

The Jali Screens of Rajasthan: An Exploration of Climate Response, Craftsmanship, and Cultural Identity

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Abstract – An architectural language that combines environmental requirements with cultural identity and expert craftsmanship has been shaped by Rajasthan's harsh desert climate. The jali, a perforated screen made primarily of stone, wood, or later metal and other materials, is one of this tradition's most characteristic features. The origins, development, materials, crafting methods, climatic performance, sociocultural role, and reinterpretation of the jali in contemporary architecture are all examined in this study. The research demonstrates that jalis are much more than just ornamental elements through a review of the literature and architectural analysis; they serve as useful instruments for controlling light, ventilation, and privacy while improving aesthetic appeal. The study emphasises the importance of jalis and their enduring relevance in a variety of historical and modern building types.

Key Words: Jali, Rajasthan Architecture, Climate-responsive Facade, Traditional Craft, Screen Architecture, Perforated Elements.

1. INTRODUCTION

Rajasthan's use of locally accessible materials, cultural customs, and harsh climate have all influenced the state's architectural heritage.

The jali, a perforated architectural screen, is still one of the most recognisable components of this vernacular heritage [1]. Jalis, which are typically made of sandstone, marble, wood, or metal, can be found throughout the region in palaces, havelis, temples, and residential structures [2].

Jalis have significant practical uses in addition to being decorative. They provide privacy, enhance ventilation, filter intense sunlight, lower interior temperatures, and produce rhythmic patterns on facades [3]. Generations of expert craftsmanship are reflected in their elaborate designs, which are based on geometric logic and floral motifs [4]



Figure 1: Master craftsman Ramawtar carving white marble at Frozen Music atelier, Jaipur, Rajasthan. (Image credit: David Horsman).

Traditional components like the jali provide important lessons in passive cooling and natural light control as design practices increasingly emphasise sustainability and climate-responsive solutions [5]. The historical evolution, practical significance, material craftsmanship, typology, and changing application of jalis in Rajasthan are all examined in this study.

2. LITERATURE STUDY

2.1 Historical Origins

It is thought that early Hindu and Indo-Islamic stone carving traditions are where the jali first appeared [1]. It changed over time as a result of Persian, Mughal, and Rajput architectural influences [6]. The availability of workable sandstone in Rajasthan made it possible for craftspeople to create incredibly delicate perforations, which led to the development of regionally distinctive jali styles [2].

Historic examples include:

Jaisalmer Havelis

Some of the most exquisite sandstone jalis can be found in the opulently decorated havelis of Jaisalmer [2].

City Palace of Jaipur

Incorporates jalis into its interior screens and facades to provide regulated ventilation and lighting [1].

Mehrangarh Fort

In Jodhpur, displays sturdy yet elaborate stone screens in Jodhpur that combine climatic performance with Rajput aesthetics [1].

Bundi and Kota Palaces

They exhibit jalis that combine narrative motifs with precise geometry [4].

These structures demonstrate the jali as both a decorative and climatic device.

2.2 Socio-Cultural Function

In Rajasthan's traditional architecture, jalis had deep sociocultural significance and served purposes that went well beyond their aesthetic value. The most crucial roles stemmed from [6]:

Purdah tradition

where women from royal and noble households could watch street activities, ceremonial processions, and outdoor events without being seen by the general public thanks to elaborately carved screens. Social engagement was made possible while upholding the era's privacy standards thanks to this nuanced mediation between visibility and seclusion [1].

Symbolic representation

Through their patterns and motifs, which were frequently influenced by religious iconography, cosmic diagrams, and concepts of sacred geometry, Jalis frequently communicated deeper symbolic meanings. Each jali was seen as an expression of philosophical ideas rather than just a structural component because these patterns were thought to represent spiritual harmony, protection, and cultural identity [4].

Royal privacy

In royal settings, Jalis served as covert screening devices for viewing galleries, balconies, and jharokhas, enabling rulers and members of the royal family to observe public events, durbars, and celebrations without drawing attention to themselves. In Rajasthan's architectural fabric, jalis acted as cultural mediators, upholding traditional customs, facilitating symbolic communication, and reinforcing social hierarchies [6].

