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An Investigation of Exemplars of Sustainable Architecture in Traditional Architecture of Tabriz Mosques

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ABSTRACT

Sustainable development is an environment-based change in employment of natural resources and orientation toward technology development so as to make compatible changes with present and future demands. In sustainable architecture, which includes concepts and principles of sustainable development in architectural area, a building not only matches itself with the region's climatic conditions, but also makes attempts to achieve appropriate spatial quality, skeleton, and form using building ecology that focuses on compatibility of buildings with environmental factors. The present research is carried out using descriptive-analytical method with the purpose to express techniques and patterns used in Tabriz traditional architecture especially mosques that are compatible with modern concepts in sustainable architecture arena. Results showed that Tabriz mosques are successful exemplars in application of sustainable architecture principles to provide replies for region's climate.
KEY WORDS: Sustainable architecture; climate; ecology; mosque; Tabriz architecture

INTRODUCTION

Climate change crises, resource shrinkage, and human lifestyle-induced environmental pollution are the most important global challenges in our present-day world. Aberrant architectural activities and construction manners and lifestyles in ordinary buildings have had a substantial share in giving rise to above-said crises. In doing so, invention of ideas and adoption of effective measures in improvement of the *status quo* are ranked top in architectural development plans. The assortment of thoughts and measures related to this type of architecture are identified under the rubric "sustainable architecture" [1]. A not very broadened study will demonstrate that a good number of our traditional buildings are fairly regarded as sustainable architecture, since such factors as culture and originality, climate, region materials, and suitable functional relationships have played significant roles in such constructions. Although, these buildings are relatively stable, and no construction is one-hundred percent stable since our architectural needs are subject to change during time; that is why, we can have a relatively stable type of architecture in any architectural style, provided that they are close to indices of sustainable architecture [2]. Therefore, paying attention to context of Iranian ancient cities including their cold climates is noteworthy. Despite stringent environmental climates, Iranian cold climates have provided bliss conditions for their residents and their present and future needs for human beings [3]. A mixed human-nature principle of harmony causes a positive force; on the contrary, disagreements, separations, attempts to make futile overtaking, and, ultimately, natural environment demolish this force. A climatic lookout tends to look at a construction as a mechanical object which is bound to provide its users' climatic comfort. This is only through making an appropriate environment for users that energy consumption is optimized and different solutions are made [4].

Statement of Problem

Achievement of high standards in quality, security, and serenity that help secure human beings' health are among the most important objectives of sustainable architecture. In the meanwhile, employment of our ancestors' experiences aimed at improvement of quality of architecture would be a key to the riddle of sustainable plans. An investigation of Tabriz mosques is indicative of the fact that such mosques, due to Tabriz's cold climate, follow such rules and techniques as establishment of dome-shaped porches and employment of materials with high heat capacity in order to cope with the coldness of the environment where human beings live.

Objectives of the Research

a. Investigation and explanation of the manner whereby regulations and rules of sustainable architecture come to compatibility with one another in Tabriz mosques; and,

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b. Employment of the climatic measures used in the Tabriz traditional architecture in designation of new buildings in order to make use of green and unlimited energies and reduce air pollution caused by fossil fuels.

RESEARCH METHODOLOGY

Descriptive-analytic method is adopted to conduct this study, which, firstly, intends to explain concepts and paradigms of sustainable architecture and, then, analyze architecture of Tabriz traditional mosques. Finally, exemplars of sustainable architecture patterns in Tabriz Kabood Mosque are investigated.

Hypotheses of the Research

a. It seems that climatic issues have played large-scale roles in designation and construction of Tabriz mosques;
b. It seems that many modern concepts have been observed in sustainable architecture of Tabriz mosques;
c. It seems that Tabriz mosques are successful examples of sustainable architecture in which climatic principles as well as rules of natural building materials are observed.

