APPROACH TO ENERGY EFFECIENT BUILDING ELEMENTS

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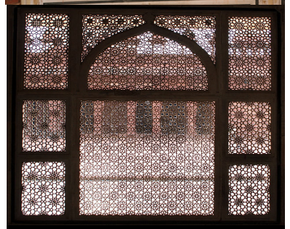


INTRODUCTION

INTRODUCTION

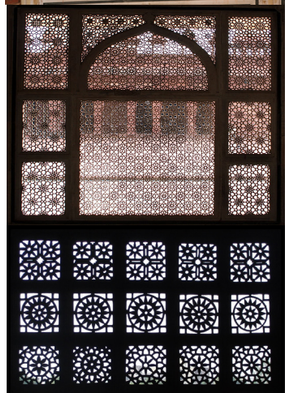
The simplest form of addressing human needs, is seemingly forgotten in modern architecture due to urbanisation. However, due to recent rises in energy costs and climatic change, the trend has sensibly swung the other way.

Adapting to the differences in the environment requires inventiveness, without inventiveness humans will not be able to survive in most climates we live in today. But in order to progress in the future of architecture and buildings, we must first gain knowledge of the past and employ these strategies in a proper way to balance the chaos created in the environment

The traditional structures have proven to be energy efficient and altogether sustainable as in ancient period people knew to build and survive in harmony with nature. The low-tech methods of creating housing in the past were perfectly adapted to the climate of that area.

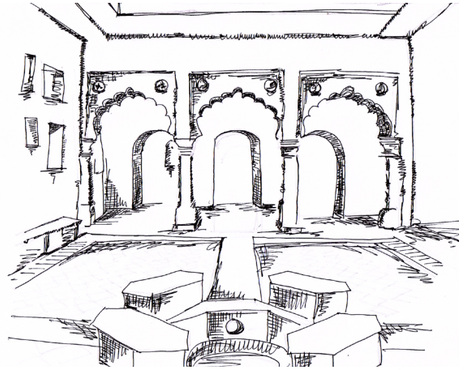
Therefore, this study analyzes the use of energy efficient or low-tech elements in the past (traditional buildings) and the process of its transformation over the period of time (i.e Past ,present and future).This study research focuses on only two such energy efficient traditional elements-

- Courtyards
- Jaali



COURTYARD

2.a Introduction



Courtyard View of a Traditional Rajasthani house

Openings play a major role in any building. In openings courtyards places an important part in maintaining the comforts in a building in terms of lighting ,ventilation and thermal comfort. " A courtyard is defined as an unroofed area that is completely or partially enclosed by walls or buildings, typically one forming part of a castle or large house".[10]

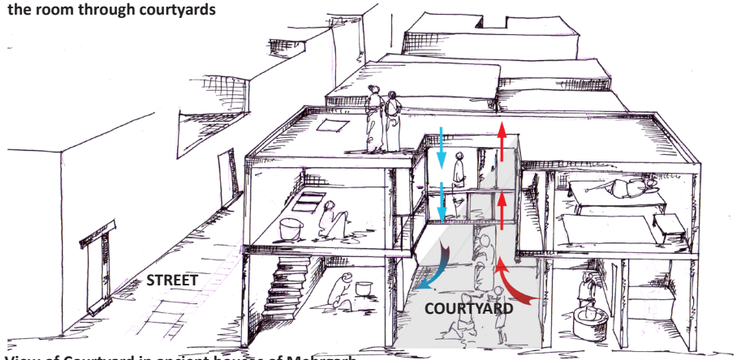
Charles Correa explains the importance of courtyard in the Indian context," To cross a desert and enter even the humblest courtyard is a pleasure beyond mere photogenic image making. It is the quality of light and the ambience of moving air that forms the essence of our experience".[6]

Map of Indus valley Civilization depicting location of Mehrgarh [14]

2.b Courtyard in Past

The origin of courtyards can be traced to the Indus valley civilization , the first courtyard houses, according to historical evidence appeared to have originated in Mehrgarh probably around 6500-6000 B.C , which was a part of Indus valley civilization. in that region ,open spaces were conceived and built inside the houses for the need of light and ventilation, due absence of openings on the exterior facade.(for the purpose of safety and security). Objects such as grinding stones, pots, shells, charred wheat e.t.c have been found in the central courtyard as to point it as the main activity area of the house. The entrance area to a house led into the central courtyard from where the rooms were accessible. The front façade presented a blank face to the street and any person standing at the entrance could not see into the house which offered a high degree of privacy .Thus ,the working spaces were all surrounding the courtyard which was the only source for light and ventilation.

Hot air being light rises up and to take its place cool air enters ,thus maintaining proper circulation of air into the room through courtyards



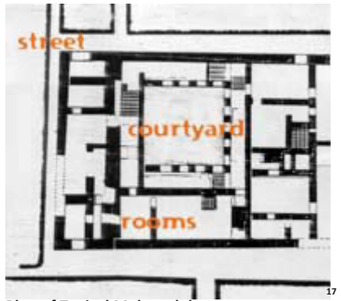
View of Courtyard in ancient houses of Mehrgarh

After the indus valley civilization the traditional courtyard was built on the principle of vastu purusha mandala ,which states that all spaces emerge from a single point i.e the centre of the house which was called the Brahmasthana or courtyard,

This courtyard as a design element continued with the Aryans (before 10th century).But it was with the entry of the Islamic rulers (14th Century) into northern India that brought the key issue of treating open spaces in building design ,to respond to the harsh climate.

