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Reinterpretation of Passive Cooling Strategies in Hot And Dry Climate Traditional Architecture: Vents in The Building

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ABSTRACT

The building sector is among the most critical factors affecting environmental sustainability due to its impacts, such as energy consumption and greenhouse gas production. The reasons for energy consumption and greenhouse gas production in the building sector may vary according to climatic characteristics. In hot and arid climate regions, a significant portion of energy consumption is caused by indoor cooling, especially since the focus is on reducing the indoor temperature. In the periods when traditional architecture was developed, the lack of technological products that would increase energy consumption was effective in providing indoor air conditioning with passive design strategies. This study aims to identify the building openings for natural ventilation and cooling used in the traditional architecture of hot and dry climates and to analyze and evaluate their modern interpretations. A total of 235 award-winning projects were analyzed, and 21 were included in the study. In this context, it was determined that 16 different strategies used in traditional architecture were re-interpretation, and their modern interpretations were analyzed through award-winning projects. The traditional passive design strategies identified in this context have been adapted to modern architecture in 18 types. Wind orientators come to the forefront. In addition, it was determined that the strategies adapted to modern architecture are generally integrated. This study guides modern interpretations of traditional passive design strategies for sustainable building design.

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1. Introduction

Building sector is responsible for 30% of greenhouse gas emissions and about 40% of the energy consumed, which negatively affects environmental sustainability, such as climate change, global warming, and consumption of natural resources. This energy consumption in buildings is expected to reach 50% by 2050 (IEA, 2021; UNEP, 2020). Especially with the energy crisis in 1970, it became clear that the current building sector was unsustainable. Since then, achieving building sustainability has become one of the main goals of many countries (Kojok et al., 2016).

The preservation of the natural environment, efficient use of energy, and utilization of natural energy resources without using to fossil fuels to achieve thermal comfort have been instrumental in making traditional architecture a sustainable building (Heidari et al., 2017). Therefore, the design strategies of traditional architecture are essential for ensuring the sustainability of modern buildings (Foruzanmehr, 2015; Mileto et al., 2021).

Modern adaptations of the systems used in traditional architecture still need to be sufficient (Berghout & Forgues, 2020). However, it can be easily understood from award-winning projects and academic studies that there is a severe tendency to go in this direction. Bagasi et al., 2021; Guillaud et al., 2014; Hassan et al., 2016; Manzano-Agugliaro et al., 2015 are some academic studies in this field. However, it is tough to apply traditional passive design strategies in the same way in the current conditions, considering the current human and environmental conditions. Direct imitation of traditional architecture will take away the comfort brought by modernism from users (Kimura, 1994; Suleiman & Himmo, 2012). Therefore, using the sustainable design criteria in traditional architecture as a guide and making modern adaptations would be more appropriate for today's conditions.

The design criteria used for passive ventilation and cooling in the traditional architecture of hot and arid climates can be defined as a guide for determining the air conditioning strategies to be used in modern architecture. The biggest challenge in achieving climatic comfort in hot climates is cooling (Azimi Fereidani et al., 2021). The energy spent for cooling in these climatic zones is equivalent to approximately 50% of the energy spent in providing climatic comfort (Dabaieh et al., 2015). The efficiency of these strategies depends on building physics such as direction, size, proportion, location and climatic characteristics such as prevailing wind direction, day-night temperature difference (Pacheco et al., 2012).

In this study, modern interpretations of building-scale natural ventilation and cooling strategies used in hot and dry climate traditional architecture are analyzed and evaluated in the context of award-winning projects. The main objective is to provide a guide to modern interpretations of traditional passive design strategies for natural ventilation and cooling for sustainable building design. The creation of this guide is based on detailed literature reviews.

2. Material and Method

The searches to identify the strategies used for natural ventilation and cooling in traditional hot and dry climate architecture were based on Web of Science and Scopus databases and supported by Google Scholar. Literature review were conducted between June 2021 and May 2023 to identify traditional passive design strategies for hot and dry climates. The literature review was conducted for passive design strategies for natural ventilation and cooling at the building scale in hot and dry climate traditional architecture and modern interpretations of passive design strategies. The design parameters at the building scale are divided into two groups: semi-open spatial discharge. Building envelope is grouped into wall and roof openings and incorporate passive systems. These groupings are based on the utilization criteria of passive design strategies (Ergün & Bekleyen, 2024).

The scope of literature reviews identified 16 different strategies for cooling with natural ventilation (Figure 1).

