (cubic space) of premises, ventilated attic spaces, transforming open spaces with fences for the evening and night stay, arrangement of modern ventilating shafts – improved (bhud-geers), vineyards on terraces and galleries, aeration of premises, i.e., the arrangement of swimming pools and splash fountains, use of walls with high heat-protective qualities (capitation and ventilation of multi-layer materials), arrangement of buildings with deflectors and aeration skylights, reflective surfaces, vertical and horizontal shading, use of solar panels, and wind generators.

3.4. The Southern construction design zone

The Southern construction design zone (S DCZ) is located near the coast of the Persian Gulf and the Gulf of Oman with hot humid climate. The zone has rather extreme, but at the same time comfortable seasonal weather, conducive to the development of resort centers and recreational complexes.

A characteristic feature of the zone is the adverse ecological situation caused by high levels of air and soil contamination by harmful chemical compounds, resulting from oil exploration,

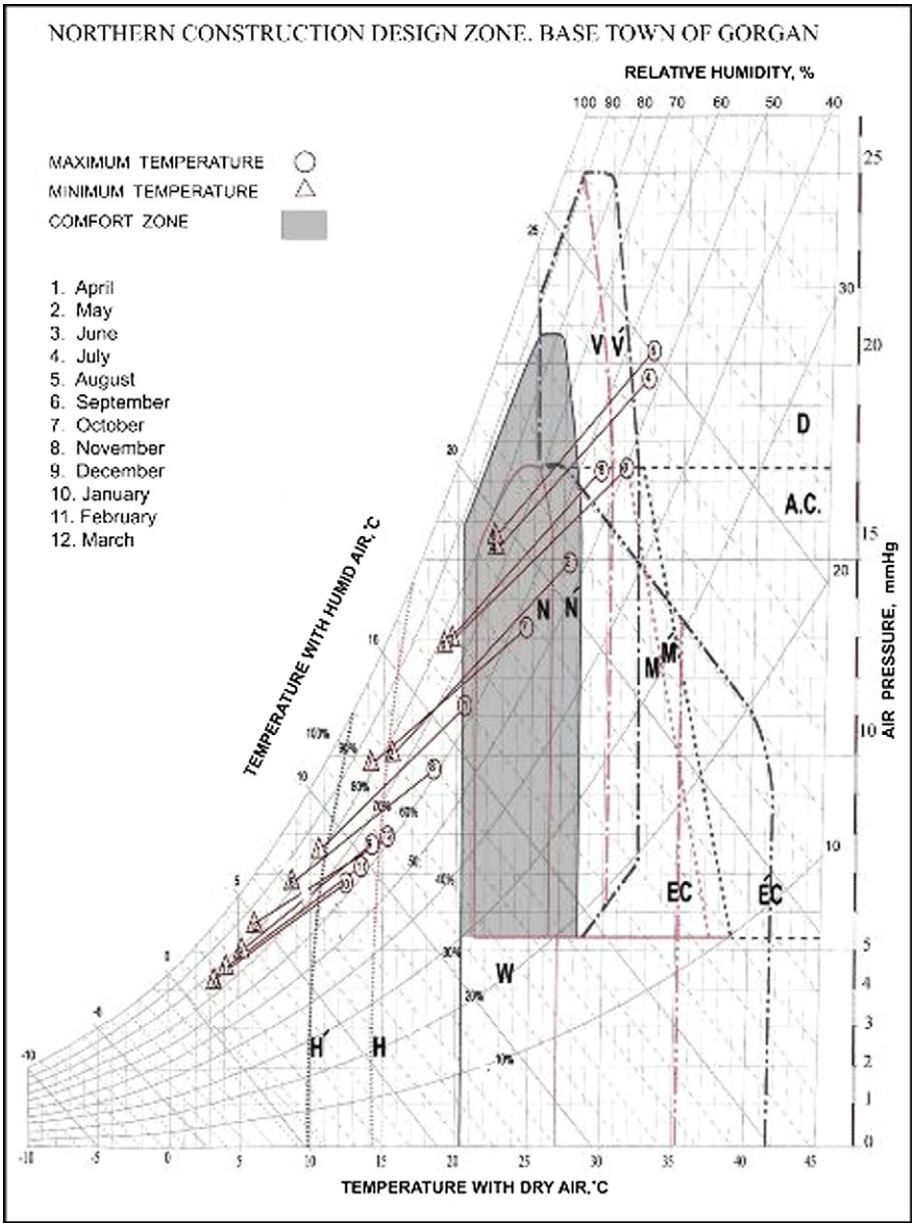

Figure 8 Climate-ecological modelling of space (for warm humid climate Northern CDZ) (Kasmai and Ahmadinezhad, 2003; Tahbaz and Jalilian, 2008).

as well as high seismic activity and the complex engineering-geological conditions (Moradchelleh, 2008; Shaterian, 1999).