Courtyard in Fatehpur Sikri with Anup Talao 15

Fatehpur sikri- Akbar's city of victory was founded in 1585 A.D as his new capital. The entire palace complex is laid out as a vast fortified rectangle.The palace complex consist of a sequence of interconnecting courts accommodating various functions surrounded by colonnades.



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Plan of Typical Mehrgarh house.

Courtyard near Diwane-Khas in Amer Fort 16

But the british invasion brought a very different style of architecture in India –the colonial style. Prevalent in a country of cold climates, the courtyard had no existence here. Instead, formal rooms came into existence , and at one point of time, the usage of a courtyard had disappeared in houses.

One can see major variations in the nature of courtyard as one moves from one region to another. Climate is one of the features which decides the scale ,proportion and positioning of courtyard. The proportion of space changes with the climatic condition of regions.

Courtyard in Hot and Dry Climate

Courts in hot and dry regions of north India are taller as compared to its width to increase efficiency of mutual shading .Even palaces and havelis do not have larger courts for grandeur but have multiple small courts instead.

The architectural built form of typical Shekhwati havelis in Rajasthan has evolved in response to the climate, lifestyle and availability of material. In hot climates where cooling is important, buildings with internal courtyards were considered most appropriate.

Location map of Shekhawati 18

It acted as a perfect shading technique, while also allowing light inside. The arcade along the court, or the high wall around it, kept the interiors cool. These courtyard havelis were developed when the concept of air-conditioning did not exist. No mechanical devices were used to achieve desirable thermal comfort conditions .

Shekhawati Haveli courtyard 19

Shekhawati Haveli courtyard 20

Shekhawati haveli entrance 21

Courtyard of a shekhawati haveli with a fountain and surrounded by colonnade with beautiful paintings and frescos. 22

Plan and Section of typical Shekhawati haveli 23

Havelis in Shekhawati consisted of two courtyards — an outer one for the men which serves as an extended threshold, and the inner one, for the women, as in a male dominated society, they required privacy for their women.

The largest havelis could have up to three or four courtyards and were two to three stories high.

Rajasthan having extreme climatic conditions, the courtyards is seen as a building element throughout the state.

Location map of Chettinad region 24

central courtyard 25

Entrance towards the central courtyard 26

Courtyard in Hot and Humid Climate.

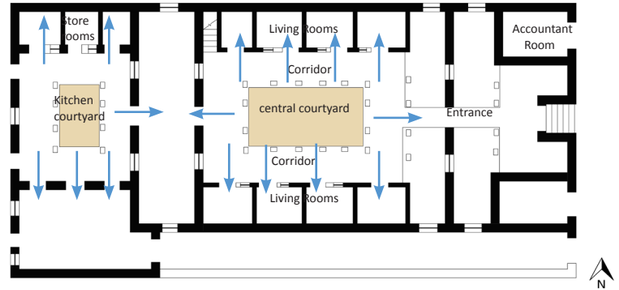
Houses in hot and humid regions of India have shallow courts to allow proper movement of air.

Chettinad region is in the heart of Tamil Nadu .This is a region which is majorly inhabited by Nattukottai chettiars (merchants).

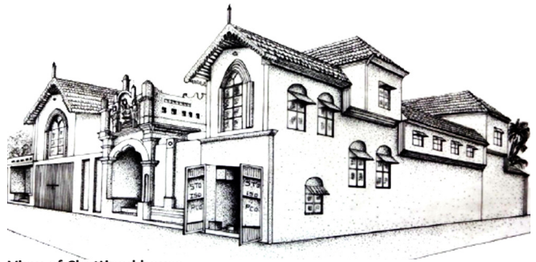
The architecture of the chettinad region has elaborate palatial type houses with courtyards. The central courtyard becomes the important area and all the other activities happen around the courtyard.

The height of the Chettinad house never exceeds two levels, ground floor and first floor.

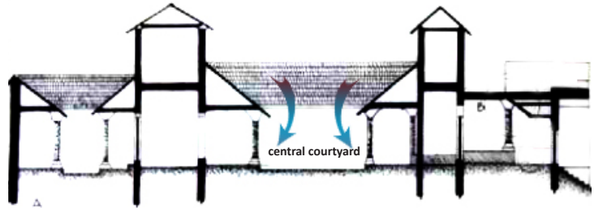
The inner or the first courtyard is known as the 'valavu vaasal' is also a common space where functions and marriages take place . Thus, the inner courtyard is considered to be a semi-public space.The courtyard is surrounded by double rooms called 'veedu'The next courtyard is considered as private space as this part is only used by servants and women. Generally food materials and grains for drying are stored in this area.



Plan of Typical Chettinad house showing circulation of air



View of Chettinad house 27



Section of Chettinad house 28

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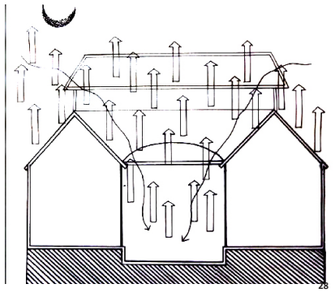
Corridor surrounding the courtyard

The courtyard roof is projected 0.26m into the courtyard.By this projection ,the roof provides ample shadow to the corridor as well as the room surrounding the corridor, in turn reducing the intensity of heat.