Sustainable Architecture

For an architect, sustainability is a very complex idea. A large portion of sustainability definition refers to conservation of energy and application of technologies such as lifecycle evaluation for maintaining balance among value of capital and amount of long-term assets for global warming. A sustainable plan addresses establishment of healthy environments in both economic and social-sensitive terms. Such designation is related to paying tribute to natural systems and apprehension of ecological processes. Three main environmental, social, and economic aspects of the sustainable development that have led to re-flourishing of architecture have common cross-sections with architecture as viewed by Vitruvius in his triangles with usability, beauty, and durability as its sides (Fig. 4) [1].

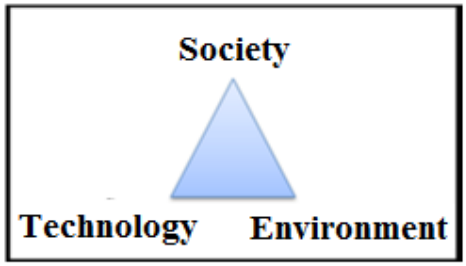

Fig. 1: Three sections of a sustainable designation (4)

In a sustainable outlook, deigns are conducted in such a way to locate the three above-mentioned aspects in a proper commutative cycle in order to take advantage of outcomes of resources consumption in the future (Fig. 2) [4].

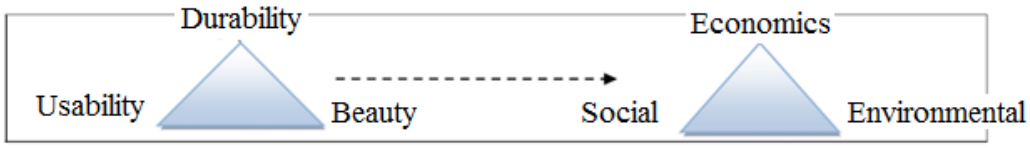

Fig. 2: Similarity between the Vitruvius Triangle and sustainable development triangle (4)

Principles of Sustainable Architecture

Following principles and measures should be adopted to arrive at a sustainable development:

- Employment and stabilization of renewable resources like wind, sunlight, etc.;
- Optimization of utilization of resources and minimization of natural resources consumption levels as being less than their natural growth;
- Minimization of generation of wastes and pollution that are attracted in local to global scale capacities; and,
- Procurement of humanity and society basic needs and establishment of a healthy environment for future generations [5].

Climate of Tabriz

Tabriz is the capital city of the Eastern Azerbaijan Province. It is located in 46 degrees 22 minutes east and 33 degrees 2 minutes north from the Prime meridian. The city's height from the mean sea level is 1,341 meters [6]. Average monthly temperature and rainfall in Tabriz since 1951 to 2014 is displayed in the Table 1.

Table 1: Tabriz's average monthly temperature and rainfall (1951 to 2014)

Month and parameter	Dey	Bahman	Esfand	Farvardin	Ordibehesht	Khordad	Tir	Mordad	Shahrivar	Mehr	Aban	Azar
Average temperature (°C)	-1.7	0.3	5.4	11.4	16.6	21.9	26	25.8	21.3	14.4	7	1.1
Average monthly rainfall (mm)	22.3	24.2	40.6	52.7	42.6	16.9	5.8	3.2	7.6	21.9	27.9	23.2

Traditional Mosques of Tabriz

Ina application of penthouse designs in mosque constructions, Muslims removed fireboxes from the interior spaces and covered the Qibla side with wall and Qibla symbol. In order to internalize and pall the penthouse space, they adjoined doorways, hallways, corridors, interior courtyard, doors, and exterior walls [8].

