THINK INDIA JOURNAL

ISSN:0971-1260
Vol-22-Issue-34-December -2019

RAJPUTANA STRUCTURES:

A SYMBOL OF CLIMATE RESPONSIVE ARCHITECTURE

ManmeetSingh[1], Harleen kaur[1]

[1]*Department of Architecture, Lovely Professional University, India*

Abstract

Symbolic of luxury, power and strength, Rajputana structures define an era of architecturebrilliance. The paper is based on the exploration of the palatial structures and havelis of theRajasthan. Today many cities are adopting modern architecture and techniques and trying tobe superior from one another. In the race they are forgetting that they are harming ourenvironment in one or another way. Not only environmentally, people are affected socially aswell, they are forgetting their traditions and traditional architecture. To revive the traditionsand maintain the cycle of environment; it is advisable to look at the passive techniques.Paper focuses on the various Rajputana structures like havelis, palaces, etc, that howthey thrive the harsh hot and dry climate and still standing in their glory. It makes an attemptto examine various techniques, styles and elements encountered in these buildings. This paperemphasize on the use of traditional techniques in the modern architecture and tomaintain the balance between the climatic conditions providing delicacy and beauty to theFacade and rich aesthetic variations in the elements of the buildings.

Keywords:*Palatial structures, Passive techniques, traditional architecture,modern Architecture*

1. INTRODUCTION

Rajasthan is a northern bharat state bordering Asian country, its palaces and forts are reminders of the many kingdoms that traditionally vied for the region. Rajasthan is the land of kings, land of royalty, land of wars and also the land of marvelous morphology. Its capital Jaipur conjointlycelebrated as "the pink city" is worldwide noticed for its distinctive design,forts, palaces, gardens, Vastu, art and craft and its culture. Jaipur architecture is known for its detailingbecause it is based on the Indian vastuthought. Maharaja Sawai Jai Singh II- the founder of Jaipur was a good designer and astronomer. He conjointly had a good data for the Indian vastu. This is often the most reason that the morphology of the Jaipur is a thought for the modern architects. The structures of the Jaipur are passive in one or another way. They

Respond passively to the hot and dry climate and still they'restanding in their glory. The main reason being that passive techniques are incorporated in the structures whether or not

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it's a residence of a king or a residence of a somebody. Totally different style components like jarokha, jaali, courtyard, etc are used in the building that are not solely helps to face up the cruel climate of Rajasthanhowever conjointly helps within the energy potency of the buildings.

In tropical climate like India, harsh sun rays and hot climate is the primary issue that causes thermal discomfort. So, occupants demands for the cool interiors to get comfort. In modern buildings, HVAC systems are accustomed to get the thermal comfort. As a resultconventional resources are decreasing and energy prices are rising day by day. Because of this there's a necessity of looking back to the design practices used. In the past, the strategies used in the buildings for ventilation, daylight, cooling and heating were corporative with the nature, not only this but the use of the locally available materials were atmosphere friendly.

2. LITERATURE REVIEW

Rajasthani architecture developed in 16th century. The rajput rulers has a keen sense of beauty and architecture that can be seen in the morphology of the rajas than. Rajsthani architecture is a fusion of the Mughal and Rajput architecture. The challenge to the architects at that time was the harsh and hot climate of Rajasthan. That they have intelligently came over by designing different types of design elements and incorporated them in the structures of the Rajasthan.

Design elements like courtyard, jharokha, jali, etc were designed to maintain the comfortable temperature inside the buildings and to cut off the harsh sun rays. Not only passively, these design elements were aesthetically good as well. Different types of carvings and art work was done at that time. As one of the famous architecture quote says that- "god is in details" that we can observe in the Rajasthani morphology. The materials used in the buildings was locally available.