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Night Analysis of houses in chettinad region

In the night the absorbed heat is radiated out through the courtyard.

The main ventilation by which the light enters the house is through central courtyard. It acts like a thermostat which controls the temperature of the house. The hot air rises up through the courtyard ,creating low pressure, which helps to draw more cool air inside.

Kitchen Courtyard 30

Kitchen courtyard is considered to be a private space, used only by women and servants.

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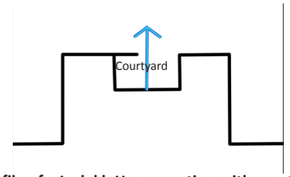
Courtyard in the second floor of Ladakh houses 32



Profile of a Ladakh House section with courtyard

Courtyard in Cold climate

Ladakh is located in the northern most part of jammu and Kashmir.It is situated in the rain shadow region of Himalayas,thus it hardly receives any rain.

In Ladakh the courtyard is placed on the top floor as it is used only in certain periods of time. Ground floor is the place for animals ,First floor is the winter quarters with small openings and kitchen in the south –east corner .The second floor consist of courtyard ,its orientation is towards south for maximum sun penetration and the courtyard in the second floor is also surrounded by rooms and a small kitchen too.

A meter wide verandah acts as a transition space between the open courtyard and the covered spaces.

Conclusion

Courtyard house architecture in india was not just an architectural style ,it was a way of life .It was a structure's core. The courtyard in Indian house not only represented the lifestyle of that region and era but also controlled the inside environment by balancing the outside temperature and thus, served the needs of the inhabitants. Every climate is unique in its expression which in turn influence the nature of courtyards. Courtyard existed in every part of India only its form, elements and arrangement changed according to the climate .

Typical Section of Ladakh house (In winters, thses courtyards are simply used for soaking sun.) 33

2.c Courtyard in Present time

Courtyards all across India are generic element found in building forms with little variation of its geographic contexts."It is a timeless spatial element of Indian architecture and it is still valid today".[10]

Pearl Academy of Fashion, Jaipur

Pearl Academy ,located on the outskirts of Jaipur, consist of traditional energy efficient elements such as courtyard, jaali, water body in the form of step well.

The courtyard designed in this building controls the internal temperature as well as provide sufficient daylight and ventilation inside studios and classrooms. The lowest floor of the building is sunken 4m below the ground level so that cool humidified air which is heavier than warm dry air might be contained and the sunken courtyard also provides privacy for the student gatherings.

Courtyard view of Pearl Academy [34]

Analysis-

Internal Organisation-In this building the lower floor is sunken ,the courtyard is enclosed by classrooms and studios on the first and second floor from all the sides.

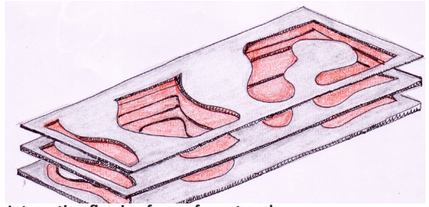
Form and scale – Interesting flowing form are formed to create courtyards within a rectangular plan.

Elements of Courtyards- Inspired from the baodi of Rajasthan , a waterbody designed like a stepwell is provided in one of the courtyards ,which is surrounded by stepped walkways.

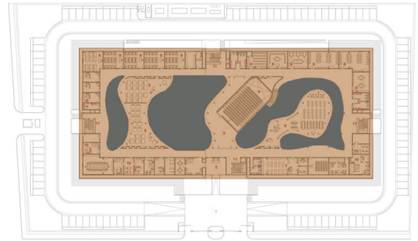
Connectivity- All the courtyards are interconnected

Courtyard view of Pearl Academy with the waterbody [35]

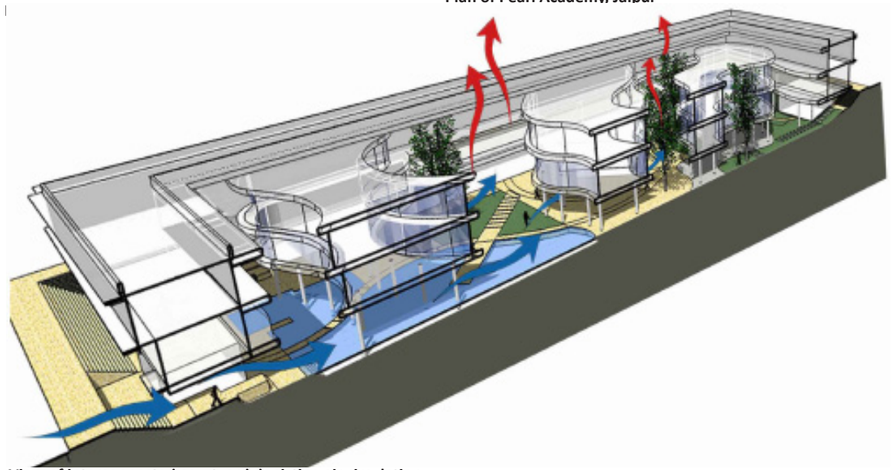
Seating in Courtyard inspired from Stepwells [36]