2.3 Typological Variations

Rajasthan displays an astounding variety of jali typologies, each influenced by regional craftsmanship, cultural symbolism, and the geological properties of accessible materials like [4]:

Geometric jalis

Use mathematically derived shapes such as hexagons, stars, interlocking polygons, and others to showcase the artisans' advanced knowledge of symmetry, proportion, and modular repetition.

Floral jalis

Inspired by vines, petals, lotus flowers, and other botanical elements, present a softer, more organic aesthetic that reflects the long-standing tradition of nature-based ornamentation in the area.

Linear lattices

Built with straightforward grid-based designs that prioritise functional transparency and structural clarity, they frequently have more practical uses in residential and semi-public areas.

Relief-carved jalis

By adding different depths and surface articulations, you can add a sculptural dimension to the screen and create dynamic light and shadow interplay.

The distinctive jali styles that contribute to the architectural identity of Rajasthan's varied cities and settlements are the result of these typological variations that developed in response to variations in regional stone quality, local artistic practices, and cultural preferences.

3. MATERIALS AND CRAFTSMANSHIP

3.1 Traditional Material Palette

Rajasthan's long-standing artisanal heritage and geological diversity are reflected in the traditional material palette used to make jalis [2].

Sandstone

Because of its fine grain, workability, and local abundance, which allowed artisans to precisely carve intricate perforations, this material—which comes in shades of yellow, red, and buff became the most popular [5].

Marble

The famous Makrana marble, whose smooth texture allowed for delicate detailing and created a striking contrast against sandstone facades, was only used for temples, palaces, and other high-status buildings where durability, luminosity, and aesthetic refinement were crucial [2].



Figure 2: Sandstone jalis at the New Building for the Parliament of India were inspired by the country's history of architectural crafts. Image © Kavin Kumar La Sa

Wood

played a vital part, particularly in the Shekhawati region's havelis, where elaborately carved wooden jalis adorned windows, doors, and interior partitions, showcasing the adaptability of timber crafts- manship [4].

Metal

Constructed from iron, brass, or later cast alloys—appeared as ornamental and occasionally structural screens in later eras, providing a distinct visual language with more elaborate filigree-like patterns and slender profiles [7].

3.2 Craft Technique

The craft of jali carving demanded exceptional skill from the sangtarash, or traditional stone craftsmen, who employed a meticulous and sequential process [8]:

1. The first step in the project was the meticulous selection of stone blocks, which were picked for their structural stability, uniform grain, and suitability for fine detailing.
2. After the stone was ready, artisans marked the geometric grids that formed the foundation for the finished design using charcoal or natural pigments, guaranteeing both mathematical accuracy and aesthetic harmony.
3. After that, solid stone was gradually transformed into a delicate lattice by chiselling the initial perforations with a combination of pointed, flat, and toothed chisels. Because the piece could easily be fractured by excessive force or inaccurate angling, this stage required a thorough understanding of material behaviour.
4. Following the definition of the openings, craftspeople carefully polished the edges, sharpened motifs, and added surface detailing to increase the intricacy of the design.
5. In order to achieve a smooth finish that highlighted the craftsmanship and improved the play of light across the surface, the jali was finally polished using abrasives.

These techniques were often passed through artisan guilds across generations [9].

3.3 Geometric Logic

Traditional proportional systems, which blend mathematical accuracy with aesthetic harmony, are the foundation of Rajasthani jalis' geometric logic.

-Mandala geometry: In order to represent cosmic order and symbolic balance, patterns are arranged around radial axes, concentric circles, and grid-based frameworks.

-Symmetry: plays an equally important role in directing the placement of motifs in bilateral, rotational, or radial configurations to maintain visual equilibrium across the screen.

-Repetition: Complex lattices that appear both continuous and dynamic are created by methodically repeating modular units, such as stars, polygons, or floral forms.

-Fractal-like divisions: Intricate layers of depth and visual richness are produced by breaking patterns down into progressively smaller components.

In addition to adding to the artistic sophistication of Rajasthani jalis, this strict geometric foundation guaranteed their structural stability, allowing delicate perforations to endure despite their thin profiles.