1. Problems in the present day buildings

During the last 30-40 years we are experiencing global warming, ozone depletion, resource depletion, energy scarcity, ecological toxicity, acid rains, etc that are harming the earth, one of the reason of these is the mechanical systems installed in the modern buildings. In the past, the problem was the same as today, the hot and dry climate, but the way they operated with those buildings was different, they designed the buildings in a ecofriendly way that was both passive and energy saving. The motive was same as the modern buildings to provide the thermal comfort. But the today's buildings are using more energy and not providing that comfort as the traditional buildings were providing. Before the industrial revolution, man was inventing the passive techniques as they were aware of the scarcity of resources. At that time man and nature had a close relationship. But after the industrial revolution took place modern architecture came into existence which results in the ample use of the non-renewable resources and high energy expenditures.

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2. Importance of our heritage in terms of passive cooling and ventilation techniques

The Rajputana morphology not only represents the beauty of craft, carving and form but also responds in a passive way to the nature. The buildings designed by our ancestors were better in many ways than the todays buildings, the concept of the natural ventilation and natural light was considered in those buildings. The structures of Rajasthan like havelis, palaces, etc have a marvelous architecture that's an inspiration for the architects of 21st century. The use of the locally available materials was very good point of structures of that time. The building occupants were having the comfortable interiors. By using the landscaping elements, our ancestors tried to create the microclimate around the building. The landscaping elements not only good aesthetically good but also serves as the gathering spaces. The profound use of courtyard and jaali seems to be very impressive in the Rajputana structures.

3.Design elements

The morphology of the Rajasthan exhibits the use of different design elements like courtyard, jaali, jharokha, water bodies, etc.From the above mentioned elements various elements amongst them perform multiple functions, for example- water bodies helps in thermal cooling and also act as aaesthetic feature and a gathering place. Courtyard acts as a source of ventilation and also builta relation between indoor and outdoor. Jaali serves us with many functions like ventilation , privacy and aesthetics. All the above mentioned design elements have been used in the buildings of the Rajasthan for heating and ventilation.

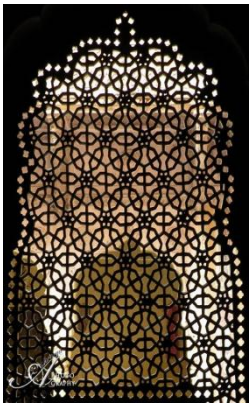
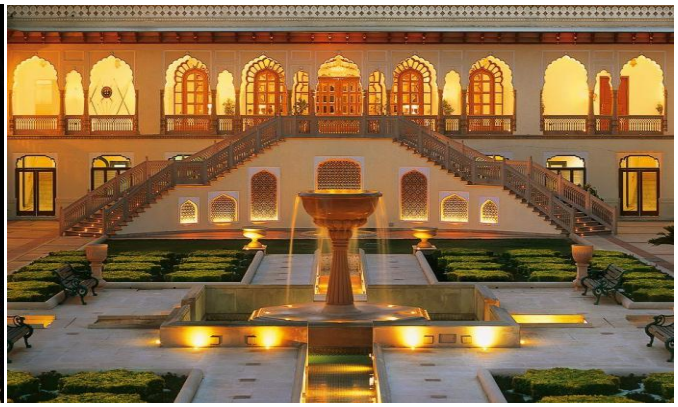


Figure 1:JaaliFigure 2: CourtyardFigure 3:jharokha

Source: bernadgagon/rajasthani architecture elements/jainstones.in/2013

In this paper we will be discussing about different design elements used in the traditional buildings of Jaipur that can be integrated in the modern architecture buildings through some case examples.

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CASE EXAMPLES

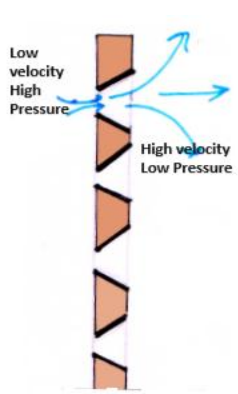
1. HawaMahal, Jaipur

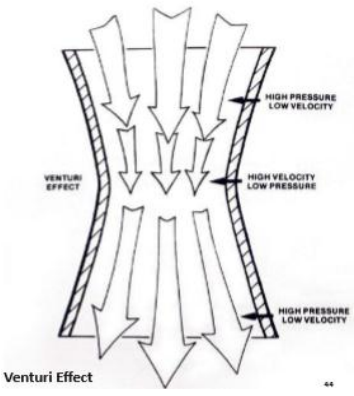
HawaMahal is additionally called the palace of winds. It had been engineered by maharaja swaiPratapsingh he dedicated this mahal to lord Krishna galvanized from his crown. Hawa mahal was constructed as a separate complex for royal women as they'll watch the lifestyle on street through windows whereas remaining hidden within.