The ratio of urban to rural population is almost 1:1, but the population density is very low. The zone is characterized by low levels of construction logistics and construction materials base, as well as the poor design and construction base. In traditional national architecture (dwellings), the flat and domical forms of the roof are dominant; the basic dwelling premises are focused on a South-east or the South; buildings are often placed on the ground or on a small plinth. Moreover, the arrangement of bhud-geers is very popular for natural ventilation. Furthermore, buildings, linear in plan, standing separately are predominant in the zone (Kasmai, 1980; Zomorshidi, 1994). In hot humid climate of Southern CDZ, construction materials of low durability are used in the civil architecture, and the advanced linear form of the plan dominates. Also, the high number of windows and doorways is typical and bright color palettes of building facades are employed (Fig. 6) (Brent and Brolin, 2007; Tahbaz and Jalilian, 2008; Tavassoli, 2002).

The basic types of residential developments on the coast are the houses formed around half-open or closed patios (two, three patios). Various types of constructions from locked chain double row, up to high density carpet patios, are recommended. In order to improve the microclimate in build-up areas, the followings are recommended:

– Arrangement of ventilated attic spaces and walls with ventilated cavities and roofs and ventilating shafts (bhud-geers).

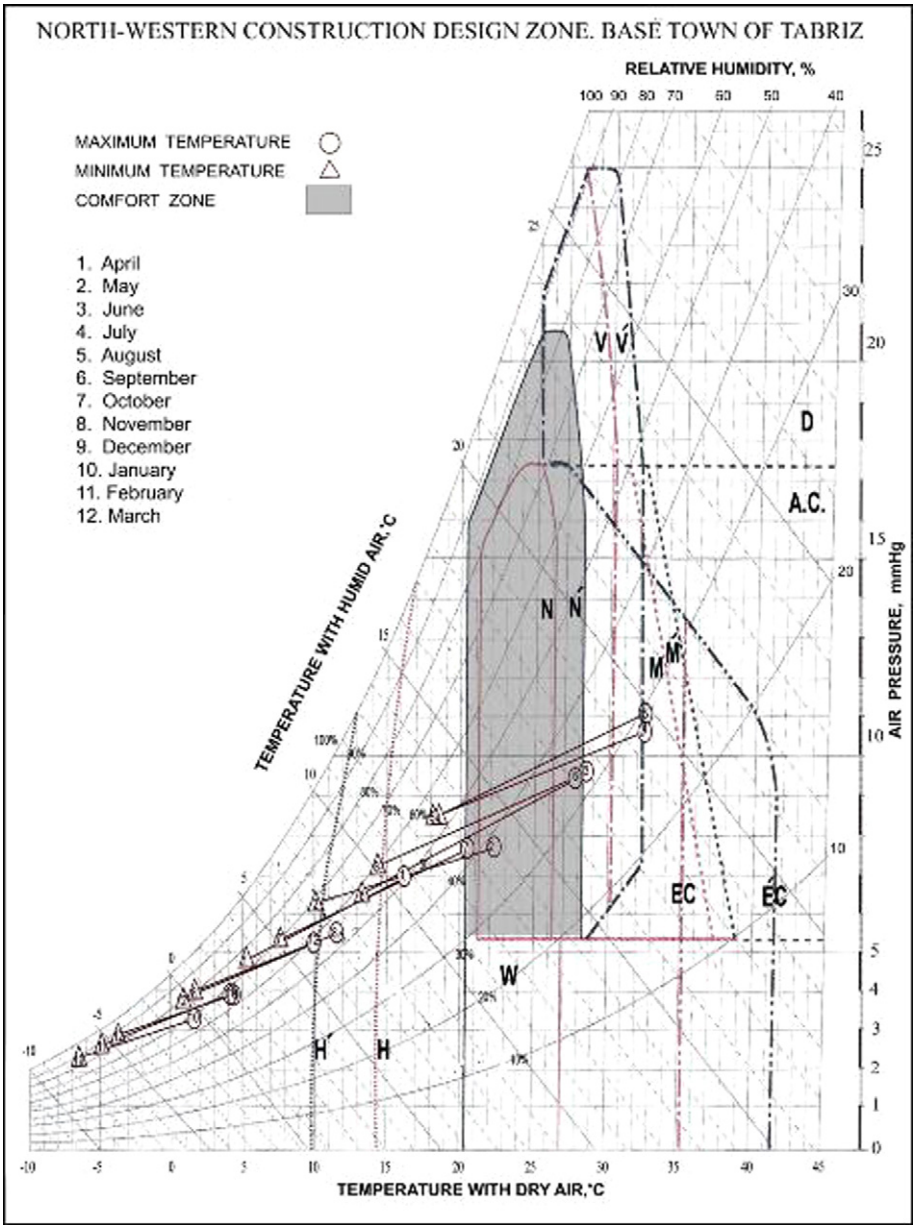