4. CLIMATIC AND FUNCTIONAL PERFORMANCE

4.1 Daylighting Control

Jalis are essential for regulating daylight to create comfortable interior conditions in Rajasthan's harsh desert environment. By dispersing incoming rays and lowering direct glare, their perforated surfaces mitigate the region's intense sunlight, preventing overheating and visual discomfort. Because it filters light in a way that keeps interiors naturally lit throughout the day without allowing excessive heat gain, the angled orientation of the openings is especially effective. By reducing the need for artificial lighting, this controlled diffusion creates a soft, ambient luminosity that improves spatial quality. Long before the development of contemporary building technologies, Jalis showed a deep understanding of climate adaptation and energy-efficient design through this passive daylighting technique. [3]

4.2 Passive Cooling

The hot and dry climate of Rajasthan makes the jali an ideal passive cooling tool [5].

Cross-ventilation

Consistent airflow is made possible by its perforated structure, which promotes natural cross-ventilation that helps replace warm indoor air with cooler breezes.

Venturi effect

The Venturi effect, in which air entering through tiny perforations accelerates and improves interior cooling, is frequently produced by the tiny, carefully placed openings.

Thermal buffering

Even in extremely hot conditions, the thermal mass of stone or terracotta jalis helps maintain cooler indoor environments by absorbing heat during the day and releasing it gradually at night. Jalis dramatically reduce the reliance on mechanical cooling systems by regulating air movement and lowering direct solar gain, demonstrating the effectiveness of conventional passive design techniques in hot desert areas.

4.3 Privacy

Rajasthani architecture has always placed a high value on privacy, and the jali was crucial to meeting this social and cultural need. In keeping with the purdah system's emphasis on seclusion, its lattice structure allowed residents—particularly women from royal or noble households—to observe the outside world without being noticed. Because of the jali's visual permeability, outward visibility was guaranteed while inward sightlines were blocked, resulting in a subtle but effective barrier that protected privacy without sacrificing ventilation or daylight. Jalis were frequently placed in balconies, hallways, and upper floors of palaces, havelis, and temples to allow for covert observation of public gatherings, processions, or courtyard activities. As a result, the jali served as an architectural mediator, striking a balance between environmental comfort, open space, and cultural norms. [6] [1]

4.4 Dust and Noise Filtering

Jalis filter dust and modulate sound in addition to controlling light and air. Sandstorms and dusty winds are common in Rajasthan, especially in the desert areas of Jaisalmer and Barmer. The jali's tiny holes serve as a barrier that prevents suspended particles from entering while still permitting sufficient airflow. This enhances indoor air quality and keeps interiors cleaner. Similarly, the complex lattice lessens the intensity of outside noise and produces quieter interior spaces by dispersing and breaking down sound waves. The jali's multipurpose effectiveness is demonstrated by the combination of dust filtration and acoustic moderation, highlighting its importance as a climatic and environmental buffer in traditional desert architecture. [1]

5. CASE STUDIES

5.1 Patwon ki Haveli, Jaisalmer

One of Rajasthan's most renowned examples of elaborate sandstone jali craftsmanship is Patwon ki Haveli in Jaisalmer. This group of five havelis, built in the early 19th century, features incredibly intricate jalis carved from the distinctive golden-yellow sandstone of the area. These screens, which showcase the skill of regional craftspeople renowned for their ability to carve delicate filigree patterns out of comparatively soft stone, adorn balconies, facades, and interior partitions. The jalis here serve multiple functions:



Figure 3: Patwon ki Haveli, Jaisalmer

- They improve natural ventilation within the small urban fabric of Jaisalmer's old city, protect residents' privacy, and filter the harsh Thar Desert sunlight.

- The socioeconomic standing of the merchant families who commissioned the havelis is also revealed by their geometric intricacy and fine detailing, highlighting the function of jalis as symbols of wealth, creativity, and cultural identity.

- As a result, Patwon ki Haveli serves as both a living museum of Rajasthani traditional jali craftsmanship and an architectural landmark.

5.2 Hawa Mahal, Jaipur

Hawa Mahal, constructed in 1799 by Maharaja Sawai Pratap Singh, is perhaps the most iconic architectural example of jali usage in India. The facade features an astonishing 953 small jali windows, or jharokhas, arranged across its pyramidal elevation.



Figure 4: Hawa Mahal, Jaipur

- The "Palace of Winds" got its name from the cool breezes that could pass through the building thanks to these perforated openings.

- The jalis were made to provide privacy without blocking visibility for the royal women who watched ceremonial processions and street life below.

- By directing wind through Jaipur's winding streets and into interior spaces, the dense arrangement of tiny apertures encourages passive cooling.