Figure 4:HawaMahal Figure 5:Jharokha and Jali

Source: Hawamahal the crown of Jaipur/amerjaipur.in/2016

It has 953 small jharokha or covered windows. This 16th century carved jali catches the breeze using principles found in modern air conditioning, offering both security and air circulation. It works on the principle of venturi effect and Bernoulli theorem. Venturi principle states that air is compressed and increases its speed when passed through a funnel causing a breeze.Thus when air passes through small apertures of the jali, its velocity increases. So even with a mild breeze outside, one can feel the air velocity inside.





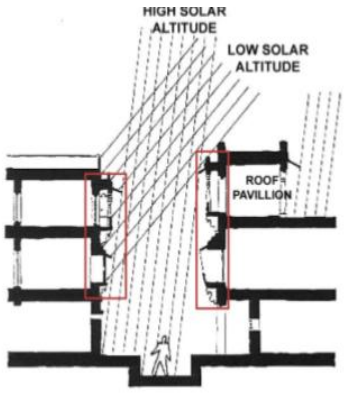


Figure 6:Jali sectionFigure 7:venturi effect sketch Figure 8:jharokha in narrowstreet

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Source: ankitaarora/architectural research on climate responsive architecture of Rajasthan

Jharokhais mainly used in palaces, havelis and temples. These helps to bring the filtered light inside the building being its any climate they bring the channelized air inside the building. These openings are provided with the chajja overhead for shading and to protect the building from the harsh sun rays by cutting them down.

As we go on the upper floors, the speed of the wind increases and therefore more cooling effect can be seen. Structural design of Hawamahal is like bee-hive. congested, attached sections with one another, large number of windows, jali, etcare some points which helps the air to circulate throughout the building.

Design elements used:jharokha, jaali, red sandstone, stained glass

2. Amer fort

The construction of amer fort was started in 1592. It was modified on regular intervals by several rulers and the trend continued up until late 1600. The fort was basically constructed with red sandstone and white marble. The architectural style of the fort is the blend of mughal and rajput architecture. The special feature of the structure is the flow of water throughout the building , making the entire hall air conditioned. Various gardens are provided, the garden resembles the char bagh and there is a star shaped pool at the center of the garden. A series of courtyards have been provided in the fort that helps in the evaporative cooling.