Interesting flowing form of courtyards



Plan of Pearl Academy, Jaipur



View of interconnected courtyard depicting air circulation [37]

Conclusion

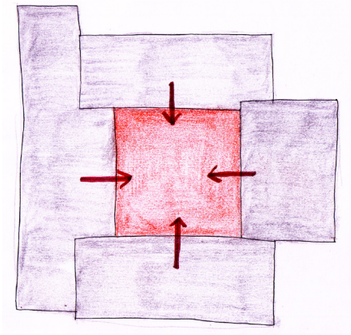
The size or the scale of the courtyard according to building height is appropriate as the buildings provide proper shade making it an interactive space for the students. As it is surrounded by buildings on all four side it also provide a private space for activities as was used in the past. The Lower floor is sunken and filled with water so that as soon as hot air in the courtyard rises up ,the outside air taking its place gets cooled by the waterbody present.

Courtyard with a sitting space in Abu Abraham's residence 38

Courtyard view of Abu Abraham's residence 39

Mr. Abu Abrahim's Residence, Thiruvanthapuram.

The house is designed by Mr. Laurie Baker with bricks and stone and with the concept of central courtyard .This courtyard is given the character of a garden with a little landscaping and a small lily pool. The rooms above and below look into the courtyard and the entire house is oriented towards it.



A conceptual sketch of Abu Abrahim's residence showing courtyard in tht centre of the house and all the rooms can be accessed through this courtyard.

Analysis-

Internal Organisation- In this building, the courtyard is located in the centre of the house and the rooms in both the floors are oriented towards the central courtyard.

Form and scale- The minimum residential courtyard dimension should not be less than 1.5 times the height of the ceiling of the lowest enclosing floor, thus the size the of the rectangular courtyard in this house is appropriate according to the height of the building.

Elements of courtyard- The courtyards consist of lily pool, trees and pebble pathway with seating space.

Connectivity- One can access other rooms through the courtyard.

Courtyard view of Koramangala House 40

Stepped seating like stepwell in the second courtyard 41

Koramangala House, Bangalore

In this house, designed by Charles Correa, the space revolves around the centrally placed courtyard .As it is inspired by the traditional houses of kerala, the rooms are arranged around the courtyard which has the champa tree.

Analysis-

Internal Organisation- In this building also, the courtyard is located in the centre of the house and the rooms are arranged around it.

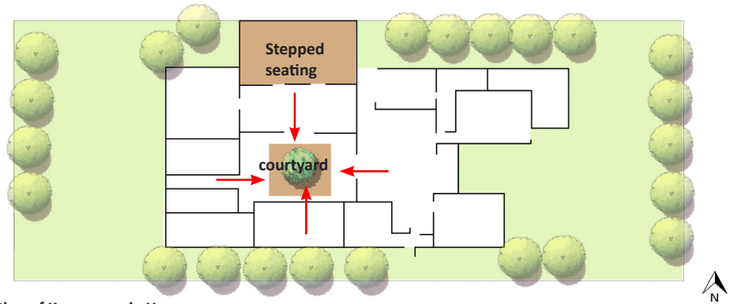
Form and scale- The square courtyard is small in size but is enough to provide proper light in ventilation .

Elements of courtyard- Most part of the courtyard is paved with a champa tree in the centre.

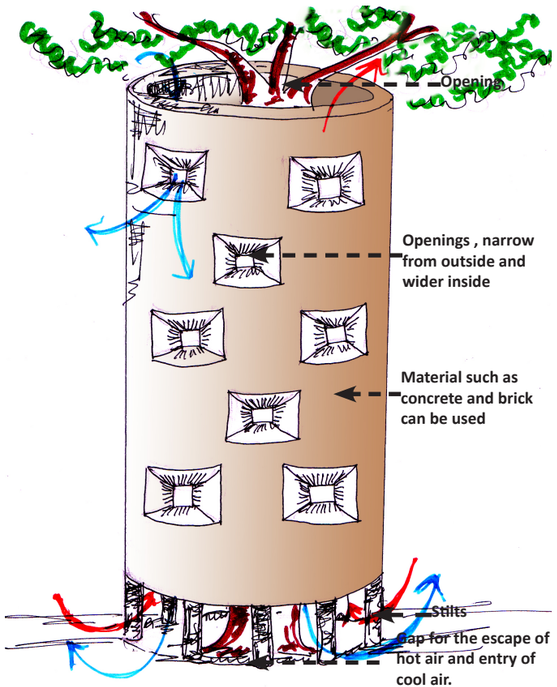
Connectivity- From the courtyard ,the other rooms or studio are accessible.

Conclusion-

In both the above residences , the courtyard is located in the centre of the house, inspired from traditional building plans. The courtyard provide an open to sky private space for the residents as well as create a feeling of openness by improving the aesthetics from inside of the house.