Figure 9 Climate-ecological modelling of space (for cold climate North-western CDZ) (Kasmai and Ahmadinezhad, 2003; Tahbaz and Jalilian, 2008).

– Protection of public playgrounds, footpaths, patios, and dwellings from hot scorching Northwest (with sand and dust) and Northeast winter winds.
– Formation of construction areas from compact rarefied to carpet high density to reduce overheating.
– Planting, watering, landscaping, and forming open spaces.

Following the traditions is focused on the erection of public buildings of domical and ayvan types with patios and one or two-tier arcades. The following demands are imposed in designing these buildings: linear arrangement of buildings along the sea, orientation of ledged terraces, living rooms and public premises overlooking the sea, thorough and angular ventilation of premises, protection of premises from overheating in summer time (by increasing the external thermal protection structures, multi-layered fencing, vertical and horizontal shading, and cultivation of vineyards and heat-resistant vines (lianas)), organization of open summer premises (hyatts, galleries, terraces). Travel business requires a special development, ensure buildings and complexes having European comfort level, as well as having modern energy-saving technologies using solar and wind energy.

4. Main trends in the design of civil buildings

Thus, considering the nature and climatic conditions of Iran, the followings are among the most important tasks in civil buildings design.

1. Protecting buildings from hot air.
2. Protecting buildings from rain.
3. Increasing the air humidity inside a building.

