

Role of Facade in Sustainability Enhancement of Contemporary Iranian Buildings

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Abstract—A growing demand for sustainability makes sustainability as one of the significant debates of nowadays. Energy saving is one of the main criteria to be considered in the context of sustainability. Reducing energy use in buildings is one of the most important ways to reduce humans' overall environmental impact. Taking this into consideration, study of different design strategies, which can assist in reducing energy use and subsequently improving the sustainability level of today's buildings would be an essential task. The sustainability level of a building is highly affected by the sustainability performance of its components. One of the main building components, which can have a great impact on energy saving and sustainability level of the building, is its facade. The aim of this study is to investigate on the role of facade in sustainability enhancement of the contemporary buildings of Iran. In this study, the concept of sustainability in architecture, the building facades, and their relationship to sustainability are explained briefly. Following that, a number of contemporary Iranian buildings are discussed and analyzed in terms of different design strategies used in their facades in accordance to the sustainability concepts. The methods used in this study are descriptive and analytic. The results of this paper would assist in generating a wider vision and a source of inspiration for the current designers to design and create environmental and sustainable buildings for the future.

Keywords—Building facade, contemporary buildings, Iran, sustainability.

I. INTRODUCTION

BUILDINGS as one of the dominant energy consumers have a significant impact on the environment. Therefore, there is a necessity to apply appropriate strategies to make buildings more sustainable. Sustainability is a complex notion, and nowadays is one of the main concerns in the building industry. Sustainability is about enhancing the quality of life, which results in living in a healthy environment, with improved environmental, social, and economic conditions [1]. A sustainable building needs to be designed, built, and used in an ecological and resource efficient manner [2]. For that reason, designers should consider some strategies to control and reduce energy consumption and the environmental impact of a building from the design stage.

Facades are known as one of the main building components, which highly effect on the energy consumption of a building. They create barriers between the exterior and interior environment, providing building occupants with thermally, visually, and acoustically comfortable spaces [3]. Considering that, in order to have more sustainable buildings, it is necessary to have more sustainable facades. Sustainable

facades need to block unpleasant external environmental effects and maintain internal comfort conditions with minimum energy consumption [4]; to achieve this, designers need to consider many variables in selecting appropriate design strategies.

This study therefore discusses the design strategies used in facades, those assisting on energy saving and enhancing the sustainability level of the building. In view of that, a number of contemporary Iranian buildings have been selected to demonstrate the utilization of such strategies. The first part of the paper discusses about the concept of sustainability in architecture, following that building facades and their relationship to sustainability are explained. Then, the case studies are introduced and discussed with emphasis on the various design strategies used in their facades and their role in sustainability enhancement of the building.

II. SUSTAINABILITY IN ARCHITECTURE

Sustainability has become an essential aspect of contemporary architectural design. It is necessary to create sustainable buildings that offer least energy consumption, minimal environmental impact, and maximum human comfort.

The proper architectural measure for sustainability is efficient design, energy use, waste control, and resource efficiency [5].

Sustainability has been generally defined as the extent to which progress and development should meet the need of the present without compromising the ability of future generations to meet their needs [6]. This general definition for sustainability covers a variety of levels and scales; however, it was further developed to include sustainable building practices mainly as: the use of local materials; the continuation of traditional techniques, by means of regional resources; energy-efficient design strategies; exchange of information on all features of construction associated with the environment, especially for non-renewable resources; investigation on techniques regarding the recycling and reuse of building materials, particularly the ones, which use energy throughout their manufacturing process; and utilization of clean technologies [7].

III. BUILDING FACADES AND SUSTAINABILITY

Buildings consume energy mainly for cooling, heating, and lighting [8]. Facades as the main components in terms of controlling the physical environmental factors can be considered as one of the most significant contributors to the energy consumption and the comfort parameters of any

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building. Therefore, in order to have more sustainable buildings, it is crucial to design more sustainable facades that use least possible amount of energy to maintain a comfortable environment with less negative impact on environment.

Sustainable facades have a great impact on reducing energy consumption of buildings. In view of that, the properties of sustainable building facades can be mentioned as: providing enough daylight for inside; blocking undesired heat to get in; reducing thermal exchange and keeping heat inside the wall by means of a proper insulation; being an air/vapour barrier; and providing natural ventilation to make the interior spaces cooler. Such properties are greatly related to the orientation of the building, its function and the climatic situation of a region [9]. These properties need to be considered during the design process, and in view of that, some design strategies should be developed in order to improve occupants' comfort with minimum energy use.