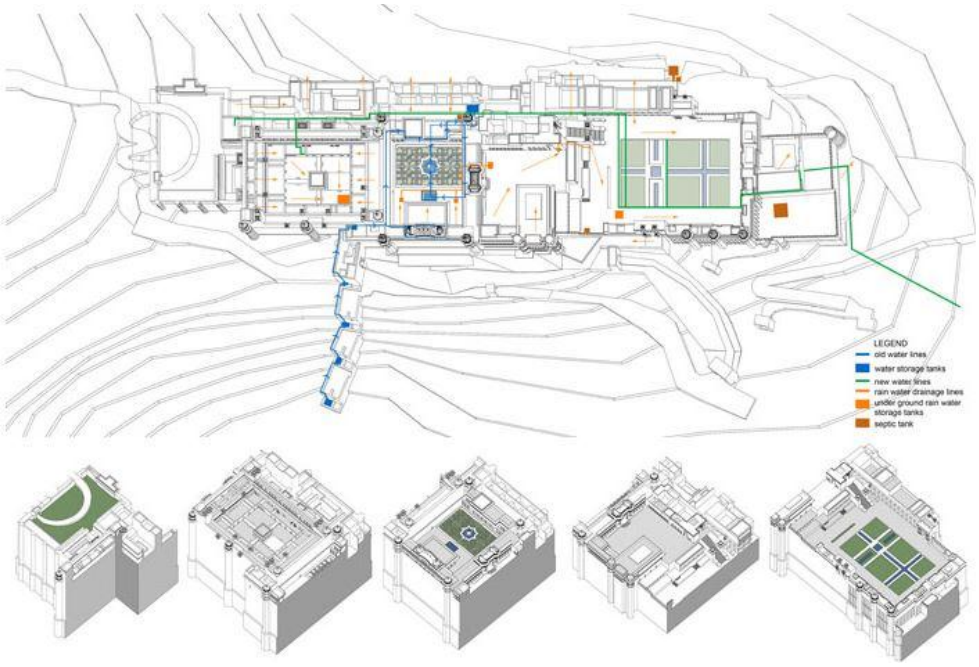

Figure 9:Plan of amer fort with the series of courtyards

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Source: amerfortgardens/cpreecenvis.nic.in/2013

The repetition of the red sandstone jali and jharokha is observed in the fort. Various types of gardens are found in the courtyards with the beautiful patterns.These octagonal patterns not only look aesthetically good but have spirituals reasons behind them which were inspired from the mughal architecture.

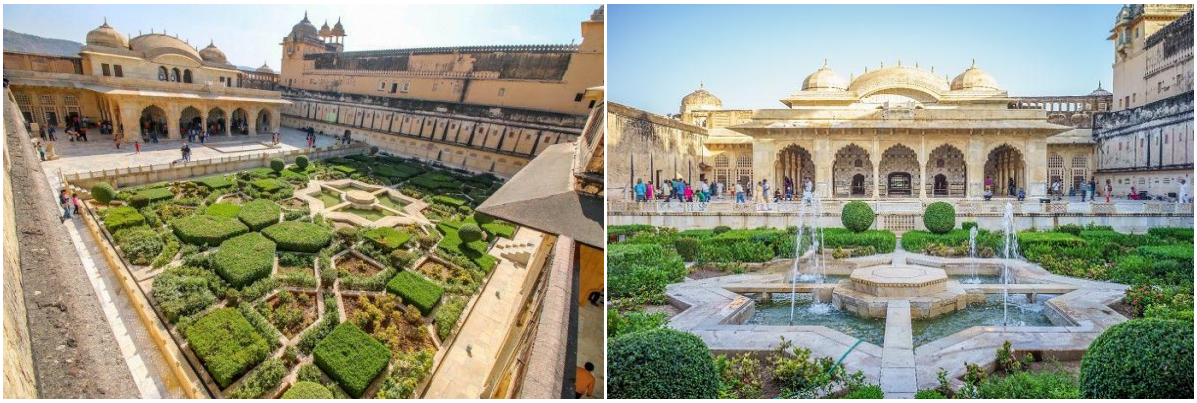

Figure 10:Gardens in the Amer fort

Source: amerfortgardens/cpreecenvis.nic.in/2013

Design elements used: courtyards, red sandstone, jharokha, jali, geometrical patterns in gardens, pillared halls, central pool, fountains

3. Shekhawatihaveli

The havelis shows a mix of mughal and rajasthani architecture in their doors, windows, etc. The façade of the havelis is covered with the motifs and paintings. Thesehavelis generally have 2 floors and a terrace. Thesehavelis usually have two courtyards separated on gender bases.

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Figure 11:Plan ofhaveli showing courtyard

Figure 12:courtyard view of havelis

Source: sharell cook/shekhawati haveli/tripsavvy.com/2013

Due to the introvert thinking of the society the courtyards were divided into two parts, one for the women and other foe the men, one being the private and other being the semi private. Courtyard is also known as chownk. It is surrounded by partly or fully shaded places. It helps in enhancing the air circulation and getting ample of daylight inside the building. It also act as a social gathering place. It serves many purposes, it also helps in worshiping the tulsi plant. The concept of courtyard is based on the Indian vastu. Which means it is centrally located and all the rooms are radiating out of the center part. Courtyard also act as a microclimate modifier.

