

Biophilic Design as Part of the Contemporary Interior of Airport Terminals

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Abstract – Airport terminal buildings are a reflection of modern technology, as well as representation of the distinctive identity of each country and contemporary interior design trends. This paper aims to examine the impact biophilic design has on passenger perception. The research is focused on the implementation of main design principles related to biophilia, namely: natural light and materials, green vegetation, water features. Biophilic design is proven to be not only an aesthetic part of contemporary interiors, but a useful tool for navigation, bringing a sense of place and creating fascinating atmospheres. A research on global tendencies is conducted to support the affirmation that biophilic design has a positive impact on passenger experience and comfort and has the potential to enhance passenger well-being. The paper suggests strategic ways to implement these design principles in airport terminals, in order to reduce stress levels in passengers and improve their overall experience in the airport terminal building.

Keywords – contemporary interiors, airport terminals, biophilic design, passenger experience, natural materials, comfort

I. INTRODUCTION

The rise of the air traffic industry throughout the 20th and 21st century requires a transformation in airport complex design. The passenger terminal is positioned and rethought as the most important building in the airport city. Airport terminals hold emblematic value due to the creation of the first and last impression of the given location and are characterized by their complex and multifunctional structure. A smooth integration between various spaces is needed, for example: extensive, interconnected areas for social interaction, numerous commercial outlets (including shops, airline offices, hotel chains, etc.) and technical zones. The complex structure is only successful when the following critical requirements are met: functionality, operational efficiency, environmental comfort, positive passenger experience and sustainability.

Contemporary airport terminals reflect technological progress, national identity and the latest architecture and interior design trends. Recent years have shifted the main focus in the design process to key issues such as: sustainability, inclusivity of built environment and passenger well-being. The clear direction pushes the standards for design beyond functionality and aesthetics, which were just enough in the past. One of the most important aspects for a successful development and attractiveness of a contemporary airport is passenger experience.

In the light of current ecological concerns interior design trends are also focused on sustainability and the restoration of the human-nature connection. Biophilic design is grounded on the same ideology, aiming the successful integration of natural materials, daylight, vegetation and water features into the interior space.

This study aims to explore the influence of biophilic design on passengers' perceptions and its ability to create distinctive atmospheres. Through the extensive analysis of relevant scientific literature and established best practices, the research confirms the positive impact of such innovative approaches on the passenger experience and comfort. As a result, the paper suggests strategic ways to implement these design principles

in airport terminals, in order to reduce stress levels in passengers and improve their overall well-being.

II. BIOPHILIC DESIGN: INTEGRATING NATURE INTO THE INTERIOR ENVIRONMENT

Stephen Kellert defines biophilic design as “the missing link in sustainable design.” The term derives from the Greek roots "bios" (life) and "philia" (affection or love), and in its contemporary interpretation refers to the innate human need for contact with nature even in the interior space of the built environment. The intuitive belief that integration of natural elements into interior spaces positively affects human health and well-being has been repeatedly supported by scientific evidence. Current research highlights benefits in various settings, including improved patient recovery in healthcare environments, enhanced cognitive function in children, and increased focus among office workers.

A. Core Implementation Approaches

The application of biophilic design in interior spaces is categorised by the following main approaches:

- **Direct contact with nature:** refers to the incorporation of natural elements directly into the interior space, such as daylight, live plants, water features, vegetation and fresh air.
- **Indirect contact with nature:** refers to the use of natural materials, organic shapes, nature-inspired textures, patterns and color patterns, reminiscent of the natural world.
- **Nature-inspired spatial organization:** focuses on the visual or sensory representation of nature through the use of artwork, imagery, structural elements, interactive installations or multimedia screens.

III. CREATING A DISTINCTIVE ATMOSPHERE THROUGH BIOPHILIC DESIGN

The study focuses on key techniques for implementing biophilic design in modern airport terminals, particularly through environmental characteristics. Nature is explored not only for its aesthetic contribution to interior identity but also as a powerful tool for creating a unique and emotionally resonant atmosphere.

A. Natural light

Natural daylight is a fundamental factor in the favorable perception of interior environments. Its architectural integration enhances both energy efficiency and interior ambiance. Exposure to natural light supports the circadian rhythm, boosts overall mood, and reduces anxiety. Contemporary strategies include glazed roofs, smart glass systems, multi-glazing technologies, and mirrored devices that redirect sunlight into internal spaces.

B. Plants and greenery

The use of vegetation in interior environments serves not only as an aesthetic role but also demonstrably improves comfort and satisfaction. Natural greenery enhances air quality, captures attention, and establishes a calming atmosphere - an effective strategy for reducing passenger stress and improving their experience. Applications include vertical gardens, indoor parks, and decorative or partitioning elements with integrated plants in the waiting areas.