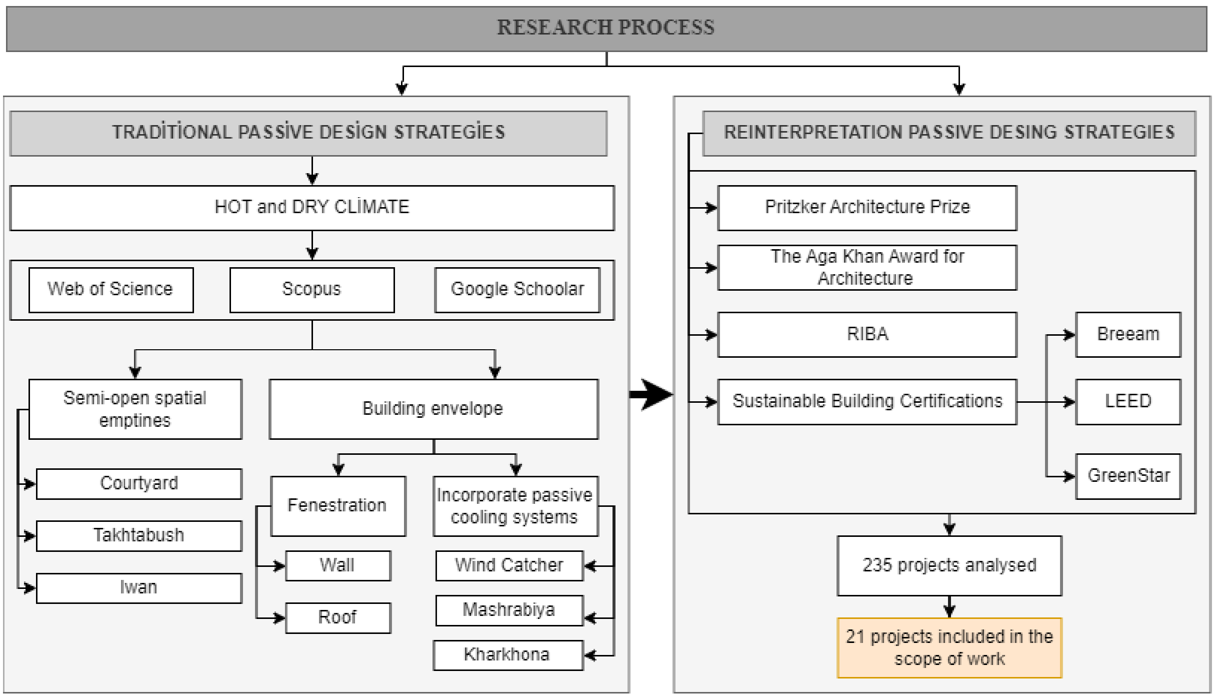


Figure 1 Research process

Modern interpretations of passive design strategies are analyzed through award-winning projects. These projects were analyzed through a literature review: architects' descriptions, academic studies, descriptions on the pages where they received awards, architects' websites, social media pages, Arch Daily, archello, architecture in development, and other leading websites of architecture and detailed observations. Projects that received one or more RIBA awards, Aga Khan Architecture Award or shortlist, Breeam, GreenStar, or LEED certification awards were analyzed. In addition, all the projects of the architects who received the Pritzker Architecture Prize are included in the study. The main reason for selecting these buildings is that they have proven their design features internationally by having one or more of the most prestigious architecture awards in the world. In addition, projects that did not receive any awards but developed an original design proposal for the modernization of traditional passive design strategies were also included in the scope of the study. In this context, a total of 235 projects were analyzed. Buildings designed without using similar strategies and without being inspired by natural ventilation and cooling strategies in traditional architecture were excluded, and 21 projects were included.

3. Results and Evaluation

The traditional passive design strategies from the literature review are categorized into two main groups: semi-open spatial discharge and building envelope.

Within the semi-open space discharge; courtyard, iwan and takhtabush were analysed. Within the building envelope, openings and integrated passive cooling systems are analysed (Figure 2) (Ergün & Bekleyen, 2024).

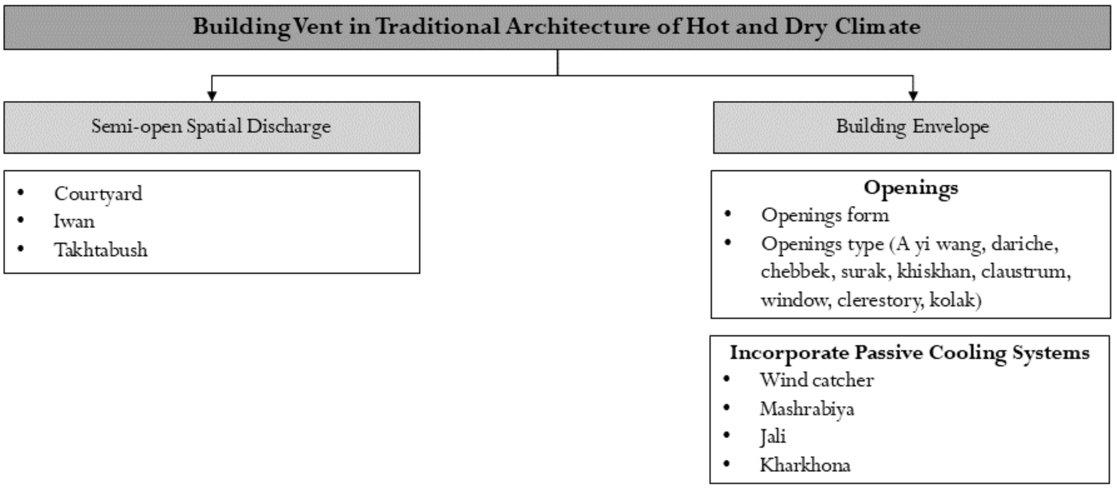


Figure 2 Classification of traditional passive design strategies (edited by Ergün & Bekleyen, 2024)

Re-interpretation of these traditional passive design strategies are analyzed and evaluated through award-winning projects.

3.1 Semi-open Spatial Discharge

3.1.1 Courtyard and Takhtabush

The courtyard has been used for shading and indoor cooling in hot and dry climates traditional architecture (Taleghani et al., 2012). Courtyards can shade interior spaces by blocking solar radiation on hot summer days. (Muhaisen & Gadi, 2005). Courtyards can also be used for cooling interior spaces (Ergün & Akın, 2024). The air of the courtyard and interior spaces, heated by solar radiation during the daytime, rises towards the night hours and is thrown out, while the cold air outside settles in the courtyard. The cold air that settles in the courtyard at night cools the rooms the next day. The outside air, which is hot during the day, passes over the courtyard without entering it and only creates vortices inside (Edwards et al., 2006).

The use of deciduous trees on the south-facing north façade of the courtyard and deciduous vines above the courtyard can provide shading during the summer and shed their leaves during the winter to allow solar radiation to enter the interior (Sahebzadeh et al., 2020; Tavassoli, 2016; Bekleyen & Dalkılıç, 2012). Plants are also involved in indoor cooling by evading water from their leaves (Abdulkareem, 2016). In addition to plants, another frequently used landscape element in the courtyard is the water element. The water element is used as a pool or well in these spaces. Water pools directly involve evaporative cooling (Edwards et al., 2017) (Figure 2).