Architecture of Tabriz mosques is devoid of the significance other courtyards carry in other regions. Some mosques such as Kabood Mosque, Seyed Hamzeh Mosque, etc., totally dispossess courtyards; while, others with central courtyards do not have a strong relation between their courtyards and seraglios. Mosques' plans are mostly combined with their milieus and are connected to their adjacent buildings—the fact which contributes to preservation of heat inside both mosques and their adjacent buildings. Thanks to their wholly enclosed and brick-made thick frameworks, such mosques are relatively suitable for cold weather of Tabriz. Dimensions of entrances are often small and limited in quantity in these mosques. The materials used in traditional mosques of Tabriz include stone and brick that have high heat mass. Such materials, which are both cost-effective and omnipresent, adjust inside temperature of the building and preserve daily heat for nighttime. Since ceilings of most important Tabriz mosques are domed and made of brick, they need thick stone- and brick-made pillars so as to increase thermal mass and reduce heat loss. Heights of most mosques at these regions are short, which facilitates preservation of heat inside the constructions and interiors spaces as for fewer cross-sections with the exterior spaces [5]. The principles observed in traditional and indigenous architecture of cold regions are presented in the Table 4.

Table 2: principles observed in traditional and indigenous architecture of cold regions [9]

Type of climate	Type of materials	Type of plan	Building	Level and number of windows	Natural ventilation	Context	External color
Cold and mountainous	High heat capacity	Compressed	On-land	Low	Low	Condensed	Blackened

Kabood Mosque

Historical monument of the Kabood Mosque (or, Mozafariyeh Mosque) is an invaluable work constructed in the Kara Koyunlu Dynasty that was built at the behest of Jahanshah ibn-Ghareh Yousef. As expressed by the engrossed inscription installed at the gate, the building was completed in 1448. Main monument of the mosque that included a series of buildings like schools, bathrooms, monasteries, libraries, etc., was unfortunately totally demolished in the 1772 earthquake. Architecture of this valuable mosque is an assortment of ordinary Persian architectural methods, especially Azari and Isfahani ones.

Kabood Mosque is composed of gate, minaret, dome, and seraglio in terms of its architectural spaces. Family tomb of Jahanshah is, also, located inside the Mosque at its southern section. It has an unbreakable link with the mosque respecting its building and designing contexts. Buildings of the two seraglios are established with two totally different building patterns. In addition to the above, sanctuary of the Mosque, which constitutes a common cross-section of the seraglios, is situated in one of the principal roofs of both domes (an ordinary *Panjohaft*-type). With a harness of 17 meters and height of 20 meters, brick-made arches of the Kabood Mosque are one of the largest works constructed by Muslim architects in the ninth century AH inspired by Islamic architecture of Ilkhani Period generated by bricks. Abreast with its wonderful blended architectural style, Kabood Mosque is prominently characterized by tiling mosaic, brick-tile combination, and execution of miraculous turgid motifs that decorate all its interior and exterior surfaces. Because of its livid and blue colored tiles and its extraordinary greatness and pulchritude, Kabood Mosque is renowned as Turquoise of Islam (Figures 1 and 2). Commixture of tiles with different colors and beautiful profiles at this Mosque has granted it an exceptional order, symmetry, and color fitness. Azure ceiling of the Tabriz's Kabood Mosque is embellished with gold, which has given it brilliant resplendency (Fig. 3) [10].

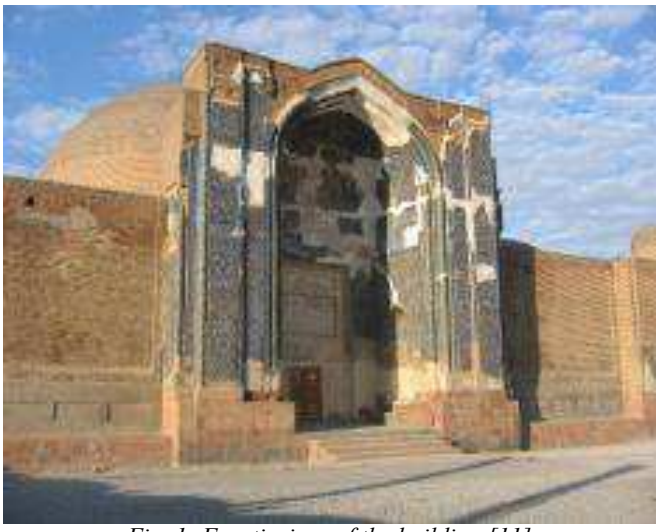

Fig. 1: Frontispiece of the building [11]