C. Water features

Water elements can serve as a focal point in the interior design concept of airport terminals. While technically complex, their inclusion has a profound psychological impact. The presence of water fosters a harmonious and calming environment for passengers. Interior applications may include artificial waterfalls, decorative water walls, still water surfaces, and reflective pools.

D. Natural materials

Humans subconsciously favour natural over synthetic materials - even when imitations are visually similar. The use of natural materials such as wood, stone, and natural fibers aligns with the principles of sustainable design and helps reduce environmental impact. Their application in interiors fosters a sensory connection with nature, creating a soothing, warm, and welcoming atmosphere.

IV. THE IMPACT OF BIOPHILIC DESIGN ON PASSENGER PERCEPTION

The success and profitability of investments in the aviation sector are traditionally measured by ROI (Return on Investment), which reflects the time required to recover initial capital. However, the modern development of airport terminals necessitates the inclusion of a new metric - PEI (Passenger Experience Index) - which places passengers and their overall experience at the core of evaluation and long-term success.

Biophilic design contributes significantly to the holistic perception of interior spaces, making it particularly relevant to airport terminals, which are often associated with sterile environments, high noise levels, stress, and a lack of natural connection. In the past decade, numerous studies have

examined the psychological and physiological effects of biophilic design on occupants of the airport terminal building.

The 2019 annual report of Munich Airport focused on sustainable development and confirmed the positive effects of biophilia, when applied in the interior spaces. The study recorded a 30% reduction in passenger anxiety in waiting areas enhanced with natural elements such as vertical gardens and daylight. Similar findings are documented in the annual report of Singapore's Changi Airport.

In 2018, a study conducted by the Passenger Experience Association examined passengers' orientation within airport terminals. The results indicated a 40% improvement in wayfinding when biophilic design elements were applied, such as green walls, water features in key zones, and natural materials for space zoning.

V. GLOBAL TRENDS AND BEST PRACTICES

Through an analysis of global trends, the study affirms the positive impact of implementing biophilic design in airport interiors on passenger experience and comfort. The research examines three leading airports developed over the past twenty years, with a focus on sustainability, operational efficiency, and passenger satisfaction. These selected examples stand out for their distinctive character, strong expression of cultural identity, and design by prominent architectural studios.

A. Madrid-Barajas Airport, Spain, Terminals 4 and 4S (2005)

Terminal 4 at Madrid-Barajas Airport was designed by Estudio Lamela and Rogers Stirk Harbour + Partners. Located near the other airport terminals, the project was completed in 2005 and spans a total area of 1,100,000 sqm. The Terminal 4 building is the main component of a multifunctional complex that also includes a large parking facility and a satellite terminal for non-Schengen flights. It is one of the largest airports in Europe and has won numerous awards, including the RIBA Stirling Prize for the most significant building of 2006. According to the 2024 Skytrax World Airport Rankings, Madrid-Barajas ranks 15th globally.



Fig. 1. Madrid-Barajas Airport Terminal 4 / Archdaily [1]

The architectural project focuses on humanizing the interior spaces of airport terminals. The design incorporates human-scale principles to reduce passengers' sense of anonymity and lack of belonging. The building's silhouette evokes the wings of a bird in flight (fig. 1). Its iconic roof structure is clad in bamboo, creating a sense of lightness and elegance (fig. 2). The use of natural materials and fluid lines enhances both the

sustainability and visual appeal of the terminal. Vivid colors mark the structural beams, helping to distinguish between different functions and improve wayfinding. Another characteristic feature is the presence of large skylights in the roof, which allow natural light to reach all floor levels (fig. 2). These so-called “canyons” not only enhance aesthetics by bringing the landscape inside but also serve as part of the natural ventilation system, improving energy efficiency and reducing maintenance costs.

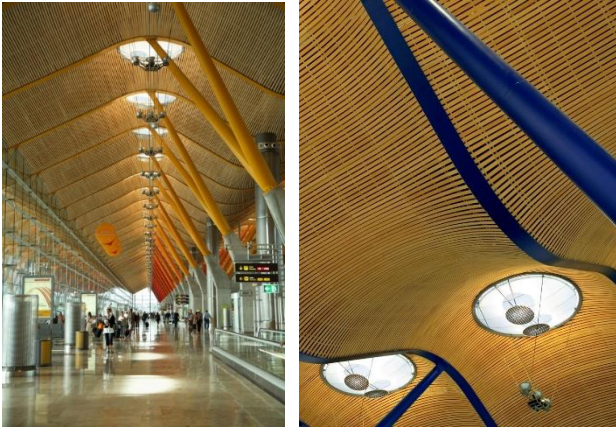


Fig. 2. Madrid-Barajas Airport Terminal 4 /Archdaily [1]

In 2022, a new relaxation zone was created to enhance the Passenger Experience Index (PEI). Designed using sustainable methods and seamlessly integrated into the existing interior, this area was developed by Green Furniture Concept. It features 99 Mediterranean trees, ergonomic layered wood seating, plant planters, decorative lighting, and built-in technological solutions (fig. 3). This intervention improved passenger satisfaction by 20%, according to the 2023 Aena Sustainability Report.