Takhtabush is a space that usually connects two courtyards at ground level and is covered by a terrace or seating area. The hot air in the courtyard is directly exposed to the sun rises. Due to the effect of the temperature difference, air flows from the cool courtyard to the warm courtyard through the takhtabush. In this way, the courtyard, and thus the surrounding spaces, are ventilated and cooled (Figure 3) (Ernest & Ford, 2012; Fathy, 1986).

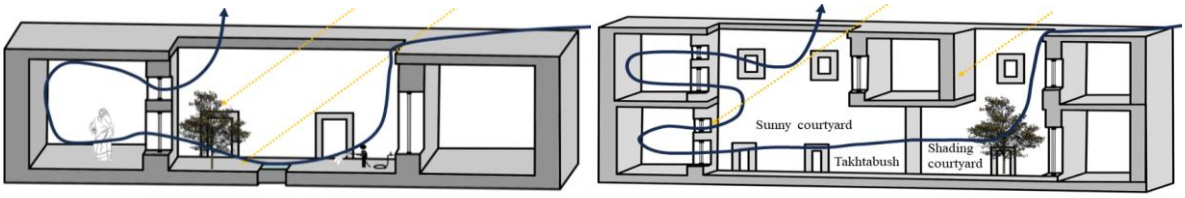


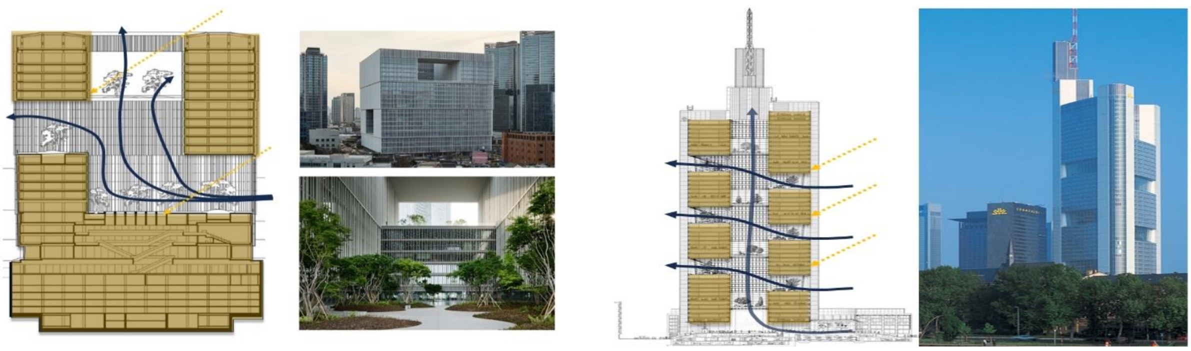
Figure 3 Courtyard and takhtabush's working principle

In designs such as the Mughal Sheraton Hotel, the courtyard and takhtabush are at ground level, similar to the use in traditional architecture, and spaces can often be arranged around them. The courtyard and takhtabush are among the essential strategies re-interpreted for modern architecture. In addition to using the central courtyard, similar to traditional architecture, it can also be used on the upper floors. Its use on the upper floors is especially for ventilation and cooling. In designs such as the Mughal Sheraton Hotel, similar to the use in traditional architecture, the courtyard and takhtabush are on the ground level, and spaces are usually arranged around them (Figure 4)

Name: Mughal Sheraton Hotel
Architect: Ravindra Bhan and Associates
Awards: Aga Khan Award for Architecture-(1978-1980)
Location: Agra/India
References: (Edited by Sarbjit Bahga, 2019)

Figure 4 The first type of courtyard.

In buildings such as Amorepasific Headquarters, Menara Mesiniaga, and Commerzbank Headquarters, spatial evacuations were made on various floors to give courtyard function to the spaces defined as sky courtyards (Figure 5).



Name: Amorepasific Headquarters
Architect: Sir David Chipperfield / The Pritzker Architecture Prize / 2023
Awards: RIBA International Awards for Excellence 2021Short List
Location: Seoul/South Korea
References: (Edited by David Chipperfield Architects, 2017)

Name: Commerzbank Headquarters
Architect: Norman Foster / The Pritzker Architecture Prize
Location: Frankfurt/Germany
References:(Edited by Buchanan, 2012)

Figure 5 The twice type of courtyard

3.1.2 Iwan

One of the most essential advantages of the iwan is natural ventilation and cooling. In places with low air velocity at ground level, airflow is provided from the courtyard to the iwan with the buoyancy effect. This airflow is transmitted to the interior spaces, and cooling is provided (Figure 6) (Sahebzadeh et al., 2017).

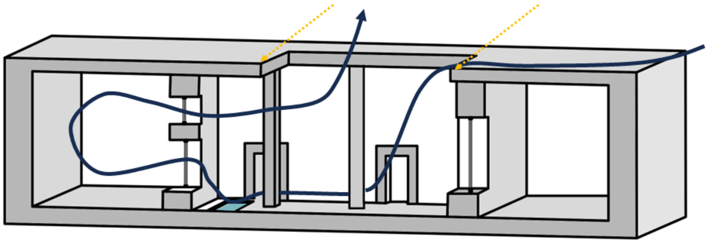
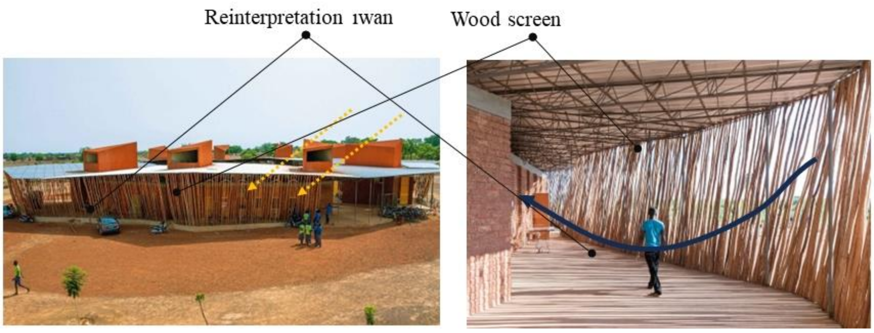


Figure 6 Iwan's working principle

The projects within the scope of the study interpret it in three different ways.