Fig. 2: internal space of the building [11]

Fig. 3: a part of the ceiling of the building (tomb) [11]

Exemplars of Sustainable Climate Design in the Kabood Mosque

Orientation and spatial structure of the construction

An investigation of architecture in cold regions indicates that special measures are adopted in construction of traditional buildings. In order to provide replies for climatic issues, a building should be designed in such a way to preserve the maximum heat in winters and minimum heat in summers [12]. In Tabriz, buildings are generally established in 20 degrees to west and 45 degrees to east along the northern-southern axis [13]. The mosque under question is established along the northern-southern axis and rotation angle of approximately 20 degrees west and 45 degrees east (Fig. 4) [11].

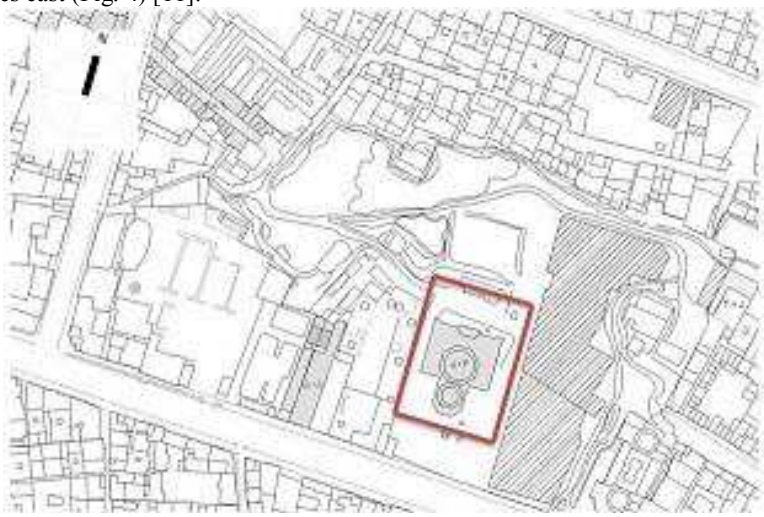

Fig. 4: urban location of the Kabood Mosque [11]

Relationship of exterior shell of the construction and its low volume

In architecture of cold regions, cuboid or rectangular prism forms whose proportion of external and internal surfaces is low are usually applied to lessen heat exchange level between inside and outside spaces [14]. A rectangular prism form is used in the mosque under question (Fig. 5) [11].

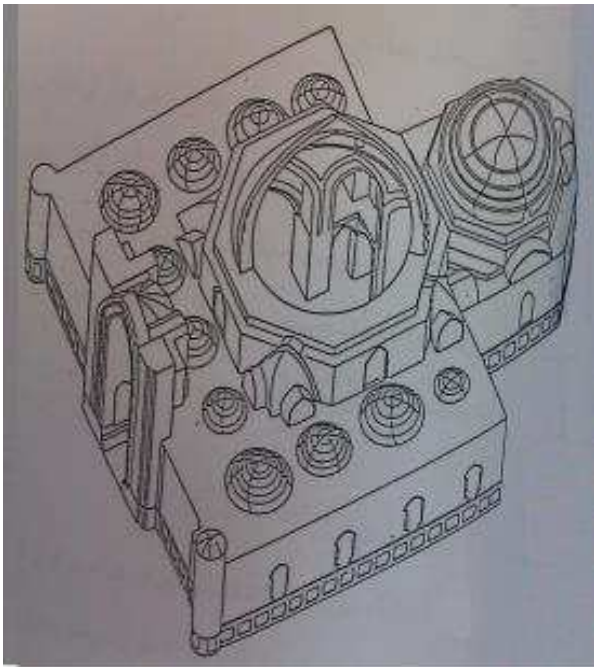

Fig. 5: rectangular prism form of the Kabood Mosque [11]