IV. CASE STUDIES: CONTEMPORARY IRANIAN BUILDINGS

In this section, a number of contemporary Iranian buildings are introduced and discussed in terms of utilization of various design strategies in their facades, and their impacts on energy saving and sustainability enhancement of the building. It should be mentioned that the necessary information on each one of the buildings has been taken from the official website of the related architectural firm.

A. Kahrizak Residential Building by CAAT Studio

The six-storey building located in the southwest of Tehran, the capital city of Iran; the main focus of the architects in this building was on the southern facade, where they designed a series of sloping brick screens in the recessed balconies. These brick structures provide shadows on windows and the perforated ones, allow fresh air and natural light to pass through the facade. There is a full height window in each apartment, which provides sufficient day light.

Brick modules were designed based on the geometric patterns mostly found in the traditional Iranian architecture. The modules were shaped in such a way to create comfortable interiors by gathering or partly blocking sunlight at different periods of the day. Therefore, with the proper brick arrangement, each space behind the southern facade would have enough day lighting. Angled screens of perforated brick provide ventilation and shade for this housing block, and assist in moderating the hot and dry climate of the city for its users.

The limited budget of the client for this project led the

architects to use a locally produced material and to engage local people to minimize the cost of the project.

The choice of material is a significant parameter in the sustainability enhancement of this building; because of being locally available, it greatly reduced time, energy, and overall project's cost. Besides that, its arrangement created the high quality interior spaces while minimizing energy consumption.



Fig. 1 Kahrizak Residential Building by CAAT Studio [10]

B. Andarzgoo Residential Building by Ayeneh Office

The six-storey building located in the north of Tehran has a textured facade with ridged granite and slatted timber. Slatted timber shutters provide privacy and shade for this apartment block.

Local zoning rules prevented the architects from adding balconies at the front of the building, so they inserted deep glazed recesses into each apartment instead, which provide internal terraces, and bring light and ventilation into the living spaces.

The private areas are located at the back and the communal areas along the main facade, which faces south-west, to invite sunlight inside the main living space.

The architects created a movable wooden shell (timber shutters) to control and block the annoying sunlight from the west, which hits the apartments in the afternoon. These sit flush with the granite exterior when closed.

The shutters are made from a heat-treated timber, which is suitable for the climate in Tehran, where average temperatures can range from one to 37 degrees Celsius throughout the year.

In this building, the integration of the terraces into the living spaces together with the utilization of a movable wooden shell was the main design strategies used in the main facade to create comfortable interior spaces while utilising less energy. Moreover, the architects used factory off-cuts of granite for the building's facade, which were laid in strips of varying depths to create a ridged surface; reuse of such waste materials is another sustainability feature in this building.



Fig. 2 Andarzgoo Residential Building by Ayeneh Office [11]

C. Sharifi-Ha House by Next Office

Sharifi-ha House located in the north of Tehran, possesses three rooms, which have the capability of being rotated 90 degrees; this feature gives the possibility of having more open and transparent facade during the hot summers, and being totally closed to keep the house warmer during the cold winters of Tehran.

Rotating rooms give Sharifi-ha House a shape-shifting facade, and allow the owners of this house to adapt to Tehran's fluctuating temperatures by opening up rooms in summer, or turning those inwards during winter.

According to the architect, the openness and closure of the building is a reference to traditional Iranian houses, which offer both a winter and a summer living room.

The main design strategy in this house is the flexibility and transformability of its facade from a two-dimensional facade to a three-dimensional one, which provides a great opportunity for the inhabitants to simply adjust their living environment with the climatic situation of the region to achieve maximum comfort with least amount of energy.



Fig. 3 Sharifi-ha House by Next Office [12]

D. Apartment No. 1 by AbCT

This five-storey apartment block constructed by useless off-cuts from local stonecutting businesses. Stonecutting is the largest trade in that region, which has a wasteful process, and more than half of its produce is discarded. Therefore, the architect decided to recycle the material and use it as cladding for the building.

The thicknesses of these waste pieces are all the same and are easy to put the pieces together in rows to form a wall. In some parts of the facade, the wall is angled toward outside, which protect the small windows next to them from direct sunlight. For larger windows, timber shutters have been designed, which made from local wood and assist controlling light and temperature in the apartments at the hottest times of the year.

Utilization of the waste and local materials along with the angular walls and the use of timber shutters all can be mentioned as the main strategies applied in this building facade regarding the sustainability issues.

E. Orsi-Khaneh by Keivani Architects

The main feature of this seven-storey apartment block in Tehran is the faceted window frames projected from the

slatted timber and stained-glass of its facade.