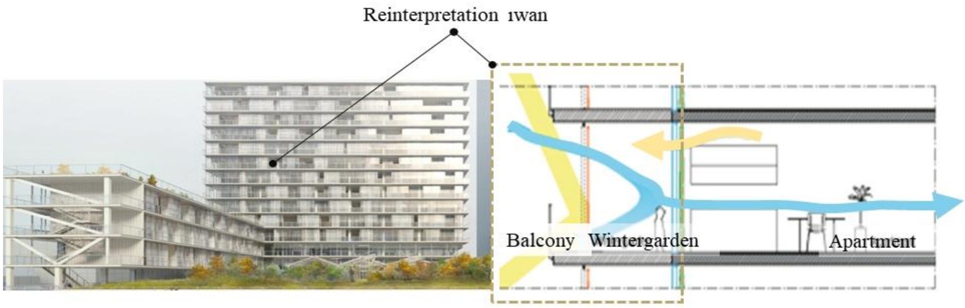
The second facades are designed to create intermediate transition spaces in the first type. Salam Cardiac Surgery Center and Lycee Schorge projects can be given as examples. While the second facade designed in front of the building is half open, it also has upper covers. The area between the two facades can be characterized as an iwan. In this context, the semi-open facade prevents solar radiation and dust transportation more than the traditional iwan while also providing ventilation, cooling, and insulation (Figure 7) (Gada, 2022; Kere Architecture, n.d.).



Name: Lycee Schorge **Location:** Koudougou/Burkina Faso
Architect: Francis Kere / The Pritzker Architecture Prize – 2022 **References:** (Edited by Lancaster, 2022)

Figure 7 The first type of ıwan

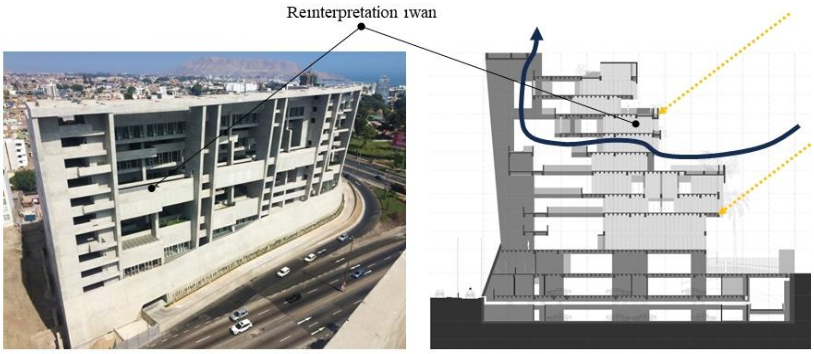
The Maaglive project interprets the iwan as a retractable winter garden. This design can be defined as the second type of adaptation. In this context, while the upper cover of the winter garden provides shading when the facade is opened, it can provide natural ventilation and cooling (Lacaton & Vassal, 2020). In addition to the traditional use of the iwan, the winter garden can also be used for heating during cold winter (Figure 8).



Name: Maaglive **Architect:** Anne Lacaton and Jean-Philippe Vassal / The Pritzer Architecture Prize – 2021
Location: Zürich/Suisse **References:** (Edited by Lacaton & Vassal, 2020)

Figure 8 The twice type of ıwan

The third type of iwan adaptation is achieved through circulation elements. In the UTEC-Universidad de Ingeneria y Technologia project, horizontal circulation elements are designed semi-open on the north facade. The deep horizontal and vertical curtain walls protect these elements on the north facade from solar radiation, allowing cool air to penetrate the building without heating (Farrell et al., 2016). Using these semi-open spaces on the north facade can be defined as another modern interpretation of the iwan in traditional architecture (Figure 9).



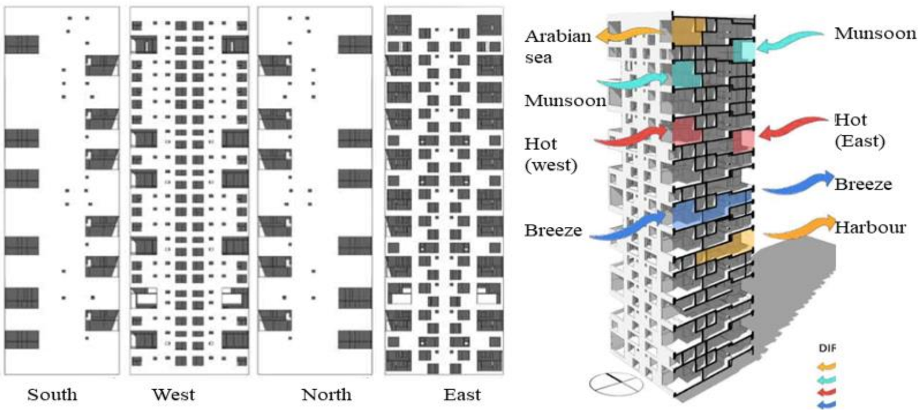
Name: UTEC-Universidad de Ingeniería y Tecnología **Awards:** RIBA International Prize 2016
Architect: Yvonne Farrell and Shelly McNamara/ The Pritzer Architecture Prize – 2020
Location: Lima/Peru
References: (Edited by Archdaily, n.d.)