Plan of Koramangala House



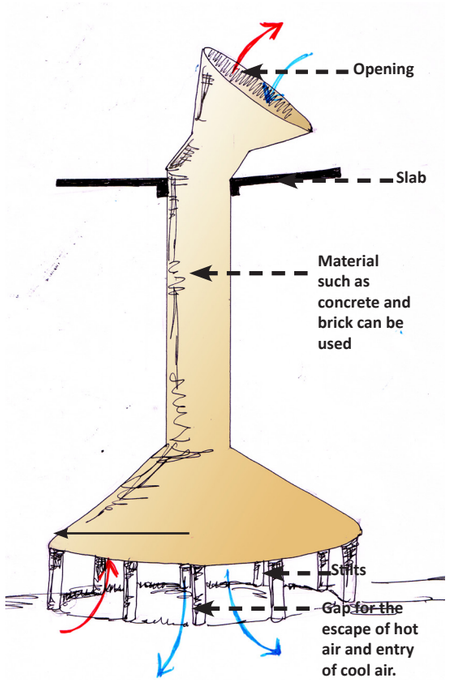
Honey - comb well

2.d Courtyard in Future

Having said this much about the essence and articulation of courtyards ,one might wonder why in spite of all these –having a private open space secure from the outside world which brings natural light and air into the house –courtyard houses are disappearing. Even though people appreciate such beautiful houses, for their own self they do not prefer courtyards. One reason can be that people often associate courtyards with palaces and havelis or buildings of such scale and to some extend it is true, courtyard houses are generally of not a very small size and the other reasons are and will be rapid industrialization, growth of population, pressure on land and breakup of joint family.

Therefore, some conceptual sketches are proposed so that courtyard buildings do not disappear.

The **first sketch (Honey-comb well)** represents a cylinderical open to sky structure or tower, which can be constructed inside a residence or any kind of building. As the
size of the plots are and will be reduced so the size of the courtyard can also be reduced. Thus, this open to sky structure is a reduced form of a courtyard that is based on the technique or the function of a courtyard.
The structure is lifted on stilts and contains openings all over its surface. These openings are wider on the inside and narrower towards the outside surface. As mentioned in later chapter that according to Venturi effect when air is compressed its velocity increases, so the fresh air entering from the opening at the top will enter the rooms with great force, cooling the temperature inside.

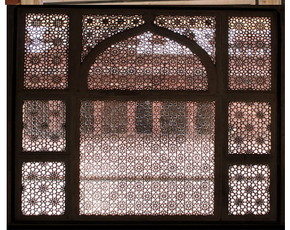


Funnel Tower

The hot air being light will rise up from the gap at the lower part of the structure, and the cool air, from outside will take its place by entring from the top opening then through the small apertures on the surface and also through the bottom gap ,creating a proper circulation and distribution the cool and fresh air inside a room.
This stucture will provide proper light and ventilation in a building, avoiding direct glare of the sun.

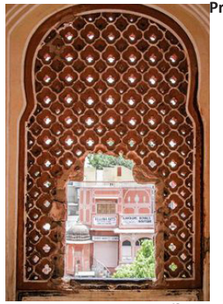
The **second sketch (Funnel Tower)** is a cylinderical funnel shaped structure , also lifted on stilts creating a gap for the escape of hot air and entry of cool air. This structure if constructed in a building will allow the entry of diffused light.
The concept of its shape is based on the same venturi and bernoulli principle that when air travels through a narrow path , it gets compressed and its velocity increases but pressure decreases .So as soon as ,air is released into a wider path its pressure increases with low velocity and by releasing heat ,becomes cool.Thus, the above principle can be followed with this shape which will provide circulation of cool breeze inside a building.

The sketches are conceptual ideas or sketches which are proposed to revive this courtyard in the generation to come. when there will be lack of space in the future then, maybe not the concept but at least its technique of passive cooling can be developed so that this design can last many more centuries in new 'avatars'. As Charles Correa puts it " Courtyards as the centre of a house becomes its source of energy ;the entire house seems to be radiating out of it .And not only that ,it is a wonderful experience to have one's own private open space, one's own sky in different shapes and sizes "[6]



JAALI

Hawa Mahal 42



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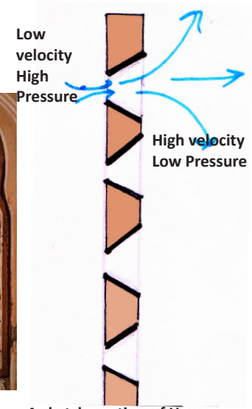
Jaali of Hawa Mahal ,narrower outside and broader inside



A sketch section of Hawa Mahal Jaali based on the principle of bernoulli and venturi effect

3.a Introduction

"Jaali is the term for a perforated stone or latticed screen ,usually with an ornamental pattern constructed through the use of calligraphy and geometry".[10]

This particular element is perforated and so when used in interiors space ,it divides but does not separate a space visually. When used on the external façade it allows the entry of diffused light and conditioned air.

Jaali is one such element of architecture that has been an effective tool in addressing environmental comfort.Jaali breaks the complete consolidated window into number of small holes. Generally the size of each jaali aperture is same or smaller that the thickness of the material with which it is built.

The proportion of holes is larger and percentage of opacity is less in jaalis of hot and humid climate.