Design elements used: courtyards

4. Patwahaveli

The havelis was basically a large residence for employees and public. These were constructed around one or more courtyard and are airy. The size of the openings in the front façade of the havelis was small to cut out the harsh sun and hot wind and also to maintain the privacy inside. Due to the conservative needs of the society introvert character was observed in the planning of the havelis as there are no exterior windows except the front façade. Usually one courtyard for male and public and other for females were provided to maintain the privacy.

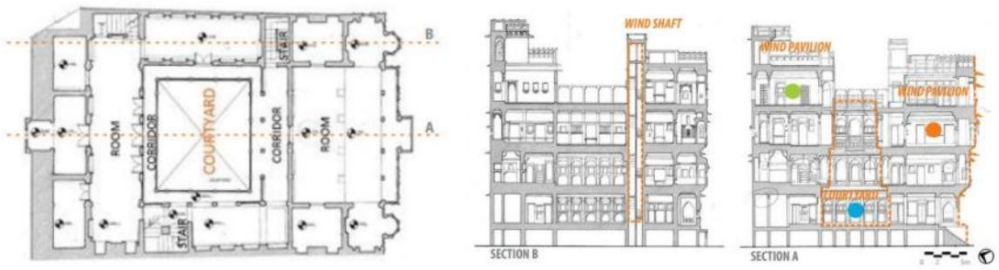

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Figure 13:Plan of the havelis Figure 14:Sections showing wind pavilionand shaft

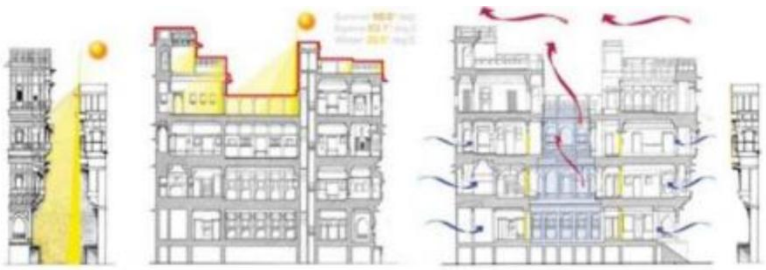


Figure 15: Sections showing radiation control and night ventilation

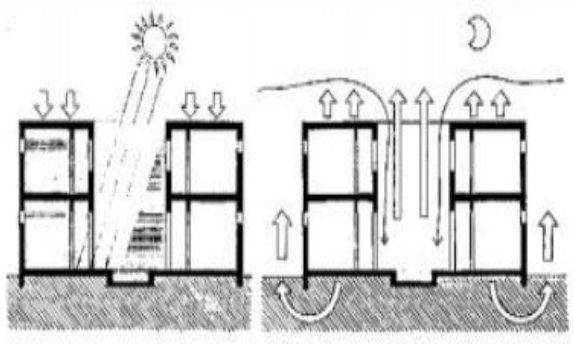
The havelis is north west to south east oriented and is of rectangular form. The havelis is a six Floor buildings consisting of three main floors, two wind pavilions and a basement floor. There is a central courtyard. The two connecting staircase acts as a wind shaft. The walls and

the roof of the havelis are made up of stone. Jharokha and balconies are provided to shade the lower floors. Narrow vertical ducts and staircase shafts are provided for deflecting wind into the built form.

Design elements used: courtyard, jharokha, jali, red sandstone

3. FINDINGS

The following design elements are used in the various case studies mentioned in this paper, that will help in the modern architecture to respond passively to the environment.

Courtyard 	Courtyard is very important technique in cutting down the heat inside the house. It helps in evaporative cooling of the building, with the help of vegetation and water bodies in it. It behaves differently in summer and winter. It is used in amer fort, Patwahaveli, Shekhawatihaveli