Figure 9 The third type of courtyard

3.2 Building Envelope

3.2.1 Openings

Kanchanjunga apartment can be cited as an example of the modern interpretation of the dimensions, proportions, and directions of the openings connected to the facade. In the region where the prevailing wind direction is west, the number of openings on the west and east facades of the building is higher. This allows the wind coming from the west facade to exit from the east facade through cross-ventilation. The interior design is also designed to increase this ventilation. The openings on the other facades have more depth and fewer openings. This can protect from solar radiation (Fig 10).



Name: Kanchanjunga Apartments
Architect: Charles Correa / RIBA Royal Gold Medal
Location: Mumbai/India
References: (Edited by Özkan, 2009)

Figure 10 The first type of open ratio

In order to increase the cooling function of openings in the roof or wall, various design features have been developed, which differ from region to region. In Sistan, Iran, openings defined as surak and daricheh (Sahebzadeh et al., 2017) were used. In Erbil, Iraq (Algburi & Beyhan, 2019); Diyarbakir, Turkey; and Al-Dakhla, Egypt, wall openings defined as taka, skylight, or Arusha were designed (Hailu et al., 2021). In Es-Salt, Jordan, openings are defined as shukhshaikhas (Almatarneh, 2013). In addition to the windows on the upper level, grid-shaped openings can also be seen on the upper level adjacent to the main window. An example is the grid-shaped openings made of plaster in Evora, Portugal (Figure 11) (Fernandes et al., 2015).

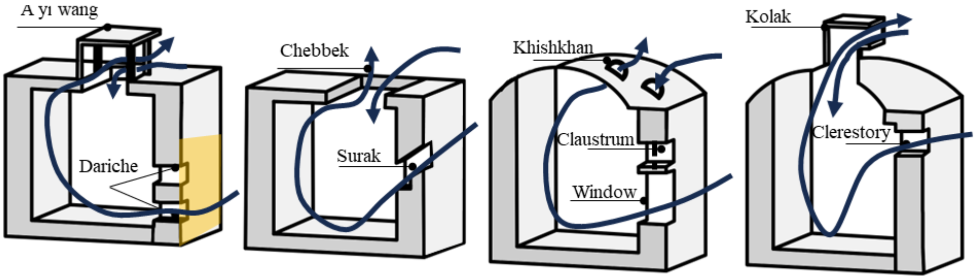


Figure 11 Opening's working principles

Roof openings can be used for ventilation and cooling purposes in an integrated manner with wall openings. In some regions, they are referred to by different names depending on their structural characteristics. Examples include kolak in Sistan and khishkhan in Yazd, Iran, chebbek in M'zab, Algeria, and a yi wang in Gansu and Ningxia in northwest China (Bensayah et al., 2019; Heidari et al., 2017; Liu et al., 2006; Sahebzadeh et al., 2017).

Wall and roof openings in traditional architecture are often reinterpreted in modern architecture for interior ventilation and cooling. In addition to the normal use of windows, various openings of different elevations and sizes have been designed. Examples include Moulmein Rise, Startup Lions campus, Lycee Schorge and Storey's Field Center, and Eddington Nursery. In this context, it can be said that openness types are interpreted in three different ways (Figure 12).

	**Name:** Moulmein Rise **Architect:** WOHA Architects **Award:** Aga Khan Award for Architecture-(2005-2007) **Location:** Singapore/Singapore **References:** (Edited by Zainab Faruqui Ali, 2003)

Figure 12 The first type of wall opening

In the first interpretation, a new design of the window opening has been developed to allow the outdoor air to be transmitted to the interior from the vertical surface and the horizontal plane. This window system was developed in the Moulmein Rise project. The lower horizontal windows and upper vertical windows used in the apartments can serve as the main window and skylight used in traditional architecture, providing chimney-effective ventilation (WOHA Architects, 2007; Zainab Faruqui Ali, 2003).

The second type is reinterpreted by integrating the wall and the roof opening of the kolak type. Startup Lions Campus and Lycee Schorge are examples of this. In the Lycee Schorge project, a water element was added under the seating areas consisting of hollowed concrete blocks in front of the facade openings (Gada, 2022). In addition, roof openings were designed to exceed the upper cover of the building. After evaporative cooling is provided through the water entering through the wall opening, the heated air is discharged through the roof opening (Gonzalez, n.d.) This use is similar to the Startup Lions project; no water element is used in the wall opening (Figure 13) (WA Contents, 2021).

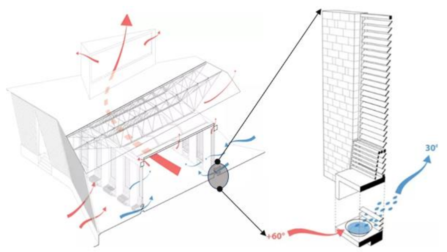
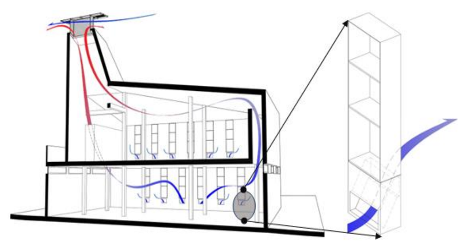
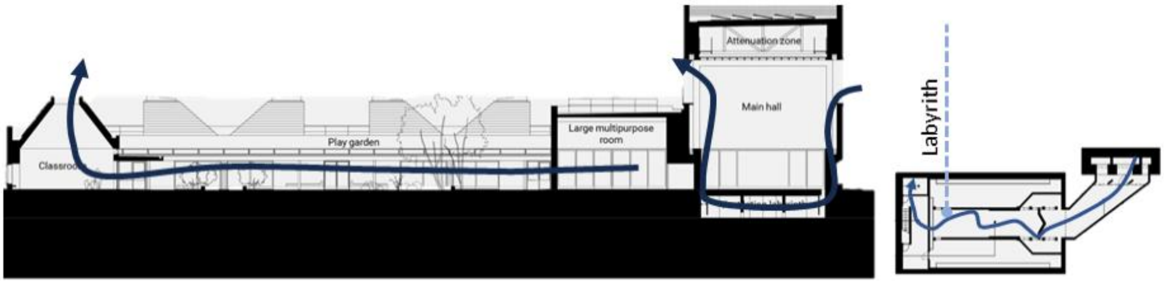
	