The facade transforms into a dynamic play of light, shadow, and airflow, highlighting the jali as an essential part of the building's environmental performance rather than just an ornamental element. Thus, Hawa Mahal is a monument to the blending of social customs, climatic intelligence, and Rajput aesthetics.

5.3 Mehrangarh Fort, Jodhpur

Jalis are widely used in the palaces, courtyards, and royal chambers of Mehrangarh Fort, which rises above the blue city of Jodhpur. In contrast to the delicate filigree found in Jaisalmer, the jalis here frequently strike a balance between the robustness required by the fort's defensive structure and intricate detailing.



Figure 5: Mehrangarh Fort, Jodhpur

- Many of the stone screens, which feature a combination of geometric grids, floral motifs, and sculptural relief work, combine Mughal and Rajput stylistic influences.

- In contrast to the intense heat outside, these jalis control light penetration into the interiors with thick walls, creating cool, shaded spaces.

- Additionally, they protect the royal household's privacy, especially in areas like the zenana (women's quarters).

The jalis of Mehrangarh Fort are excellent examples of architectural integration because they combine climatic function, security, and aesthetic refinement. This shows how perforated screens can simultaneously address environmental, cultural, and defensive needs.

6. CONTEMPORARY REINTERPRETATIONS

6.1 Modern Materials and Technologies

The use of contemporary materials and fabrication techniques has significantly reinterpreted the jali in modern architectural practice.

CNC-cut stone

Architects are increasingly using CNC-cut stone panels, which enable highly precise and intricate designs that were previously very labor-intensive, even though the traditional stone-carved jali is still a timeless symbol of craftsmanship. [10]

Laser-cut metal panels

gained popularity due to their durability, light weight, and capacity to create intricate patterns with little structural thickness. [10]

Precast concrete blocks

Provide a modular, affordable substitute that is appropriate for large-scale facades that need to be both environmentally friendly and aesthetically pleasing [8].

Terracotta perforated units

Incorporate a warm, earthy texture while preserving efficient ventilation and shading, drawing inspiration from traditional cooling devices like jaali bricks and jali tiles [8].

Parametric design models

With the use of tools, architects can create performance-based jali geometries that react to variables like airflow, visibility, heat gain, and sun angles. [10]

These cutting-edge technologies enable the jali to transcend its traditional form while maintaining its essential characteristics of visual porosity and climate responsiveness.

6.2 Applications in Modern Buildings

Jalis are incorporated into many different building types in contemporary architecture, proving their ongoing value as both practical and decorative design components.

- **Institutional buildings:** Reduce glare and filter daylight to help control solar exposure and create comfortable learning environments. [10]
- **Residential facades:** Echoing traditional domestic uses in a modern setting, use contemporary jalis to maintain privacy while allowing airflow [8].
- **Commercial complexes:** Make use of large-scale perforated screens as expressive envelope treatments to create unique visual identities, lower energy loads, and offer shading [10].
- **Cultural centers and public buildings:** Using cutting-edge materials and geometrically optimized patterns, adopt jalis to evoke regional heritage while fusing tradition and modernity [8].

In all of these typologies, the modern jali serves as a strategic facade system that improves environmental performance, mediates light and air, and strengthens the place-based nature of architecture in addition to being decorative cladding. This resurgence demonstrates the jali's enduring versatility as a classic architectural element appropriate for both historical and contemporary settings.

7. DISCUSSION

The study claims that jalis are more than just decorations in Rajasthan; they are also very useful cultural and climatic elements. They skillfully regulate daylight, airflow, and privacy while reflecting the local aesthetic traditions and social values. They show a deep understanding of structure, proportion, and environmental requirements through their material craftsmanship and geometric accuracy. [6]

New fabrication techniques provide more options for jali-like screens as building practices and technologies change. But this change also raises questions about whether traditional craftsmanship will continue. Sustaining the cultural and practical significance of jalis requires striking a balance between changing design strategies and the preservation of artisan skills.

8. CONCLUSION

According to the study, Rajasthani jalis are a clever blend of expert craftsmanship, cultural significance, and climate-friendly design. They are still significant because they offer privacy, regulate sunlight, and naturally lower temperatures. Architects can now create new jalis with the aid of contemporary tools and materials, but it is still crucial to preserve the traditional carving techniques. Jalis will remain valuable and significant in architecture if both new methods and traditional craftsmanship are preserved. [3] [9]

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