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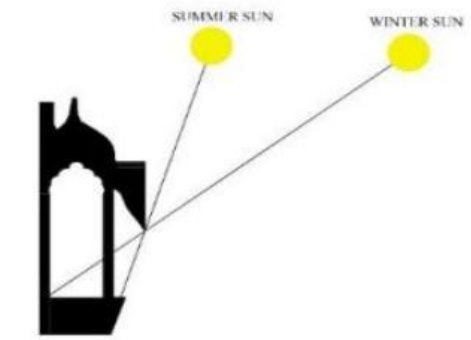
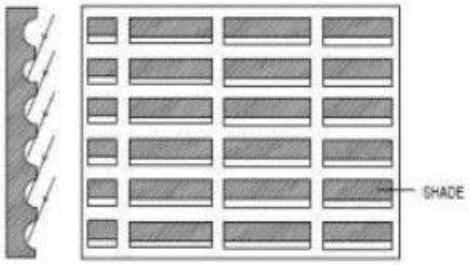
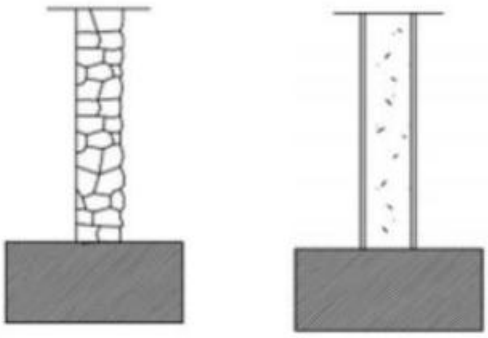
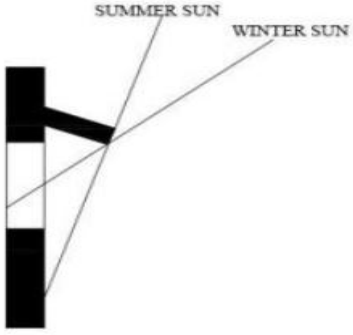
Jharokha 	Jharokha are used to cut down the harsh sun and give shade to the areas. To enhance the performance jali is used along with it for the Circulation of the air. It is used in Hawamahal, amer fort, Patwa haveli
Shading by wall texture 	Highly textured walls have a portion of their surface in shade. This permits the sunlit surface to stay cooler as well as to cool down faster at night. It is used in Patwahaveli, amer fort
Walls 	The walls studies in the dwellings are stone walls and mud walls. Thickness of the walls vary according to the dwellings. Red sandstone was used on all the dwellings. It is used in all above mentioned buildings.
Shading devices 	The shading devices like chajjas helps in reducing the intake of solar radiation inside the building. The illustration of solar radiation entering into a building on summer solstice and winter solstice is shown in the section. It is used in Hawamahal, Patwahaveli, amer fort

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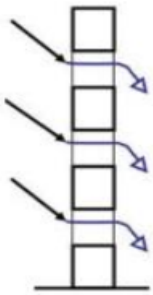
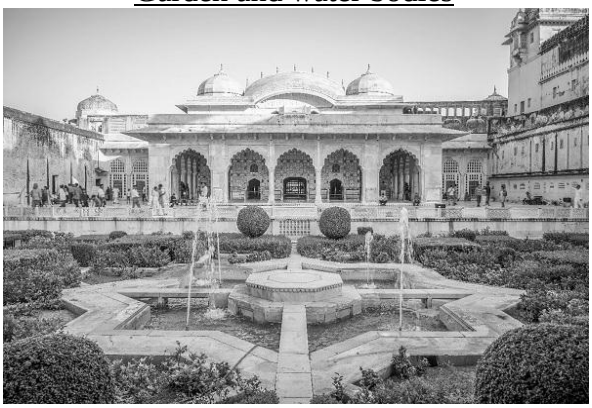
Jali 	The jali helps in lowering the temperature by Compressing the sir through the holes. It can be made into various textures and patterns. It is used in Hawamahal, amer fort, Patwa haveli
Garden and water bodies 	Gardens and water bodies are one of the most effective way in lowering the temperature inside the building. these not only enhance the microclimate of the building but also helps in adding royal and aesthetic look. It is used in amer fort.