Name: Lycee Schorge **Architect:** Francis Kere / The Pritzker Architecture Prize **Location:** Koudougou/Burkina Faso **References:** (Edited by Gonzalez, n.d.)	**Name:** Startup Lions Campus **Architect:** Francis Kere / The Pritzker Architecture Prize **Location:** Turkana/Kenya **References:** (Edited by WA Contents, 2021)

Figure 13 The second type of wall and roof opening

The soil's heat could also be utilized in the third type of modern adaptation. Storey's Field Center and Eddington Nursery project is an example of this. A labyrinth system was designed under the floor of the main hall of the building to provide natural ventilation and cooling. The air drawn from the cool courtyard is transmitted to this labyrinth without being transmitted indoors. The air that hits the concrete walls of the maze is further cooled using soil cooling. The cooled air is used for indoor cooling. The air heated indoors is transmitted to the outdoor environment through openings hidden in the roof (Figure 14) (Hartman, 2018).



Name: Storey's Field Center and Eddington Nursery
Awards: RIBA East Award 2018, RIBA East Sustainability 2018
Architect: MUMA Architect
Location: Cambridge/United States
References: (Edited by Hartman, 2018)

Figure 14 The third type of wall and roof opening

3.2.2 Incoporate Passive Ventilation Systems

Traditional wind catcher, mashrabiya, jali, and kharkhona and their modern interpretations are analyzed within the scope of incorporate passive ventilation systems.

Wind Catcher

The outdoor air directed indoors by the wind catcher is circulated indoors and then transferred to the outdoor environment through another opening or the opening of the wind catcher (Oropeza-Perez & Østergaard, 2018). These devices work in two different ways depending on the buoyancy effect of the outdoor wind and the temperature difference. According to the first method, the wind is captured by the wind catcher and cooled by the underground space, water or directly by the tower of the wind chiller until it is transmitted indoors. In the second method, the indoor space is cooled by expelling the heated indoor air to the outdoor environment through the wind catcher acting as a solar chimney, or the cold outdoor air settles on the wind catcher (Figure 15) (Bahadori, 1978; Hassan et al., 2016; Saadatian et al., 2013). Especially outdoor wind pressure is about 75% more effective than the buoyancy effect. Therefore, the outdoor wind is significant within the scope of microclimate (Hughes & Mak, 2011). Egypt, Iraq, Iran, Iran, Qatar, Algeria, and Türkiye can be given as examples of the regions where it is used (Bekleyen & Melīkoğlu, 2019 and 2021; Bouchahm et al., 2011; Ghaemmmaghami & Mahmoudi, 2005; Pirhayati et al., 2013; Soflaee & Shokouhian, 2005).

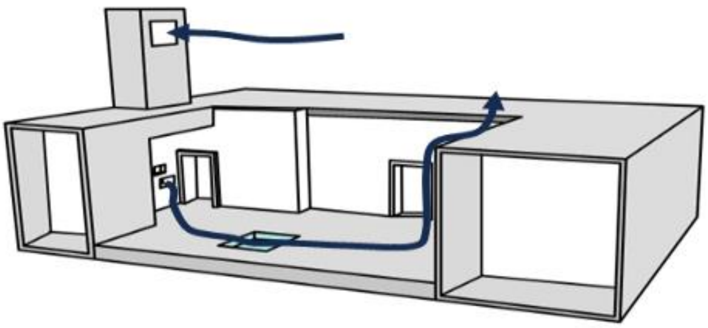


Figure 15 Wind Catcher's working principle

In the projects within the scope of the study, wind catcher have been re-interpretated in five different types. In the first type, it is interpreted as a chimney connected to all floors adjacent to the building facade. BSkyB Broadcast Center and Pixel Building can be given as examples. In the BSkyB Broadcast Centre project, cold air is drawn indoors through adjustable grilles that detach the building about 1 meter from the ground. This air is distributed indoors through wall and ceiling openings. The heated air inside the building rises and is drawn into the ceiling space. The air drawn into the attic space is transmitted to the ventilation shaft and discharged from there (ArchDaily, 2013).

In the Pixel building project, the chimney-shaped opening starts from the point exceeding the upper elevation of the roof and captures the air from the outside environment. There are heat exchangers to cool the captured air in hot seasons and heat the captured air in cold seasons, and two fans transmit this air to the interior. Once heated or cooled, the fresh air is delivered indoors through openings in the floors of all office rooms. In this way, ventilation, heating, and cooling are provided. The air heated indoors is captured through the chimney and openings in the upper levels of the interior spaces and delivered to the outdoors through the second opening of the chimney. The fans and heat exchangers used in this system operate with deficient energy, and the necessary energy is obtained from solar panels and wind turbines used on the roof of the building (Figure 16) (Archilovers, 2012).