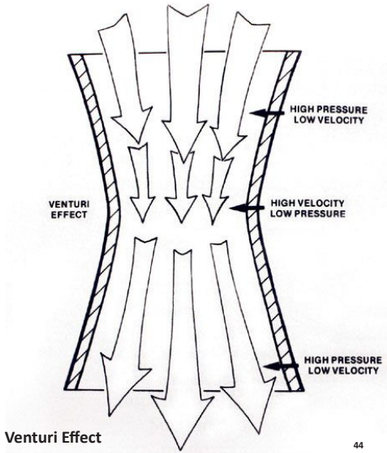
3.b Jaali in Past

The Mughals had already been using Jaalis in architecture of their region. During Mughal invasions in India, the architecture of Rajasthan was also influenced .

In 14th and 16th century Stone carved Jaali in Rajasthan. The ancient buildings of Rajasthan flaunt the Jaali work on the doors and windows .Even the Jaalis which were made from sandstone and marble were used in the windows of zenanas to enable women to view events from the other side of the 'purdah'.

The best example of intricate Rajasthani carved Jaalis is Hawa Mahal in Jaipur with 953 small Jharokhas or covered windows. This 16th century carved jaali would catch the breeze using principles found in modern air-conditioning, offering both security and circulation.

Two laws of physics turn jaali into air-conditioners: the principles of Venturi and Bernoulli.



Venturi Effect 44

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Jaali in Taj Mahal

"Venturi's principal states that air is compressed and increases its speed when passed through a funnel causing a breeze".[10] Thus, when air passes through small apertures of the Jaali ,its velocity increases. So even with the mild breeze outside ,one can feel the air velocity inside.

"Bernoulli law states that when air is compressed and released it becomes cool".[10]This is similar to the principle of air-conditioning ,in which the compressor ,compresses the air and releases through micro-holes. Jaali also follows the same principle , when the air passes through small apertures of the jaali ,it becomes cool.

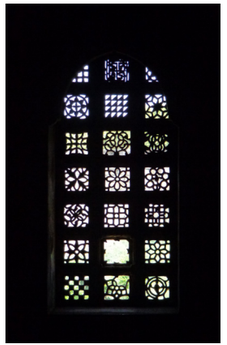
In the 17th and 18th century sandstone was extensively used as a building material ,and all the openings were surfaced with intricately patterned Jaali .Geometric patterns were in demand as the period was dominated by mughal emperors."

Mughals were very strong with geometry and all their geometric principles took the shape of intricately carved jaalis which adorned the arches and the openings"[8] . This screen exhibits three distinct geometric patterns—the star-based pattern in the interior of the arch, the interlace design above the arch, and the simple geometric border that frames the entire rectangular screen.

The best example for intricate jaali works is The Taj Mahal.

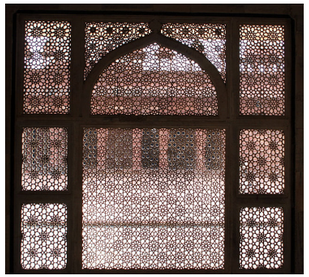
the Jaalis,including all the doorways were carved from single marble. Designs based on abstract geometric pattern create an enchanting woven effect and also reduces the glare of the sun.

There are many other examples of Jaali in india such as Siddi Syyed Mosque in Ahmedabad and Salim Chisti Darga in Fatehpur Sikri ,Agra.



Jaali of Saher ki Masjid

Jaali of Saher ki Masjid



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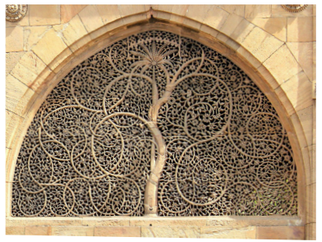
Jaali of Salim Chisti Durgah



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Jaali of Siddi Syyed Mosque

Another example can be Saher ki masjid in Champaner .This mosque consisted of jaali at every opening , each opening being approximately 300mm thick, the jaali screen was fixed at the edge of every opening. Thus, creating a box like window ,obstructing the glare of the sun with proper circulation of air and penetration of light.

As visible in the pictures ,the complete screen is made up of different pattern of stone jali forming interesting designs. Mughal jaalis in mosques and mousoleums were not only used to create peaceful ,cool ambience but also to create a separate prayer space for ladies ,as the most interesting charater of a jali is ,from within, everything outside is visible through Jaali holes but from the outside, nothing gets visible inside due to light difference. Thus maintaining privacy and on the same time not obstructing the outside view.

Conclusion-

The Jaali in ancient India was an important architectural element which was as a symbol to increase the grandeur of a fort or palace. The geometric pattern thus created by skilled craftsmen of that era were used as windows or room dividers, allowing light and air to enter the room while minimising the glare of the sun and the gazes of the passers-by. The intricately carved jaali designs created a subtle play of light and shadow in the interior, emphasizing the characteristics of symmetry by forming interesting patterns.