The main concept of this project originated from Iranian traditional architecture. The aim of the architect was to reinterpret a special type of window, locally called "orsi", made by wooden lattice and stained glasses with effective technical functions; typically used to reduce sunlight and heat in the hot climate.

The main facade of this building is made from a double layer timber, together with panes of stained glass along with planting, that is for aesthetic reason as well as controlling the temperature. Slatted sunshades over the windows can also provide additional control of sunlight. The material used for the large window frames is a type of stone called travertine and their shape assists in reducing heat. The building materials are recyclable and native materials. All these features together would save a considerable amount of energy and enhance the sustainability level of the building.



Fig. 4 Apartment No. 1 by AbCT [13]



Fig. 5 Orsi-Khaneh by Keivani Architects [14]

F. Saba Apartment by TDC Office

Eight-storey apartment block in Tehran with a grid organization on its facade consists of stone blocks and recessed windows. These windows are covered with slatted wood having wavy edges, which positioned vertically on rails in front of the full height windows. Based on the users' need for light, view and privacy, each one of these wooden shutters can be adjusted by hand.

The positioning of the block separates the street from a garden at the back; the building's facade on the garden side is made from the local brick and has the same grid of recessed windows. There are deep balconies with flower boxes on the back facade, which is drip-irrigated using rainwater collected

in tanks on the roof.

The idea of recessed balconies together with the wooden shutters and planting can greatly assist the users to adjust the temperature of interior spaces in Tehran's fluctuating climate. All these features together have a significant impact on energy saving of the building.

G. Saadat Abad Office Building by LP2 Architects

The seven-storey office building in the northwest of Tehran; its facade possesses variety of materials, openings, and transparency levels by utilization of rotating panels and recessed openings, which create flexible and comfortable spaces for occupants. Some parts of the southern facade have been pushed inside to open a perfect view. Wooden louvres used on the facades protect the users from harsh midday sun; since they can be rotated, the users can block the light completely, or direct it towards different parts of the room. These surfaces could change into thousands of forms based on users' needs and desires. Therefore, such design strategies for the facades would be so effective in terms of reducing energy consumption of the building.

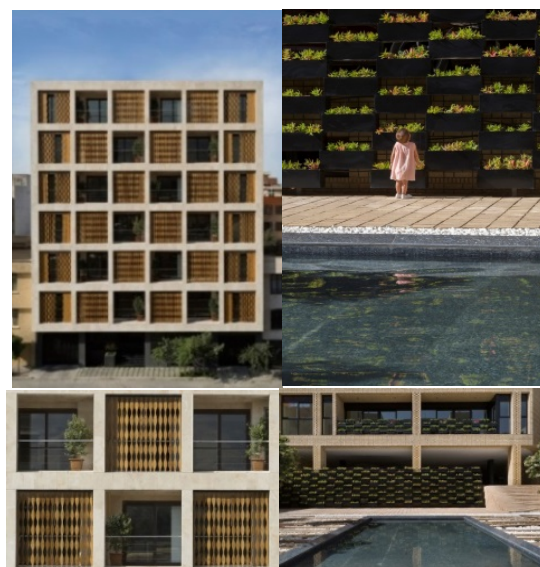


Fig. 6 Saba Apartment by TDC Office [15]



Fig. 7 Saadat Abad Office Building by LP2 Architects [16]

V. CONCLUSION

Moving toward sustainable buildings is an essential task, when considering environmental protection. The challenge for designers is to find out innovative ways that cover different aspects of sustainability. The designers must be aware of the impacts of every design decision on the local resources, regional and global environments. Therefore, it is necessary to ensure that the environmental factors and energy-efficiency strategies are integrated with the design process.

By considering the case studies and the various design strategies used in their facades, basic design strategies for designing sustainable facades can be summarized as proper orientation to achieve maximum comfort with a relatively low consumption of energy, appropriate ratio and arrangement of openings on facades to allow natural light to get in, shading

elements to control cooling loads and improve thermal comfort, using natural ventilation to enhance air quality and reduce cooling loads; and the use of daylighting to minimize energy used for artificial lighting. Selection of materials and their properties is also an important factor in designing sustainable facades, and design decisions relating to material properties can greatly influence their performance and highly reduce energy used for mechanical cooling and heating. Moreover, considering the environmental impact of the materials, the ones which have the least negative effect on the environment should be selected.

Paying attention to such strategies throughout the design process would significantly affect a building's overall energy consumption, as well as its occupants' well-being, health, comfort, and productivity, which in general results in

enhancing the quality of life and sustainability.

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