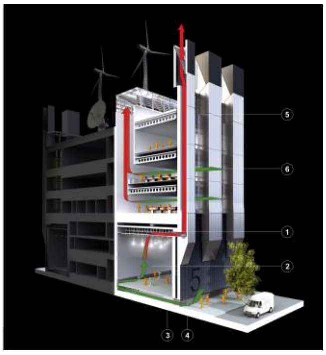
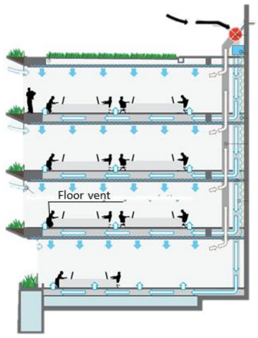
	**Name:** BSKyB Broadcast Centre **Awards:** BREEAM Excellent Certificate **Architect:** Arup Associates **Location:** Londra/UK **References:** (Edited by ArchDaily, 2013)		**Name:** Pixel Building **Awards:** 105 GreenStar+105 Leed Certificate **Architect:** Studio 505 **Location:** Melbourne/Austria **References:** (Archilovers, 2012)

Figure 16 The first type of wind catcher

In the interpretation defined as the second type, a vertical cavity is created within the building itself, giving it the characteristic of a wind channelizer. Wafra Wind Tower is an example of this. In the center of the building, a chimney is designed to continue from the ground floor to the top floor. The hot air accumulated in the apartments is transmitted to this chimney through openings and transferred to the external environment through the chimney. On the other hand, clean and high-density cool air collapses from the external environment into this chimney and is transferred to the apartments (Figure 17) (The Aga Khan Award for Architecture, 2020).

Name: Wafra Wind Tower **Awards:** Aga Khan Award for Architecture-2020-2022 Cycle-Shortlisted
Architect: AGI Architect **Location:** Salmıya/Kuwait
References:(Edited by The Aga Khan Award for Architecture, 2020)

Figure 17 The twice type of wind catcher

In the third type, the opening between the double skin is used as a wind catcher. Torre Agbar is an essential example of this. In addition to the space between the walls, an opening was left at the top of the building to allow the air accumulated between the walls to escape. The second wall of the building is composed of sunshades. As this facade heats up, it can draw the heated air from the apartments and transmit it to the outside environment through the overhead opening (Figure 18) (Ateliers Jean Nouvel, 2006).

Name: Torre Agbar
Architect: Jean Nouvel / The Pritzker Architecture Prize-2008
Location: Barcelona/Spain
References:(Edited by Architectuul., n.d.)

Figure 18 The third type of wind catcher

In the fourth type, a wind catcher is placed on top of the upper cover, similar to traditional architecture. Cool air from the outdoor environment is directed into the interior, and the air heated indoors is transmitted to the external environment through the building's wind catcher or other openings. The BedZed project can be an example of this adaptation. The small opening in the wind catchers consisting of two openings receives the calm outdoor wind, while the large openings are used to expel the heated air indoors. One of the most critical design strategies is the ability of the wind catchers to rotate according to the wind direction. In this way, wind catchers can play an influential role in ventilation and cooling. The wind catchers, which also play an active role in expelling the heated air indoors, also take the heat of this air and ensure that it is heated and transmitted indoors when the outdoor air is colder than desired (Figure 19) (Hodge & Haltrecht, 2010).

Name: BedZed
Awards: 2003 RIBA Stirlink Prize
Architect: Bill Dunster
Location: Londra/UK **References:** (Edited by Enes, 2014)

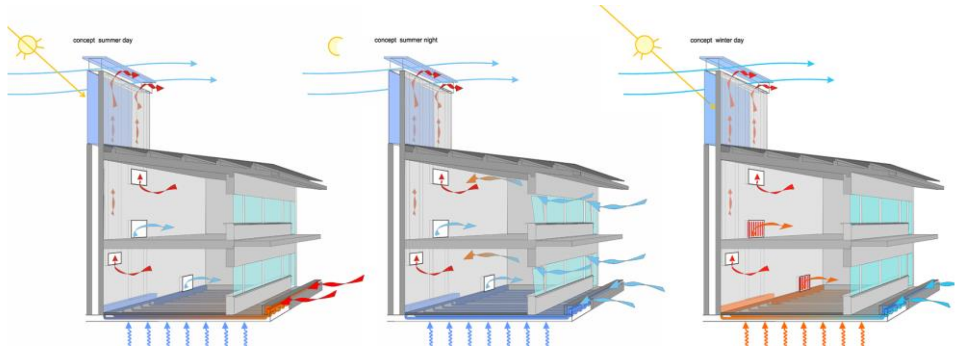
Figure 19 The fourth type of open ratio

In the fifth type, unlike the fourth type, the wind catcher also acts as a structural element of the building. It can be located at different elevations, unlike the upper cover. George Davies Centre is an essential example of this. With the help of grilles placed in the structural elements that also serve as columns on the ground floor of the building, the air is transmitted to the pipes and the labyrinth system under the soil. With the help of the soil, the air is cooled on hot summer days and transmitted to the interior spaces through shallow floor slabs. The air heated indoors is discharged through the courtyard. The cycle is reversed during cold winter periods (Figure 20) (Ball, n.d.).

Name: George Davies Centre
Awards: Breem Excellent
Architect: Bill Dunster
Location: Leicester/UK **References:** (Edited by Ball, n.d.)

Figure 20 The fifth type of wind catcher

The wind catcher is reinterpreted as a solar chimney in the sixth type. The Lycee Français Charles De Gaulle project is an important example of this. In this project, outdoor air is transmitted through openings close to the ground level to pipes embedded in the ground floor slab. As this air, used for indoor cooling, warms up, it is discharged from the solar chimney to the outdoor environment through chimney-effect ventilation. Cool air is delivered to the interior at night through pipes buried in the ground, wall openings, and solar chimneys to provide indoor cooling (Figure 21) (Transsolar, 2008).