Pearl Academy jaali facade

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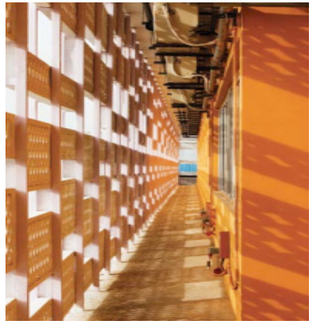


49

Jaali of Pearl Academy is 1.2m away from the walls of the rooms creating a buffer space

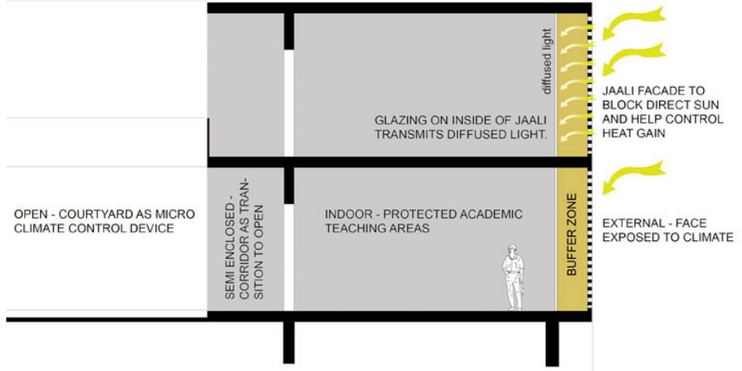
3.c Jaali in Present

Jaali became popular as a building element from grand forts of Mughals and Rajput to buildings in Rajasthan and Kerala.

Pearl Academy of Fashion ,Jaipur

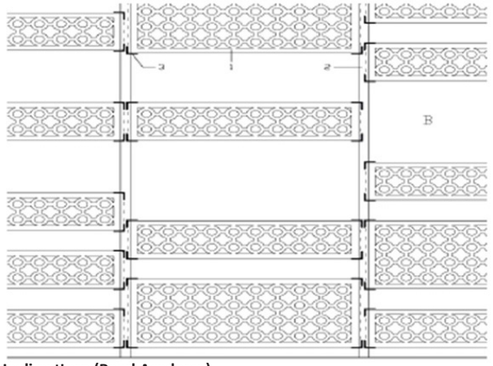
The architecture Building located on the outskirts of Jaipur consist of traditional energy efficient elements such as courtyard, jaali, water body in the form of step well.

The building is covered with jaali which is 1.2 meters away from inner walls .It acts as a thermal buffer between the building and the surrounding.



Section Of Jaali (Pearl Academy)

50



Jaali pattern (Pearl Academy)

51

Jaali of Loyola Hostel

52

53

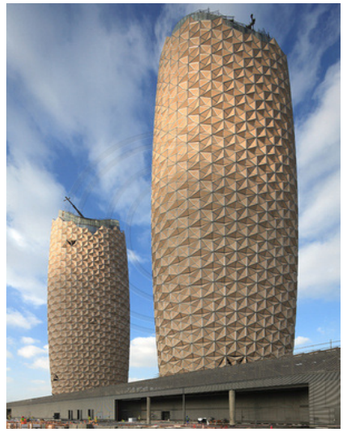
Analysis (Pearl Academy)-

The complete façade of the building is covered with concrete jaali, arranged in an interesting pattern. The jaali façade is 1.2M away the external wall of the building thus protecting the building from heat and direct sunlight and aesthetically improves the appearance of the building but due to the form of the perforation these jaali will not be able to produce venture effect.

Loyola Women's Hostel, Trivandum

This is a building designed by Laurie Baker, as he was an architect who believed in cost effectiveness, he designed the complete wall with exposed brick jaali to minimise the use of windows to reduce cost. The Jaali designed by him is broader on the outside surface and narrower to inside ,mainly to avoid rainwater to penetrate

This brick jaali was influenced from traditional south Indian patterned wooden grillwork; gaps between bricks lead air and daylight through the wall while diffusing the glare of direct sunlight. This brick walled jaali created interesting light and shadow pattern.



Al-Bahar Towers, Abu Dabi

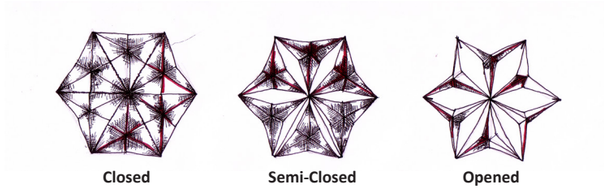
Jaali Of Al-Bahar Towers

Al Bahar Tower,Abu Dabi

The climate of Abu Dabi is hot and arid so they designed façade which is a innovation of Jaali The dynamic façade of this building is the interpretation of the traditional Islamic 'mashrabiya', a popular form of wooden lattice screen used to provide privacy and reduce glare. .The 'mashrabiya' in Al- Bahar comprises of transparent umbrella like components that open and close in response to the sun path .Each of the two towers consist of 1000 individual shading devices that are controlled via the building management system.