Fig. 3. Adolfo Suárez Madrid-Barajas Airport/Green Furniture Concept [2]

C. Oslo-Gardermoen Airport, Norway, Expansion (2017)

The expansion of Oslo Airport was completed in 2017 to increase its annual passenger capacity to 35 million. The design by Nordic Office of Architecture aimed to achieve the highest sustainability standards and reduce the airport’s carbon footprint. Covering an area of 115,000 sqm, the extension is recognized as one of the world’s most environmentally friendly terminals and is certified with a top BREEAM (Sustainable Building Certification) rating.

An innovative approach was used to collect snow from runways in winter and store the water for cooling purposes in summer. The extension was designed as a natural continuation of the existing terminal, with a curved architectural envelope that maximizes daylight exposure. The extensive glazing

connects the interior with the outdoors and helps manage the lack of light in winter and the abundance of sunlight in summer — conditions typical for Scandinavia (fig. 4).

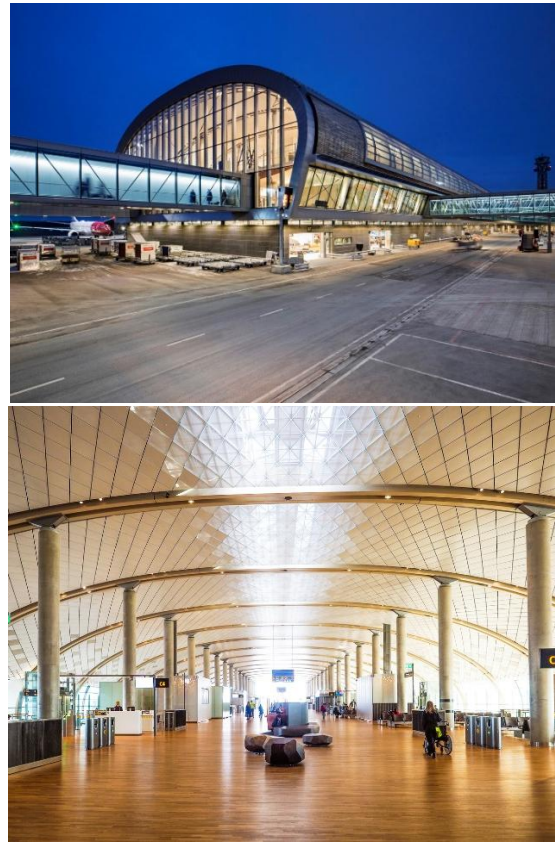


Fig. 4. Oslo Airport Expansion /Nordic Office of Architecture /Archdaily [3]

The interior environment incorporates numerous biophilic design elements, fostering a sense of calm for passengers. The human-nature connection is emphasized through living vegetation (such as trees in the dining area and green walls) and water features (like fountains and water walls). The use of natural materials, exposed wood structures, and glazing contributes to cultural identity and enhances the airport’s image as a “gateway” to Norway (fig. 5). The duty-free zone, inspired by Norwegian landscapes, mimics large river stones that guide passenger flow and aid in functional zoning. A “less is more” approach was applied for navigation — with clear forms and minimal signage — creating a distinctive, low-stress atmosphere that improves passengers’ psychological well-being.

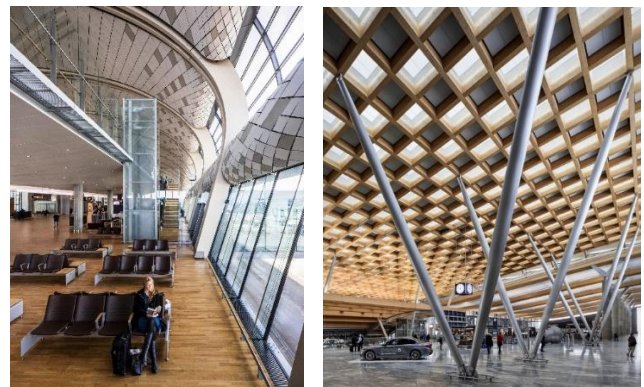


Fig. 5. Oslo Airport Expansion / Nordic Office of Architecture / Interiors / Archdaily [3]

D. Changi Airport, Singapore (2019)

Singapore's Changi Airport is globally recognized as the most distinguished airport, having won the Skytrax World's Best Airport Award for 12 consecutive years. The "Jewel" terminal, designed by Safdie Architects, is a large-scale project completed in 2019 and covers 135,700 sqm. It offers a nature-integrated experience and features a wide array of recreational facilities and striking architectural elements.