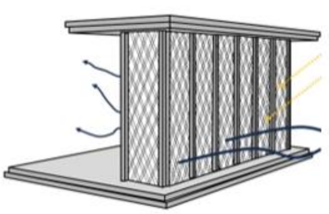


Name: Lycee Français Charles De Gaulle **Awards:** Aga Khan Award for Architecture-2011-2013 Cycle-Shortlisted
Architect: Transsolar
Location: Damascus/Syria
References:(Edited by Transsolar, 2008)

Figure 21 The sixth type of wind catcher

Mashrabiya and Jali

Mashrabiya can be defined as a wooden frame that decorates the building facade and covers the window opening (Bagasi et al., 2021; Fathy, 1986). Air leaking through the small openings of the mashrabiya can be directed into the interior space to provide cooling (Bagasi et al., 2021). Jali can be defined as a type of mashrabiya built of stone material (Figure 22a) (Prasad et al., 2022). As a result of the examinations carried out within the scope of the study, modern interpretations of mashrabiya and jali are used in two types. The first type focuses on porous building material. Kohan Ceram Central Office Building is an important example of this. Perforated bricks and perforated window shutters were used in this project. Ventilation and cooling were provided through perforated bricks and shutters (Figure 22b)(Hooba Design Group, n.d.).



Name: Kohan Ceram Central Office Building
Architect: Hooba Design Group
Awards: RIBA International Awards for Excellence
Location: Tehran/Iran
References: (Edited by ArchDaily, n.d.)

Figure 22 a) Mashrabiya's working principle, b) The first type of mashrabiya

The second type of adaptation is based on the porosity of the outer wall of the double-skinned building. Doha Tower and NMAAHC projects can be given as examples. Doha Tower is surrounded by an outer shell of porous aluminum, inspired (Boissiere, n.d.; The Aga Khan Award for Architecture, 2016). In the NMAAHC project, the facade is clad in porous bronze metal. The pore density varies from region to region depending on the solar radiation. Depending on where it is used, the porosity prevents solar radiation from penetrating the interior while providing cooling with natural ventilation (Figure 23) (U.S. Green Building Council, 2022).

TYPE 2	
	
Name: Doha Tower **Architect:** Ateliers Jean Nouvel / The Pritzker Architecture Prize **Location:** Doha / Qatar **References:**(Edited by AJN, n.d.)	**Name:** NMAAHC **Architect:** David Adjaye / 2021 Royal Gold Medal **Location:** Washington / USA **References:**(Edited by Castro, 2016)

Figure 23 The second type of mashrabiya

Kharkhona

Kharkhona is an evaporative cooling method used in the traditional architecture of Sistan, Iran. Its use in another region has yet to be identified. In Sistan traditional architecture, where the prevailing wind direction is northwest, thorny plants were piled in front of the openings of the rooms in this direction, and water was sprayed on them. Kharkhona can reduce the indoor temperature by about nine °C (Davtalab & Heidari, 2021; Heidari & Davtalab, 2022).

A Honeycomb Interpretation can be shown as an example of a modern interpretation of using the water retention feature of external elements for evaporative cooling. The honeycomb interpretation used as an evaporative cooling element has not yet been used in an award-winning project (Figure 24). However, it is included in the study as it is an important modern adaptation of the traditional Kharkhona cooling system

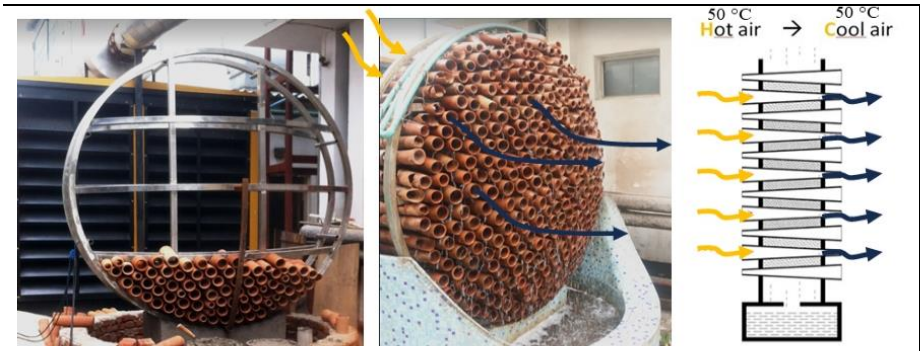
	**Name:** A Honeycomb Interpretation **Architect:** Ant Studio **Location:** New Delhi / India **References:** (Edited by Archello, n.d.)

Figure 24 The first type of kharkhona

It is formed by combining the elements of clay, earthenware, and water. Due to their production material, earthenware pots are constantly sprayed with water and can hold water. The fan is placed on top of the system and powered by the electricity generated by photovoltaic panels. This fan acts on the water and provides evaporative cooling. In addition to the fan, the hot air generated by the generators during operation can also be directed to this system and used for evaporative cooling (Archello, n.d.).

4. Conclusion

The main objective of this study is to provide a guide for sustainable building design within the scope of modern interpretations of traditional passive design strategies. Ventilation openings in buildings used for natural ventilation and cooling in hot and dry climates of traditional architecture are included in the scope. Passive design strategies within this scope were identified, and modern interpretations were analyzed and evaluated within the scope of award-winning projects. A total of 16 different strategies were identified within the scope of the ventilation openings of the buildings. Three of these strategies are grouped as semi-open spatial discharge, and the remaining 13 are grouped within the scope of the building envelope. Of the 13 strategies within the scope of the building envelope, wind catcher, mashrabiya, jali, and kharkhona are included in the internal passive systems sub-heading. The remaining nine strategies are grouped as wall and roof openings. In this context, it has been determined that the traditional passive design strategies developed for natural ventilation and cooling are primarily focused on wall and roof openings. It was determined that 18 different types of traditional natural ventilation and cooling strategies used in the hot and dry climate region were adapted to modern architecture. Within the scope of adaptation to modern architecture, wind deflectors come to the fore with six different types of use. The identified strategies are generally used in an integrated manner similar to traditional architecture.

This study can be defined as the first stage of a comprehensive guide that can be created for modern interpretations of traditional passive design strategies for hot and dry climates. Further studies can be carried out that can be a guide for modern interpretations of traditional passive design strategies for different climates.

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