Compressed plan and climate-consistent central courtyard

A glance at the Iranian traditional architecture well illustrates that designation of constructions based on climatic issues such as sunlight, wind, etc., has been taken into account while carrying out architectural designs. Building

pattern of the Kabood Mosque is, much like many other central Iran-located seraglio mosques which have four porches and a central courtyard, changed into a large domed mansions due to cold weather. This is concluded that the architect, with his/her full meticulousness and without making any sort of manipulation in previous acceptable samples, has designed such great seraglios as proportionate with weather climates of Tabriz city (Fig. 6). The grout used in both interior and exterior building decorations is mortar which is in agreement with cold weather of Tabriz [11].

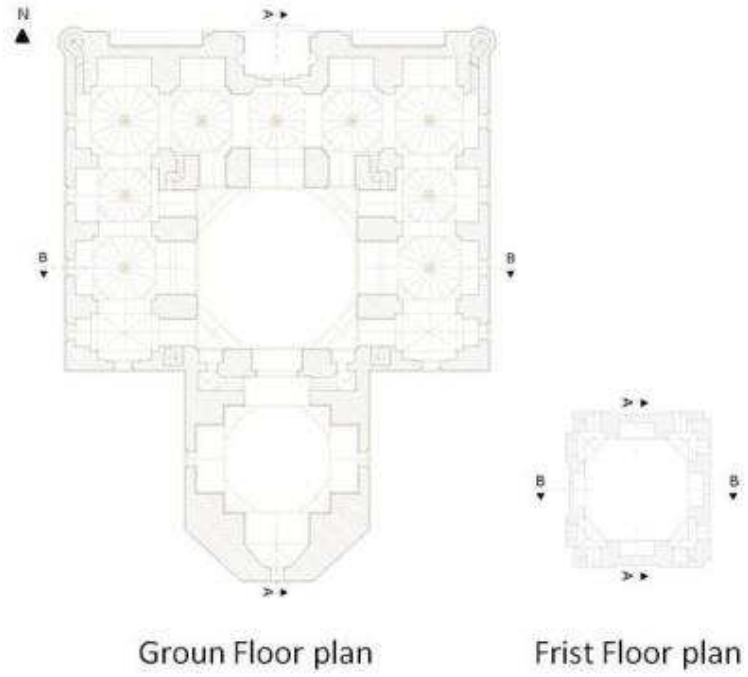

Fig. 6: introspective and compressed plan to preserve heat in winters [11]

Thick walls made of materials with high heat capacity

In traditional architecture of Iranian cold regions, thick walls have been highly used, which causes the heat absorbed by walls during the day to be gradually released during the night [12]. Thickness of exterior walls of the Kabood Mosque is 90 centimeters (Fig. 7) [11].

In Iranian traditional architecture, paying attention to the materials available in the region to be used in construction of the buildings has been a critical point. Another chief principle in native architecture of cold climates is application of materials with suitable heat capacity [13]. Most materials used in the mosque under investigation are bricks, stones, and woods, all of which possessing high heat capacity and being among IDARI materials (Fig. 8). Mortar grout, lime concrete, and thatch are used to construct this building which is compatible with cold weather of Tabriz city. Darkness of the tiles used all over the frontage of the construction brings about absorption of heat from external environment and transmission of it into the building [11].