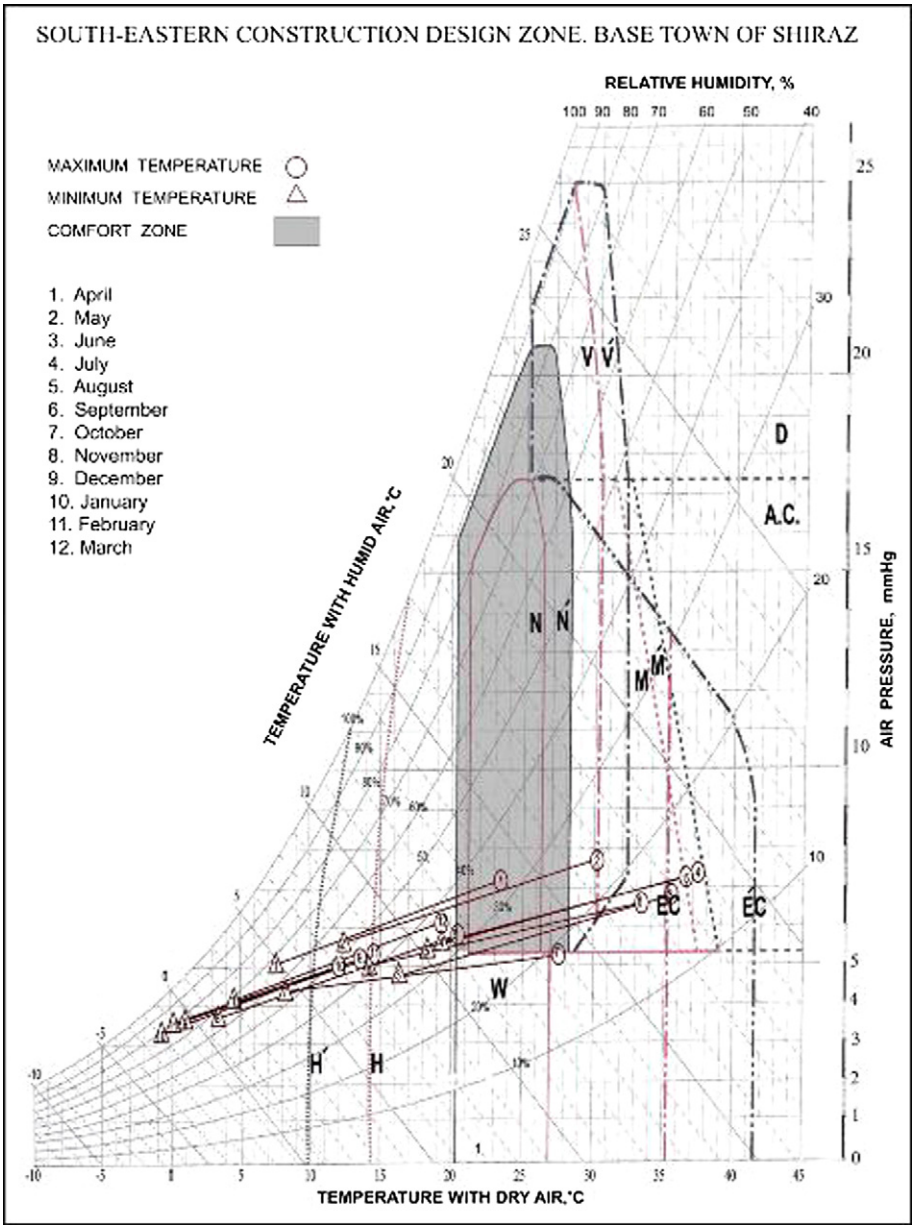

Figure 10 Climate-ecological modelling of space (for hot arid climate South-eastern CDZ) (Kasmai and Ahmadinezhad, 2003; Tahbaz and Jalilian, 2008).

4. Creating the aeration conditions in the inner space.
5. Making use of favorable factors of outdoor air and the temperature differences throughout the day.
6. Solar protection of the building (vertical and horizontal shading).
7. Using solar and wind energy as energy-saving factors (heating, lighting) for the building.
8. Reducing the influence of dusty winds on the buildings.
9. Reducing heat conductivity of structures and improving energy efficiency of space-planning decisions of the building.

The typical methods of control the climate influence on the buildings in Iran are displayed in Fig. 7. The main common characteristics of the Iranian traditional architecture, in accordance with the construction design zoning, are presented in Table 2.

Graphical interpretation of climatic and ecological modeling of architectural space for the aforementioned construction design zones (CDZ) are presented in Figs. 8–11. The figures for each zone – N CDZ (Fig. 8), NW CDZ (Fig. 9), SE CDZ (Fig. 10), and S CDZ (Fig. 11) in accordance with the extreme (maximum and minimum) air temperatures during the year (Kasmai, 1980; Kasmai and Ahmadinezhad, 2003; Shaterian, 1999; Tahbaz and Jalilian, 2008; Tavassoli, 2002; William and Daniel, 2007):

– Zones of temperate climate, and also zones in which various actions took place affecting the regulation of indoor microclimate, among which the selection of corresponding building materials, use of indoor natural ventilation, airing, and humidity are particularly outlined.