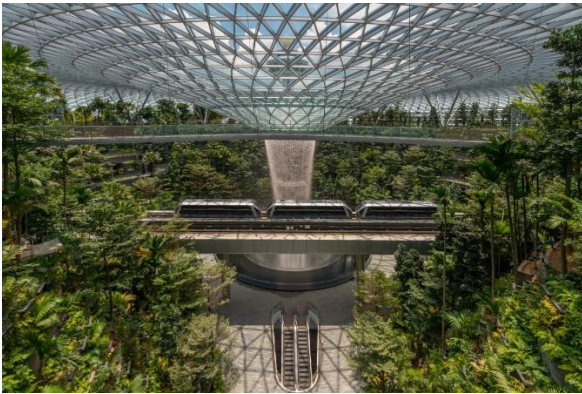


Fig. 6. Jewel Changi Airport / Safdie Architects / Interiors / Archdaily [4]

Jewel serves as a connector between the existing terminals and integrates a vast commercial complex, technological hubs, social spaces, restaurants, a hotel, and a tropical garden. The design is entirely focused on the human experience and is a benchmark for biophilic design in modern airport terminals. Terminals are connected to Jewel via pedestrian bridges and an internal train that travels through the terminal gardens (fig. 6).

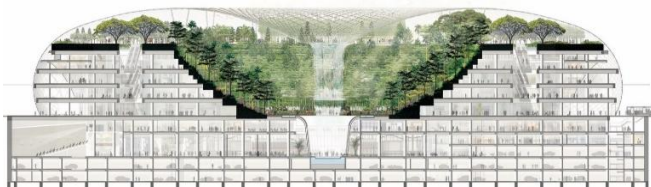


Fig. 7. Jewel Changi Airport /Safdie Architects /Cross-section /Archdaily [4]

The architectural shell consists of a glass dome that floods the interior with natural light and contributes to energy generation through photovoltaic panels. At the heart of this dome is the main attraction — the Rain Vortex, the tallest indoor waterfall in the world (fig. 7). Spanning all garden levels, the waterfall produces a light and sound show and also functions as a cooling element, promoting air circulation and rainwater reuse during thunderstorm-heavy months.

The terminal is centered around a massive terraced indoor garden stretching across four levels and featuring over 200 plant species, walking trails, waterfalls, and secluded rest areas (fig. 8). Each cardinal direction is marked with plant-covered portals to improve orientation. The fifth and top level houses a 14,000 sqm park with installations, attractions, climbing nets, and labyrinths. The resulting interior composition forms a dynamic environment with a changing lighting cycle adjusted to the time of day and mood. At night, the building's glass shell fades into the background, drawing attention to the lush greenery of the central garden.



Fig. 8. Jewel Changi Airport / Safdie Architects / Interiors / Archdaily [4]

VI. CONCLUSION

Contemporary airport terminals are innovative multifunctional buildings that must meet the highest standards of technology, functionality, aesthetics, and environmental comfort. The dynamic development of air travel and its direct correlation with passenger satisfaction demands a clear focus on the passenger experience when designing terminal interiors.

Biophilic design is a proven approach to strengthening the human-nature connection. Its application helps reduce stress and anxiety among passengers and staff, creates an artistic atmosphere, emphasizes functional zoning, and fosters a sense of belonging and tranquility.

The conducted study of three airport terminals notable for biophilic interior applications confirms the positive impact on passenger experience and comfort. Each example ranks among the world's best and offers a unique regional interpretation of biophilic principles. While the strategies differ in scale, they share similar meanings and form strategic guidelines for implementation:

- Use of natural materials: bamboo roof cladding, wooden finishes, natural stone, and other locally sourced materials.
- Maximization of natural light through roof openings and extensive glazing.
- Harmonization of color palettes and forms with those found in nature. Rich interior landscaping using diverse, local, and region-specific plant species.
- Creation of focal elements and spatial hierarchy using water features, waterfalls, and decorative walls.

These diverse approaches to enhancing passenger satisfaction through biophilic design validate the initial thesis and open opportunities for creative authorship. The relevance of the topic and the limited number of studies in this field suggest a valuable potential for further development and enrichment of the current research.

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