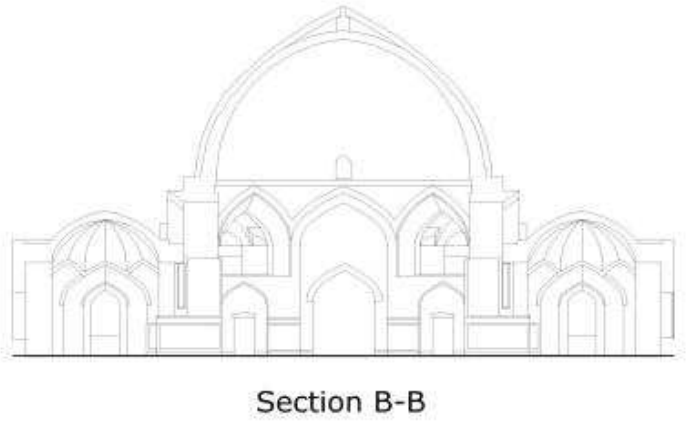

Fig. 7: thick exterior walls to preserve the heat at the interior spaces [11]

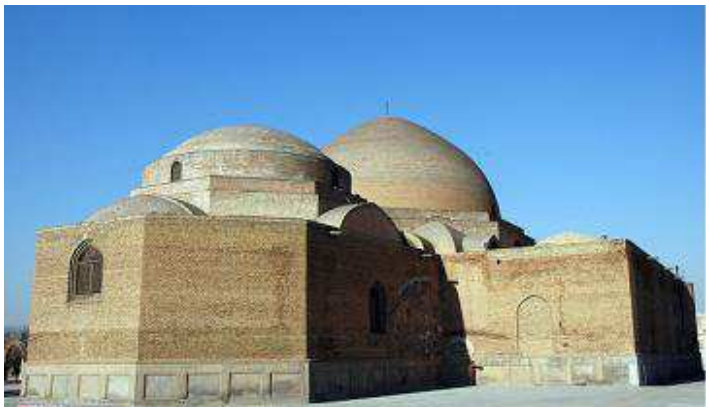

Fig. 8: the materials used in construction of the building [11]

Small Openings at Eastern and Western Frontages

In these regions, a small and limited number of openings is used to prevent heat exchange between interior and exterior spaces of the construction. In case windows are large, canopies are mandatorily to be used. At southern side, wider and larger openings are chosen so as to make maximum use of the sunlight.

Moreover, openings should be avoided to be established along cold wind. Double glazed windows are more suitable to bring down the heat exchange levels as lower as possible. In addition, air exchange between interior space and natural ventilation should be minimized in order to prevent breeze at interior and exterior spaces [13]. In architecture of Tabriz traditional constructions, large openings are prevented to be established in eastern and western frontages in order to minimize infiltration of cold weather since the dominant, undesirable wind blows in eastern north to western south direction [11]. In construction of the mosque under question, there are five openings at each eastern and western side (Figures 9 and 10). At the opposite of openings at eastern and western frontages, brick-made meshy walls are constructed (Fig. 11) in order to reduce infiltration of cold wind from the eastern front and diminish undesirable western sunlight into the construction. Three openings are installed at the southern side, which, save for the tomb opening, the other two openings are obstructed (Fig. 12) [11].

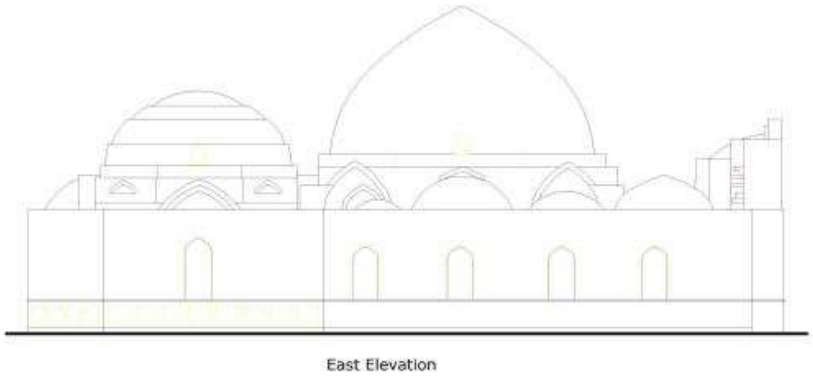

Fig. 9: small openings at eastern frontage to reduce infiltration of cold wind into the construction [11]