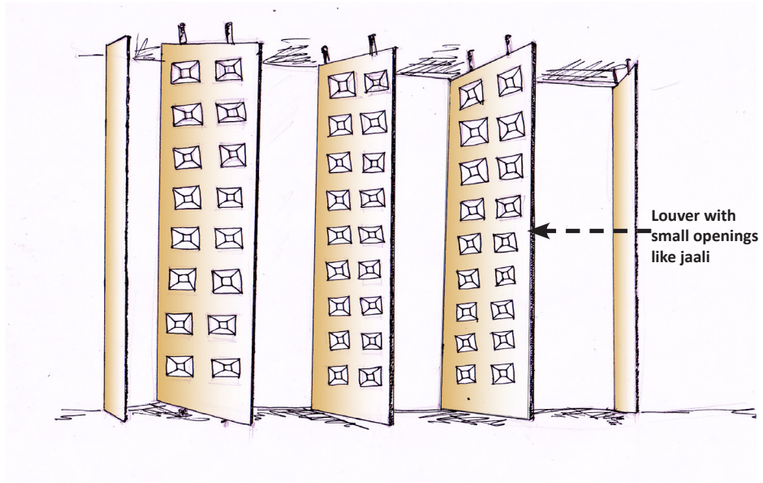
Analysis-

The main function of a jaali is to reduce glare, in this building sunlight can be diffused according to the sun path by opening and closing of jaali. This reduces the use of air conditioners and thus reduces harmful gas emissions to the atmosphere. Though this technique is not cost effective but its energy efficient



Jaali (Al-Bahar Tower)Opens and closes according to sun movement

3.d Jaali in Future



Adjustable jaali

A look at the traditional architecture reveal that jaalis have proven their performance over centuries in terms of harmonising with environmental conditions using least or no energy spent for the same.

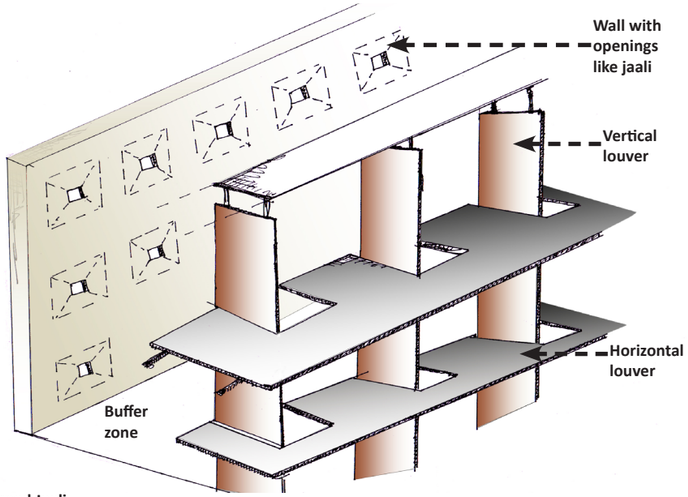
Contemporary use of jaali has shifted from public areas to more of interiors as now very few people are aware of the primary purpose of using jaali.

The basic function of jaali is that it cuts the glare but lets illumination through, not affecting the intensity of light and also provide proper circulation of air.

But Jaalis are now mostly used for aesthetic purposes, to give a royal or traditional look in the buildings.

But due to load on resources, there will a huge energy crisis in the future. Therefore, jaali which is an energy effecient element yet provides comfort ,can be incoporated in building designs.

Keeping in mind all the above points ,a conceptual sketches is proposed, to revive the technique or the function of a jaali and not just its aesthetics.



Transformed Jaali

The **first sketch (Adjustable jaali)** represents louvers with apertures as jaali. Each louver is a jaali with narrow openings on one side and wider on the other , thus, can rotated ,opened or closed as per required.

The **second sketch (Transformed jaali)** represents a wall with small openings, wider on the other side and narrower towards the buffer zone. This wall is atleast 2.5-3m away from the louvers creating a buffer zone. There are vertical as well as horizontal louvers on the outer side with works like swings of an air- conditioner. With the help of these adjustable louvers, glare of the sun and wind direction can be controlled.

These sketches are just conceptual ideas of using the technique of jaali in an innovative way so that jaalis can exist in future buildings not only for aesthetics but also for its characteristics.

4.CONCLUSION

Courtyards have been playing a major role as a building component since the past in creating better lighting, ventilation and thermal comfort. It also plays an important role in creating a social space within the building or group of buildings, a space to gather and interact. The most amazing character of a courtyard is that ,a single space can be used for so many different activities and functions.

Jaalis are small apertures on a wall .Jaalis can effectively replace glass for a transparent view and yet is more useful than glass by controlling glare and heat and also allowing movement of air. Thus, glamour of glass for unobstructed view is not new anymore; Jaali achieved the same with better aesthetics as well as environment management along with providing privacy and security.

Having analysed all the different functions of the these versatile elements it is clear that these elements can be a part of our modern buildings, creating nature as a part of designs and also providing better living solutions. These elements have infinity number of variations, as at each moment, subtle changes in the quality of light and air changes the entire ambience of that area or space. These elements creates different feeling with every change in the angle of sun and the movement of air.

Ancient people were well aware of the fact that man's relationship with Nature is only Give and take, the more you provide, the more you will be provided. Thus, invented building methods which along with their comfort also harmonises with nature.

But in this century,building methods invented are according to comfort of the human beings but not to nature as it is rightly said by Mahatma Gandhi "The Earth provides enough to satisfy every man's needs, but not every man's greed."

So, as a result we have reached a stage where we cannot afford to waste any nature's resources Thus, this means that the buildings should be designed in such a way that the building itelf must,through its ways form the controls which the user needs without harming the resources and the environment.

Adapting and learning lessons from the past construction as well as from buildings that had already incorporated the traditional techniques ,such simple elements like courtyard and jaali can be included in current as well as future building construction to design self controlled buildings which are comfortable as well as energy efficient.

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