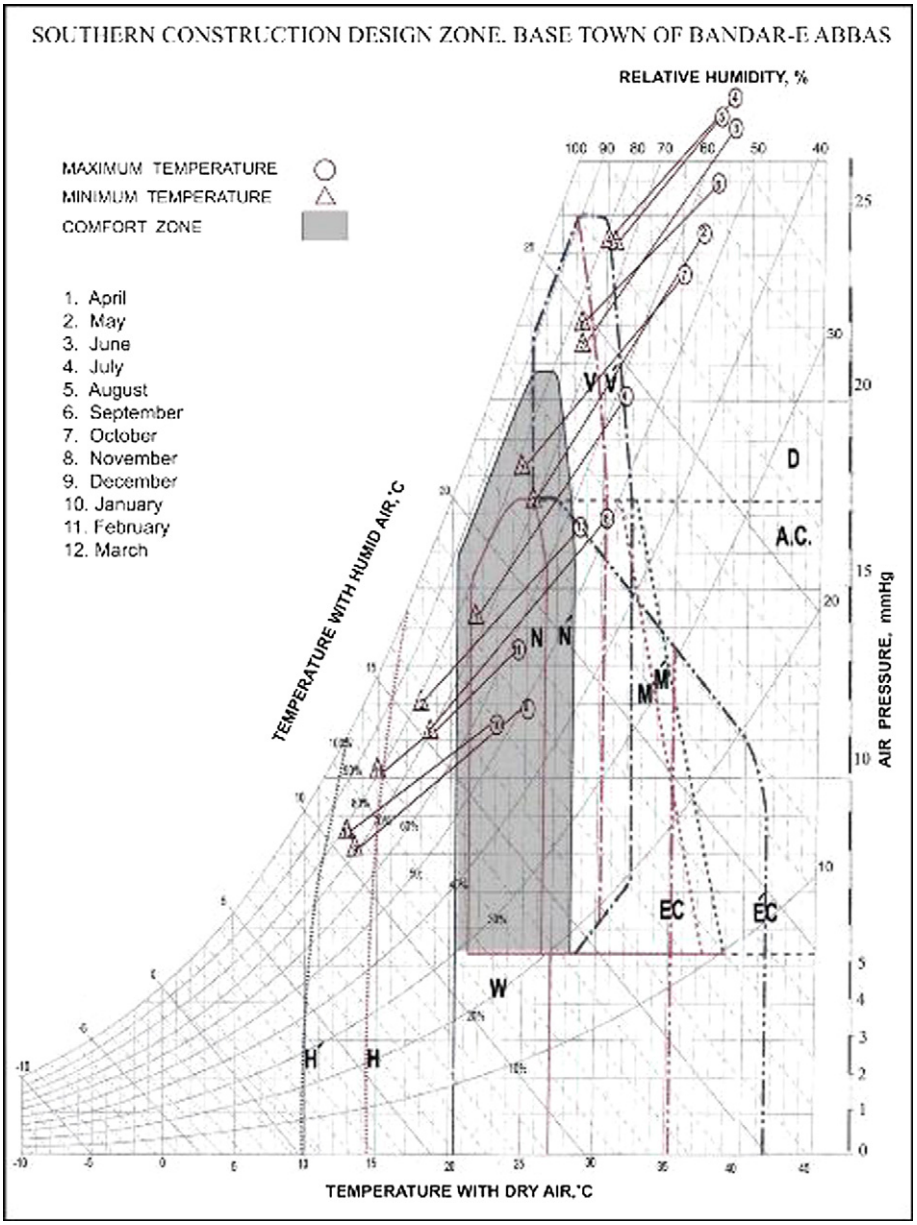

Figure 11 Climate-ecological modelling of space (for hot humid climate Southern CDZ) (Kasmai and Ahmadinezhad, 2003; Tahbaz and Jalilian, 2008).

– Types of weather (comfortable, warm dry, hot arid, hot humid, cool, cold, very cold) are determined by quantitative indicators of temperature, humidity, and wind speed.
– Type of maintenance modes of premises (open, half-open, and closed) considering the weather are classified.
– The general requirements for design and construction in the named zones are formulated.

The accepted symbols on the diagrams (Fig. 8–11):

N: the zone of comfortable climate.
N′: the zone of temperate climate.
M: the zone with selection of building materials with regard to the climate that renders significant influence on the temperature inside buildings.
M′: the zone of temperate climate with selection of building materials.
V: the zone of aeration.
V′: the zone of ventilation and natural ventilation.
EC: the zone of use of water conditioners.
EC′: the zone of use of the water conditioners in buildings with sunshields, with coloring the buildings in white.
AC: the zone requiring enhanced ventilation.
D: The zone, premises of which require humidifying the air.
W: The zone, premises of which require extracts/fans, using devices to reduce humidity.
H: The zone of significant influence of building materials on the thermal insulation of buildings.
H′: the zone of thermal insulation materials for buildings, depending on the climate.

5. Conclusion

The maximum use of Iranian traditional principles and forms in modern residential architecture is historically justified, and compositionally effective. The study showed that most of the traditional principles, elements, and methods of architectural structural morphology correspond to the objective conditions of climate, religion, and way of life in Iran. These three major factors of architectural shaping of the dwellings remain unchanged for centuries and have retained their importance nowadays. The new level of development of civil buildings of the country should be qualitatively based on development of national traditions in architecture, ecology of human beings, natural-climatic zoning, climate-ecological modeling of spaces, and conservation and restoration of the environment. This provision does not exclude the possibility that the current pace and nature of construction activities require certain changes in the use of traditional technologies and materials. Adaptations are required mainly related to the working out problems of construction industrialization, increased construction volumes, comfort and quality of life, expansion of the typology of buildings and structures (for instance, skyscrapers), all of which do not have functional and space-planning counterparts in the traditional architecture of the country. It is believed that the proposed development will be successfully used in the design of regional civil buildings. Furthermore, it can be subsequently implemented in in-depth researches into the problems of effective use of traditions in modern shaping of civil architecture of Iran, which would be a useful tool for improving the architecture of the Muslim world.

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