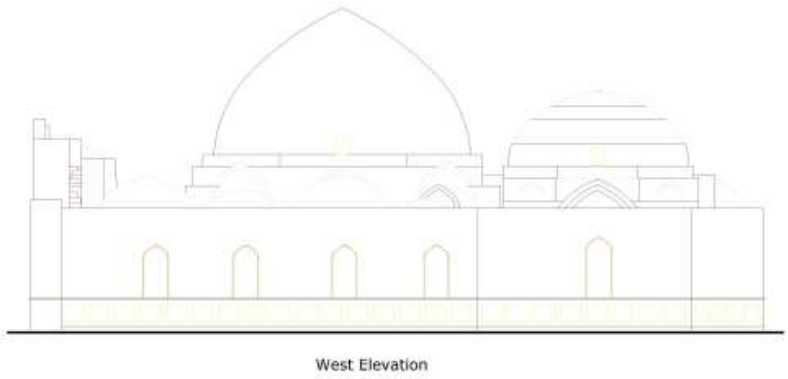

Fig. 10: small openings at western frontage to reduce entrance of undesirable western sunlight[11]

Fig. 11: a sample of meshy walls at the opposite of openings at eastern and western frontage [11]

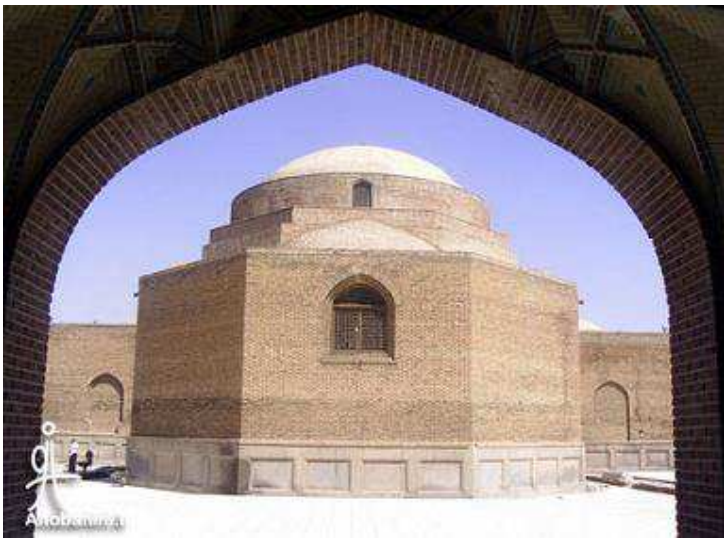

Fig. 12: opening at southern side of the construction [11]

Conclusions

Since unconventional application of fossil energy and generation of environmental pollutions changed into a threatening and serious matter for humanity, human beings undertook to discover different solutions to establish stability in environment. The manner to organize environmental stability as a main subcategory of sustainable development shall not be achievable unless practical patterns, as an element of the general human needs, are applied. Iranian native architecture had well managed to make tolerable for their residents many climatic problems even in a probably relative manner using region-specific measures and considering visual aesthetic factors. This study made attempts to explicate characteristics of the Kabood Mosque so as to elaborate on the ancestors' architectural relationships aimed at making optimized use of energy and reaching at environmental stability. Results showed that some principles of sustainable architecture in cold climates (such as application of large and wide openings at southern frontages in order to make maximum use of thermal energy generated by the sun in winters) have not been observed in this Mosque due seemingly to the fact that this edifice was obliterated by the 1772 earthquake and that no architectural documents were available upon its reconstruction.

Other measures applied in construction of this Mosque, including domed portico (roofed central courtyard), thick walls, application of natural building materials with high heat capacity to deal with annoying coldness, etc., have offered an architectural paradigm compatible with cold weather of Tabriz city. Therefore, architecture of Kabood Mosque can be regarded as a successful example of sustainable architecture, whose integration with new conditions can result in a well-designed pattern in present-day development and urbanization.

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