4. DESIGN RESPONSE WITH PRESENT CONDITIONS

1. Pearl academy, Jaipur

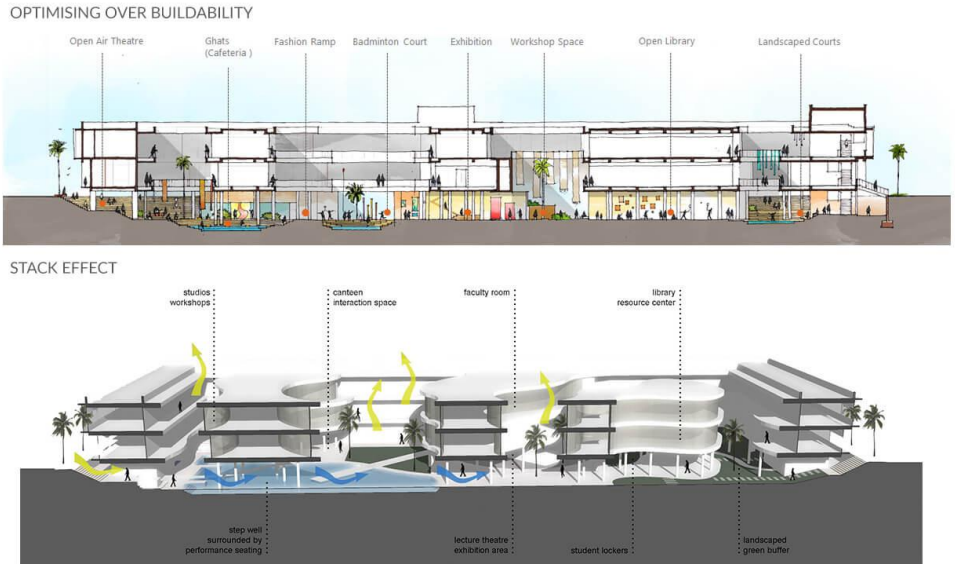


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Figure no:16

Pearl academy located on the outskirts of the Jaipur consists of the traditional energy efficient Elements such as courtyard, jali, water body in the form of the step well inspired from the traditional baodi of Rajasthan. The courtyard designed in this building controls the internal temperature and helps to provide light and ventilation to the studios and classrooms. The lowest floor of the building is sunken 4m below the ground level and it also provides privacy.

Figure 17:Jali is used in the outer façade of the pearl academy

The ancient reverse pot technique is used in the roof of the building so as to lower the internal temperature of the building. The outer façade of the building is a double skin façade in which jali is provided to enhance the daylight performance and to circulate the cool air inside the building.

Design elements used:jaali, courtyard, step well, reverse pot technique. There are some more buildings in which the ancient passive techniques are applied like

Sanjaypuri architect's office in Jaipur. The outer façade is the jali façade and courtyards are provided in the building.

Figure 18:Jali façade, sanjaypuri office, Jaipur

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4. CONCLUSION

Today we are living in 21st century trying to be modern adopting modern culture, modern food, modern technologies for the luxury and comfort. But the use of such techniques is good till some extent. To get the comfortable interiors modern hvac systems are installed in thebuildings, that are harming our environment in one or other way. It is advisable to look back at passive techniques for the inspiration. Traditional buildings if the Jaipur are the good example of passive architecture. Courtyard is an essential design element for the ventilation and day lighting in hot and dry climate. An understanding of jaali is essential to effectively use them in the design to ensure greater thermal comfort.

5. RECOMMENDATIONS

Today is the alarming time that is in the need of the passive architecture that responds to the environment positively. As it is truly said that the "dwellings of the future, inspired by the past" , thus traditional techniques should be used in the modern architecture. The perfect examples are the pearl academy and the sanjaypuri's office, that how they have incorporated the traditional techniques in the modern buildings that respond to the atmosphere in ecofriendly way and also look aesthetically good. Jali and courtyard are one of the most used elements in historic architecture. We can look upon them and modify them according to the today's need. Futuristic courtyards and jali can be invented that can used in today's buildings.What is required on our part, as designers, is consciousness and a careful reinterpretation of traditional and regional aspects, existing well within the parameters of contemporary times. We need to go back in context, to rekindle our lost values, which were not just visible in the ethos, but alsoin functional aspects of buildings back then. So why shouldn't we gain inspiration from the past when it can revitalize our present and future?

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